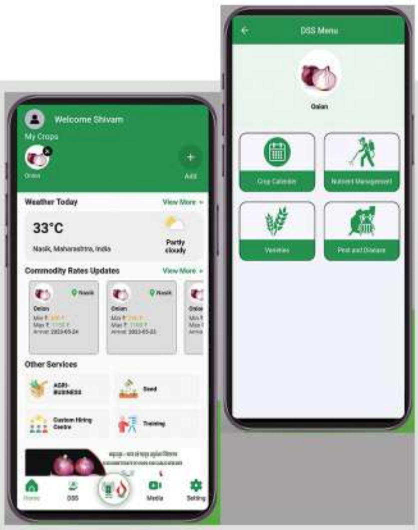
वार्षिक प्रतिवेदन
Annual Report
2022



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Designed by: ICAR-Directorate of Onion and Garlic Research, Pune

Preface

I feel privileged to present Annual Report of ICAR-Directorate of Onion and Garlic Research for the year 2022. Onion and garlic are two important essential vegetable commodities used mostly for culinary purpose. Beside culinary uses, these also have several medicinal values. Being a prime Institute exclusively on these two commodities, ICAR-DOGR continued various research, extension and development activities related to onion and garlic crops.

ICAR-DOGR is maintaining 89 wild and underutilized *Allium* lines of 17 different species under field condition. Systemic value chain development efforts are being carried for *Allium tuberosum* based on three E's *viz*. Evaluation of production performance, Exploration of consumer response and quality perceptions and Exploration of market potential and sustainability. Onion germplasm were evaluated during *kharif*, late *kharif* and *rabi* seasons. Mutation breeding, using gamma radiation, colchicines and EMS treatments were attempted in garlic lines for creating variability in response to yield, bulb size and stability. Inoculation of onion seedlings with *Azotobacter* spp. performed superiorly under waterlogging stress based on crop phenotypic growth and bulb yield performance. ICAR-DOGR has also registered two germplasm with ICAR-NBPGR for waterlogging (IC0645764) and drought (IC0645763) tolerance in onion. The efforts are also being made to develop haploids through gynogenesis. Currently, sixty-seven double haploid lines have been maintained at the institute.

Inclusion of maize as preceding crop and application of inorganic fertilizers alone produced significantly higher bulb yield compared to other fertilizer treatments. The yield increase in INM plot, and chemical fertilizer alone applied treatment was higher by 54.7-56.4% compared to organic treatments. Application of 100% (110 kg/ha) and 150% (165 kg/ha) N through drip and sprinkler increased onion yield significantly compared to flood irrigation system. In garlic, application of ICAR-CIRCOT nano-sulphur application @ 15 kg/ha and 23 kg/ha recorded higher yield compared to the remaining treatments, whereas, application of bentonite sulphur @ 30 kg/ha recorded the highest yield compared to the rest of the treatments in onion.

The fungal pathogens of onion (*Colletotrichum* spp., *Fusarium* spp., *Alternaria* spp., *Stemphylium* spp) were collected, isolated, and characterized using morphology as well as molecular tools using ITS and TEF primers. In addition, bio-agents *Trichoderma* spp. were also isolated (11 isolates) and tested against *Stemphylium* and Anthracnose diseases. Eight isolates showed inhibitory action against fungal pathogens in which *Trichoderma* isolate NRCG-8 showed a maximum of 33-40%, 44% and 50% inhibition on *Stemphylium*, Anthracnose and twister, respectively. The Amritpani-based organic formulations tested against Anthracnose in onions.

DOGROF3, a formulation comprised of a mixture of Bajra flour, *Calotropis* leaves, Karanj leaves, Ginger powder, Turmeric powder, Hing powder and water, was effective in inhibiting *Stemphylium* by 36% and Anthracnose by 32% and increased the bulb yield. The effect of chitosan nanoparticles seed priming on growth and resistance to *Stemphylium* Leaf Blight was assessed. The chitosan priming showed better germination, vigour and less disease severity index than untreated seeds. Likewise, the effect of zinc nanoparticles on the fungal pathogen *Fusarium* causing basal rot of onion was investigated by determining the fungal radial growth. Nanoparticles can be exploited for the better control of onion pathogens. Pathogenicity of anthracnose-twister studied via artificial inoculation. A miniature parasitoid wasp, *Megaphragma amalphitanum*, was recorded on thrips. The bio-efficacy of commercial formulations of entomopathogens, including *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii*, and the botanical pesticide neem oil, was tested against onion thrips, both alone and in combination with the biological pesticide spinosad. The occurrence of beetle, *Carpophilus hemipterus* is recorded in the onion storage. The pollination potential of the native stingless bee *Tetragonula iridipennis* was assessed. The stingless bee species visiting onion in various locations of Maharashtra was documented. Further, the complete mitogenome of *T. iridipennis* was characterized for the first time. Reducing the storage losses and value addition are the two inevitable things to make the onion crop cultivation more economical. ICAR-DOGR is working on refinement of storage structures for reducing the storage losses and development of processed products from onion and garlic.

Three decision support systems viz., 'ONDSS', 'SmartOnion' 'ODPAdviser' have been developed to assist farmers in making informed decisions regarding nutrient management, disease and pest management, and variety selection. Additionally, a mobile application called "Onion Crop Advisor" is developed for farmers to provide comprehensive information, advisories, and decision support tools for onion farming. Multimedia-based news bulletins '*Kanda va Lasun Samachar*' in Marathi and '*Pyaj evam Lahsun Samachar*' in Hindi and social media platforms are used to disseminate agro-advisories and technological information. Furthermore, a value chain model for wild Alliums has been established, ensuring a steady supply of produce. The Agri-Business Incubation (ABI) centre was established to support registered start-ups in the agricultural sector. Four Start-ups enrolled for incubation. In the year 2022, a total of seven onion varieties were licensed to 39 seed companies at the institute level. Additionally, an exclusive license for the 'Controlled Onion Storage Structure' technology was granted to Kala Biotech Pvt. Ltd. Furthermore, the institute conducted six contract trials and established collaborations with six organizations for research purposes and student guidance.

A total of 355 frontline demonstrations took place in Maharashtra state, encompassing the *kharif* (285), late *kharif* (30), and *rabi* (40) seasons, with the support of the Institute project (30), SCSP (280), and MGMG (45). Also, 95 demonstrations were held in NEH region. Additionally, as part of the contract trial, 240 demonstrations were carried out in Pune and Ahmednagar districts, focusing on the implementation of Raised Bed with Drip Irrigation Technology. A total of 58 demonstrations in *kharif* and 85 demonstrations in *rabi* were conducted under TSP during the year 2022. Under *Mera Gaon Mera Gaurav* scheme, 15 villages were adopted and several awareness programmes and trainings were conducted. During the reporting period ICAR-DOGR organized 54 trainings under MGMG, NEH, TSP, SCSP, ATMA, etc., schemes which were attended by 2254 farmers and other stakeholders and participated in 4 exhibitions to showcase onion and garlic technologies.

I extend my sincere thanks to the support extended by ICAR and encouragement and guidance by Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR; Dr. A K Singh, Deputy Director General (Horticulture Science), Dr. Tilak Raj Sharma, Additional charge-Deputy Director General (Horticulture Science), Dr. Sudhakar Pandey, Assistant Director General (Flower, Vegetables, Spices and Medicinal Plants), Dr. V. B. Patel, Assistant Director General (Fruits and Plantation Crops). I appreciate the efforts of all the scientific, technical, administrative and supporting staff of the Directorate in all achievements. My acknowledgments are due to the editorial board for timely compilation and editing of annual report. I hope, the information provided in this report will be useful to the stakeholders of onion and garlic.

Date: July, 2023 (Vijay Mahajan)

ICAR-DOGR, Pune Director

Contents

कार्यकारी सारांश

भाकृअनुप-प्याज एवं लहसुन अनुसंधान निदेशालय द्वारा वर्ष 2022 के दौरान अनुसंधान, विस्तार और विकास कार्य आंतरिक अनुसंधान परियोजनाओं और तदर्थ/बाह्य वित्त पोषित परियोजनाओं के माध्यम से किया गया। रिपोर्टाधीन अवधि के दौरान निदेशालयने मेरा गांव मेरा गौरव, जनजातीय उप-योजना, अनुसूचित जाती उप-योजना, आत्मा, आदि योजनाएं के तहत 54 प्रशिक्षण आयोजित किए, जिनमें 2254 से अधिक किसानों और अन्य हितधारकों ने भाग लिया। निदेशालय ने प्याज और लहसुन प्रौद्योगिकियों को प्रदर्शित करने के लिए 4 प्रदर्शनियों में भी भाग लिया। रिपोर्टाधीन अवधि के दौरान संस्थान की परियोजनाओं के अलावा, निदेशालय ने डीएसटी, डीबीटी और सहयोगी या अनुबंध अनुसंधान परीक्षण जैसी 20 से ज्यादा बाहरी वित्त पोषित परियोजनाओं द्वारा अनुसन्धान कार्य किया। वर्ष 2020 में किए गए अनुसंधान, विस्तार और विकास गतिविधियों का संक्षिप्त सारांश नीचे प्रस्तुत किया गया है।

फसल सुधार

भाकृअनुप-प्याज एवं लहसुन अनुसंधान निदेशालय क्षेत्र की स्थिति के तहत 17 विभिन्न प्रजातियों की 89 वन्य और कम उपयोग वाली *एलियम* वंशक्रमों का रखरखाव कर रहा है। इन प्रजातियों की पत्ते की उपज, वृद्धि, गुणवत्ता, फूल व्यवहार, उपभोक्ता प्राथमिकता के लिए जांच की गई और उनका प्रजनन कार्यक्रम में उपयोग किया गया। *एलियम ट्यूबरोसम* के लिए प्रणालीगत मूल्य श्रृंखला विकास प्रयास तीन "ई" अर्थात "उत्पादन प्रदर्शन का मूल्यांकन, उपभोक्ता प्रतिक्रिया एवं गुणवत्ता धारणाओं की खोज और बाजार की क्षमता एवं स्थिरता की खोज " के आधार पर किए जा रहे हैं। अधिकांश रूपात्मक, वृद्धि और उपज लक्षणों के लिए, *एलियम ट्यूबरोसम* कजाकिस्तान ऑल-1587 वंशक्रमने सबसे अच्छा वृद्धि प्रदर्शन, वार्षिक उपज, पत्ते और पोषण गुणवत्ता दर्ज की, इसके बाद *ए. ट्यूबरोसम* सीजीएन-16418 और *ए. ट्यूबरोसम* रॅटल एक्स-स्प्रकुचाई सीजीएन-16373 रहे।

प्याज के जननद्रव्य का मूल्यांकन खरीफ, पछेती खरीफ और रबी मौसम के दौरान किया गया। सफेद और पीले प्याज के जननद्रव्य के मामले में, रबी (52 सफेद और 2 पीली प्राप्तियां) और पछेती खरीफ (15 सफेद प्राप्तियां) के दौरान मूल्यांकन किया गया। रबी के दौरान, डब्ल्यू -361 ने सबसे अधिक विपणन योग्य उपज प्रदर्शित की, उसके बाद डब्ल्यू -398 और व्हाइट न्यू जीनपूल का स्थान रहा। पछेती ख़रीफ़ में, डब्ल्यू -453 और डब्ल्यू -458 ने बेहतर विपणन योग्य उपज दर्ज की और यह तोर वाले कन्दों से भी मुक्त थे। जननद्रव्य, भू-प्रजातियां और किस्मों से युक्त लगभग 700 लहसुन वंशक्रमों का रखरखाव प्रजनन गतिविधियों के लिए निदेशालयमें किया गया हैं। रबी के दौरान लहसुन के जननद्रव्य का मूल्यांकन किया गया। वंशक्रम 569, जीएस-1, जी-10, 224 और 63 में उच्चतम विपणन योग्य उपज दर्ज की गई। ख़रीफ़ में, 12 लहसुन की किस्मों का उनके ख़रीफ़ मौसम में उपयुक्तता और कृषि-रूपात्मक विशेषताओं के लिए मूल्यांकन किया गया। दो वंशक्रमों को छोड़कर सभी जीनप्ररूपों द्वारा 5 टन/हेक्टेयर से अधिक की औसत विपणन योग्य उपज दर्ज की गई। उपज, कन्द के आकार और स्थिरता के लिए परिवर्तनशीलता उत्पन्न करने हेतु लहसुन की वंशक्रमों में गामा विकिरण, कोल्चीसिन और ईएमएस उपचार का उपयोग करके उत्परिवर्तन प्रजनन का प्रयास किया गया।

लाल प्याज के उपलब्ध जननद्रव्यों का भी तुलनीय किस्मों के साथ पछेती खरीफ (170), रबी (192) और खरीफ (165) में मूल्यांकन किया गया। पछेती खरीफ मौसम में, एसीसी. 1794 में बिना किसी तोर के 58 टन/हेक्टेयर उपज प्राप्त हुई। डीओजीआर-1168 (एलजी-107-3) में रबी मौसम में 7.63% तोर वाले कन्दों के साथ अधिकतम उपज प्राप्त हुई। जबकि, एसीसी. 1321 में 100% विपणन योग्य कन्दों के साथ लगभग 60 टन/हेक्टेयर उपज मिली। ख़रीफ़ मौसम में, एसीसी.1634 में बिना किसी तोर के अधिकतम उत्पादन हुआ। अग्रिम प्रजनन वंशक्रमों में, पछेती ख़रीफ़ मौसम में, डीओजीआर-1608 और डीओजीआर-1614 ने कम तोर वाले कन्दों के साथ अधिकतम उपज दर्ज की। रबी मौसम के दौरान, डीओजीआर-1048-सेल. (31.70 टन/हेक्टेयर) ने तुलनीय किस्म की तुलना में अधिकतम उपज दी, जबकि ख़रीफ़ में, डीओजीआर-1014- जीडीआर काफी बेहतर पाई गई। प्रारंभिक प्रजनन वंशक्रमों में, एलके-07-सी2/एलआर-1, एलके-07-सी2/एलआर-1 और रेड कॉम्प-1 (केएच-12) क्रमशः पछेती खरीफ, रबी और खरीफ मौसम में तुलनीय

किस्म की तुलना में बेहतर पाए गए। निदेशालय ने प्याज में जलभराव (आईसी0645764) और सूखा (आईसी0645763) सहनशीलता के लिए आईसीएआर-एनबीपीजीआर के साथ दो जननद्रव्य पंजीकृत किए। निदेशालय ने उपज और अन्य विशेषताओं के लिए संकरों पर भी ध्यान केंद्रित किया। संकर MS111A × 1608 (पछेती खरीफ), MS111A × RGP-1 (रबी) और MS111A × 1605 (खरीफ) ने तुलनीय किस्म की तुलना में बेहतर प्रदर्शन किया।

गाइनोजेनेसिस के माध्यम से हैप्लोइड विकसित करने का भी प्रयास किया जा रहा है। वर्तमान में, संस्थान में 67 डबल हैप्लोइड वंशक्रमों का रखरखाव किया गया हैं। चमकदार पौधे जैविक और अजैविक दोनों प्रकार के तनावों से सुरक्षा प्रदान करते हैं। चमकदार उत्परिवर्ती और इसकी वन्य प्रकार की मोमी किस्मों में मोमी छल्ली-संबंधित जीन की अभिव्यक्ति विविधता को समझने के लिए आरएनए- सीक्वेंस किया गया। आरएनए-सीक्वेंस डेटा के विभेदक जीन अभिव्यक्ति विश्लेषण से पता चला कि मोम जैवसंश्लेषण में शामिल जीन, जैसे *AcCER1*, *AcCER26*, *AcMAH1*, और *AcWSD1*, चमकदार उत्परिवर्ती में डाउन-विनियमित थे।

एज़ोटोबैक्टर स्पीसीज के साथ प्याज की पौध का टीकाकरण करने से जलभराव तनाव की स्थिति में फसल प्ररूपी विकास और कन्द उपज प्रदर्शन के आधार पर बेहतर प्रदर्शन रहा। इसके अलावा, 50 पीपीएम की दर से मेलाटोनिन का पर्णीय छिड़काव जलभराव के तनाव की स्थिति में प्याज की फसल की वृद्धि और कन्द की उपज में सुधार करता है। आरएनए अनुक्रम का उपयोग करके प्रतिलेख अनुक्रमण प्रौद्योगिकी से समूह VII ईआरएफ जैसे आरएपी2-12 और आरएपी2-3 जैसे जलभराव सहनशीलता से संबंधित जीनों की अधिक संख्या दिखाई दी, जो पौधों में सहिष्णुता विकसित करने में महत्वपूर्ण भूमिका निभाते हैं, उन्हें विशेष रूप से जलभराव सहिष्णु प्याज जीनप्ररूप एसीसी 1666 में संवेदनशील की तुलना में अप-विनियमित पाया गया। 42 डिग्री सेल्सियस और इससे अधिक का उच्च तापमान प्याज की फसल की वृद्धि और विकास के लिए हानिकारक पाया गया।

फ़सल उत्पादन

पिछली फसल के रूप में मक्के को शामिल करने और अकेले अकार्बनिक उर्वरकों के प्रयोग से अन्य उर्वरक उपचारों की तुलना में काफी अधिक कन्द उपज प्राप्त हुई। अकेले 10 टन केंचुए की खाद /हेक्टेयर के प्रयोग से 18.9 टन/हेक्टेयर प्याज की पैदावार हुई जो अन्य उर्वरक उपचारों की तुलना में काफी कम थी। जबकि, खनिज उर्वरकों और केंचुए की खाद के संयुक्त अनुप्रयोग से सोयाबीन और मक्का दोनों खण्डों में अकेले लागू किए गए उपचारों की तुलना में मिट्टी में काफी अधिक जैविक कार्बन और उपलब्ध नत्रजन पाया गया। अकार्बनिक उपचारों की तुलना में जैविक उपचारों में अधिकतम जीव जंतुओं की विविधता देखी गई।

समेकीत पोषक तत्व प्रबंधन भूखंड में, और केवल रासायनिक उर्वरक द्वारा उपचार से जैविक उपचार की तुलना में 54.7-56.4% अधिक उपज में वृद्धि पाई गई। जैविक उपचार की तुलना में पारंपरिक और समेकीत पोषक तत्व प्रबंधन भूखंड में एन, पी, के और एस का अवशोषण काफी अधिक था। मृदा विश्लेषण से पता चला कि मिट्टी में जैविक कार्बन और मिट्टी में उपलब्ध नत्रजन सांद्रता समेकीत पोषक तत्व प्रबंधन और पारंपरिक खेती की तुलना में जैविक उपचार में अधिक पाई गई। जैविक पौध संरक्षण उपाय प्राप्त भूखंडों में थ्रिप्स की आबादी सबसे अधिक थी। बाढ़ सिंचाई प्रणाली की तुलना में टपक तथा फव्वारा के माध्यम से 100% (110 किग्रा/हेक्टेयर) और 150% (165 किग्रा/हेक्टेयर) नत्रजन के प्रयोग से प्याज की उपज में उल्लेखनीय वृद्धि हुई। हालाँकि, सिंचाई उपचारों ने पौधे की ऊँचाई, पत्तियों की संख्या, पत्ती की लंबाई और पत्ती क्षेत्र सूचकांक को प्रभावित नहीं किया। नत्रजन उपचारों में, 100% और 150% नत्रजन के अनुप्रयोग से नियंत्रित भूखंड और 50% नत्रजन प्रयुक्त उपचारों की तुलना में पौधों के विकास मापदंडों, प्याज की उपज और कुल घुलनशील ठोस पदार्थों में वृद्धि हुई। प्याज के भंडारण का नुकसान नियंत्रित भूखंडों में सबसे अधिक और तीनों सिंचाई विधियों में 100% और 150% नत्रजन प्रयुक्त उपचार में सबसे कम पाया गया। जल-जमाव की स्थिति में पानी में घुलनशील उर्वरक के पत्तों पर प्रयोग से पौधों की वृद्धि हुई तथा प्याज के जीनोटाइप, भीमा डार्क रेड और एसीसी 1666 की उपज में अन्य जीनोटाइप की तुलना में काफी महत्वपूर्ण वृद्धि हुई। सहिष्णु जीनोटाइप एसीसी 1666 और भीमा डार्क रेड में अधिक जीवित रहने का प्रतिशत (>90%), पौधों की अच्छी स्थिति, उच्च क्लोरोफिल सामग्री, बेहतर सेलुलर झिल्ली स्थिरता देखी गई।

लहसुन में आईसीएआर-सिरकोट नैनो-सल्फर का 15 किग्रा/हेक्टेयर और 23 किग्रा/हेक्टेयर की दर से अनुप्रयोग करने से शेष उपचारों की तुलना में अधिक उपज दर्ज की गई, जबकि, बेंटोनाइट सल्फर का 30 किग्रा/हेक्टेयर की दर से अनुप्रयोग करने से बाकी प्याज में उपचारों की तुलना में उच्चतम उपज दर्ज की गई।

फसल सुरक्षा

प्याज के फफूंदीय रोगजनकों (*कोलेटोट्राइकम* स्पीसीज, *फ्यूसेरियम* स्पीसीज, *अल्टरनेरिया* स्पीसीज, *स्टेम्फिलियम* स्पीसीज) को आईटीएस और टीईएफ प्राइमरों का उपयोग करके आकृति विज्ञान के साथ-साथ आणविक उपकरणों का उपयोग करके एकत्र किया गया, अलग किया गया और चित्रित किया गया। इसके अलावा, जैव-एजेंट ट्राइकोडर्मा एसपीपी को भी अलग किया गया (11 आइसोलेट्स) और *स्टैम्फिलियम* और एन्थ्रेक्नोज रोगों के खिलाफ इसका परीक्षण किया गया। आठ आइसोलेट्स ने फंगल रोगजनकों के खिलाफ निरोधात्मक क्रिया दिखाई, जिसमें ट्राइकोडर्मा आइसोलेट एनआरसीजी-8 ने *स्टेम्फिलियम*, एन्थ्रेक्नोज और ट्विस्टर पर अधिकतम 33-40%, 44% और 50% अवरोध क्रमशः दिखाया।

प्याज की वृद्धि और उपज पर जैव-घटकों के प्रभाव से पता चला कि आइसोलेट टी-166 ने पौधे की ऊंचाई, छद्म तने का व्यास और उपज 27% तक बढ़ा दी। मौजूदा विधियां (ईपी), किसानों की विधियां (एफपी), और पूर्ण नियंत्रण (एसी) के साथ चार आईडीएम मॉड्यूल (एम1, एम2, एम3 और एम4) का रबी 2022 में मूल्यांकन किया गया था। मॉड्यूल एम1, गहन प्रबंधन, के इस्तेमाल से ख़रीफ़ और रबी प्याज में क्रमशः एन्थ्रेक्नोज (10-30%) और स्टेम्फिलियम (5-51%) को प्रभावी ढंग से रोका गया और कन्द की उपज में 24% तक की वृद्धि हुई। अमृतपानी आधारित जैविक फॉर्मूलेशन का प्याज में एन्थ्रेक्नोज के खिलाफ परीक्षण किया गया। डीओजीआर ऑफ़ शूी, बाजरे का आटा, कैलोट्रोपिस पत्तियां, करंज पत्तियां, अदरक पाउडर, हल्दी पाउडर, हिंग पाउडर और पानी के मिश्रण से बना एक फॉर्मूलेशन, स्टेम्फिलियम को 36% और एन्थ्रेक्नोज को 32% तक रोकने में प्रभावी रहा और इसके उपयोग से कन्द की उपज में वृद्धि हुई। रोग प्रतिरोधक क्षमता के लिए छत्तीस सफेद प्याज के जननद्रव्यों का परीक्षण किया गया, और इसमें से छह प्रविष्टियाँ स्टैम्फिलियम के खिलाफ आशाजनक पाई गई।

माइक्रोआरएनए (miRNA) पौधों के विकास, बीमारी और तनाव प्रतिक्रिया आदि में आवश्यक प्रक्रियाओं को नियंत्रित करते हैं। प्याज जीनोम (PRJEB29505) से कुल 119 miRNA और उनके लक्ष्य जीन की पहचान की गई। इसके अलावा, बैंगनी धब्बा संक्रमण, सूखा और जलभराव तनाव में लक्ष्य जीन की अभिव्यक्ति का भी पिछले RNAseq का उपयोग करके अध्ययन किया गया। इनमें से, 73 miRNAs ने प्याज में उपरोक्त स्थितियों में उल्लिखित तनाव में अभिव्यक्ति दिखाई, जिसमें 14 miRNAs ने रोग, जलभराव और सूखे की तनाव स्थितियों में ऊपर या नीचे-विनियमन के लगातार अभिव्यक्ति स्तर दिखाए। Ace-MIR408a, Ace-MIR2275b, Ace-MIR168c, Ace-MIR166c, और Ace-MIR69a इन miRNA जीनों ने ए. पोरी संक्रमण के लिए अभिव्यक्ति में भिन्नता दिखाई।

स्टैम्फिलियम लीफ ब्लाइट के विकास और प्रतिरोध पर काइटोसीन नैनोकण बीज प्राइमिंग के प्रभाव का आकलन किया गया। काइटोसीन प्राइमिंग ने अनुपचारित बीजों की तुलना में बेहतर अंकुरण, शक्ति और कम रोग गंभीरता सूचकांक दिखाया। इससे पता चलता है कि काइटोसीन नैनोकण प्रेरित प्रतिरोध के माध्यम से प्याज के पौधों में रक्षा प्रतिक्रिया को बढ़ावा दे सकते हैं, और बीज प्राइमिंग + पत्तेदार अनुप्रयोग सबसे अच्छा संयोजन रहा। इसके अलावा, यह काइटोसीन -उपचारित पौधों में क्लोरोफिल, फ्लेवोनोइड, फिनोल सामग्री और रोगजनन-संबंधित प्रोटीन (पीआर 1 और पीआर 4) की मात्रा को बढ़ाता है। इसी तरह, प्याज के जड़ सड़न का कारण बनने वाले फफूंदी रोगज़नक़ फ्यूसेरियम पर जिंक नैनोकणों के प्रभाव की जांच फफूंदी रेडियल वृद्धि का निर्धारण करके की गई थी। रोगज़नक़ की न्यूनतम रेडियल वृद्धि 200 पीपीएम (50% कमी) में दर्ज की गई, इसके बाद 100 पीपीएम में दर्ज की गई। इस प्रकार, प्याज के रोगजनकों के बेहतर नियंत्रण के लिए नैनोकणों का उपयोग किया जा सकता है।

कृत्रिम टीकाकरण के माध्यम से एन्थ्रेक्नोज-ट्विस्टर की रोगजनकता का अध्ययन किया गया। *कोलेटोट्राइकम ग्लियोस्पोरियोइड्स* से टीका लगाए गए प्याज के पौधे में कृत्रिम टीकाकरण के 4 दिन बाद पहली बार ग्रीवा में वृद्धि देखी गई; और कृत्रिम टीकाकरण के 5 दिन बाद जल-भिगोने वाले घाव दिखाई दिए। बाद में, पत्ती के सतह पर धँसे

हुए अंडाकार घाव और गर्दन पर पत्ती के आवरण पर दबे हुए घाव कृत्रिम टीकाकरण के 6 दिन पश्चात सैमन/नारंगी रंग के शंकुधारी द्रव्यमान के साथ विकसित हुए और कृत्रिम टीकाकरण के 6 दिन बाद घाव परिगलित या परिपक्व हो गए, जिसमें *सी. ग्लियोस्पोरियोइड्स* (कृत्रिम टीकाकरण के 8 दिन बाद) के एसरवुलि के समूह शामिल थे। अंततः, इससे तना सड़ गया।

प्याज-लहसुन के प्रमुख फफूंद जनित रोगों से बचाने हेतु *ट्राइकोडर्मा* स्पीसीज के द्वितीयक मेटाबोलाइट्स की भूमिका की जांच करने के लिए इंडोल एसिटिक एसिड (आईएए), साइडरोफोर्स उत्पादन फास्फोरस, पोटेशियम और जिंक घुलनशीलता जैसे लक्षण निर्धारित किए गए थे। *टी. स्पेकुलम* और एनआरसीजी-8 उपभेदों में आईएए का ऊंचा स्तर और उच्च साइडरोफोर्स उत्पादन दर्ज किया गया। आइसोलेट्स टी-18, टी-166, टी-292, और *टी. स्पेकुलम* में फॉस्फेट घुलनशीलता क्षेत्र था। *टी. टैबासी* आबादी की आनुवंशिक संरचना का अध्ययन माइटोकॉन्ड्रियल सीओआई जीन अनुक्रमों का उपयोग करके किया गया था। एमटीसीओआई जीन के भीतर स्थान के अनुसार भिन्नता पाई गई। स्थान के अनुसार, दर्ज की गई कुल रीडिंग से प्रतिशत भिन्नता की गणना की गई। सभी इलाकों में, 307_पालमपुर उच्चतम न्यूक्लियोटाइड बहुरूपता का प्रतिनिधित्व करता है। *टी. टैबासी* के संपूर्ण माइटोकॉन्ड्रियल जीनोम की भी विशेषता बताई गई। *टी. टैबासी* के बारह प्रोटीन-कोडिंग जीन (पीसीजी), दो आरआरएनए जीन और बीस टीआरएनए जीन में गोलाकार जीनोम की लंबाई 12,033 आधार जोड़े (बीपी) मापी गई। एक लघु परजीवी ततैया, *मेगफ्राग्मा अमाल्फिटानम*, थ्रिप्स पर देखा गया।

ब्यूवेरिया बैसियाना, मेथैरिज़ियम एनिसोप्लिया, लेकनिसिलियम लेकानी और वनस्पति कीटनाशक नीम तेल सहित एंटोमोपैथोजेन के व्यावसायिक फॉर्मूलेशन की जैव-प्रभावकारिता का परीक्षण एकल एवं जैविक कीटनाशक स्पिनोसैड के साथ संयोजन में प्याज थ्रिप्स के खिलाफ किया गया। कीट-रोगज़नक़-उपचारित भूखंडों में, वयस्क थ्रिप्स की आबादी 30.3 से 36.2% कम हो गई, जबकि अर्भक 35.5 से 41.9% कम हो गए। नियंत्रित भूखंडों से कुल औसत कमी 32.9 से 39.1% पाई गई। नीम के तेल और *एल. लेकानी* के संयोजन ने थ्रिप्स वयस्कों और अर्भकों के विरुद्ध बेहतर प्रभावकारिता दिखाई, और इससे इनकी आबादी में 41.2% तक की कमी आई, इसके बाद नीम के तेल और *बी. बैसियाना* के संयोजन में इनकी कमी देखी गई। नई पीढ़ी के कम जोखिम वाले कीटनाशकों, अर्थात् स्पिरोटेरामाट 150 ओडी और स्पिनेटोरम 11.7 एससी का प्याज थ्रिप्स के खिलाफ क्षेत्र परीक्षण किया गया। दोनों को प्याज थ्रिप्स के खिलाफ प्रभावी पाया गया, और उनकी प्रभावकारिता प्रोफेनोफोस के बराबर पाई गई। मुख्य खेत में रोपे गए प्याज को प्याज के थ्रिप्स से बचाने के लिए पौध जड़ डुबोने की रणनीति विकसित करने के लिए एक अध्ययन किया गया। एक कम जोखिम वाले डायमाइड कीटनाशक सायनट्रानिलिप्रोल का पौध जड़ उपचार के रूप में प्याज थ्रिप्स के खिलाफ परीक्षण किया गया, यह प्याज थ्रिप्स संक्रमण को कम करने में प्रभावी रहा।

प्याज भंडारण में भृंग, *कार्पोफिलस हेमिप्टेरस* की उपस्थिति दर्ज की गई। इस प्रजाति की पुष्टि रूपात्मक अवलोकन और आगे डीएनए बारकोडिंग का उपयोग करके की गई। कीट आम तौर पर खेत से भंडारण तक फैलते हैं। इसके अलावा, प्याज के कन्दों को खराब करने वाले भंडारण कवक को अलग कर दिया गया और उनकी पहचान की गई और वे एस्परगिलस और फ्यूजेरियम प्रजातियों से संबंधित पाए गए। प्रमुख प्याज उगाने वाले जिलों से लिए गए भंडारण कन्दों का कीटनाशक अवशेषों के लिए विश्लेषण किया गया, सभी नमूनों में अवशेष उप-एमआरएल स्तर के पाए गए। देशी डंक रहित मधुमक्खी *टेट्रागोनुला इरिडिपेनिस* की परागण क्षमता का आकलन किया गया। महाराष्ट्र के विभिन्न स्थानों में प्याज पर डंक रहित मधुमक्खी प्रजातियों का दस्तावेजीकरण किया गया। इसके अलावा, *टी. इरीडिपेनिस* के संपूर्ण माइटोजेनोम का पहली बार चरित्रीकरण किया गया।

कटाई उपरांत प्रौद्योगिकी

प्याज की फसल की खेती को अधिक किफायती बनाने के लिए भंडारण नुकसान को कम करना और मूल्य संवर्धन, दो अपरिहार्य बातें हैं। निदेशालय भंडारण नुकसान को कम करने और प्याज और लहसुन से प्रसंस्कृत उत्पादों के विकास के लिए भंडारण संरचनाओं के शोधन पर काम कर रहा है। रिपोर्टाधीन अवधि के दौरान, कटाई के बाद की प्रौद्योगिकी के तहत लाल प्याज की किस्मों को सुखाने और पुनर्जलीकरण के लिए प्रक्रिया प्रोटोकॉल तैयार करना,

प्याज के बीज के तेल के निष्कर्षण के लिए प्रक्रिया प्रोटोकॉल के अनुकूलन और भंडारण के लिए प्याज के वायुगतिकीय गुणों पर अध्ययन पर काम किया गया।

विस्तार

पोषक तत्व प्रबंधन, रोग और कीट प्रबंधन और किस्म चयन के संबंध में सूचित निर्णय लेने में किसानों की सहायता के लिए तीन निर्णय समर्थन प्रणालियाँ विकसित की गई हैं। 'ओएनडीएसएस' प्रणाली किसानों को मृदा स्वास्थ्य रिपोर्ट और अनुशंसित पोषक खुराक के आधार पर पोषक तत्व प्रबंधन को संतुलित करने में मदद करती है। 'ओडीपीएडवाइजर' प्रणाली लक्षण-आधारित पहचान और सिफारिशों के माध्यम से कीटों और रोगों की पहचान और प्रबंधन में सहायता करती है। 'स्मार्टऑनियन' प्रणाली किसानों को उनकी विशिष्ट आवश्यकताओं के लिए उपयुक्त प्याज की किस्मों का चयन करने में सहायता करती है। इसके अतिरिक्त, किसानों को प्याज की खेती के लिए व्यापक जानकारी, सलाह और निर्णय समर्थन टूल प्रदान करने के लिए "प्याज फसल सलाहकार" नामक एक मोबाइल एप्लिकेशन विकसित किया गया। मल्टीमीडिया-आधारित समाचार बुलेटिन मराठी में ' कांदा व लसूण समाचार' और हिंदी में 'प्याज एवं लहसुन समाचार' और सोशल मीडिया प्लेटफार्मों का उपयोग कृषि-सलाह और तकनीकी जानकारी प्रसारित करने के लिए किया जा रहा है। इसके अलावा, वन्य *एलियम* के लिए एक मूल्य श्रृंखला मॉडल स्थापित किया गया है, जो उपज की स्थिर आपूर्ति सुनिश्चित करता है।

संस्थान परियोजना (30), अनुसूचित जाती उप-योजना (280), और मेरा गांव मेरा गौरव (45). इसके अतिरिक्त, अनुबंध परीक्षण में, टपक सिंचाई प्रौद्योगिकी के साथ उठी हुई क्यारियों के कार्यान्वयन पर ध्यान केंद्रित करते हुए, पुणे और अहमदनगर जिलों में 240 अग्रिम पंक्ति प्रदर्शन आयोजित किए गए। इसके अलावा पूर्वोत्तर पर्वतीय क्षेत्र में 95 प्रदर्शन आयोजित किए गए। वर्ष 2022 के दौरान जनजातीय उप-योजना के तहत खरीफ में 58 प्रदर्शन और रबी में 85 प्रदर्शन आयोजित किए गए। जनजातीय उप-योजना के तहत महाराष्ट्र, लेह (लद्दाख) और उत्तर प्रदेश में कुल दस प्रशिक्षण/प्रक्षेत्र दिवस आयोजित किए गए, जिनमें 693 आदिवासी किसानों ने भाग लिया। मेरा गांव मेरा गौरव योजना के तहत 15 गांवों को अपनाया गया और इन गावों में कई जागरूकता कार्यक्रम और 35 प्रशिक्षण आयोजित किए गए।

कृषि क्षेत्र में पंजीकृत स्टार्ट-अप को समर्थन देने के लिए कृषि-व्यवसाय उन्नयन केंद्र की स्थापना की गई। चार स्टार्ट-अप अर्थात् थिंकप्योर ऑर्गेनिक प्रोड्यूस प्राइवेट लिमिटेड, फार्मर्स स्माइल फार्मर प्रोड्यूसर कंपनी, वाघेश्वर फार्मर प्रोड्यूसर कंपनी और पलांदुह फार्मर प्रोड्यूसर कंपनी लिमिटेड ने समझौता ज्ञापन पर हस्ताक्षर किए और उन्नयन (इनक्यूबेशन) के लिए नामांकन किया। वर्ष 2022 में, संस्थान स्तर के पर 39 बीज कंपनियों को कुल सात प्याज किस्मों का लाइसेंस दिया गया। इसके अतिरिक्त, कला बायोटेक प्राइवेट लिमिटेड को 'नियंत्रित प्याज भंडारण संरचना' तकनीक के लिए एक विशेष लाइसेंस प्रदान किया गया। इसके अलावा, संस्थान ने छह अनुबंध परीक्षण आयोजित किए और अनुसंधान उद्देश्यों और छात्र मार्गदर्शन के लिए छह संगठनों के साथ सहयोग स्थापित किया।

निदेशालय ने अखिल भारतीय प्याज एवं लहसुन नेटवर्क अनुसंधान परियोजना (एआईएनआरपीओजी) की तेरहवीं वार्षिक समूह बैठक दिनांक 5-7 अगस्त 2022 के दौरान धारवाड़ (कर्नाटक) में आयोजित की। विभिन्न संस्थागत गतिविधियाँ जैसे संस्थान अनुसंधान समिति, संस्थान प्रबंधन समिति, आदि की बैठकें समय पर आयोजित की गई। निदेशालय ने भारतीय प्रौद्योगिकी संस्थान (आईआईटी), मुंबई के सहयोग से "प्याज की कटाई के पश्चात भंडारण प्रौद्योगिकी और प्रबंधन" पर कार्यशाला भी आयोजित की, जिसमें 80 हितधारकों ने भाग लिया। प्याज और लहसुन अनुसंधान के क्षेत्र में उत्कृष्ट योगदान के लिए कर्मचारियों को कई पुरस्कार और मान्यताएँ भी मिलीं। निदेशालय को उपभोक्ता मामले, खाद्य और सार्वजनिक वितरण मंत्रालय (एमओसीएएफपीडी) द्वारा 'प्याज के प्राथमिक प्रसंस्करण, भंडारण और मूल्य निर्धारण के लिए प्रौद्योगिकियों' को विकसित करने के लिए शुरू किए गए *'ग्रैंड अनियन चैलेंज'* में ज्ञान और मूल्यांकन भागीदार के रूप में मान्यता दी गई है। निदेशालय की 23वीं अनुसंधान सलाहकार समिति (आरएसी) की बैठक 20 फरवरी, 2022 को संपन्न हुई। निदेशालय की 5वीं पंचवार्षिक समीक्षा बैठक 20-22 दिसंबर 2022 के दौरान आयोजित की गई। निदेशालय में गणतंत्र दिवस, स्वतंत्रता दिवस, अंतर्राष्ट्रीय महिला दिवस, विश्व मृदा दिवस मनाएं गए। दैनिक कार्यालयीन कामकाज में हिंदी के महत्व को बढ़ाने के लिए हिंदी पखवाड़ा भी आयोजित किया गया। वर्ष 2022 में निदेशालय ने 105.04 लाख का राजस्व अर्जित किया।

Executive Summary

The research, extension and development work of ICAR-Directorate of Onion and Garlic Research was carried out through institutional research projects and adhoc/externally funded projects during the year 2022. During the reporting period ICAR-DOGR organized 54 trainings under MGMG, NEH, TSP, SCSP, ATMA, etc., schemes which were attended by more than 2250 farmers and other stakeholders and participated in 4 exhibitions to showcase *onion* and garlic technologies. Apart from the twenty institute projects, ICAR-DOGR handled more than 20 externally funded DST, DBT, and collaborative or contract research trials during the reporting period. Brief summary of the research, extension and development activities carried out in the year 2022 is presented below.

Crop Improvement

ICAR-DOGR is maintaining 89 wild and underutilized *Allium* lines of 17 different species under field condition. These species were screened for foliage yield, growth, quality, flowering behaviour, consumer preference and were utilized in breeding programme. Systemic value chain development efforts are being carried for *Allium tuberosum* based on three E's *viz*. Evaluation of production performance, Exploration of consumer response and quality perceptions and Exploration of market potential and sustainability. For most of the morphological, growth and yield characters, the line *Allium tuberosum* Kazakhstan *All-1587* recorded best growth performance, annual yield, foliage and nutritional quality followed by *A. tuberosum* CGN-16418 and *A. tuberosum Rottl* Ex-sprkucchai CGN-16373.

Onion germplasm were evaluated during *kharif*, late *kharif* and *rabi* seasons. In case of white and yellow onion germplasm, during *rabi* (52 white and 2 yellow accessions) and late-*kharif* (15 white accessions) were evaluated. During *rabi*, W-361 exhibited highest marketable yield followed by W-398 and White New Genepool. In late *kharif*, W-453 and W-458 were recorded with superior marketable yield and were also free from bolters. Almost 700 garlic lines comprising germplasm, landraces, and varieties are under maintenance for breeding activities at ICAR-DOGR. Garlic germplasm were evaluated during *rabi*. The lines 569, GS-1, G-10, 224 and 63 were recorded with highest marketable yield. In *kharif*, 12 garlic lines were evaluated for their *kharif* season suitability and agro-morphological traits. The average marketable yield of more than 5 t/ha was recorded by all the genotypes except two lines. Mutation breeding, using gamma radiation, colchicines and EMS treatments were attempted in garlic lines for creating variability in response to yield, bulb size and stability.

Available germplasm of red onion was evaluated in late *kharif* (170), *rabi* (192) and *kharif* (165) seasons along with suitable checks. In late *kharif* season, Acc. 1794 yielded 58 t/ha with no bolting. DOGR- 1168 (LG-107-3) yielded maximum with 7.63% bolting while in *rabi*, Acc. 1321 exhibited nearly 60 t/ha yield with 100% marketable bulbs. In *kharif* season, Acc. 1634 yielded maximum with no bolting. Among advance breeding lines, in late *kharif* season, DOGR-1608 and DOGR-1614 recorded maximum yield with less bolting. During *rabi* season, DOGR-1048-Sel (31.70 t/ha) gave maximum yield compared to check while in *kharif* season, DOGR-1014-GDR was found to be significantly superior. Among initial breeding lines, LK-07-C2/LR-1, LK-07-C2/LR-1 and Red Comp-1 (Kh-12) found to be superior compared to check in late *kharif*, *rabi* and *kharif* seasons, respectively. ICAR-DOGR had also registered two germplasm with ICAR-NBPGR for waterlogging (IC0645764) and drought (IC0645763) tolerance in onion. The Directorate also focused on hybrids for yield and other characters. The hybrids MS111A × 1608 (*late-kharif*), MS111A × RGP-1 (*rabi*) and MS111A × 1605 (*kharif*) gave superior performance compared to checks.

The efforts are also being made to develop haploids through gynogenesis. Currently, sixty-seven double haploid lines have been maintained at the institute. The glossy plants provide protection against both biotic and abiotic stresses. RNA-seq was done to comprehend the expression variations of waxy cuticle-related genes in the glossy mutant and its wild-type waxy cultivars. Differential gene expression analysis of the RNA-seq data revealed that the genes involved in wax biosynthesis, such as *AcCER1, AcCER26, AcMAH1,* and *AcWSD1*, were down regulated in the glossy mutant.

Inoculation of onion seedlings with *Azotobacter* spp. performed better under waterlogging stress based on crop phenotypic growth and bulb yield performance. Furthermore, foliar spray of Melatonin @ 50ppm improved onion crop growth and bulb yield under waterlogging stress. Transcriptome sequencing using RNA seq. technology showed higher number of waterlogging tolerance-related genes like group VII *ERFs* such as *RAP2-12* and *RAP2-3* that play a crucial role in developing tolerance in plants, were found to be exclusively up-regulated in waterlogging tolerant onion genotype Acc.1666 than in sensitive one. High temperature of 42 °C and more was detrimental for onion crop growth and development.

Crop Production

Inclusion of maize as the preceding crop and the application of inorganic fertilizers alone produced significantly higher bulb yields compared to other fertilizer treatments. Application of 10 t/ha vermicompost alone produced 18.9 t/ha onion yield which was significantly lower than other fertilizer treatments. Whereas, combined application of mineral fertilizers and vermicompost showed significantly higher soil organic carbon and soil available N compared to mineral fertilizer alone applied treatments in both soybean and maize block. Maximum faunal diversity was observed in organic treatments in comparison to inorganic treatments.

The yield increase in INM plot, and chemical fertilizer alone applied treatment was higher by 54.7-56.4% compared to organic treatments. N, P, K and S uptake were significantly higher in conventional and INM plots compared to organic treatments. Soil analysis showed that soil organic carbon and soil available N concentration were higher in organic treatments compared to INM and conventional farming. *Thrips* population was the highest in plots received organic plant protection measures.

Application of 100% (110 kg/ha) and 150% (165 kg/ha) N through drip and sprinkler increased onion yield significantly compared to flood irrigation system. However, the irrigation treatments did not affect plant height, number of leaves, leaf length, and leaf area index. Among N treatments, application of 100% and 150% N increased plant growth parameters, onion yield, and total soluble solids compared to the control plot and 50% N applied treatments. The storage losses of onion were highest in the control plots and lowest in 100% and 150% N applied treatments in all three irrigation methods. Foliar application of water-soluble fertilizer increased plant growth and yield of onion genotypes, Bhima Dark Red and Acc. 1666 significantly compared to the other genotypes under water-logged conditions. The tolerant genotypes Acc. 1666 and Bhima Dark Red showed higher survival percentage (>90%), good plant stand, higher chlorophyll content, better cellular membrane stability.

In garlic, application of ICAR-CIRCOT nano-sulphur application @ 15 kg/ha and 23 kg/ha recorded higher yield compared to the remaining treatments, whereas, application of bentonite sulphur @ 30 kg/ha recorded the highest yield compared to the rest of the treatments in onion.

Crop Protection

The fungal pathogens of onion (*Colletotrichum* spp., *Fusarium* spp., *Alternaria* spp., *Stemphylium* spp) were collected, isolated, and characterized using morphology as well as molecular tools using ITS and TEF primers. In addition, bio-agents *Trichoderma* spp. were also isolated (11 isolates) and tested against *Stemphylium* and anthracnose diseases. Eight isolates showed inhibitory action against fungal pathogens in which *Trichoderma* isolate NRCG-8 showed a maximum of 33-40%, 44% and 50% inhibition on *Stemphylium*, Anthracnose and twister, respectively.

Bio-agents' effect on onion growth and yield revealed that isolate T-166 enhanced plant height, pseudostem diameter, and yield by up to 27%. Four IDM modules (M1, M2, M3 and M4) with existing practice (EP), farmers' practice (FP), and absolute control (AC) were evaluated in *rabi* 2022. Module M1, intensive management, effectively inhibited Anthracnose (10-30%) and *Stemphylium* (5-51%) in *kharif* and *rabi* onion, respectively, and increased bulb yield by 24%. The Amritpani-based organic formulations tested against Anthracnose in onions. DOGROF3, a formulation comprised of a mixture of Bajra flour, Calotropis leaves, Karanj leaves, Ginger powder, Turmeric powder, Hing powder and water, was effective in inhibiting *Stemphylium* by 36% and Anthracnose by 32% and increased the bulb yield. Thirty-six white onion germplasms were tested for disease resistance, and six entries were found promising against *Stemphylium*.

MicroRNAs (miRNA) reportedly regulate essential processes in plant development, disease and stress response, etc. A total of 119 miRNA and their target genes from the onion genome (PRJEB29505) were identified. Further, the expression of target genes in purple blotch infection, drought and waterlogging stress was also studied using previous RNAseq. Of these, 73 miRNAs showed expression in the stress mentioned above conditions in onion, in which 14 miRNAs showed consistent expression levels of up or down-regulation in disease, waterlogging and drought stress conditions. *Ace-MIR408a, Ace-MIR2275b, Ace-MIR168c, Ace-MIR166c,* and *Ace-MIR69a* these miRNA genes showed variation in expression in response to *A. porri* infection.

The effect of chitosan nanoparticles seed priming on growth and resistance to *Stemphylium* Leaf Blight was assessed. The chitosan priming showed better germination, vigour and less disease severity index than untreated seeds. This suggests that chitosan nanoparticles can boost the defence response in onion plants via induced resistance, and seed priming + foliar application was the best combination. Further, it enhances the amount of Chlorophyll, flavonoid, phenol content and pathogenesis-related protein (PR1 and PR4) in chitosan-treated plants. Likewise, the effect of zinc nanoparticles on the fungal pathogen *Fusarium* causing basal rot of onion was investigated by determining the fungal radial growth. The minimum radial growth of the pathogen was recorded at 200 ppm (50% reduction), followed by 100 ppm. Thus, Nanoparticles can be exploited for the better control of onion pathogens.

Pathogenicity of anthracnose-twister studied via artificial inoculation. Onion plant inoculated with *Colletotrichum gloeosporioides* showed first neck elongation after 4DAI; water-soaking lesions at 5DAI. The sunken oval lesions on the leaf blades and depressed lesions on the leaf sheaths at the neck; later, these lesions developed with salmon/orange-coloured conidial mass on 6 DAI on 7 DAI lesions becoming necrotic or matured which contained clusters of acervuli of *C. gloeosporioides* (8 DAI). Finally, it leads to the rotting of the stem.

To investigate the role of secondary metabolites of *Trichoderma* spp. isolates against major fungal diseases of onion-garlic, the traits such as Indole acetic acid (IAA) siderophores production phosphorus, potassium and zinc solubilization were determined. The elevated level of IAA and higher siderophores production was recorded in *T. speculum* and NRCG-8 strains. The isolates T-18, T-166, T-292, and *T. speculum* had phosphate solubilization zone. The genetic structure of the *T. tabaci* population was studied using mitochondrial COI gene sequences. The location-wise variation within the *mtCOI* gene has been reported. Locality-wise, per cent variations have been calculated from the total reads recorded. Among all localities, 307_Palampur represents the highest nucleotide polymorphism. The complete mitochondrial genome of *T. tabaci* has also been characterized. The circular genome of *T. tabaci* measured 12,033 base pairs (bp) in length: twelve protein-coding genes (PCGs), two *rRNA* genes and twenty *tRNA* genes. A miniature parasitoid wasp, *Megaphragma amalphitanum*, was recorded on thrips.

The bio-efficacy of commercial formulations of entomopathogens, including *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii*, and the botanical pesticide neem oil, was tested against onion thrips, both alone and in combination with the biological pesticide spinosad. In the insect-pathogen-treated plots, the adult thrips population was reduced by 30.3 to 36.2%, while nymphs were reduced by 35.5 to 41.9%. The overall mean reduction was 32.9 to 39.1% over control. The combination of neem oil and *L. lecanii* showed better efficacy against the thrips adults and nymphs, and that produced up to 41.2% population reduction, followed by the neem oil *and B. bassiana* combination. Two new-generation reduced-risk insecticides, namely Spiroteramat 150 OD and Spinetoram 11.7 SC were field tested against the onion thrips. Both were found to be effective against onion thrips, and their efficacy was on bar with Profenofos. A study was conducted to develop a seedling root dipping strategy for protecting transplanted onions from onion thrips in the main field. Cyantraniliprole, a reduced-risk diamide insecticide, was tested against onion thrips as a seedling root treatment and was effective in suppressing onion thrips infestation.

The occurrence of beetle, *Carpophilus hemipterus* is recorded in the onion storage. The species was confirmed with morphological observation and further using DNA barcoding. The pest spread to the storage generally carried from the field to storage. Further, the storage fungi causing spoilage to onion bulbs have been isolated and characterized and belong to *Aspergillus* and *Fusarium* species. The storage bulbs sampled from major onion-growing districts were analyzed for pesticide residues, and residues were found to be sub-MRL levels in all the samples. The pollination potential of the native stingless bee *Tetragonula iridipennis* was assessed. The stingless bee species visiting onion in various locations of Maharashtra was documented. Further, the complete mitogenome of *T. iridipennis* was characterized for the first time.

Post-Harvest Technology

Reducing the storage losses and value addition are the two inevitable things to make onion crop cultivation more profitable. ICAR-DOGR is working on the refinement of storage structures for reducing the storage losses and development of processed products from onion and garlic. During the reporting period under post-harvest technology, work on the development of process protocols for drying and rehydration of red onion cultivars, optimization of process protocol for extraction of onion seed oil and study on the aerodynamic properties of onion for storage was carried out.

Extension

Three decision support systems have been developed to assist farmers in making informed decisions regarding nutrient management, disease and pest management, and variety selection. The 'ONDSS' system helps farmers balance nutrient management based on soil health reports and recommended nutrient doses. *The 'ODP Adviser'* system aids in identifying and managing pests and diseases through symptom-based identification and recommendations. The *'Smart Onion'* system assists farmers in selecting suitable onion varieties for their specific requirements. Additionally, a mobile application called "Onion Crop Advisor" is developed for farmers to provide comprehensive information, advisories, and decision support tools for onion farming. Multimedia-based news bulletins '*Kanda va Lasun Samachar*' in Marathi and '*Pyaj evam Lahsun Samachar*' in Hindi and social media platforms are used to disseminate agro-advisories and technological information. Furthermore, a value chain model for wild alliums has been established, ensuring a steady supply of produce.

A total of 355 frontline demonstrations took place in Maharashtra state, encompassing the *kharif* (285), late *kharif* (30), and *rabi* (40) seasons, with the support of the institute project (30), SCSP (280), and MGMG (45). Also, 95 demonstrations were held in NEH region. Additionally, as part of the contract trial, 240 demonstrations were carried out in Pune and Ahmednagar districts, focusing on the implementation of Raised Bed with Drip Irrigation Technology. A total of 58 demonstrations in *kharif* and 85 demonstrations in *rabi* were conducted under TSP during the year 2022. A total of ten trainings/ field day (s) were organized under TSP in Maharashtra, Leh (Ladakh) and Uttar Pradesh in which 693 tribal farmers participated. Under Mera Gaon Mera Gaurav scheme 15 villages were adopted and several awareness programmes and trainings were conducted.

The Agri-Business Incubation (ABI) centre was established to support registered start-ups in the agricultural sector. Four Start-ups namely Thinkpure Organic Produce Pvt. Ltd, Farmers Smile Farmer Producer Company, Vagheshwar Farmer Producer Company, Palanduh Farmer Producer Company Ltd. Signed MoU and enrolled for incubation. In the year 2022, a total of seven onion varieties were licensed to 39 seed companies at the institute level. Additionally, an exclusive license for the 'Controlled Onion Storage Structure' technology was granted to Kala Biotech Pvt. Ltd.

Furthermore, the institute conducted six contract research trials and established collaborations with six organizations for research purposes and student guidance.

The Directorate organized XIII Annual Group Meeting of All India Network Research Project on Onion and Garlic (AINRPOG) during 5-7 August 2022 at Dharwad (Karnataka). The various Institutional activities viz., IRC, IMC, etc. meetings were held timely. ICAR-DOGR, Pune and IIT-Bombay, collaboratively organized a training workshop on 'Post Harvest Storage Technology and Management of Onion' at ICAR-DOGR campus where more than 80 of farmers, Farmer producer company (FPCs) and officials of the state government agriculture department, actively participated in the training workshop. The staff also received several awards and recognitions for their outstanding contribution in the field of onion and garlic research. ICAR-DOGR recognized as a Knowledge and Evaluation partner in the '*Grand Onion Challenge*' launched by the Ministry of Consumer Affairs, Food and Public Distribution (MoCAFPD) to develop 'Technologies for Primary Processing, Storage and Valorization of Onions'. The 23rd Research Advisory Committee (RAC) meeting of ICAR-DOGR was conducted on 20 February, 2022. The 5th Quinquennial Review Meeting was conducted during 20-22 December, 2022. Republic Day, Independence Day, International Women's Day, World Soil Day were celebrated. To increase the importance of Hindi in daily work Hindi Pakhwada was also organized. During the year 2022, ICAR-DOGR generated a revenue of 105.04 lakhs.

A. Introduction

The Directorate

Realizing the importance of onion and garlic in the country, the Indian Council of Agricultural Research (ICAR) established National Research Centre for Onion and Garlic in VIII Plan at Nashik in 1994. Later, the Centre was shifted to Pune on 16 June, 1998. Due to the expansion of R&D activities of onion and garlic, the center was rechristened and upgraded to ICAR-Directorate of Onion and Garlic Research (DOGR) in December 2008 along with All India Network Research Project on Onion and Garlic with 28 participating centers across the country.

Location and weather

The Head Quarter of the Directorate located at Chandoli, Pune, Maharashtra on Pune -Nashik Highway. It is 18.32' N and 73.51' E at 553.8 m above m.s.l. with a temperature range of 5.5-42.0 °Cand having annual average rainfall of 669 mm.

Infrastructure

The centre has 52 acres of research farm with perennial irrigation facilities at Rajgurunagar, 55 acres at Kalus, 10 acres at Manjari and 4 acres at Baner. The centre has research laboratories for biotechnology, soil science, plant protection, seed technology and post-harvest technology with modern state of the art equipment. The library at the centre has extensive collection of books, journals, e-sources on *Alliums*. The internet and e-mail connectivity has been strengthened for easy literature access. The centre has its own website: www.dogr.icar.gov.in, which provides rapid updates and all relevant information on onion and garlic and administrative matters of ICAR-DOGR.

Vision

To improve production, productivity, export and add on value of onion and garlic.

Mission

To promote overall growth of onion and garlic in terms of enhancement of quality production, export and processing.

Mandate

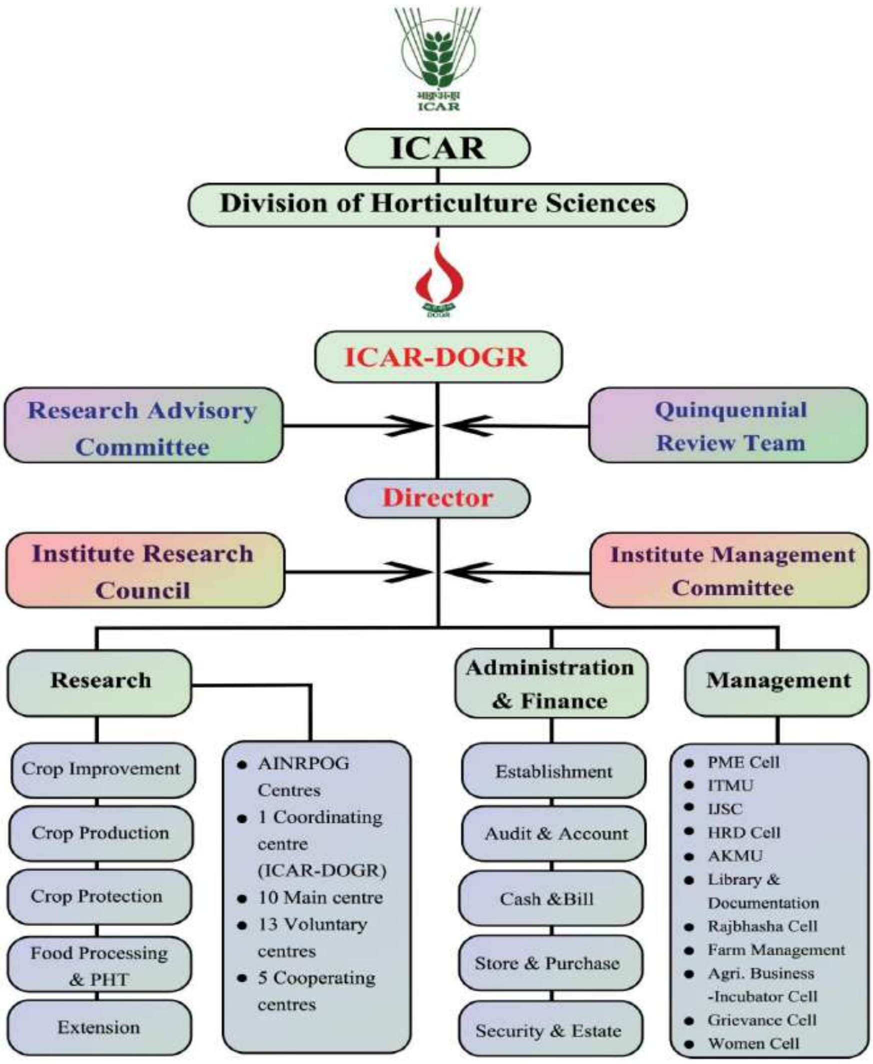
- Basic, strategic and applied research on genetic resource management, crop improvement and production technologies for enhancing and sustaining production of onion and garlic

- Transfer of technology and capacity building of stakeholders for enhancing productivity of onion and garlic

- Coordinate research and validation of technologies through AINRP on onion and garlic

ICAR-Directorate of Onion and Garlic Research

Organogram



B. Research Highlights

1. Crop Improvement

1.1 Genetic improvement of white and yellow onion including underutilized *Alliums*

Agriculture faces a notable threat due to the depletion of local cultivars and land races. It is essential to systematically collect, assess, characterize, and conserve germplasm at both molecular and phenotypic levels in order to address current and future challenges. Having a diverse genetic foundation with a range of variable germplasm is crucial for any breeding program. Germplasm acts as the fundamental source for identifying important traits like pest and disease resistance, nutritional and biochemical attributes as well as the ability to withstand environmental stresses. The vast geographical diversity of India enables the effective utilization of these germplasms to develop varieties that are well-suited for diverse agro-climatic conditions. Germplasm were collected from various regions of the country, including wild *Alliums* and these are being utilized for their nutritional properties, resistance to pests and diseases, and availability during off-seasons. In 2021, the market size of processed white onion products reached 233.84 thousand tons, with India accounting for 31.1% of the total export earnings, amounting to 1588.91 lakh USD in foreign exchange [World Integrated Trade Solution (WITS), Data on Export, Import, Tariff, NTM worldbank.org]. However, achieving stable and consistent levels of total soluble solids (TSS) and yield remains a concern. ICAR-DOGR has been conducting research for the past two decades to develop high TSS white onion lines. This report provides a brief summary of their findings and research efforts for the current year.

1.1.1 Evaluation of white and yellow germplasm

During *rabi* 2021-22, fifty-two white onion germplasm was multiplied and evaluated with the check variety Bhima Shweta. Out of these, fifteen germplasm exhibited significant superiority in terms of marketable yield (MY) and total yield (TY) compared to check (40.56 t/ha). The highest MY was observed in W-361 (62.02 t/ha) followed by W-398 (56.71 t/ha) and White New Genepool (54.29 t/ha). The MY ranged from 23.03 to 62.06 t/ha and eleven germplasm were found to be free from bolting. After four months of storage, the losses varied from 19.89% to 61.09%. W-353 (19.89%) had the lowest storage losses followed by White GP Composite-6 (26.60%) compared to check (39.97%). The Total Soluble Solids (TSS) ranged between 11.00% and 14.30%. W-385 (14.30%) had the highest TSS followed by W-175 (14.20%). Additionally, seven germplasm received from ICAR-NBPGR were evaluated, IC-49102 (W) (42.46 t/ha) performing significantly better in terms of MY compared to check (40.81 t/ha). Furthermore, two lines of yellow onion germplasm were also evaluated, where Y-005 exhibited significantly superior MY (50 t/ha) compared to check variety Arka Pitamber. The range of bolting observed was between 1.23% and 8.50%. After four months of storage, the storage losses varied from 47.97% to 72.03% (Table 1.1).

Table 1.1 Evaluation of white and yellow onion germplasm during *rabi* 2021-22

No. of germplasm	Superior lines for MY	MY (t/ha)	SL4M (%)	Bolter (%)	TSS (°Brix)
(White) 52	16 (15+1IC)	23.03-62.06	18.89-61.09	0.00-44.65	11.00-14.30
(Yellow) 2	1	39.80-50.00	47.57-72.03	1.23- 8.50	11.73-12.13

(MY: Marketable Yield; TSS: Total Soluble Solid; SL4M: Storage Loss in 4 Months)

In late-*kharif* 2021-22, fifteen white onion germplasm was evaluated along with the check variety Bhima Shubhra. The MY ranged from 4.69 to 40.70 t/ha. Two germplasm, W-453 (40.70 t/ha) and W-458 (34.07 t/ha), exhibited significantly superior MY compared to Bhima Shubhra (29.64 t/ha). These lines along with W-063 and W-208 were also observed to be free from bolting. After two months of storage, the losses varied between 17.01% and 45.01%. Germplasm White Composite-7 (17.01%) had the lowest storage losses followed by W-364 (18.20%) in comparison to check variety (33.20%) (Table: 1.2).

Table 1.2 Evaluation of white onion germplasm during late-*kharif* 2021-22

No. of germplasm	Superior lines for MY	MY (t/ha)	SL2M (%)	Bolter (%)	TSS (°Brix)
15	2	4.69 - 40.70	17.01-45.01	0.00-19.27	12.10-14.00

(MY: Marketable Yield; TSS: Total Soluble Solid; SL2M; Storage Loss in 2 Months)

1.1.2 Evaluation of white onion breeding lines

In *rabi* 2021-22**,** sixty-nine white onion breeding lines were evaluated and compared with the check variety Bhima Shweta. Among them, ten lines exhibited significant superiority in MY compared to check (40.56 t/ha). The line W-407AD-6 (55.59 t/ha) achieved the highest MY followed by W-172AD-5 (50.30 t/ha) and W-418 M-1 (50.29 t/ha). Among these, seventeen lines were free from bolting and thirty-three lines from double bulbs. The line W-085AD-7 (17.56%) had the lowest storage losses after four months of storage followed by W-543 M-1 (25.43%) compared to check (39.97%) (Table: 1.3).

Table 1.3 Evaluation of white onion breeding lines during *rabi* 2021-22

No. of germplasm	Superior lines for MY	MY (t/ha)	SL4M (%)	Bolter (%)	TSS (°Brix)
(White) 69	10	10.33-55.69	17.56-64.06	0.00 -13.71	11.00-14.90

(MY: Marketable Yield; TSS: Total Soluble Solid; SL4M; Storage Loss in 4 Months)

During late-*kharif* season, forty-five advanced/initial breeding lines were evaluated along with check Bhima Shubhra. Among these, line W-448 BR-11 (36.74 t/ha) demonstrated significantly superior performance in terms of MY compared to check (30.63 t/ha). The MY across the evaluated lines ranged from 3.94 to 36.74 t/ha. Among the assessed lines, eleven lines were bolter-free and four lines exhibited the absence of double bulbs. The storage losses after a 2-month ranged between 15.86% to 51.17% as compared to check (41.32%) (Table: 1.4).

Table 1.4 Evaluation of white onion breeding lines during late-*kharif* 2021-22

Season	Germplasm evaluated	Superior lines for MY t/ha	Marketable yield t/ha	Storage losses (%)	Bolting (%)	TSS (%)
Late-*kharif*	45	1	3.94-36.74	15.86 - 51.17	0.00-22.99	11.53-14.40

(TY: Total Yield; MY: Marketable Yield; TSS: Total Soluble Solid; SL2M: Storage Loss in 2 Months)

In *kharif* 2022, twelve advanced/initial breeding lines were multiplied and evaluated along with check variety Bhima Shubhra. Unfortunately, there was a severe incidence of anthracnose disease during the cropping period, resulting in significantly lower yields ranging from 0.35 to 14.67 t/ha. None of the evaluated germplasm or breeding lines exhibited superior performance compared to the check (16.34 t/ha). The TSS content of these onions ranged between 10.80% and 13.80%.

1.1.3 Evaluation of high TSS lines

During *rabi* 2021-22, forty-three high-TSS lines were evaluated in the 11th generation along with the check variety Bhima Shweta. Among these, four lines were significantly superior for MY compared to Bhima Shweta (32.01 t/ha). The line HT-GR-5B-M-7-2-1 (51.33 t/ha) recorded the highest MY. The TSS ranged from 10.90% to 18.84% with the line WHTB-GT-18-M-9-MC (18.84%) showed the highest TSS followed by WHTB-3C-GT-18-MC-M-7 (18.67%) and WHTB-GT-18-M-10-SC (18.48%). Seven lines were bolting free while seventeen were free of double bulbs. The storage losses after four months ranged from 13.37% to 55.93%. Two lines, HT-GR-1C-M-7-2-2 (48.93%) and HT-GR-23A-2-1-M-1 (17.77%), had lower storage losses compared to the check variety Bhima Shweta (46.47%) (Table: 1.5).

Table 1.5 Evaluation of white onion high TSS lines during *rabi* 2021-22

Entries	% bulbs in population having TSS >15 ^{0}Brix	Average population TSS
WHTB-GT-18-M-9-MC	95.99	18.84
WHTB-GT-18-M-10-SC	93.53	18.48
WHTB-3C-GT-18-MC-M-7	92.99	18.67
WHTB-15-18-M-10-SC	89.22	18.17
HT-GR-2A-M-6-BIG BULB-(15-17.8) 1-3	87.50	18.05
WHTB-SE-GT-15-SC-M-7	84.54	16.33
HT-GR-2A-M-9-SGT-18	80.70	16.58
WHTS-15-18-M-10-SC	77.04	16.55
HT-GR-2A-M-7-SGT-18	76.34	15.95
WHTS-GT-18-M-9-MC	74.89	16.12
Check varieties	0	<12.5

During late-*kharif*, twenty *rabi* lines with high TSS were evaluated and compared with the check variety Bhima Shubhra. These lines exhibited TSS values ranging from 13.33% to 16.80%. The line WHTB-GT-18-M-9-SC (16.80%) achieved the highest TSS content followed by HT-GR-2B-M-8-SGT-18 (16.47%) and WHTB-1A-GT-18-SC-M-7 (16.00%) over the check (11.94%). Three lines *viz*. WHTB-1A-GT-18-SC-M-7, WHTB-GT-18-M-9-SC, and WHTB-3C-GT-18-MC-M-8 were found to be bolter free. The minimum storage loss was recorded in the line WHTS-15-18-M-8-MC (18.60%) compared to the check (33.20%).

1.1.4 Evaluation of white onion bolting tolerant lines

In late-*kharif* 2021-22, six bolting-tolerant lines were evaluated and compared to the check variety Bhima Shubhra. The MY of these selected lines ranged from 5.69 to 31.78 t/ha. Among these, the line White Genepool LG-107-6 (31.78 t/ha) exhibited at par MY with a low bolting percentage of 0.66% compared to check (30.63 t/ha) and bolting (8.83%). Furthermore, White GP Comp. LG-209-4 was found to be completely bolter free compared to its original parent, White GP Comp-7 (19.27). In storage, total losses after 2 months varied between 15.25% and 48.18%. Notably, the line W-448 LG-209-6 (15.25%) recorded the lowest total storage losses with no instances of sprouting during storage.

1.1.5 Development of F_1 hybrids in white onion

During *rabi* 2021-22, fifteen F_1 hybrids were evaluated along with check variety Bhima Shweta. The hybrid MS-100 × W-408 F_1M_1 (67.74 t/ha) exhibited the highest MY followed by MS-100 × W-340 F_1M_1 (55.66 t/ha) and HT-GR-1A-M-7 (>18) × Bhima Shweta (10.2) (54.06 t/ha) compared to check (40.81 t/ha). The hybrid MS-100 × W-408 F_1M_1 displayed a heterosis of 65.54% for MY and 70.27% for TY. None of these hybrids were found to be bolter-free. In addition to these hybrids, HT-GR-2A-M-6 (15-18) (20.2) × Bhima Shubhra hybrid had a high TSS (15.20%) followed by HT-GR-1A-M-7 (>18) × Bhima Shweta (15%) compared to check (11.90%). Furthermore, twenty-one inbred white onion lines were multiplied in the second generation (Table: 1.6).

Table 1.6 Evaluation of white onion hybrids during *rabi* 2021-22

Crosses	MY (t/ ha)	Heterosis (%)	TY (t/ha)	Heterosis (%)	Bolter (%)	TSS (^{0}Brix)	SL4M (%)
MS-100 × W-408 F_1M_1	67.74	65.54	70.51	70.27	2.88	11.50	84.11
MS 100 × HT-GR-2A-M-7(SC)	50.41	63.14	58.48	79.76	11.13	12.40	52.77
MS-100 × W-340 F_1M_1	55.66	61.33	61.73	66.07	04.38	11.80	37.34
HT-GR-1A-M-7 (>18) × B. Shweta (10.2)	54.06	32.47	56.69	34.33	02.30	15.00	36.24
MS-100 × W-396	53.90	12.20	56.37	02.75	04.31	11.10	24.36
Bhima Shweta (Check)	40.81	-	42.20	-	00.90	11.90	55.02

(MY: Marketable Yield; TY: Total Yield; TSS: Total Soluble Solid; SL4M: Storage Loss in 4 Months)

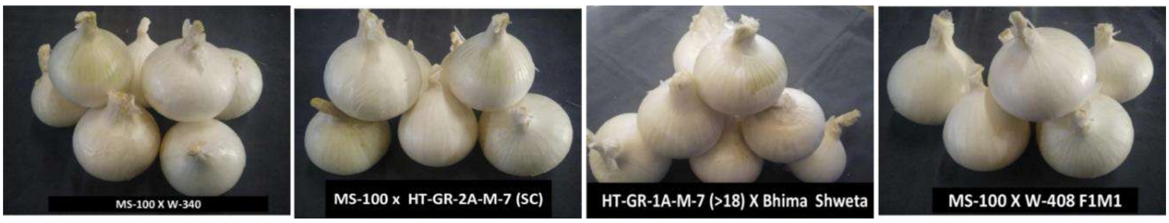


Fig. 1.1 High yielding white onion F_1 hybrids during *rabi* 2021-22

1.1.6 Evaluation of white and yellow population developed through crosses between long-day and short-day onion

In *rabi* season, nine populations of long day (LD) and short day (SD) white and yellow onions, which were in the 7th generation were evaluated along with check variety Arka Pitamber. The MY of these populations varied between 35.50 to 54.81 t/ha. Among them, three populations *viz*. N-14 × W-23 (White) F_1M_5 (54.81 t/ha), N-14 × B-2 (Yellow) F_1M_5

(52.79 t/ha) and F-6 × L-12 (Yellow) F_1M_5 (46.47 t/ha) exhibited superior MY compared to check variety Arka Pitamber (39.79 t/ha). Two lines, N-14 × B-2 (Yellow) F_1M_5 and N-14 × W-23 (White) F_1M_5 were found to be free of double bulbs. The desirable traits related to bulb shape, size, neck thickness and good storability could be successfully transferred to short day onions. Selected white and yellow bulbs from these populations were sent to ICAR-CITH for seed production and half of the bulbs from these lines were also planted at ICAR-DOGR to induce flowering under short day condition (Fig. 1.2).

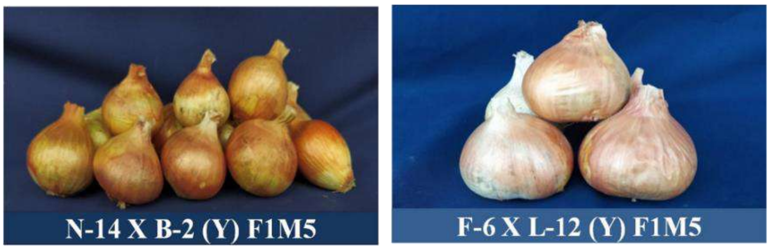


Fig. 1.2 High yielding F_1 hybrids crosses between LD and SD onion in 7th generation

1.1.7 Morphological and molecular characterization of late-*kharif* germplasm

In this study, the polar diameter (mm) and marketable yield (t/ha) exhibited the highest positive correlation, with a value of 0.31. None of the examined traits showed a significant negative correlation with marketable yield. The genetic diversity of the thirty white onion genotypes was analysed using 30 Intron Length Polymorphic (ILP) markers. The Polymorphic Information Content (PIC) values ranged from 0.06 to 0.44, with an average of 0.20. Amplification of the markers revealed a total of 78 loci, with five of them being monomorphic. A total of 2311 bands were obtained, with an average of 3.7 bands per genotype. Using the UPGMA method, a dendrogram was constructed, dividing the thirty onion genotypes into 10 clusters. The genotypes W-489 M6 and W-361 GP exhibited the highest degree of similarity, with a similarity coefficient of 0.97, while the lowest degree of similarity was observed between genotypes W-500 GP and W-498, with a coefficient of 0.37. Genetic diversity among the white onion genotypes was estimated based on the molecular markers' similarity coefficient and Pearson's correlation coefficient analysis. This study on onions facilitates the selection of diverse parent lines, which can contribute to the generation of desirable segregates in future breeding programs (Fig. 1.3).

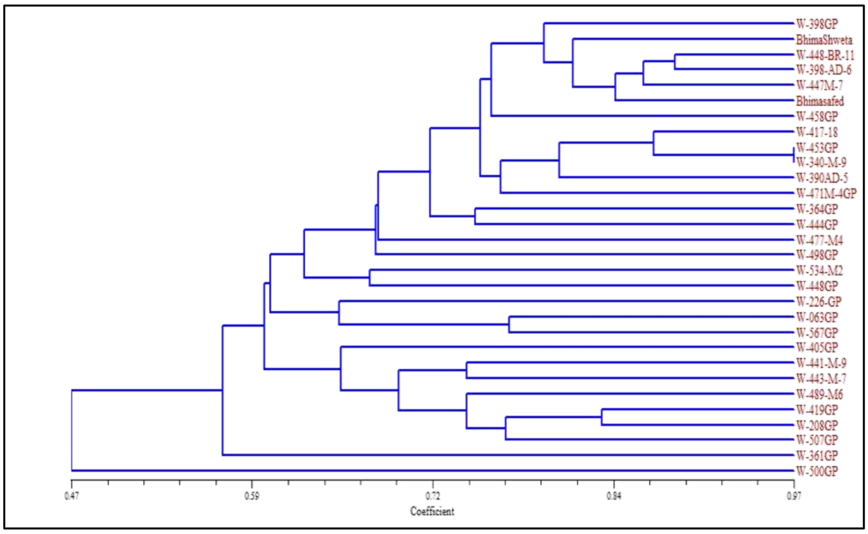


Fig. 1.3 Dendrogram generated using Jaccard's coefficient and UPGMA cluster analysis using NTSYS-pc software

1.1.8 Maintenance and utilization of underutilized/ wild *Alliums*

1.1.8.1 Conservation and popularization of wild and underutilized Alliums species

ICAR-DOGR is currently maintaining and evaluating 89 wild and underutilized *Allium* lines of 17 different species. The wild germplasm bank at ICAR-DOGR have collections from diverse sources such as Leh and Ladakh, Arunachal Pradesh, Assam, Sikkim, Manipur, Himachal Pradesh, Tamil Nadu, and others. Additionally, accessions from countries like the United States, Central Asia, and the Netherlands have been obtained through the ICAR-NBPGR. Furthermore, selected underutilized lines are being cultivated on a larger scale for the purpose of popularization. Recognizing the significance of flowering characteristics in their subsequent utilization for breeding purposes, ICAR-DOGR is diligently recording the flowering patterns of these lines within the specific agro-climatic conditions of the institute.

1.1.8.2 Flowering status of Allium species at ICAR-DOGR

The similar flowering patterns were observed in identified twenty-six flowering *Allium* species as recorded in previous year. *A. altaicum* Pall displayed flowering from January to May while eleven lines of *A. fistulosum* flowered between February and March. Two lines of *A. schoenoprasum* exhibited flowering in February whereas *A. tuberosum* lines were flowered in May. This flora of flowering in *Allium* species is being utilized for the development of inter-specific hybrids for transferring desired characters.

1.1.8.3 Evaluation of underutilized Allium Species for Popularization and Commercialization

Systemic value chain development efforts for *Allium tuberosum* are being carried out by ICAR-DOGR based on three E's *viz*. Evaluation of production performance, Exploration of consumer response and quality perceptions, and Exploration of market potential and sustainability. *Allium tuberosum*, commonly known as "Chinese chives" or "Garlic chives," is an underutilized *Allium* species that is consumed for its green foliage, which has a milder flavour profile compared to onion and garlic. ICAR-DOGR is actively engaged in the systematic development of the value chain for this species, based on three E's aspects: Evaluation of production performance, Exploration of consumer response and quality perceptions, and Exploration of market potential and sustainability.

Fig. 1.4 *Allium tuberosum* growth and packages being sold by different value chain entities

At ICAR-DOGR, an experiment was done to explore the performance of different *Allium tuberosum* lines (*A. tuberosum* Kazakhstan All-1587, *A. tuberosum* CGN-16418, and *Allium tuberosum* Rottl Ex-sprkuchaai CGN-16373) under Western Ghat region. The analysis focused on assessing the growth performance of these lines during various seasonal harvesting windows, namely January to March, April to June, July to September, and October to December. Among the evaluated morphological, growth and yield characteristics, *Allium tuberosum* Kazakhstan All-1587 exhibited the best performance for growth, annual yield, foliage quality and nutritional properties (protein- 3.45%, crude fibre- 13.83% and crude fat- 2.63%). The findings from this study emphasized the suitability of cultivating *Allium tuberosum* in the region and provided insights into the development of a seasonal plan to ensure sustained quality. The growth characteristics of *Allium tuberosum* were primarily assessed based on plant height, number of tillers and crop spread. The influence of the season on regenerative plant height was found to be significant, with a Least Significant Difference (LSD) of 1.02 in the first year and 1.32 in the second year. The number of tillers gradually increased with successive monthly cuttings resulting in a relative expansion of the crop. By the end of the second year, the mean number of tillers reached 26.95 compared to 15.44 at the end of the first year. *Allium tuberosum* CGN-16418 exhibited a generally higher leafing characteristic (6.14 to 6.50 leaves per tiller) compared to *Allium tuberosum* Rottl Ex-sprkucchai CGN-16373 and *Allium tuberosum* Kazakhstan All-1587. However, it had relatively thinner leaves. The season had a significant impact on leaf width and pseudostem length. The seasonal window of July to September was observed to produce longer stems (ranging from 6.43 to 7.81 cm) and thinner leaves, which necessitated the removal of extra stems before marketing. An increasing yield trend was observed as the number of tillers increased. The highest yield was recorded in *Allium tuberosum* Kazakhstan All-1587 (40.82 t/ha and 105.72 t/ha of green foliage in the first and second year, respectively) followed by *Allium tuberosum* CGN-16418 (39.04 and 110.29 t/ha) and *Allium tuberosum* Rottl Ex-sprkucchai CGN-16373 (16.96 and 105.11 t/ha) (Fig. 1.5). The quality was evaluated based on the ratio of stem length to plant height and the generated waste. To quantify the proportion of waste generated, the waste-to-total foliage yield ratio was calculated. The seasonal windows of July to September exhibited the highest proportionate waste, with 8.60% in the first year and 7.86% in the second year. Additionally, during this period, poor quality was observed due to the presence of longer pseudostem length portions, which had a negative impact on the overall yield.

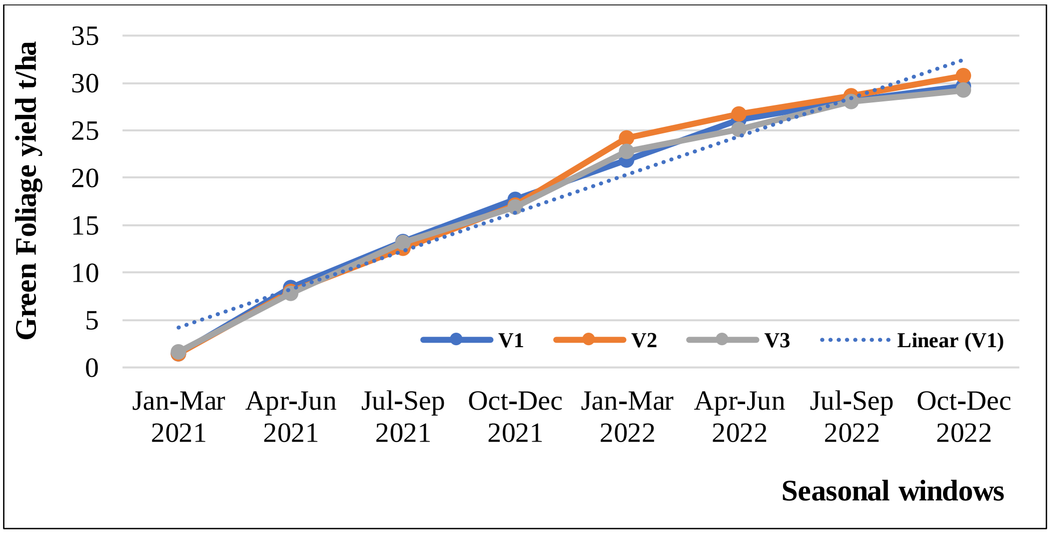


Fig. 1.5 Seasonal foliage yield of *Allium tuberosum* lines (t/ha)
(V1: *Allium tuberosum* Kazakhstan All-1587; V2: *Allium tuberosum* CGN-16418 and V3: *Allium tuberosum* Rottl Ex-sprkucchai CGN-16373)

To establish a value chain model and commercialize *Allium tuberosum* efforts have been made through a fresh vegetable supply chain managed by a farmer-producer company called Kisan Konnect (Fig. 1.4). This initiative has been successful in generating a three-fold increase in demand and attracting non-traditional consumers. Simultaneously, pre-packaged garlic chives are being commercialized through another supply chain, Big Basket (a TATA product). The underutilized *Allium tuberosum* has garnered significant interest as a potential vegetable in the region. The value-added products derived from this species were being sold at consumer endpoints at prices ranging from ₹ 900 to 2500/kg.

1.1.8.4 Inter-specific Hybridization in Alliums

In inter-specific hybridization, the study related to hybrid development and progeny advancement has been undergoing. The fertility and bulb traits of all the progenies were thoroughly characterized (Table 1.7). Progenies showing promising bulbing traits were selected for further advancement. The investigation into the variability in fertility status between the progeny and their respective parents was undertaken using RNA transcriptomic analysis. The genes that were identified as influential will be prioritized in planning future breeding activities (Fig. 1.6).

Table 1.7 Variation in F_1 interspecific hybrids for morphological traits

F_1 HC	PH (cm)	NT	NLT	PH (cm)	PD (mm)	W4L (mm)	UT	UH (cm)	UW (mm)
IH101	67.35	5.78	6.38	15.63	13.61	8.64	0.89	60.26	9.95
IH102	47.78	13.00	5.45	14.81	12.45	5.24	1.00	41.19	10.03
IH104	72.04	24.00	6.83	12.96	13.14	4.71	1.00	69.88	10.49
IH105	65.08	15.00	7.47	16.43	15.39	5.29	1.07	68.05	12.69
IH106	49.18	12.00	5.92	16.82	10.82	3.90	1.04	45.24	8.36
IH107	70.89	12.67	6.28	16.85	16.28	4.47	1.00	71.86	10.88
IH108	80.63	16.50	6.56	17.25	16.82	4.84	1.00	70.39	11.76
IH109	65.57	10.67	6.86	15.31	15.65	5.01	1.00	66.00	11.70
IH110	59.16	7.67	6.10	16.37	15.08	4.30	1.05	55.98	12.50
IH111	57.20	4.75	4.09	15.00	11.28	4.57	1.00	55.40	12.06
IH112	61.96	6.00	4.22	15.53	15.83	5.68	0.89	52.75	12.51
IH301	40.10	2.00	4.00	13.15	16.04	13.41	1.00	77.20	20.69
IH302	66.83	6.00	7.50	15.63	22.84	8.45	1.00	74.98	19.34
IH304	77.20	1.00	5.00	16.10	16.36	5.12	1.00	66.30	13.90
IH306	80.13	3.00	7.33	13.17	30.33	8.84	1.00	57.17	21.91
IH309	48.46	5.00	4.20	10.64	15.53	4.08	1.00	58.13	13.53
IH207	67.77	3.00	2.33	13.53	16.37	4.98	1.67	66.13	11.13
IH204	73.92	2.00	5.55	18.84	20.60	10.05	1.00	74.36	17.37
IH208	37.10	0.00	3.00	10.11	10.57	0.00	1.00	62.20	9.18
IH308	69.10	0.00	7.00	23.10	21.74	7.10	1.00	87.20	15.81

(HC: Hybrid Code; PH: Plant Height; NT: Number of Tillers; NLT: Number of Leaves per Tiller; PH: Pseudostem Height; PD: Pseudostem Diameter; W4L: Width of 4th Leaf; UT: Umbels per Tiller; UH: Umbel Height; UW: Umbel Width)

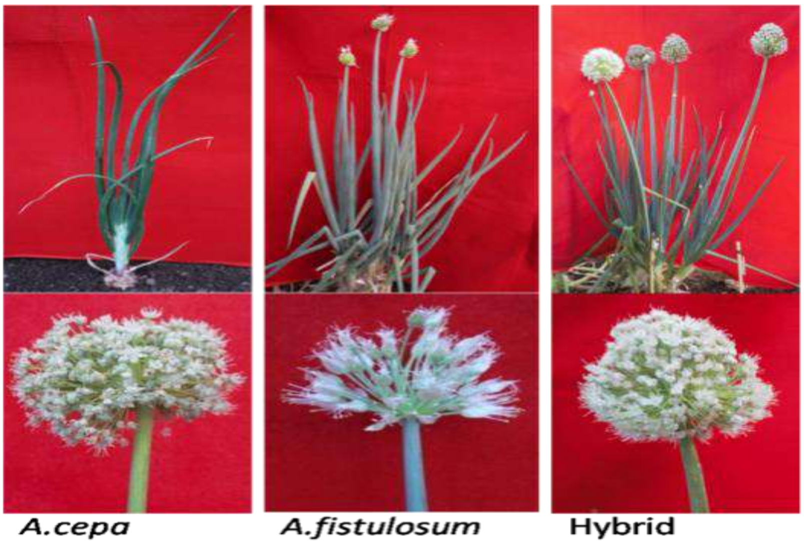


Fig. 1.6 Variation in parents and inter-specific hybrid

1.1.8.5 Molecular diversity in wild Allium

A comprehensive screening was performed in seventeen *Allium* species, including *Allium cepa* and *Allium sativum* by using 30 polymorphic ILP (Inter-Simple Sequence Repeat Length Polymorphism) markers. The resulting dendrogram exhibited clear grouping of the species into two distinct classes, which further subdivided into subsections based on species classification. These primers will be further useful in species identification and for studying the phylogenetic relationships among *Allium* species (Fig. 1.7).

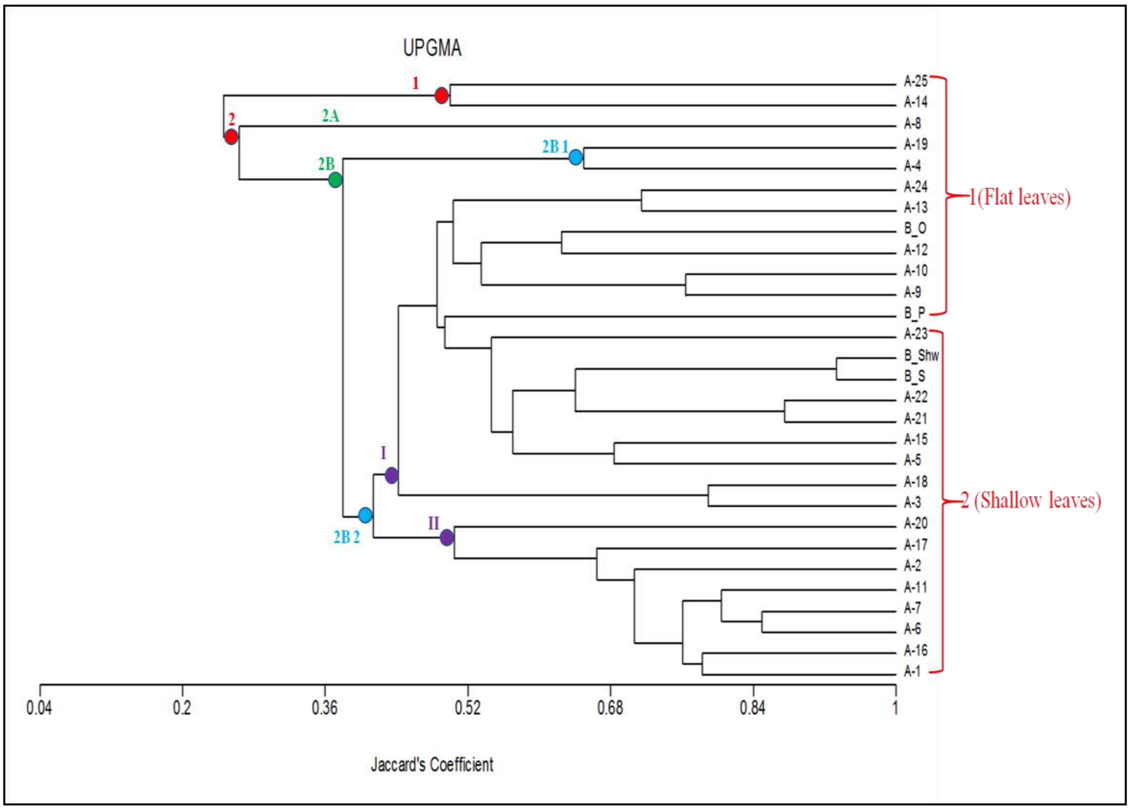


Fig. 1.7 Dendrogram showing genetic relationship among *Allium*

1.2 Genetic improvement of red onion

1.2.1 Collection, evaluation, conservation and documentation of red onion germplasm

The evaluation of onion germplasm was conducted during three seasons viz., late-*kharif* with 170 accessions, *rabi* with 192 accessions, and *kharif* with 165 accessions, including suitable checks. All the onion accessions were characterized with 24 important traits. A total of 642 red onion germplasm seeds have been preserved in mid-term storage at ICAR-DOGR.

In late-*kharif* 2021-22, Acc. 1794, 1281, 1802, 1656, 1668 and 1664 displayed highest MY (>40 t/ha), compared to check variety, Bhima Shakti (32.93 t/ha). These accessions also yielded >74% marketable bulbs and were free from doubles and bolters, except for Acc. 1656, 1668, and 1664. The Acc. 1281, 1668, 1794, and 1802 showed minimum days to harvesting (118 days) compared to check (122 days). The Acc. 1395 showed minimum (20.30%) storage losses after four months of storage followed by 1283 (22.32%) and 1246 (24.62%) compared to check (45.06%) (Table 1.8).

Table 1.8 The best performing red onion accessions during late-*kharif* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolter (%)	TSS (%)	DTH
1794	58.00	100.00	87.00	0.00	0.00	11.55	118.00
1281	51.11	100.00	76.67	0.00	0.00	11.40	118.00
1802	49.78	100.00	74.67	0.00	0.00	11.80	118.00
1656	44.07	74.70	85.00	25.30	0.00	11.16	126.00
1668	41.75	74.81	84.62	14.99	10.20	11.30	118.00
1664	40.55	80.60	79.00	6.24	13.16	11.78	117.50
1603	39.87	83.34	88.73	10.87	5.78	11.80	118.00
Bhima Shakti (C)	32.93	78.30	85.13	15.82	4.98	11.89	122.00
Bhima Super (C)	28.65	81.50	66.39	2.38	14.02	11.25	119.33
Phule Samarth (C)	27.95	72.55	78.09	2.72	23.19	11.27	114.00
CV (%)	11.50	10.29	11.36	29.86	32.16	4.18	3.47
LSD (P=0.05)	4.38	12.53	10.80	12.21	9.23	0.80	6.74

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest)

Among the bolting-free group during the late-*kharif* season, DOGR-1168 (LG-107-3) (29.29 t/ha), Bhima Shakti (LG-107-3) (28.49 t/ha) and Bhima Kiran (LG-107-3 (28.13 t/ha) exhibited superior performance compared to check variety, Bhima Shakti. These accessions also achieved >86% marketable bulbs and had < 3% double bulbs while their bolting performance was comparable to Bhima Shakti (5.71%). The Acc. DOGR-1133 showed minimum storage loss (38.12%) followed by Bhima Kiran (LG-107-3) (39.74%), Bhima Shakti (LG-107-3) (45.26%) and DOGR-1168 (LG-107-3) (49.31%) after four months of storage compared to check (53.71%) (Table 1.9).

Table 1.9 The best performing red onion LG group accessions during late-*kharif*

Entries	MY (t/ha)	MB (%)	ABW (g)	Double (%)	Bolter (%)	TSS (%)	DTH	E:P
DOGR-1168 (LG-107-3)	29.29	87.59	63.61	3.27	7.63	13.05	117.6	1.19
Bhima Shakti (LG-107-3)	28.49	86.80	63.11	3.39	8.84	12.60	121.0	1.13
Bhima Kiran (LG-107-3)	28.13	91.30	60.07	1.70	5.45	12.57	119.6	1.13
Bhima Super (LG-107-3)	26.67	82.51	56.91	1.14	15.60	12.19	117.3	1.11
Bhima Red (LG-107-3)	26.35	84.83	60.26	1.38	12.65	12.59	120.0	1.13
Red Genepool-1(LG-107-3)	25.96	78.37	60.79	2.61	18.37	11.99	118.6	1.12
Bhima Raj (LG-107-3)	24.71	83.77	51.43	1.13	13.55	12.45	115.0	1.13
Bhima Super (C)	25.61	83.62	58.06	2.78	12.50	12.65	118.6	1.11
Bhima Shakti (C)	25.47	89.83	58.13	2.52	5.71	12.72	117.3	1.10
Phule Samarth (C)	21.14	74.05	54.33	1.97	22.17	12.65	117.0	1.12
CV (%)	9.39	4.02	7.75	18.05	22.81	3.94	2.77	-
LSD (P=0.05)	2.10	5.66	7.71	4.06	4.97	0.84	5.55	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

During *rabi* 2021-22, accessions 1321, 1309, 1297, 1280, and 1627 achieved MY exceeding 46 t/ha, surpassing the performance of the check variety, Bhima Shakti (27.75 t/ha). These accessions also attained >90% marketable bulbs and were free from double bulbs and bolters, except for accession 1280 (9.93%). Among these accessions, 1309 and 1280 had the minimum harvesting time (90 days) compared to check (101 days). The Acc. 1343 exhibited minimum loss (21.51%) followed by 1297 at 23.02% and 1217 at 24.41% after four months, outperforming the check (42.93%) (Table 1.10).

Table 1.10 The best performing red onion accessions during *rabi* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolter (%)	TSS (%)	DTH	E:P
1321	58.33	100.00	87.50	0.00	0.00	9.88	104.0	1.29
1309	52.14	100.00	78.21	0.00	0.00	11.40	90.0	1.17
1297	48.56	100.00	78.92	0.00	0.00	11.60	97.0	1.24
1280	48.40	90.07	80.67	9.93	0.00	10.96	90.0	1.19
1627	46.29	100.00	74.77	0.00	0.00	12.32	104.0	1.31
1738	44.36	100.00	71.29	0.00	0.00	11.76	97.0	1.29
1369	43.87	100.00	82.25	0.00	0.00	10.72	104.0	1.27
Bhima Shakti (C)	27.75	95.86	47.49	0.00	0.00	11.92	101.6	1.24
BLR (C)	26.66	95.12	51.72	0.00	0.00	12.35	104.0	1.26
Bhima Kiran (C)	25.99	95.25	44.60	0.00	0.00	12.53	99.33	1.23
CV (%)	10.69	3.94	12.70	17.94	2.95	4.97	7.58	-
LSD (P=0.05)	5.00	6.03	9.97	1.95	0.00	0.91	12.57	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

In *kharif* 2022, accessions 1634, 1616, and 1829 showed superior performance by achieving MY (>27 t/ha), compared to check variety Bhima Super (22.50 t/ha). These accessions also attained >80% marketable bulbs (Table 1.11). The Acc. 1634 was free from double bulbs and bolters. Among these accessions, 1634 recorded minimum days to harvesting (108 days) followed by 1616 and 1829 (110 days) as compared to check (111.33 days)

Table 1.11 The best performing red onion accessions during *kharif* 2022

Entries	MY (t/ha)	MB (%)	ABW (g)	Double (%)	Bolters (%)	TSS (%)	DTH	E:P
1634	33.67	80.12	101.00	0.00	0.00	11.10	108.0	1.12
1616	32.72	81.51	112.45	11.76	0.91	12.48	110.0	1.08
1829	27.98	87.93	89.87	8.85	0.00	11.91	110.0	1.14
1832	23.30	72.30	90.55	6.96	0.00	11.94	110.0	1.10
1664	23.06	76.74	102.82	8.40	0.00	11.40	109.0	1.09
1802	21.33	68.09	80.00	20.43	0.00	11.65	112.0	1.09
1624	20.92	70.22	91.07	21.99	0.00	12.39	110.0	1.12
B. Super (C)	22.50	83.06	102.43	7.50	0.00	12.47	111.3	1.10
BDR (C)	20.33	62.44	99.41	16.78	0.00	12.45	109.0	1.09
CV (%)	8.44	11.23	9.97	28.88	15.71	5.28	2.98	-
LSD (P=0.05)	3.30	12.80	18.08	5.22	1.34	1.04	5.30	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

1.2.2 Breeding of improved red onion varieties for table purpose

A comprehensive assessment of advanced breeding lines, comprising 35 lines during late-*kharif* season, 34 lines during the *rabi* season, and 37 lines during *kharif* season was conducted. These lines were evaluated along with checks for a total of 24 agro-morphological traits.

Evaluation of advance breeding lines

In late-*kharif* 2021-22, a total of thirty-five lines were evaluated, DOGR-1608, DOGR-1614, DOGR-1610, DOGR-1610, DOGR-1613, and DOGR-1607 achieved superior MY (> 30 t/ha) as compared to check variety Bhima Shakti (26.63 t/ha). They also showed dark red, globe and medium sized bulbs (58-70 g), >81% marketable bulbs (Table 1.12). A line DOGR-1610 was free from doubles while DOGR-1608, DOGR-1610 (119 days) recorded minimum days to harvesting followed by DOGR-1607 (120 days). DOGR-1414 exhibited the lowest storage loss (31.79%) after four months of storage followed by DOGR-1203-DR (35.72%) and DOGR-1607 (35.88%) whereas, the check variety Bhima Shakti recorded a higher storage loss (45.06%).

Table 1.12 The best performing advance breeding lines during late-*kharif* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Double (%)	Bolter (%)	TSS (%)	DTH	E:P
DOGR-1608	33.27	86.44	66.41	2.51	9.67	11.65	119.0	1.08
DOGR-1614	32.95	97.05	59.67	0.42	2.11	11.55	122.0	1.16
DOGR-1610	32.93	82.68	70.57	0.00	14.23	11.16	119.0	1.17
DOGR-1613	31.73	81.27	67.76	7.62	9.97	11.55	122.6	1.15
DOGR-1607	30.51	82.15	58.79	7.53	9.46	11.89	120.0	1.10
DOGR-1043-DR	29.60	83.70	61.24	9.43	6.22	11.97	120.6	1.12
DOGR-1014-GDR	28.87	77.36	62.36	4.54	18.10	11.42	119.0	1.11
Bhima Shakti (C)	26.63	87.18	67.10	3.44	7.86	11.72	119.6	1.10
Bhima Super (C)	25.61	83.62	58.06	2.78	12.50	12.65	118.6	1.11
Phule Samarth (C)	21.14	74.05	54.33	1.97	22.17	12.65	117.0	1.12
CV (%)	11.81	7.84	9.53	27.00	31.53	4.14	2.05	-
LSD (P=0.05)	3.16	10.30	9.01	6.06	10.65	0.79	4.00	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

During *rabi* 2021-22, DOGR-1048-Sel (31.70 t/ha), KH-M-1 (31.21 t/ha), KH-M-2 (30.18 t/ha), DOGR-1614 (29.42 t/ha) and DOGR-1611 (28.94 t/ha) demonstrated superior performance compared to check variety Bhima Shakti (25.55 t/ha). They exhibited desirable characteristics such as dark red colour, globe-shaped bulbs of medium size (50-57 g), high marketable bulbs (>97%) and were free from double bulbs and bolters, except for KH-M-1 which had a double bulb percentage of 0.69%. Furthermore, DOGR-1172-DR and DOGR-1203-DR exhibited the minimum storage loss after four months of storage (33.13%) followed by DOGR-1044-Sel (33.92%) and KH-M-3 (34.47%), outperforming the check variety Bhima Kiran (37.20%) (Table 1.13).

Table 1.13 The best performing advance breeding lines during *rabi* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P
DOGR-1048-Sel.	31.70	100.00	55.43	0.00	0.00	12.00	106.67	1.23
KH-M-1	31.21	98.11	57.69	0.69	0.00	11.80	105.33	1.33
KH-M-2	30.18	97.75	56.60	0.00	0.00	12.15	103.33	1.24
DOGR-1614	29.42	97.69	51.70	0.00	0.00	12.67	102.67	1.26
DOGR-1611	28.94	97.14	50.00	0.00	0.00	11.68	104.67	1.17
DOGR-1014-GDR	28.49	99.40	52.66	0.00	0.00	12.59	106.33	1.11
DOGR-1608	27.78	98.44	52.67	0.00	0.00	12.85	106.33	1.22
Bhima Shakti (C)	25.55	97.39	46.31	0.00	0.00	12.87	103.67	1.22
ALR (C)	23.53	96.08	46.42	0.00	0.00	12.56	105.33	1.24
Bhima Kiran (C)	20.98	96.60	39.16	0.00	0.00	13.75	106.33	1.22
CV (%)	9.71	2.87	11.35	22.89	23.80	5.92	4.14	-
LSD (P=0.05)	3.27	4.49	8.98	0.90	0.53	1.20	7.02	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

During *kharif* 2022, DOGR-1014-GDR (33.56 t/ha), DOGR-1414 (24.76 t/ha), and DOGR-1172-DR (23.94 t/ha) exhibited superior performance compared to check variety Bhima Super (19.96 t/ha). They also showed better desirable characteristics such as dark red colour, globe-shaped bulbs and >81% marketable bulbs. Additionally, all these lines were free from bolters (Table 1.14).

Table 1.14 The best performing advance breeding lines during *kharif* 2022

Entries	MY (t/ha)	MB (%)	ABW (g)	Double (%)	Bolter (%)	TSS (%)	DTH	E:P
DOGR-1014-GDR	33.56	91.18	93.42	3.57	0.00	11.79	113.00	1.10
DOGR-1414	24.76	81.36	89.35	14.81	0.00	11.87	111.33	1.13
DOGR-1172-DR	23.94	93.80	93.68	5.28	0.00	12.55	112.00	1.10
KH-M-2	22.91	74.94	90.31	17.64	0.00	12.69	112.33	1.11
DOGR-1639	22.84	85.08	96.06	7.68	0.41	11.87	111.67	1.12
RGP-4	22.30	77.93	89.95	13.96	0.56	12.20	112.33	1.07
RGP-2	21.87	79.20	92.91	16.94	0.00	12.51	112.00	1.09
Bhima Super (C)	19.96	84.01	89.71	9.50	0.00	12.11	112.67	1.09
Bhima Red (C)	19.73	78.00	86.14	14.05	0.00	11.68	113.33	1.14
BDR (C)	18.59	80.44	88.18	14.38	0.00	12.33	112.67	1.09
CV (%)	8.98	11.32	12.76	23.03	24.55	4.49	1.29	-
LSD (P=0.05)	3.28	11.05	9.22	4.98	0.31	0.88	2.36	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

1.2.3 Evaluation of initial breeding lines

During late-*kharif*, *rabi* and *kharif* season, a total of fifty-one breeding lines including checks were assessed. In late-*kharif* 2021-22, lines LK-07-C2/LR-1, DOGR-1043-GLR, LK-07-C2/DR-3, LK-07-C2/LR-4, and RGP-1-LK-Sel exhibited MY (>32 t/ha), compared to check variety Bhima Super (28.65 t/ha). These lines featured medium-sized bulbs (67-83 g) with a red, globe shape and >73% of marketable bulbs. The line DOGR-1043-GLR recorded the minimum days to harvest (115 days), followed by LK-07-C2/LR-4 (116 days) and RGP-1-LK-Sel (118 days). In storage, line LK-07-C2/LR-2 recorded the lowest loss (34.21%) followed by DOGR-1043-GLR (35.44%) and LK-07-C2/DR-2 (37.07%) compared to check (45.79%) after four months of storage (Table 1.15).

Table 1.15 The best performing initial breeding lines during late-*kharif* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P
LK-07-C2/LR-1	42.13	88.33	74.35	0.00	11.67	12.40	119.00	1.20
DOGR-1043-GLR	34.34	89.04	67.49	3.39	7.19	12.37	115.00	1.12
LK-07-C2/DR-3	33.53	85.69	83.83	0.00	14.31	11.64	119.00	1.07
LK-07-C2/LR-4	33.44	96.68	71.73	0.00	3.32	11.39	116.33	1.11
RGP-1-LK-Sel.	32.34	73.08	74.52	4.29	22.19	12.01	118.67	1.13
DOGR-REC-Sel.	31.64	79.26	73.30	10.49	9.60	11.87	121.00	1.13
LK-07-C2/LR-3	31.32	89.27	73.84	9.13	1.60	11.92	116.33	1.14
Bhima Super (C)	28.65	81.50	66.39	2.38	14.02	11.25	119.33	1.16
Bhima Shakti (C)	26.63	87.18	77.10	3.44	7.86	11.72	119.67	1.10
Phule Samarth (C)	23.76	80.63	60.38	2.58	16.52	11.68	115.00	1.10
CV (%)	9.36	13.37	10.94	30.83	23.06	4.87	1.51	-
LSD (P=0.05)	3.14	11.45	11.12	11.46	11.94	0.94	2.83	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

During *rabi* 2021-22, LK-07-C2/LR-1 (34.29 t/ha) and Red Genepool-3 (32.24 t/ha) exhibited better performance compared to check variety Bhima Shakti (27.73 t/ha). These lines featured dark red, globe-shaped bulbs of medium size (56-59 g) and achieved >94% marketable bulbs. A line Red Genepool-1 demonstrated the lowest storage loss (30.40%) after four months followed by DOGR-1043-GLR (30.44%) and DOGR-670-Sel (33.28%), outperforming the check (37.13%) (Table 1.16).

Table 1.16 The best performing initial breeding lines during *rabi* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P
LK-07-C2/LR-1	34.29	94.90	59.69	0.00	0.00	12.47	102.67	1.27
Red Genepool-3	32.24	97.05	56.29	0.00	0.00	11.80	100.33	1.32
R-LK-M-IV	30.85	94.41	56.81	0.00	1.60	12.00	112.00	1.26
RGP-1-LK-Sel.	30.19	95.78	54.39	0.00	0.19	11.85	98.00	1.27
R-Rb-M-II	30.14	94.54	57.10	0.00	0.89	11.97	107.33	1.31
RGP-1-Rb-Sel.	29.89	95.30	54.80	0.27	0.00	11.89	91.00	1.34
RGP-2-LK-Sel.	29.34	97.75	54.27	0.00	0.00	12.44	102.67	1.23
BLR (C)	26.66	95.12	51.72	0.00	0.00	12.35	104.00	1.26
Bhima Shakti (C)	27.73	94.63	50.96	0.00	0.00	11.80	102.67	1.24
Bhima Kiran (C)	27.32	94.12	51.30	0.00	0.00	12.63	100.33	1.28
CV (%)	12.37	3.17	10.27	33.44	30.03	5.58	7.27	-
LSD (P=0.05)	3.60	4.80	8.74	0.89	1.22	1.08	11.88	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

During *kharif* 2022, Red Comp-1 (Kh-12) (27.88 t/ha), R-LK-M-II (26.90 t/ha), and R-LK-M-III (26.87 t/ha) showed better performance compared to check variety Bhima Super (22.50 t/ha). These varieties showed superior characters like dark red, globe-shaped bulbs of large size (81-86 g) and >79% marketable bulbs. The lines Red Comp-1 (Kh-12) and R-LK-M-III were both free from bolters (Table 1.17).

Table 1.17 The best performing initial breeding lines during *kharif* 2022

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P
Red Comp-1 (Kh-12)	27.88	84.59	81.89	8.10	0.00	12.27	113.33	1.11
R-LK-M-II	26.90	79.97	81.90	12.03	2.87	12.28	112.33	1.12
R-LK-M-III	26.87	84.78	85.74	5.51	0.00	11.88	111.67	1.09
R-Rb-M-II	25.21	77.61	78.36	6.57	0.98	12.44	112.33	1.13
Red Genepool-7	24.72	82.33	89.00	10.18	0.00	13.24	111.00	1.22
DOGR-650-Sel.	24.55	82.79	85.21	9.07	0.00	11.89	111.67	1.19
Red Genepool-1	23.34	65.03	82.99	23.23	0.00	11.91	112.00	1.14
Bhima Super (C)	22.50	83.06	102.43	7.50	0.00	12.47	111.33	1.10
Bhima Red (C)	17.75	62.49	75.82	18.57	0.00	12.32	112.00	1.12
Bhima Dark Red (C)	17.15	58.57	78.24	14.82	2.31	12.17	112.33	1.13
CV (%)	8.53	12.09	13.69	17.74	24.91	4.89	1.28	-
LSD (P=0.05)	2.77	13.69	11.20	10.11	2.60	0.97	2.33	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio)

Onion lines under AINRPOG

During 2022-23 AINRPOG trials, three red onion lines, namely DOGR-1757, DOGR-1758, and DOGR-1773, were introduced as IET (Initial Evaluation Trials). Additionally, DOGR-1606, DOGR-1654, and DOGR-1657 were being assessed as AVT-I (Advanced Varietal Trial-I) during the same period.

1.2.4 Unique genetic stock in onion

ICAR-DOGR had registered four distinct genetic stocks of common/multiplier onion with ICAR-NBPGR, New Delhi and obtained registration number for all the accessions. The onion genetic stock Acc-1666 (IC0645764) had registered with Reg. No. INGR22082 for waterlogging tolerance. Similarly, Acc-1656 (IC0645763) was also registered for drought tolerance with the Reg. No. INGR22083. The onion line DOGR-1168 exhibits unique characteristics such as bolting tolerance during late-*kharif* and *rabi* seasons. Moreover, the multiplier onion line DOGR-1523-Agg possesses dark red bulbs, early maturation and uniform bulblets numbering 5-6. This line is capable of multiplication through bulblets during both *kharif* and *rabi* seasons (Fig. 1.8).

DOGR-1656 **DOGR-1666** **DOGR-1168** **DOGR-1523-Agg.**

Fig. 1.8 Unique genetic stock of onion

1.2.5 Development of F_1 hybrids in red onion

1.2.5.1 Evaluation of F_1 hybrids developed through male sterile lines

A total of sixty F_1 hybrids, along with their respective parents and checks were assessed during late-*kharif* 2021-22 (Table: 1.18).

Table 1.18 The best performing F_1 hybrids during late-*kharif* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P	SH
MS111A × 1608	56.89	100.00	85.33	0.00	0.00	10.90	119	1.20	72.76
MS111A × 1613	45.13	91.19	80.00	0.00	0.00	11.40	119	1.10	37.05
MS1600A × RGP-4	44.83	100.00	67.25	0.00	0.00	10.80	124	1.10	36.14
MS111A × RGP-3	41.67	100.00	62.50	0.00	0.00	10.20	116	1.09	26.54
MS1600A × 1607	39.25	85.48	67.29	14.52	0.00	10.88	119	1.07	19.19
MS1600A × 1606	36.82	85.53	80.26	12.95	1.52	11.77	122	1.06	-
MS1600A × KH-M-2	35.60	100.00	66.75	0.00	0.00	13.30	119	1.10	-
Bhima Shakti (C)	32.93	78.30	85.13	15.82	4.98	11.89	122	1.11	-
Orient (BSS-133) (C)	31.73	92.13	61.69	7.02	0.00	11.95	126	1.13	-
Bhima Super (C)	29.52	92.14	66.78	2.69	4.58	12.04	126	1.12	-
CV (%)	10.64	11.26	11.51	25.48	30.09	4.00	4	-	-
LSD (P=0.05)	4.67	10.48	11.74	12.48	9.71	0.76	7	-	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio; SH: Standard Heterosis over best check)

Among them, five F_1 hybrids, namely, MS111A × 1608, MS111A × 1613, MS1600A × RGP-4, MS111A × RGP-3 and MS1600A × 1607 displayed heterosis from 19-72% for MY compared to check Bhima Shakti (32.93 t/ha). These hybrids showed uniform bulbs and were free from double bulbs and bolters, with the exception of MS1600A ×1607, which recorded the incidence of 14.52% doubles. The F_1 hybrid MS111A × RGP-3 exhibited earliness to harvest (116 days) followed by MS111A × 1608 and MS111A × 1613 (119 days). In terms of storage, the hybrid MS111A × 1657 recorded the lowest storage loss after four months (31.52%), followed by MS222A × 1629 (32.94%) and MS111A×571-LR (34.05%) compared to check (45.06%).

During *rabi* 2021-22, a total of 93 F_1 hybrids, along with their respective parental lines and checks were evaluated. Among them, five F_1 hybrids, namely MS111A × RGP-1, MS1600A × 1657, MS111A × RGP-3, MS222A × 1608 and MS111A × 1630 exhibited heterosis of over 45% for MY compared to check Bhima Shakti (28.68 t/ha). These hybrids featured uniform bulbs and were free from double bulbs and bolters. The F_1 hybrid MS111A × RGP-3 required minimum time to harvest (90 days) followed by MS111A×RGP-1 and MS1600A × 1657 (97 days) in contrast to the check variety Bhima Shakti (104 days). In terms of storage, the F_1 hybrid MS1600A × 1608 recorded the lowest storage loss after four months (19.70%) followed by MS65A×1604 (37.08%) and MS1600A×RGP-3 (37.09%) compared to check (53.14%) (Table 1.19).

Table 1.19 The best performing F_1 hybrids during *rabi* 2021-22

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P	SH
MS111A × RGP-1	52.00	100.00	87.00	0.00	0.00	11.24	97	1.26	81.32
MS1600A × 1657	51.33	100.00	96.25	0.00	0.00	11.68	97.00	1.23	78.99
MS111A × RGP-3	48.97	100.00	73.46	0.00	0.00	12.04	90.00	1.34	70.77
MS222A × 1608	45.21	100.00	72.33	0.00	0.00	11.68	104.00	1.24	57.63
MS111A × 1630	41.87	100.00	69.78	0.00	0.00	11.68	104.00	1.30	45.98
MS111A × 1608	40.00	100.00	60.00	0.00	0.00	11.60	90.00	1.35	-
MS1600A × 546-DR	38.97	90.37	76.00	9.63	0.00	12.36	104.00	1.24	-
Bhima Shakti (C)	28.68	97.35	48.57	0.89	0.00	12.19	104.00	1.28	-
BLR (C)	26.76	100.00	50.56	0.00	0.00	12.08	106.33	1.17	-
Bhima Kiran (C)	25.67	96.57	44.35	0.00	0.00	11.84	97.00	1.25	-
Orient (BSS-133) (C)	25.30	99.59	51.80	0.00	0.00	11.89	99.33	1.28	-
CV (%)	11.29	3.61	12.41	11.19	2.53	4.92	6.16	-	-
LSD (P=0.05)	4.94	5.67	10.05	1.89	0.00	0.94	10.17	-	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio; SH: Standard Heterosis over best check)

During *kharif* 2022, a total of 22 F_1 hybrids, along with their respective parental lines and checks were evaluated. The hybrids MS111A × 1605, MS222A × 1605, MS111A × RGP-2 and MS111A × 1608 exhibited over 20% heterosis for MY compared to check Bhima Dark Red (25.35 t/ha). These hybrids achieved >77% marketable bulbs and were free from double bulbs and bolters, except for MS222A × 1605 (12.39%) and MS111A × RGP-2 (3.57%) which exhibited double bulbs. The F_1 hybrid MS111A × 1605 recorded minimum days to harvest (105 days) followed by MS111A × 1608 (109 days) and MS222A × 1605 (110 days) compared to check (113 days) (Table: 1.20).

Table 1.20 The best performing F_1 hybrids during *kharif* 2022

Entries	MY (t/ha)	MB (%)	ABW (g)	Doubles (%)	Bolters (%)	TSS (%)	DTH	E:P	SH
MS111A × 1605	42.27	80.00	78.40	0.00	0.00	12.91	105.00	1.04	66.75
MS222A × 1605	35.12	77.71	93.33	12.39	0.00	12.27	110.00	1.07	38.54
MS111A × RGP-2	31.77	87.39	73.39	3.57	0.00	11.88	111.33	1.04	25.33
MS111A × 1608	30.53	83.42	66.22	0.00	0.00	12.10	109.33	1.08	20.43
MS111A × 1630	29.76	80.34	81.41	0.00	0.00	11.83	109.00	1.08	17.40
MS111A × 1612	28.87	91.07	58.17	0.00	0.00	11.73	107.00	1.08	-
MS111A × KH-M-1	28.44	86.12	67.39	0.00	0.00	11.90	109.00	1.13	-
Bhima Dark Red (C)	25.35	80.35	64.79	6.41	0.00	12.88	110.00	1.09	-
Bhima Super (C)	24.39	87.50	78.84	7.41	0.00	12.32	113.00	1.12	-
Bhima Red (C)	18.92	83.31	66.08	0.90	0.00	12.53	108.00	1.10	
CV (%)	7.79	12.14	9.48	24.63	3.64	5.29	2.86	-	-
LSD (P=0.05)	3.74	8.69	11.00	9.52	0.00	1.06	5.07	-	-

(MY: Marketable Yield; MB: Marketable Bulbs; ABW: Average Bulb Weight; TSS: Total Soluble Solid; DTH: Days to Harvest; E:P: Equatorial: Polar ratio; SH: Standard Heterosis over best check)

In addition to this, a total of 110 F_1 hybrids of red onion were generated through the crossing of five MS lines (MS 48A, MS 65A, MS 111A, MS 222A, and MS 1600A) with selected 22 elite lines as pollinators, namely 546-DR, 571-LR, KH-M-1, KH-M-2, RGP-1, RGP-2, RGP-3, RGP-4, RGP-5, 1604, 1605, 1606, 1607, 1608, 1609, 1612, 1613, 1629, 1630, 1657, 1663, and 1666. The evaluation process for these hybrids is currently ongoing. Moreover, the evaluation of nine synthetic crosses derived from selected six elite lines is also currently underway.

F_1 Hybrids under AINRPOG

During 2022-23 period, two red onion F_1 hybrids, namely DOGR Hy-56 and DOGR Hy-155, were introduced in AINRPOG trials as Initial Evaluation Trials (IET). However, DOGR Hy-156 and DOGR Hy-172 are currently undergoing evaluation as Advanced Varietal Trial-I (AVT-I) during the same period.

1.2.5.2 Development of male sterile lines and inbreds in red onion

Purification and multiplication of five red onion male sterile lines were continued with the selected bulbs. A total of five combinations in BC_2 stage and three combinations in BC_3 stage for transfer of male sterility in the different varietal background of DOGR varieties. There are 96 inbreds in I_1, 22 inbreds in I_2 and 20 inbreds in I_3 stage developed from single bulb of selected parents

1.2.6 Improving short-day onion through introgression of genes from long day onion.

The introgression breeding program was initiated at ICAR-DOGR in collaboration with ICAR-CITH, Srinagar. A total of 135 crosses were made by combining available exotic onion hybrids with short day varieties. The progenies obtained from these crosses were selected based on bulb colour, shape, size and storability at ICAR-DOGR and ICAR-CITH. The selected bulbs from each cross were then sent back to ICAR-CITH for seed production. Currently, eighteen populations in sixth generation are being evaluated under short day conditions. The prominent populations include A-1 × H-8, A-1 × M-13, Q-17 × K-11, and U-21 × M-13, which exhibit high bulb yield and better bulb storability under short day conditions.

1.3 Genetic improvement of garlic through conventional and biotechnological approaches

1.3.1 Garlic germplasm maintenance at ICAR-DOGR

ICAR-DOGR is a National Active Germplasm Site for Garlic and other *Allium* species. The following table (Table 3.1) illustrates garlic accessions which are preserved at ICAR-DOGR. The maintenance and breeding activities at ICAR-DOGR involve around 1,111 garlic lines, including germplasm, landraces, and varieties. Presently, four high-yielding entries, namely DOGR-404, DOGR-793, DOGR-48, DOGR-746, DOGR-G-1-19 (PB-5-Gy-Mut), and DOGR-G-2-19 (PB-EMS-1) are being evaluated in the AINRPOG garlic varietal trial (Table: 1.21).

Table 1.21 Garlic germplasm collection at ICAR-DOGR, Pune

Particulars	Accessions	Particulars	Accessions
Germplasm	483	Elite lines	62
Core collection	42	Mutated lines	470
Kharif suitable lines	11	Varieties under maintenance	37
Entries under AINRPOG	6		

1.3.2 Evaluation of high yielding garlic lines during *rabi* 2021-22

In germplasm evaluation, the entire collection of garlic genotypes was evaluated for thirteen morphological traits. Regarding varietal development activities, a total of ten elite lines, namely 48-W, 788, 793, 493, 513, 569, 746, 709, GS-1, and GS-10 were assessed for their yield potential and other contributing traits. All the lines were evaluated showed an average marketable yield of >5 t/ha. The lines 569, GS-1, and GS-10 exhibited significantly higher MY (>8t/ha) compared variety Bhima Purple (Table: 1.22).

Table 1.22 Performance of elite garlic lines for yield and contributing traits

Entry	MY (q/ha)	SBW (g)	W50C (g)	TSS (°Brix)	TSL (%)	SMB	BSC
746	75.15	16.00	54.00	42.08	23.34	OB	P
709	56.22	15.05	44.00	41.5	26.23	TE	P
569	98.91	17.15	60.20	43.94	24.12	OB	W
513	56.08	19.85	48.00	44.35	23.21	OB	P
493	80.28	14.90	29.00	43.77	21.11	OB	P
48-W	66.97	26.30	53.00	46.08	20.34	OB	W
793	50.26	18.25	59.20	41.25	25.67	TE	P
788	90.50	17.10	60.00	42.90	20.98	TE	P
GS-1	86.42	16.90	50.00	42.83	21.23	OB	P
GS-10	100.81	21.55	55.00	43.06	23.21	TE	P
BP	50.11	18.79	46.76	44.54	21.21	TE	W
CD@5%	15.11	09.21	08.87	03.43	10.21	-	-

(MY: Marketable Yield; SBW: Single Bulb Weight; W50C: Weight of 50 Cloves; TSS: Total Soluble Solids; TSL: Total Storage Losses; SMB: Shape of bulb; BSC: Bulb skin colour; P: Purple; W: White; OB: Oblong, TE: Terpedo)

1.3.3 Evaluation of garlic lines for red colour clove skin

Elite garlic lines were evaluated for MY and other morphological traits. The lines 444 showed large clove size (weighing 11-13 grams per bulb) with a minimum number of cloves per bulb (9 cloves) followed by 388 and 258 (Table: 1.23). These two lines exhibited high average bulb size. Line 419 recorded the highest TSS (47 °Brix). However, lines 224 and 63 achieved the highest marketable yield (>8 t/ha) compared to check variety Godavari (7 t/ha).

Table 1.23 Performance of red colour garlic lines for yield and related traits

Entry	MY (q/ha)	SBW (g)	NOC	W50C (g)	SMB	BSC	CC	TSS (°Brix)
63	82.17	8.05	11.40	32.50	TE	P	P	43.31
258	63.74	12.90	13.10	47.50	OB	P	P	39.48
266	71.36	10.91	13.70	38.00	OB	P	P	41.94
224	83.88	11.40	13.60	34.50	TE	P	P	41.41
444	81.33	11.30	09.90	52.50	TE	P	P	42.54
388	56.21	13.80	17.80	59.00	OB	P	P	38.76
756	65.90	12.65	13.90	45.50	TE	p	p	43.04
534	70.00	11.50	11.10	37.50	TE	P	P	41.07
303	59.83	06.00	10.00	32.50	OB	P	P	42.64
419	33.02	10.45	12.80	46.00	OB	P	P	47.51
301	29.81	11.70	13.60	48.50	TE	P	P	41.99
353	59.88	11.50	13.90	41.00	OB	P	P	43.12
341	52.67	10.47	13.60	48.50	TE	P	P	43.34
Phule Baswant	79.17	11.00	16.50	46.50	TE	P	P	42.73
Godavari	76.07	15.34	13.50	55.00	TE	P	P	44.58

(MY: Marketable Yield; SBW: Single bulb weight; NOC: Average number of cloves per bulb; W50C: Weight of 50 cloves; BSC: Bulb skin colour; CC: Clove colour; TE: Terpedo; OB: Oblong; P: Purple)

1.3.4 Evaluation of garlic lines for *kharif* season suitability

Twelve garlic lines were evaluated for their suitability in the *kharif* season as well as for agro-morphological traits. Among all genotypes, line 555 yielded highest marketable yield followed G-282 and Bhima Purple. The TSS was ranged from 33.90 to 44.70 ˚Brix (Table: 1.24).

Table 1.24 Evaluation of *kharif* garlic elite lines for yield and related traits

Entry	DTH	MY (q/ha)	PD (mm)	ED (mm)	SBW	NOC	W50C (g)	BS	BSC	CC	TSS (°Brix)
BP	135	33.57	23.66	28.06	06.00	5.60	35.00	OB	P	P	41.38
555	136	35.41	25.49	30.76	09.30	11.00	40.00	TE	W	W	44.70
324	122	30.25	18.55	19.03	04.10	07.00	21.00	OB	W	W	36.64
23	123	15.94	27.20	31.68	13.50	06.20	42.00	TE	W	W	36.10
G-282	123	34.80	28.13	35.60	13.10	11.00	52.00	TE	W	W	39.32
296	136	29.09	22.09	18.26	4.40	6.80	25.00	TE	P	P	34.50
282	136	28.76	23.41	28.94	4.70	7.40	26.00	TE	P	P	33.90
100	136	23.66	23.28	28.96	7.30	11.00	34.00	TE	P	P	40.74
G-41	136	20.41	22.95	23.44	7.70	8.40	35.00	TE	W	W	38.34
26	136	29.88	24.17	31.52	8.30	12.00	42.00	TE	W	W	42.36
27-W	136	17.30	24.25	30.70	8.90	12.00	41.00	TE	W	W	42.92

(BP- Bhima Purple DTH: Days to Harvest; MY: Marketable yield; PD: Polar Dia; ED: Equatorial Dia.; SBW: Single Bulb Weight; NOC: Average no. of cloves per bulb; BS: Bulb Shape; BSC: Bulb skin colour; CC: Clove Colour; TSS: Total Soluble Solids, TE: Terpedo; OB: Oblong; P: Purple; W: White)

Garlic Bulbs produced in Kharif were planted in *rabi* to evaluate the growth pattern and yield. A total of 16 traits have been recorded in *rabi* season (Table 1.25) as like in *kharif*. The average value of all the growth parameters have been increased during *rabi* including marketable yield.

Table 1.25 Characterization of *kharif* garlic elite lines during *rabi* season for yield and related traits

Entry	MY (q/ha)	PD (mm)	ED (mm)	SBW (g)	NOC	W50C (g)	BS	BSC	CC	TSS (°Brix)
27-P	95.91	23.72	38.78	12.80	17.40	30.50	TE	P	P	44.22
27-W	60.06	25.26	35.34	16.75	15.90	31.50	OB	W	W	42.92
26	25.81	23.78	38.55	11.40	20.80	36.50	TE	W	W	44.42
100	53.55	24.45	37.04	11.60	16.90	33.50	OB	W	W	43.84
23	48.70	23.94	38.57	18.02	18.60	57.70	OB	P	P	42.07
282	69.83	25.74	41.14	17.62	16.90	52.00	TE	P	P	43.31
296	33.88	23.89	37.43	13.12	14.80	47.00	TE	P	P	43.27
555	52.55	25.03	38.20	13.37	15.20	42.50	OB	P	P	44.2
G-282	49.00	21.57	38.70	25.22	19.60	55.50	OB	W	W	42.5
G-41	84.55	28.89	42.12	21.27	19.80	54.00	TE	W	W	44.06
G-324	71.95	24.45	37.97	15.92	15.50	42.00	TE	W	W	45.94
BP	75.78	26.60	39.61	11.70	15.20	53.50	TE	P	P	44.74

(MY: Marketable Yield; PD: Polar Diameter; ED: Equatorial Diameter; SBW: Single Bulb Weight; NOC: Average number of cloves per bulb; W50C: Weight of 50 Cloves; BS: Bulb Shape; BSC: Bulb Skin Colour; CC: Clove Colour; TSS: Total Soluble Solids, TE: Terpedo; OB: Oblong; P: Purple; W: White)

1.3.5 Mutation breeding in garlic

In mutation breeding, garlic bulbs were subjected to gamma radiation, colchicine and EMS treatments on Bhima Purple, Bhima Omkar, G-41 and G-282. Out of these lines, 26 lines were selected based on criteria such as yield, bulb size, and storability. These chosen lines will undergo further assessment to determine their MY and evaluate their impact on other contributing traits (Table: 1.26).

Table 1.26 Performance of garlic mutation lines

Entry	PH (cm)	LP	LL (cm)	LW (cm)	PL (cm)	PW (mm)	FA	DM	TY (q/ha)
BP-4GY-M-2	48.58	8.3	27.61	1.32	8.3	7.04	Erect	144	85.91
BP-5GY-M-2	53.35	8.8	32.66	1.43	9.46	8.1	Erect	144	118.69
BP-6GY-M-2	56.04	9.3	32.93	1.28	10.03	9.61	Erect	144	82.65
BO-3GY-M-2	51.80	9.1	31.42	1.04	7.59	7.38	Erect	144	74.53
BO-4GY-M-2	52.49	9	32.49	1.45	8.13	7.99	Erect	144	78.61
BO-5GY-M-2	53.76	9.5	33.74	1.26	8.13	7.21	Erect	144	70.63

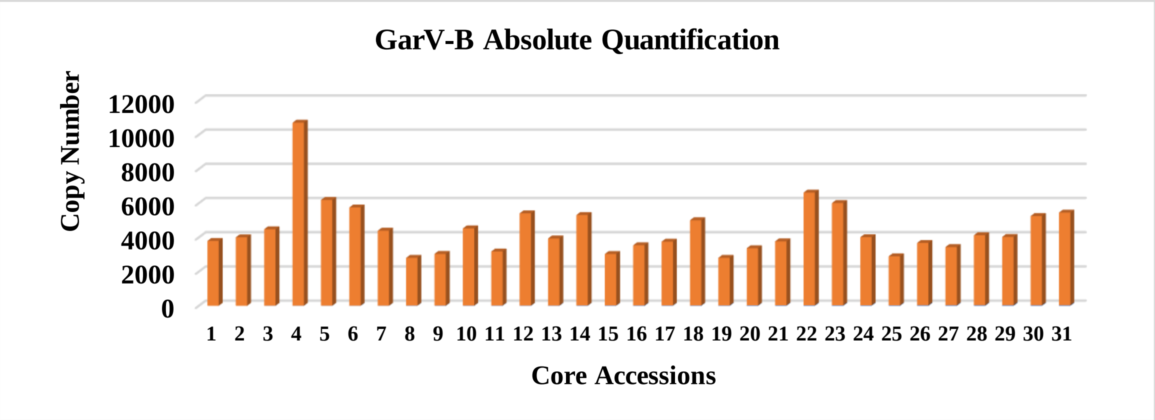
Continued…

Entry	SL (%)	PD (mm)	ED (mm)	SBW (g)	NOC	W50C (g)	BS	BSC &CC	TSS (°Brix)
BP-4GY-M-2	12.27	28.02	38.85	12.85	14.1	47	TE	P	44.48
BP-5GY-M-2	21.89	32.21	42.58	18.5	14.6	62.5	TE	P	44.10
BP-6GY-M-2	13.08	29.72	39.49	14.3	14	54	TE	P	44.36
BO-3GY-M-2	12.82	30.29	40.15	17.55	15.7	46	TE	W	43.28
BO-4GY-M-2	11	29.86	38.23	16.55	15.4	52	TE	W	44.68
BO-5GY-M-2	18.14	29.65	36.90	13.5	14.7	44	TE	W	43.62

(BP: Bhima Purple; BO: Bhima Omkar; PH: Plant Height; LP: Number of Leaves per Plant; LL: 4th Leaf Length; LW: 4th Leaf width; PL: Pseudostem Length; PW: Pseudostem width; FA: Foliage Attitude; E: Erect; DM: Days to Maturity; TY: Total Yield; SL: Storage Losses PD: Polar diameter; ED: Equatorial Diameter; SBW: Single bulb Weight; NOC: Average number of Cloves per Bulb; W50C: Weight of 50 Cloves; BS: Bulb shape; BSC: Bulb Skin Colour; CC: Clove Colour; TE: Terpedo; OB: Oblong; P: Purple; W: White, TSS: Total Soluble Solids)

1.3.6 Development of virus free garlic planting material

A standardized protocol was developed to effectively eradicate prominent garlic-infecting viruses, namely Onion Yellow Dwarf Virus (OYDV), Garlic Common Latent Virus (GCLV) and Shallot Latent Virus (SLV). This protocol involved a combination of heat therapy and meristem isolation followed by chemotherapy. This protocol successfully eliminated the major garlic viruses through core collection except allexi viruses. Therefore, the garlic core collection was subjected to virus indexing for garlic virus B using rtPCR. Remarkably, the RT-PCR analysis revealed that a few accessions showed minimal presence of allexi virus-B (Fig. 1.9). Those accessions could be the potential material for virus free garlic production.



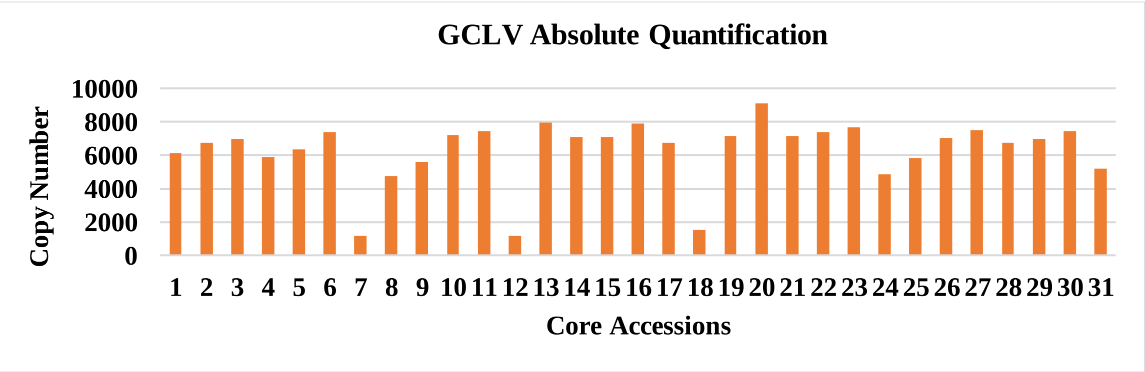


Fig. 1.9 Absolute quantification of garlic virus Gar-V-B and Garlic Common Latent Virus in garlic core accessions

1.4 Biotechnological approaches for improvement of onion and garlic

1.4.1 *In vitro* haploid induction in onion through gynogenesis

For haploid induction in onion through gynogenesis had achieved by inoculating unopened flower buds from 5 different cultivars on a shoot medium. The details of number of haploid plants generated through gynogenesis is enlisted in the following Table 1.27.

Table 1.27 Details of haploid induction in onion through gynogenesis

Cultivars	No. of haploids
Bhima Shweta	8
Bhima Super	18
Bhima Dark Red	24
Bhima Raj	13
Bhima Shakti	4

1.4.2 Profiling cuticular wax biosynthesis pathway genes in glossy mutants

The M_2 glossy mutant phenotype bulbs were harvested and subsequently planted individually. M_2 plants were selfed and the subsequent M_3 generation was found to be glossy. F_1 plants derived from the cross between M_2 and WT exhibited the waxy phenotype. However, when F_1 plants were backcrossed with M_3 glossy mutant, the subsequent BC_1F_1 population segregated in a 1:1 ratio (waxy: glossy). Hence, the inheritance of the mutant's glossy phenotype was determined to be recessive and single locus (Table 1.28).

Table 1.28 Segregation pattern of glossy mutant lines

Population	Total no. of plants	Phenotype	
		Waxy WT	Glossy mutant
M2	4	0	4
M3	15	0	15
F1	17	17	0
BC_1F_1	21	11	10*
WT	34	34	0

*Chi square analysis was performed in BC_1F_1 population. Calculated p value is 0.83. The difference was statistically non-significant

RNA sequencing of 6-weeks-old leaves of wild-type onion and its glossy mutant was performed in duplicate using the Illumina platform (NovaSeq6000) with 2 x 150 bp chemistry. After stringent quality assessment and data filtering, a total of 104.33 million pair end reads corresponded to 30.26 Gb of sequence data were generated. A total of 596 annotated unigenes were found to be differentially expressed between wild-type and glossy mutant, with 295 upregulated and 301 downregulated genes in glossy mutant. In the glossy mutant, out of 301 downregulated unigenes, 4 critical genes related to wax biosynthesis pathway *i.e. AcMAH1, AcWSD1, AcCER1* and *AcCER26* were significantly downregulated (Table: 1.29). Differentially expressed gene analysis of RNA-seq data had shown 1.74, 2.72, 2.12 and 2.59-fold down-regulation of *ECR26, ECR1, WSD1* and *MAH1* genes, respectively. To validate the RNA-seq results, expression levels of these genes were evaluated by semi-quantitative PCR, which also showed down-regulation of these genes in the glossy mutant. Semi-quantitative PCR analysis had also shown 1.17, 2.19, 1.61 and 1.95-fold down-regulation of *ECR26, ECR1, WSD1* and *MAH1* genes, respectively. The results of the semi-quantitative PCR were consistent with those of the RNA-seq analysis (Fig. 1.10).

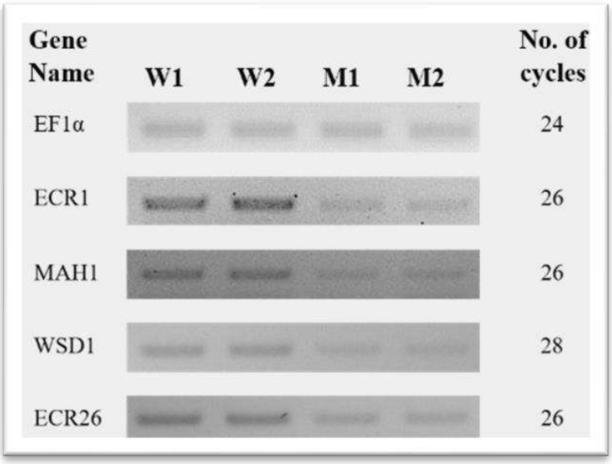


Fig. 1.10 Validation of 4 downregulated genes of cuticular wax biosynthesis pathway by semi-quantitative RT-PCR. W1 and W2: Waxy, whereas M1 and M2 Glossy Mutant

Table 1.29 Differentially expressed unigenes associated with cuticular wax biosynthesis

Sl. No.	Unigene ID	SwissProt annotation	COG class annotation	Log_2 fold change			
				Semi-qRT PCR		RNA-seq	
				Waxy WT	Glossy mutant	Waxy WT	Glossy mutant
1	g304621	Protein ECERIFERUM 26	Lipid transport and metabolism	1	-1.17	1	-1.74
2	g367838	Protein ECERIFERUM 1	Lipid transport and metabolism	1	-2.19	1	-2.72
3	g50966	O-acyltransferase WSD1	Lipid transport and metabolism	1	-1.61	1	-2.12
4	g259833	alkane hydroxylase MAH1	Lipid transport and metabolism	1	-1.95	1	-2.59

1.4.3 Identification and characterization of waterlogging responsive genes in contrasting onion genotypes using RNA seq. technology

To understand the molecular mechanism regulating waterlogging stress tolerance in onion crop transcriptome sequencing using RNA seq. technology was done in leaf tissue to water-logging tolerant (Acc.1666) and sensitive (W-344) genotype. Differential gene expression analysis revealed 1629 genes were up regulated and 3271 genes were down regulated in Acc. 1666 while in W-344, 2134 genes showed up regulated and 1909 genes were down regulated under waterlogging stress. These DEGs regulate several key biological processes to combat waterlogging stress such as phytohormones biosynthesis, antioxidant enzymes activity, programmed cell death, aerenchyma formation, energy production etc. COG pathway analysis showed enrichment of post-translational modification, energy production, and carbohydrate metabolism- related pathways under waterlogging conditions. The higher number of waterlogging tolerance-related genes like group VII ERFs such as *RAP2-12* and *RAP2-3* that play a crucial role in developing waterlogging tolerance, were found to be exclusively up-regulated in tolerant genotype Acc.1666 than in sensitive one (Fig. 1.11). These results suggest that significant fine reprogramming for gene expression was occurring in response to waterlogging stress in onion crop. The molecular information about DEGs obtained from the present study would be valuable for improving stress tolerance and developing waterlogging tolerant onion variety.

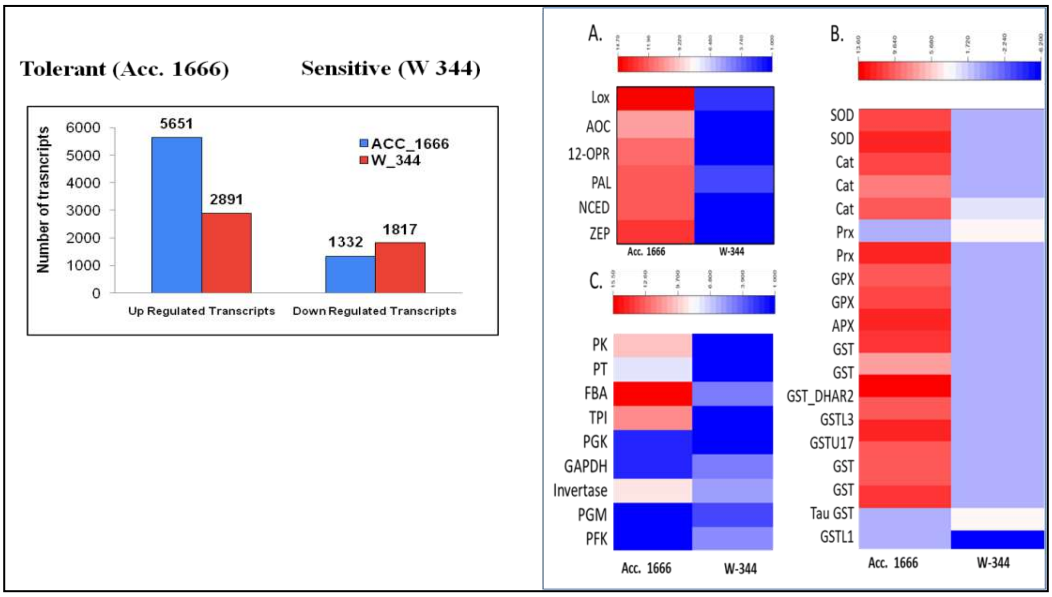


Fig. 1.11 Differential gene expression analysis in contrasting onion genotypes under waterlogging stress

1.5 Breeding for abiotic stress tolerance in *Allium* species

1.5.1 Genetic architecture of waterlogging and drought tolerance in onion

The mapping population was developed by crossing water-logging tolerant (Acc.1666) and susceptible line (Acc. 1639) in red onion and also in white onion (W-355 tolerant and W-085). The F_1 plants were raised in *kharif* 2022 for the bulb production and these bulbs were planted in *Rabi*-2022 for the back cross and F_2 population development. The drought tolerant line Acc. 1656 and drought susceptible line Acc. 1627 were crossed in the *Rabi*-21 to develop F_1 population. The F_1 plants were raised in *kharif* 2022 for the bulb production and screening for drought tolerance. These bulbs were planted in *Rabi*-2022 for the back cross and F_2 population development.

1.5.2 Cloning and characterization of UV- Resistance 8 (*UVR8*) gene in onion

The high doses of UV-B radiation can cause damage to plant macromolecules by disrupting DNA, triggering the accumulation of reactive oxygen species, and impeding photosynthesis. To enhance tolerance to UV-B stress, the UV-B receptor UV RESISTANCE LOCUS 8 (*UVR8*) plays a crucial role in promoting the production of flavonoids. Thus, it becomes essential to characterize UVR8 at the molecular level to comprehend its function in UV-B stress response. In this present study, the molecular characterization of the UVR8 gene in the short-day onion (*Allium cepa* L.) was conducted to better grasp its significance in response to UV-B exposure. A 555 bp fragment of the single copy *UVR8* gene was isolated from the cDNA of onion cultivar Bhima Super leaf tissue and inserted into the PJET1.2 sequencing vector. The vector was then transformed into *E. coli* strain *DH5α*, and the transformed colonies were verified through colony analysis, restriction digestion, and sequencing. Upon confirmation of the sequence, the gene was further cloned into the binary vector pCambia1300. The transformed colonies of *E. coli* were validated through colony PCR and restriction digestion using *BamHI* and *KpnI*. Through a triparental mating technique, the recombinant plasmid was transferred into *Agrobacterium* strain LBA4404, utilizing the helper strain pRK2013 and *E. coli* harbouring the recombinant plasmid (Fig. 1.12). The *Agrobacterium* containing the recombinant plasmid will be utilized for the transformation of onion plants to proceed with further characterization.

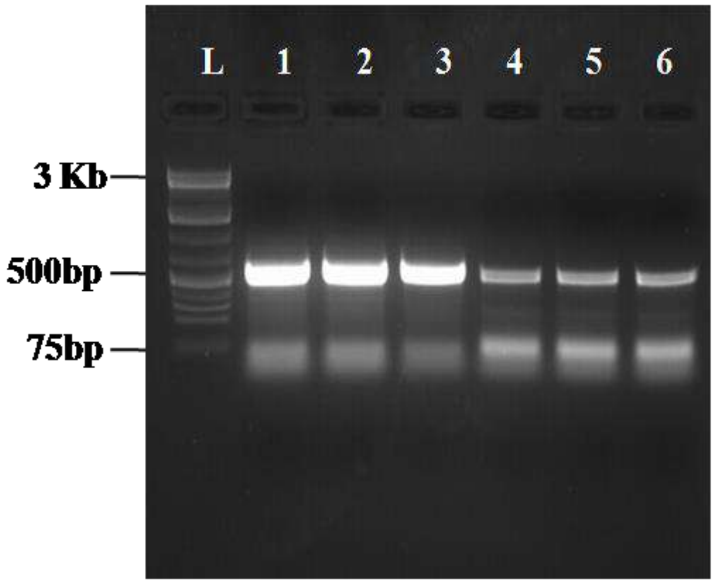


Fig. 1.12 Agarose gel (1.5%) electrophoresis of the cDNA showing PCR amplification of UVR8 gene, L - 1Kb plus ladder, 1 - 6 - UVR 8 gene was amplified

1.5.3 Genome wide identification of simple sequence repeats in onion

The genome sequence of *Allium cepa* was downloaded from GenBank assembly under accession number GCA_905187595. Perl scripts from MISA were used to perform SSR identification with the default parameters (http://pgrc.ipk-gatersleben.de/misa/). The identification criteria were as follows: tri-nucleotide repeat motifs with six repeats, tetra-nucleotide, penta- and hexa-nucleotide repeat motifs with five repeats. Compound SSRs were defined as those with a < 100-nt interval between two repeat motifs. A total of 59,481 SSRs were identified from eight chromosomal regions. Analysis of SSR distribution on each chromosome revealed that the largest number of SSRs was present on chromosome 02 (11,510) followed by chromosome 01 (8727). Tri-nucleotide motifs were the most abundant followed by tetra nucleotide motifs. Of the tri nucleotide motifs, AAT/ATT motifs had the highest occurrence followed by AAG/CTT type (Table 1.30).

Table 1.30 Chromosome-wide distribution of microsatellites in onion genome

SSR Motif	Chromosome							
	01	02	03	04	05	06	07	08
Tri	5368	6999	4874	4272	3919	4891	3513	2846
Tetra	2968	4060	2649	2341	2159	2782	1844	1468
Penta	141	166	127	120	101	147	75	65
Hexa	250	285	235	180	169	216	147	104
Size	345.49	443.74	309.98	284.87	256.60	315.55	232.91	186.27
SSR/Mb	25.26	25.94	25.44	24.27	24.74	25.47	23.95	24.07
Total SSR	8727	11510	7885	6913	6348	8036	5579	4483

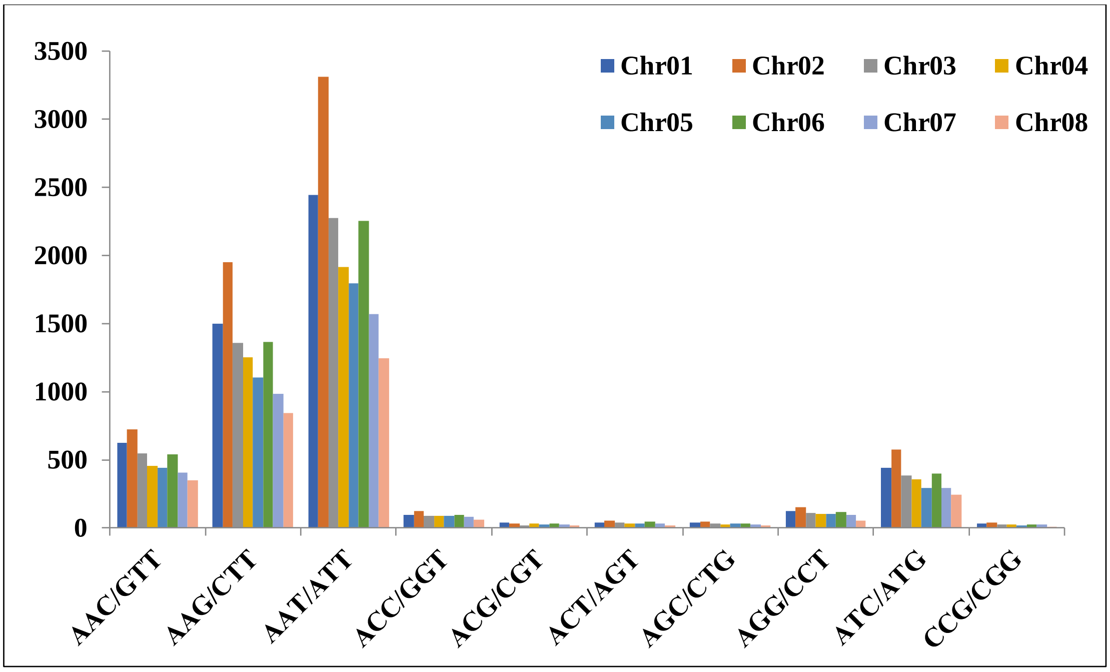


Fig. 1.13 Distribution of tri-nucleotide repeat motif in onion genome

1.6 Development of onion hybrids for quality and yielding traits

1.6.1 Characterization of *Alliums* for genetic improvement

In the genus *Allium*, atp6 gene transferability was assessed which was transferred across the species. The allelic frequency ranges from 0.011 to 0.811, with the highest allelic frequency at 800 bp loci and the lowest at 500 and 490 bp loci with the PIC is 0.101. The results of the diversity analysis revealed that 95 genotypes were divided into 12 groups, in which *A. cepa* and *A. sativum* grouped together, whereas other species grouped separately. The results reveal that the closest species based on atp6 gene transferability, which is a candidate gene for male sterility restoration in alliums. Furthermore, the finding could aid in the future studies of male fertility restorer allele's evolution, spread and introgression among *Allium* crops (Fig. 1.14).

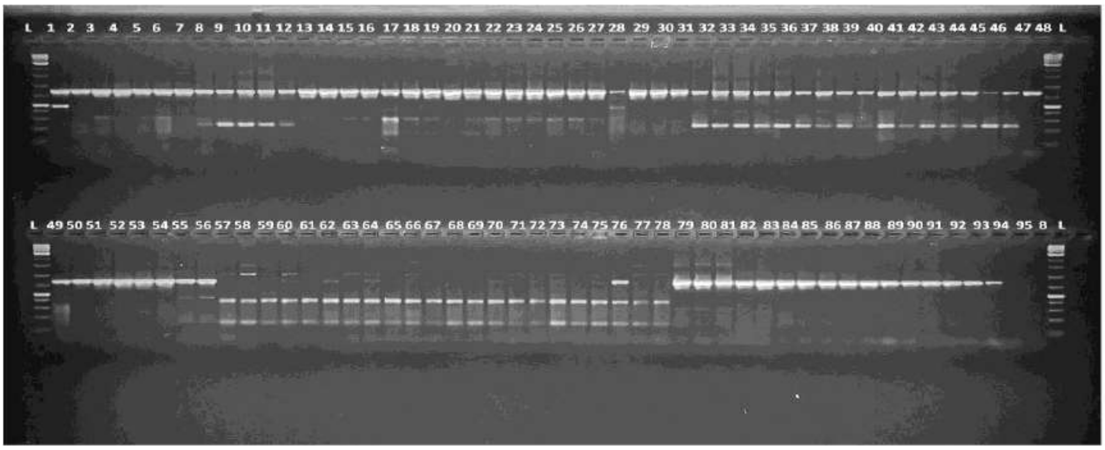


Fig. 1.14 Transferability of *atp*6 gene with variable amplicons among the *Allium* species

Intron Length Polymorphic (ILP) markers derived from exon-flanking introns have been demonstrated to be accurate co-dominant markers in eukaryotes via the use of this polymorphism potential. In the present study, the genetic diversity among 95 accessions of

Alliums from the 13 species was revealed by ILP markers via UPGMA method, and population structure was also studied. Twenty-two ILP markers generated 75 loci with an average of 25.4 amplicons per loci. The Polymorphic Information content (PIC) ranges from 0.02 – 0.99, which is the lowest to highest polymorphic marker. The clustering pattern revealed the population, which were grouped into three major clusters, such as major cluster I grouped by semi-domesticated and wild species, major cluster II consist of cultivated *Allium* species (onion, garlic and bunching onions) and major cluster III was out grouped which consisted of genotypes belong to *Allium hookeri*. The population structure studied also revealed the highest ΔK at 3, which inferred that the population was grouped into 3 genetic groups, which were correlated to the UPGMA clustering. From the finding of the diversity and phylogenetic relationship among the Allium species could be employed in further breeding programs for genetic improvement through inter-specific hybridization, to introgress the desirable traits from semi domesticated to the cultivated species. The Interspecific hybrid three populations developed from *Allium cepa* and *Allium fistulosum* grouped separately (Fig. 1.15).

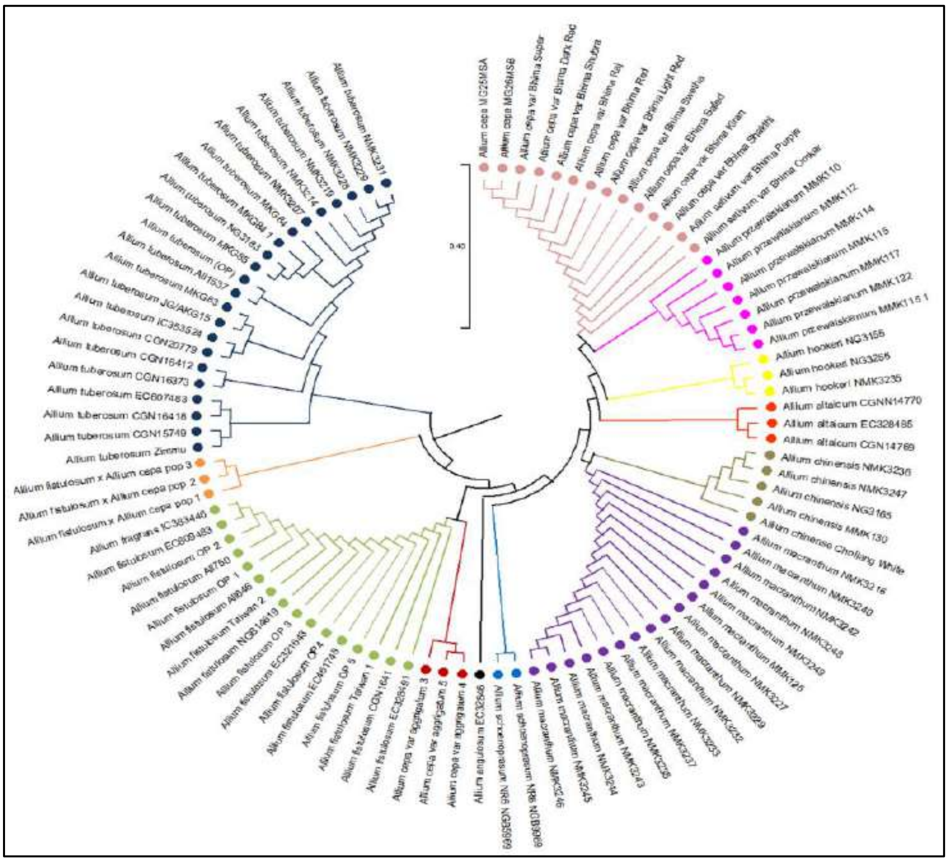


Fig. 1.15 Genetic diversity of *Allium* spp. using ILP markers through UPGMA method

Onion genetic resources characterization was done by using the most recently produced polymorphic DNA-based molecular markers in onion (ILP, intron length polymorphic markers). The genetic diversity of 48 onion genotypes is examined using 15 ILP markers in this study. The PIC values ranged from 0.08 to 0.96, with an average of 0.47, and amplification of ILP markers revealed a total of 18 loci, three of which are monomorphic. There were total of 647 bands obtained, with an average of 9.01 bands per genotype. The UPGMA dendrogram for the 48 onion genotypes is generated, based on Jaccard's similarity coefficient, results revealed by two diverse major groups. The average genetic similarity among 48 onion genotypes was found to be 0.665. PCoA analysis verified the clear division of the genotypes investigated into analogous clusters, similar to UPGMA analysis. Further the study revealed that, the genotypes collected have a wide range of diversity, and that molecular markers can be used to for characterization and to describe the level and pattern of genetic diversity in short-day onion for selection of diverse parental lines for hybridization, genetic improvement and breeding. The morphological features of the male gametophytes of Chives (*Allium schoenoprasum* L.) have been revealed through Field Emission Scanning Electron Microscopy (FESEM), the surface of the male gametophyte was reticulate and shrivelled of surface, pollen found to be sub-ovoid shapes, with long regulate and striated sexine. The elemental composition and distribution were unveiled by FESEM based Energy Dispersive X-ray Spectroscopy (EDS) spectra. The micrograph of anther sample enumerated the C, O, K, P, N, Fe, Mn, Cu, and Mg minerals, and C, O, N, Fe, P, K, Zn, Mn, Cl, Ca, and Na minerals in the pollen grain. These insights could aid in the better understanding, characterization and identification of species based on the male gametophytes.

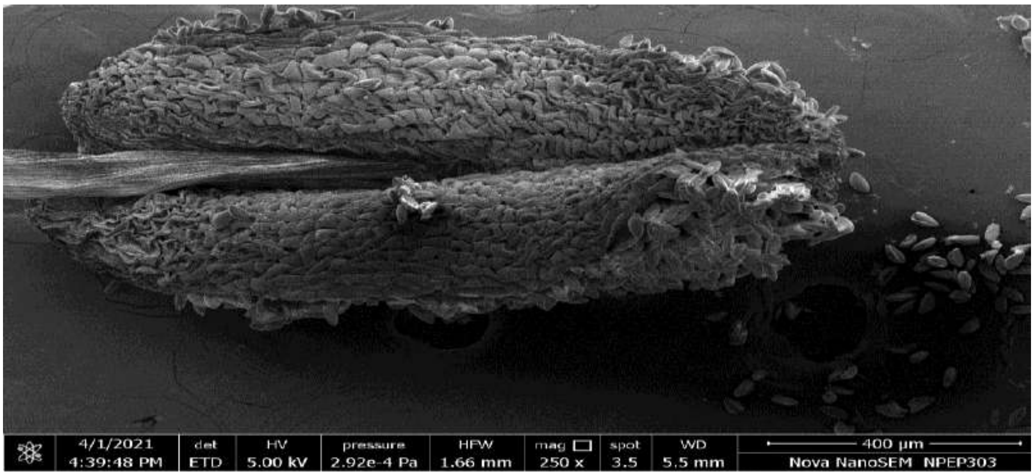


Fig. 1.16 Micro analysis of male gametophytes, striated anther, with pollen grains, pollen clump, and pollen with long regulate and striated sexine

The Bunching onion (*Allium fistulosum* L.) species collections were assessed for identification of male-sterile trait among the germplasm. As a resultant identified a male sterile line, phenotypically and which was confirmed by the orf725 gene and orf501 gene-specific markers conferred linkage for male sterility cytoplasm of S and normal (N) cytoplasm. The manifestation of the male-sterile trait in Bunching onion genotypes could be attributed to the ms genes expression. Phenotypically male-sterile plants produce flowers, does produce pollen grains they were lacking in the anthers. The anthers are slightly green at an immature stage, and yellowish trans-lucent at the mature stage, without pollen grains spores inside the anther sac, matured anthers were shrivelled, empty and fused anther sacs (Fig. 1.16). Soon, the male-sterile line will be used as parental material in hybridization for heterosis breeding to boost Bunching onion.

1.6.2 Genetic improvement of onion for exploitation of heterosis

The study aimed to identify the male-fertility restoration locus (Ms) among 72 breeding lines of onion (Allium cepa L.) by genotyping, which is crucial in the development of F1 hybrid onions using cytoplasmic-genic male sterility (CGMS) system. Thus, two markers were used to identify the Ms locus, the simple PCR marker namely jnurf20 is dominant nature cover across the breeding lines genetic backgrounds, whereas the PsaO gene-specific marker could not spread all along the breeding lines evaluated in the study (Fig. 1.17). Since all reported markers are may or may not have marker genotype association across different genetic backgrounds of onion breeding lines. However, these molecular markers are highly useful in the marker-assisted selection of Ms locus. Thus, this study reveals the amplification of validated markers among the breeding lines used, the study essential to advance the marker-assisted breeding for the development of F1 hybrid onions in near future. Fifty hybrids were developed and evaluated for agronomical traits during 2021-22 using male sterile lines available at DOGR namely ms125 × L39, 125 × L150, 125 × L153, 125 × L154, 125 × Y103, 125 × L156, 125 × B.D.R, 125 × B. Shakti, 125 × B. Kiran, 125 × B. Super, ms126 × L39, 126 × L150, 126 × L153, 126 × L154, 126 × Y103, 126 × L156, 126 × B.D.R, 126 × B. Shakti, 126 × B. Kiran, 126 × B. Super, ms111 × L39, 111 × L150, 111 × L153, 1`11 × L154, 111 × Y103, 111 × L156, 111 × B.D.R, 111 × B. Shakti, 111 × B. Kiran, 111 × B. Super, ms222 × L39, 222 × L150, 222 × L153, 222 × L154, 222 × Y103, 222 × L156, 222 × B.D.R, 222 × B. Shakti, 222 × B. Kiran, 222 × B. Super, ms160 × L39, 160 × L150, 160 × L153, 160 × L154, 160 × Y103m, 160 × L156, 160 × B.D.R, 160 × B. Shakti, 160 × B.Kiran,160 × B. Super.

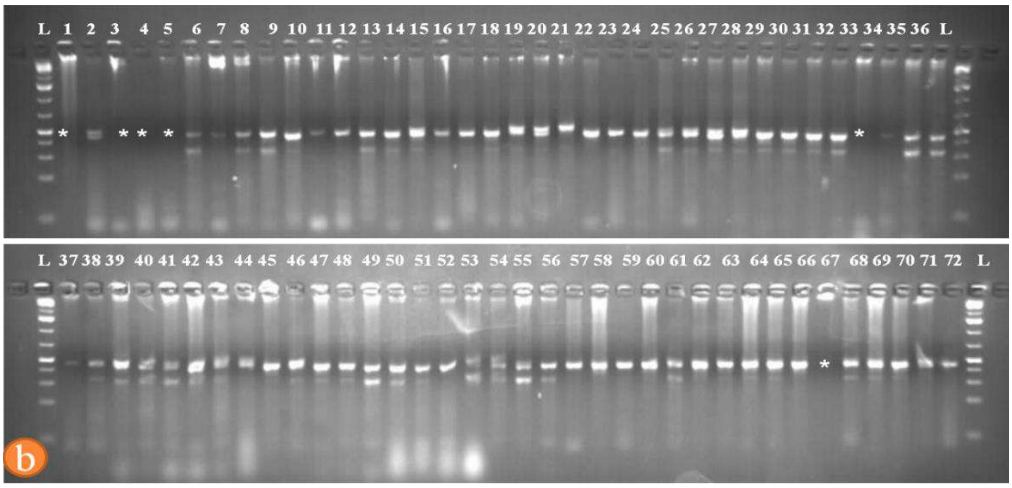


Fig. 1.17 Marker assisted selection of *Ms* locus among breeding lines

a) jnurf 20 marker genotyping for Dominant locus (*Ms)*, b) *PsaO* gene markers genotypes for dominant (*Ms*)and recessive (*ms*) locus, O' GeneRuler 1kb plus DNA ladder used for comparison of amplicon fragments

Externally Funded Project: ICAR-National Fellow

1.7 Haploid induction in onion through genome elimination

1.7.1 Multiplication of Seeds expressing GFP tailswap construct

T_1 bulbs of 6 events of transgenic plants expressing GFP tailswap construct were planted in *Kharif* 2021 season. T_1 plants of all the events were analysed segregation analysis. All the events were segregated as per mendelian fashion. The bulbs of heterozygous and homozygous lines were planted in *Rabi* 2021 season and T_2 seeds were harvested at the end of *Rabi* season. The details of seeds collected from each event is enlisted in the following Table: 1.31.

Table 1.31 T_2 Seed harvested from transgenic plants expressing GFP tailswap construct

S. No.	Transgenic event ID	No. of seeds from Homozygous plants	No. of seeds from Heterozygous plants
1	GFP 1	80	24
2	GFP 2	174	49
3	GFP 3	151	82
4	GFP 4	79	18
5	GFP 5	189	41
6	GFP 6	45	6

1.7.2 Segregation analysis of T_1 seeds expressing *AcCENH3 RNAi*

T_0 bulbs of 5 events of transgenic plants expressing *AcCENH3* RNAi construct were planted in *Rabi* 2021. TAIL PCR analysis was done for all the events and sites of insertion were mapped. The flowers of T_0 bulbs (Event #1, #2 and #5) were selfed to get T_1 seeds. Event #3 and Event #5 did not blossom. These T_1 seeds were planted in *kharif* 2022 and analysed for the zygosity level by PCR analysis (Fig. 1.18, Table 1.32). T_1 plants had shown distorted segregation.

Table 1.32 Segregation analysis of *AcCENH3* RNAi T_1 plants

Sl. No.	Transgenic event ID	No. of seeds sown	No. of seeds germinated	Homozygous	Heterozygous	Azygous
1	RNAi 1	146	99	0	24	75
2	RNAi 2	138	85	1	20	64
3	RNAi 3	0	0	0	0	0
4	RNAi 4	0	0	0	0	0
5	RNAi 5	29	14	0	2	0

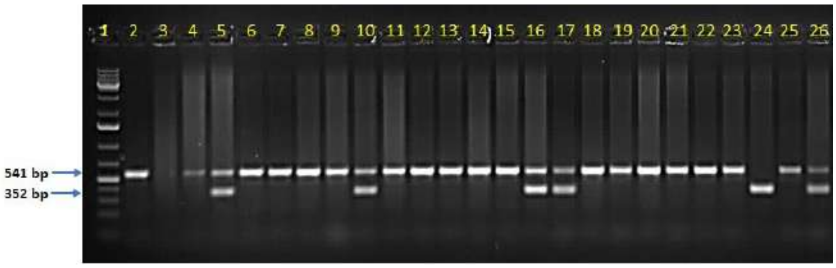


Fig. 1.18 Representative image of segregation analysis of T_1 transgenic plants

PCR analysis of T_1 transgenic plants to analyze segregation of *AcCENH3* RNAi T_1 population

[1: 1 KB plus ladder, 2: B. super, 3: RNAi2-1, 4: RNAi2-2, 5: RNAi2-3, 6: RNAi2-4, 7: RNAi2-5, 8: RNAi2-6, 9: RNAi2-7, 10: RNAi2-8, 11: RNAi2-9, 12: RNAi2-10, 13: RNAi2-11, 14: RNAi2-12, 15: RNAi2-13, 16: RNAi2-14, 17: RNAi2-15, 18: RNAi2-16, 19: RNAi2-17, 20: RNAi2-18, 21: RNAi2-19, 22: RNAi2-20, 23: RNAi2-21, 24: RNAi2-22, 25,26: RNAi2-23, 24]

1.7.3 *Agrobacterium*-mediated transformation of CRISPR/cas9 construct in onion for haploid induction

Agrobacterium strain LBA4404 harboring binary vectors pCAMBIA1305.1-*misAcCENH3*-AcCENH3 sgRNA and pCAMBIA1305.1-AcCENH3 dual target sgRNA were used independently for *Agrobacterium*-mediated transformation of 8-weeks-old embryogenic calli induced from seedling radicle of onion cv. B. super. After resting period of 15 days, putative transformed calli were screened in 3 rounds (15 days each) on 50 µg/L Hygromycin B containing selection media. The survived calli were transferred to shooting media containing 50 µg/L and 30 µg/L Hygromycin B. So far, 15 batches were transformed, 5 batches are in shooting stage (Fig. 1.19), 7 batches are in different selection stages and 3 batches are in resting stage. The details of number of calli in different stages of transformation are enlisted in the following Table 1.33.

Table 1.33 Details of calli in different stages of transformation co-cultivated by AcCENH3-sgRNA constructs

Co-cultivation	No. of calli					
	Resting	Selection I	Selection II	Selection III	Shooting 50	Shooting 30
pC1305.1 - misAcCENH3-AcCENH3 sgRNA	168	146	98	78	39	16
pC1305.1-AcCENH3 dual target sgRNA	133	105	61	40	21	11

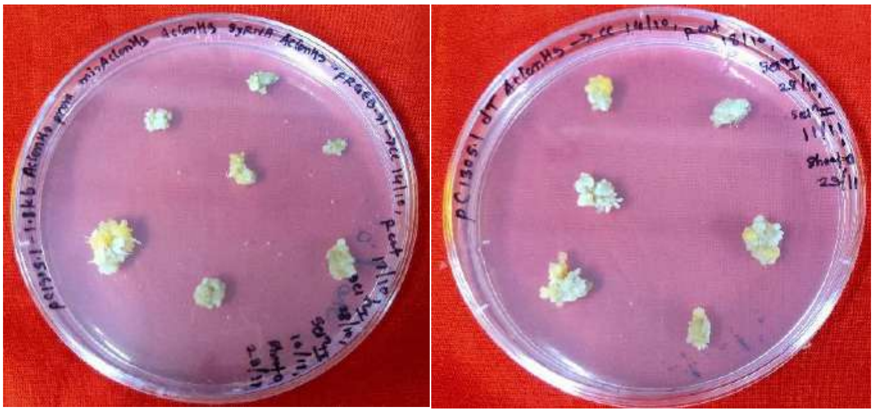


Fig. 1.19 Putative transgenic calli expressing *AcCENH3* sgRNA on shooting medium

Externally Funded Project: DST-SERB

1.8 Development of cytoplasmic male sterile lines in onion (*Allium cepa* L.) through targeted mutagenesis of *AcMSH1* gene

1.8.1 *Agrobacterium*-mediated transformation of pRGEB31-AcMSH1 target constructs in onion

CRISPR/cas9 binary vectors pRGEB31-AcMSH1 exon2 target and pRGEB31-AcMSH1 exon3 target were cloned, transformed interpedently into *Agrobacterium* strain LBA4404 and used for *Agrobacterium*-mediated transformation of 8-weeks-old embryogenic calli induced from seedling radicle of onion cv. B. super. After resting period of 15 days, putative transformed calli were screened in 3 rounds (15 days each) on 50 µg/L Hygromycin B containing selection media. The survived calli were transferred to shooting media containing 50 µg/L and 30 µg/L Hygromycin B. So far, 11 batches were transformed, 1 batch of each construct is in shooting 50 and shooting 30 stage, shooting stage (Fig. 1.20), 7 batches are in selection stage and 2 batches are in resting stage. The details of number of calli in different stages of transformation are enlisted in the following Table 1.34.

Table 1.34 Details of calli in different stages of transformation co-cultivated by AcMSH1-CRISPR/cas9 constructs

	No. of calli					
	Resting	Selection I	Selection II	Selection III	Shooting 50	Shooting 30
pRGEB31-AcMSH1 exon2 target	133	105	62	48	21	18
pRGEB31-AcMSH1 exon3 target	149	112	74	53	37	16

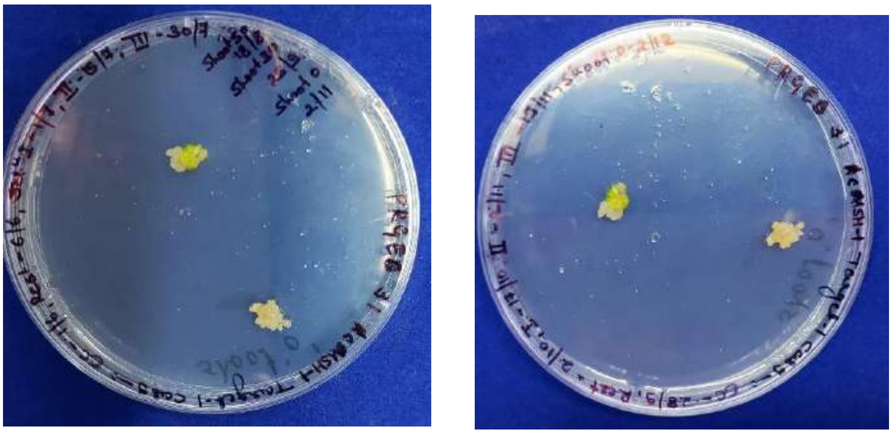


Fig. 1.20 Putative transgenic calli expressing *AcMSH1* CRISPR/cas9 construct on shooting medium

1.8.2 Localization of *AcMSH1* protein

The quantitative immunoassay was performed for detection of localization of *AcMSH1* protein in cell organelles. Intact chloroplast, intact mitochondria, their fractions and total protein was isolated from shoot tissues of onion cv. B. Super. An indirect assay was performed in 96-well ELISA plate coated with *AcMSH1* protein as an antigen by coating 2 µg protein in 3 replicates. ELISA results revealed that the highest level of *AcMSH1* protein was present in isolated mitochondria, followed by the chloroplast and negligible amount was present in mitochondrial and chloroplast fractions (Fig. 1.17). This result elucidated that *AcMSH1* protein is localized in mitochondria and chloroplast organelles.

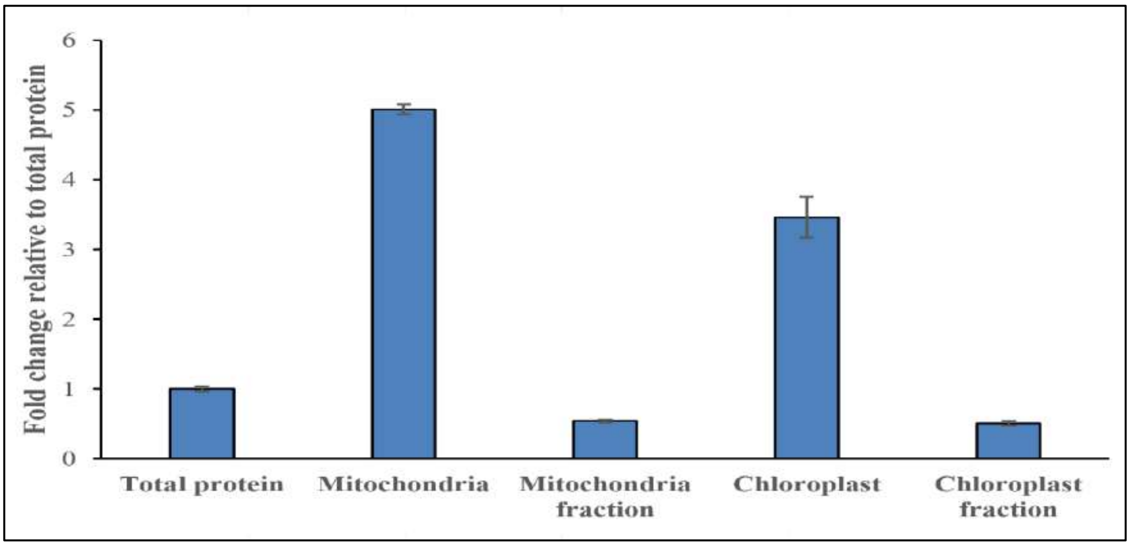


Fig. 1.21 Localization of *AcMSH1* protein in mitochondria and chloroplast

2. Crop Production

2.1 Development of Improved Nutrient Management Practices for Onion and Garlic

2.1.1 Effect of continuous use of inorganic fertilizers and manures on onion production and soil fertility status

Permanent manurial experiment was initiated during *rabi* 2013-14 with eight treatments. Each block was assigned for specific fertilizer treatment and care was taken to avoid mixing of soil from one block to another. Vermicompost (VC) @ 10 t/ha was included during 2015-16. Field experiment was conducted to study the effect fertilizer treatments on onion production, soil fertility status and faunal diversity under soybean/maize (*kharif*) - onion (*rabi*) cropping system. Inclusion of maize as preceding crop and application of inorganic fertilizers alone produced significantly higher bulb yield compared to other fertilizer treatments. Application of 10 t vermicompost/ha alone produced 18.9 t/ha onion yield which was significantly lower than other fertilizer treatments (Fig. 2.1). Plots received both organic manures and mineral fertilizers, and mineral fertilizer alone showed significantly onion yield in soybean block in comparison to maize block. Addition of mineral fertilizers alone to onion crop in maize block produced significantly higher yield compared to the remaining fertilizer treatments. Onion yield in INM treatments of Maize block also decreased significantly in comparison to chemical fertilizer treatments. Whereas, combined application of mineral fertilizers and vermicompost showed significantly higher soil organic carbon and soil available N compared to mineral fertilizer alone applied treatments in both soybean and maize block. Soil organic carbon and soil available nutrients were higher in soybean block compared to the maize block. Initial soil fertility status was maintained in all the fertilizer treatments. Lower yield recorded in soybean block was due to high incidence of *Stemphyllium* incidence. Similar trend was recorded during the last four years.

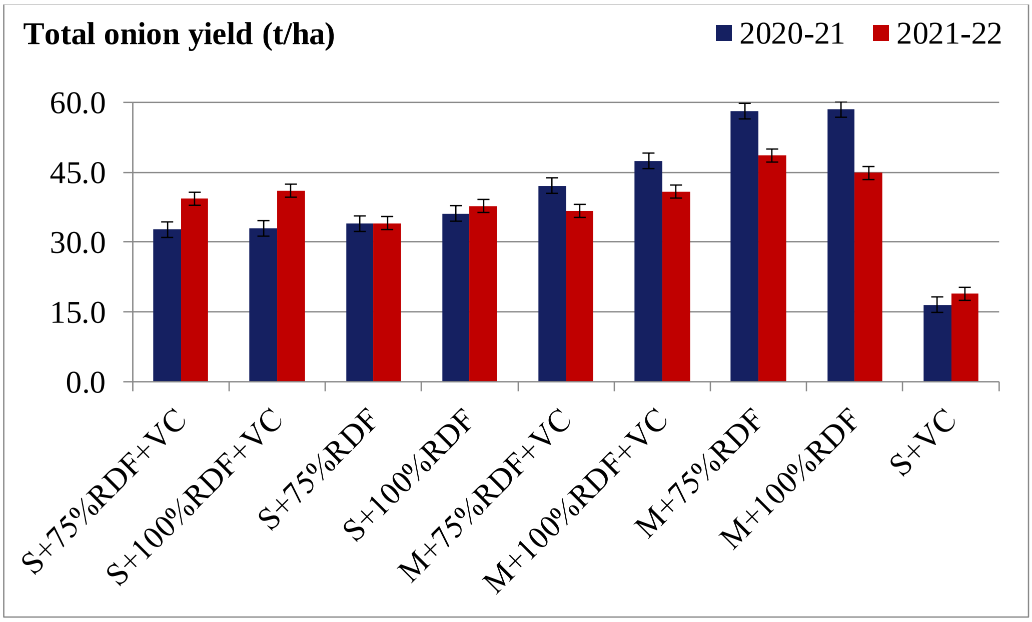


Fig. 2.1 Effect of long-term application of mineral fertilizers and organic manures on onion bulb yield

(100% RDF-150:50:50:50 NPKS kg/ha + 20 t FYM/ha; 75% RDF-150:50:50:50 NPKS kg/ha + 5 tFYM/ha)

Faunal diversity of insect pests and their natural enemies in different onion-based agroecosystem (both organic and inorganic fields)

Observations on pest and natural enemy population were recorded on 30, 45, 60 and 90 DAT in both organic and inorganic trials. Visual inspection for thrips population was done in a sample size of Quadrat of 1 m^2 area from each plot. Aerial insects were caught using sweep nets and sticky traps. Among the different orders of insects, Coleoptera (representing beetles and weevils) dominated the onion ecosystem in terms of species diversity, irrespective of the treatments. With respect to the maximum number of individuals caught, order Thysanoptera dominated under both trials with 672 in organic, whereas 574 in inorganic treatment. However, the activity of onion thrips was first recorded on 25^{th} January (2.7 and 3.8 thrips/plant, respectively on organic and inorganic plots) and reached to its peak (38.4 and 11.8 thrips/plant, respectively on organic and inorganic plots) on 17^{th} February (45 DAP). Later, the population declined to 2.7 and 2.0 thrips/plant respectively on organic and inorganic plots towards the end of March. The highest thrips population was observed during February in all treatment plots. The present study revealed that maximum species diversity was found in organic treatments in comparison to inorganic treatments; thereby making them a more stable agro-ecosystem.

2.1.2 Effect of organic farming on onion production compared to conventional farming

The field experiment was conducted to study the effect of organic farming on onion production and nutritional quality in comparison to conventional farming. The experiment was laid out in split plot design with 14 replications. The mail plot consisted of six organic and inorganic fertilizer treatments and sub-plots consisted inorganic and organic plant protection practices. The experimental results showed that conventional farming and integrated nutrient management plots produced significantly higher bulb yield compared to organic treatments. The yield increase in INM plot, and chemical fertilizer alone applied treatment was higher by 54.7-56.4% compared to organic treatments (Fig. 2.2). No significant difference was observed between INM plot and chemical fertilizer alone applied treatments for onion yield. Among the organic treatments, combined application of farm yard manure (7.5 t/ha), vermicompost (1.5 t/ha), neem cake (0.75 t/ha), phosphorus solubilizing bacteria and Azotobacter @ 5 kg each/ha with inorganic pest and disease management practices (OM2) produced significantly higher yield compared to other organic treatments. Furthermore, organic nutrient management practices with chemical pest management practices produced 10.3-16.9% higher yield compared to organic nutrient and pest management practices. The treatment received mineral fertilizers alone showed the lowest total stage losses after five months of storage (Fig. 2.3). The values were statistically comparable to the treatment received both mineral fertilizers and organic manures. The plant protection measures did not show any effect on total storage losses. N, P, K and S uptake were significantly higher in conventional and INM plots compared to organic treatments. Soil analysis showed that soil organic carbon and soil available N concentration were higher in organic treatments compared to INM and conventional farming. The lowest soil organic carbon and soil available N was recorded in INM and conventional treatments. *Thrips* population was the highest in plots received organic plant protection measures.

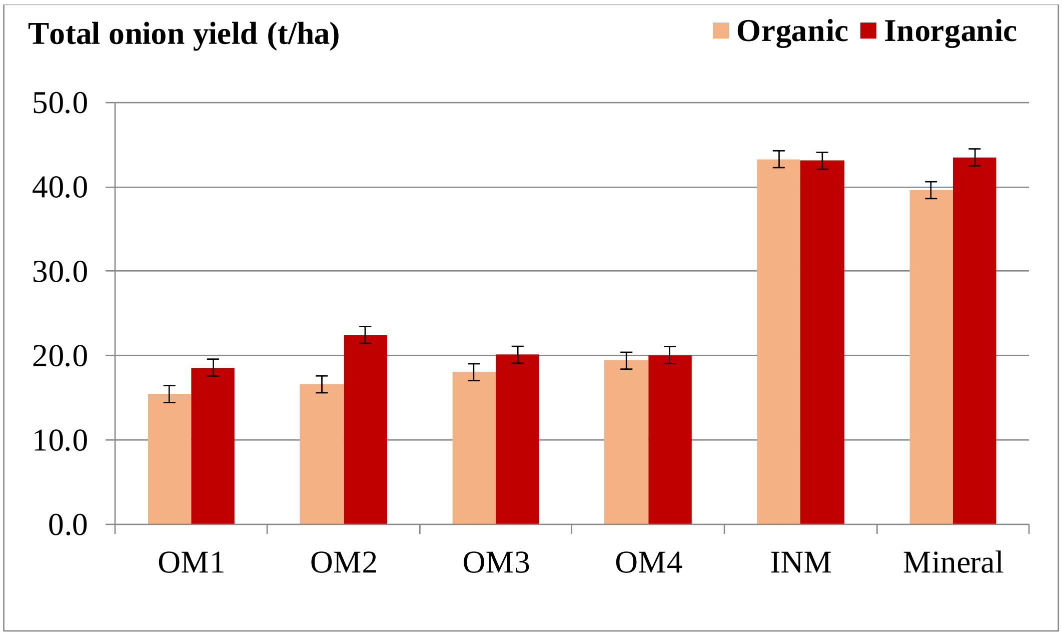


Fig. 2.2 Effect of organic farming practices on onion bulb yield
(1: OM1, Organic module 1, 2: OM2, Organic module 2, 3: OM3, Organic module 3, 4: OM4, Organic module 4, 5: INM, Integrated nutrient management, 6: Mineral, Mineral fertilizers).

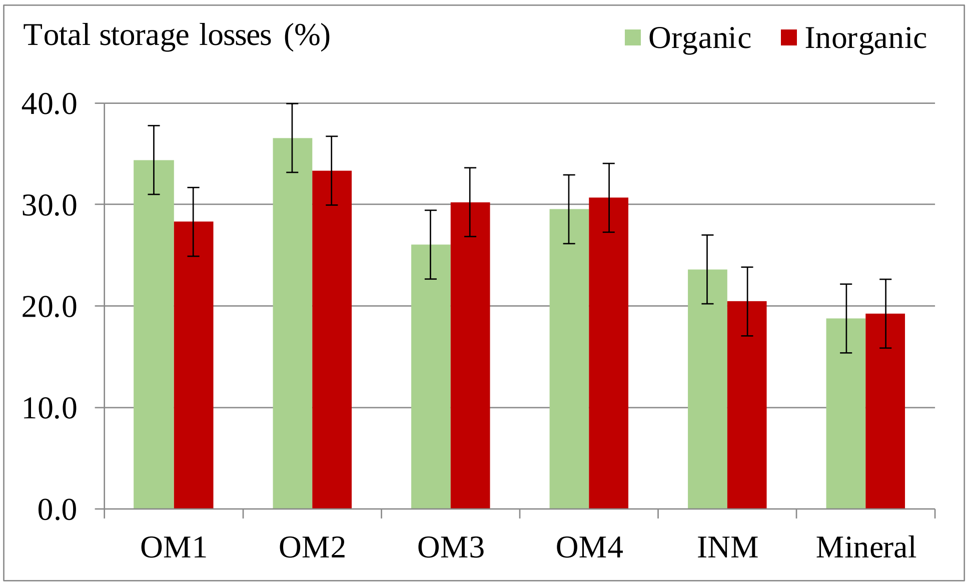


Fig. 2.3 Effect of organic farming practices on total storage losses of onion
(1: OM1, Organic module 1, 2: OM2, Organic module 2, 3: OM3, Organic module 3, 4: OM4, Organic module 4, 5: INM, Integrated nutrient management, 6: Mineral, Mineral fertilizers)

2.1.3 Effect of nitrogen fertilizer and irrigation regimes on plant growth, yield and storage quality of onion

The field experiment was conducted to study the effect of nitrogen fertilizers and irrigation regimes on plant growth, yield, and total storage losses of onion. The experiment was designed on strip plot design and each treatment was replicated four times. Factor A consisted of irrigations methods namely drip, sprinkler and flood irrigation system, and Factor B consisted of four levels of nitrogen fertilizers (0, 50, 100, and 150% of recommended nitrogen dose). Twenty percent nitrogen fertilizer was applied as a basal at transplanting and remaining N dose was applied in three equal splits as top dressing at 15, 30 and 45 days after transplanting to all the treatments. The results showed that 100% (110 kg/ha) and 150% N (165 kg/ha) application through drip and sprinkler increased onion yield significantly compared to flood irrigation system. However, the irrigation treatments did not affect plant height, number of leaves, leaf length, and leaf area index. Among N treatments, application of 100% and 150% N increased plant growth parameters, onion yield, and total soluble solids compared to the control plot and 50% N applied treatments (Fig. 2.4). 100% and 150% applied treatments through sprinkler irrigation showed higher neck thickness of onion bulbs compared flood and drip irrigation system. In addition, onion bulbs harvested from different N and irrigation treatments were stored for four months. The storage losses of onion were the highest in the control plots and the lowest in 100% and 150% N applied treatments in all three irrigation methods (Fig. 2.5). This result indicated that balanced application of N as per crop requirement may have reduced the total storage losses. This study needs to be repeated for confirmation.

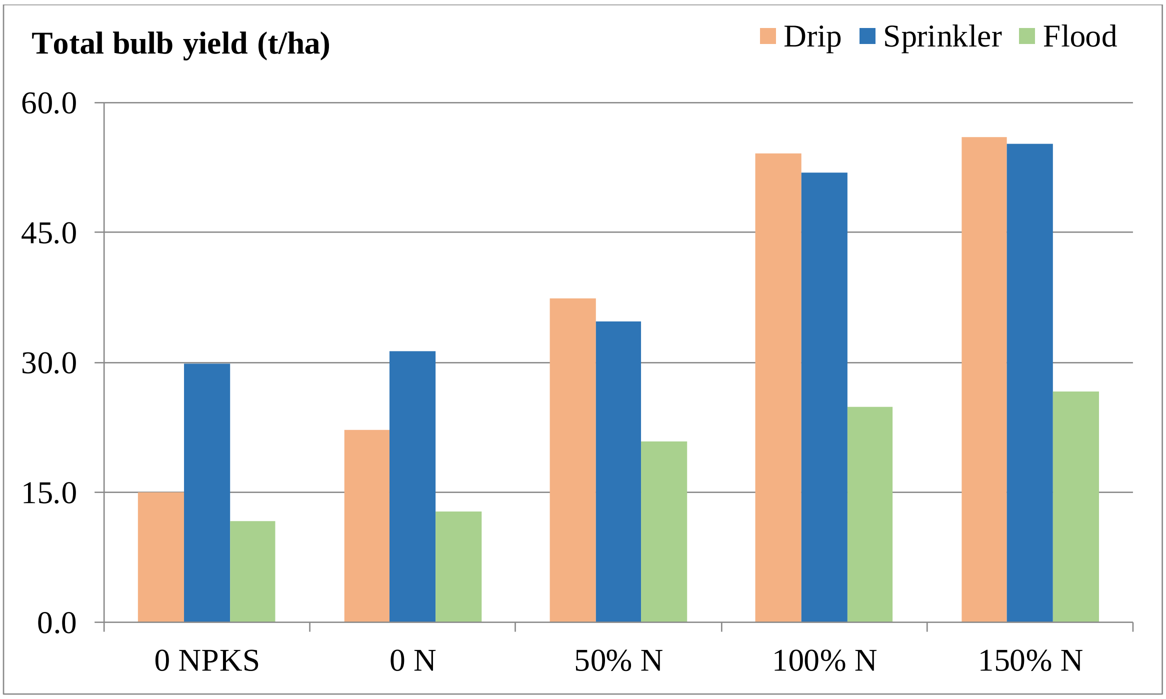


Fig. 2.4 Effect of Nitrogen fertilizers and irrigation methods on onion yield
(1: 0 NPKS, No NPKS fertilizers applied, 2: 0 N, No nitrogen fertilizer applied, 3: 50%, 55 kg N/ha, 4: 100% N, 110 kg N/ha, and 5: 150% N, 165 kg N/ha)

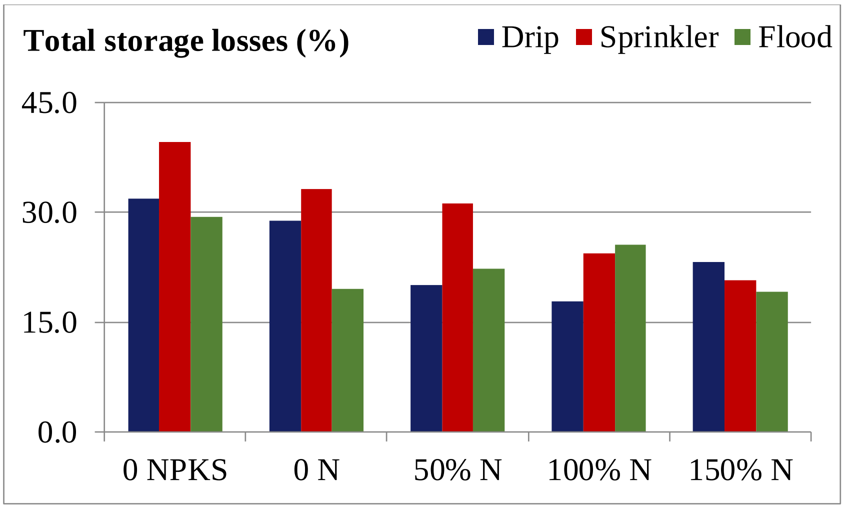


Fig. 2.5 Effect of Nitrogen fertilizers and irrigation methods on onion yield
(1: 0 NPKS, No NPKS fertilizers applied, 2: 0 N, No nitrogen fertilizer applied, 3: 50%, 55 kg N/ha, 4: 100% N, 110 kg N/ha, and 5: 150% N, 165 kg N/ha)

2.1.4 Field evaluation of identified contrasting onion genotypes for water-logging tolerance

A field experiment was conducted to evaluate the effect of water-logging stress in four onion genotypes (W 355, Acc. 1630, Acc. 1666, and Bhima Dark Red). Seedlings were transplanted on raised bed of 6 sqm by maintaining a spacing of 10x15cm. Water-logging treatment was imposed on seedlings 45 days after transplanting for continuous 20 days by flooding. Field was irrigated through sprinkler system. In addition to this, about 200 mm rainfall was received during the stress 30 to 80 days after transplanting. Foliar application of water-soluble fertilizer increased plant growth and yield of onion genotypes, Bhima Dark Red and Acc. 1666 significantly compared to the other genotypes under water-logged condition. The tolerant genotypes Acc. 1666 and Bhima Dark Red showed higher survival percentage (>90%), good plant stand, higher chlorophyll content, better cellular membrane stability. These two genotypes produced more B grade bulbs (bulb size 30-60 mm diameter) under water-logging condition with less than 30% change in bulb weight compared to the control plants.

2.2 Efficacy evaluation of ICAR-CIRCOT Nano-Sulphur as fertilizer formulation for different field crops (Collaborative Project with ICAR-CIRCOT)

The field experiment was conducted to study the effect of ICAR-CIRCOT nano-sulphur on yield, nutrient uptake and storage quality of onion and garlic. The experiment was performed with twelve treatment combinations in split plot design. Each treatment was replicated four times. Factor A consisted of six sulphur treatments namely 1. 0 S: No sulphur, 2. NS (0.5%): ICAR-CIRCOT Nano sulphur foliar application @ 5 ml/litre, 3. 15 NS: ICAR-CIRCOT Nano-sulphur @ 15 kg/ha, 4. 23 NS: ICAR-CIRCOT Nano-sulphur @ 23 kg/ha, 5. 30 NS: ICAR-CIRCOT Nano-sulphur @ 30 kg/ha, 5. 30 ES: Bentonite sulphur (90%) @ 30 kg/ha, and Factor B consisted of two FYM treatments (1. No FYM: 0 Farm yard manure, 2. With FYM: Farm yard manure @ 5 t/ha). The results showed that the plots received ICAR-CIRCOT nano-sulphur alone increased marketable yield by 8-12% compared to the control plot, whereas bentonite sulphur alone increased onion yield by 23% (Fig 2.6). However, combined application of ICAR-CIRCOT Nano-sulphur and FYM increased onion by 3.8-8.3%, whereas, bentonite sulphur application increased onion yield by 3.6%. In case of garlic, ICAR-CIRCOT Nano-sulphur and bentonite sulphur increased yield significantly compared to the control. Without FYM, ICAR-CIRCOT nano-sulphur application increased garlic yield by 10.8-16.3% and bentonite sulphur increased garlic yield by 5.7% compared to the control (Fig. 2.7). Combined application of farm yard manure and Nano-sulphur showed lesser yield increase in both onion and garlic. In garlic, application of ICAR-CIRCOT Nano-sulphur application @ 15 kg/ha and 23 kg/ha recorded higher yield compared to the remaining treatments, whereas, application of bentonite sulphur @ 30 kg/ha recorded the highest yield compared to the rest of the treatments in onion.

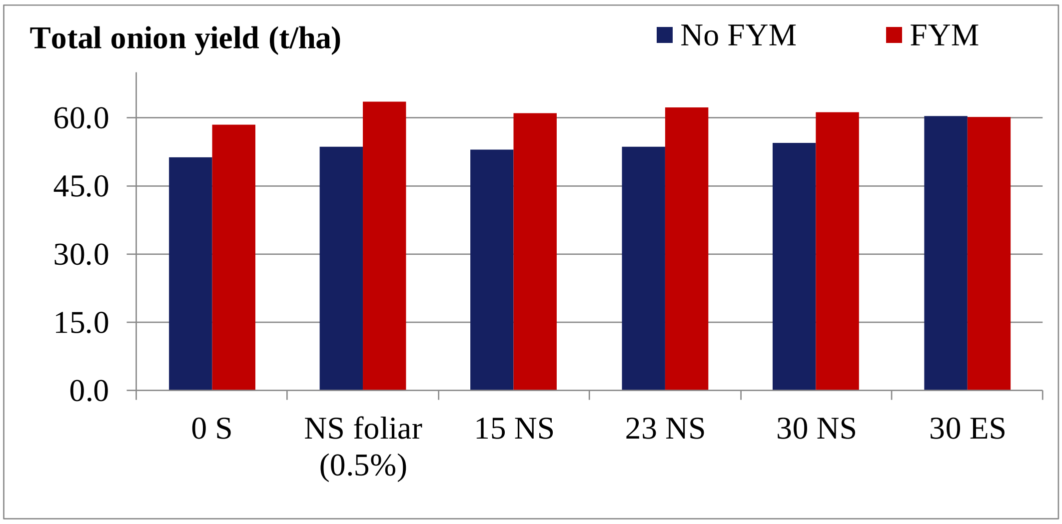


Fig. 2.6 Effect of ICAR-CIRCOT Nano-Sulphur application on onion yield

(1:0 S, No sulphur, 2: NS (0.5%), ICAR-CIRCOT Nano sulphur foliar @ 5 ml/litre, 3: 15 NS, ICAR-CIRCOT Nano-sulphur @ 15kg/ha, 4: 23 NS, ICAR-CIRCOT Nano-sulphur @ 23kg/ha, 5: 30 NS, CIRCOT Nano-sulphur @30 kg/ha, 6: 30 ES, Bentonite sulphur (90%) @30 kg/ha)

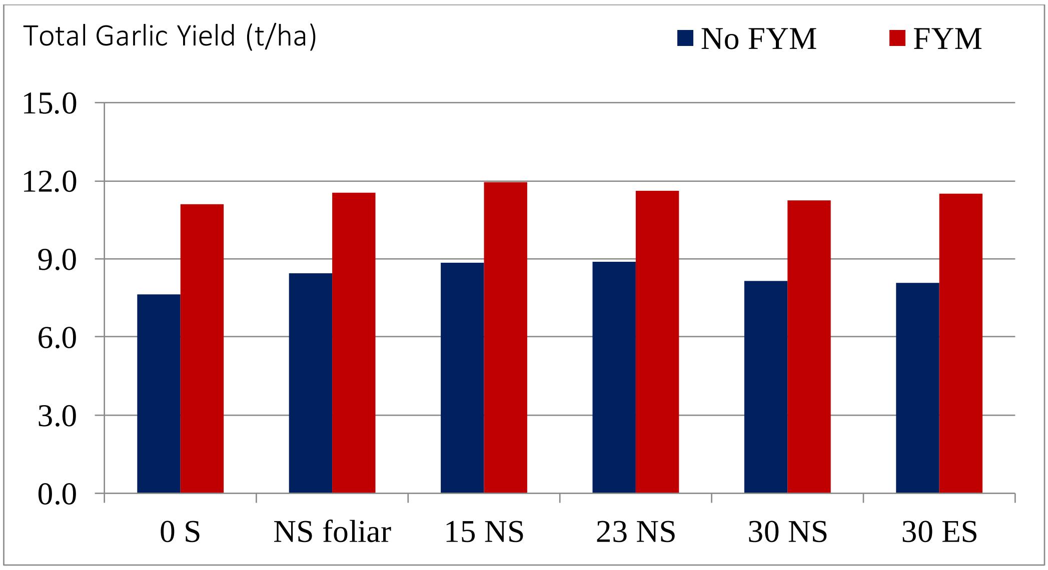


Fig. 2.7 Effect of ICAR-CIRCOT nano-sulphur application on garlic yield

(1:0 S, No sulphur, 2: NS (0.5%), ICAR-CIRCOT Nano-sulphur foliar application @ 5 ml/litre, 3: 15 NS, ICAR-CIRCOT Nano-sulphur @ 15 kg/ha, 4: 23 NS, ICAR-CIRCOT Nano-sulphur @ 23 kg/ha, 5: 30 NS, ICAR-CIRCOT Nano-sulphur @ 30 kg/ha, 6: 30 ES, Bentonite sulphur (90%) @ 30 kg/ha)

2.3 Abiotic Stress Management in Onion and Garlic

2.3.1 Impact of plant growth promoting microbes on onion crop growth and yield subjected to waterlogging stress

Plant associated microbial communities promote plant growth under extreme climatic conditions like waterlogging by mineral solubilization, phytohormones production and many more. A pot experiment was conducted during *kharif* 2022 where the seedlings of onion variety Bhima Dark Red and genotype Acc. 1666 were inoculated with the well-known plant growth promoting microbial strains including *Azotobacter spp*, *Azospirillum spp*, *Piriformospora indica*, Phosphorus Solubilizing Bacteria and Potassium Mobilizing Biofertilizers before transplanting. Waterlogging stress was imposed 40 days after seedling transplantation for continuous 5 days by creating an artificial water-logging condition in tanks. Different physiological, biochemical and yield contributing traits were evaluated from both controlled and treated samples. Significant difference was recorded for bulb yield under control and water-logged condition. However, it was found that microbial treatments help the plant to maintain the growth and bulb yield under waterlogged condition. Seedling inoculated with *Azotobacter* spp. performed superiorly under control and stress regime in both the genotypes based on the crop phenotypic growth and bulb yield performance (22-25 t/ha under waterlogging stress). The study thus concludes that *Azotobacter* spp plays significant role in onion crop under waterlogging stress (Fig. 2.8).

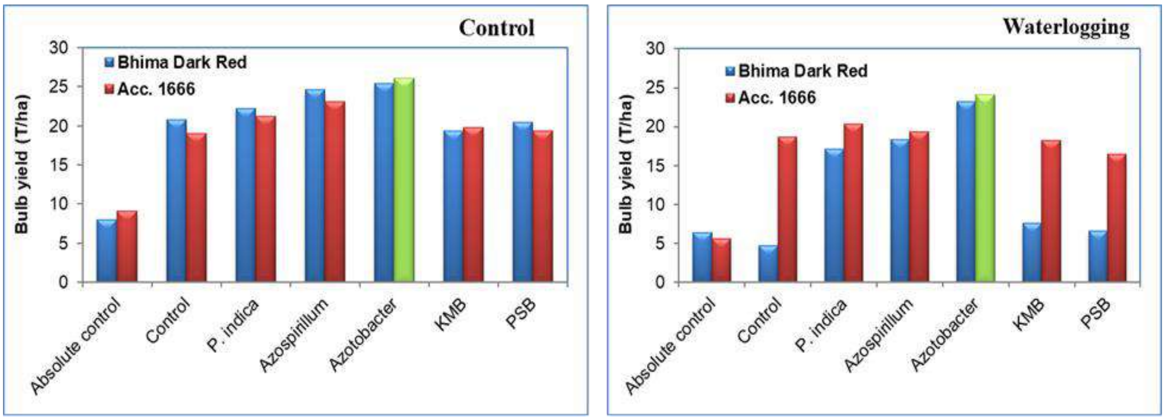


Fig. 2.8 Effect of microbial treatments on onion bulb yield under water-logging stress

2.3.2 Effect of plant growth regulators on onion crop and yield under water-logging stress

Plant growth regulators (PGRs) play a significant role in plant developmental process and modulating plant replies to various abiotic constraints including waterlogging stress. A field experiment was conducted to evaluate the effect of different plant growth regulators namely, Putrescine (50, 100, 200 ppm), Spermine (50, 100, 200 ppm), Gibberellic acid (50, 100, 200 ppm), Salicylic acid (50, 100, 200 ppm), Kinetin (50, 100, 200 ppm) and Melatonin (50, 100, 200 ppm) in onion variety namely, Bhima Dark Red under waterlogging stress (Fig. 2.9). Foliar application of PGRs was done 10 days prior waterlogging treatment. Waterlogging stress was imposed 45 days after seedling transplantation for continuous 5 days by creating an artificial water-logging condition in tanks. Different physiological, biochemical and yield contributing traits were evaluated from both controlled and treated samples. Foliar spray of Melatonin @ 50 ppm improves onion crop growth and bulb yield under both control and waterlogging stress compared to other treatment. Thus, it can be concluded that foliar spray of Melatonin @ 50ppm improves onion crop growth under waterlogging stress.

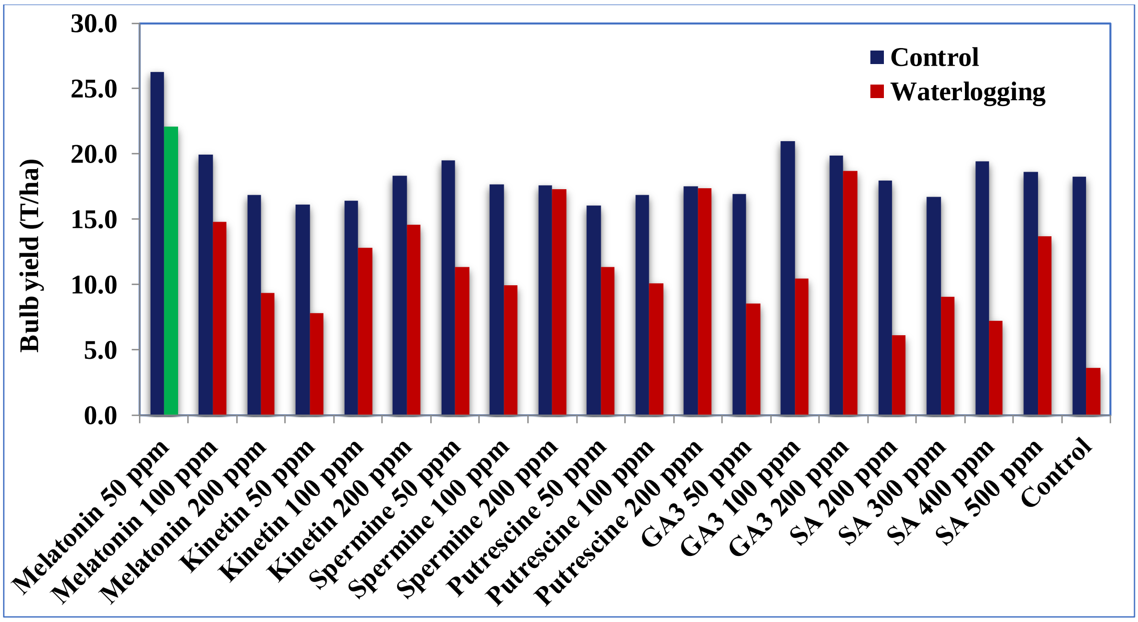


Fig. 2.9 Effect of plant growth regulators on onion bulb yield under water-logging stress

2.3.3 Effect of high temperature stress on onion crop growth and yield

A pot experiment was conducted to evaluate the effect of high temperature stress on onion crop growth and performance in two onion variety Bhima Shakti and Bhima Kiran. Temperature conditions were set in growth chamber where 45 days old plants were exposed to increasing temperature range of 26, 30, 35, 38, 40, 42, 45 °C for 24 hours. A set of control plants were kept under normal growth condition (temperature 26 ± 1°C) in open field. No significant difference was recorded for the plant's morphological traits like plant height, leaf area, leaf senescence and chlorophyll content when plants were exposed to temperature of 26, 30 & 35^{0}C compared to control plants. However, as the temperature increases beyond 35^{0}C significant alteration in plant phenotypic growth were recorded in both the variety. Reduction in leaf area and induction in leaf senescence were observed as the temperature increases. Plants exposed to 42°C recorded with wilting symptoms and poor plant growth during recovery time but get 50-60% recovered after stress period. However, plants exposed to 45^{0}C failed to recover after stress period. Thus, it can be concluded that 42°C temperature and beyond that are damaging for onion crop growth and development.

3. Crop Protection

3.1. Development, refinement and validation of management strategies for major fungal diseases-pests of onion-garlic

3.1.1. Collection, isolation, and identification of fungal pathogens and bio-agents

The samples of diseases (Anthracnose, Purple blotch, *Stemphylium blight*, White rot, Damping off, Basal rot, and post-harvest pathogens) were collected from the ICAR-DOGR field and from adjoining places (Fig. 3.1). Pathogens were isolated, and cultures identified from *Colletotrichum* spp., *Fusarium* spp., *Alternaria* spp., *Stemphylium* spp. etc., based on morphological characters and are maintained. In addition to that, bio-agents including *Trichoderma* spp., were also isolated.

Fig. 3.1 Experimental field at ICAR-DOGR, Pune

3.1.2. Evaluation of *Trichoderma* species/isolates on crop growth of onion and disease management of onion under field condition during *rabi* 2021-22 and *kharif*-2022

Crop growth

The effect of *Trichoderma* spp./isolates (11 isolates) on onion crop growth was studied. Observations on growth parameters were recorded. Results reveal that enhanced growth among *Trichoderma* spp./isolate T-166 treatment and plant height up to 8% and pseudostem diameter up to 5% were recorded in *rabi* onion. However, in *kharif* onion, *Trichoderma* spp./isolates treated plants showed enhanced plant height (ranging from 0-7%) and pseudostem diameter (range, 2-18%) over control.

Effect on diseases

Eleven *Trichoderma* spp./isolates were evaluated against *Stemphylium* pathogens during *rabi* 2022. Eight isolates inhibited *Stemphylium* disease from 8-33% over control. The maximum (33%) inhibition recorded in *Trichoderma* isolate NRCG-8.

Similarly, during *kharif* 2022, all the isolates inhibited anthracnose, twister and *Stemphylium* diseases. Again, the maximum inhibition of anthracnose (44%), twister (50%), and *Stemphylium* (40%) were recorded with *Trichoderma* isolate, NRCG-8.

Fig. 3.2 Typical symptoms of onion Anthracnose

Bulb yield

Among the 11 *Trichoderma* spp evaluated, all isolates enhanced the yield by 2-27%. The maximum (27%) increase was supported by *Trichoderma* T-166 (21 t/ha) over control (16.7 t/ha) in *rabi* 2022. Whereas, during *kharif*, among the 11 *Trichoderma* spp./isolates evaluated, ten isolates enhanced the yield ranging from 4-29%. The maximum (29%) increase was recorded in *Trichoderma* T-8R (22 t/ha) treated plots over control (17 t/ha).

Molecular characterization

The molecular characterization of 11 *Trichoderma* isolates were performed using PCR and using sequencing of internal transcribed spacer (ITS) and translation elongation factor 1 alpha (TEF) based primers. PCR products were purified and sequenced. Phylogenetic tree was constructed with MEGA 11 software program using the Neighbor-Joining distance algorithm method (Fig. 3.3).

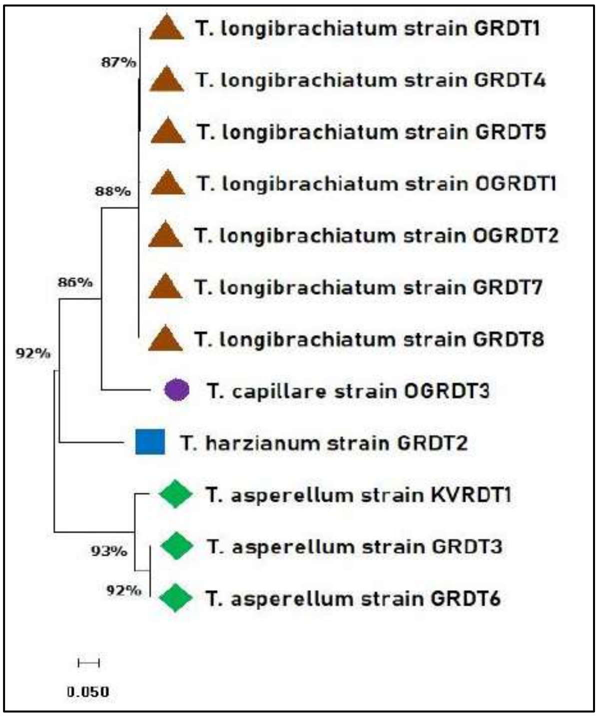


Fig. 3.3 Phylogenetic tree of partial ITS/*Tef1* gene sequences by maximum likelihood

3.1.3. Evaluation of disease management modules against major fungal diseases of onion

Effect on diseases

Four modules (M1, M2, M3, M4) with existing practice (EP), farmers' practice (FP), and absolute control (AC) were evaluated during *rabi*-2022. All the modules inhibited the *Stemphylium* disease, ranging from 10-30% over control. The maximum (30%) inhibition was recorded with M1 (Intensive management) being at par with M2. During *kharif* 2022 season, all the modules inhibited the Anthracnose disease ranging from 5-51% over control, maximum with M1. While comparing with FP, the maximum inhibition was recorded with M1 (48%).

Bulb yield

Among the above four modules (M1, M2, M3, M4), M1 supported 24% and 13% higher yield over control (21 t/ha) and FP (23 t/ha) during the *rabi* 2022. Again, during *kharif* 2022, the pattern was the same, where M1 (19 t/ha) registered 27% higher yield over control (15 t/ha).

3.1.4. Evaluation of *Amritpani* based organic formulations

Effect on diseases

Four *Amritpani*-based organic formulations (DOGROF1, DOGROF2, DOGROF3, and DOGROF4) were evaluated against major onion diseases in *rabi* 2022. The maximum (36%) *Stemphylium* inhibition was recorded in the treatment, DOGROF3 (*Bajra flour, Calotropis leaves, Karanj leaves, Ginger powder, Turmeric powder, Hing powder to Water*), followed by DOGROF4 (27%). A maximum of 73 PDI (*Stemphylium*) was recorded, with control being a minimum with DOGROF3 (47 PDI). Similar trends were recorded during the *kharif* 2022 season, where DOGROF3 supported maximum (32%) inhibition of Anthracnose, followed by DOGROF1 (24%) being at par with DOGROF4. The maximum 60 PDI (Anthracnose) was recorded with the control being minimum with DOGROF3 (40 PDI).

Bulb yield

DOGROF3 recorded a 7% higher yield (27.9 t/ha) than the control (25.9 t/ha) during *rabi* 2022. Similarly, in *kharif* 2022, DOGROF3 treatment produced a maximum 28% higher yield (16.40 t/ha) followed by DOGROF1 than the control (12.80 t/ha).

3.1.5. Evaluation of onion germplasm for diseases

Eighteen white onion germplasm along with checks were evaluated against *Stemphylium* disease in *rabi* 2022. All the germplasm received disease ranging from 13-23 PDI. Six germplasm namely, WHTB-9I-LT-15-SMC-M7, WHTS-7G-GT-15-SC-M7, W-337, W-448, WHTB-10J-T-15-SMC-M7, WHT-23A-3 received <15 PDI, rest received higher PDI. Among 19 red germplasms evaluated, all recorded Stemphylium disease ranging from 9-20 PDI. Among them, 11 germplasm *viz*., DOGR-Hy-6, 1819, DOGR-Hy-8, 1613, DOGR-Hy-56, 1621, 1628, 1649, 1622, 1774, 1618 received <15 PDI. Eighteen white onion germplasm evaluated against anthracnose disease, all germplasm received higher disease ranging from 56-100 PDI, and eight germplasm could not survive till the end. Further, 15 red onion germplasm along with checks evaluated, all germplasm received higher anthracnose disease ranging from 44-100 PDI (Fig.3.4).

Fig. 3.4 Twister disease in germplasm at ICAR-DOGR, Pune

3.2. Biotechnological approaches for biotic stress management

3.2.1. Identification and expression analysis of stress related miRNA in onion (*Allium cepa*)

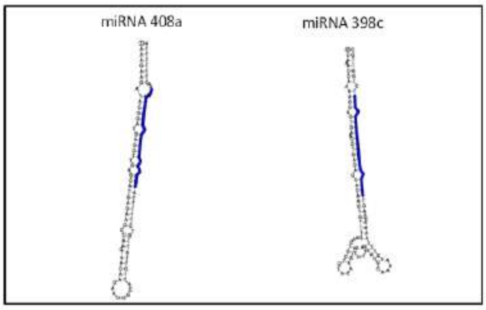


Fig. 3.2.1 Hairpin structure of predicted miRNA

MicroRNA (miRNA) is one of the key components in the regulation of gene expression. miRNAs are 20–24 nucleotide-long, endogenous non-coding RNAs that regulate their target gene expression. miRNAs reportedly involved in regulating important processes in plant development, disease and stress response, hormone signalling etc. With the availability of computational tools and genomic resources, miRNAs from numerous plants are identified. In onion, limited numbers of miRNAs were identified due to the non-availability of genome sequence and limited genomic resources. We identified the 119 miRNA and their target genes from the onion genome (PRJEB29505). Expression of target genes in purple blotch infection, drought and waterlogging stress was studied using previous RNAseq. The information generated in the present investigation will be a foundation for elucidating the miRNA mediated gene regulation in onion in response to disease and stress conditions. PatMaN (Pattern Matching in Nucleotide databases) tool was used to identify the homologous miRNA sequences to the miRNA in onion genome sequences. To provide transcriptional evidence of the role of miRNA genes in biotic and abiotic stress in onion, RNAseq data generated in our previous experiment for biotic stress, drought and waterlogging was used. The BAM scale was used to get normalized quantifications of the expression of miRNA genes from RNAseq data (Pongor et al., 2020), and transcript level quantification was expressed in FPKM. Out of 119 miRNA genes, 73 showed expression different stress conditions in onion. Out of these 73 miRNA genes, 14 were showed a consistent expression level of up or down regulation in disease, waterlogging and drought stress conditions. The miRNA genes, including *Ace-MIR408a*, *Ace-MIR2275b*, *Ace-MIR168c*, *Ace-MIR166c* and *Ace-MIR69a*, showed variation in expression in response to *A. porri* infection (Fig. 3.5). The miRNA genes like *Ace-MIR168a*, *Ace-MIR159a*, *Ace-MIR827a*, *Ace-MIR398b*, *Ace-MIR398c* and *Ace-MIR393a* were found to be differentially expressed in drought stress in onion genotypes. In waterlogging stress, the following miRNA genes, *Ace-MIR2275b*, *Ace-MIR168b*, *Ace-MIR168c*, and *Ace-MIR69a*, showed differential expression in onion.

3.2.2. Chitosan-Nano conjugate promotes growth and Stemphylium Leaf Blight resistance in onion

Nano natural polymers are becoming increasingly popular for managing pathogens since they offer a potentially safe alternative to chemical pesticides and fungicides. Among these nano-polymers, chitosan nanoparticles (CNPs) have attracted considerable interest for use as biomaterial-based agrochemicals due to their unique qualities, such as non-toxicity, low cost, biodegradability, high permeability through biological membranes, and broad antifungal activities against numerous phytopathogenic fungi. Experiments were conducted to test the effect of chitosan nanoparticles on growth and resistance to Stemphylium Leaf Blight in onions by seed treatment, foliar spray and the combination of seed treatment and foliar spray. In addition, the effect of treatments on vegetative, reproductive growth and yield of onion was studied.

3.2.3. Effect of chitosan on onion seed germination, growth of onion and yield

The chitosan treated onion seeds showed better germination and vigour than untreated seeds. Three treatments were used (seed treatment, foliar spray and seed treatment + foliar spray) in the field and pot experiment along with the control. It was observed that seed + spray treatment showed better growth parameters like plant height, leaf length, leaf width, pseudo stem length and width. Similarly, onion bulb yield was also higher in all chitosan treated samples than control. The highest yield was recorded in seed + spray treatment which are 17% higher than control, which indicates the growth promoting effect of chitosan in onion (Fig.3.6).

Fig. 3.6 Germination and vigour of the onion seedlings A. 15 days and B. 35 days

3.2.4. Chitosan priming enhanced resistance against Stemphylium Leaf Blight

The disease severity index was measured, and it was found that the severity of SLB was 20% lower in seed + spray treatment as compared to that of control. Lower disease severity in chitosan treated plants suggests that chitosan nanoparticles can boost the defence response in onion plants. Percent Disease Index (PDI) were recorded at 30, 45, 60, and 75 days after transplantation (Fig. 3.7). The PDI found reduced in those treatments where chitosan was used as seed + spray treatment in the field compared to untreated plants and other treatments (seed treatment, foliar spray). The highest PDI (28.6%) were recorded in the control plants and the lowest PDI (20.8%) were recorded in the treatment where seeds were treated with 1% chitosan combined with foliar spray.

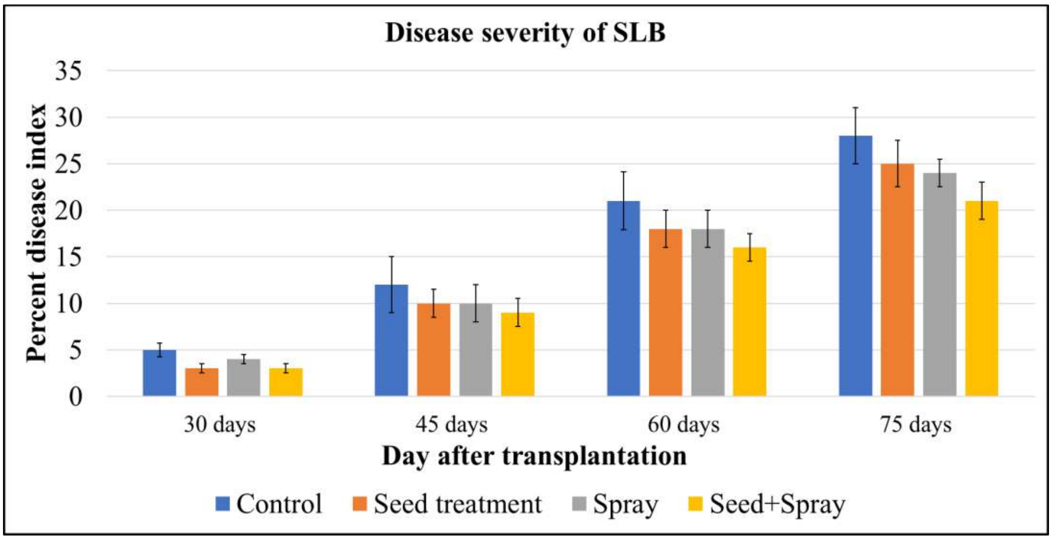


Fig. 3.7 Disease severity after chitosan treatment in field condition

3.2.5. Biochemical and molecular analysis

Higher growth and disease resistance in onion plants after chitosan priming were further evaluated at the biochemical and molecular level. Chlorophyll, flavonoid and phenol content were found to be higher in chitosan treated plants. Similarly, pathogenesis related protein (PR1 and PR4) gene expression levels were also found to be higher in chitosan treated plants. It suggests that chitosan nanoparticles induce systemic resistance in onions against SLB. The results suggest that a combination of seed treatment and foliar spray can be used to control the SLB of onion with growth promotion (Fig. 3.8).

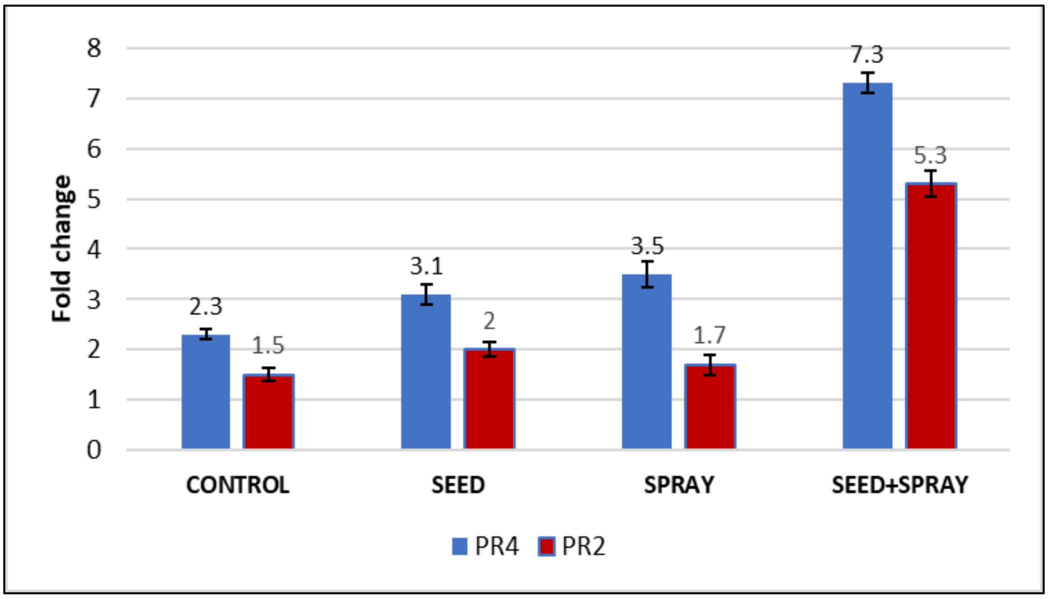


Fig. 3.8 Expression of PR1 and PR4 response to SLB infection in chitosan treated plants

3.2.6. Zn -Nanoparticles against Fusarium causing basal rot of onion

With the rapid advancement of nanotechnology, there is a growing interest in using nanoparticles to control plant pathogens. Here, we used zinc nano particles to control different fungal pathogen *Fusarium* causing basal rot of onion. These ZnO-NPs are synthesized in both chemical and biological methods were used in present study. Different concentrations like 10 ppm, 30 ppm, 50 ppm, 100ppm and 200ppm of ZnO and ZnO-NP (both chemically and biologically synthesised) were added in the PDA medium while the medium was poured into Petri plates. A mycelial disc with having a diameter of 4 mm was cut from the ten-day-old fungus cultures and inoculated these petri plates. Incubated for 10 days at 27 ± 1 ºC. A significant growth difference among the different concentrations was observed under in vitro conditions. In the PDA Petri plates, the results clearly show that as the concentrations of the ZnO-NP increased, the radial growth of the pathogen was decreased. The minimum radial growth was recorded at 200 ppm followed by 100 ppm. At 200 ppm there was more than 50% decrease in the radial growth of Fusarium. Thus, Nanoparticles can be exploited for the better control of onion pathogens.

3.2.7. Population genetic structure based on mitochondrial COI gene sequences in *Thrips tabaci* Lindeman

Thrips are globally important crop pests also acting as vectors of plant viral diseases, causing huge economic losses in agriculture. Thus, precise characterization of thrips is foremost and fundamental step to for effective disease management. Therefore, to unravel the genetic variation and structure of *T. tabaci* on onion hosts from different geographic locations across India by amplicon sequencing of *mtCOI* gene through next generation sequencing (NGS). The intra-species genetic variation in *mtCOI* gene of *T. tabaci* population in India investigated. A raw amplicon sequencing statistics was given (Fig. 3.9). The highest numbers of reads were generated in sample from Sikkim (247,362) and lowest reads were from Tamil Nadu (204,698). GC content was ranged between 33.6 to 34.5 %. More than 84 % of reads were passed the 30 phred score, indicating good data quality. Phred quality score numerically expresses the accuracy of each nucleotide. Higher Q number signifies higher accuracy of data.

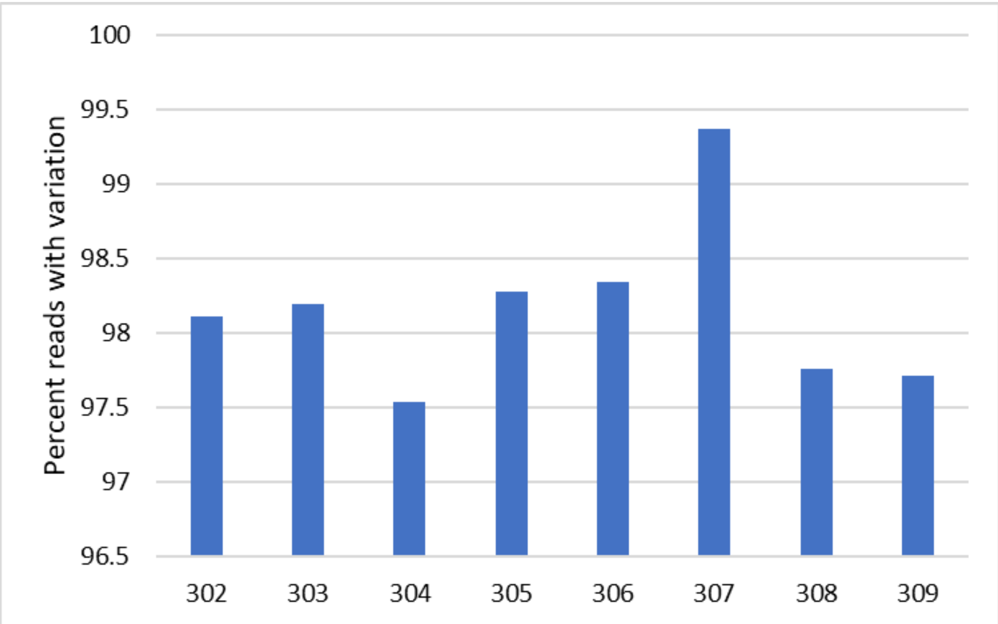


Fig. 3.9 Locality wise percent reads with variations

The high level of variations was found within *mtCOI* gene with respective localities in India. Locality wise percent variations have been calculated from total reads recorded. Among all localities, 307_Palampur represents highest nucleotide polymorphism followed by 306_Tamilnadu, 305_Maharashtra, 303_Haryana and 302_Gujrat. Compared to other localities, low level of mitochondrial genetic variation was observed in 304_Delhi isolates.

3.3. Epidemiology and bio-management of major fungal diseases of onion-garlic

3.3.1. Deciphering the infectious process of major fungal diseases of onion-garlic through basic, biochemical and molecular approach

Identification of phenotypic factors that aids infection process

Pathogenicity of anthracnose-twister was confirmed after inoculating the 40 days old onion seedlings (*var*. Bhima Super) with the fungal suspensions of *Colletotrichum gloeosporioides* with 100% disease incidence. The first symptom appeared three days after inoculation, initially observed a slight neck elongation and on 4 DAI observed the twisting of the leaves as well as the development of water-soaking sign with depressed lesions on the leaves. Gradually elongation of lesions occurred from 5 DAI, and the leaves showed sunken oval lesions on the leaf blades and depressed lesions on the leaf sheaths at the neck; later, these lesions developed with salmon/orange-coloured conidial mass on 6 DAI on 7 DAI lesions becoming necrotic or matured. These lesions contained clusters of acervuli of *C. gloeosporioides* (8 DAI). Further it leads to rotting of stem. Dieback and wilting symptoms were also observed, with final PDI of 54.32. The most extended neck (3.69 cm) and twisting of leave at the neck later these lesions developed with salmon/orange-coloured conidial mass from 6 DAI, and on 7 DAI lesions becoming necrotic or matured. These lesions contained clusters of acervuli of *C. gloeosporioides* (8 DAI). Further, it leads to rotting of the stem. Dieback and wilting symptoms were also observed with higher magnitude of disease (PDI, 54.32) (Fig. 3.10). The most extended neck (3.69 cm) and twisting of leaves were very evident in inoculated as compared to control. Seedlings inoculated with sterile distilled water remain unaffected. The two pathogens were re-isolated from the diseased onion plants to satisfy Koch's postulates.

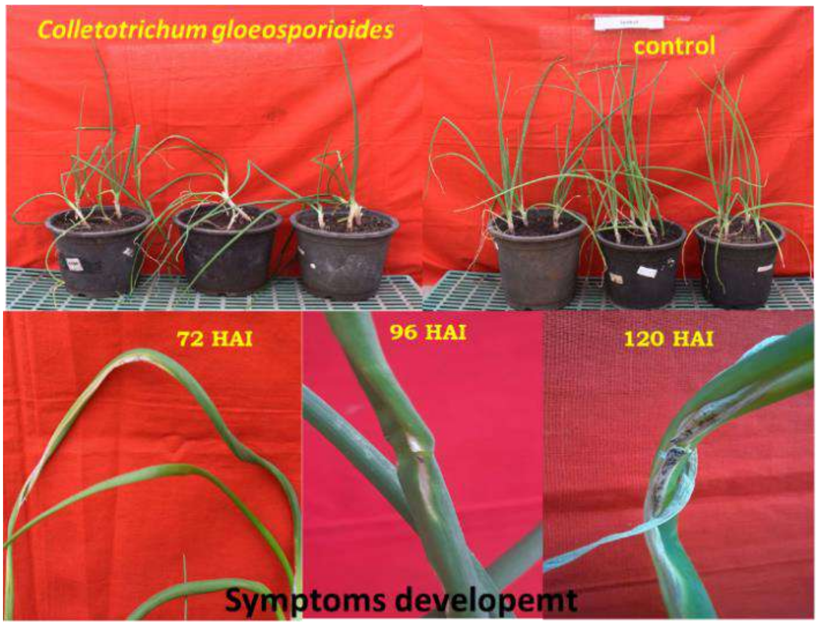


Fig. 3.10 Infection process of *C. gloeosporioides* on onion plants

3.3.2. Understanding the role of secondary metabolites of biocontrol agents against major fungal diseases of onion-garlic

Extraction of secondary metabolites from Trichoderma spp.

Eleven native *in vitro*-promoting traits *viz*., Indole acetic acid (IAA) Siderophores production, phosphorus, potassium and zinc solubalization were determined. IAA content of different *Trichoderma* strains was varied from 23.52 to 45.65 µg/ml. *T. asperullum* and NRCG-8 strains produced the highest IAA concentrations of 45.65 and 45.54 µg/ml were detected respectively, in culture filtrates. Siderophore production varied from 30.00 to 40.45 % production. Maximum siderophore production was observed in *T. asperullum* (40.45%), NRCG-8 (39.40%) *T. harzianum* S-1 (39.40%) *T. harziamun* S-2 (38.51%) and T-354 (38.43%) that improved the plant growth, yield and storage quality of onion. T-18, T-166, T-292, and *T. asperullum* had the ability to produce phosphate solubalization zone of 3.59, 3.10, 2.15 and 1.40 cm remaining six strains viz., *T. harzianum* S-1, *T. harziamun* S-2, *T. viride*, T-4R, NRCG-8 and T-29 had no ability of phosphate solubalization (Fig. 3.11). All eleven strains could solubilize the zinc on the medium. *T. harzianum* S-1 showed maximum zinc solubalization zone of 5.6 cm followed by *T. viride*, *T. harzianum* S-2 andT-18 (Fig. 3.12).

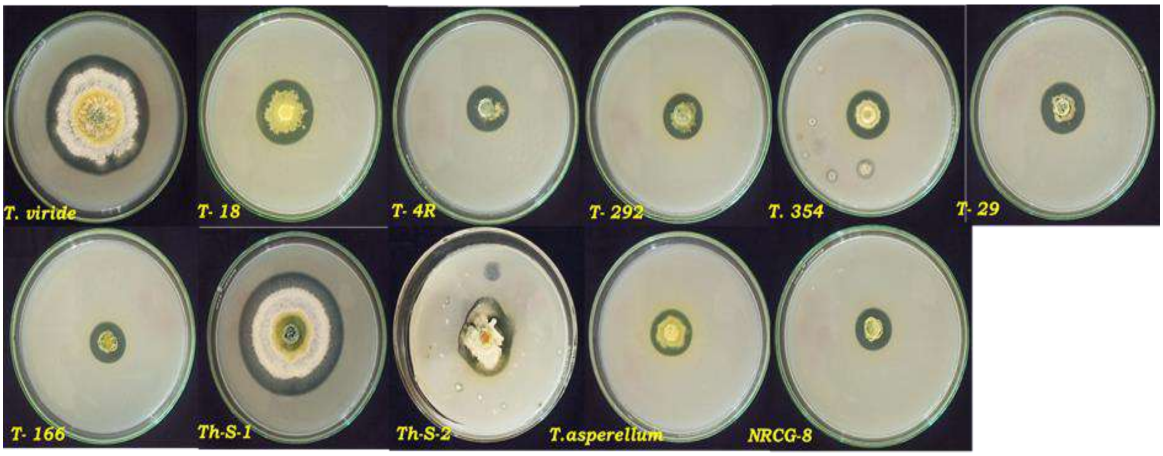


Fig. 3.11 Zinc solubalization ability of *Trichoderma* spp.

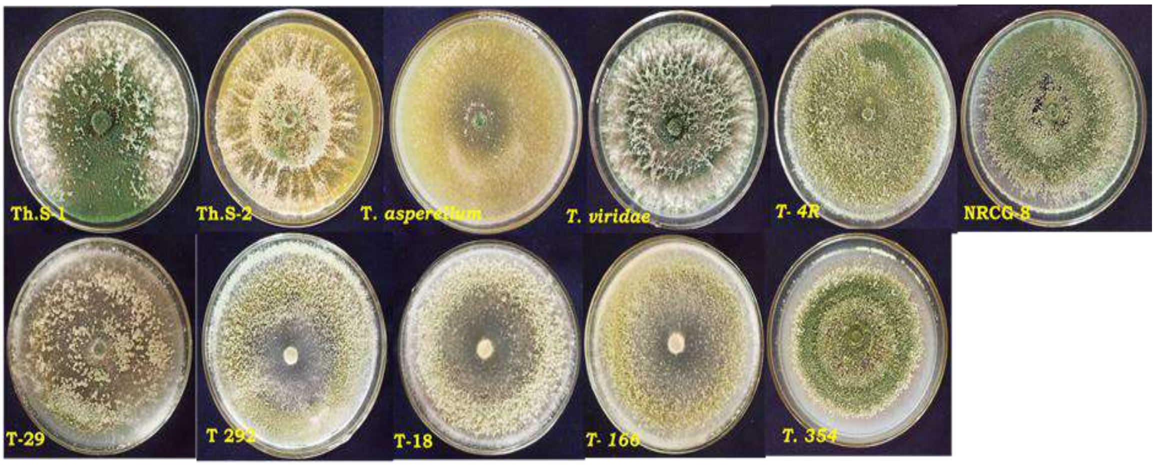


Fig. 3.12 Phosphate solubalization ability of *Trichoderma* spp.

3.4. Bio-intensive IPM strategies for insect pests of onion and garlic

3.4.1. Evaluation of entomopathogens against onion thrips

The bioefficacy of three entomopathogenic fungi: *Lecanicillium lecanii*, *Beauveria bassiana*, *Metarhizium anisopliae*, and plant-origin insecticide, i.e., neem oil and their 1:1 combination with neem oil were tested against onion thrips *Thrips tabaci*. Spinosad, a biological pesticide, is taken as a positive control. Results revealed that all three insect pathogens were effective against nymph and adult populations of onion thrips and significantly superior over untreated control. In the insect-pathogen treated plots, the adult thrips population was reduced by 30.3 to 36.2%, while nymphs were reduced by 35.5 to 41.9%. The overall mean reduction was 32.9 to 39.1% over control. Among the entomopathogens, *L. lecanii* was promising against onion thrips, followed by *B. bassiana*. The combination of neem oil and *L. lecanii* showed better efficacy against the thrips adults and nymphs, and that produced up to 41.2% population reduction, followed by the neem oil *and B. bassiana* combination. Spinosad was the most effective treatment against thrips adults and nymphs, which produced a population reduction of 79.1% and 88.6%, respectively. The order of efficacy of insect pathogens and their combinations was spinosad > neem oil plus *L. lecanii* > neem oil plus *B. bassiana* > neem oil plus *M. anisopliae* > neem oil >*L. lecanii* > *B. bassiana* >*M. anisopliae* (Fig.3.13).

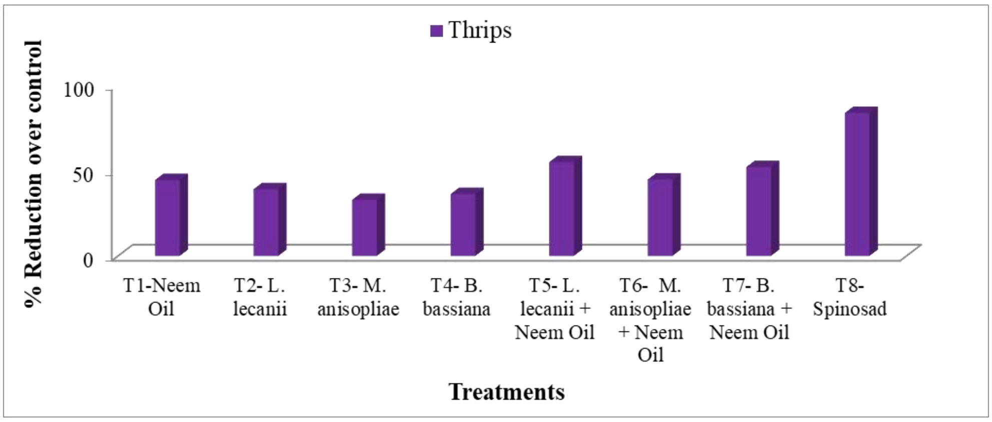


Fig. 3.13 Bio-efficacy of insect pathogens and biological pesticide against onion thrips

3.4.2. Evaluation of reduced-risk insecticides against onion thrips

The bio-efficacy of two new-generation insecticides, namely Spiroteramat 150 OD and Spinetoram 11.7 SC, along with Profenofos 50EC, were tested against the onion thrips in the late-*kharif* season. (Fig. 3.14).

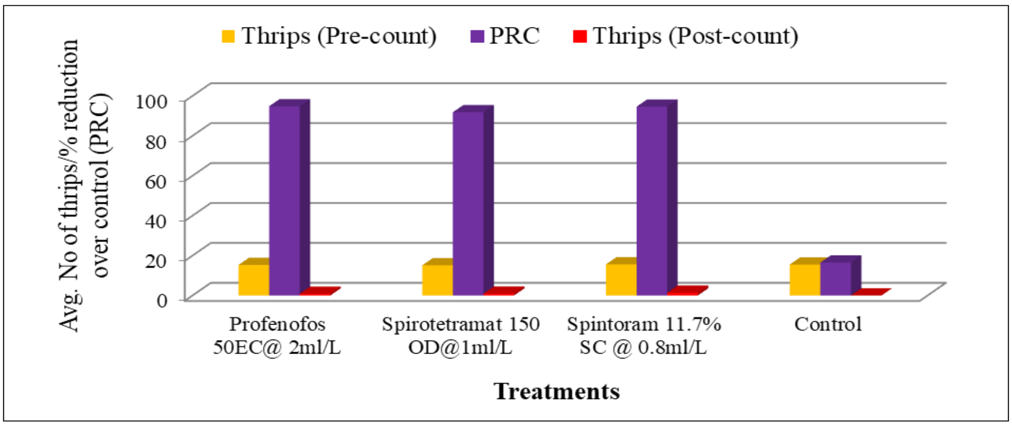


Fig. 3.14 Bio-efficacy of reduced risk insecticide against onion thrips

Both the insecticides were effective against onion thrips, and their efficacy was on bar with Profenofos. Spirotetramat produced a 92% thrips population reduction over control, while Spinetoram and Profenofos treatment registered a 95% reduction

3.4.3. Management of onion thrips through seedling treatment

Cyantraniliprole is a diamide insecticide (reduced-risk insecticide) with a novel mode of action against chewing and sucking pests. The upward translocation of Cyantraniliprole by xylem to new leaves was also reported and found effective against pests when applied as a seed treatment. A study was conducted to develop a seedling root dipping strategy for protecting transplanted onions from onion thrips in the main field. Treatment consisted of five doses of Cyantranilirprole (0.4, 0.8, 1.2, 1.6 and 2.4 ml/lit) and Carbosulfan 2 ml/lit as a positive control and untreated control. The newly uprooted onion seedlings were root dipped (cv. Bhima Kiran) in each concentration separately for 2 hrs and transplanted in the main field. The onion seedlings treated with insecticides were monitored for thrips infestation up to 35 days after transplanting, and the population was recorded. The results revealed that uprooted seedlings treated with Cyantraniliprole 10% OD at various doses recorded fewer thrips larvae compared to Carbosulfan-treated and untreated control; fewer adults compared to untreated control. The treatment concentration of 1.6 ml/lit recorded the least number of nymphs (11.1 thrips/plant) and adult thrips (14.9 thrips/plant). The mean number of thrips in Carbosulfan treatments was 14.3 thrips/plant (nymph) and 17.7 thrips/plant (adult) (Fig. 3.15).

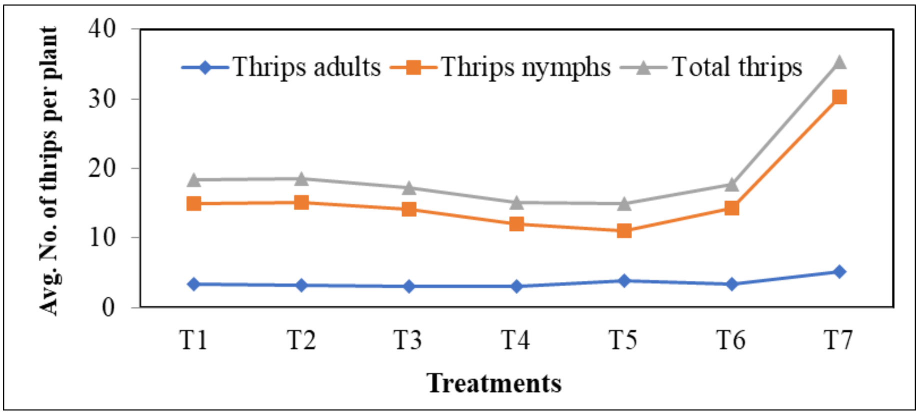


Fig. 3.15 Effect of Cyantranilirpole seedling dipping on thrips in transplanted onion
T1- Cyantranilirpole @ 0.4 ml/lit; **T2-** Cyantranilirpole @ 0.8 ml/lit; **T3-** Cyantranilirpole @ 1.2 ml/lit; **T4-** Cyantranilirpole @ 1.6 ml/lit; **T5-** Cyantranilirpole @ 2.4 ml/lit; **T6-** Carbosulfan @ 2.0 ml/lit

3.4.4. Evaluation of newer chemistry molecules against *Thrips tabaci* in seed crop

Field experiment was conducted during *rabi* to evaluate the efficacy of newer insecticides *viz.*, Chlorantraniliprole 18.5% SC (150 ml/ha), Spinosad 45% SC (160 ml/ha), Imidacloprid 17.8% SL (100 ml/ha), carbosulfan, Fipronil 5% SC (1000 ml/ha) and Neem oil 0.5% (5000 ml/ha) along with standard check Profenofos 50% EC (1000 ml/ha) against *Thrips tabaci* in onion seed crop at ICAR-Directorate of Onion and Garlic Research, Pune. Insecticides treatments were repeated thrice during the cropping season when pest population crossed the economic threshold level (ETL=30thrips /plant). The results showed that all insecticides significantly ($p<0.001$) reduced the onion thrips population than untreated check. Both, carbosulfan and Profenophos were found to be on par followed by Imidacloprid in seed crop. With regard to the seed yield, carbosulfan treated plants yielded maximum with 3.5 g/ plant.

3.5. Post harvest management of storage insect pests and diseases in onion and garlic

3.5.1. Documentation of insect pests and fungal pathogens from stored onions

Record of new insect pest from onion storage

Carpophilus hemipterus is a minute beetle with short, truncate elytra that only partially cover the abdomen. The larvae are whitish or yellowish with a brown head, final length of 5-7 mm. Species generally infest dried fruits (Fig. 3.5.1 a). The adults are brown, black-brown, or black, the antennae are 11-segmented, and the legs are yellow-red. The short elytra are generally yellow-brown, and the body is 2-4 mm in length. Elytra is dark brown, and each elytron' with a large, and distinct pale yellowish spot at the apex and a similar smaller spot at the base (Fig. 3.16). Beetles are strong fliers, capable of covering several kilometres in search of food. The eggs are laid on fresh or rotted onion bulbs. Infestation is generally carried from the field to storage. Mature larvae emerge from the bulb and pupate in the soil. Adults can live 6-12 months and deposit 500-1000 eggs. Adults and larvae occur in all seasons, and several generations are produced annually. Development from egg to adult takes 16-21 days at 27 °C and 12-15 days at 32 °C. Simultaneously confirmed through DNA barcode, which involves DNA sequence analysis of a portion (typically between 600-900 bp) of the mitochondrial gene *cytochrome c oxidase subunit I (COI*). LCO 1480 and HCO 1298 primers were used for the study. Amplicons were sequenced and identified as *Carpophilus hemipterus*.

Grub **Adult Beetle**

Fig. 3.16 (a) Grub of *Carpophilus hemipterus;* (b) Adult beetle

3.5.2. Isolation and identification of fungi from stored onion

The onion bulbs harvested in the *rabi* season of 2021-22 were stored in the naturally ventilated onion storage structure. The stored onion bulbs were sorted periodically to get the rotted bulb samples. The fungal pathogens from the rotted bulb samples were isolated in the laboratory on potato dextrose agar medium. They were allowed to proliferate, followed by sub-culturing to obtain a pure culture. For identification of fungal isolated, the DNA was extracted, and the ITS region was amplified by PCR using primer pair ITS-1 (TCCGTAGGTGAACCTGCGG) and ITS-4 (TCCTCCGCTTATTGATATGC). The amplified PCR product was then sequenced, and BLAST analysis was carried out. Among the five isolates, two are *Aspergillus niger*, and one each of *Fusarium falciforme, Aspergillus welwitschiae* and *Aspergillus ochraceus* were characterized (Fig. 3.17).

Fig. 3.17 Fungal isolates from stored onion

3.5.3 Monitoring of pesticide residues levels in onion bulbs from different parts of Maharashtra

Pesticide residue levels in onion bulbs were analyzed from different onion producing areas of Maharashtra, namely Pune, Solapur, Nasik, Ahmednagar, Dhule, Jalgaon, Amravati and Akola. The survey's main objective is to understand the common pesticides/ agrochemicals used in onion-based agroecosystems and to monitor the pesticide residue levels in the bulbs (Table 3.5.1). The survey results demonstrated widespread incorrect pesticide use, storage, and disposal practices at the investigated locations.

Table 3.5.1: Pesticide levels detected in onion bulbs from different onion producing areas of Maharashtra

District	Market/ village	Detection of pesticide	Residues (μg/kg)	MRLs mg/kg	Method
Pune	Alephata Market	No Pesticide detected	NA	NA	LC-MS/MS
	Manchar Market				
	Farmer storage; (Shirur)				
	DOGR, Pune				
Solapur	Farmer storage (Karmala)	No Pesticide detected	NA	NA	LC-MS/MS
Nashik	Niphad Market	Carbofuran	0.025	0.3	LC-MS/MS
	Lasalgaon Market	No Pesticide detected	NA	NA	LC-MS/MS
Dhule	Farmer storage; Dhule				
Jalgaon	Farmer storage; Chalisgaon	Chlorpyrifos	0.01	0.05	GC-MS/MS
Ahmednagar	Farmer storage; Nagar	Carbofuran	0.008	0.3	LC-MS/MS
	Tisgaon Market	No Pesticide detected	NA	NA	LC-MS/MS
Akola	Farmer storage; Akola				

Types of pesticide used by farmer during the onion cultivation:

Insecticide: Profenofos***; Carbofuran**; Chlorpyrifos; Phorate; Cypermethrin; lambda-Cyhalothrin***; fipronil**; Carbosulfan; **Fungicide:** chlorothalonil; Sulphur; mancozeb***; pyraclostrobin 5% + mitiram 55%***; carbendazim; **Herbicide:** Oxyfluorfen***

With the help of the QuEChERS technique, pesticide concentrations could be measured. Three samples (S6, S9 & S10) out of 12 tested positive for the two major insecticides, Carbofuran (0.07-0.025 g/kg) and Chlorpyrifos (0.01 g/kg). Sub-MRL levels of organophosphates and carbamates (as defined by Codex Alimentarius and the European Union) were found. The research conducted in Maharashtra found that the cultivation methods used in onion-producing villages and the consumption of onions pose no risks to human health.

3.5.4. Sequencing and characterization of the complete mitochondrial genome sequencing of the onion thrips (*Thrips tabaci*)

Thrips is an important and major pest of the Onion crop. The complete mitochondrial genome of Onion thrips, *Thrips tabaci* was sequenced for first the time (Fig. 3.18). The circular genome of *T. tabaci* measured 12,033 base pairs (bp) in length. Twelve protein-coding genes (PCGs), two *rRNA* genes and twenty *tRN*A genes. With an average gene length of 321 bp, the maximum, and minimum gene length of 1521 bp and 57 bp of *tRNA-S1* and *Cox-1*, respectively. The genes *tRNA-Pro, tRNA-Tyr*, *ND-4. ND-4l* and *ND-5* are located on the light strand. However, all other genes are on the heavy strand. Among the 12 PCGs, the *ATP-8* were repeated once. Likewise, among *tRNA, tRNA-Ser* was repeated four times.

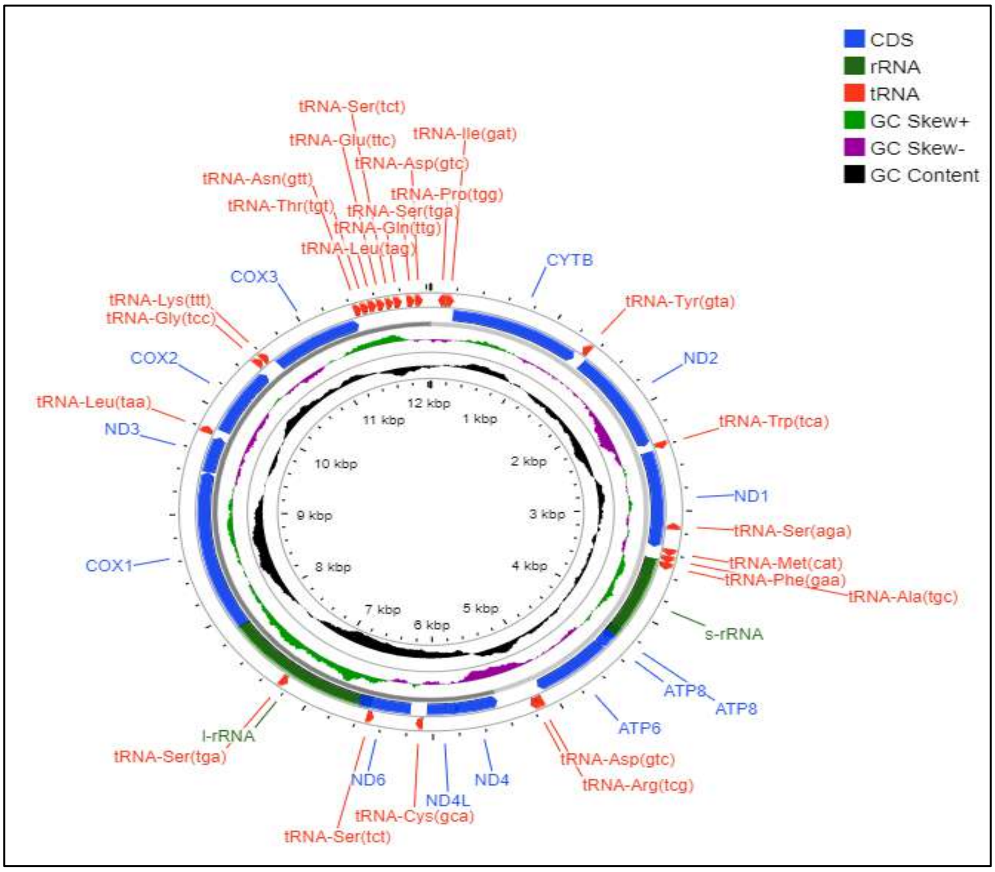


Fig. 3.18 Complete mitochondrial genome of *Thrips tabaci*

3.5.5. Record of a miniature parasitoid wasp, *Megaphragma amalphitanum*

The parasitoid wasp *Megaphragma amalphitanum* (Hymenoptera: Trichogrammatidae, subfamily Oligositinae) is one of the smallest known insects, whose size (250 µm adult length) is comparable with unicellular eukaryotes and even some bacteria. This parasitoid was revealed in association with *Thrips tabaci*, whose existence was realized through whole mt genome sequencing of thrips. The sequence obtained has been submitted to NCBI Genbank. The genus Megaphragma (tribe *Oligositini*) currently contains 15 species, all of which are egg parasitoids of Thysanoptera e.g; Genus *Megaphragma* is known to parasitize greenhouse thrips, *Heliothrips haemorrhoidalis*. A detailed study on the biology and rearing of this parasitoid is needed as this could act as a potential biological control agent to manage thrips.

Externally Funded Project: SERB-DST

3.6. Taping the potential of native stingless bee *Tetragonula iridipennis* Smith for pollination enhancement and profitable onion seed production

3.6.1. Survey and documentation of native stingless bee species visiting onion

Surveys were conducted for stingless bee activity in seed onions at a total of 9 locations in the Pune district, 7 locations in the Ahmednagar district, 17 locations in the Nashik district, 11 locations in the Satara district, and 8 locations in the Nandurbar district of Maharashtra. The presence of stingless bees was recorded in 20 of the 52 survey locations. They were the dominating species in the districts of Pune and Ahmednagar. However, only a few locations in Nashik (Takli and Vinchir), one location each at Satara (Khed), and Pilipadi, Shravani, and Gansavangi (Nandurbar) recorded the species activity. Location-wise, the stingless bees that visited onion umbels have been collected and further taken into DNA barcoding for species identification. The 650bp cytochrome *c* oxidase I (*COI*) gene was amplified and sequenced. *Cytochrome c oxidase I* DNA barcode sequence of the species has been established. The sequences revealed the prevalence of five different species of stingless bees, including *Tetragonula*, *Trigona*, *Oxytrigona*, *Scaura* and *Melipona*, with a similarity range between 83 to 90% with the available nucleotide sequences. The morphometry of the stingless species *T. iridipennis* was recorded, including body length, head length, head width including eyes, Antennal length, lapping tongue length, thorax length, thorax width, mesoscutellum length and width, fore and hind wing length and width, number of hamuli, tibial, tarsus, and abdominal length and width.

3.6.2. The complete mitochondrial genome of *Tetragonula iridipennis*

The stingless bees (Hymenoptera: Apidae: Meliponini) are a predominant non-*Apis* pollinating species and are considered a viable substitute to tone down the pollination deficit in many horticultural ecosystems including onion. The Stingless bee *Tetragonula iridipennis* (Smith) is an economically important species known as the Indian Dammer bee. Stingless bees' smaller size and overlapping morphometric characteristics are becoming challenging and time-consuming to identify these species. Furthermore, many taxa's evolutionary histories remain unexplored and not evident in the Meliponini tribe. In this context, the complete mitochondrial genome of *T. iridipennis* (15,045 bp) was characterized using next-generation sequencing (NGS) (Fig. 3.19). The de novo assembly encodes 34 genes: 13 protein-coding genes, 19 transfer RNA (*tRNAs*), and two ribosomal RNA. The average gene length was 400 bp; the maximum and minimum length was 1530 bp of *cox1* and 57 bp of *tRNA-S1*, respectively. The nucleotide composition of *T. iridipennis* was biased towards A+T with 75.95% of the whole mitogenome. *T. iridipennis* mitogenome exhibited the highest gene rearrangement score (78), suggesting this species has an overactive evolutionary history. The newly sequenced *T. iridipennis* was closely related to the *T. pagdeni* and *Lepidotrigona* species. The complete mitochondrial genome of *T. iridipennis* provides valuable molecular information for future studies on Meliponini insect taxonomy and a framework to unveil more of their unknown diversity and conserve this species.

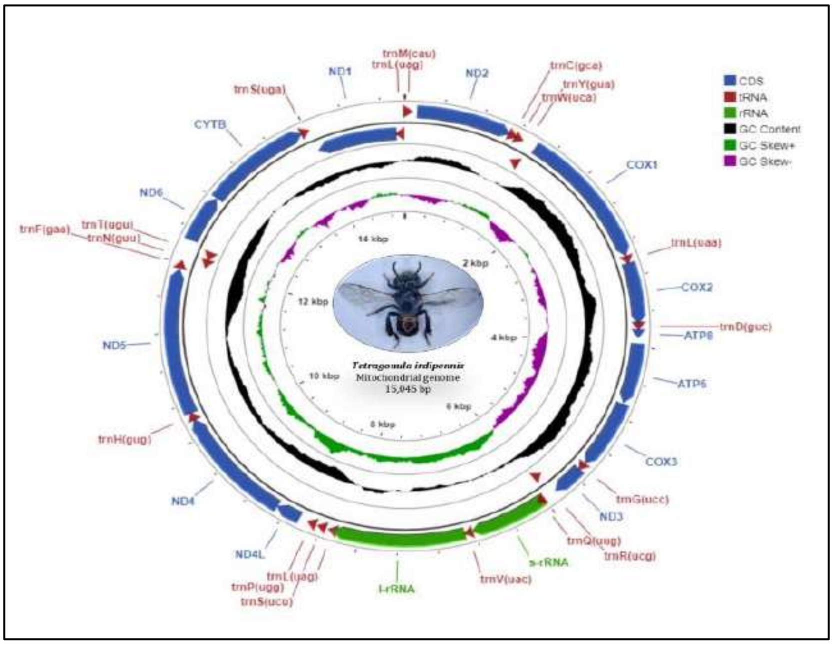


Fig. 3.19 Mitochondrial genome map of *T. iridipennis*

3.6.3. Study of foraging behaviour and pollination potential of stingless bee in onion

Foraging behaviour of stingless bee

The stingless bee**,** *T. iridipennis* hives, were obtained from private beekeeping and were relocated to an onion seed production plot (open-field) when the flowering approached 25% blooming. The parameters of foraging behaviour, including foraging time, visits per unit of time and, working behaviour (Top-worker or Side-worker), purpose of visit (Pollen or nectar), were studied for three consecutive days. The foraging abundance observations began at 7:00 A.M. They continued until 5:00 P.M. The data showed that forage visits commenced at 9.00 AM, with the highest number of bee visits (number of stingless bee visits/sq m area/5min) observed around 12.30 PM. After 3 P.M., the rate of bee visitation decreased (Fig. 3.20). The trend in visiting rate/min was similar. The observation of the purpose and behaviour of visits revealed that most visits were made to collect pollen grains, with top-working behaviour being the most common.

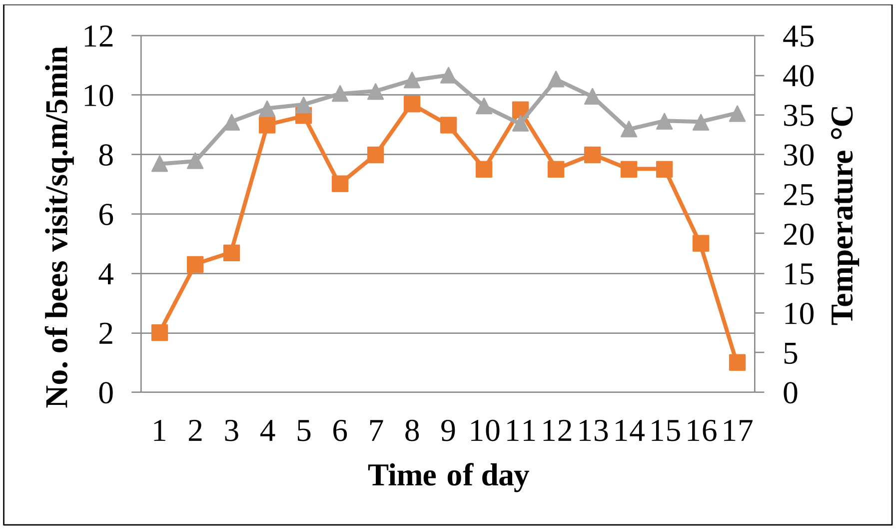


Fig. 3.20 Diurnal activity of stingless bee in onion

3.6.4. Assessment of pollination potential of stingless bees in onion

To assess the potential of stingless bee pollination in onion, an experiment has been laid out (2021-22) under nylon cages (5 × 5 m cages) with four treatment regimes including T1-European been (*Apis mellifera*), T2-Native stingless bee (*Tetragonula iridipenis*); T3-Hand pollination and T4-Pollination exclusion (no pollinators activity). The desired layout for each regime was covered with nylon before umbel initiation to avoid the forage visitation of non-targeted bee species. The seed yield parameters, including total seed yield (kg/ha), per cent umbel set, an average number of seeds per umbel, seed weight/umbel (g) and test weight of seed (g), were also recorded in each pollination regime to assess the pollination potential. The results revealed that placing stingless bee colonies at 25% onion blooming yielded the highest seed output of 236 kg/ha (Fig. 3.21 and 3.22). It was better to hand pollination and pollinator-exclusion regimes. This shows that non-*Apis* stingless bees can be essential in onion pollination and seed development.

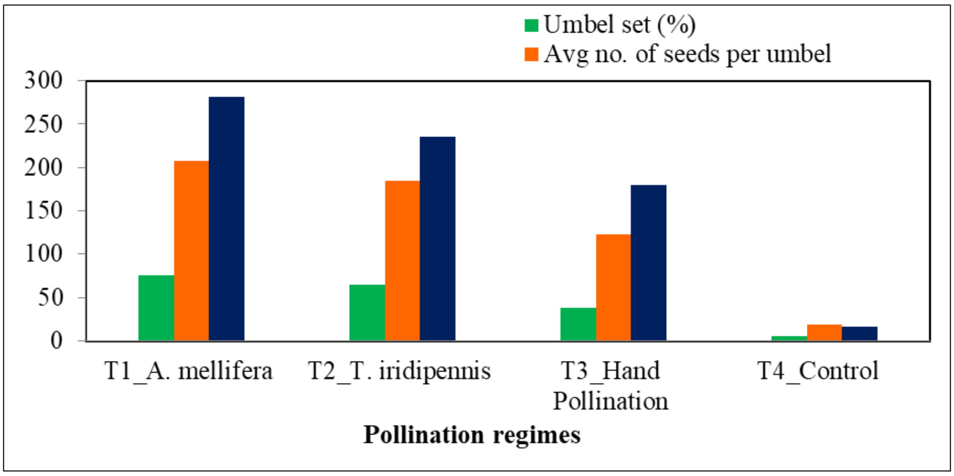


Fig. 3.21 Onion Umbel set in different pollinators regimes

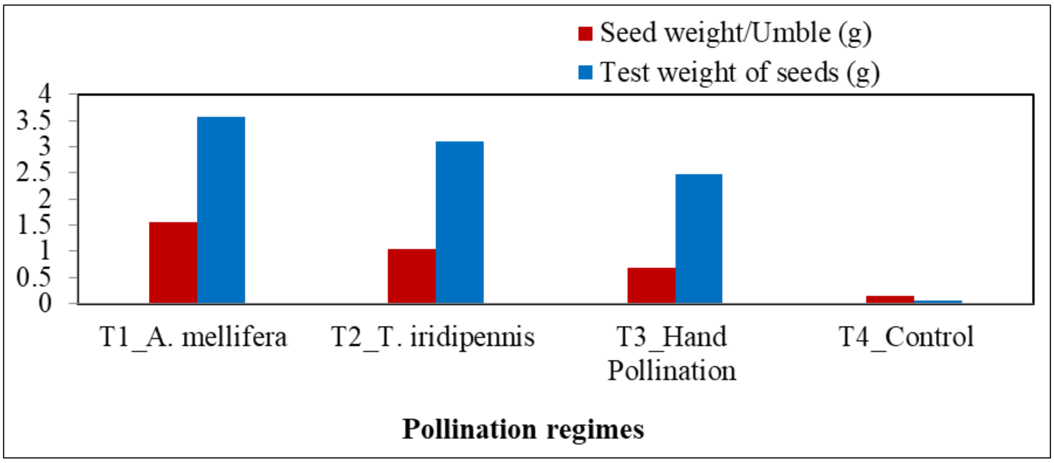


Fig. 3.22 Onion seed yield parameters in different pollination regimes

3.6.5. Determination of pollination efficiency index (PEI) of stingless bee in onion

The pollination efficiency index (PEI) estimated based on total loos pollen grains in each *A. mellifera* worker bee and stingless bee *T. iridipennis* and their abundance revealed that pollen loads of two species varied significantly, with pollen loads on larger bodied *A. mellifera* being threefold higher in *A. mellifera* compared to stingless bee *T. iridipennis*.

4. Post-Harvest Technology

4.1 Processing and value addition in onion and garlic

4.1.1 Development of process protocols for drying and rehydration of red onion cultivars

Biochemical quality evaluation of selected red onion cultivars

Drying is complex heat and mass transfer phenomena in which former is aimed at producing a high-density, high-quality product that have improved shelf-life upon adequate packaging and resultant product can be rapidly reconstituted without substantial loss of its quality. Though the production of red onion is more in India as compared to white onion cultivars, the white onion is preferred over the red by the onion dehydration industry due to various quality issues. The present investigation is focused on optimization of the process protocol for drying and rehydration of red onions. The biochemical analysis (parameters: moisture content, TSS, total pyruvic acid (PA) content, total thiosulfinates (TT), antioxidant activity (ABTS- (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)), FRAP: Ferric Reducing Antioxidant Power Assay), total flavonoid content, total sugar, reducing sugar) of selected cultivars i.e., Bhima Dark Red, Bhima Raj, Bhima Super, and Bhima Red, is carried out before drying experiments for selection of the cultivars.

Fig. 4..1: Selected red onion cultivars

Table 4.1: Observed values of selected biochemical parameters (PA, TT, ABTS and FRAP activity)

Parameters	Moisture content % wb	PA (µmol/g FW)	TT (umol/g FW)	ABTS (TEAC µmol/ g FW)	FRAP (TEAC µmol/ g FW)
Bhima Dark Red	83.35±0.25	3.97±0.57	5.65±0.09	11.39±0.97	0.75±0.04
Bhima Raj	84.65±0.15	2.55±1.09	3.02±0.6	8.09±1.22	0.75±0.02
Bhima Super	86.15±0.35	3.99±0.22	5.83±0.45	9.44±1.08	0.8±0.03
Bhima Red	85.45±0.23	3.47±0.65	3.53±0.64	9.4±0.47	0.81±0.03

PA-Pyruvic Acid; TT- Total Thiosulphinate; FW- Fresh weight, ABTS- (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)); FRAP- Ferric Reducing Antioxidant Power Assay

Table 4.2: Observed values of selected biochemical parameters (Phenols, flavonoids, sugar)

Parameters	Phenol GE (mg/g FW)	Flavonoids QE (mg/g FW)	Total Sugar g/100g FW)	Reducing Sugar (mg/g FW)
Bhima Dark Red	0.33±0	0.15±0.01	10.44±0.8	4.08±0.11
Bhima Raj	0.39±0	0.1±0.01	7.75±0.35	3.12±0.04
Bhima Super	0.3±0	0.1±0	5.76±0.99	2.82±0.09
Bhima Red	0.43±0.02	0.1±0	6.79±0.58	2.98±0.04

GE-Galic Acid Equivalent; QE- Quercetin Equivalent; FW- Fresh Weight

Optimization of pre-treatment and process parameters for drying and rehydration process for selected cultivars

The process flow carried out for the drying experiments using various preservatives is shown in figure (Fig. 4.2). For preliminary experiments for the optimization of red onion slices (3 mm thick) dehydration process was carried out using hot air-drying method at 50, 60 and 70°C. The onion slices (Bhima Super variety) were pretreated with 0.5, 1, 2% levels of NaCl and dried at 50, 60 and 70°C in hot air drier. After drying, the samples were stored in the poly propylene (PP) bags of 80 micrometer at ambient conditions. The sensory evaluation of the freshly dried samples showed that the samples pretreated with 1 and 2% NaCl levels were better in terms of color, texture and appearance. During storage, samples dried at 70°C and with 1 and 2% NaCl pretreatments showed brownish appearance after 30 and 45 days of storage. The rise in reducing sugar levels was observed at 45 days of storage in both the samples. The moisture content also increased from an initial 6.75% to 8.55%. Hence, use of NaCl pretreatment alone won't be able to maintain the quality of the dried flakes during storage. However, in combination with other pretreatments, it shown good results as it has the ability to maintain colour of the dried product intact as compared to other pre-treatments.

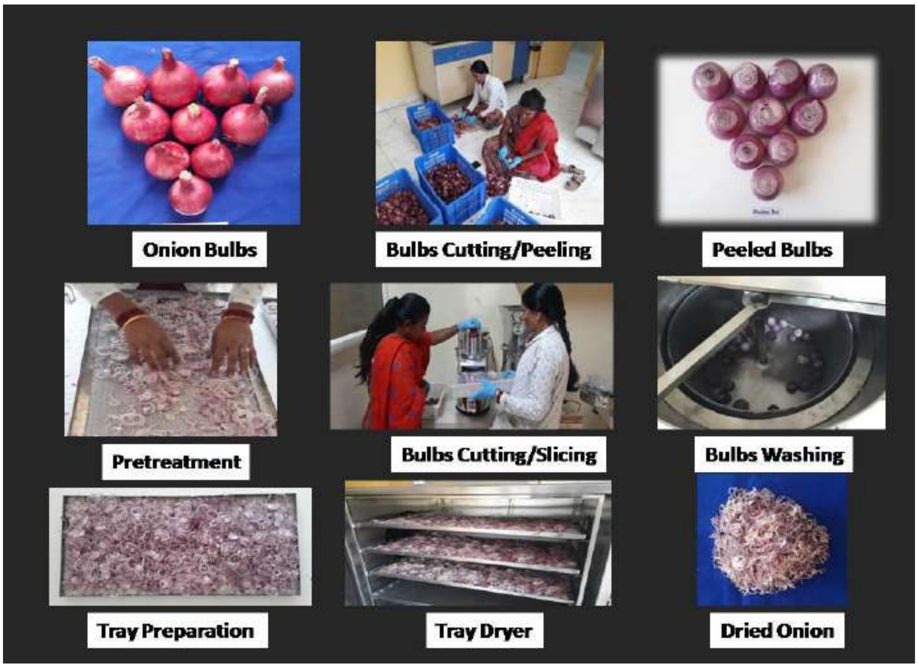


Fig. 4.2: Process flow chart for dehydration of onion

4.1.2 Optimization of protocol for extraction of onion seed oil

The experiment was planned for the optimization of process for extraction onion seed oil using mechanical extraction, soxhlet extraction etc. for better yield and oil quality. The estimation of the total oil content in the seeds of different onion cultivars (Bhima Kiran, Bhima Light Red and Bhima Super) was carried out using soxhlet apparatus (Make: Pelican soc plus 4). The onion seeds were initially dried to moisture content in a range of 5.5-7% wb. Seeds were coarsely grounded (15 g each in 3 replicates) and oil extracted using soxhlet apparatus (Make: Pelican soc plus 4). Highest oil content was observed in Bhima Super seeds (17.5-18.3%). Bhima Kiran and Bhima Light Red seeds yielded around 15-17% oil content, The mechanical extraction at 80°C setting resulted in oil recovery of 12.5, 13.8 and 14.7 ml per 100 g seeds in Bhima Kiran, Bhima Light Red and Bhima Super variety respectively.

4.2 Mechanization in onion and garlic

4.2.1 Optimisation of aerodynamic characteristics for onion storage

Physical characteristics of the selected onion cultivars for design of ventilation unit were studied. The physical characteristics of fruit and vegetables have a key role in understanding the flow behaviour of any fluid flowing through defined porous bed. The physical characters like axial dimensions, GMD, AMD, bulk density, bulb density, and porosity of Bhima Shakti and Bhima Kiran cultivars were measured for air ventilated storage and are shown below (Table 4.2).

Table 4.2: Physical characteristics of onion bulbs

Variety	ED (mm)	PD (mm)	TK (mm)	GMD (mm)	AMD (mm)	BD (kg/m^3)	TD (kg/m^3)	PO (%)
Bhima Shakti	52.7 ± 3.6	42.4 ± 3.5	43.3 ± 2.8	45.8 ± 2.9	45.2 ± 3.6	463 ± 17.3	814 ± 9.6	45.32 ± 6.1
Bhima Kiran	49.3 ± 2.8	43.2 ± 2.4	42.8 ± 2.6	43.8 ± 2.4	44.3 ± 2.8	5128 ± 11.7	938 ± 7.1	44.72± 4.3

ED: Equatorial diameter; PD: Polar diameter; TK: Thickness; BD: Bulk Density; TD: True density; PO: Porosity; GMD: Geometric Mean Diameter; AMD: Arithematic Mean Diameter

4.2.2 Selection of aerodynamic parameters

The knowledge of airflow resistance and distribution pattern in a highly porous-bed commodity like an onion is an important consideration in designing an appropriate ventilation system and for proper selection of fans. Based on reviewed literature and preliminary experiments the range of airflow to decide the Resistance to airflow through bulk onions was selected for further study is 0.04-1.0 m^3/sq. m^2 with a bed thickness of 4 feet. Airflow rate has the most critical role when flowing through any porous media and its behaviour varies with the different properties of media materials. To study the effect of entrance airflow rate on airflow resistance, the airflow rate varied from 0.4 to 1.0 m^3/s. m^2 (0.40, 0.60, 0.80, and 1.0). The experiments are planned to optimize the aerodynamic characteristics for bulk onion storage with individual control air valves for each compartment (2.75-3.00 tonne/batch).

5. Extension

5.1 Novel approaches for transfer of onion and garlic technologies

5.1.1 Development of Decision Support Systems for onion cultivation

'ONDSS': A decision support system for balanced nutrient management in onion

The unbalanced use of fertilizers without considering soil health and the actual needs of crops is a significant factor contributing to low productivity. In order to tackle this issue, a decision support system called 'ONDSS' has been developed. It encompasses key features that assist farmers in making informed decisions regarding nutrition management, thereby promoting the balanced use of fertilizers according to the specific requirements of the crops. The decision-making process in the ONDSS is based on two main factors: the soil health report available to the farmer and the scientifically recommended nutrient dose derived from the general nutrient uptake pattern of the onion crop. By considering either of these factors, farmers can determine the appropriate nutrient application for their crops. To facilitate this, the ONDSS provides a dose calculator that suggests the precise amount of fertilizer to apply. This calculation takes into account the source of the fertilizer, the method of application, and the area of the crop. By utilizing this tool, farmers can ensure that they are applying the correct quantity of fertilizer tailored to their specific farming practices. In addition to nutrient management, the ONDSS also guides farmers in identifying and managing nutrient deficiencies. It includes a symptom-based deficiency identification system, enabling farmers to recognize signs of nutrient deficiencies in their crops. Moreover, the decision support system offers recommendations and strategies for managing these deficiencies effectively.

'ODPAdviser': A Decision Support System for disease and pest management in onion

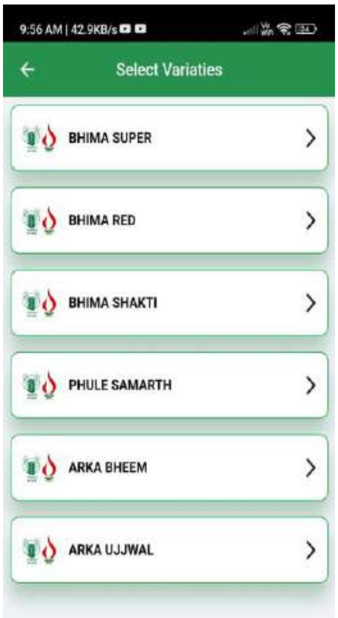
Pests and diseases pose significant threats to onion crops, often resulting in yield losses. Making timely decisions regarding pest and disease management is crucial in determining the fate of the crop. To assist farmers in making the right decisions to control these issues, a decision support system called 'ODPAdviser' has been developed specifically for disease and pest management in onions. The ODPAdviser system is designed to guide farmers through the process of identifying pests and diseases. It utilizes representative photographs of symptoms to aid in accurate identification. By comparing the symptoms observed in their crops with the visual references provided, farmers can determine the specific pests or diseases affecting their onion plants. Once the identification is established, the ODPAdviser system offers recommendations for management practices and chemical applications. These recommendations are based on scientifically proven methods and best practices for pest and disease control in onions. Farmers can rely on the system to guide them in implementing effective strategies to combat the identified pests or diseases. By utilizing the ODPAdviser system, farmers can take timely action to manage pests and diseases, thus minimizing the negative impact on their onion crops.

'SmartOnion': Decision support system for variety selection in onion

In India, the adoption of improved onion varieties and recommended agricultural practices is limited due to the prevalence of local cultivars and a lack of knowledge regarding suitable varieties and agricultural techniques. To address these challenges, a decision support system called 'SmartOnion' has been developed. This system aims to assist farmers in making informed decisions when selecting onion varieties suitable for their specific locality, season and colour preferences as well as providing guidance on timely farming operations to improve yield. Based on the information provided by the farmer, the system processes the data and provides recommendations on the most suitable variety to cultivate.

'Onion Crop advisor' mobile application for farmers

"Onion Crop Advisor" mobile application—a comprehensive tool designed and developed to provide farmers with easy access to onion farming information, empowering them to make informed decisions about adopting improved package practices, market choices, weather updates, and day-to-day operations. The mobile application offers a variety of features to support onion farmers. It provides text and video-based advisories, giving farmers valuable guidance and recommendations on various aspects of onion cultivation. These advisories cover topics ranging from seed sowing to harvesting and post-harvest operations. Furthermore, the application includes blogs and a crop calendar, keeping farmers informed about the latest happenings, events, and programs organized by the Directorate. This ensures that farmers stay updated with relevant information and stay connected to the larger farming community. The mobile application also serves as a decision support system, offering tools and features that help farmers manage nutrients, pests, and diseases effectively. It provides recommendations and solutions based on scientific research and best practices, empowering farmers to make the right choices for their crops. It serves as a one-stop resource for farmers, providing them with access to critical information, insights, and tools necessary for successful onion farming.



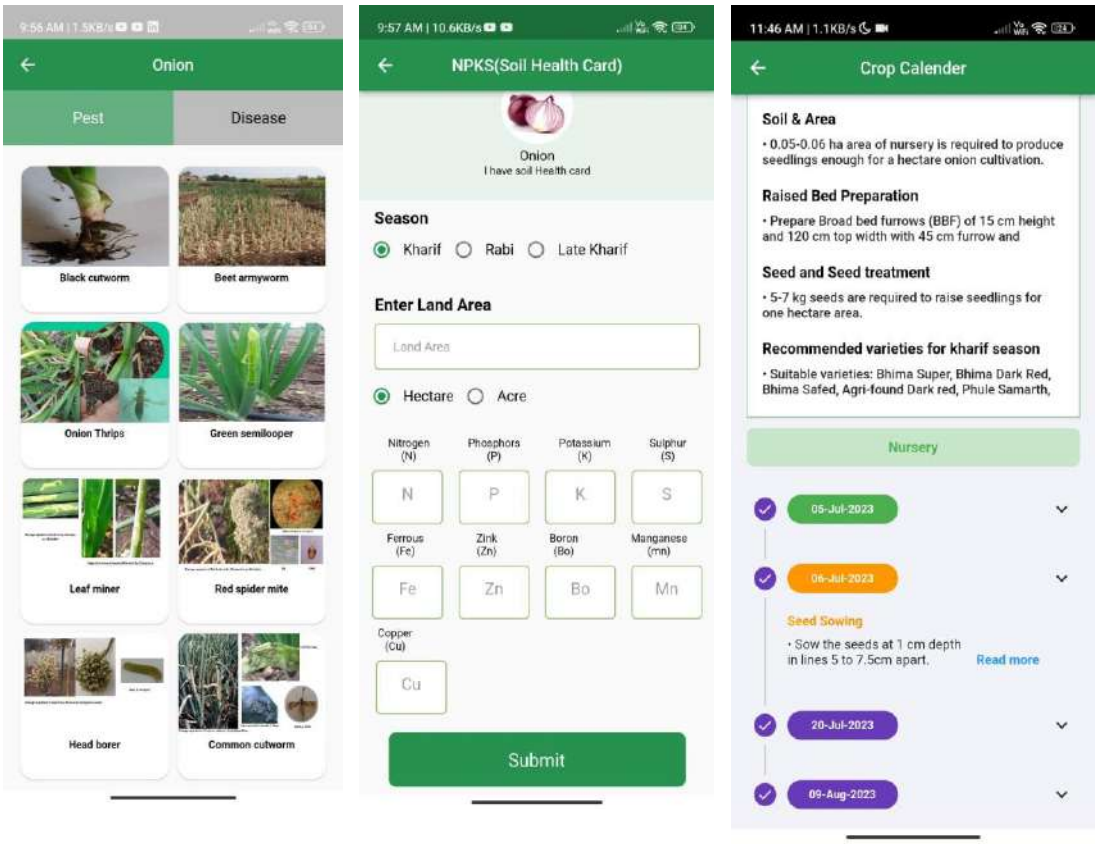


Fig 5.1 Onion Crop Advisor App

5.1.2 Initiative multimedia-based news bulletin

A new initiative has been launched to disseminate agro-advisory, technological information, and news updates from the Directorate through a multimedia-based news bulletin. This bulletin is published on the Directorate's YouTube channel in Marathi (कांदा व लसूण समाचार) and Hindi (प्याज एवं लहसुन समाचार) languages. In 2022, four episodes of the bulletin were released, and it continues to be regularly uploaded on the Directorate's YouTube channel and shared through WhatsApp groups for wider circulation. YouTube has proven to be an effective platform for disseminating this information, as evidenced by the significant engagement it has received. The bulletin has generated a total of 12,358 views, with viewers spending 366.8 hours watching the content. Moreover, the channel has gained 1,011 subscribers, indicating a growing audience for the information being shared. In addition to the regular news bulletin episodes, a multimedia-based success story highlighting the uplifting of marginalized farmers through technological interventions under the SCSP Scheme was also published on the YouTube channel. This story serves as an inspiring example of how technological advancements can bring positive change to the lives of marginalized farmers. The use of multimedia platforms such as YouTube has been instrumental in effectively disseminating agro-advisory, technological information, and news updates from the Directorate. The growing viewership, subscribers, and watch time demonstrate the utility of this initiative in reaching a wider audience and promoting knowledge sharing among farmers and stakeholders in the agriculture sector.

Fig 5.2 Multimedia-based News

5.1.3 Dissemination of agro advisories through Whatsapp groups and other social media platforms

WhatsApp, a popular social media platform, has been effectively utilized for the dissemination of technological information related to onion and garlic. To ensure targeted communication, specific onion-growing districts were identified, and block-wise WhatsApp groups were created to provide timely and location-specific crop production advisories. The advisory coverage extends to 18 districts, namely Pune, Nashik, Ahmednagar, Satara, Solapur, Osmanabad, Beed, Jalgaon, Aurangabad, Buldhana, Dhule, Parbhani, Ratnagiri, Nagpur, Jalna, Gondiya, Jalgaon, and Wardha. In these districts, a total of 80 major onion-growing blocks were selected, and farmers were included in the respective WhatsApp groups. Apart from WhatsApp, other social media platforms Instagram, Facebook, Twitter have also been employed to disseminate information.

5.1.4 Value chain model of wild *Alliums*

A value chain model for wild *Alliums*, specifically '*Allium tuberosum*,' has been successfully developed. This commercialized model ensures a regular supply of the produce in accordance with the demand from KisanKonnect Farmer Producer Company and Big Basket Pvt. Ltd, two major buyers in the market. Throughout the year, a total of 1534 kg of wild alliums were supplied to these buyers, resulting in a revenue collection of ₹159,653. The value chain model encompasses various stages, including cultivation, harvesting, post-harvest handling, packaging, branding and timely delivery to the buyers. By streamlining these processes and adhering to quality standards, the model ensures that the wild *Alliums* reach the market in optimal condition, meeting the requirements of the buyers and consumers. The collaboration with KisanKonnect Farmer Producer Company and Big Basket Pvt. Ltd has provided a reliable market outlet for the wild *alliums*. Additionally, the successful execution of the value chain model has created opportunities for income generation and market expansion for this under-utilised *Allium*.

5.2 Transfer of improved technologies of onion and garlic and their impact assessment

Extension activities not only help to disseminate the technology but also evaluate its impact for further refinement. This project aims at improving knowledge and skill of the farmers, extension workers and all others concerned with onion and garlic production through dissemination of improved technologies developed by the Directorate and conduction of various skill development activities. Total 355 demonstrations were carried out in Maharashtra state during *kharif* (285), late-*kharif* (30) and *rabi* (40) seasons through institute project (30), SCSP (280), and MGMG (45). The progress under this project is as below.

5.2.1 Demonstrations in *kharif* season

Onion varieties; Bhima Super and Bhima Dark Red were selected for *kharif* in 5 districts viz., Pune, Ahmednagar, Aurangabad, Beed and Solapur of Maharashtra state. Total 285 *kharif* demonstrations (10 from institute project, 260 from SCSP and 15 from MGMG) were carried out in these districts. For demonstration purpose, mostly 2 kg onion seed was provided for each demonstration by the Directorate. Farmers arranged the onion seed of local variety to compare the performance with the varieties of the Directorate.

5.2.2 Demonstrations in late-*kharif* season

Onion varieties; Bhima Super and Bhima Light Red were selected for late-*kharif* demonstrations in Pune district of Maharashtra state. Total 30 late-*kharif* demonstrations (15 from institute project and 15 from MGMG) were carried out in Pune district. For demonstration purpose, mostly 2 kg onion seed of each ICAR-DOGR developed variety were provided for each demonstration by the Directorate. Farmers arranged the onion seed of local variety for comparison of the performance with Directorate's onion varieties.

5.2.3 Demonstrations in *rabi* season

Onion varieties; Bhima Kiran and Bhima Light Red were selected for *rabi* demonstrations in Pune and Ahmednagar districts of Maharashtra state. Total 40 *rabi* demonstrations (5 from institute project, 20 from SCSP and 15 from MGMG) were carried out in these districts. For demonstration purpose, mostly 2 kg onion seed of each ICAR-DOGR developed were provided for each demonstration by the Directorate. Farmers arranged the onion seed of local variety to compare the performance with the varieties of the Directorate.

5.2.4 Performance of frontline demonstrations

The demonstrations in *kharif* season revealed that the germination percentage (98), average bulb weight (80 g) and yield (260 q/ha) of Bhima Super was the highest. Bhima Dark Red (255 q/ha) also yielded more than local variety (190 q/ha). In varietal demonstration trials; Bhima Super variety yielded more as compared to other varieties regardless of torrential downpour. Hence, ICAR- DOGR recommended planting of Bhima Super variety on raised beds under changing climatic conditions. The germination percentage (96), average bulb weight (85 g) and the yield (425 q/ha) of Bhima Light Red were the highest in late *kharif* demonstrations. Bhima Super (400 q/ha also yielded more than local variety (240 q/ha) in late *kharif* demonstrations. The demonstrations conducted in *rabi* in Maharashtra revealed that the germination percentage (94), average bulb weight (84 g) and marketable yield (350 q/ha) of Bhima Light Red were the highest and Bhima Kiran (345 q/ha) also yielded more than local variety (280 q/ha). The varieties developed by ICAR-DOGR were found superior over the local cultivars in all the demonstrations. The performance of trials at different locations is given in Table 5.1.

Table 5.1 Performance of frontline demonstration trials

Season	Variety	Germination (%)	Average Bulb Weight (g)	Marketable yield (q/ha)
Kharif	Bhima Super	98	80	260
	Bhima Dark Red	96	75	255
	Local	80	65	190
Late-*kharif*	Bhima Super	94	82	400
	Bhima Light Red	96	85	425
	Local	76	72	240
Rabi	Bhima Light Red	94	84	350
	Bhima Kiran	93	82	345
	Local	75	70	280

C. All India Network Research Project on Onion and Garlic

Germplasm evaluation

During the *Rabi* season, twenty-two red onion germplasm and fifteen white onion germplasm were evaluated for different characters at five distinct locations viz. Karnal, Kanpur, Jabalpur, Rajgurunagar and Coimbatore along with varietal checks.

Onion varietal

During *Kharif*, white onion AVT-I (2), in red onion AVT-I (6) and AVT-II (2) entries, in late *kharif*, white onion AVT-II (2), red onion variety AVT-II (2) and varietal performance AVT-II (9) entries, in *rabi*, white onion AVT-I (2) and AVT-II (2) and white onion Hi-TSS AVT-I (4), in red onion IET (5), AVT-I (6) and AVT-II (2), in early maturity trial, AVT-I (2) entries were tested along with check. In long day *rabi* white onion AVT-I (2) and AVT-II (2) and white onion Hi-TSS AVT-I (4), in red onion IET (5), AVT-I (6) and AVT-II (4) entries were tested along with check.

Onion Hybrid

In short day AVT-I kharif, two red onion entries and in AVT-I late *kharif*, two red onion entries were tested along with check. In AVT-I short day and long day *rabi*, four red onion entries were tested along with check.

Garlic Varietal Evaluation

In rabi, short day and long day garlic, Pre IET (3), IET (3), AVT-I (9) and long day garlic, IET (3), AVT-I (9) entries were tested along with check.

Crop Production

In crop production different trials including fertilizer scheduling through drip irrigation for onion seed crop, effect of direct sowing by onion seed drill on onion production, weed management in onion seed crop, effect of zinc and boron application on onion seed crop, determination of optimum fertilizer regime for long day onion and garlic cultivation in Kashmir and evaluation of bulbils as planting material in garlic were conducted.

Plant Health Management

Trials were conducted on survey and monitoring of major diseases and pests of onion and garlic, screening of onion and garlic varieties for disease and thrips resistance, management of pest and disease in onion and garlic, evaluation of different treatments on major foliar disease of onion and garlic and insecticides/miticides against sucking pests and mites of onion and garlic.

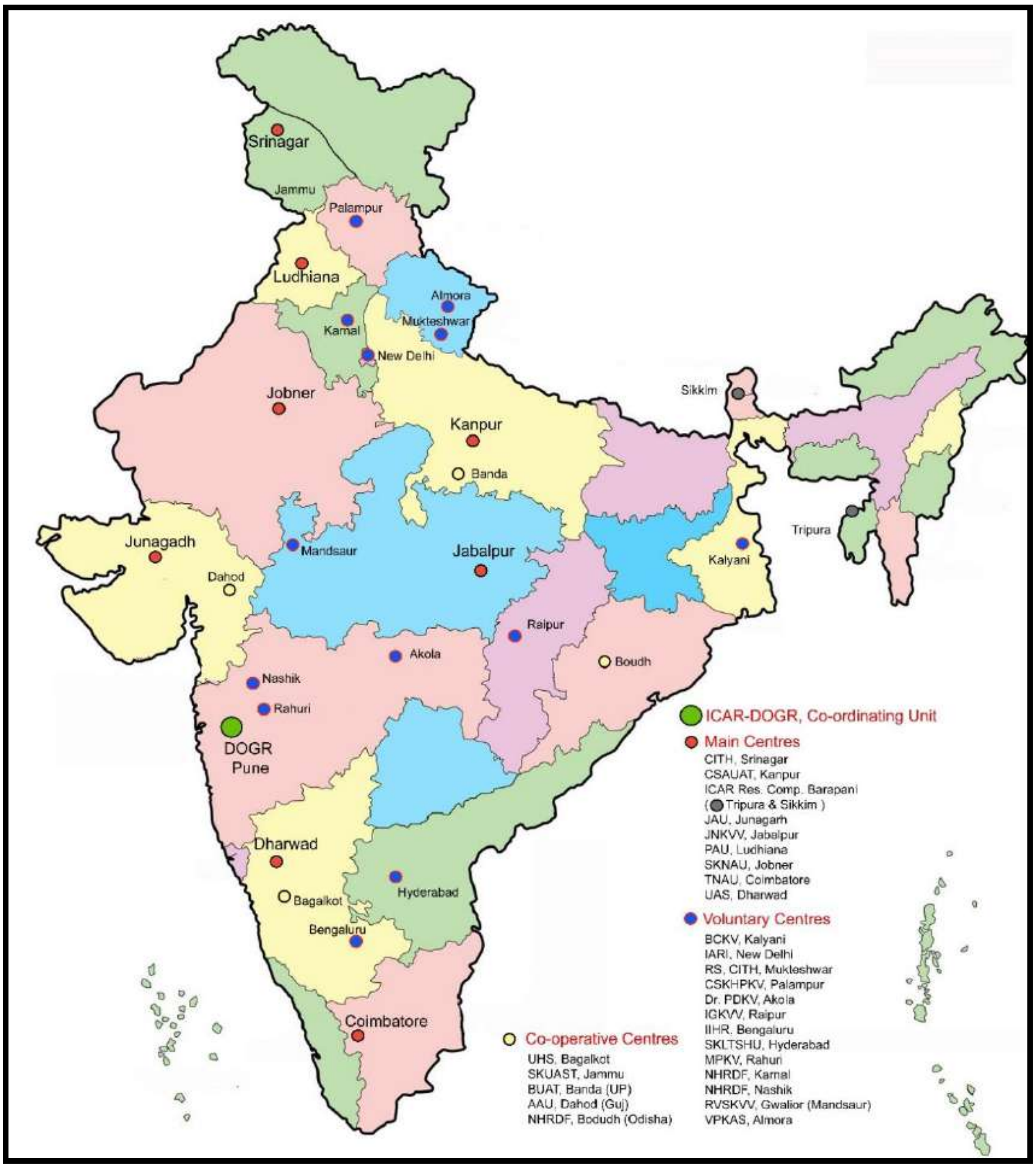


Fig 1. Locations of AINRPOG centers

D. Scheduled Caste Sub-Plan (SCSP)

The main objective of this scheme is economic development of scheduled caste farmers by providing resources for filling up the critical gaps and providing missing vital inputs. During *kharif* season, 318 kg onion seed of Bhima Super was distributed among 260 scheduled caste farmers of districts viz., Pune, Ahmednagar, Aurangabad, Beed and Solapur of Maharashtra. During *rabi* season, 20 kg onion seed of Bhima Shakti distributed among 20 scheduled caste farmers of Shrigonda taluka of Ahmednagar district of Maharashtra. The fertilizers (77732 kg, 171 litre) and pesticides (233.5 kg, 1336.95 litre) were also distributed to scheduled caste farmers. Dr. S. S. Gadge, Senior Scientist (Agricultural Extension) and Dr. R. B. Kale, Senior Scientist (Agricultural Extension) coordinated the training programmes. The following training programmes were organized under SCSP.

- Training programme on "Azadi ka Amrut Mahotsav: Onion Production Technology" attended by 30 Farmers from Pune district during 15-17 March, 2022 at ICAR-DOGR, Pune.
- Training programme on "Azadi ka Amrut Mahotsav: Onion Production Technology" attended by 30 Farmers from Pune district during 22-24 March, 2022 at ICAR-DOGR, Pune.
- Training programme on "Azadi ka Amrut Mahotsav: Onion Production Technology" attended by 22 farmers from Pune district on 16 June, 2022 at ICAR-DOGR, Pune.
- Training programme on "Scientific Cultivation of Onion and Garlic" attended by 25 farmers from Ahmednagar district on 17 October, 2022 at ICAR-DOGR, Pune.


Distribution of farm inputs under SCSP scheme

E. Tribal Sub-Plan for Onion and Garlic

Tribal Sub-Plan Activities by ICAR-DOGR

Tribal Sub-Plan (TSP) activities by ICAR-DOGR plays a vital role in food and nutritional security of tribal farmers. The systematic efforts were undertaken to improve the area and production of onion and garlic by careful application of improved technologies. Thus, focus was given in conduct of field demonstrations of improved technologies at farmer's fields through improved seed/ bulb distribution, knowledge dissemination, capacity building and entrepreneurship building. About 1110 tribal farmers were selected from 111 farmers' groups in Nandurbar district (Navapur, Akalkua and Dhadgoan talukas) and about 760 tribal farmers were selected from 76 farmers' groups in Pune district (Khed and Ambegaon talukas) of Maharashtra under TSP Scheme.

Field Demonstrations

A total of 58 demonstrations in *kharif* and 85 demonstrations in *rabi* were conducted under TSP during 2021-22. The kits containing fertilizers, fungicides, insecticides, weedicides, spray pump etc. were distributed to each selected group of tribal farmers. Each demonstration was conducted on one-acre common land of selected farmers group and each group consist about ten tribal farmers.

Trainings

A total of ten trainings/ field days were organized under TSP in Maharashtra, Leh (Ladakh) and Uttar Pradesh in which 693 tribal farmers participated.

Table 1. Trainings/ Field Day organized under TSP

Topic of Training	Sponsored Agency	Date and Venue	Participants
Azadi ka Amrit Mahotsav: Commercial cultivation of onion and garlic	ICAR-DOGR under TSP	21-23 March, 2022 ICAR-DOGR, Pune	30
Scientific cultivation of onion and garlic	ICAR-DOGR under TSP	24-26 March, 2022 ICAR-DOGR, Pune	27
Quality seed production of onion and garlic	ICAR-DOGR and KVK, Nandurbar under TSP	28-29 March, 2022 Khandawara in Navapur, Nandurbar	160
Scientific cultivation of onion and garlic	ICAR-DOGR and Agrimitra FPC under TSP	30-31 May, 2022 Purushottampur, Chunar, Mirzapur (UP)	65
Kharif onion production technology	ICAR-DOGR under TSP	22 June, 2022 Bursewadi, Khed taluka of Pune	54
Scientific cultivation of *kharif* onion	ICAR-DOGR under TSP	23 June, 2022 Gohe Khurd, Ambegaon, Pune	55
Cultivation of *kharif* onion in tribal belts of Nandurbar	ICAR-DOGR under TSP	27-28 July, 2022 Khandwara, Navapur, Nandurbar	145

Onion production technology	ICAR-DOGR under TSP	25-26 Aug, 2022 ICAR-DOGR, Pune	52
Scientific cultivation of onion in Leh District of Ladakh Union Territory	ICAR-DOGR and HMAARI-SKUAST-K, Leh	20-21 Sept, 2022 HMAARI-SKUAST-K, Leh	78
Kisan Diwas on Improved cultivation of onion	ICAR-DOGR under TSP	23 Dec, 2022 ICAR-DOGR, Pune	27


Gohe Khurd, Ambegaon, Pune, 23.06.2022


Bursewadi, Khed, Pune, 22.06.2022



HMAARI, SKUAST-K, Leh, 21.09.2022

Kisan Sangoshthi

ICAR-DOGR, Pune organized Kisan Sangoshthi on commercial cultivation of onion in collaboration with GKRDF, Varanasi and Agrimitra FPC, Mirzapur in the premises of ICAR-IIVR, Varanasi on 29th September, 2022. About 400 farmers including 260 women farmers from different parts of Mirzapur, Sonbhadra, Ghazipur, Varanasi, Chandauli, Kushinagar and Ballia districts of Uttar Pradesh and Singrauli district of Madhya Pradesh participated in the program.


Kisan Sangoshthi in the premises of ICAR-IIVR, Varanasi on 29.09.2022

F. Distinctness, Uniformity and Stability

ICAR-DOGR serves as the nodal centre for conducting the DUS test for onion and garlic. Within this project, institute is maintaining 65 onion varieties (55 *rabi* and 10 *kharif*) and 30 garlic varieties. The long day onion and garlic varieties are being maintained at ICAR-CITH, Srinagar, while multiplier onion varieties at TNAU, Coimbatore. All the relevant data in accordance with the DUS test guidelines is documented for each of the maintained onion and garlic varieties under the DUS project.

Evaluation of DUS onion varieties

Rabi

A total of fifty-five *rabi* onion varieties *viz.*, Agrifound Rose, Agrifound White, Agrifound Light Red, Arka Bindu, Arka Bheem, Arka Niketan, Arka Pitamber, Arka Pragati, Bhima Kiran, Bhima Raj, Bhima Red, Bhima Shakti, Bhima Shweta, Bhima Light Red, GWO-1, GWO-2, GWO-3, GJRO-11, HOS-4, Hissar-2, Hissar-3, Kalyanpur Red Round, N-2-4-1, NHRDF Red (L-28), NHRDF Red-2 (L-355), NHRDF Red-3 (L-625), NHRDF Fursungi (L-819), NHRDF Red-4 (L-744), PKV White, Phule Safed, Phule Samarth, Phule Suvarna, Pilipatti Junagadh, Punjab Naroya, Pusa Madhavi, Pusa Red, Pusa Sona, Pusa Riddhi, Pusa White Flat, Pusa White Round, PRO-6, Phursungi Local, RO-01, RO-59, RO-252, Sukhsagar, Talaja Red, Telagi Local, Kajara Red, VL Piaz-3 and Udaipur-102 along with one famer variety *viz.* 2881/4251 were cultivated in *rabi* 2021-22. The crop was harvested during the period of April-May 2022, and all observations were meticulously documented in accordance with the guidelines of the DUS test.

Kharif

In *kharif* 2022 season, ten onion varieties *viz.*, Agrifound Dark Red, Arka Kalyan, B-780, Bhima Raj, Bhima Red, Bhima Shubhra, Bhima Shweta, Bhima Super, Bhima Dark Red and Bhima Safed along with four farmers varieties *viz.* 22AROF-1, 22AROF-2, 22AROF-3 and 22AROF-4 were planted in three replications. The crop was harvested in November 2022 and a comprehensive record of all observations was diligently maintained in accordance with the guidelines outlined for the DUS test.

Fig. 1. DUS testing of onion varieties

Evaluation of DUS garlic varieties

In *rabi* 2021-22, a comprehensive set of thirty garlic varieties *viz.*, Bhima Omkar, Bhima Purple, Chunar Local-1, Chunar Local-2, DWDG-1, DWDG-2, G-1, G-41, G-50, G-282, G-323, G-386, G-404 (YP-10), GJG-5, GJG-6, GAG-7, GG-2, GG-3, GG-4, G-384 (YS-8), Godawari, Navapur Local, Ooty Local, Phule Baswant, Phule Nilima, PG-17, PG-18, Rani

Bennur Local, Sikkim Local and Silkuei Local were cultivated with three replications. Following the growth period, the crops were harvested in March 2022, and careful observations were recorded in adherence to the guidelines specified for the DUS test.

Fig. 2. DUS testing of garlic varieties

G. Agri-Business Incubation

In order to support registered start-ups, an Agri-business centre has been established, equipped with workspaces for incubates and a processing laboratory for hands-on training. On the 13 June, 2022, an official inauguration ceremony was held for the Agri-Business Incubation (ABI) centre. During the event, four Memorandums of Understanding (MoUs) were signed with the following companies, in the presence of all the members of the ABI advisory committee:

(i) Farmers Smile Farmer Producer Company, located in Khed, Pune, aims to develop a supply chain for high-quality onions and onion seeds.

(ii) Vagheshwar Farmer Producer Company, also based in Khed, Pune, has expressed interest in adding value and processing onion and garlic crops.

(iii) Thinkpure Organic Produce Pvt. Ltd., situated in Akola, Maharashtra, intends to establish a seed processing unit and promote the use of quality organic seeds.

(iv) An MoU was signed to provide assistance in the formation of a registered Farmer Producer Company (FPC) named Palanduh Farmer Producer Company Ltd. in Vijayapura district, Karnataka. This FPC will focus on developing an onion value chain within the same district.

The ABI project has generated a total sum of ₹ 20,000/- from registration fees for incubation during the financial year 2022-23.

A total of four meetings were conducted by the ABI Advisory committee in the year 2022. These meetings took place on the following dates: 14 January, 31 March, 13 June, and 21 November, 2022. The purpose of these meetings was to discuss various matters such as the selection of relevant applications, approval of Detailed Project Reports (DPRs) for incubation, signing of Memorandums of Understanding (MoUs) with selected candidates, expenditure and utilization of funds allocated to the ABI, as well as the establishment of a Custom Hiring Centre at ICAR-DOGR. During these meetings, new registration applications were received and deliberated upon by the ABI advisory committee for incubation at the ABI centre, ICAR-DOGR. The main focus of these applications was on activities such as onion seed oil extraction and value addition, developing value chains and processing of onions and garlic, dehydration processing, honey bee rearing for onion seed production, and processing of onions and garlic. In addition to the meetings, the ABI centre at ICAR-DOGR organized a Technology Demonstration and Stakeholders Meet on 3 January, 2022. The purpose of this event was to showcase the newly designed controlled onion structure. Furthermore, an interface meeting titled "Strengthening Onion Value Chain: Research-Extension-Farmers and Start-ups Interface" was held on 27-28 January, 2022. One of the registered start-ups, named "Thinkpure Organic Produce Org. Pvt. Ltd." located in Akola, Maharashtra, has successfully established a Seed Processing unit. This incubatee is now providing seed processing facilities to farmers in Akola district on a rental basis. Furthermore, a Farmer Producer Company (FPC) called "Palanduh Farmer Producer Company Limited" has been created, and the certificate of incorporation was received on 1 November, 2022, from the Ministry of Corporate Affairs, Government of India.




H. Institute Technology Management Unit

The Institute Technology Management Unit (ITMU) operates in accordance with ICAR guidelines to support Intellectual Property Management, as well as Technology Transfer and Commercialization. The primary objectives of ITMU are to engage in activities related to the protection, maintenance, and transfer/commercialization of intellectual property associated with technologies developed at the Institute level. ITMU serves as a coordinating unit and facilitator, responsible for identifying promising technologies developed within the institute. It oversees the process of filing patents and maintains the Institute's intellectual property portfolios through the Institute Technology Management Committee (ITMC). In the year 2022, a total of seven onion varieties were licensed to 39 seed companies at the institute level. Additionally, an exclusive license for the 'controlled onion storage structure' technology was granted to Kala Biotech Pvt. Ltd. Furthermore, the institute conducted six contract trials and established collaborations with six organizations for research purposes and student guidance. The detailed overview of the work during the year is given below.

Technology licensing

Variety

Total 39 licensing agreements were executed during the year 2022 for different varieties developed by ICAR-DOGR. It led to revenue generation of ₹ 39,00,000/-.

Table 1. Licensing of onion varieties to seed companies

Sr. No.	Company / FPC / Organisations	Revenue (₹)	Variety	Date
1.	Atharv Seeds, Jalna, Maharashtra	100000	B. Kiran	05/01/2022
2.	Grape Master Organic FPC Limited, Nashik	100000	B. Kiran	05/01/2022
3.	Vijay Seeds Company Limited, Jalna,	100000	B. Shakti	14/02/2022
4.	Mansoon Seeds Pvt. Ltd. Pune, Maharashtra	100000	B. Shakti	16/03/2022
5.	Mansoon Seeds Pvt. Ltd. Pune, Maharashtra	100000	B. Raj	16/03/2022
6.	Indo US Bio-Tech Limited Ahmedabad	100000	B. Super	23/04/2022
7.	Indo US Bio-Tech Limited Ahmedabad	100000	B. Red	23/04/2022
8.	Yajnarup Vision Tech Pvt. Ltd.	100000	B. Super	24/06/2022
9.	Pasaidan Farmers Producer company Ltd.	100000	B. Super	24/06/2022
10.	Star Alankar Farmer Producer Company Ltd.	100000	B. Raj	24/06/2022
11.	Star Alankar Farmer Producer Company Ltd.	100000	B. Shakti	24/06/2022
12.	Veedant Seeds & Biotech Pvt Ltd	100000	B. Kiran	24/06/2022
13.	Ruchi Green Seeds	100000	B. Shakti	24/06/2022
14.	Jindal Crop Sciences Pvt. Ltd.	100000	B. Red	24/06/2022
15.	Jindal Crop Sciences Pvt. Ltd.	100000	B. Shubhra	24/06/2022
16.	Om Gayatri Farmer Producer Company Ltd.	100000	B. Shakti	24/06/2022
17.	Om Gayatri Farmer Producer Company Ltd	100000	B. D. Red	24/06/2022
18.	Shri Baliraja Seeds & Chemicals	100000	B. Shakti	24/06/2022

19.	Shri Baliraja Seeds & Chemicals	100000	B. D. Red	24/06/2022
20.	Radha Shyam Seeds & Biotech Pvt. Ltd	100000	B. Shakti	24/06/2022
21.	Jain Agri Park	100000	B. Super	24/06/2022
22.	Jain Agri Park	100000	B. Shakti	24/06/2022
23.	Sakol Farmers Agro producer company Ltd.	100000	B. Shakti	20/08/2022
24.	Divya Seeds Company	100000	B. Shubhra	20/08/2022
25.	Pancharatna Seeds Company	100000	B. Red	20/08/2022
26.	Pancharatna Seeds Company	100000	B. Shubhra	20/08/2022
27.	Pollen Bioseeds	100000	B. Shakti	20/08/2022
28.	Smiling Farmers Seeds Pvt. Ltd	100000	B. Shakti	20/08/2022
29.	Sidhant seeds, Auragabad	100000	B. Shakti	03/102022
30.	Agrimitra FPC, Mirzapur	100000	B. D. Red	03/102022
31.	M/S. Mahadev Agri clinic & Agribusiness Centre, Ayodhya	100000	B. Shakti	14/10/2022
32.	SaiMauli Seeds, Nashik	100000	B. Kiran	21/10/2022
33.	Kapileshwar agro & biotec services, Odisha	100000	B. Shakti	21/11/2022
34.	Kapileshwar agro & biotec services, Odisha	100000	B. Super	21/11/2022
35.	Rajganesh natural seeds, Satara	100000	B. Shakti	21/11/2022
36.	Rajganesh natural seeds, Satara	100000	B. Super	21/11/2022
37.	Thinkpure organic produce Ltd, Akola	100000	B. Shakti	21/11/2022
38.	Swadarshan farmer producer company, Ahmednagar	100000	B. Shakti	21/11/2022
39.	Mayur seeds corporation	100000	B. Shubhra	30/11/2022
Total		**₹ 39,00,000/-**		

Bhima shakti was most popular technology and is licensed with 17 companies and its contribution is 44% of total revenue generated.

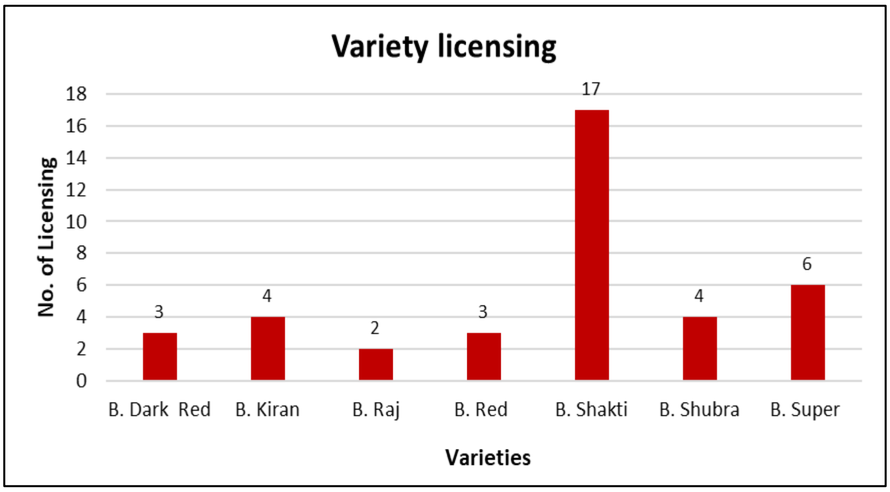


Fig. 1. Variety-wise licensing/MoUs

As majority of onion is produced from Maharashtra and therefore licensing of varieties is also more in Maharashtra.

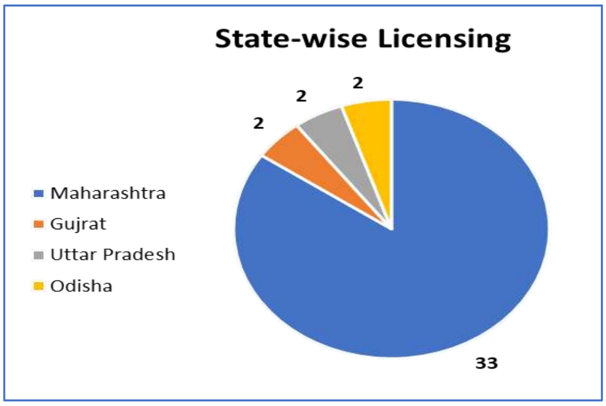


Fig. 2 State-wise licensing/MoUs

Commercialization and licensing of controlled onion storage structure

Controlled onion storage structure developed under public private partnership in collaboration with Kala Biotech Pvt Ltd. Its exclusive license was given to Kala biotech Pvt. Ltd. for its commercial use. This technology was licensed through Agrinnovate India Ltd in June 2022.

Contract research trials

The following contract research trials are being executed at institute funded by private companies' worth ₹ 88,52,045/-

Table 2. Contract research trials at ICAR-DOGR

Funding Agency	PI	Title of project	Revenue (₹)
Sirius India Limited, New Delhi	Dr. Thangasamy A.	POLY-4 Rate Response Trial on Onion and Garlic	35,15,220
Smartchem Technologies Limited, Pune	Dr. Thangasamy A.	Bio-efficacy of Bensulf SUPERFAST on Onion	14,80,900
UPL, Mumbai	Dr. Thangasamy A.	Evaluation of Bio-Efficacy of Gph 1821 For Controlling Weeds in Onion	14,69,100
Development Support Centre Narayangaon, ITC mission Sunehara Kal	Dr. Rajiv B. Kale	Capacity building and demonstration of improved technologies to enhance water use efficiency in onion	6,99,272
TATA Steel	Dr. B. R. Bibwe	Evaluation of AgroNest Smart Warehouse in reducing storage losses & prolonging the storage life of Onion	10,54,153
Godaam Innovation Pvt. Ltd., Nashik	Dr. B.R. Bibwe	Evaluation of IOT based device	6,33,400
Total (₹)			**88,52,045/-**

MoUs for Collaborative Research

MoUs for collaborative and student research were singed with public and private institutes.

Table 3. Collaboration for research

Sr. No.	Collaborating Agencies	Purpose
1.	SAGE University, Indore	Research on underutilised *Alliums*
2.	KisanKonnect Farmers Producer Company, Ahmednagar	To popularize and develop value chain model of the underutilized alliums (*Allium tuberosum* and others species.
3.	ESDS Software Solution Pvt. Ltd., Nashik	Development of Decision Support System on various aspects Alliums cultivation
4.	TIH Foundation for IoT and IoE, IIT Bombay	Collaborative research involving IoT and IoE
5.	Savitribai Phule Pune University, Pune	M.Sc./ Ph.D Students Training/Research
6.	Dr. C V Raman University, Khandwa	M.Sc./Ph.D Students Training/Research

I. North Eastern Hill Program

Popularization of onion cultivation in NEH region

The North-Eastern region is made up of folded hills and mountains, plateaus, and hills with near-tropical and alpine climates. Onion growing was mostly done for kitchen gardens on a small scale during the *rabi* season. The people of the NEH region must purchase their onions from other parts of the country because onion farming is not common in this area. There was a great deal of opportunity for commercial onion farming in kharif to bring in more money than other conventionally cultivated vegetables during the rabi season. The poor quality of local varieties of onion bulbs also had an impact on the earnings. Systematic attempts were made to increase the area and output of onions in *kharif* as well *rabi* through the cautious application of superior varieties and recommended production techniques. The emphasis was on improved technological field demonstrations in farmers' fields, knowledge distribution, capacity building, and entrepreneurial growth. In order to encourage onion production in the NEH area, ICAR-DOGR began various operations under the NEH plan for the benefit of tribal people. The states designated to boost onion growth in the NEH area are Arunachal Pradesh, Nagaland, Meghalaya, Tripura, and Sikkim.

Demonstrations and Training Program:

- In total, 95 field demonstrations were held in four NEH states: Arunachal Pradesh, Nagaland, Tripura, and Sikkim, with directly benefiting 1739 farmers.
- The village viz., Namsing, Runne, Sille, Sikha Tode, Rayeng, Sebo, Jarong, Mirku, Dikking, Mirsem, PakkeKesang, Sikha Bamin, Ledum, Mirem, Mebo, Gadun, Ayeng, Gadum, Kebang,Pangkang, Mangnang, Riew, Riga,Lipin, Mirem of East Siang District, Yingkiang, Tuting of Upper Siang district, Didu area, Sekar, Rapum, Lungte of ShiYomi /West Siang (Monigoog) district, Paglam,Banggo,Keba, Kergati, Roing of Lower Dibang Valley (Namsai) of Arunachal Pradesh, Beisumpuikam of Peren district, Renthan of Wokha district and Medziphema district of Nagaland, Mabong and Karjee Gangtok ,Dzongu, Namthang from West Sikkim, East Sikkim, North Sikkim, South Sikkim district of Sikkim , Jetra, Dobasipara, Arimile, angsangre, Garogadha district of West Agro Hills, Tura of Meghalaya and Kachucherra of Dhalai (Salema) district, Patalia and lakhibil of Sepahijala district, Lankamura of West Tripura (Barjala) district, Indiranagar of South Tripura (Sabroom) district of Tripura were selected for carrying out the demonstrations.
- The KVKs operating in these regions were also contacted and participated in a number of demonstrations on better onion bulb growing.
- ICAR-DOGR gave farmers with onion seed of Bhima Super and Bhima Dark Red in the *kharif* season and Bhima Shakti and Bhima Kiran in the *rabi* season. Farmers were also given demonstration kits containing organic inputs.
- In these states, 56 training conducted were held to offer farmers with knowledge about the *kharif* and *rabi* onion growing techniques developed by ICAR-DOGR, with a total of 2303 farmers participating.

Tura, Meghalaya

Beisumpuikam, Peren, Nagaland

Daring village, Sikkim

Tripura

Training and demonstration programme organized in NEH region

Daring village, Sikkim

Tura, Meghalaya

Distribution of inputs in NEH region

J. Transfer of Technology

Training programs organized

Topic of Training	Sponsoring Agency	Date and Venue	No. of Participants
Azadi ka Amrut Mahotsav: *Rabi* onion crop management	MGMG, ICAR-DOGR, Pune	19 January, 2022 Khadakwadi, Pune	24 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion crop management	MGMG, ICAR-DOGR, Pune	20 January, 2022 Gosasi, Pune	27 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion crop management	MGMG, ICAR-DOGR, Pune	23 February, 2022 Warude, Pune	25 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion crop management	MGMG, ICAR-DOGR, Pune	5 March, 2022 Khadakwadi, Pune	27 Farmers
Azadi ka Amrut Mahotsav: Onion production technology	SCSP, ICAR-DOGR, Pune	15-17 March, 2022 ICAR-DOGR, Pune	30 Farmers
Azadi ka Amrut Mahotsav: Late *kharif* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	19 March, 2022 Pondewadi, Pune	21 Farmers
Azadi ka Amrut Mahotsav: Commercial cultivation of onion and garlic (Bhimashankar)	TSP, ICAR-DOGR, Pune	21-23 March 2022 ICAR-DOGR, Pune	30 Farmers
Azadi ka Amrut Mahotsav: Onion production technology	SCSP, ICAR-DOGR, Pune	22-24 March, 2022 ICAR-DOGR, Pune	30 Farmers
One-day Hands-On training programme on “Techniques in molecular biology” under scientific social responsibility (SSR)	DST-SERB	26 March, 2022 ICAR- DOGR, Pune	15 Students and Assistant Professors
Azadi ka Amrut Mahotsav: Scientific cultivation of onion and garlic (Bursewadi)	TSP, ICAR-DOGR, Pune	24-26 March, 2022 ICAR-DOGR, Pune	27 Farmers
Azadi ka Amrut Mahotsav: Scientific cultivation of onion and garlic	Project Director, ATMA, East Champaran, Motihari (Bihar)	26-28 March, 2022 ICAR-DOGR, Pune	25 Farmers
Azadi ka Amrut Mahotsav: Quality seed production of onion and garlic in tribal belt of Nandurbar	TSP, ICAR-DOGR, Pune	28-29 March, 2022 Nandurbar	160 Farmers

Azadi ka Amrut Mahotsav: Late *kharif* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	29 March, 2022 Khairewadi, Pune	28 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	30 March, 2022 Mitgudwadi, Pune	25 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	31 March, 2022 Gadakhwadi, Pune	26 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	4 April, 2022 Gulani, Pune	24 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	13 April, 2022 Jawulke, Pune	28 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	27 April, 2022 Dhamni, Pune	30 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion harvesting and post-harvest management	MGMG, ICAR-DOGR, Pune	29 April, 2022 Ranmala, Pune	28 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion production technology	MGMG, ICAR-DOGR, Pune	2 May, 2022 KanhurMesai, Pune	23 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion production technology	MGMG, ICAR-DOGR, Pune	12 May, 2022 Khairenagar, Pune	25 Farmers
Azadi ka Amrut Mahotsav: Nursery preparation of *kharif* onion	MGMG, ICAR-DOGR, Pune	17 May, 2022 Gosasi, Pune	28 Farmers
Scientific cultivation of onion and garlic	ICAR-DOGR and Agrimitra FPC	30-31 May, 2022 Purushottampur, Mirzapur	65 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion nursery preparation	MGMG, ICAR-DOGR, Pune	31 May, 2022 Mitgudwadi, Pune	24 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	7 June, 2022 Gadakhwadi, Pune	32 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	15 June, 2022 Dhamni, Pune	25 Farmers
Azadi ka Amrut Mahotsav: Onion production technology	SCSP, ICAR-DOGR, Pune	16 June, 2022 ICAR-DOGR, Pune	22 Farmers
Azadi ka Amrut Mahotsav: Nursery management in *kharif* onion production	MGMG, ICAR-DOGR, Pune	21 June, 2022 Pondewadi, Pune	29 Farmers

Kharif onion production technology	ICAR-DOGR under TSP	22 June, 2022 Bursewadi, Khed taluka of Pune	54 Farmers
Scientific cultivation of *kharif* onion	ICAR-DOGR under TSP	23 June, 2022 Gohe Khurd, Pune	55 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	2 July, 2022 Wafgaon, Pune	28 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	7 July, 2022 Khadakwadi, Pune	30 Farmers
Training Workshop on Post Harvest Management of Onion" in collaboration with IIT, Mumbai	Project on Climate Resilient Agriculture	8 July, 2022 ICAR-DOGR, Pune	80 Farmers, FPC, State Govt. Officials
Azadi ka Amrut Mahotsav: *Kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	14 July, 2022 Varude, Pune	28 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	18 July, 2022 Gulani, Pune	22 Farmers
Cultivation of *kharif* onion in tribal belts of Nandurbar	ICAR-DOGR under TSP	27-28 July, 2022 Khandwara, Nandurbar	145 Farmers
Azadi ka Amrut Mahotsav: Late *kharif* onion nursery management	MGMG, ICAR-DOGR, Pune	19 August, 2022 Jawulke, Pune	31 Farmers
Onion production technology	ICAR-DOGR under TSP, Pune	25-26 August, 2022 ICAR- DOGR, Pune	52 Farmers
Azadi ka Amrut Mahotsav: Improved practices of Onion and Garlic cultivation	ATMA, Sikar (Rajasthan)	5-7 September, 2022 ICAR-DOGR, Pune	25 Farmers
Azadi ka Amrut Mahotsav: Late-*kharif* onion production technology	MGMG, ICAR-DOGR, Pune	13 September, 2022 Pondewadi, Pune	28 Farmers
Azadi ka Amrut Mahotsav: Late- *kharif* onion crop management	MGMG, ICAR-DOGR, Pune	16 September, 2022 Loni, Pune	22 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion production technology	MGMG, ICAR-DOGR, Pune	19 September, 2022 Dhamni, Pune	26 Farmers
Scientific cultivation of onion in Leh District of Ladakh Union Territory	ICAR-DOGR and HMAARI-SKUAST-K, Leh under TSP	20-21 September, 2022 HMAARI-SKUAST-K, Leh	78 Farmers

Azadi ka Amrut Mahotsav: *Rabi* onion nursery management	MGMG, ICAR-DOGR, Pune	26 September, 2022 Ranmala, Pune	23 Farmers
Kisan Sangosthi on Commercial cultivation of onion	ICAR-DOGR and Agrimitra FPC under TSP	29 September, 2022 ICAR-IIVR, Varanasi	400 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion production technology	MGMG, ICAR-DOGR, Pune	30 September, 2022 Gadakhwadi, Pune	22 Farmers
Azadi ka Amrut Mahotsav: *Rabi* onion production technology	MGMG, ICAR-DOGR, Pune	4 October, 2022 Varude, Pune	25 Farmers
Azadi ka Amrut Mahotsav: Scientific cultivation of onion and garlic	SCSP, ICAR-DOGR, Pune	17 October, 2022 ICAR-DOGR, Pune	25 Farmers
Azadi ka Amrut Mahotsav: Onion production technology	MGMG, ICAR-DOGR, Pune	28 October, 2022 Khairenagar, Pune	22 Farmers
Azadi ka Amrut Mahotsav: Onion production technology	MGMG, ICAR-DOGR, Pune	25 November, 2022 Mitgudwadi, Pune	32 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion harvesting technology	MGMG, ICAR-DOGR, Pune	03 December, 2022 Wafgaon, Pune	28 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion harvesting	MGMG, ICAR-DOGR, Pune	09 December, 2022 Khadakwadi, Pune	29 Farmers
Azadi ka Amrut Mahotsav: *Kharif* onion harvesting	MGMG, ICAR-DOGR, Pune	12 December, 2022 Gosasi, Pune	29 Farmers
Kisan Diwas on improved cultivation of onion	ICAR-DOGR under TSP	23 December, 2022 ICAR- DOGR, Pune	27 farmers

Participation in Exhibitions

Exhibition	Organizer	Date	Venue
Kisan 2022	Kisan Pvt. Ltd., Pune	23-27 March, 2022	Moshi, Pune
Shining Maharashtra	Sansa Foundation, Phaltan	25-27 March, 2022	Phaltan, Satara
Exhibition on Horticulture Value Chain and Agricultural Technologies	Department of Agriculture and Farmers Welfare, New Delhi	1-2 November, 2022	VAMNICOM, Pune
Kisan 2022	Kisan Forum Pvt. Ltd., Pune	14-18 December, 2022	Moshi, Pune

Lectures delivered

Topic	**Event and organizer**	**Date and venue**
Vijay Mahajan		
Improved practices of onion bulb production	Three days training programme on “Improved practices of onion and garlic production”	5-7 September, 2022 ICAR-DOGR, Pune
Onion bulb production in Rabi Season 2022-23	Crop production technology training programme	15 September, 2022 at State Agriculture Department, District Central Horticulture Nursary, Pune
Onion bulb production	Three days training programme on “Scientific Cultivation of Onion and Garlic”	17-19 October, 2022 ICAR-DOGR, Pune
Production and productivity status of onion and garlic	Three days training programme on “Scientific Cultivation of Onion and Garlic”	17-19 October, 2022 ICAR-DOGR, Pune
Ram Dutta		
Management of fungal diseases in onion and garlic	Training Programme on Azadi Ka Amrut Mahotsav: “Scientific Cultivation of Onion and Garlic" under TSP	22 March, 2022 ICAR-DOGR, Pune
Management of fungal diseases in onion and garlic	Training Programme on Azadi Ka Amrut Mahotsav: “Onion Production Technology" under SCSP	23 March, 2022 ICAR-DOGR, Pune
Management of fungal diseases in onion and Garlic	Training Programme on Azadi Ka Amrut Mahotsav: “Scientific Cultivation of Onion and Garlic" under TSP	25 March, 2022 ICAR-DOGR, Pune
Management of fungal diseases in onion	Training Programme on Azadi Ka Amrut Mahotsav: “Scientific Cultivation of Onion and Garlic" under ATMA	27 March, 2022 ICAR-DOGR, Pune
Hygienic cultivation of onion and garlic	Soil health day organized by ICAR-DOGR	05 December, 2022 ICAR-DOGR, Pune
Amar Jeet Gupta		
Improved varieties of onion	Three days training programme on Azadi Ka Amrut Mahotsav: “onion	15 March, 2022 ICAR-DOGR, Pune

	production technology" under SCSP	
TSP activities and improved varieties of onion and garlic	Three days training-cum-awareness programme on Azadi Ka Amrut Mahotsav: "commercial cultivation of onion and garlic" under TSP	21 March, 2022 ICAR-DOGR, Pune
Improved varieties of onion	Three days training programme on Azadi Ka Amrut Mahotsav: "onion production technology" under SCSP	22 March, 2022 ICAR-DOGR, Pune
TSP activities and Improved varieties of onion and garlic	Three days training-cum-Awareness programme on Azadi Ka Amrut Mahotsav: "scientific cultivation of onion and garlic" under TSP	24 March, 2022 ICAR-DOGR, Pune
Improved varieties of onion	Three days training programme on Azadi Ka Amrut Mahotsav: "scientific cultivation of onion and garlic" under ATMA scheme	26 March, 2022 ICAR-DOGR, Pune
TSP activities and improved varieties of onion and garlic	Two days training programme on "cultivation of onion and garlic in tribal belts of Nandurbar" under TSP	28 March, 2022 Navapur, Nandurbar
Onion and garlic production technology	Two days training programme on "cultivation of onion and garlic in tribal belts of Nandurbar" under TSP	29 March, 2022 Navapur, Nandurbar
Kharif onion production technology	Training-cum-awareness program on "Scientific cultivation of onion and garlic" under TSP	28 May, 2022 Purushottampur, Chunar, Mirzapur (UP)
Improved varieties of onion and *kharif* onion production technology	"Cultivation of *kharif* onion in tribal belts of Nandurbar" under TSP	27-28 July, 2022 Khandwara, Navapur, Nandurbar
Kharif onion production technology	Interaction meeting and distribution of Agri-inputs to tribal farmers under TSP	25-26 August, 2022 ICAR-DOGR, Pune
Improved varieties of onion and garlic	Three days training program on "improved practices of onion and garlic cultivation" under NABARD	6 September, 2022 ICAR-DOGR, Pune

Scientific cultivation of onion in Leh	"Scientific cultivation of onion" in Leh District of LadakhUnion Territory	20-21 September, 2022 HMAARI-SKUAST-K, Leh
Extending *kharif* onion cultivation in eastern parts of UP	Kisan Sangosthi on "Commercial cultivation of onion" organized by ICAR-DOGR and Agrimitra FPC on under TSP	29 September, 2022 ICAR-IIVR, Varanasi
Improved varieties of onion and garlic	Three days training program on "scientific cultivation of onion and garlic" at ICAR-DOGR	18 October, 2022 ICAR-DOGR, Pune
S. S. Gadge		
Rabi onion crop management	Training programme on Rabi onion crop management under MGMG	19 January, 2022 Khadakwadi, Pune
Rabi onion crop management	Training programme on Rabi onion crop management under MGMG	20 January, 2022 Gosasi, Pune
Rabi onion crop management	Training programme on Rabi onion crop management under MGMG	23 February, 2022 Warude, Pune
Rabi onion crop management	Rabi onion crop management under MGMG	5 March, 2022 Khadakwadi, Pune
Role of Self Help Group in increasing Socio-economic status of onion farmers	Training programme on "Onion Production Technology" under SCSP	15-17 March, 2022 ICAR-DOGR, Pune
Role of Self Help Group in increasing Socio-economic status of onion farmers	Training programme on "Commercial Cultivation of Onion and Garlic" under TSP	21-23 March, 2022 ICAR-DOGR, Pune
Role of Self Help Group in increasing Socio-economic status of onion	Training programme on "Onion Production Technology" farmers under SCSP	22-24 March, 2022 ICAR-DOGR, Pune
Role of Self Help Group in increasing Socio-economic status of onion farmers	Training programme on "Commercial Cultivation of Onion and Garlic" under TSP	24-26 March, 2022 ICAR-DOGR, Pune
Role of Self Help Group in increasing Socio-economic status of onion farmers	Training programme on "Scientific Cultivation of Onion and Garlic" under ATMA scheme	26-28 March, 2022 ICAR-DOGR, Pune

Late kharif onion harvesting and post-harvest management	Training programme on Late kharif onion harvesting and post-harvest management under MGMG	29 March, 2022 Khairewadi, Pune
Rabi onion harvesting and post-harvest management	Training programme on Rabi onion harvesting and post-harvest management under MGMG	30 March, 2022 Mitgudwadi, Pune
Rabi onion harvesting and post-harvest management	Training programme on Rabi onion harvesting and post-harvest management under MGMG	31 March, 2022 Gadakhwadi, Pune
Rabi onion harvesting and post-harvest management	Training programme on Azadi ka Amrut Mahotsav: Rabi onion harvesting and post-harvest management under MGMG	4 April, 2022 Gulani, Pune
Rabi onion harvesting and post-harvest management	Training programme on Azadi ka Amrut Mahotsav: Rabi onion harvesting and post-harvest management under MGMG	27 April, 2022 Dhamni, Pune
Rabi onion harvesting and post-harvest	Training programme on Azadi ka Amrut Mahotsav: Rabi onion harvesting and post-harvest management under MGMG	29 April, 2022 Ranmala, District Pune
Kharif onion production technology	Training programme on Azadi ka Amrut Mahotsav: Kharif onion production technology under MGMG	2 May, 2022 Kanhur Mesai, Pune
Kharif onion production technology	Training programme on Azadi ka Amrut Mahotsav: Kharif onion production technology under MGMG	12 May, 2022 Khairenagar, Pune
Nursery preparation of kharif onion	Training programme on Azadi ka Amrut Mahotsav: Nursery preparation of kharif onion under MGMG	17 May, 2022 Gosasi, Pune
Kharif onion nursery management	Training programme on Azadi ka Amrut Mahotsav: Kharif onion nursery management under MGMG	7 June, 2022 Gadakhwadi, Pune
Kharif onion nursery management	Training programme on Azadi ka Amrut Mahotsav: Kharif onion nursery management under MGMG	15 June, 2022 Dhamni, Pune

Onion production technology developed by ICAR-DOGR	Training programme on “Azadi ka Amrut Mahotsav: Onion Production Technology” under SCSP	16 June, 2022 ICAR-DOGR, Pune
Nursery management in kharif onion production	Training programme on Azadi ka Amrut Mahotsav: Nursery management in kharif onion production under MGMG	21 June, 2022 Pondewadi, Pune
Kharif onion nursery management	Training programme on Azadi ka Amrut Mahotsav: Kharif onion nursery management under MGMG	2 July, 2022 Wafgaon, Pune
Kharif onion nursery management	Training programme on Azadi ka Amrut Mahotsav: Kharif onion nursery management under MGMG	7 July, 2022 at Khadakwadi, Pune
Post Harvest Management of Onion	Training Workshop on “Azadi ka Amrut Mahotsav: Post Harvest Management of Onion” organized by IIT, Mumbai	8 July, 2022 ICAR-DOGR, Pune
Kharif onion nursery management	Training programme on Azadi ka Amrut Mahotsav: Kharif onion nursery management under MGMG	14 July, 2022 Varude, Pune
Kharif onion nursery management	Training programme on Azadi ka Amrut Mahotsav: Kharif onion nursery management under MGMG	18 July, 2022 Gulani, Pune
Role of Self Help Group in increasing Socio-economic status of onion farmers	Training programme on “Azadi ka Amrut Mahotsav: Improved Practices of Onion and Garlic” under ATMA scheme	5-7 September, 2022 ICAR-DOGR, Pune
Role of Self Help Group in increasing Socio-economic status of onion	Training programme on “Scientific Cultivation of Onion and Garlic” under SCSP	17 October, 2022 ICAR-DOGR, Pune.
Onion production technology	Training programme on Azadi ka Amrut Mahotsav: Onion production technology under MGMG	28 October, 2022 Khairenagar, Pune
Onion production technology	Training programme on Azadi ka Amrut Mahotsav: onion production technology under MGMG	25 November, 2022 Mitgudwadi, Pune

Kharif onion harvesting technology	Training programme on Azadi ka Amrut Mahotsav: Kharif onion harvesting technology under MGMG	3 December, 2022 Wafgaon, Pune
Kharif onion harvesting	Training programme on Azadi ka Amrut Mahotsav: Kharif onion harvesting" under MGMG	9 December, 2022 Khadakwadi, Pune
Kharif onion harvesting	Training programme on Azadi ka Amrut Mahotsav: Kharif onion harvesting under MGMG	12 December, 2022 Gosasi, Pune
A. Thangasamy		
Improved technology for onion cultivation	Interface meeting on "Strengthening onion value chain-Research Extension - Farmers -Start-ups Interface"	27-28 January, 2022 ICAR-DOGR, Pune
Nutrient and water management in onion	Three days training programme on Azadi Ka Amrut Mahotsav: Onion Production Technology under SCSP scheme	15-17 March, 2022 ICAR-DOGR, Pune
Integrated nutrient and weed management in onion and garlic	Three days training programme on Azadi Ka Amrut Mahotsav: Commercial Cultivation of Onion and Garlic under TSP scheme	21-23 March, 2022 ICAR-DOGR, Pune
Nutrient and water management in onion	Three days training programme on Azadi Ka Amrut Mahotsav: Onion Production Technology under SCSP scheme	22-24 March, 2022 ICAR-DOGR, Pune
Integrated nutrient and weed management in onion and garlic	Three days training programme on Azadi Ka Amrut Mahotsav: Scientific Cultivation of Onion and Garlic under TSP scheme	24-27 March, 2022 ICAR-DOGR, Pune
Nutrient and water management in onion	Three days training programme on Azadi Ka Amrut Mahotsav: Scientific Cultivation of Onion and Garlic under ATMA Scheme for the farmers of East Champaran Dist of Bihar	26-28 March, 2022 ICAR-DOGR, Pune

Good Agricultural Practices of nutrient and Water management in onion and garlic	Five days online training programme on "Good Agricultural Practices on Onion and Garlic Production" organized by ICAR-DOGR, Pune and MANAGE, Hyderabad	02-06 May, 2022 ICAR-DOGR, Pune
Improved nutrient and water management in onion and garlic	Three days online training programme on" Improved Practices of Onion and Garlic Cultivation"	05-09 September, 2022 ICAR-DOGR, Pune
Improved nutrient and water management in onion and garlic	Three days training programme on "Scientific Cultivation on Onion and Garlic" organized by ICAR-DOGR, Pune	17-19 October, 2022 ICAR-DOGR, Pune
V. Karuppaiah		
Management of insect pests in onion	Three days training programme on Azadi Ka Amrut Mahotsav: "Onion Production Technology" under SCSP Scheme	15-17 March, 2022 ICAR-DOGR, Pune
Management of insect pests in onion	Three days training programme on Azadi Ka Amrut Mahotsav: "Commercial Cultivation of Onion and Garlic" under TSP Scheme	21-23 March, 2022 ICAR-DOGR, Pune
Management of insect pests in onion	Three days training programme on Azadi Ka Amrut Mahotsav: "Commercial Cultivation of Onion and Garlic" under SCSP Scheme	22-24 March, 2022 ICAR-DOGR, Pune
Management of insect pests in onion and garlic	Three days training programme on Azadi Ka Amrut Mahotsav: "Scientific cultivation of onion and garlic" under TSP Scheme	24-26 March, 2022 ICAR-DOGR, Pune
Management of insect pests in onion	Three days training programme on "Scientific cultivation of onion and garlic" under ATMA Scheme to the farmers of East Champaran, Motihari	26 -28 March, 2022 ICAR –DOGR, Pune
Integrated pest management in onion and	Three days training programme on "Good	2-6 May, 2022 ICAR –DOGR Pune

garlic	Agricultural Practices in Onion and Garlic Production”	
Management of insect pests in onion and garlic	Three days training programme on “Improved Practices of Onion and Garlic”	5-7 September, 2022 ICAR –DOGR Pune
Management of insect pests in onion and garlic	Three days training programmeon “Scientific Cultivation of Onion and Garlic”	17-19 October, 2022 ICAR –DOGR, Pune
Satish Kumar		
Medicinal properties of *Alliums*	Three days training programme on “Scientific Cultivation of Onion and Garlic”	17-19 October, 2022 ICAR –DOGR, Pune
Rajiv B. Kale		
Farmer participatory value chain in onion: scope and opportunities	Training programme on “Good Agricultural Practices in Onion and Garlic Production” organisedby ICAR-DOGR, Pune and MANAGE	06 May, 2022 ICAR-DOGR, Pune
Value chain management in onion	One day Workshop on Post-Harvest Management of Onion” organized by ICAR-DOGR in collaboration with IIT, Mumbai and PoCRA. ICAR-DOGR, Pune	08 July, 2022 ICAR-DOGR
Improved practices of onion cultivation	Farmers meet organised by Gadavari Valley Farmers Producer Company Ltd.	15 September, 2022 Kalamunuri, Hingoli
New cropping techniques and modern technologies	Refresher training program on “Agri Advisory services and Market Linkages for FPOs “under AC&ABC Scheme organised by KVK, Narayangaon	13 October, 2022 Krishi Vigyan Kendra, Narayangaon Pune
Improved technology to enhance the water use efficiency in onion	Training programme organized by ITC mission Sunhera Kal	14 October, 2022 Rewadewadi, Shirur, Pune
Sustainable onion production through efficient water management	Training programme organized by ITC mission Sunhera Kal	14 October, 2022 Ukkadgaon, Shrigonda, Pune

Good Agricultural Practices to enhance the water use efficiency in onion	Training Programme organized by ITC mission Sunhera Kal	14 October, 2022 Nimgaonsawa, Junner, Pune
Improved technology to enhance the water use efficiency in onion	Training Programme organized by ITC mission Sunhera Kal	18 October, 2022 Chombhut, Parner, Ahmednagar
Improved technology to enhance the water use efficiency in onion	Training Programme organized by ITC mission Sunhera Kal	01 December, 2022 GanegaonKhalsa, Shirur, Pune
Status of onion production: Opportunities and challenges	Training programme on “Onion Production Technology” organised by RAMETI, Pune	31December, 2022 Rameti, Pune
Onion seed production technology	Training programme on “Onion Production Technology” organised by RAMETI, Pune	31 December, 2022 Rameti, Pune
Supply chain management of onion	Training programme on “Onion Production Technology” organized by RAMETI, Pune	31 December, 2022 Rameti, Pune
Improved storage technology of onion	Training programme on “Onion Production Technology” organized by RAMETI, Pune	31 December, 2022 Rameti, Pune
Ashwini P. Benke		
Improved varieties and cultivation practices for quality garlic production	Good Agricultural Practices on Onion and Garlic Production organized by MANAGE, Hyderabad and ICAR-DOGR,	2-6 May, 2022 ICAR-DOGR, Pune
Garlic Production technology	Three days training programme on “Scientific cultivation of Onion and garlic” organized by ICAR-DOGR	17-19 October, 2022 ICAR-DOGR, Pune
Rajkumar Dagadkhair		
Medicinal and nutraceutical properties of onion and garlic	Three days training on “Good Agricultural Practices in Onion and Garlic Production” organized by MANAGE, Hyderabad in collaboration with ICAR DOGR, Pune	2-6 May, 2022 ICAR-DOGR, Pune
Soumia P. S.		
Insecticide safety management	Three days training programme on Azadi Ka	16 March, 2022 ICAR-DOGR, Pune

	Amrut Mahotsav: "Scientific Cultivation of Onion and Garlic" under SCSP Scheme	
Insecticide safety management	Three days training programme on Azadi Ka Amrut Mahotsav: "Scientific Cultivation of Onion and Garlic" under SCSP Scheme	23 March, 2022 ICAR-DOGR, Pune
Molecular dimensions of insect taxonomy	One-day hands-on training programme on "Techniques in Molecular Biology" under Scientific Social Responsibility (SSR) of DST-SERB funded project	26 March, 2022 ICAR-DOGR, Pune
Insecticide safety management	Three days training programme on Azadi Ka Amrut Mahotsav: "Scientific Cultivation of Onion and Garlic" under TSP Scheme	26 March, 2022 ICAR-DOGR, Pune
Insecticide safety management	Three days training programme on Azadi Ka Amrut Mahotsav: "Scientific Cultivation of Onion and Garlic" under ATMA Scheme	27 March, 2022 ICAR-DOGR, Pune
Storage pest management and safety measures in plant protection operations	Five days online training programme on" Good Agricultural Practices on Onion and Garlic Production" organized by ICAR-DOGR, Rajgurunagar in collaboration with MANAGE, Hyderabad	05 May, 2022 ICAR-DOGR, Pune
Bhushan R. Bibwe		
Post-harvest management of onion	Training program on "Strengthening onion value chain: research-extension-farmers and start-ups Interface"	28 January, 2022 ICAR-DOGR, Pune
Post-harvest management of onion	Three days training program on Azadi Ka Amrut Mahotsav: "Onion Production Technology under SCSP scheme".	16 March, 2022 ICAR-DOGR, Pune
Post-harvest management	three days training cum awareness program on 'Azadi ka Amrut Mahostav:	22 March, 2022 ICAR-DOGR, Pune

	Commercial cultivation of onion and garlic under TSP scheme	
Post-harvest management of onion	Three days training program on Azadi Ka Amrut Mahotsav: “Onion Production Technology” under SCSP scheme	23 March, 2022 ICAR-DOGR, Pune
Post-harvest Management	Three days training program on Azadi Ka Amrut Mahotsav: “Scientific Cultivation of Onion and Garlic” under TSP scheme	25 March, 2022 ICAR-DOGR, Pune
Post-harvest management of onion	Three days training program on Azadi Ka Amrut Mahotsav: “Scientific cultivation of onion and garlic” under ATMA scheme for East Chmparan, Motihari	27 March, 2022 ICAR-DOGR, Pune
Mechanization in onion and garlic	Training on “Good agricultural Practices on Onion and Garlic Production”	06 May, 2022 ICAR-DOGR, Pune
Post-harvest management of onions	One Day training workshop for farmers & FPCs on “Onion Post harvest Storage Technologies and Management”	08 July, 2022 ICAR-DOGR, Pune
Mechanization of onion processing and its entrepreneurial potential	Skill Development Programme under NAHEP on “Farm Mechanization for Post-Harvest Operations” for training programme at ICAR-CIPHET, Ludhiana.	29 July, 2022 online
Post-harvest management in onion and garlic	Training on “Improved practices of Onion and Garlic cultivation”	07 September, 2022 ICAR-DOGR, Pune
Mechanization in onion and garlic	Training program on “Onion Production Technology”	29 December, 2022 RAMETI, Pune
Processing and value addition in onion	Training program on “Onion Production Technology”	29 December, 2022 RAMETI, Pune
Yogesh P. Khade		
Nursery management in onion	Three days training programme on Azadi Ka Amrut Mahotsav: “Onion	15-17 March, 2022 ICAR-DOGR, Pune

	Production Technology" under SCSP scheme	
Nursery management and micro-irrigation in onion and garlic	Three days training programme on Azadi Ka Amrut Mahotsav: "Commercial Cultivation of Onion and Garlic" under TSP scheme	22-24 March, 2022 ICAR-DOGR, Pune
Nursery management in onion	Three days training programme on Azadi Ka Amrut Mahotsav: "Onion Production Technology" under SCSP scheme	22-24 March, 2022 ICAR-DOGR, Pune
Nursery management and micro-irrigation in onion and garlic	Three days training programme on Azadi Ka Amrut Mahotsav: "Scientific Cultivation of Onion and Garlic" under TSP scheme	24-26 March, 2022 ICAR-DOGR, Pune
Nursery management in onion	Three days training programme on Azadi Ka Amrut Mahotsav: "Scientific Cultivation of Onion and Garlic" under ATMA scheme	26-28 March, 2022 ICAR-DOGR, Pune
Jayalakshmi K		
Empowering Girls for a Brighter Tomorrow during National Girl child day in collaboration with Podar International School, Chakan	National Girl child day in collaboration with Podar International School, Chakan.	24 January, 2022 ICAR-DOGR, Pune

Mera Gaon Mera Gaurav

The objective of "Mera Gaon Mera Gaurav" (My Village My Pride) scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages. Under this scheme, ICAR-DOGR has identified 15 villages *viz.,* Gadakwadi, Varude, Gulani, Wafgaon, Jawulke, Khadakwadi, Loni, Pondewadi, Dhamni, Ranmala, Gosasi, Mitgudwadi, Kanhur Mesai, Khairewadi and Khairenagar. The various activities, such as meetings, visits, awareness programmes, trainings were organized in these villages by the scientific staff of ICAR-DOGR. Awareness about cleanliness was also created among the people of these villages and conducted cleanliness activities by involving the villagers under Swachh Bharat Abhiyan. Dr. S. S. Gadge, Senior Scientist planned and monitored the activities as Nodal Officer of MGMG scheme. Total 35 training programmes were organized in different villages adopted under MGMG scheme.

Research Projects

Institute Projects

IXX16154: Genetic improvement of red onion

PI: Dr. A.J. Gupta and **Co-PIs:** Dr. V. Mahajan, Dr. S.J. Gawande, Dr. Anandhan S., V. Karuppaiah, Dr. Kalyani Gorrepati, Mrs. Ashwini P. Benke, Dr. Pranjali Gedam, Dr. Manjunath Gowda DC., Dr. Y.P. Khade and Dr. Rajkumar Dagadkhair

IXX16120: Genetic improvement of white and yellow onion

PI: Dr. V. Mahajan and **Co-PIs:** Dr. A. J. Gupta, Dr. Ram Dutta, Dr. S.J. Gawande, Dr. Karruppaiah, Mrs. Ashwini P. Benke, Dr. Pranjali Gedam, Dr. Manjunath Gowda D C., Dr. Soumia P.S., Dr. Y. P. Khade, Dr. Shabeer Ahmed (NRCG, Pune) and Dr. Geetika Shameer (CITH, Shrinagar)

IXX16060: Development of onion hybrids for quality and yielding traits

PI: Dr. Manjunath Gowda D C. and **Co-PIs:** Dr. A. J. Gupta, Dr. V. Mahajan, and Dr. Ashwini P. Benke

IXX16059: Genetic improvement of garlic through conventional and biotechnological approaches

PI: Mrs. Ashwini P. Benke and **Co-PIs:** Dr. V. Mahajan, Dr. A. J. Gupta, Dr. S.J. Gawande, Dr. Pranjali Gedam, Dr. Manjunath Gowda D C. and Dr. Geetika Shameer (CITH, Shrinagar).

IXX16093: Biotechnological approaches for improvement of onion

PI: Dr. Anandhan S. and **Co-PIs**: Dr. Soumia P.S. and Dr. Y.P. Khade

IXX16107: Breeding for abiotic stress tolerance in Allium species

PI: Dr. Y.P. Khade and **Co-PIs:** Dr. V. Mahajan, Dr. A. J. Gupta, Dr. Pranjali Gedam and Mr. Radhakrishna A.

IXX16221: Abiotic stress management in onion and garlic

PI: Dr. Pranjali Gedam and **Co-PIs**: Dr. V. Mahajan, Dr. A. J. Gupta, Dr. S.J. Gawande, Dr. A. Thangasamy, Dr. Y.P. Khade, Dr. Satish Kumar., Dr. Sanket More., Dr. Kiran Bhagat (ICAR_DFR, Pune)., Dr. Shabeer Ahmed (NRCG, Pune) and Dr. Rajkumar Dagadkhair

IXX16403: Development of improved nutrient management practices for onion and garlic

PI: Dr. A. Thangasamy and **Co-PIs:** Dr. V. Karuppaiah, Dr. Soumia P.S., Dr. Pranjali Gedam, Dr. Bhushan Bibwe and Dr. Shabeer Ahmed (NRCG, Pune)

IXX16077: Bio-intensive IPM strategies for insect pests of Onion and Garlic

PI: Dr. V. Karuppaiah **Co-PIs:** Dr. Ram Dutta, Dr. A. Thangasamy and Dr. Soumia P.S.

IXX16111: Post-harvest management of storage insect pests and diseases in onion and garlic

PI: Dr. Soumia PS and **Co-PIs:** Dr. Ram Dutta, Dr. S.J. Gawande, Dr. A. Thangasamy, Dr. V. Karuppaiah and Dr. Kalyani Gorrepati

IXX16074: Development, refinement and validation of management strategies for major fungal diseases of Onion-Garlic

PI: Dr. Ram Dutta and **Co-PIs:** Dr. V. Mahajan, Dr. S.J. Gawande, V. Karuppaiah, Mrs. Ashwini P. Benke, Dr. Soumia P.S., Dr. Y.P. Khade, Dr. Kiran Bhagat (DFR, Pune), Dr. Satish Kumar, Mr. Radhakrishna A. and Dr. Jayalakshmi K

IXX16061: Biotechnological approaches for biotic stress management

PI: Dr. S.J. Gawande and **Co-PIs:** Dr. Ram Dutta, Dr. S. Anandhan, Dr. V. Karuppaiah, Dr. Pranjali Gedam, Dr. Soumia P.S. and Dr. Y.P. Khade, Dr. Jayalakshmi K

IXX16540: Epidemiology and Bio-management of major fungal diseases of Onion and Garlic

PI: Dr. Jayalakshmi K. and **Co-PIs**: Dr. Ram Dutta, Dr. Suresh J. Gawande and Mrs. Ashwini P. Benke

IXX19658: Exploring the molecular, biochemical and microbial processes associated with onion spoilage for devising eco-friendly solutions to post-harvest losses

PI: Dr. Satish Kumar, **Co-PIs:** Dr Ram Dutta, Dr. Suresh Gawande, Dr. Vijay Mahajan, Dr. Amarjeet Gupta, Dr. Radhakrishna A, Dr. Kalyani Gorrepati, Dr. Rajiv Kale, Dr. Bhushan Bibwe, Dr. Pranjali Gedam and Dr. Rajkumar Dagadkhair

IXX16210: Refinement of storage technologies in onion and garlic

PI: Dr. Kalyani Gorrepati, **Co-PIs:** Dr. Bhushan Bibwe, Dr. Rajkumar Dagadkhair, Dr. S.S. Gadge and Dr. R.B. Kale

IXX16113: Processing and value addition in onion and garlic

PI: Dr. Bhushan Bibwe and **Co-PIs:** Dr. Kalyani Gorrepati and Dr. Rajkumar Dagadkhair

IXX16114: Mechanization in onion and garlic

PI: Dr. Bhushan Bibwe and **Co-PIs:** Dr. S.S. Gadge, Dr. Kalyani Gorrepati and Dr. R.B. Kale

IXX19349: Enhancing the nutraceutical delivery potential of onion through probiotication

PI: Dr. Rajkumar Dagadkhair and **Co-PIs:** Kalyani Gorrepati, Dr. Bhushan Bibwe, Dr. Ram Dutta, Dr. S. Gawande, Dr. Satish Kumar, Dr. Rajiv kale and Pranjali Ghodke

IXX16214: Transfer of improved onion and garlic technologies and impact assessment

PI: Dr. S.S. Gadge and **Co-PI:** Dr. R.B. Kale

IXX16155: Novel approaches for transfer of Onion and Garlic Technologies

PI: Rajiv B Kale and **Co-PI:** Dr. S.S. Gadge

Externally Funded/Other projects

Project 1: All India Network Research Project on Onion and Garlic (AINRPOG)

Dr. V. Mahajan, Nodal Officer, Funding: ICAR

Project 2: DUS testing through ICAR-SAU's system

Dr. A.J. Gupta, Nodal Officer, Funding: PPV&FRA

Project 3: Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology Scheme (IPMTCATS)

PI: Dr. Rajiv B Kale and Member Secretary, Funding: ICAR

Project 4: Agri Business Incubation Project

PI: Dr. Rajiv B Kale and **Co-PI**: Dr. Kalyani Gorrepati, Funding: ICAR

Project 5: Tribal Sub-Plan (TSP) for onion and garlic

Dr. A.J. Gupta, Nodal Officer, and **Co-PI**: Dr. S. S. Gadge, Dr. R. B. Kale, Mrs. Ashwini P. Benke, Mr. A. R. Wakhare, Mr. H. S. Gawali

Project 6: North East Hill Plan

Dr. V. Mahajan, Nodal Officer and Dr. S. S. Gadge, Funding: ICAR

Project 7: Scheduled Caste Sub-Plan (SCSP) for onion and garlic

Dr. S. S. Gadge, Nodal Officer, Dr. R. B. Kale and Dr. A. Thangasamy, Funding: ICAR

Project 8: Haploid induction in onion (*Allium cepa* L.) through genome elimination

PI: Dr. S Anandhan, Funding: ICAR-National Fellow

Project 9: Development of cytoplasmic male sterile lines in onion (*Allium cepa* L.) through targeted mutagenesis of *AcMSH1* gene

PI: Dr. S Anandhan, Co-PIs: Ashok Kumar, Funding: Department of Science and Technology, New Delhi

Project 10: Tapping the potential of stingless bee Tetragonula iridipennis Smith for pollination enhancement and profitable onion seed production

PI: Karuppaiah V, Funding: SERB-Department of Science and Technology, New Delhi

Project 11: Deciphering the gut microbiome profile of Apis species in Onion (Allium Cepa) to enhance ecosystem

PI: Dr. Soumia PS, Funding: Department of Science and Technology, New Delhi

Project 12: Development of hybrids in onion: A joint venture with Beej Sheetal

PI: Dr. A.J. Gupta, Funding: Beej Sheetal Seeds Pvt. Ltd. and ICAR-DOGR

Project 13: Efficacy evaluation of ICAR-CIRCOT Nano-Sulphur as fertilizer formulation for different field crops (Collaborative Project ICAR-DOGR and ICAR-CIRCOT)

PI: Dr. A. Thangasamy, **Co-PI**: Dr. Bhushan Bibwe

Project 14: POLY4 Rate Response Trial on Onion and Garlic

PI: Dr. A. Thangasamy, Funding: AngloAmerican, New Delhi

Project 15: Evaluation of bio-efficacy of GPH 1821 for controlling weeds in onion

PI: Dr. A. Thangasamy, Funding: UPL India Ltd. Mumbai

Project 16: Bio-efficacy Evaluation of Bensulf SUPERFAST on Onion

PI: Dr. A. Thangasamy, Funding: Smartchem Technologies Limited, Pune

Project 17: Evaluation of RCF's Nano-Urea in onion

PI: Dr. A. Thangasamy, Funding: Rashtriya Chemicals and Fertilizers Limited, Mumbai

Project 18: Evaluation of AgroNest Smart Warehouse in reducing storage losses & prolonging the storage life of Onions

PI: Dr. Bhushan Bibwe, **Co-PI**: Rajkumar Dagadkhair, Funding: Tata Steel

Project 19: Evaluation of IOT based device developed by GODAAM INNOVATIONS

PI: Dr. Bhushan Bibwe, **Co-PI**: Kalyani Gorrepati, Funding: GODAAM Innovations

Project 20: Capacity Building and Demonstration of improved technologies to enhance water use efficiency in onion

PI: Rajiv B Kale and **Co-PIs:** Dr. S.S. Gadge and Dr. A. Thangasamy

Funding: Development Support Centre, Narayangaon, Pune

K. Awards, Honours and Recognition

1. **Best Stall Award:** ICAR-DOGR received "Best Stall Award" in the exhibition "Shining Maharashtra" held by Sansa Foundation, Phaltan during 25-27 March, 2022 at Phaltan, Satara.
2. **CHAI Appreciation Award-2022:** Dr. Vijay Mahajan received "CHAI Appreciation Award-2022" for dissemination of technologies for its large-scale adoption from CHAI, New Delhi on 28th May 2022 during National conference on Climate Resilient and Sustainable Development of Horticulture at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur.
3. **Fellow of International Society of Noni Science:** Dr. Vijay Mahajan conferred with "Fellow of International Society of Noni Science" for outstanding contribution related to Agriculture Research, from International Society of Noni Science, Chennai on 31 May, 2022 during One day national seminar on "Noni and Wellness" held at Jaunpur, UP.
4. **ISVS Fellows Award:** Dr. Amar Jeet Gupta conferred with Fellowship 'ISVS Fellows-2020' for his significant contribution in the field of Vegetable Research in the General Body Meeting of Indian Society of Vegetable Science (ISVS) held at ICAR-IIVR, Varanasi, awarded in 2022.
5. **ISHRD Fellows Award:** Dr. Amar Jeet Gupta conferred with Fellowship by Indian Society of Horticultural Research & Development (ISHRD) for outstanding contribution in the field of Horticultur**e** during Progressive Horticulture Conclave (PHC-2022) held at GBPUA&T, Pantnagar.
6. **Best Publication Award:** Kanwar Veerendra Singh Memorial All India best publication award 2022 by Sadhana, Society for advancement of human and nature, Dr YS Parmar University of Horticulture and Forestry, PO Nauni, Solan, Himachal Pradesh, India. Sahu PK, Jayalakshmi K, Tilgam J, Gupta A, Nagaraju Y, Kumar A, Hamid S, Singh HV, Minkina T, Rajput VD and Rajawat MVS (2022) ROS generated from biotic stress: Effects on plants and alleviation by endophytic microbes.
7. **Best Article of the Month:** Ghosh S, Datta D, Majumdar B, Mazumdar SP, Soumia PS and Thangasamy A. (2022). "Onion Price Fluctuation in Indian Market: Analysis and Mitigation Strategies" in VigyanVarta, 3(4): 95-98: An International E-Magazine for Science Enthusiasts for the month of April, 2022.
8. **Best Oral Presentation Award:** Effect of Biofertilizers Inoculation on Onion Yield, Nutrient Uptake and Soil Fertility Status authored by Thangasamy A, Gawande SJ, Komal Gade, Pranjali A. Gedam, Vijay Mahajan and Major Singh (2022) during Climate Resilient and Sustainable Development of Horticulture held at CSAUA&T, Kanpur, Uttar Pradesh during May 28-31, 2022.
9. **Best Oral Presentation Award:** Dr. Karuppaiah V Received "Best Oral Presentation Award" for paper entitled Predicting climate change impact on the potential geographical distribution of Onion thrips *Thripstabaci* in India using maximum entropy ecological niche modeling at National Seminar on climate resilient technologies for sustainable agriculture intervention and approaches (CRTSAIA-2022) during 26-27 March, 2022 at M.S. Swaminathan School of

Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha-761211.

10. **Subject matter expert for drafting concept document of "Onion Grand Challenge"**: Dr. Bhushan Bibwe, Dr. Rajiv B Kale, Dr. Kalyani Gorrepati, and Dr. Rajkumar Dagadkhair acted as a subject matter expert for drafting concept document a mega national event organized by Ministry of Commerce and Ministry of Education, Govt of India during May –June, 2022.

11. **Nomination as Evaluator for "Onion Grand Challenge":** Dr. Bhushan Bibwe, Dr. Rajiv B Kale, Dr. A. Thangasamy, and Dr. Rajkumar Dagadkhair acted as an evaluator for ideas submitted in Grand Onion Challenge Hackathon 2022-2023 conducted by Department of Consumer Affairs, Ministry of Consumer Affairs, Food & Public Distribution.

12. **Editorial Board Member:** Dr. Suresh Gawande inducted as Academic editor in Editorial board of the journal 'Peer J' (NAAS Rating 9.06) and journal 'BMC Plant Biology' (NAAS Rating 11.26).

13. **Review Editor in Editorial Board:** Dr. Satish Kumar inducted as Review Editor in Editorial Board of the journal 'Frontiers in Microbiology' (NAAS Rating: -11.4)

14. **Editor Board Member:** Dr. Bhushan Bibwe acted as editor board member for NASS Journal of Agricultural Science, Bilingual publishing Co. 17 December, 2021 to 16 December, 2022.

L. Publications

Papers in referred journals

1. Benke AP, Mahajan V, Manjunathagowda DC and Mokat DN. (2022). Interspecific hybridization in Allium crops: status and prospectus. *Genetic Resources and Crop Evolution*, 1-9.https://doi.org/10.1007/s10722-021-01283-5.
2. Bibwe B, Mahawar MK, Jalgaonkar K, Meena VS and Kadam DM. (2022). Mass modeling of guava (cv. Allahabad safeda) fruit with selected dimensional attributes: Regression analysis approach. *Journal of Food Process Engineering* e13978. https://doi.org/10.1111/jfpe.13978.
3. Chaudhari GV, Hedau NK, Ram H, Khade YP, Kant L and Khar A. (2022). Garlic: retrospect, status quo and dimensions. *Genetic Resources and Crop Evolution*. 69: 2645-2660.
4. Dagadkhair RA, Pawar VN, Sharma AK, Devkatte AN, Raichurkar SJ, Athawale GH. (2022). Improving Survivability of Probiotics (*L. Acidophilus*) in ManjariMedika Grape Juice. *SpecialusisUgdymas*, 1 (43): 6476-648
5. Das A, Yadav RK, Bharadwaj R, Choudhary H and Khade YP. (2022). Study of heterotic potential for important antioxidant and nutritional traits in okra (*Abelmoschus esculentus*). *Indian Journal of Agricultural Sciences*, 92(8): 986-990.
6. Dukare A, Bibwe B, Samota MK, Dawange S, Kumar M, and Lorenzo JM. (2022). Assessment of bioactive compounds, physicochemical properties, and microbial attributes of hot air–dried mango seed kernel powder: an approach for quality and safety evaluation of hot air-dried mango seed kernel powder. *Food Analytical Methods*, 15: 2675–2690, https://doi.org/10.1007/s12161-022-02318-y.
7. Dukare A, Mhatre PH, Maheshwari HS, Bagul SY, Manjunatha BS, Khade Y and Kamble U. (2022). Delineation of mechanistic approaches of rhizosphere microorganisms facilitated plant health and resilience under challenging conditions. *3 Biotech*. 12(57):1-33.
8. Dukare A, Samota MK, Bibwe B, and Dawange S. (2022). Using convective hot air drying to stabilize mango peel (Cv-Chausa): evaluating effect on bioactive compounds, physicochemical attributes, mineral profile, recovery of fermentable sugar, and microbial safety. *Journal of Food Measurement and Characterization*, 16: 3897–3909. https://doi.org/10.1007/s11694-022-01496-x .
9. Dutta R, Jayalakshmi K, Nadig SM, Manjunathagowda, DC, Gurav VS, and Singh M. (2022). Anthracnose of onion (*Allium cepa* L.): A twister disease. *Pathogens*, 11, 884. https://doi.org/10.3390/pathogens11080884.
10. Gedam P, Shirsat DV, Arunachalam T, Ghosh S, Gawande SJ, Mahajan V, Gupta AJ. and Singh M. (2022). Screening of onion (*Allium cepa* L.) genotypes for waterlogging tolerance. *Frontiers in Plant Science*, 12, p.72726.
11. Gowd TYM, Deo C, Manjunathagowda DC. et al. (2022). Allelic variability and transferability of atp6 gene among Allium species. *Genet Resources and Crop Evolution*, 70: 281-287. https://doi.org/10.1007/s10722-022-01475-7.
12. Gupta AJ, Anandhan S, Manjunathagowda DC, Benke AP, Mahajan V, Kad SK and Singh M. (2022). Complement test for distinctiveness, uniformity and stability

testing of kharif onion (*Allium cepa L.*) varieties. *Genetic Resources and Crop Evolution*,69 (6): 2217-2229.

13. Gupta AJ, Jayaswall K, Khar A, Mahajan V, Kad SK, and Singh M, (2021). Analysis of genetic diversity among Indian garlic (*Allium sativum* L.) genotypes using SSR markers and morphological traits. *Vegetable Science, 48*(2): 219-227.
14. Jaiswal DK, Gawande SJ, Soumia PS, Krishna R, Vaishnav A, and Ade AB. (2022). Biocontrol strategies: an eco-smart tool for integrated pest and diseases management. *BMC microbiology*, 22(1): 1-5. https://doi.org/10.1186/s12866-022-02744-2.
15. Jayaswall K, Sharma H, Bhandawat A, Sagar R, Jayaswal D, Kumar A, Chaturvedi P, Mahajan V, Kumar S and Singh M. (2022). Chloroplast derived SSRs reveals genetic relationships in domesticated alliums and wild relatives. *Genetic Resources and Crop Evolution*, 69: 363-372.
16. Karuppaiah V, Chaware GG, Soumia PS, and Singh M. (2022). A checklist of insect pests of onion. *Indian Journal of Entomology*, 1–15. https://doi.org/10.55446/IJE.2021.364
17. Karuppaiah V, Soumia PS, Shinde PS, Benke A, Mahajan V, and Singh M. (2022). Evaluation of Garlic Genotypes for Resistance to *Thripstabaci* Lindeman. *Indian Journal of Entomology*, 84(2): 459-462. https://doi.org/10.55446/IJE.2021.259.
18. Kate AE, Pawar D, Chakraborty SK, and Gorepatti K. (2022). Development and evaluation of onion bulb descaler for removal and collection of surface dry peel. *Journal of Food Science and Technology*, 59: 2448–2459.
19. Khade YP, Salunkhe SR, Manjunathagowda DC, Sinhasane SR, Yeswanth MGT, Mahajan V and Singh M. (2022). Molecular characterization of short-day onion genotypes by Intron Length Polymorphic (ILP) markers. *Genetic Resources and Crop Evolution*, 69: 2077-2086.
20. Khandagale K, Roylawar P, Kulkarni O, Khambalkar P, Avinash Ade, Kulkarni A, Singh M and Gawande S. (2022). Comparative transcriptome analysis of onion in response to infection by Alternaria porri (Ellis) Cifferi. *Frontiers in Plant Science*. https://doi.org/10.3389/fpls.2022.857306
21. Khandagale K, Roylawar P, Randive P, Karuppaih V, Soumia PS, Shirsat D, Gedam P, Ade A, Gawande S and Singh M. (2022). Isolation and Expression Profiling of Insecticidal Lectins from Wild Alliums Against Onion Thrips (*Thripstabaci* Lindeman). *Proceedings of the National Academy of Sciences, India Section B*: *Biological Sciences*, **92**, 451–459. https://doi.org/10.1007/s40011-022-01360-4
22. Khar A, Zimik M, Verma P, Singh H, Mangal M, Singh MC and Gupta AJ. (2022). Molecular marker-based characterization of cytoplasm and restorer of male sterility (Ms) locus in commercially grown onions in India. *Molecular Biology Reports*,49 (6): 5535-5545.
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24. Kumar N, Kumar S, Singh AK, Gite A, Patole PB, and Thorat ST. (2022). Exploring mitigating role of zinc nanoparticles on arsenic, ammonia and temperature stress

using molecular signature in fish. *Journal of Trace Elements in Medicine and Biology*, 74 (2022): 127076.

25. Mahajan V, Manjunathagowda DC, Gupta AJ, Benke AP, and Singh M. (2021). Onion (*Allium cepa L.):* Breeding for quality traits and export. *Vegetable Science*, 48(2):123-135. (28 April 2022).
26. Manape TK, Satheesh V, Singh S, Singh M, Anandhan S. (2022). Improved method for regeneration and *Agrobacterium*-mediated transformation of Indian short-day onion (*Allium cepa* L.). *Plant Cell, Tissue and Organ Culture (PCTOC)*, 148:61–72.
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29. Manjunathagowda DC, Benke AP, Mahajan V, and Singh M. (2022). Standardization of Meristem Tip Culture in Short Day Garlic Varieties. *International Journal of Agriculture and Biology* 27(6): 399-404.
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31. Manjunathagowda DC, Selvakumar R, Shilpashree S, Anjanappa M, Dutta R, Sharath, MN, Shalaka SR. and Mahajan V. (2022). Purple blotch disease of onion (*Allium cepa*): perspective and prospects. *International Journal of Agriculture and Biology*, 27(6): 394-398.
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Papers and Abstracts in Conference/ Seminar/ Symposia

Lead Lecture

1. Vijay Mahajan presented lead lecture at National Conference on climate resilient and sustainable development of horticulture, held on 28-30 May, 2022 at CSAUA&T, Kanpur, UP.

Oral presentations

1. Gupta AJ, Mahajan V, Benke AP, and Singh M. (2022). Performance of trait specific onion genotypes under different climatic conditions. Abstracts: AICRP (VC) Golden Jubilee National Symposium on New opportunities in vegetable production for sustainable development, 20-22 December, 2022 organized by ICAR-IIVR, Varanasi. Pp: 56.
2. Jayalakshmi K, Dutta R, Sharath MN, and Gurav VS. (2022). Evaluation of effective modules for management of onion anthracnose in Maharashtra, India. 8th International Conference (hybrid mode) on "Plant Pathology: Retrospect and Prospects" at Sri Karan Narendra Agriculture University, Jobner-Jaipur, Rajasthan, India during March 23-26, 2022.
3. Khade YP, Mainkar PS, Salunkhe SR, Radhakrishna A. and Mahajan V. (2022). Molecular cloning and characterization of AcLEAFY gene in short-day onion (*Allium cepa* L.) characterization of short-day onion genotypes by Intron Length Polymorphic (ILP) markers during 3 days (28-30 September, 2022) International Conference on advances in agricultural, veterinary and allied sciences for improving livelihood and environmental security (AAVASILES-2022), University of Kashmir.
4. Khade YP, Shalaka R S, Mainkar PS, Radhakrishna A. and Mahajan V. (2022). Molecular Characterization of onion varieties by using Potential Intron Polymorphic (PIP) and microsatellite (SSR) markers authored by during 3 days (28-30 September, 2022) International Conference on advances in agricultural, veterinary and allied sciences for improving livelihood and environmental security (AAVASILES-2022), University of Kashmir.
5. Singh M, Mahajan V and Thangasamy A. (2022). Impact and improvement strategies for climate resilience and sustainability in onion and garlic. In H.P. Singh *et al.* (2022). Book of Abstracts, Climate Resilient and Sustainable Development of Horticulture, ASM Foundation, New Delhi, Pp: 208.
6. Thakur V, Rane J, Kumar S. (2022). Image facilitated assessment of intra-spike variation in grain size in wheat genotypes exposed to terminal high-temperature stress and terminal drought stress, paper presented at 7th International Plant Phenotyping Symposium, held at Wageningen, the Netherlands, September 26-30, 2022.
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8. Thangasamy A, Gawande SJ, Gade K, Gedam PA, Mahajan V and Singh M. (2022). Effect of biofertilizers inoculation on onion yield, nutrient uptake and soil fertility status. In H.P. Singh *et al.* (2022). Book of Abstracts, Climate resilient and

sustainable development of horticulture held at CSAUA&T, Kanpur, Uttar Pradesh during May 28-30, 2022.

9. Thangasamy, A, Soumia PS, Karuppaiah V, Gade KA, Satpute SD and Mahajan V (2022). Effect of continuous use of inorganic fertilizers and manures on onion production and soil fertility status. In Book of Abstracts. 86th Annual convention and national seminar on developments in soil science: held at MPKV, Rahuri during November 15-18, 2022.

10. Wakchaure GC, Khapte PS, Kumar S and Rane J. (2022). Exogenous plant growth chemicals enhance productivity and postharvest quality of fruiting vegetables in water scarce regions, paper presented at International Conference on Advances in Agriculture and Food System Towards Sustainable Development Goals, University of Agricultural Sciences, Bangalore, August 22 - 24, 2022.

Poster Presentation

1. Gupta AJ, Mahajan V, Khar A, and Singh M. (2022). Protection of onion and garlic varieties through PPV&FRA. Abstracts: AICRP (VC) Golden Jubilee National Symposium on New opportunities in vegetable production for sustainable development, 20-22 Dec, 2022 organized by ICAR-IIVR, Varanasi. pp. 294-295.

Book/Manual/Report

1. Indian Standard: Supply Chain of Onions —Guidelines, Venkat R., Sivakumar R, Ramanujam T. S. Prusty B. K., Kumar D, Bajaj A, Kale, R., Gajanana T. M. Raghu R Tripathi R. D., Kaul S. K., Singh B Siddhanta A., Gupta P. K., Shalendra, Gummagolmath K. C., Shalini R, Soni, S (Drafting Panelists) (2022). Published by Bureau of Indian Standards, New Delhi IS 17912: 2022.
2. Kale R. B., Gadge S. S., Venkata Rao B., Mahajan V. and Singh M. (Eds) (2022). E-book on "Good Agricultural Practices in Onion and Garlic Production". National Institute of Agricultural Extension Management (MANAGE) & ICAR-Directorate of Onion and Garlic Research, Rajgurunagar.
3. Major Singh, S. Anandhan, Soumia P.S., Yogesh P. Khade, Tushar K., Manape, Dhananjay V. Shirsat (2022). Training Manual on Techniques in Molecular Biology. Pp:35

Book Chapters

1. Bhagat KP, Kale RB, Benke A, Manjunath Gowda DC, Ghodke PH, Shirsat DV, Jawalekar K, Mahajan V, and Singh M. (2022). Abiotic Stresses in Onion and Garlic Production. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 79-84.
2. Bibwe B, Benke AP, Khade YP, Kale RB. (2022). Mechanization in onion and garlic value chain. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 105-118.
3. Bibwe B, Dagadkhair R and Gorrepati K, (2022). Opportunities in processing, storage and value addition of onion and garlic processing. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 85-93.

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5. Dagadkhair R, Bibwe B and Gorrepati K. (2022). Medicinal and Nutraceutical Properties of Onion and Garlic. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 94-104.

6. Dagadkhair RA (2022). Cashew Apple Processing and Value Addition, in Cashew Production and Post-Harvest Technologies, pp 110-131.

7. Gadge SS, Kale RB, Gupta AJ, Thangasamy A, Mahajan V, and Major Singh (2022). Impact of Improved Onion and Garlic Technologies at Farmers' Field. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 146-163

8. Ghodki BM, Kate A, Gorrepati K, Narsaiah K, and Kotwaliwale N. (2022). Storage and value addition of onion. In: Post-Harvest Technologies for Promoting Agro-Processing. Eds. Balakrishnan R, Yadav DN, Mann S, Khwairakpam B. and Kumar V. ICAR-CIPHET, Ludhiana. Pp: 58-64.

9. Gupta AJ, Mahajan V, and Singh M. (2022). Harnessing the benefits of PPV&FRA for traditional growers of onion and garlic. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 72-78.

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11. Guru-Pirasanna-Pandi, G, Babu, SB, Meher C, Soumia PS, Basana-Gowda, G, Annamalai, M, Patil NB, Adak T, and Rath PC. (2022). Insect Pest Dynamics in Rice-Based Production Systems under Changing Climate. In: Climate Resilient Technologies for Rice- Based Production Systems in eastern India. Eds. Battacharyya P, Chakraborty K, Molla KA, Poonam A, Bhaduri D, Sah RP, Paul S, Hangaji PS, Basanna-Gowda, G. and Swain P. ICAR-NRRI, Cuttack, Odisha, India. Pp: 248-262. (ISBN 818840902-2).

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and Mushrooms. Part I: Plantation crops. Apple Academic Press and CRC Press (Taylor & Francis Group): Pp: 97-118.

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18. Khade YP, Kale RB, Soumia PS, Bibwe BR, Karuppaiah V and Mahajan V. (2022). Improved varieties of onion for enhancing the production. In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 19-26.
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21. Kumar S, Wakchaure GC, Meena A, Meena KK, Sorty AM, Bitla UM, Kumar M, Gurumurty S, Harish CB. (2022). Halophytes for managing salinity stresses in agriculture, In: *Abiotic Stresses in Agriculture: Impacts and Management* (Vol-1). Eds. Pathak H *et. al.*, ICAR-NIASM, Baramati. Pp: 401-413, (eISBN No. 978-81-949091-0-1).
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32. Wadkar SK, and Kale RB. (2022) National policy for farmer producers' organizations (FPOs). In: Good Agricultural Practices in Onion and Garlic Production. Eds. Kale RB, Gadge SS, Venkata Rao B, Mahajan V, and Singh M. MANAGE and ICAR-DOGR, Pune, Pp: 136-145

33. Wakchaure GC, Kumar S, et al., (2022). Sugarcane: Impact and Management of Abiotic Stresses. In: *Abiotic Stresses in Agriculture: Impacts and Management* (Vol-1). *Eds.* Pathak H et. al., ICAR-NIASM, Baramati., Pp: 272-279, (eISBN No. 978-81-949091-0-1).

Technical/Extension Bulletins

1. Adiga JD, and Dagadkhair RA. (2022). Nethra Jumbo: A New Cashew Hybrid for Extra Income. ICAR – DCR. Pp: 6.

2. Manjesh GN and Dagadkhair R. (2022). Management of commercial cashew nursery. ICAR – DCR. Pp: 29.
3. Thangasamy A, Gadge SS, Karuppaiah V, Gawande S, Mahajan V, Kale RB, Soumia PS, Gedam PA, Khade YP, and Singh M. (2022). Improved cultivation Practices for Garlic. Technical Bulletin no. 38. ICAR-Directorate of Onion and Garlic Research, Pune 410 505. Pp: 32.
4. Thangasamy A, Gadge SS, Karuppaiah V, Soumia PS, Mahajan V, Gawande S, Kale RB, Kalyani G, Gupta AJ, and Singh M. (2022). Improved cultivation Practices for Onion. Technical bulletin no. 37. ICAR - Directorate of Onion and Garlic Research, Pune 410 505. Pp: 40.

Technical / Popular Articles/ E-publication

1. Bibwe B, Gorrepati K, Khade Y, Mahawar MK, Bhushan B, Singh M. (2022). *Lahsun ka prasanskaran evm mulyavardhan*, *Krushichetna*, IIMR, ICAR-IIMR, Vol 5 (22): 53-55.
2. Gadge SS and Kale RB. (2022). *Shastriya paddhatine karakanda beejotpadan* (Onion Seed Production through Scientific Methods) Agrowon. 4 December, 2022. Sakal Media Group, Pune. Pp: 7.
3. Ghosh S, Datta D, Majumdar B, Mazumdar SP, Soumia PS, and Thangasamy A. (2022). Onion Price Fluctuation in Indian Market: Analysis and Mitigation Strategies. Vigyan Varta 3(4): 95-98. E-ISSN: 2582-9467.
4. Ghosh S, Thangasamy A, Khade YP, Soumia PS, Shirath DV, Datta S, and Singh M. (2022). Monocot Weeds in Onion Agro-Ecosystems: Biology and Management Strategies. VigyanVarta. 3(6): 163-168. E-ISSN: 2582-9467.
5. Gupta AJ, Mahajan V, and Singh M. (2022). Raising of early *kharif* onion through sets technology (Hindi). ICAR-Phal Phool (March-April, 2022): 22-24.
6. Jayalakshmi K, Sahu PK, Saranya R and Nazia M. (2022). False smut (*Villosiclava virens*) disease an emerging threat in rice crop (/diseasemanagement/1411-false-smut-villosiclava-virens-disease-an-emerging-threat-in-rice-crop.html) https://www.krishisewa.com/disease-management/1411-false-smut-villosiclava-virens-disease-an-emerging-threat-in-rice-crop.html.
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9. Karuppaiah V, Soumia PS, Mahajan V and Singh M. (2022). Pests of garlic. Agriculture and Environment E-Newsletter, 3(1): 11-15. Article ID: AEN-2022-03-01-003.
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12. Khade YP, Soumia PS and Doke P. (2022). Polymerase Chain Reaction *in training manual on Techniques in Molecular Biology* at ICAR-DOGR on 26 March, 2022. Pp: 13-16.
13. Mahajan V, Kale RB, Khade YP and Gadge SS. (2022). *Kanda kadhani, pratwarivasathavanuk* (Onion harvesting, grading and storage). Shetkari, Feb.2022. Commissionarate of Maharashtra.
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20. Sinhasane SR, Khade YP and Mahajan V. (2022). Shallot Onion: Crucial wild gems of Alliaceae. Agriculture and Environment. 3(8): 49-51.
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Documentary film/TV Shows/ Radio Talks

Documentary film

Developed a documentary film of five minutes on Extending commercial cultivation of onion in eastern parts of Uttar Pradesh: A Success Story which was released by Dr. G. Kalloo, Ex-DDG (Hort.) ICAR and Ex-VC, JNKVV, Jabalpur during Kisan Sangoshthi organized in the premises of ICAR-IIVR, Varanasi on 29 September, 2022.

TV Talk

1. Dr. Vijay Mahajan delivered Phone-In-Live TV Talk on “Production of Export Quality Rabi Onion (*Niryatksham Rabbi Kanda Lagavadiche Vyavasthapan*)” on 10 November, 2022 at DD Sahydari, Mumbai.
2. Dr. Rajiv Kale delivered TV Talk on ‘Care of Onion crop in changing climatic conditions’ (*Badalatya hawamanat Kanda Pikachi Kalji*)” on 19 August, 2022 at DD Sahydari, Pune.
3. Dr. Pranjali Gedam delivered TV talk on Kanda Pikatil Ajayvik Tan Vyawasthapan (*Abiotic stress management in onion crop*). 2 December, 2022 Krishidarshan Program, Prasar Bharati, Doordarshan, Pune.
4. Dr. Bhushan Bibwe delivered TV talk on Kanda Pikantil Yantrikikaran, Krishidarshan Program on Doordarshan: 6 December, 2022, 6:00 PM.
5. Dr. Yogesh Khade Delivered Krishidarshan -Programme on topic “Kandava Lasnachya Sudharit Jati” on 7 July, 2022 on DD Sahyadri at Warli, Mumbai.

Radio Talk

1. Dr. Thangasamy, A participated as Special Guest in 'Live Radio Listeners' interaction program over KODAI FM on Scientific onion and garlic production technology on 2 March, 2022 at 9 AM.
2. Dr. Rajiv Kale delivered radio talk on Onion Value Chain Management, at Aakashwani radio, on 11 April, 2022, 7:30 PM.
3. Dr. Bhushan Bibwe delivered radio talk on Onion and Garlic Processing, at Aakashwani radio, on 14 June, 2022, 7:30 PM.

M. INSTITUTIONAL ACTIVITIES

Technology demonstration and Stakeholders meet for controlled onion structure

ABI centre, ICAR-DOGR, Pune organized a one-day technology demonstration and stakeholders meet for newly developed controlled onion structure designed by ICAR-Directorate of Onion and Garlic Research, Pune in Collaboration with Kala Biotech Pvt. Ltd. on 03.01.2022 at KALA Freeze and cold storages, Pune Nashik Highway, Gat No. 102, Varchi Bhambarwadi, Khed, Pune. The agenda of the meet was to display the innovation of newly designed onion storage structure with controlled conditions in storage for minimizing the onion losses, grading and sorting facility to various stakeholders. After successful demonstration of 200 MT capacity storage structure, and acting on the feedback from various stakeholders, upgraded structure with 2000 MT capacity which was suitable for multi-commodity was demonstrated. Along with the officials from ICAR-DOGR and Kala Biotech Pvt. Ltd. various dignitaries from central and state agricultural departments, NABARD, officials from Ministry of Food Processing Industries, GoI, NHM, NHB etc joined this meet. Participation and feedback were acknowledged for the success of the programme and up-scaling the new technology.


Celebration of 73rd Republic Day

ICAR-DOGR celebrated India's 73rd Republic Day on 26 January, 2022 with great enthusiasm. Dr. Major Singh, Director, ICAR-DOGR hoisted the national flag, symbolizing unity and freedom. Mr. Amarendra Kishore, Administrative Officer, warmly welcomed the guests.


The campus was decorated with patriotic colors, creating a sense of national pride. Staff and students gathered to honour this important day. Dr. Major Singh emphasized the significance of the Republic Day and ICAR-DOGR's commitment to agricultural progress. The celebration included a cultural program and sports competitions for the children of DOGR-staff family organized by employee welfare committee. As the festivities concluded, the spirit of patriotism and unity continued to inspire all participants.

Start-ups Interface for promoting agri-business

Agri-Business Incubation (ABI) unit at ICAR-DOGR organized an interface meeting on "Strengthening onion value chain: Research- Extension-Farmers and Start-ups Interface" during 27-28 January, 2022. A total of 25 participants including scientists, entrepreneurs, stake-holders, farmers from different parts of Maharashtra were present in the program. The meeting was presided over by Dr. Major Singh, Director ICAR-DOGR, Pune and the program was coordinated by Dr. Rajiv B. Kale, Sr. Scientist, ICAR-DOGR and Dr. A. Thangasamy, Sr. Scientist, ICAR-DOGR. Various technical sessions and field visits were conducted on "Onion seed production technology", "Improved technology for onion cultivation", "post-harvest management of onion", "Agri-business incubation centre: Opportunities for start-ups" and "onion cultivation on mulching" respectively.

23rd Research Advisory Committee Meeting of ICAR-DOGR

The 23rd Research Advisory Committee (RAC) meeting of ICAR-DOGR was held through hybrid mode on 20 Feb, 2022 under the Chairmanship of Dr. H.P. Singh, Ex-Deputy Director General (Horticulture), ICAR, New Delhi. The members participated in the meeting were, Dr. SK Dash, Ex-Dean, College of Agricultural Engineering, OUAT, Bhubaneswar; Dr. AS Dhatt, Professor & ADR, PAU, Ludhiana; Dr. AB Rai, Ex-Head, Crop Protection, IIVR, Varanasi; Dr. AN Ganeshmurthy, Ex-Head, NRM, IIHR, Bengaluru; Dr. Kaushik Banerjee, Principal Scientist, NRC Grapes Pune; Dr. Vikramaditya Pandey, Asst. Director General (HS-I), ICAR-New Delhi, two Non-Official members, Navnath Pawar, and Mr Ashok Allapur.

Dr. Major Singh, Director, ICAR-DOGR, welcomed the Chairman and members of RAC and highlighted the achievements made by the institute. Member Secretary RAC Dr. Suresh Gawande presented the Action Taken Report (ATR) of the previous RAC recommendations followed by the presentations of progress reports by the scientists of the ongoing research projects. The Chairman and members of the RAC critically reviewed the progress report and discussed the results in detail. The chairman and the members of the RAC expressed their satisfaction with the progress made by ICAR-DOGR and gave suggestions to improve the research programs of the ICAR-DOGR. The meeting was ended with a vote of thanks by Dr. V. Mahajan, Principal Scientist.

Onion field-cum-feedback visit conducted at farmer's field

Monitoring of improved onion crop

Creation of water facility for irrigation

A field-cum-feedback visit conducted in an onion field at Peth Village, Ambegaon Taluka, Pune District. Shri Vijay Motilal Bhansali a farmer who is using the latest farming practices such as micro-irrigation, water harvesting and improved agronomic practices. The farmer has been cultivating potato in his entire farm for a long time, but this year he has planned to switch to onion as a major crop during the *late kharif* season, covering about 5 acre area. He has approached ICAR-DOGR to make a farm visit to see all of his ongoing activities as well as diagnostic visit to diagnose plant health issues and for better crop management practices. Consequently, experts from DOGR did a diagnostic visit on 16.12.2021 and diagnosed the problem faced in 45 days old onion crop, advised to use DOGR developed package of practices for improved plant health management. A team of experts from ICAR-DOGR, led by Dr. Amar Jeet Gupta, Pr. Scientist (Hort.) and Dr. V. Karuppaiah Scientist (Agril. Entomology), visited his onion field on 4.1.2022 and observed notable improvement in the crop health and growth. The team has appreciated the farmers for his efforts in adopting DOGR technologies and the farmer in turn, expressed his appreciation for the DOGR package of practices and support.

International Women's Day celebration on March 8, 2022


The Women Cell of ICAR-DOGR has organized International Women's Day 2022 on 8th March with the theme "Break the bias" in the seminar hall of ICAR-DOGR, Pune. Dr. Soumia P.S. welcomed all the participants and briefed them about the history of the International women's day celebration. The program was presided by Dr. Vijay Mahajan, Director (Act), ICAR- DOGR, who spoke on the History of Women's days and also emphasized the various role and the value of woman in the society which makes them indispensable. Various competitions like extempore talk, musical chair, lemon and spoon race and mehandi competitions were organized during the program, wherein around 80 participants including students, YPs/ JRF/ SRF and RA attended the program. Dr. Vijay Mahajan, Director (Act), ICAR- DOGR, Dr. Ram Dutta, Principal Scientist, Dr. Soumia P.S., Scientist and I/c women cell and Dr. Jayalakshmi K., Scientist, attended the programme. Dr. Vijay Mahajan and Dr. Ram Dutta felicitated the winners of the competitions with cash prizes. The program ended with the vote of thanks.

ICAR-DOGR organized two training programmes under SCSP

ICAR-Directorate of Onion and Garlic Research, Pune organized two training programmes on "Onion Production Technology" under Scheduled Caste Sub Plan (SCSP) for farmers of District Pune and Ahmednagar (MS) during 15-17 March, 2022 and 22-24 March, 2022. These trainings were attended by 56 scheduled caste farmers. Dr. Major Singh, Director, ICAR-DOGR welcomed the participants and briefed about the ongoing activities of Directorate for the farmers. Dr. Singh emphasized on the importance of improved technologies in increasing quality onion production for socio-economic development of scheduled caste farmers. Dr. Vijay Mahajan, Principal Scientist (Horticulture) also expressed views on commercialization of technologies for betterment of the farmers. The different topics related to onion cultivation starting from seed to harvest and post-harvest technologies were covered by ICAR-DOGR scientists in the training programme. The programme was coordinated by Dr. Shailendra S. Gadge, Senior Scientist (Agricultural Extension) and Dr. Rajiv B. Kale, Scientist (Agricultural Extension).

Training Program on Commercial Cultivation of Onion and Garlic for Tribal Farmers

ICAR-DOGR, Pune organized three days Training-cum-Awareness Program on "Azadi ka Amrit Mahotsav: Commercial cultivation of onion and garlic" under TSP during 21-23 March, 2022 at ICAR-DOGR, Pune. The aim of the TSP is to bridge the gap between ST population and others by accelerating the development of ST farmers through technological interventions. A total of 30 tribal farmers participated in the program from different parts of Ambegaon taluka of Pune (Maharashtra). Dr. Major Singh, Director, ICAR-DOGR, briefed about the technologies developed by ICAR-DOGR to the farmers as well as production and productivity status of onion and garlic. Dr. Amar Jeet Gupta, Principal Scientist (Hort.) & Nodal Officer (TSP), briefed about the importance and scope of TSP on livelihood of tribal farmers. Lectures on different aspects on cultivation of onion and garlic were arranged. Certificates were distributed to all the participants under training program. In addition to lectures and field visits, ICAR-DOGR facilitated to visit 'Kisan 2022' in Pune for all the trainees.

ICAR-DOGR participated in 'Kisan 2022' Exhibition

ICAR-Directorate of Onion and Garlic Research participated in Agricultural Exhibition "Kisan 2022" organized by Kisan Forum Pvt. Ltd., Pune during 23-27 March 2022 at Moshi, Pune. The technologies developed by ICAR-DOGR were showcased at ICAR-DOGR stall. Dr. S. S. Gadge, Dr. Yogesh Khade, Dr. Soumia P.S., Dr. Manjunatha Gowda D.C., Dr. Bhushan Bibwe, Dr. A. Thangasamy, Dr. V. Karuppaiah and Dr. R. B. Kale with technical and supporting staff participated in exhibition with ICAR-DOGR stall. It invoked the great response from the farmers and large numbers of publication were sold out. The exhibition 'Kisan 2022' was visited by about one lakh farmers.

Training-cum-Awareness Program under TSP on 24-26 March 2022

ICAR-DOGR, Pune organized three days Training-cum-Awareness Program on "Scientific Cultivation of Onion and Garlic" under TSP on 24-26 March, 2022 at ICAR-DOGR, Pune. A total of 27 selected tribal farmers from different parts of Khed taluka of Pune (Maharashtra) including 10 ladies farmers participated in the program. Dr. Vijay Mahajan, In-charge Director, ICAR-DOGR, briefed about the technologies developed by ICAR-DOGR to the farmers as well as production and productivity status of onion and garlic. Dr. Amar Jeet Gupta, Principal Scientist (Hort.) & Nodal Officer (TSP), briefed about the activities under TSP and benefits gained by the farmers from this scheme. Farmers from Khed taluka expressed our satisfaction and appreciated ICAR-DOGR for excellent work to the tribal farmers. Dr. Major Singh, Director, ICAR-DOGR, appreciated the feedback received from the farmers regarding the training program. Certificates were distributed to all the participants under training program. In addition to lectures and field visits, ICAR-DOGR facilitated to visit 'Kisan 2022' in Pune for all the trainees.

Best stall award to ICAR-DOGR in 'Shining Maharashtra 2022'

ICAR-Directorate of Onion and Garlic Research participated in agricultural exhibition 'Shining Maharashtra 2022' organized by Sansa Foundation at Phaltan, District- Satara (MS) during 25-27 March, 2022. Dr. Rajkumar Dagadkhair, Shri. D. M. Panchal and Shri. Satish B. Tapkir participated in the exhibition with ICAR-DOGR stall. The technologies developed by the Directorate were showcased at ICAR-DOGR stall. The exhibition 'Shining Maharashtra 2022' was visited by about fifty thousand farmers. ICAR-DOGR stall received the best stall award of the exhibition.

Hands-on training on "Techniques in Molecular Biology" Under Scientific Social Responsibility (SSR) of DST-SERB funded project

The one-day hands-on training programme on "Techniques in Molecular Biology" Under Scientific Social Responsibility (SSR) of DST-SERB funded project "Development of male sterile lines in onion (*Allium cepa* L.) through targeted mutagenesis of *AcMSH1* gene" was organized on 26 March, 2022. The training was aimed for creating awareness among the students on the basic techniques involved in molecular biology and to provide hands-on training in DNA isolation and PCR techniques. Fifteen participants, including Assistant Professors and students from the Department of Botany and Zoology at Hutatma Rajguru Arts, Science, and Commerce College, Rajgurunagar, attended the training. Training programme was included with lecture sessions and practical hands-on DNA isolation and PCR techniques, by Dr. S. Anandhan, Dr. Soumia P. S., Dr. Tushar Manape, Mr. Dhananjay V. Shirsat and Dr. Pawan Mainkar. In the valedictory session, Dr. Vijay Mahajan, Director (act), emphasised the importance of the biotechnology and also motivated the students for their career development. Certificates were distributed to all the participants and program ended with the formal vote of thanks presented by Ms. Ankita Chinche.

Scientific cultivation of onion and garlic training under ATMA

A training programme on "Scientific cultivation of onion and garlic" was organized by ICAR-DOGR under ATMA scheme for farmers of District East Champaran (Bihar) during 26-28 March, 2022. Dr. Major Singh, Director, ICAR-DOGR welcomed the participants and briefed about the ongoing activities of Directorate for the farmers.

The different topics related to onion and garlic cultivation were covered through lectures and practicals. The various agro-practices were demonstrated to the farmers at Rajgurunagar farm of the Directorate. The training was conducted by Dr. Shailendra S. Gadge, Senior Scientist (Agricultural Extension) and Dr. Rajiv B. Kale, Scientist (Agricultural Extension).

ICAR-DOGR organized training program for tribal farmers in Nandurbar under TSP

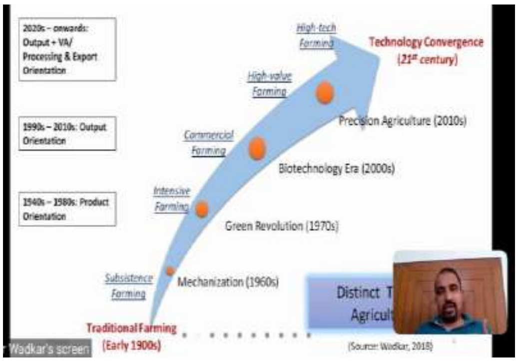
ICAR-DOGR, Pune organized two days training program on “Quality seed production of onion and garlic” for tribal farmers of Nandurbar in collaboration with KVK, Nandurbar on 28-29 March, 2022 to promote entrepreneurship and improve the livelihood of tribal farmers. About 160 tribal farmers from various villages of Nandurbar attended the program. Training program was coordinated by Dr. Amar Jeet Gupta. First day training program was organized at Gram Sadan, Nimboni and second day at Khandawara KVK office in Navapur taluka of Nandurbar. Mr. Rajendra Dahtonde, Head, KVK, Nandurbar formally welcomed the participants and elaborated the theme of the program and briefed about KVK activities to the farmers. Dr. A.J. Gupta, Principal Scientist and Nodal Officer (TSP) explained TSP activities and impact from last eight years in Nandurbar. Fifty-six demonstrations on onion and garlic cultivation and seed production were conducted successfully during *rabi* 2021-22. Most of the tribal farmers are now cultivating onion and garlic at commercial level.

Farmers Fair and Farmers-Scientists Interface under Kisan Bhagidari Prathmikta Hamari Compaign

ICAR-DOGR in collaboration with Gramonnati Mandal Krishi Vigyan Kendra Narayangaon (Pune II), Maharashtra State Agriculture Department, and ATMA, Pune organized Kisan Mela (Farmers fair), exhibition of improved technologies and farmer scientist interface on 26 April, 2022 at Krishi Vigyan Kendra Narayangaon (Pune II) as part of the Kisan Bhagidari-Prathmikta Hamari Campaign during Azadi Ka Amrit Mahotsav conducted during 25-30 April, 2022.

A total of 210 participants including farmers and farmer producer organizations, staff of the agriculture department and KVKs were participated in the programme. The programme was graced by the presence of Dr. Lakhan Singh, Director, ATARI, Pune, Mr. Anil Meher (Chairman, KVK Narayangaon), Mr. Dashrath Tambale (Agri. Director (ATMA) Maharashtra State, Pune), Mr. Manoj kumarDhage (SDAO, Rajgurunagar), Mr. Prashant Shete (Senior Scientist and Head, KVK Narayangaon), Dr. Rajiv Kale (Senior Scientist, Agriculture Extension, ICAR-DOGR, Pune). Dr Singh addressed the participants and appreciated the efforts of the KVK towards farmer participatory technology transfer to improve the yield and income of the farmers. Mr. Meher stressed on post-harvest and marketing aspect where the farmers participation and skill development is necessary. Mr. Tambale focused on the strengthening Farmer Producers Companies to develop farmer participatory value chain. Dr Rajiv Kale, co-ordinated the programme from ICAR-DOGR and also delivered talk on Onion storage and post-harvest management in farmer scientist interface.

ICAR-DOGR, Pune and MANAGE, Hyderabad collaborative online training programme on Good Agricultural Practices in Onion and Garlic Production



ICAR-Directorate of Onion and Garlic Research (ICAR-DOGR), Pune in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad organised an online training programme on “Good agricultural Practices in Onion and Garlic Production” during 02-06 May, 2022 sponsored by MANAGE, Hyderabad. A total of 78 participants including scientists, farmers and farmer producer organizations, staff of the agriculture departments and various universities and KVKs participated in the training programme through the online mode. Dr. Vijay Mahajan, acting director ICAR-DOGR appreciated the efforts of MANAGE and ICAR-DOGR for organising this collaborative training, he emphasised on the urgent need to transfer GAPs for onion and garlic crops starting from the sowing to harvest and post-harvest management. Experts from ICAR-DOGR and other organizations delivered lectures covering various relevant topics. An online exam was conducted in the last session of the training programme and feedback was taken from the participants. The training programme was co-ordinated by Dr. Rajiv Kale and Dr. S. S. Gadge.

Agri-Business Incubation (ABI) centre inaugurated at ICAR-DOGR, Pune


Dr. Major Singh Director, ICAR-DOGR inaugurated the Agri-Business Incubation (ABI) centre on Monday, 13 June, 2022 in the campus of ICAR-DOGR. It was sanctioned in the year 2019 by ICAR Incubation Fund (Component II) under XII Plan scheme of IP&TM unit, ICAR *i.e*. National Agricultural Innovation Fund (NAIF). Dr. Singh, Director ICAR-DOGR said that the ABI Centre aims to create a conducive environment for the entrepreneurs, farmer producer companies and farmers to establish new start-ups and targets entrepreneurship development. Along with the inaugural ceremony of ABI centre, Memorandum of Agreements (MoA) were also signed with four start-ups, including one formation of farmer producer company (FPO) for incubation at ICAR-DOGR, Pune.

The MoAs were done with the 'Farmers Smile Farmer Producer Company", from Khed, Pune aiming development of supply chain for quality onion & onion seeds; "Vagheshwar Farmer Producer Company" which has applied for value addition and processing of onion & garlic crop; "Thinkpure Organic Produced Pvt. Ltd." from Akola district for establishment of seed processing unit & promotion of quality organic seeds; "Palandu Farmer Producer Company" for formation of Farmer Producer Company (FPO) at Vijayapura, Karnataka to later establish an onion processing industry in his district. Dr. Major Singh, Director, ICAR-DOGR, Pune and Dr. Rajiv B. Kale, In-charge, ABI signed the Memorandum of Agreement (MoA) along with the representatives of the companies and welcomed them for incubation at ICAR-DOGR, Pune. The occasion was dignified by the presence of Dr. Ajay Kumar Sharma, Principal Scientist, ICAR-NRC Grapes, Mr. Shantanu Jagtap, Associate Director, MCCIA-Pune, ITMC members, Scientists and project staff of ICAR-DOGR, Pune.

Training-cum-seed distribution of *kharif* onion under TSP

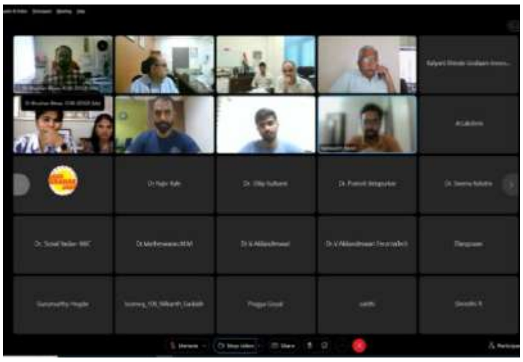

ICAR-Directorate of Onion and Garlic Research, Pune organized training-cum-seed distribution program on 22 June, 2022 under TSP at Bursewadi, Khed taluka of Pune, Maharashtra to promote entrepreneurship and improve the livelihood of tribal farmers. The training program was coordinated by Dr. Amar Jeet Gupta, Principal Scientist (Hort.) & Nodal Officer (TSP). About 54 tribal farmers from Khed taluka of Pune participated in the program including 25 ladies. Dr. Vijay Mahajan, Incharge Director, briefed about the technologies developed by ICAR-DOGR to the farmers as well as production and productivity status of onion. Dr. Gupta briefed about the importance and scope of TSP on livelihood development of tribal farmers and delivered lecture on kharif onion production technology. Farmers including Shri Ramdas Chandaravle, Shri Kailas Osawale, Shri Dipak Nirmal, Mrs. Mangala Burse, Mrs. Sangita Tanpure expressed their satisfaction regarding fruitful training for the tribal farmers. Onion seeds of 'Bhima Super' variety were distributed to 26 groups of tribal farmers. Program ended with the vote of thanks presented by Mr. Dattatray Kondawale.

Training on Scientific cultivation of kharif onion under TSP in Ambegaon taluka of Pune

ICAR-DOGR, Pune organized a Training-cum-Awareness program on "Scientific cultivation of *kharif* onion" on 23 June, 2022 at Gohe Khurd, Ambegaon taluka of Pune. A total of 55 selected tribal farmers from different parts of Ambegaon taluka of Pune participated in the program. Dr. Amar Jeet Gupta, Principal Scientist (Hort.) & Nodal Officer (TSP) briefed about the technologies developed by ICAR-DOGR to the farmers as well as production and productivity status of onion in India. He also spoke about the activities under TSP and benefits gained by the farmers from this scheme. Dr. V. Karuppaiah delivered lecture on management of insect and pest in onion.

Farmers including Shri Somnath Sudam Gongaje, Shri Rohidas Bhaware, Shri Bhivsen Lokare, Shri Vinayak Dangat expressed their satisfaction and appreciated ICAR-DOGR for excellent work for the tribal farmers. Seeds of 'Bhima Super' variety were distributed to tribal farmers 26 groups to conduct field demonstrations.

ICAR-DOGR is recognized as a Knowledge and Evaluation partner in Grand Onion challenge organized by Department of Consumer Affairs (DoCA), GoI



The Ministry of Consumer Affairs, Food and Public Distribution (MoCAFPD) announced (June, 2022) to develop 'Technologies for Primary Processing, Storage and Valorization of Onions' via 'Grand Challenge on Onion Storage'. ICAR-DOGR recognized as a Knowledge and Evaluation partner in the Grand Onion challenge. Dr. Vijay Mahajan, Director, ICAR-DOGR is serving as a Member of National level steering committee. The expert scientist of ICAR-DOGR, Dr. Bhushan Bibwe, Dr. Kalyani Gorrepati, Dr. Rajiv Kale and Dr. Rajkumar Dagadkhair were actively involved in the drafting of the Grand Onion challenge and its verticals. Dr Thangasamy along with these experts is also serving as expert member for evaluation of submitted ideas during the various stages of the challenge.

Training Workshop on 'Post Harvest Storage Technologies and Management of Onion''

ICAR- Directorate of Onion and Garlic Research, Pune and Indian Institute of Technology Mumbai (IIT-Bombay), collaboratively organized one day training workshop on 'Post Harvest Storage Technology and Management of Onion' on 08 July, 2022 at ICAR-DOGR campus under the sponsorship of Project on Climate Resilient Agriculture (POCRA), Govt. of Maharashtra (Nanaji Deshmukh Krishi Sanjivani Prakalp). More than 80 of farmers, Farmer producer company (FPCs) representatives and official of Agriculture Department, Govt. of Maharashtra from various districts (Aurangabad, Jalna, Beed, Buldhana, Usmanabad and Nashik) of Maharashtra actively participated in the training workshop.

Dr. Vijay Mahajan, Director, ICAR-DOGR presided the inauguration function and addressed the gathering, on adoption of ICAR-DOGR recommended storage structures for minimizing the losses in onion during storage. Mr. Vijay Kolekar, Agronomist, PoCRA was the chief guest of the function. He addressed the gathering with major focus on quality onion seed production, adoptions of modern onion storage structures and responsibilities of FPOS towards strengthening of the agriculture as a business. Dr. Bhushan Bibwe and Dr. Rajiv Kale, subject experts of ICAR-DOGR delivered the lectures on post-harvest management and value chain of onion followed by the field visit. The research work on advanced and agnostic onion storage structure was elaborated by Mr. Nilesh Vadgave. (Ph.D Research Scholar) under the abled guideship of Dr. Amit Arora, IIT, Mumbai. Dr. Bhushan Bibwe and Mr. Rajkumar Dagadkhair were co-ordinators of the program.

XIII Annual Workshop of Onion and Garlic (AINRPOG) organized at the University of Agricultural Sciences, Dharwad

ICAR-Directorate of Onion and Garlic Research (DOGR), Pune organized the XIII Annual Group meeting of All India Network Research Project on Onion and Garlic at University of Agricultural Sciences (UAS), Dharwad on 5-7 August, 2022.

The inaugural session was presided by Hon'ble Dr. Basavarajappa, VC-UAS, Dharwad. The meeting was attended by more than 80 delegates from various parts of the country. Farmers, students and other faculty members were also present. Dr. P.L. Patil, Director of Research, UAS, Dharwad welcomed all the delegates and briefed about the research activities at UAS, Dharwad including the onion and garlic. Dr. Vijay Mahajan, Director, ICAR-DOGR briefed about ICAR-DOGR and AINRPOG project and also presented a brief report about the research work undertaken by the main, voluntary and cooperating centers working in different parts of the country. Dr. R. P. Gupta, Ex-Director, NHRDF, guest of honour highlighted the importance and national significance of onion and garlic. Dr. K.E. Lawande, Ex-VC, Dr. BSKKV, Dapoli & Ex-Director, ICAR-DOGR, guest of honour suggested giving more emphasis on the development of hybrid onion for rabi season and longer storage, refinement of technologies for increased onion and garlic productivity, resistant breeding for onion twister disease focus on more virus free garlic seed production, mechanization and storage technologies through a consortium approach and joint venture programme. Dr. Basavarajappa in his presidential address briefed the importance of these crops in domestic as well as in foreign exchange and stressed the working group to give more emphasis on maintenance breeding, storage and availability of quality seed. NHRDF Award 2021 was announced by Dr. P. K. Gupta, Director, NHRDF for significant contribution in the promotion of onion and garlic to Dr. B.S. Tomar, I/c Head, Division of Vegetable Science & JDE, IARI, New Delhi. The meeting was ended with vote of thanks proposed by Dr. Ram Dutta, Principal Scientist & Co-Nodal Officer, ICAR-DOGR, Pune.

Celebration of 75th Independence Day

ICAR-DOGR celebrated India's 75th Independence Day on 15 August 2022 with great enthusiasm. As part of the *Azadi Ka Amrit Mahotsav* celebrations, the '*Har Ghar Tiranga*' campaign was actively celebrated by the DOGR employees. The DOGR campus was illuminated with lightening and decorated with tricolor flags and balloons. The beautification and decoration with tricolor theme were done right from the main gate to office. Dr. Vijay Mahajan, the Director (Act), hoisted the flag, symbolizing our freedom, Dr. Vijay Mahajan, in his address, highlighted the importance of the Independence Day in upholding democratic values and fostering progress. He emphasized ICAR-DOGR's commitment to agricultural advancements for the betterment of the nation. Meritorious children of the staff who got top success in SSC and HSC also felicitated by the Director, A flag march past, also known as a parade or procession, is planned in the ICAR-DOGR campus and residential areas. The employees of directorate were encouraged to click selfie with Tiranga and upload it on their social media handles using the tag #harghartiranga. The ceremony ended with a renewed sense of patriotism and a collective commitment to a stronger India. The event served as a reminder of our shared history, achievements, and the path towards a brighter future**.**

Interaction meeting and distribution of Agri-inputs to the tribal farmers

ICAR-Directorate of Onion and Garlic Research, Pune conducted an interaction meeting with the selected tribal farmers and distributed various Agri-inputs to the tribal farmers on 25-26 August, 2022 under TSP. This programme was coordinated by Dr. Amar Jeet Gupta, Principal Scientist (Hort. Sci.) and Nodal Officer TSP. Dr. V. Mahajan, Director of ICAR-DOGR motivated the farmers and guided them on the efficient use of *kharif* onion production technology to get maximum yield. Dr. Gupta, Nodal officer of TSP spoke on the overall role of onion as a cash crop and explained the activities of the TSP Scheme in onion cultivation. A total of 52 farmer representatives of 52 groups of tribal farmers including 26 groups from Bursewadi, Taluka Khed and 26 groups from Gohe, Taluka Ambegoan, District Pune were present for the distribution program. A total of 52 tribal farmers attended the program and were given a package which include fertilizers, insecticides, fungicides, weedicides, micronutrients, neemcake, sprayers, tarpaulin etc. under TSP from ICAR-DOGR. Program ended with the vote of thanks presented by Dr. Rajiv B. Kale.

संस्थान में हिन्दी पखवाड़ा का आयोजन

इस वर्ष (2022) के दौरान संस्थान में राजभाषा हिंदी के प्रगामी प्रयोग को बढ़ावा देने हेतु, राजभाषा हिंदी पखवाड़ा का आयोजन 14 सितंबर से 30 सितंबर के बीच किया गया। हिंदी दिवस तथा हिंदी पखवाड़ा का उद्घाटन संस्थान के निदेशक डॉ. विजय महाजन जी के मार्गदर्शन में 14 सितंबर को किया गया। हिंदी पखवाड़ा के दौरान संस्थान में विभिन्न प्रतियोगियो जैसे कि श्रुतलेखन प्रतियोगिता, हिंदी निबंध लेखन प्रतियोगिता, प्रश्नोत्तरी प्रतियोगिता, आशुभाषण प्रतियोगिता, एवं वाद-विवाद प्रतियोगिता का आयोजन किया गया। संस्थान में कार्यरत सभी अधिकारी, कर्मचारी तथा संविदा कर्मचारी, छात्र, एवं अनुसंधान सहयोगीयों ने इन प्रतियोगिता ओंमें बढ़-चढ़कर हिस्सा लिया। हिंदी पखवाड़ा का ‘समापन एवं पुरस्कार वितरण समारोह 03 अक्टूबर 2022 को आयोजित किया गया। हिन्दी

पखवाड़ा के समापन एवं पुरस्कार वितरण समारोह के मुख्य अतिथि के रूप में लेखक, समीक्षक एवं वरिष्ठ सरकारी अधिकारी डॉ. अनंत डी. दुबे रहे, जिन्होंने संस्थान के सभी अधिकारी एवं कर्मचारीयों को अपनी रचना ओंसे अवगत करवाया तथा सभी को अपने कार्यालय से जुड़े कार्यों का संचालन हिन्दी में करने के लिये प्रेरित किया। 03 अक्टूबर 2022 को संस्थान में एकदिवासिए हिन्दी कार्यशाला का आयोजन भी किया गया, जिसमे डॉ. अनंत डी. दुबे जी ने भगवान राम के जीवनको रेखित करते हुए, अपने जीवन में नैतिकमूल्यों को अपनाने पर बल दिया तथा साथ ही अधिकाधिक कार्यालयसंबंधी कार्य हिन्दी में करने के सुगमतरीकों की चर्चा की।

Promotion of onion cultivation in Union Territory of Ladakh

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops in India and it is extensively grown in Ladakh. Farmers are facing problems due to lack of recommended varieties, cultural practices and onion bulb storage structures. To overcome the existing problems of the onion growers regarding improved onion varieties as well as production and protection technologies, ICAR-DOGR, Pune have initiated and conducted field demonstrations on improved onion varieties in collaboration with HMAARI, SKUAST-K, Leh and KVK, SKUAST-K, Kargil-1. With the motivation and support of DDG (Hort. Sci.), ICAR, Dr. A. K. Singh, regarding promotion of onion cultivation, ICAR-DOGR conducted Training-cum-Awareness program on "Scientific Cultivation of Onion in Leh" in collaboration with HMAARI, SKUAST-K, Leh on 21.9.2022 under TSP. A total of 78 tribal farmers including 57 ladies from different parts of Leh participated in the program. Dr. Amar Jeet Gupta, Principal Scientist (Hort.) and Nodal Officer (TSP) coordinated the program. Dr. M.S. Kanwar, Chief Scientist, HMAARI, Leh formally welcomed the participants and elaborated the theme of the training program. Dr. Vijay Mahajan, Director (Acting), ICAR-DOGR appreciated the farmers of Leh for their interest and hard work in conducting field demonstrations on improved onion varieties. Dr. Gupta emphasized on the current situation of onion cultivation as well as livelihood security of farmers through onion cultivation in Leh. We have monitored the demos conducted at the fields of different farmers. Performance of all the demos on improved variety of onion in good conditions. However, onion maggots are the major problem in Leh and organically protection measures are the need of the hour. Farmers expressed their satisfaction regarding fruitful training for the tribal farmers in Leh.

Kisan Sangoshthi on extending *Kharif* onion production in eastern parts of Uttar Pradesh

ICAR-DOGR, Pune organized a Kisan Sangoshthi on commercial cultivation of onion in collaboration with the GKRDF, Varanasi and Agrimitra FPC Ltd, Mirzapur in the premises of ICAR-IIVR, Varanasi on 29 September, 2022. About 400 farmers including 260 women farmers from different parts of Mirzapur, Sonbhadra, Ghazipur, Varanasi, Chandauli, Kushinagar and Ballia districts of Uttar Pradesh and Singrauli district of Madhya Pradesh participated in the program.


The event was presided over by Dr. G. Kalloo, Ex-DDG (Hort.) ICAR and Ex-VC, JNKVV, Jabalpur. On this auspicious occasion 'Technical Folder as well as a Documentary Film on "Extending commercial cultivation of onion in eastern parts of Uttar Pradesh: A Success Story" was released by Dr. G. Kalloo and Dignitaries on dias. The Chief Guest, Dr. Major Singh, Member, ASRB, New Delhi highlighted the importance of onion cultivation in Purvanchal and emphasized to promote cultivation of kharif onion to stabilize price fluctuation during September to February. Dr. V. Mahajan, Director (Acting), ICAR-DOGR, Pune encouraged farmers for promotion of onion cultivation in Purvanchal. On this occasion selected farmers were honoured with certificates for their excellent work in onion cultivation. Dr. AJ Gupta, Pr. Scientist, (Hort. Sci.) and Nodal Officer (TSP), ICAR-DOGR, Pune coordinated the program. Programme was ended with the vote of thanks presented by Dr. A.K Singh, Director, Agrimitra FPC, Mirzapur.

Swachha Bharat Abhiyan

1. **Regular Swachchta activities at ICAR-DOGR**

Swachh Bharat Abhiyan is implemented and following activities were carried out as per the directions of constituted committee for making the event successful in the directorate.

- Cleanliness programs are organized at different places of the Directorate on Wednesdays of the second and fourth week of every month from 4.15-4.45 pm.
- Directorate personnel have been divided into two groups for this campaign. Members of Group 1 carried out cleanliness work on Wednesday of the second week of every month while members of Group 2 carried out cleanliness work on Wednesday of the fourth week of every month and submitted the report every month to the council.

2. **ICAR-DOGR Action Plan Special Swachchta Campaign 2.0**

Directorate observed the Special Swachchta Campaign 2.0 for disposal of Pending Matters from 2nd to 31st October 2022, the following activities were performed by ICAR-DOGR.

- Cleanliness activities at outside the ICAR-DOGR campus on 7, 14 and 21 Oct, 2022.
- Cleanliness activities at Primary School and Panchayat Office of Chandoli village to create awareness in the students and village persons on 7 Oct, 2022.
- Cleanliness activities were performed in villages selected under Mera Gaon and Mera Gaurav on 12 and 26 Oct, 2022 by I and II group, respectively.
- Cleanliness activities performed in Shiroli village on 14 Oct, 2022 by I Group and 21 Oct, 2022 by II group.
- During Special Campaign 2.0 on Cleanliness from October 2-31, 2022, the 800 sq. meters space has been freed by ICAR-DOGR, Pune (Maharashtra) including Office Spaces, Store of old building, Exhibition Hall, store rooms of inputs and fertilizers of ICAR-DOGR etc. and freed spaces are now in use for office activities.

3. **Swachhta Pakhwada**

ICAR-DOGR observed Swachhata Pakhawada during 16-31 Dec 2022 including ‘Kisan Diwas’ on 23rd Dec, 2022 in ICAR-DOGR. The event started with the Pleadge taking ceremony on 16th Dec 2022. The Swachhta Pakhwada banners were displayed in prominent public places and the importance of Swachhata Mission was briefed. All of the ICAR-DOGR, Pune staffs, including temporary workers and outside visitors actively participated in the various swachhta activities carried out in and outside the directorate campus.






Glimpses of Swachh Bharat Abhiyan, Swachchta Campaign 2.0 and Swachhta Pakhwada

Vigilance Awareness Week - 2022

ICAR- DOGR observed the Vigilance Awareness Week-2022 during 31 October, 2022 to 06 November, 2022 with the theme "Corruption free India for a developed Nation". The observance of Vigilance Awareness Week was commenced with pledge taking ceremony on 31th Oct 2022 at 11.00 AM by all the staff members of the Directorate to maintain public service, truthfulness, honesty and transparency without corruption in this Institution. All the staffs of the directorate are also encouraged to take 'Online Integrity Pledge' (e-pledge) by visiting the CVC's website (https://www.cvc.gov.in). During the observance week, various activities were organized such as display of banners and posters, pledge taking ceremony, various competitions such as debate, essay and quiz competition for staff of the directorate to create awareness among the employees against the corruption. The certificate and prizes were distributed to the winners of various competitions organized during Vigilance Awareness. During valedictory function, Dr. Vijay Mahajan, Director, ICAR-DOGR substantiated their remarks on various activities of this vigilance awareness week and on improving productivity and its internal processes, increased transparency in the decision making and brings in citizen participation. The Vigilance Awareness Week was concluded on 7 November, 2022 with Vote of Thanks by Dr Suresh Gawande, Principal Scientist and Vigilance Officer of ICAR-DOGR.

Dr. R.C. Agarwal, Registrar General of PPV&FR Authority visits ICAR-DOGR

Dr. R.C. Agarwal, Registrar General of PPV&FR and Dr. S.B. Chaudhary, Registrar of PPV&FRA monitored DUS Onion and Garlic trials at ICAR-DOGR, Pune and conducted review meeting with Dr. Vijay Mahajan, Director (Acting), DOGR on 15 November, 2022. Dr. A.J. Gupta, Nodal Officer, DUS and other scientists were also present. Dr. A.J. Gupta showed the DUS trials of onion and garlic varieties to the visiting team. Dr. Agarwal also visited the demonstration park, experimental trials, museum and other facilities of DOGR. Dr. Agarwal was very much impressed by the cleanliness and well-maintained farm, laboratories, storage and processing facilities of Directorate. He commented that DUS experiments on onion and garlic are being conducted nicely and as per DUS guidelines. He congratulated the Director and the staff for excellent work.

Demonstration of DUS trials to monitoring team

World Soil Day Celebration at ICAR-DOGR, Pune

ICAR-Directorate of Onion and Garlic Research, Pune and ICAR-National Research Centre for Gapes, Pune (ICAR-NRCG) jointly organized World Soil Day on 5 December, 2022 at ICAR-DOGR. The programme was celebrated to highlight the importance of healthy soil and promote sustainable management of soil resources. The theme for world soil day 2022 is Soils: Where Food Begins. Farmer-Scientist interaction was also organized during the meeting. All the scientists from ICAR-DOGR, and Onion and Grape Growers were participated in the event.

Dr. Rajiv Kale, Scientist welcomed all the participants. Dr. Thangasamy, A., Senior Scientist and Nodal Officer (Soil Health Card Scheme) briefed about the programme. Dr. Ram Dutta, Principal Scientist, ICAR-DOGR presented lecture on Hygienic Cultivation of Onion and Garlic with reference to soil borne diseases to the farmers. Dr. Ajay Kumar Upadhyay, Principal Scientist, ICAR-NRCG delivered World Soil Day lecture on 'Importance of soil testing and balanced fertilization'. Dr. Vijay Mahajan Director, ICAR-DOGR in his remarks stated about the importance of world soil day. Dr. R. G. Somkuwar, Director, ICAR-NRCG, Chief Guest of the function distributed soil health cards to onion and grape farmers. In Chief Guest Address, he urged the farmers to follow Integrated Nutrient Management practices for sustainable soil health and crop productivity. Forty-five farmers from Pune district were participated in the event. The programme was co-ordinated by Dr. A. Thangasamy, Senior Scientist and Nodal Officer (Soil Health Card Scheme).

Institutional Research Council (IRC) Meeting

The 27th Institutional Research Council (IRC) meeting was held during 5-6 Dec, 2022 at ICAR-Directorate of Onion and Garlic Research, Pune under the chairmanship of Dr. Vijay Mahajan, Director (Acting). All the scientists of the Directorate presented the progress report and salient achievements of the projects in the meeting. Recently joined scientists also made their new proposals. After thorough discussion of on-going projects and new proposals, recommendations were made. Chairman of IRC, praised all the scientists for their research achievements and encourage the scientist for publications and externally funded projects. Meeting ended with vote of thanks presented by Dr. Amar Jeet Gupta, Member Secretary, IRC of ICAR-DOGR.

Fifth Quinquennial Review Team (QRT) First Meeting

The V Quinquennial Review Team Meeting of ICAR-DOGR was held during 20-22 December, 2022 under the Chairmanship of Dr. Prakash S. Naik, Former Director, ICAR-IIVR, Varanasi.

The expert members participated in the meeting were, Dr. Satish Bhonde, Former Additional Director, NHRDF, Dr. SK. Choudhary Dean, College of Agriculture- Indore, Dr.HB. Singh, Former Head, Mycology and Pl. Pathology, BHU, Dr. MN. Dabhi, Professor and Head, Dept. of Processing & Food Engineering, Junagadh Agricultural University- Junagadh, Dr. D. Sreenivasa Murthy, Principal Scientist (Agril. Economics), ICAR-IIHR, Bangalore. Dr. Vijay Mahajan, Director, ICAR-DOGR, welcomed the Chairman and members of QRT and highlighted the achievements made by the institute. Member Secretary QRT Dr. Ram Dutta, Principal Scientist (Plant Pathology) presented the Action Taken Report (ATR) of the previous QRT recommendations followed by the presentations of achievements and progress reports of different sections by the respective scientists, and AINRPOG by the Co-Nodal Officer. The Chairman and members of the QRT critically reviewed the progress report, achievements, extension work of ICAR-DOGR and AINRPOG. The chairman and the members of the QRT expressed their satisfaction with the achievements made and gave suggestions to improve the future research programs.

N. Technology licensing, Commercialization, Collaborations

ICAR-DOGR Signed Technology License Agreement of 'Controlled Onion Storage Structure Technology' with Kala Biotech Pvt. Ltd. through Agrinnovate New Delhi

The ICAR-Directorate of Onion and Garlic Research, Pune, transferred the Controlled Onion Storage Structure Technology to M/s Kala Biotech Pvt. Ltd. through Agrinnovate India Limited on 2 June, 2022. The Tripartite Technology License Agreement was signed by ICAR- DOGR, Pune, with M/s Kala Biotech Pvt. Ltd. and Agrinnovate India for the technology transfer of "Controlled Onion Storage Structure Technology". Dr. Major Singh, Director, ICAR-DOGR stated that this innovative storage technology will prove as an important intervention for onion price stabilization. The technology has been developed in public private partnership mode between ICAR-DOGR, Pune and Kala Biotech Pvt. Ltd. Dr. Sudha Mysore, CEO, Agrinnovate congratulated the team of the innovator, Dr. Major Singh, Dr. Kalyani Gorrepati and Dr. Rajiv B. Kale from ICAR-DOGR and private partner Kala Biotech Pvt Ltd. for developing the modern technology which is the need of an hour. I CAR-DOGR was also represented by Members of ITMC including Dr. Ram Dutta, PS (Patho.) and I/c PME, Dr. A. J. Gupta, PS (Hort.), Mr. HSC Shaikh, I/c AKMU and Dr. R. B. Kale, Sr. Sci. (Agril. Extn.) and I/c ITMU. M/s. Kala Biotech Pvt. Ltd. was represented by Mr. Manoj Phutane, Managing Director and Mr. Pravin Phutane, Finance Director. A vote of thanks was expressed by Dr. R. B. Kale.

ICAR-DOGR signed MoU for licensing Onion Varieties

A meeting of the ITMC was held on 24 June, 2022 under the chairmanship of the Director, ICAR-DOGR, Pune to sign the MoUs' with seed companies. ICAR-DOGR has signed MoU with ten seed companies for licensing of onion varieties. Yajnarup Vision Tech Private Limited, Pasaidan Farmers Producer company Ltd., Jain Agri Park were signed MoU for Bhima Super. Star Alankar Farmer Producer Company Ltd. Ruchi Green Seeds, Om Gayatri Farmer Producer Company Limited, Shri Baliraja Seeds & Chemicals, RadhaShyam Seeds & Biotech Pvt. Ltd and Jain Agri Park made agreement for Bhima Shakti. Similarly for varieties like B. Red, B. Raj, B. Shubra and B. dark red were also licensed by different seed companies for commercial seed production. The meeting was attended by the ITMC members. Dr. Rajiv Kale, In-charge ITMU welcomed all and presented the MoU to be signed afore the committee members. Dr. Vijay Mahajan, Director (Acting) ICAR-DOGR, Pune signed MoU on behalf of ICAR-DOGR, Pune.

Onion varieties licensed to seed companies

ICAR-DOGR has signed MoU with five seed companies for breeder seed of onion varieties. Companies like Sakol Farmers Agro producer company Ltd. Pollen Bioseeds, Smiling farmers seeds pvt. Ltd licensed Bhima Shakti. Divya Seeds Company and Pancharatna Seeds Company signed MoU for onion variety Bhima Subhra for commercial seed production. A meeting of the ITMC was held on 20 August, 2022 under the chairmanship of the Director, ICAR-DOGR, Pune to sign the MoUs' with these seed companies. The meeting was attended by the ITMC members. Dr. Rajiv Kale, In-charge ITMU welcomed all and presented the MoU to be signed afore the committee members. Dr. Vijay Mahajan, Director (Acting) ICAR-DOGR, Pune signed MoU on behalf of ICAR-DOGR, Pune.

ICAR-DOGR signed agreement with seed companies and university

A meeting of the ITMC was held on 03 October, 2022 under the chairmanship of the Director, ICAR-DOGR, Pune to sign the MoUs' with different companies for breeder seeds and with university for students' training/postgraduate research at ICAR-DOGR. The meeting was attended by the ITMC members. Dr. Rajiv B. Kale, In-charge ITMU welcomed all and presented the MoU to be signed afore the committee members. Dr. Vijay Mahajan, Director (Acting) ICAR-DOGR, Pune signed MoU with the representative Dr. CV Raman University for students' training/postgraduate research at ICAR-DOGR. While discussing, the committee members individually provided their valuable suggestions to be incorporated in the MoU. Along with the above-mentioned agreement, Dr. Vijay Mahajan, Director (Acting) ICAR-DOGR, Pune also signed MoUs with two seed companies namely, Siddhant seeds Pvt. Ltd., Dist. Ahmednagar, Maharashtra and Agrimitra farmers producer company, Dist. Mirzapur, Uttar Pradesh for the breeder seeds of onion varieties, Bhima Shakti and Bhima Dark Red respectively.

ICAR-DOGR signed MoU with TIH Foundation for IoT and IoE (TIH-IoT), IIT-Bombay, for collaborative research work in Effective and Efficient Agriculture Project

ICAR-DOGR have signed MoU with TIH Foundation for IoT and IoE (TIH-IoT) which have been set up at the Indian Institute of Technology Bombay, as a Section-8 company (not-for-profit) under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS). A meeting of the ITMC was held on 17 October, 2022 under the chairmanship of the Director, ICAR-DOGR, Pune to sign the MoUs' with these organizations. ICAR-DOGR and TIH-IoT agreed for collaboration to work jointly on various sub projects in the broad area of 'Effective and Efficient Agriculture Project'. Dr. Rajiv Kale, In-charge ITMU welcomed all and presented the MoU to be signed afore the committee members. Dr. Vijay Mahajan, Director (Acting) ICAR-DOGR and representatives of governing body of TIH-IoT signed the MoU. ICAR-DOGR was also represented by members of ITMC including Dr. Ram Dutta, I/C PME, Dr. A. J. Gupta, PS (Hort.) and Dr Bhushan Bibwe, Scientist (AS&PE). The meeting was ended with a vote of thanks by Dr. Bhushan Bibwe.

Directorate commercialized improved onion seed varieties through seed companies

ICAR-DOGR has signed MoU with six seed companies for breeder seed of onion varieties. Kapileshwar Agro and Biotech services Pvt. Ltd. Odisha and Raj Ganesh natural Seeds Pvt. Ltd, Satara signed MoU for two varieties namely Bhima Super and Bhima Shakti. Swadarshan FPC, Bhableshwar and Thinkpure Organic produce ltd, Akola, singed MoU for Bhima Shakti and Mayur seed corporation, Jalgoan signed MoU for variety Bhima Shubra for commercial seed production. A meeting of the ITMC was held on 21 November, 2022 under the chairmanship of the Director, ICAR-DOGR, Puneto sign the MoUs' with these seed companies. The meeting was attended by the ITMC members. Dr. Rajiv Kale, In-charge ITMU welcomed all and presented the MoU to be signed afore the committee members. Dr. Vijay Mahajan, Director (Acting), ICAR-DOGR, Pune signed MoU on behalf of ICAR-DOGR, Pune.

O. Human Resource Development

Training Programs Attended	
Title	**Date and Venue**
Rajkumar Dagadkhair	
Seven days Hands-on Training Program on "Advances in Biochemical Techniques and Applications"	1-8 September, 2022 Department of Biochemistry North-Eastern Hill University Shillong, Meghalaya
Conferences/ Symposiums/ Seminars /Workshops/Group Meetings	
Vijay Mahajan	
ICAR-University-NAAS-Stakeholders Interface Meeting as Director, ICAR-DOGR, Pune	17 June, 2022 ICAR-NIASM, Baramati
XXXXVIII Meeting of Plant Germplasm Registration Committee organized by ICAR-NBPGR, New Delhi	08 July, 2022 ICAR-NBPGR, New Delhi
XIII AINRPOG Group Meeting	5-7 August, 2022 UAS, Dharwad, Karnataka
SOC Meeting held under Chairmanship of Secretary DARE & DG	08 August, 2022 New Delhi
Interaction Meeting of Directors of ICAR Institutes	30 August, 2022 New Delhi
336th Executive Council Meeting of MPKV, Rahuri	29 September, 2022 MPKV, Rahuri
Demonstration-cum-training programme of scientific cultivation of onion at Leh under TSP with Chief Guest DDG(H), ICAR, New Delhi	19 – 22 September, 2022 Leh
Foundation day of ICAR-IIVR, Varanasi and conducted Kisan Sangosthi on "Commercial cultivation of onion" and monitored of Demos in Mirzapur/ Sonbhadra Districts of UP under TSP in collaboration with Agrimitra Farmer Producer Company, Mirzapur and GK Research Development Foundation, Varanasi	28-29 September, 2022 ICAR-IIVR, Varanasi
170th Meeting of Managing Committee of NHRDF	23 December, 2022 New Delhi
Ram Dutta	
IMC Meeting of ICAR-ATARI, Umiam (Barapani), Meghalaya	15 January, 2022 Online
IMC Meeting of ICAR-ATARI, Umiam (Barapani),	15 February, 2022 Online
12th IMC Meeting of ICAR-ATARI, Umiam, Meghalaya for discussion on various agenda items	30 December, 2022 Online

Amar Jeet Gupta	
Monitoring of onion field at Peth Village, Ambegaon Taluka, Pune District using the latest farming practices such as micro-irrigation, water harvesting and improved agronomic practices	4 January, 2022 Peth Village, Pune
Nominated as Member of Selection Committee for interview of the post of Subject Matter Specialist-Horticulture in KVK, Jalna	29 January, 2022 KVK, Jalna
Attended National Hindi Workshop on "Azadi ka Amrit Mahotsav evamRajbhasha" as Hindi Officer organized by ICAR-Directorate of Weed Research, Jabalpur (MP)	7-8 March, 2022 Jabalpur
Monitoring of AINRPOG trials	7 March, 2022 JNKVV, Jabalpur
Chairman of Monitoring Committee for monitoring of onion breeder seed production plots at nine different farmers selected under TSP in Nandurbar (MS)	28 March, 2022 Nandurbar
Chairman of Monitoring Committee for monitoring of onion breeder seed production plots at four locations through KVK, Tuljapur (MS)	4 April, 2022 KVK, Tuljapur (MS)
Chairman of Monitoring Committee for monitoring of onion breeder seed production two plots	5 April, 2022 KVK, Jalna (MS)
Chairman of Monitoring Committee for monitoring of onion breeder seed production two plots through KVK, Pal (MS)	6 April, 2022 KVK, Pal (MS)
Monitoring of TSP Field Demos in tribal belts of Nandurbar under TSP in Nandurbar	27-28 July, 2022 Nadurbar
Attended 13th AINRPOG Annual Group Meeting held at UAS, Dharwad	5-7 August, 2022 UAS, Dharwad
DUS Review Meeting and Foundation Day Celebrations organized by PPV&FRA at NASC Complex, New Delhi	10-11 November, 2022 NASC Complex, New Delhi
Participated and presented achievements of crop improvement onion and garlic in 5th QRT Meeting held at ICAR-DOGR, Pune	20 December, 2022 ICAR-DOGR, Pune
S. J. Gawande	
Round Table Discussion on "Technologies for IoT and IoE in Agriculture" to enable the futuristic technologies developed/to-be-developed at TIH-IoT in the Agriculture Sector to solve the problems of the end and provide deployable solutions	23 September, 2022 Girish Gaitonde Lecture Hall Complex, EE Dept. IIT Bombay
S. Anandhan	
IBSC meeting of ICAR-DOGR	23 December, 2021 ICAR-DOGR

S. S. Gadge	
Kisan Exhibition	23-27 March, 2022 International Exhibition and Convention Centre, Pune.
Kisan Exhibition	14-18 December, 2022 International Exhibition and Convention Centre, Pune.
A. Thangasamy	
Departmental Promotion Committee Meeting to assess the promotion case of upper division clerk to Assistant under Departmental Promotion	19 April, 2022 ICAR-DOGR, Pune
National Conference on Climate Resilient and Sustainable Development of Horticulture organized by ASM foundation and Confederation of Horticulture Associations of India, New Delhi	28-31 May, 2022 CSAUA&T, Kanpur, Uttar Pradesh
Brainstorming session on, 'Applications of ICAR-CIRCOT nano sulphur for various field conditions for different crops'	06 June, 2022 ICAR-CIRCOT, Mumbai
Thirteenth Annual Workshop of AINRPOG organized by ICAR-DOGR, Pune	5-7 August, 2022 UAS, Dharwad
Round Table Discussion on Effective and Efficient Agriculture, Technology Innovation Hub, Indian Institute of Technology, Bombay	23 September, 2022 IIT, Bombay
Attended Annual Co-operators Conference organized by Anglo American, New Delhi and ICAR-CRIDA, Hyderabad	17-18 October, 2022 ICAR-CRIDA, Hyderabad
86th Annual Convention and National Seminar on Developments in Soil Science 2022 organized by Indian Society of Soil Science, New Delhi	15-18 November, 2022 MPKV, Rahuri
Technology exhibition event organized by Technology Innovation Hub for IoT and IoE at IIT Bombay on 2 December, 2022 to showcase the outcomes from technology development projects of their researchers, innovators, and startups	02 December, 2022 IIT, Bombay
V. Karuppaiah	
KISAN Exhibition	14-18 December, 2022 International Exhibition and Convention Centre, Pune
National Seminar on climate resilient technologies for sustainable agriculture intervention and approaches (CRTSAIA -2022)	26 –27 March, 2022 School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha
National Conference on climate resilient and sustainable development Horticulture	28 –31 May, 2022 CSAUA&T, Kanpur, Uttar Pradesh
12th Annual Workshop on Onion and Garlic (AINRPOG)	5 –7 August, 2022 UAS, Dharward, Karnataka

International Conference IESIC 2022 Sustainable Agricultural Innovations for Resilient Agri -Food Systems	13–15 October, 2022 SKUAST, Jammu
3rd National Symposium Entomology 2022: Innovation and Enterpreneurship -Virtual	8 –10 December, 2022 Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad
RAC interface meeting	20 February, 2022 ICAR-DOGR, Pune
Satish Kumar	
नगर राजभाषा कार्यान्वयन समिति, नराकास (कार्या- 2), पुणे की बैठक	2 दिसंबर, 2022 सी.एस.आई.आर-एन.सी.एल. डॉ. होमीभाभा मार्ग, पाषाण, पुणे
KISAN Exhibition	15 December, 2022 International Exhibition and Convention Centre, Pune
Rajiv B. Kale	
Advisory committee of ABI Centre of ICAR-NRC for Grapes, Pune	29 January, 2022 NRCG, Pune
Technology demonstration and Stakeholders meet for controlled onion structure organized by ICAR-Directorate of Onion and Garlic Research, Pune in Collaboration with Kala Biotech Pvt. Ltd.	03 January, 2022 KALA Freeze and cold storages, Pune
Panel Meeting for development of Indian standards of Warehouse Management Services Sectional Committee organised by Bureau of Indian Standards, National Standards Body of India under Ministry of Consumer Affairs, Food & Public Distribution, Government of India	8 February, 2022 Online
Meeting on policy planning and effective implementation of onion storage component under MIDH	04 February, 2022 ATMA hall, Sakhar Sankul, Pune
Meeting on policy planning and effective implementation of onion storage component under MIDH	04 March, 2022 ATMA hall, Sakhar Sankul, Pune
Panel Meeting for development of Indian standards of Warehouse Management Services Sectional Committee organised by Bureau of Indian Standards, National Standards Body of India under Ministry of Consumer Affairs, Food & Public Distribution, Government of India	16 March, 2022 Online
3rd meeting of the Export Promotion Forum for Onion organised by APEDA, New Delhi	17 March, 2022 Online

Panel Meeting for development of Indian standards of Supply Chain Management Sectional Committee organised by Bureau of Indian Standards, National Standards Body of India under Ministry of Consumer Affairs, Food & Public Distribution, Government of India	30 March, 2022 Online
Advisory committee of ABI Centre of ICAR-NRC for Grapes, Pune for MoA Signing Ceremony	07 April, 2022 NRCG, Pune
Meeting on Policy planning and effective implementation of Onion storage component under MIDH	13 April, 2022 ATMA hall, Sakhar Sankul, Pune
A meeting is convened to discuss IPR related issues of two promising incubatees of ABI ICAR-NRC for Grapes	23 April, 2022 NRCG, Pune
State Level Committee meeting of Mission on Integrated Development of Horticulture	12 May, 2022
Advisory committee of ABI Centre of ICAR-NRC for Grapes, Pune	18 June, 2022 NRCG, Pune
Meeting on Policy planning and effective implementation of Onion storage component under MIDH	23 June, 2022 ATMA hall, Sakhar Sankul, Pune,
Orientation workshop on Agri Drone Project during annual zonal workshop of KVKs	07 July, 2022 Anand Agricultural University, Anand
Meeting with Mr. Yogesh Patil (IAS 2020) Asst Secretary, Dept of Consumer Affairs, regarding Onion Grand Challenge during his visit to ICAR-DOGR	28 July, 2022 ICAR-DOGR, Pune
Delivered presentation on the best practices of FPO in Onion Value chain models in Symposium, a People Convention on “FPO Models for sustaining small scale farming” organized by DHAN Foundation, Madurai	29 July, 2022 Gokhale Institute of Politics and Economics, Pune
Advisory committee meeting of ABI Centre of ICAR-NRC for Grapes, Pune	13 September, 2022 NRCG, Pune
Scientific Advisory Committee Meeting of KVK Baramati	11 October, 2022 KVK Baramati
Panel Meeting for development of Indian standards of Warehouse Management Services Sectional Committee organised by Bureau of Indian Standards, National Standards Body of India under Ministry of Consumer Affairs, Food & Public Distribution, Government	19 October, 2022 Online
Meeting on Policy planning and effective implementation of Onion storage component under MIDH	16 November, 2022 ATMA hall, Sakhar Sankul, Pune

Meeting for improvement of guideline for Cold Storage and Onion Storage Structure scheme under SMART Project	02 December, 2022 Pune
Ashwini P. Benke	
XXXXVIII meeting of Plant Germplasm Registration committee held by ICAR - National Bureau of Plant Genetic Resources Pusa Campus, New Delhi-110 012	08 July, 2022 Online
2nd International Conference and Buyeeers Sellers meet on Medicinal Plants used in Lifestyle Products. University, Kolkata in Technical assistance with Regional Cum Facilitating Centre (RCFC)- Eastern Region (ER), National medicinal Board (NMPB), Ministry of Ayush, Government of India	28 - 30 June, 2022 Online
9th Governing Body Meeting of ITPGRFA, New Delhi Stakeholder meeting Consultation for India's Position on GB agenda "Meeting of Researchers working with plant genetic resources"	5 August, 2022 Online
Hindi Rajbhasha Meeting	22 July, 2022 ICAR-DOGR, Pune
Radhakrishna A.	
KISAN Exhibition	14-18 December, 2022 International Exhibition and Convention Centre, Pune
Rajkumar Dagadkhair	
Meeting with Mr. Yogesh Patil (IAS 2020) Asst Secretary, Dept of Consumer Affairs, regarding Onion Grand Challenge during his visit to ICAR-DOGR, Pune	28 July, 2022 ICAR-DOGR, Pune
Meeting for the signing of MoU between TIH IoT and ICAR-DOGR, Pune. Finalized the Draft of MoU after a series of meetings and discussions. Under "Effective and Efficient Agriculture" which consists of six sub-projects	14 October, 2022 ICAR-DOGR, Pune
Soumia P. S.	
Technology demonstration and Stakeholders meet for controlled onion structure organized by ICAR-Directorate of Onion and Garlic Research, Pune in Collaboration with Kala Biotech Pvt. Ltd.	03 January, 2022 KALA Freeze and cold storages, Pune
KISAN exhibition	24 March, 2022 International Exhibition and Convention Centre, Pune
Bhushan R. Bibwe	
Technology demonstration and Stakeholders meet for controlled onion structure organized by ICAR-Directorate of Onion and Garlic Research, Pune in Collaboration with Kala Biotech Pvt. Ltd.	03 January, 2022 KALA Freeze and cold storages, Pune

Brainstorming workshop on Applications of ICAR-CIRCOT nanosulphur for various field conditions for different crops	14 June, 2022 ICAR-CIRCOT, Mumbai
Webinar on Food textural Analysis	29 July, 2022 , Online
Meeting about controlled onion storage organised by Manoharan Kannan	15 July, 2022 Online
Meeting on onion storage by Project unit MIDH (diary no 2296-18.07.2022),	18 July, 2022 Online
Meeting with Mr. Yogesh Patil (IAS 2020) Asst Secretary, Dept of Consumer Affairs, regarding Onion Grand Challenge during his visit to ICAR-DOGR	28 July, 2022 ICAR-DOGR, Pune
Meeting with team of TiH- IIT Bombay, Director and the staff of ICAR-DOGR	15 September, 2022 ICAR-DOGR, Pune
Round table discussion on "Technologies for IoT and IoE in Agriculture" orgainsed by TIH-IoT, IIT Bombay	23 September, 2022 Girish Gaitonde Lecture Hall Complex, EE Dept. IIT Bombay
Meeting for the signing of MoU between TIH IoT and ICAR-DOGR, Pune. Finalized the Draft of MoU after a series of meetings and discussions. Under "Effective and Efficient Agriculture" which consists of six sub-projects	14 October, 2022 ICAR-DOGR, Pune
Meeting on revision of cost norms for onion storage and cold storage by Project Co-ordination and Management unit- SMART project	09 November, 2022 Online
KISAN Exhibition	16 December, 2022 International Exhibition and Convention Centre, Pune
Yogesh Khade	
13thAnnual Workshop of AINRPOG	5-7 August, 2022 UAS Dharwad
KISAN Exhibition	17 December, 2022 International Exhibition and Convention Centre, Pune
Jayalakshmi K.	
8th International Conference on “Plant Pathology: Retrospect and Prospects” at Sri Karan Narendra Agriculture University, Jobner-Jaipur, Rajasthan, India	23-26 March, 2022 Online
Rajendra Kulkarni	
Capacity Building Program for CJSC members of ICAr Institute and Head quarter	15-19 November, 2022 ICAR-NAARM, Hydrabad

P. PERSONNEL

Retirement/Superannuation, Promotion/ Assessment, Transfer/ New joining

(January to December, 2022)

A. Retirement/ Superannuation

Sr. No.	Name	Designation	Date of Birth	Date of Superannuation
A.	**RMP**			
1.	Dr. Major Singh	Director	20.06.1960	19.06.2022
B.	**Skilled Support Staff**			
1	Shri. Sunil Said	Skilled Support Staff	09.12.1962	31.12.2022

B. Promotion /Assessment

Sl. No	Name and Designation	Pay Band & Grade Pay	Promoted post	Promoted post-Pay Band & Grade Pay	Date of Promotion
A	**Administrative Staff**				
1.	Sh. Dedage Rajan Krushnarao	PML-5	Assistant	PML- 6	20.04.2022

C. Transfer

S. No.	Name of Officer/ Official	Joining date at ICAR-DOGR, Pune	Transferred on	Transferred to
A.	**Scientific**			
1	Dr. Manjunatha Gowda D. C., Scientist	09.04.2014	06.06.2022	ICAR-IIHR, Benguluru
B.	**Administrative**			
1	Mr. Amarendra Kishore	08.04.2019	07.07.2022	ICAR-IARI, New Delhi
2	Mr. D.B. Mundharikar	29.10.1998	10.08.2022	ICAR-CCRI, Nagpur

D. New Joining

Sl. No	Name and Designation	PML and Basic	Date of Appointment at ICAR-DOGR	Relieved From
	Scientific			
1.	Mr. Rajkumar Dagadkhair, Scientist (Food Technology)	PML-11	07.03.2022	ICAR-DCR, Puttur
2	Dr. Radhakrishna Scientist (Biotechnology)	PML-12	25.04.2022	ICAR-IGFRI, Jhansi
3	Dr. Satish Kumar Sr. Scientist (Biochemistry)	PML-12	02.05.2022	ICAR-NIASM, Baramati
4	Dr. Sanket More Scientist (Veg Science)	PML-11	16.08.2022	ICAR- CTCRI, Thiruvanthapuram
	Administration			
1.	Sh. J.R. Mangale Finance and Account Officer	PML-10	24.05.2022	ICAR-DFR, Pune

STAFF STRENGTH (As on 31.12.2022)

Category	Sanctioned Strength	In Position	Vacant
Scientific	22+1	21+0	02
Technical	10	10	00
Administration	15	05	10
Skilled Support Staff	11	08	03
Total:	**58+1**	**43+1**	**15**

Scientific Staff Strength (as on 31.12.2022)

S. No.	Name of Discipline	Revised Cadre Strength							
		Scientist		Sr. Scientist		Principal Scientist		**Total**	
		SS	IP	SS	IP	SS	IP	SS	IP
1.	Agricultural Biotechnology	1	1	1	1	0	0	2	2
2.	Agricultural Entomology	2	2	0	0	0	0	2	2
3.	Agricultural Extension	1	1	1	1	0	0	2	2
4.	Agricultural Structure and Process Engineering	2	2	0	0	0	0	2	2
5.	Agronomy	1	0	0	0	0	0	1	0
6.	Genetics & Plant Breeding	2	1	0	0	0	0	2	1
7.	Plant Biochemistry	1	0	0	0	0	0	1	1
8.	Plant Pathology	1	1	1	1	1	1	3	3
9.	Plant Physiology	1	1	0	0	0	0	1	1
10.	Seed Science & Technology*	1	0	0	0	0	0	1	1
11.	Soil Science	1	1	0	0	0	0	1	1
12.	Vegetable Science	2	2	1	1	1	1	4	4
	Total	**16**	**11**	**4**	**4**	**2**	**2**	**22**	**20**

- *Adjusted with Food technology as per council order

Scientific Staff (as on 31.12.2022)

Sr. No.	**Name**	**Designation**
1	Dr. V. Mahajan	Director (Act.)
2	Dr. Ram Dutta	Pr. Scientist, Plant Pathology
3	Dr. A.J. Gupta	Pr. Scientist, Horticulture
4	Dr. S.J. Gawande	Pr. Scientist, Plant Pathology
5	Dr. S. Anandhan	Pr. Scientist, Biotechnology
6	Dr. S.S. Gadge	Sr. Scientist, Agri. Extension
7	Dr. A. Thangasamy	Sr. Scientist, Soil Science
8	Dr. V. Karuppaiah	Sr. Scientist, Agri. Entomology
9	Dr. Kalyani Gorrepati	Sr. Scientist, ASPE
10	Dr. Satish Kumar	Sr. Scientist, Biochemistry
11	Dr. Rajiv Kale	Sr. Scientist, Agri. Extension
12	Sh. Radhakrishana A.	Scientist (SS), Biotechnology
13	Mrs. Ashwini Benke	Scientist (SS), Genetics
14	Dr. Pranjali Gedam	Scientist (SS), Plant Physiology
15	Dr. Rajkumar Dagadkhair	Scientist (SS), Food Technology
16	Dr. Soumia P.S.	Scientist (SS), Agri. Entomology
17	Dr. Bhushan Ratnakar Bibwe	Scientist (SS), ASPE
18	Dr. Yogesh Khade	Scientist, Vegetable Science
19	Dr. Sanket More	Scientist (SS), Vegetable Science
20	Dr. Jayalakshmi K	Scientist, Plant Pathology

Administrative Staff

Sr. No.	Name	Designation
1.	Sh. J.R. Mangale	Finance and Account Officer
2.	Mrs. Mangala S. Sala	Asstt. Administrative Officer
3.	Mrs. Neha R. Gaikwad	Assistant
4.	Sh. Rajan K. Dedage	Assistant
5.	Sh. Nilesh S. Warkar	Upper Division Clerk

Technical Staff

Sr. No.	Name	Designation
1	Sh. H.S.C. Shaikh	Asstt. Chief Technical Officer
2	Sh. R.B. Baria	Technical Officer
3	Sh. S.P. Yeole	Technical Officer (Driver)
4	Dr. A.R. Wakhare	Technical Officer
5	Sh. D.M. Panchal	Technical Officer
6	Sh. B. A. Dahale	Technical Assistant
7	Sh. Vishal S. Gurav	Sr. Technical Assistant
8	Sh. H.S. Gawali	Technical Assistant
9	Sh. Ram Y. Bombale	Sr. Technician
10	Mrs. Poonam V. Shelke	Sr. Technician

Skilled Supporting Staff

Sr. No.	Name
1	Sh. Rajendra S. Kulkarni
2	Sh. Pandharinath R. Sonawane
3	Sh. Popat E. Tadge
4	Sh. Mahadu S. Kale
5	Sh. Sanjay D. Waghmare
6	Sh. Nayeem H. Shaikh
7	Sh. Satish B. Tapkir

Q. Financial Statement

FINANCIAL STATEMENT (2021-22) of ICAR-DOGR		
BUDGET HEAD	**BUDGET 2021-22** (₹ in Lakhs)	**EXPENDITURE 2021-22** (₹in Lakhs)
SALARY	676.16	676.16
PENSION	34.25	33.15
TOTAL (A)	**710.41**	**709.31**
CAPITAL	110.00	110.00
GENERAL	500.00	379.65
NETWORK PROJECT	-	120.35
NEH - GENERAL	225.00	225.00
TSP - GENERAL	45.00	45.00
SCSP - CAPITAL	1.00	0.99
SCSP - GENERAL	35.00	35.00
TOTAL(B)	**916.00**	**915.99**
GRAND TOTAL (A+B)	**1626.41**	**1625.30**

Revenue Generation	Amount (₹in Lakhs)
Sale of Farm Produce	5.65
Sale of Publication	0.26
Licensing Fees	88.00
Analytical Testing Fees	2.88
Training	0.64
Interest from STD/TDR	4.61
Other Income	3.00
TOTAL	**105.04**

R. Meteorological Data

Meteorological data for January- December 2022

Month	Av. Temperature (°C)		Av. Relative Humidity (%)		Wind velocity (km/h)	Bright sunshine hour (h/day)	Total Rainfall (mm)	Avg. Evaporation (mm)
	Max.	Min.	Max.	Min.				
January	25.6	11.7	78	59	2.9	7.5	0.0	3.2
February	30.8	14.5	72	52	4.7	9.1	0.0	3.5
March	39.7	24.5	80	53	4.1	8.4	0.0	5.0
April	38.1	20.0	64	41	4.3	8.0	0.0	5.6
May	37.2	23.2	69	49	10.0	8.5	0.0	6.2
June	33.9	23.1	79	63	7.5	6.0	106.4	4.7
July	26.5	21.8	89	82	7.2	2.2	308.8	1.1
August	28.5	22.8	91	80	6.8	4.3	185.0	1.6
September	29.1	21.2	91	79	3.9	3.5	209.6	1.6
October	29.7	19.0	85	69	5.4	6.1	154.8	2.4
November	32.3	15.1	78	62	2.9	9.5	0.0	3.5
December	30.4	14.3	79	54	2.5	7.2	0.0	3.4

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch


भाकृअनुप- प्याज एवं लहसुन अनुसंधान निदेशालय
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