ANNUAL REPORT

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National Research Centre for Onion & Garlic

Rajgurunagar, Pune, Maharashtra - 410 505

NRCOG

ANNUAL REPORT 2002-2003

NATIONAL RESEARCH CENTRE FOR ONION AND GARLIC
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
RAJGURUNAGAR, DIST. PUNE 410 505, MAHARASHTRA, INDIA

NRCOG Annual Report 2002-2003

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EXECUTIVE SUMMARY

Since its inception, the National Research Centre for onion and garlic has created very good impression among the farmers of onion growing states of the country as judged by increased demand for seed, technical bulletins, technical know how on production and post harvest handling and number of visitors who visited the centre. The year 2002-03 is another progressive year for NRCOG with the establishment of laboratories, procurement of laboratory equipments and formulation of new research programme and experiments in order to solve the short term and long term problems faced by the farming community of Maharashtra , Gujarat, Rajasthan and nation as a whole. The salient achievements of the year are summarised here under.

This year has contributed significantly towards upgrading the genetic resources of onion and garlic. A good number of germplasm, 120 lines of red and light red onion, 80 lines of white onion and 50 lines of garlic were added to genebank. The evaluation, characterisation and documentation of this new germplasm is in progress. Promising new accessions NRCOG-12-2-R of onion showed supremacy in yield upto 40 t/ha surpassing all the check varieties namely Arka Niketan, Arka Kalyan, Agri found dark red and B-780 . Two accessions i.e. NRCOG-592 and NRCOG- 597 were found to be superior in terms of storage as well as marketable yield in late kharif conditions against N-2-4-1 and B-780. Further, genotype environment interaction studies revealed that the superior performance of NRCOG 597 and NRCOG 592 was established in terms of higher and stable marketable yield for different agroclimatic conditions. During the year under report, the NRCOG has identified two varieties each i.e. NRCOG-780-5-3-1 (Red) and NRCOG-780-5-2-2 onion and garlic NRCOG-W-200 and NRCOG-W-050 for evaluation trial in All India Co-ordinated Vegetable Improvement Project. Evaluation of F1 hybrids developed utilizing male sterile lines need further testing in order to identify stable hybrids suitable for commercial exploitation.

In white onion research, NRCOG has made significant achievement in terms of identifying high TSS lines with higher marketable yield and suitable for processing dehydration and value added products. Three lines of white onion, NRCOG-W-397, NRCOG-W-408 and NRCOG-418 showed supremacy in yield for the consecutive years in kharif season. NRCOG-W-307 recorded high yield in late kharif, NRCOG-W-415, NRCOG-W-418 and NRCOG-W-421 for rabi were found suitable in terms of yield. These result need further testing to come out with the conclusions.

Post harvest studies revealed that after 7 months of storage only one entry NRCOG-W-421 recorded better performance with 45% storage loss as compared to the variety Agrifound white which reported 79.0% storage loss. The work on breeding yellow onion suitable for export was also initiated. The preliminary evaluation trials revealed that two entries NRCOG-Y-004 and NRCOG-Y-029 recorded high yield 45.0 and 49.0 t/ha, respectively.

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CONTENTS

I. INTRODUCTION

ABOUT THE CENTRE

Onion and garlic, as vegetable spices, form an important constituent of diet for large section of Indian population. Besides, culinary purpose, these are considered as a valuable medicinal items also. Though, India stands second in respect of area in the world, it occupies second and third position in terms of production of onion and garlic, respectively. However, productivity per unit area is much lower as compared to other countries. Over the last four decades, research work in onion and garlic has led to the development of many improved varieties. But, hybrids of onion and large cloved garlic varieties are still elusive. Moreover, no standard variety with total resistance to major pests and diseases exists. In order to augur a profit oriented prospects for onion farmers in terms of productivity, to masses in terms of quality and to exporters in terms of trade, concrete steps towards the goal with a mission mode research is a must. While contemplating these constraints, Indian Council of Agricultural Research sanctioned National Research Centre for Onion and Garlic during VIIIth Plan and established it in the year 1994 with its headquarters at Nasik. Presently, the centre has been shifted to Rajgurunagar, 43 km away from Pune on Pune-Nasik highway and started functioning from June 1998. Since, the establishment in new place, efforts were being made for developing infrastructure facilities and launching sound research programme for resolving major constraints in production of onion and garlic.

LOCATION AND WEATHER

The centre is located at 18.32^0 N (latitude) and 73.51^0 E (longitude) at 553.8 mtr. above m.s.l with a temperature range of $5.5\ ^0C - 42.0\ ^0C$ with an annual mean rainfallof 669 mm .

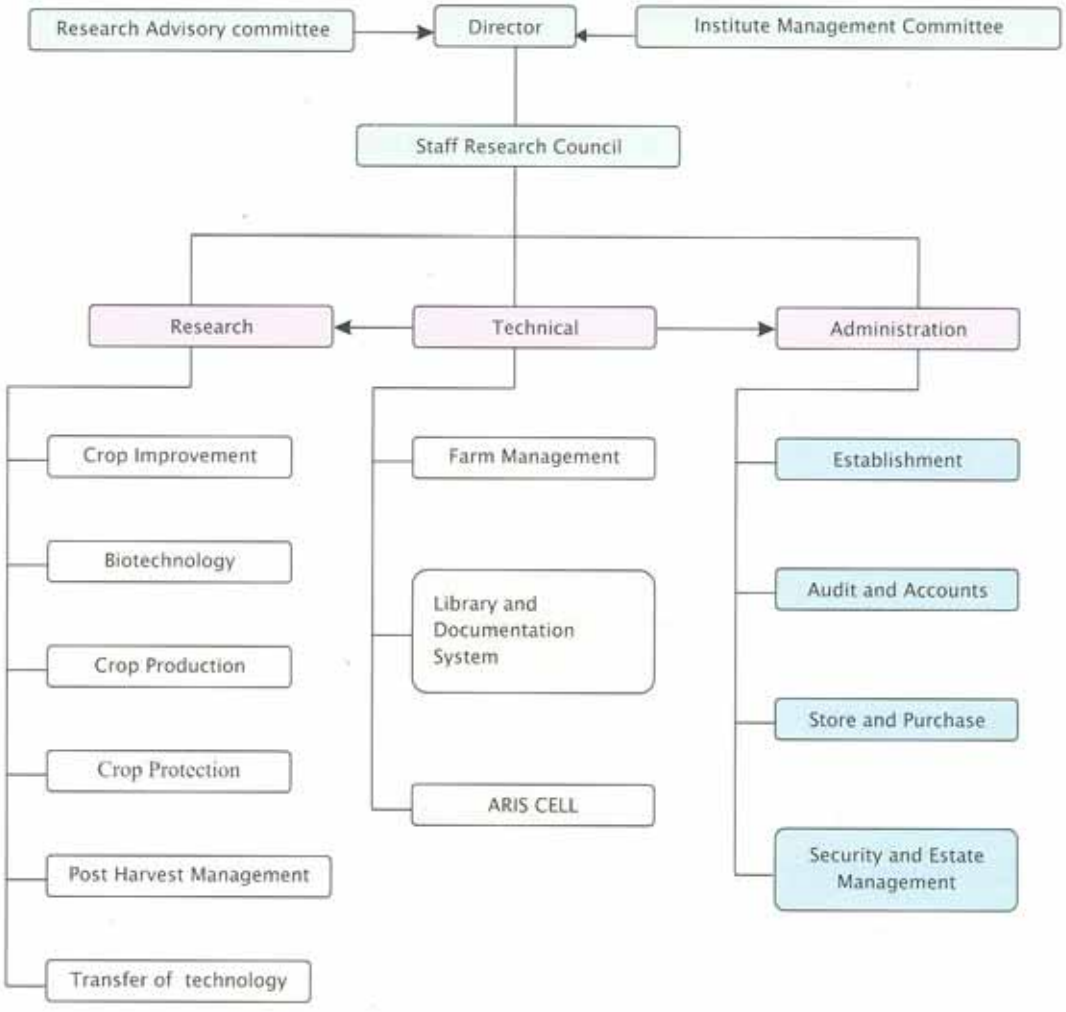
MANDATE

- To collect, maintain and act as national repository for onion and garlic germplasm
- To develop hybrids/varieties suitable for domestic as well as export market coupled with resistance to biotic and abiotic stresses
- To enhance and sustain productivity and quantity of seed as well as bulb crop through agronomic manipulations
- To develop packages for post harvest handling and value addition
- To act as clearing house of research and general information relating to onion and garlic
- To study seed technology of onion
- To act as national trainers training centre for onion and garlic

INFRASTRUCTURE

The centre has 55 acres research farm with perennial irrigation facilities and was handed over by CPRI, Shimla. The old structures were renovated and given new face-lift. The irrigation facilities with modern approaches of micro irrigation have been created. The new administrative-cum-laboratory building has been completed and research laboratories such as horticulture, biotechnology, soil science, plant protection, post harvest technology have also been set up with need based modern equipments. The facilities for internet and e-mail connectivity have been created. The library is having 395 books, 23 regular journals, CD server, Hort-CD, Current contents and other relevant facilities.

ORGANOGRAM



II. RESEARCH ACHIEVEMENTS

III. CROP IMRPOVEMENT

MAIN PROJECT: COLLECTION, CHARACTERISATION, EVALUATION AND MAINTENANCE OF TROPICAL ONION (ALLIUM CEPA L.) AND GARLIC (ALLIUM SATIVUM L.) GERMPLASM.

Experiment 1 Evaluation of onion germplasm during kharif season

A total of 19 germplasm lines were evaluated along with six check varieties. Transplanting was done on 29th July, 2002 and harvesting on 28th Nov. 2002. The experiment was laid out in a randomised block design in two replications having plot size of 1 m^2. It was observed that Acc. 12-2-R (36.88 t/ha) recorded yield at par with B-780 (39.14 t/ha) whereas 6 accessions with Arka Niketan (30.60 t/ha), 10 accessions with Arka Kalyan (27.13 t/ha) and 4 accessions with ADR (33.95) recorded at par marketable yield. Among the check varieties, Arka Bindu recorded highest TSS (15.50°B) and one accession 121-DR recorded significantly higher TSS (16.30°B) than Arka Bindu. Two exotic accessions from Egypt, Behairy Red and Egypt local were also evaluated along with local material . Percent plant stand (10.0%) and total yield of Behairy Red (5.75 t/ha) was very low whereas Egypt local had a medium plant stand (62.86%) and yield was less (14.38 t/ha) as compared to local varieties. These will be further tried for adaptation under our conditions.

Experiment 2 Storability potential studies of onion germplasm

The storage potential of some promising lines was evaluated from March 2003 to Nov., 2003 for a period of 240 days along with commercial check varieties B-780 and N-2-4-1. It was observed that all accessions except 546 were at par with N-2-4-1 in terms of percent loss in bulb count and sprout count (Fig 1), whereas in terms of loss in bulb weight and rot count , all accessions were at par with N-2-4-1. Furthermore, accession no. 592 and 597 were also found to be significantly superior than N-2-4-1 in terms of marketable yield during rangda 2001-02. Hence these lines will be further tested for yield and storage potential vis a vis N-2-4-1 and B-780 to see their stability and yield advantage.

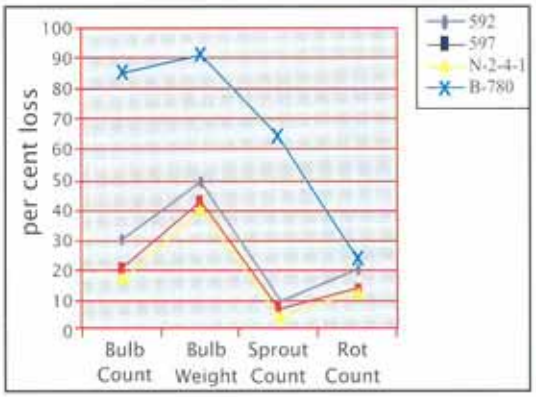


Fig. 1: Storability potential of promising lines of onion

Experiment 3 Evaluation of elite germplasm during rangda and rabi season 2002-03

Ten lines of onion germplasm selected on the basis of their storability potential and general vigour were evaluated during rangda and rabi season alongwith standard check varieties B-780

and N-2-4-1. It is evident from the table 1that accession NRCOG 597 exhibited 9.96 % increase in yield over B-780 and 57.67 % increase in yield over N-2-4-1 during rangda season whereas NRCOG 592 exhbited higher yield percent than N-2-4-1 in both rangda and rabi and was marginally less yielder than B-780. But the amount of storage advantage circumvents the decrease in yield during rangda Season. Seeing the performance of storage potential and yield performance, these two accessious will be tested under multilocation trials for yield in order to exploit their potential for yield and storability. Other accessions were found to have increased yield over N-2-4-1 with a range of 8.31 - 41.88 t/ha.

Accession No. NRCOG-597

Comparative performance on the basis of marketable yield is summarised (Table 2) and it was found that NRCOG 597 recorded maximum marketable yield (44. 35 t/ha) over five seasons in three years 2000-03 and proved to be superior in yield over standard varieties, B-780 and N-2-4-1.

Table 1 : Per cent increase in marketable yield (t/ha) of elite lines over B-780 and N-2-4-1

Accessions	Rangda (Late kharif)		Rabi	
	Per cent increase over		Per cent increase over	
	B-780	N-2-4-1	B-780	N-2-4-1
NRCOG 546	-18.04	17.52	8.27	-2.96
NRCOG 571	-8.19	31.64	16.26	4.21
NRCOG 592	-4.77	36.55	18.44	6.16
NRCOG 595	-17.13	18.83	18.68	6.38
NRCOG 597	9.96	57.67	23.22	10.45
NRCOG 650	-25.86	6.30	5.36	-5.56
NRCOG 651	-43.71	-19.28	8.23	-2.99
NRCOG 654	-26.66	5.15	14.26	2.42
NRCOG 670	-40.82	15.15	15.68	3.69
NRCOG 671	-10.56	28.24	13.17	1.44

Table 2 : Comparative performance of onion elite lines (2000-2003) for marketable yield (t/ha)

Accessions	Rangda 2000-01	Rabi 2000-01	Rangda 2001-02	Rangda 2002-03	Rabi 2002-03	Average
NRCOG 546	29.73	39.89	31.43	31.90	35.76	33.74
NRCOG 571	3.37	48.17	37.47	35.73	38.4	38.23
NRCOG 592	27.00	45.75	42.43	37.07	39.12	38.27
NRCOG 595	28.33	48.42	34.87	32.26	39.2	36.62
NRCOG 597	36.70	54.26	47.27	42.80	40.7	44.35
NRCOG 650	25.13	33.79	30.93	28.86	34.8	30.70
NRCOG 651	22.23	33.61	20.60	21.91	35.75	26.82
NRCOG 654	24.47	43.88	27.77	28.54	37.74	32.48
NRCOG 670	23.93	39.95	23.87	23.03	38.21	29.79
NRCOG 671	30.93	42.53	35.60	34.81	37.38	36.25
B-780	28.83	55.86	51.20	38.92	33.03	41.57
N-2-4-1	25.93	53.61	32.53	27.14	36.85	35.21

Experiment 4 Stability analysis of some elite lines of onion in late kharif / rangda season

Ten promising lines of onion were evaluated for three years during 2000 to 2003 along with checks viz., Baswant 780, N-2-4-1, Agrifound Light Red, Agrifound Dark Red and Arka Niketan at NRCOG experimental farm, Rajgurunagar during late kharif season. Baswant 780 performed well in favourable environments for total yield and marketable yield and also had less number of leaves along with less bolters which were stable. Stability response in ALR during late kharif was unpredictable for TSS, total yield, percentage doubles and bolters. Similarly, ADR was unpredictable for plant height, number of leaves, TSS and marketable yield. N-2-4-1 was unpredictable for marketable yield and Arks Niketan for percentage bolters. All the commercial varieties, except B-780, were found to be unsuitable for late kharif season. Considering the marketable and total yield among the genotypes evaluated, genotype NRCOG 671 showed stable performance for four desirable characters viz., dwarf plant height, more polar diameter of the bulb, high marketable yield and less number of bolters which was followed by genotype NRCOG 571 for high marketable yield and less doubles and NRCOG 597 for high total yield and more polar diameter. Hence these genotypes can be exploited in breeding programme for increasing the production of onion particularly during late kharif season.

Marketable yield is the most important character was found maximum in genotype NRCOG 597 (42.8 t/ha) followed by B-780 (38.9 t/ha), NRCOG 592 (37.07 t/ha) and NRCOG 595 (32.26 t/ha) as compared to overall average performance (30.96 t/ha). All the genotypes had bi values more than 1 with non-significant S^2di indicating that these genotypes responded well in the

favourable environment whereas genotypes 571 and 671 had high mean value (35.73 and 34.81 t/ha, respectively) with bi nearer to 1, thereby, indicating their stable nature in all the environments (Table 3).

Average performance i.e., stability in all the environments was exhibited by genotype NRCOG 597 for total yield which was highest (50.82 t/ha) against an average total yield of 45.06 t/ha. Whereas NRCOG 546, 592 and 654 gave higher mean values, which ranged between 50.55-46.20 t/ha, over the environmental varietal average and genotype B-780 had mean value (45.20 t/ha) nearer to the population mean with bi greater than I and non-significant S^2di. Genotype NRCOG 671 and Arka Niketan performed better in poor environment whereas the deviation from regression was significant in genotype ALR, thereby, exhibiting unpredictable total yield.

Table 3 : Genotype x Environment interactions of 10 elite onion (late kharif) breeding lines for marketable and total yield (t/ha) under varied environments

Accessions	Marketable yield (t/ha)			Total yield (t/ha)		
	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
NRCOG 546	31.9	0.369	2.394	50.56	1.23	-8.611
NRCOG 571	35.73	1.161	0.954	43.89	0.917	-12.57
NRCOG 592	37.07	2.889	16.633	46.21	1.431	-4.164
NRCOG 595	32.26	1.207	-5.809	44.61	4.548	9.574
NRCOG 597	42.8	1.94	-5.346	50.82	1.069	-12.495
NRCOG 650	28.86	1.083	-4.496	40.3	0.887	31.773
NRCOG 651	21.91	-0.27	-5.678	38.59	0.944	20.659
NRCOG 654	28.54	0.71	25.695*	47.79	1.329	-1.272
NRCOG 670	23.03	-0.054	-2.895	42.46	1.329	12.599
NRCOG 671	34.81	3.97	7.789	45.2	1.395	-11.567
B-780	38.92	3.97	7.789	45.2	1.395	-11.567
N-2-4-1	27.14	1.086	22.466*	40.41	1.357	10.583
ALR	27.74	-0.001*	-7.356	49.34	0.414	80.125**
A. Niketan	28.44	0.503	10.103	45.54	0.269	26.81
ADR	25.37	-0.507	91.134**	43.37	0.907	-12.586
Mean	30.97			45.07		

Experiment 5 Evaluation of late kharif onion germplasm

A total of 182 lines of red onion germplasm were evaluated during late kharif/rangda season. It was observed that acc. 851, composite, 529, 617 and 545 recorded highest marketable yield than the control/check varieties but the yield was at par with recommended varieties N-2-4-1, B-780 and Arka Kalyan and acc. 851, composite and 529 were significantly superior than Arka Niketan (Table 4). For total yield, acc. 529 recorded highest yield of 66.32 t/ha which was at par with N-2-4-1. Although the accessions exhibited higher total yield but it was at par with the recommended varieties. Marketable yields ranged from 58.20-15.85 t/ha whereas total yield ranged from 72.66- 27.36 t/ha.

Table 4: Performance of elite onion lines during late kharif season

Accessions	Marketable Yield	Total Yield
	t/ha	
851	58.20	64.13
Composite	57.33	65.67
529	56.20	66.32
617	55.47	62.63
545	55.40	61.37
N-2-4-1 (Check)	54.27	64.10
B-780 (Check)	49.92	58.05
A. Kalyan (Check)	47.35	63.27
A. Niketan (Check)	44.40	57.57
CD (0.05)	11.58	

Experiment 6 Evaluation of rabi red onion germplasm

A total of 167 lines of red onion germplasm were evaluated during rabi season for yield and other horticultural traits. It was observed that the marketable yield ranged from 2.03- 43.97 t/ha whereas total yield ranged from 4.23 - 45.17 t/ha. The top five promising accessions are presented in the Table 5. No accession was found to be superior than control varieties B-780 and N-2-4-1. Accesions 642 and 531 were found to be superior than variety Arka kalyan. In terms of total yield only one accession NRCOG 642 was found to be significantly superior than Arka Kalyan and at par with recommended varieties N-2-4-1 and B-780.

Table 5 : Performance of promising rabi onion accessions

Accessions	t/ha	
	Marketable Yield	Total Yield
642	43.97	45.17
531	40.73	42.38
559	40.25	43.17
12-2-R	40.20	43.40
644	39.23	41.70
B-780 (Check)	39.13	41.03
N-2-4-1 (Check)	36.25	40.08
A. Kalyan (Check)	28.50	31.43
CD (0.05)	12.01	13.21

Experiment 7 Evaluation of garlic germplasm

A total of 136 lines were evaluated during rabi 2002-03 along with standard check variety G-41. The sowing of garlic cloves was done on 19th October 2002 and harvesting was done from 5th to 7th May 2003. The trial was laid out in a randomised block design in a plot size of 1 sq. m. G-41 recorded highest total and marketable yield and on the basis of DMRT acc. No. 345, 279, 277, 349 and 337 recorded at par total yield with G-41 (Table 6).

Table 6 : Performance of promising garlic accessions during rabi 2002-03

Accessions	Marketable Yield	Total Yield
	t/ha	
G-41 (Check)	15.58	17.43
NRCOG 345	13.4	16.73
NRCOG 279	15.13	15.53
NRCOG 277	7.67	15.37
NRCOG 349	11.62	14.92
NRCOG 337	13.88	14.68

Experiment 8 Evaluation of elite garlic germplasm

A total of 47 lines were evaluated for yield and other horticultural traits along with check varieties G-1, G-50, GG-2 and GG-3. The sowing of garlic cloves was done on 21st October 2002 and harvesting was done from 5th to 7th March 2003. The experiment was laid out in a randomised block design in a plot of 6 sq. m area. In terms of total yield, NRCOG 316 recorded highest yield (15.97 t/ha) and was at par with G-41 (Table 7). Other accessions which were significantly at par with G-41 are acc. No. 200, 72 and 183 both in terms of marketable as well as

Table 7 : Performance of promising elite garlic lines

Accessions	Marketable Yield	Total Yield
	t/ha	
NRCOG 316	14.4	15.97
G-14 (Check)	13.75	14.53
NRCOG 200	12.24	13.96
NRCOG 72	12.10	13.88
NRCOG 183	12.76	13.78
CD (0.05)	10.55	8.65

Experiment 9 : Comparative performance of garlic under Rajgurunagar and Manjri Conditions

A field trial was laid out in Rajgurunagar (Location I) and Manjri (Location II) farm to study the performance of advanced lines of garlic. The experiment was laid out in a randomised block design with three replications in a plot area of 6 sq. m. It was found that in general varieties and germplasm performed much better under Manjri conditions than Rajgurunagar. Among the germplasm, the best yielder was NRCOG 183 at both Manjri (22.77 t/ha) and Rajgurunagar (12.76 t/ha) in terms of marketable yield (Table 8). All the germplasm lines were found to be at par with the check varieties under Manjri conditions both in terms of marketable as well as total yield

Table 8 : Performance of advanced garlic germplasm under Rajgurunagar & Manjri Conditions

Acc No.	Marketable Yield (t/ha)		Marketable Yield (t/ha)	
	Location I	Location II	Location I	Location I
NRCOG 38	8.94	12.51	10.43	13.83
NRCOG 50	8.93	12.92	10.51	17.43
NRCOG 183	12.76	22.77	13.78	23.10
NRCOG 200	12.24	21.50	13.96	22.77
NRCOG 201	10.51	18.29	12.32	19.98
NRCOG 219	6.39	12.17	7.60	14.08
NRCOG 221	10.01	18.70	11.81	19.91
NRCOG 229	10.49	19.01	12.16	19.37
NRCOG 257	8.13	10.96	9.66	15.49
G-1	4.85	14.19	7.30	16.42
G-41	13.75	21.03	14.54	21.80
G-50	16.60	4.59	16.82	8.69
C D (0.05)	8.67	5.87	6.81	5.19

whereas under Rajgurunagar conditions var. G-1 was found to be inferior than acc. no. 183 and 200 for marketable yield as well as total yield whereas check G-50 was inferior than acc. No. 183, 200, 201 and 219 for marketable yield and to acc. no. 183 and 200 for total yield . The differences in yield at both the farms may be because of the mode of irrigation where in the former drip irrigation was used whereas in the latter flood irrigation was employed and also due to environment variations.

MAIN PROJECT 1: BREEDING WHITE ONIONS FOR PROCESSING AND DESIRABLE HORTICULTURAL TRAITS

Experiment 1 Evaluation of white onion germplasm during kharif 2002-03

Overall 352 white onion germplasm lines collected from different parts of M.P., Maharashtra and Gujarat were evaluated during kharif season 2002 including 3 white check varieties. Phule Safed, P-6 and PKV white. The crop was planted on 25th July, 2002 and came to harvest after 92 to 100 days of planting.

Significantly higher marketable yields were recorded in 34 entries over best two white checks viz. Phule Safed (14.5 t/ha) and P-6 (14.6 t/ha), which ranged between 20.1 to 38.5 t/ha. Accession W-009 gave significantly higher yield (38.5 t/ha) over all the checks and entries. Total yield over two white checks viz. Phule Safed (24.0 t/ha) were significantly higher in 51 entries and over PKV White (27.6 t/ha) in 20 entries. Eight entries viz. W-017 (44.9 t/ha), W-021 (42.6 t/ha), W-009 (42.5 t/ha), W-082 (41.2 t/ha), W-397 (40.2 t/ha), W-027 (39.0 t/ha), W-043 (38.7 t/ha) and W-160 (38.6 t/ha) recorded significantly highest and at par for total yield over all the entries and checks.

Significantly high and at par TSS were recorded in 15 entries which ranged from 12.99 to 13.84 ° Brix. Four entries viz. W-340, W-044, W-074 and W-047 (13.31 to 13.84 ° Brix) were significantly superior over White check P-6 (12.43), whereas, over Phule Safed (11.33 ° Brix) 65 entries gave significantly higher TSS and ranged from 12.22 to 13.84 ° Brix. over PKV White (11.97 ° Brix). 21 entries were significantly superior and TSS ranged from 12.85 to 13.84 ° Brix.

Table 9 : Mean and range values of various characters in white onion germplasmduring kharif 2002-03

Characters	Range	Mean Values	No. of Entries
Plant Height (cm)	25.65 - 58.60		
No. of Leaves	4.53 - 9.00		
Neck thickness (cm)	0.30 - 0.9	0.3 cm (Minimum)	39
A grade (%)	0.0 -59.8	Above 40 %	31
Doubles (%)	0.0 - 86.57	Below 5 % 0 % Share	41 6
Rot (%)	0.73 - 71.22	Below 10 %	10
Segregation(%)	0 - 58.52	0 %	150
Plant Stand (%)	6.67 - 97.14	Above 85 % Above 90 %	99 45
Marketable yield (%)	9.53 - 97.59 %	Above 75 %	23
	1.1 - 1.4	1.1 (Minimum ratio)	6
Equatorial/Polar ratio			
Days to maturity (days)	92-100	92 days (Earliest maturity)	6

Table 10 : Superior white onion germplasm for TSS over checks during kharif 02-03

Check Varieties	TSS (^{0}Brix)	No. of Superior entries	Range (^{0}Brix)
P. Safed	11.33	65	12.20-13.84
PKW (W)	11.97	21	12.85-13.84
P-6	12.43	4	13.31-13.84

Equatorial: Polar ratio ranged from 1.1 to 1.4. Minimum Equatorial: Polar ratio was recorded in 5 entries (W-004, W-063, W-348, W-372 and W-399) showing round shape of the bulbs. Days to maturity ranged from 92 to 100 days after planting. Earliest maturity of 92 days was recorded in 6 entries (W-005, W-019, W-026, W-030, W-038 and W-060). Percentage marketable yield above 75% was recorded in 23 entries. Percentage marketable yield varied from 9.53 to 97.59%. More than 85% bulbs came to harvest (of the total planting) in 99 entries and above 90% in 45 entries.

Segregation percentage among the germplasm varied from 0 to 58.52 and no segregation were observed in 150 entries. Percentage rotting was recorded from 0.73 to 71.22% and less than 10% rotting was recorded in 10 entries. Less than 5 percentage doubles were recorded in 41 entries and no doubles in 6 entries. Double percentage ranged from 0 to 86.57%. Percentage of A grade bulbs ranged from 0 to 59.8% and over 40% share was recorded in 31 entries. Minimum neck thickness of 0.3cm was noted in 39 entries, whereas the maximum was observed in 31 entries (0.9 cm). Plant height ranged from 25.65 to 58.6 cm and number of leaves after 75 days of planting ranged from 4.53 to 9.00 during kharif season (Table 9 & 10).

Experiment 2 Evaluation of white onion germplasm during kharif season 2001-02 & 2002-03

50 white onion germplasm including check Phule Safed, were evaluated during kharif 2002 which were also evaluated during kharif 2001 except W-412 and W-431. The crop was planted on 25th July, 2002 in a randomised block design with three replications and harvested after 92 to 100 days of planting.

During 2002, significantly higher marketable yield was recorded in three entries viz. W-404, W-418 and W-397 (23.06 to 31.41 t/ha) over check Phule Safed (14.55 t/ha). Entries W-418 and W-404 were also significantly higher over Phule Safed during 2001. Total yields were significantly high in 8 entries (W-404, W-420, W-419, W-421, W-411, W-408, W-418 and W-397) which ranged between 28.7 to 40.2 t/ha during 2002. Total yield were significantly high in 7 entries during both the years (W-397, W-404, W-408, W-418, W-419, W-420 and W-421). 9 entries recorded significantly higher TSS over Phule Safed (11.33^0 Brix, range between 12.13^0 to 13.16^0 Brix) during 2002, whereas it was at par in 8 entries with Phule Safed in 2001 (Table 11).

Table 11: Performance of white onion germplasm in two years during kharif season.

Entries	TSS° Brix			Mkt. yield t/ha			Total yield t/ha		
	2001-02	2002-03	Mean	2001-02	2002-03	Mean	2001-02	2002-03	Mean
W-397	9.5	11.28	10.4	05.28	31.41	18.34	11.67	40.3	25.96
W-404	8.7	10.82	09.7	10.16	19.15	14.65	13.24	28.7	20.99
W-408	8.8	11.22	10.0	8.42	17.52	12.97	14.98	32.8	23.88
W-411	-	11.30	11.3	5.89	17.14	11.51	09.65	31.2	20.43
W-418	8.8	12.57	10.7	6.06	23.06	14.56	11.39	36.5	23.96
W-419	8.4	12.67	10.5	7.86	15.77	11.81	11.78	30.5	21.12
W-420	8.3	11.54	9.9	6.29	13.84	10.06	11.50	29.7	20.62
W-421	8.0	11.22	9.6	7.07	17.66	12.36	12.40	30.9	21.66
P.Safed	11.0	11.33	11.0	3.20	14.55	8.87	8.70	24.0	16.36
CD (0.05)	1.2	0.78		2.12	4.13		2.66	4.66	

Experiment 3 Evaluation of white onion germplasm during Late kharif 02-03.

Three hundred eighty seven white onion germplasm were collected from different parts of Maharashtra, Madhya Pradesh and Gujrat during 2001-02. Out of which, 292 germplasm were evaluated during late kharif 2002-03. The crop was transplanted on 11th October, 2002 in three replications. The crop was harvested between 20th January, 2003 to 28th February, 2002.

Among 292 germplasm evaluated, marketable yield was significantly high in 72 entries and ranged between 50.9 to 33.2 t/ha over best check Phule Safed (23.8 t/ha). Total yield was significantly high in W-307 (66.2 t/ha) over best check Pusa White Round (50.3 t/ha), whereas, 194 entries were statistically at par with Pusa White Round for total yield. More than 75% marketable yield was recorded in 71 collections. 64 entries were significantly earlier in maturity (102 to 109 days after transplanting) over the best check Phule Safed which took 119 days whereas, Pusa White Round took 137 days after transplanting. There was no colour segregation in 118 germplasm. 23 collections recorded less than 10% doubles and 38 entries with no bolters. Percentage of A, B and C grade bulbs varied from 64.0 to 0.0, 46.3 to 3.3 and 26.9 to 1.3 per cent,

Experiment 4 Evaluation of white onion germplasm during late kharif season 2001-02 and 2002-03

53 entries collected in the form of seed from Maharashtra and Gujarat were evaluated during late kharif season for two years with check Phule Safed and Agrifound White. The crop was transplanted in October and harvested in February.

Table 12. Evaluation of white onion germplasm during Rangda 2001-2002 and 02-03

Accessions	Marketable yield (t/ha)		Mean	Total Yield (t/ha)		Mean
	2001-02	2002-03		2001-02	2002-03	
W-396	27.8	35.6	31.7	44.1	52.7	48.4
W-415	23.1	21.0	22.1	53.7	68.7	61.3
W-417	36.1	38.2	37.2	51.3	54.9	53.1
W-418	22.2	12.4	17.3	50.6	64.4	57.5
W-420	9.0	7.3	8.2	53.1	59.1	56.1
W-421	16.0	16.4	16.2	52.3	62.8	57.5
W-422	29.1	33.6	31.4	54.7	52.2	53.5
W-429	25.6	57.6	41.6	36.5	59.2	47.9
P. Safed	20.4	23.8	22.1	41.4	39.4	40.4
AFW	12.6	9.7	11.2	37.3	45.2	41.2
CD (0.05)	4.63	8.7		7.86	10.1	

Significant and higher marketable yield was recorded in 10 entries (range between 57.6 t/ha to 33.6 t/ha) over Phule Safed (23.8 t/ha) and 17 entries over Pusa White Round (29.3 t/ha). Total yield was significantly higher in 39 entries (range between 68.9 t/ha to 49.8 t/ha) over Phule Safed (39.4 t/ha), 4 entries over Pusa White Round (50.3 t/ha) and 11 entries over Agrifound White (45.2 t/ha) during 2002-03. On the basis of two years experiment 4 entries viz. W-396, W-417, W-422 and W-429 gave significantly higher marketable yield and 4 entries viz. W-415, W-418, W-420 and W-421 had significant high total yield in both the years during late kharif, (Table 12).

Experiment 5 Evaluation of white onion germplasm during Rabi season 2001-02 & 2002-03

53 entries collected in the form of seed from Maharashtra and Gujarat were evaluated during rabi season for two years with check Phule Safed. The crop was transplanted in January and harvested in May.

Significantly high yields were recorded in 20 entries which ranged between 63.31 to 45.83 t/ha over check Phule Safed (29.68 t/ha), while 16 entries were superior for marketable yield (49.28 to 36.58 t/ha) over Phule Safed (22.02 t/ha) during 2002-03. On the basis of two years experiment, 10 lines gave significantly high total yield in both the years with mean yield of 57.87 to 46.27 t/ha over Phule Safed (36.65 t/ha) and 2 entries viz. W-404 (42.56 t/ha) and W-418 (43.97t/ha) and for marketable yield as compared to Phule Safed (29.60 t/ha) (Table 13).

Table 13 : Evaluation of white onion germplasm during Rabi 2001-2002 and 02-03

Accessions showing superior performance over Phule Safed						
Acc No.	Marketable yield (t/ha)			Total yield (t/ha)		
	2001-02	2002-03	Mean	2001-02	2002-03	Mean
W-398	39.79	41.94	40.86	51.08	42.87	46.98
W-401	22.56	31.02	26.79	54.49	42.51	48.50
W-402	39.62	39.79	39.71	49.74	43.87	46.81
W-404	42.18	42.94	42.56	54.74	44.41	49.58
W-407	33.59	42.55	38.07	48.97	54.11	51.54
W-411	31.03	49.03	40.03	52.44	63.31	57.87
W-413	40.64	38.24	39.44	51.41	41.13	46.27
W-418	47.44	40.49	43.97	66.15	47.19	56.67
W-419	37.05	40.14	38.60	49.10	44.49	46.80
W-421	32.69	49.29	40.99	53.08	58.21	55.65
P. Safed	37.18	22.02	29.60	43.62	29.68	36.65
CD (0.05)	4.45	14.19		5.33	16.15	

Experiment 6 Performance of white onion germplasm during kharif, late kharif & Rabi season 2002-03.

During kharif, 352 germplasm lines were evaluated, while in late kharif 343 lines and in rabi 343 lines were evaluated, of which 10 high yielding lines on the basis of total yield in each season are given in Table 14. During kharif yield range in these lines was 37.13 - 44.94 t/ha as compared with Phule Safed 24.02 t/ha, whereas, in late kharif it was 59.05 to 68.89 t/ha in the germplasm against Phule Safed (39.4 t/ha.) Total yield during rabi season ranged between 51.03 - 65.74 t/ha as compared to Phule Safed (29.68 t/ha).

Germplasm entries W-411 & W-421 performed well in both kharif and late kharif season whereas, W-075 in kharif and rabi season on the basis of total yield.

Experiment 7 Performance of white onion germplasm in storage during late kharif

Fifty three accessions planted during late kharif were kept in two replications in storage up to 9 months along with 9 varieties. The observations were recorded after three months of storage at an interval of 2 months up to 9 months. i.e. up to November. The percentage losses were calculated and data were transformed into arc sin values and analyzed (Table 15).

Table 14 : Ten best performing white onion germplasm lines on the basis of total yield during kharif, late kharif & rabi season 02-03

Kharif		Late Kharif		Rabi	
Entries	Total yield (t/ha)	Entries	Total yield (t/ha)	Entries	Total yield (t/ha)
W-017	44.94	W-415	68.89	W-407	65.74
W-021	42.62	W-307	66.24	W-411	63.33
W-009	42.52	W-418	64.38	W-421	57.93
W-082	41.16	W-421	62.75	W-075	56.72
W-397	40.25	W-411	60.90	W-363	55.57
W-027	39.05	W-098	60.43	W-103	55.55
W-043	38.70	W-141	59.94	W-078	54.41
W-160	38.60	W-429	59.24	W-088	52.79
W-232	37.67	W-083	59.13	W-003	51.25
W-075	37.13	W-420	59.05	W-404	51.03
Phule Safed	24.02	Phule Safed	39.40	Phule Safed	29.68

Table15 : Performance of late kharif white onion germplasm in storage after 3,5,7 & 9 months, respectively

Entries	Total loss (%)			
	3 months*	5 months*	7 months*	9 months*
W-395	19.5 (26.1)	37.1 (37.4)	57.1 (49.1)	75.5 (60.4)
W-407	20.0 (26.6)	40.0 (39.3)	46.0 (42.7)	84.0 (66.5)
W-423	21.8 (27.8)	37.2 (37.5)	46.3 (42.9)	84.3 (66.9)
W-424	25.0 (30.0)	30.0 (33.2)	45.0 (42.2)	100.0 (89.7)
N-2-4-1	39.5 (38.6)	44.2 (41.5)	49.4 (44.7)	74.4 (59.7)
ALR	28.6 (32.3)	34.8 (36.1)	48.1(43.9)	71.1(57.6)
AFW	39.3 (38.8)	62.6 (52.4)	72.5 (58.6)	92.7 (74.8)
P.Safed	23.9 (29.2)	47.9 (43.8)	61.0 (51.4)	85.7 (68.2)
B-780	41.3 (39.7)	77.7 (63.4)	94.5 (77.3)	100.0 (89.7)
P. Suvarna	26.4 (30.9)	35.2 (36.4)	58.1 (49.7)	87.7 (69.7)
A.Niketan	16.6 (23.5)	21.1 (26.9)	22.5 (27.9)	46.9 (43.2)
ADR	40.5 (39.5)	74.1 (59.4)	91.6 (73.2)	98.6 (83.3)
A.Kalyan	34.4 (35.9)	47.5 (43.6)	60.6 (51.2)	84.4 (66.8)
Mean	34.6 (35.6)	48.8 (44.4)	67.3 (56.0)	88.3 (72.1)
CD (0.05)	(18.7)	(16.7)	(16.6)	(14.2)

Values in parenthesis are arc sin transformed values. * % loss Months after storage i.e. up to November.

Average total loss up to 3 months was 34.6%, whereas it was 48.8%, 62.3% and 88.3% after 5, 7 and 9 months of storage, respectively. After 3 months of storage (i.e. in May) except one germplasm line total losses were at par with Phule Safed (23.9%). Whereas, 45 lines recorded at par losses with A.Niketan (17.3%).

After 5 months of storage (up to July), except W-393 and W-397, 51 accessions were at par with Phule Safed (46.2%), whereas, 26 with A.Niketan (21.1%) in terms of total loss and ranged between 23.5% to 47.2%. Four lines viz. W-422, W-433, W-424 and W-435, total losses ranged between 23.5% to 34% were significantly superior over AFW (62.6%). 16 germplasm lines had no sprouting losses in storage which were significantly superior over Phule Safed (5.4% sprouting).

After seven months of storage one accession W-421 (44.6%) was significantly superior over AFW (78.9%) in terms of total losses. 4 lines (W-421, W-424, W-407 and W-423) were at par with A. Niketan (22.5% total loss), which was significantly superior over all the germplasm lines, whereas, 40 lines had recorded at par total losses with ALR and 50 with Phule Safed.

Total losses after 9 months of storage were at par in 49 accessions with Phule Safed (85.7%) and in 23 lines with ALR (71.1%). The losses were lowest in A. Niketan (46.9%) after 9 months of storage, whereas one line W-395 (75.5%) was significantly superior over AFW (92.7%) total loss. Sprouting was lowest in W-394 (2.5%) which was significantly superior over Phule Safed. Losses due to rotting+ physiological weight loss in 50 lines was at par with Phule Safed and 31 lines with A. Niketan (45.0%).

Experiment 8 Performance of white onion germplasm in storage during rabi 2002-03

53 accessions produced during rabi season were kept for storage studies along with 5 varieties. Observations were recorded at 2, 3, 4 and 7 months of storage i.e. up to November. The percentage losses due to rotting + phlysiological weight loss, sprouting and total loss were calculated and the values were transformed into arc sin values for analysis. The crop was harvested on 16th April, 02 and kept for storage.

The average total storage losses after 2, 3, 4 and 7 months of storage were 14.1%, 20.3%, 52.5% and 83.4%, respectively, i.e. from June to November. White germplasm viz. W-445, W-415, W-434, W-411, W-408 and W- 437 were significantly superior over Phule Safed (63.0% total loss) which ranged between 32.1 to 37% after 4 months of storage (up to August). Two lines viz. W-437 (63.3% total loss) and W-408 (63.6%) had significantly less storage loss than Phule Safed (89.6%)

Table16 : Performance of rabi white onion germplasm in storage

Acc.No.	Total loss %			
	2 months*	3 months*	4 months*	7 months*
W-407	31.5(32.4)	36.0(36.2)	51.2(45.7)	94.6(80.3)
W-408	7.9(15.9)	10.9(19.0)	32.3(34.6)	63.3(53.3)
W-411	6.6(14.9)	10.8(19.2)	35.0(35.9)	74.7(59.9)
W-415	11.6(19.9)	15.5(23.2)	35.5(36.6)	74.3(59.6)
W-434	7.5(15.2)	16.6(23.9)	35.1(36.4)	69.7(56.6)
W-437	8.2(16.6)	15.9(23.5)	28.2(32.1)	63.6(52.9)
W-445	6.2(13.9)	11.1(19.3)	36.1(37.0)	74.4(60.1)
N-2-4-1	16.1(23.6)	20.3(26.8)	29.9(33.1)	52.7(46.6)
ALR	12.0(20.2)	19.0(25.8)	25.6(30.4)	50.4(45.3)
AFW	12.3(20.2)	16.6(23.7)	46.0(42.6)	85.2(68.0)
P.Safed	2.9(9.8)	8.2(16.6)	63.0(52.6)	89.6(71.2)
B-780	40.2 (39.3)	49.4(44.7)	79.5(63.3)	98.2(82.7)
CD (0.05)	(10.9)	(11.5)	(15.2)	(16.8)
Mean	14.1(21.0)	20.3(26.1)	52.5(46.6)	83.4(68.0)

Value in parenthesis are arc sin square root transformed.

* % losses months after storage i.e. up to November.

after 7 months of storage. 24 White germplasm lines were statistically at par with ALR (25.6% total loss) after 4 months of storage and 12 germplasm with best check ALR (50.4%) after seven months of storage. Average losses due to rotting + physiological weight loss and sprouting were 14% and 0.1% after 2 months, 19% and 1.3% after 3 months, 32.2% and 20.3% after 4 months and 55.2% and 28.1% after 7 months of storage, respectively (Table 16). There was no losses due to sprouting in W-407 even after 7 months of storage but the losses were recorded due to rotting in this accession.

MAIN PROJECT : BREEDING YELLOW ONIONS FOR EXPORT

The project has been started in 2001-2002 to develop varieties suitable for export.

The approaches followed are as follows:

1. Collection, evaluation and maintenance of yellow onion germplasm.
2. Evaluation of germplasm for different seasons viz. kharif, rangda and rabi.
3. Forcing long day exotic varieties/hybrids to flower for recombination breeding.

Forty germplasm lines have been collected / isolated from segregating material and have been multiplied during rabi 2002. 28 lines were evaluated during rabi 2002-03.

Table17 : Evaluation of yellow onion germplasm

Entries	Total Yield (t/ha)	Marketable Yield (t/ha)
Y-001	47.38	29.83
Y-029	41.25	40.77
Y-004	47.34	45.52
Y-032	43.70	39.51
P. Suvarna	33.79	30.55
CD (0.05)	9.75	10.00

Out of 28 lines evaluated three yellow onion germplasm viz. Y-001, Y-029 and Y-004 gave significantly higher yield over Phule Suravna. In case of marketable yields two entries viz. Y-029 and Y-004 were superior over check Phule Suravna.

Exotic hybrids were amenable to forced flowering with the use of growth regulators and cold treatments, and the seeds were obtained which will be further evaluated and used in recombination breeding with the Indian lines/varieties.

MAIN PROJECT : DEVELOPMENTS OF HYBRIDS IN ONION

Experiment 1 Production of F1 Hybrid seed with their parents for further evaluation

Bulbs of male sterile line MS48A and MS65A were planted along with the selected inbred lines and varieties in crossing block under controlled conditions (i.e. under the cages). The crossing work is in progress and the seeds obtained will be evaluated during rabi season. The inbred lines are being maintained for maintenance and further multiplication under the cages. Selected F1 bulbs from various crosses are also being planted for selfing to create variability. Seeds produced in exotic hybrids (by forcing) are being evaluated and crosses are being made with Indian varieties also.

Experiment 2 Storage studies of the F1's along with their parents

The F1's and the parents produced during rabi season were kept in storage for studying the storage life during 2002-2003. Initial count and weight of the harvested bulbs were recorded on 17th June 2002 and final observations were recorded on 24th November i.e. after 5 months and 1 week. Among the check varieties, overall storage losses i.e. by number (33.9%) and weight (39%) were less in N-2-4-1 after 5 months and 1 week of storage. Loss in male sterile line MS48A was higher (74.6%) by number and (75% by weight) than MS65A (67.1% by number and 70% by weight). Among the other parents, losses in storage was lowest in 149-2 (21.7% by weight). while its F1 with MS 48A had 54.8% storage losses, which was followed by parent 12-3 (24%) but the losses in

F1 was very high. Losses in F1, MS65A x 158 was lowest respectively, which was followed by F1 MS48A x 208 with 30% losses whereas the losses in MS48A was 75% and in 208 it was 35% by weight. Percent storage losses after 5 months of storage in parent 179 was 54.1% but its F1 with MS 65A has 35% storage losses (Table 18).

Table 18 : Performance of some of the F1 hybrids and parents along with varieties during storage after 5 months and 7 days of storage

Parents/Crosses	% Losses by Number	% Losses by Weight (Kg)
12-3	10.9	24.0
158	84.4	85.0
65x158	0.0	24.0
149-2	6.3	21.7
48x149-2	43.6	54.8
208	25.0	35.0
48x208	15.8	30.0
179	45.5	54.1
65x179	27.7	35.0
MS48A	74.6	75.0
MS65A	67.1	70.0
ALR (check)	60.4	65.0
N-2-4-1 (check)	33.9	39.0
B-780 (check)	89.3	90.2

MAIN PROJECT : VARIETAL EVALUATION AT THE CENTRE AND UNDER AICVIP TRIALS

Experiment 1 Evaluation of advanced lines during late kharif 2002-03

Five advanced lines, selected from B-780, were evaluated during kharif season 2002 with other varieties to see the performance of selected materials. The crop was planted on 25th July, 2002 and harvested after 99 days of planting.

Significant and high marketable yield over best check A. Kalyan (29.20 t/ha) was recorded in NRCOG-780-5-3-1(Red) (32.07 t/ha). Total yield of NRCOG-780-5-3-1(Red) (35.64 t/ha) was also statistically at par over best check ADR (34.51 t/ha). Percentage of marketable yield was highest i.e 90.40% in Arka Kalyan followed by NRCOG-780-5-3-1(Red) (89.98%), NRCOG-780-SC (88.70%) and B-780 (88.49%) (Table 19). Percentage rotting was less in A.Kalyan

Table 19 : Advanced lines during kharif 2002-2003

Entries	TSS (%)	% Mkt. Yld	Mkt. Yld (t/ha)	Total Yld (t/ha)
NRCOG-780-5-2-1	10.80	83.84	20.60	24.57
NRCOG-780-5-2-2	10.71	82.46	21.48	26.05
NRCOG-780-5-3-1 (R)	11.49	89.98	32.07	35.64
NRCOG-780-5-3-1 (LR)	10.01	71.18	16.62	23.35
NRCOG-780 - SC	11.43	88.70	27.63	31.15
A. Niketan	11.76	81.91	21.92	26.76
A. Kalyan	12.63	90.40	29.20	32.30
N-53	9.86	79.82	25.28	31.67
B-780	11.92	88.49	27.21	30.75
ADR	10.52	76.12	26.27	34.51
Mean	11.11	83.67	24.82	29.67
CD (0.05)			2.41	1.99

(5.76%), NRCOG-780-SC (5.96%), NRCOG-780-5-3-1(Red) (6.74%) and B-780 (7.12%). Maximum rotting was recorded in NRCOG-780-5-3-1 (LR) (19.94%). Percentage double was also lowest in NRCOG-780-5-3-1 (Red) (3.29%) and % A grade bulb was more in NRCOG-780-5-3-1 (Red) (39.25%), B-780 (39.99%) and ADR (39.43%). Plant height was maximum in NRCOG-780-5-3-1 (Red) (53.83 cm) which was followed by NRCOG-780-5-2-2 (49.70cm), B-780 (49.37cm) and NRCOG-780-SC (49.3 cm). Neck thickness ranged from 0.81 in NRCOG-780-5-2-1 to 0.91cm in NRCOG-780 - SC.

Experiment 2 Evaluation of advanced lines during late kharif

Five advanced lines, selected from B-780, were evaluated during rangda for two years along with varieties to see the performance of selected material in three replication planted on drip irrigation system with the plot size of 12 m^2 per treatment. The crop was transplanted on 11th October, 2002 and harvested on 21.2.2003. The experimental details and results are as follows :

Total yield in four advanced lines except NRCOG-780-5-3-1 (LR) was at par with B-780, ADR, A. Niketan and ALR but it was significantly superior over A. Kalyan and N-2-4-1 during 2002. Marketable yield was significantly higher in NRCOG-780-5-3-1 (R) and NRCOG-780-5-2-2 over B-780. Percent of doubles and bolters were less in these advanced lines except NRCOG-780-5-3-1 (LR) & NRCOG-780-5-2-1. Percentage of A grade bulbs were more in these lines as compared to other varieties. On the basis of two years results NRCOG-780-5-3-1 (R) is giving higher total as well as marketable yield of 54.00 and 50.89 t/ha, respectively (Table 20).

Table 20 : Evaluation of advanced lines during rangda 2001-02 & 2002-2003

Entries	Marketable yield (t/ha)		Mean	Total yield (t/ha)		Mean
	2001-02	2002-03		2001-02	2002-03	
NRCOG-780-5-2-1	57.09	33.11	45.10	60.53	41.16	50.85
NRCOG-780-5-3-1(R)	61.07	40.70	50.89	63.64	44.36	54.00
NRCOG-780-5-3-			42.49			49.31
1(LR)	56.57	28.40		59.75	38.86	
NRCOG-780-5-2-2	53.07	41.10	47.09	56.72	45.87	51.30
B-780	49.96	35.02	42.49	59.67	45.39	52.53
A.D.R.	30.16	17.02	23.59	60.37	42.83	51.60
A. Kalyan	39.32	18.05	28.69	49.81	36.31	43.06
A. Niketan	35.32	25.16	30.24	51.64	40.29	45.97
N-2-4-1	49.96	22.97	36.47	59.98	35.84	47.91
A.L.R.	32.05	27.67	29.86	48.72	41.31	45.02
CD (0.05)	8.57	5.64		7.21	6.38	

Experiment 3 Varietal evaluation trial on onion under AICVIP during rabi IET and AVT-II

Entries for onion IET & AVT-II trial were transplanted on 3.1.2003 and harvested between 122 to 126 days after transplanting. The experimental results revealed that the marketable yield was highest in local check N-2-4-1 (23.06 t/ha) which was statistically at par with the entry PKV Sel.(21.90 t/ha) and check variety AFLR(21.25 t/ha). Percentage of doubles less than 10% and marketable yield more than 90% was recorded in A.Niketan, N-2-4-1, AFLR and JNDWO-85. Total yield was significantly highest in entry PKV Selection (26.39 t/ha) over the best check N-2-4-1 (23.17 t/ha). TSS ranged between 10.51 to 12.94^{0}B None of the entries gave higher yield than the check variety ALR and local check N-2-4-1 in terms of marketable yield (Table 21).

Experiment 4 Varietal evaluation trial on garlic under AICVIP during Rabi IET and AVT-II 2002-2003

Six entries were received under AICRP trials for IET & AVT-II evaluation trial in garlic along with three national checks and one local check. The experimental details are given in Table 22.

None of the entries could surpass the best check G-1 and other 2 checks G-50 and G-41 in IET and AVT-II trials. Marketable bulbs were not formed in Agrifound Parvati.

Checks: 2 National check (C) + 1 Local Check (LC)

Table 21 : Evaluation of onion varieties received under AICVIP trial

Entries	Market-able yield (%)	TSS (° B)	Marketable yield (t/ha)	Total yield (t/ha)	% increase in marketable yield over best check N-2-4-1
IET					
L-28	75.51	10.95	11.90	15.90	-93.8
AVT-II					
JNDWO-85	92.56	12.40	19.00	20.55	-21.4
Pb. White	74.23	11.95	13.75	18.50	-67.7
PKV Sel.	82.77	11.73	21.90	26.39	-5.3
RO-I	82.90	10.51	14.33	17.23	-60.9
PRO-6	79.29	11.07	12.54	15.89	-83.9
Checks					
AFLR (LC)	98.86	12.18	21.25	21.50	-8.52
A. Niketan (C)	98.50	12.94	19.35	19.65	-19.2
N-2-4-1 (LC)	99.56	12.64	23.06	23.17	-
Mean	87.13	11.82	17.45	19.86	
CD (0.05)		0.75	2.31	2.53	
CV		4.32	9.05	8.74	

Experiment 5 Evaluation of garlic varieties received under AICVIP for storage

Eleven varieties including 6 entries received from All India Co-ordinated Vegetable Improvement trials during 2002-03 were assessed for storage losses during 2002-03 after 3 months of storage. The losses varied from variety to variety in garlic (Table 23), and ranged from 31.12% to 82.28% between initial gross weight and GG-2 (31.45%) which was followed by G-41 (39.13%). Percent loss between gross weight to net weight after 3 months of storage varied between 10.50% in GG-3 to 38.91% in PG-17. It was also less in G-41 (12.34%), GG-2 (12.119%) and JNDG-70 (12.24%) (Table 23).

Storage losses are also more important which has to be reduced as the garlic is produced only once in a year. Hence there is urgent need to develop garlic varieties suitable for storage besides high yield and for this purpose, the germplasm should be evaluated for less storage losses along with the high yield.

Date of planting: 29.10.2002 Date of harvesting: 10.3.2003 Replications: 4
Net Plot size: 2x1.5m Entries: 4 IET + 2 AVT-II
National Check (C): 3 Local Check (LC) : 1

Table 22 Evaluation of garlic lines under AICRP during rabi 2002-03

Entries	Average number of cloves/ bulb	Wt of 50 cloves (gm)	Yield (t/ha)	% yield increase over check
IET				
JNDG-96-178	18.80	0.026	8.02	-57
AFP	0.00	0.000	2.92	-331
KGS-2	11.40	0.029	2.07	-508
PG-17	9.31	0.024	4.27	-195
AVT-II				
DG-1	14.33	0.009	5.01	-151
JNDG-70	21.35	0.026	8.67	-45
Checks				
G-283 (C)	14.80	0.039	4.98	-153
G-1 (C)	12.53	0.034	12.58	
G-50 (C)	14.45	0.035	11.27	-12
G-41(LC)	19.15	0.042	12.22	-3
Mean	13.61	0.03	7.20	
CD (0.05)	3.88	0.009	2.03	
CV			19.46	

MAIN PROJECT : CREATION OF VARIABILITY IN GARLIC THROUGH MUTATION

Half cut cloves of variety G-41 were treated with differential doses of chemical mutagens for 6 hours and 12 hours duration. Six concentrations of Sodium Azide (SA) were used which ranged between 0.01% to 0.60% and six concentrations of Ethyl Methyl Sulphonate (EMS) ranged between 0.05% to 0.55%. In case of colchicine, eight concentrations ranging between 0.05% to 0.55% were used for treating the cloves. 120 cloves were treated for each treatment of garlic and planted in two replications in the field at NRCOG, Rajgurunagar. Initial observations for survival were recorded after 45 days of planting and final observations were recorded after 140 days of planting.

Mortality rate was counted at different doses and chemical mutagen treatments. There was difference in the lethal dose at 6 and 12 hour of treatment. The concentrations required to attain LD50 was higher when treated for 6 hours as compared to 12 hours in all the three mutagens. Lethal dose of 50% was about 0.067% of colchicine for 12 hours of treatment and about 0.145% for 6 hours of treatment in garlic variety G-41. In case of Sodium Azide, lethal dose of 50% was

Table 23 : Percent storage loss (by weight) in different garlic varieties after 3 months of storage

Entries	Source	Gross Yield (initial) v/s Net Yield (after 3 months)	Gross Yield (after 3 months) v/s Net Yield (after 3 months)
DG-1	Durgapura	76.53	34.55
PG-17	Ludhiana	82.28	38.91
JNDG-70	Junagarh	45.44	12.24
G-323	NHRDF, Nasik	72.35	24.24
GG-2	NHRDF, Nasik	31.45	12.19
GG-3	NHRDF, Nasik	31.12	10.50
G-1	NHRDF, Nasik	72.39	25.55
G-50	NHRDF, Nasik	67.93	23.11
G-282	NHRDF, Nasik	43.68	16.73
G-41	NHRDF, Nasik	39.13	12.34
Mean		54.98	20.61

estimated to be 0.02% for 12 hours of treatment and about 0.125% for 6 hours of treatment. In case of gamma radiation, there was initial sprouting but later on there was no survival when treated from 3 to 21 kr. Thus the above studies will help to finalize lethal dose in field conditions and to create variability in the garlic for crop improvement with various objectives.

Table 24 : Effect of colchicine, Sodium Azide and EMS on survival in garlic

Colchicine Concentration %	Mortality** at 140 DAP* (%)	SA Concentration %	Mortality** at 140 DAP* %	EMS Concentration %	Mortality** at 140 DAP* %
12 hrs dip				12 hrs dip	
0.00-0.08	0.00-64.43	0.00-0.02	0.00-48.0	0.00 - 0.55	0.00 - 36.60
6 hrs dip				6 hrs dip	
0.00-0.15	0.00 - 54.75	0.00 - 0.1	0.00 - 44.25	0.00 - 0.55	0.00 - 26.60

*DAP : Days after planting

** Mortality estimated on the basis of 100% survival in control.

MAIN PROJECT : USE OF BIOTECHNOLOGICAL APPROACHES FOR ONION & GARLIC IMPROVEMENT

Experiment 1 Standardization of protocol for direct and indirect organogenesis in onion (Allium cepa L) and garlic (Allium sativum L)

Onion and garlic are important vegetable crops because of their economic importance and medicinal value. But a little work on in vitro studies had been done so far in India. Moreover, for germplasm conservation, exchange and other studies e.g., genetic transformation and development of new forms in sexually sterile crop i.e., garlic, in vitro techniques play an important role. Hence a project has been started to study the suitability of different explants ; to develop callus culture and regeneration protocol ; to develop protocol for multiple shoot induction in both the crops and to transfer the in vitro regenerated plants to field conditions.

In this direction, success has been achieved in getting callus from the seed explant of onion cv. B-780. Murashige and Skoog's (MS) medium alongwith 2,4-D is showing good response. Further experiments are on to identify the best protocol which gives good response over a range of genotypes.

In order to multiply a rare genotype or chance mutants or any genotype in onion or to go for mass multiplication in garlic, a protocol for multiple shoot induction in both the crops is of utmost importance.

Multiple shoots in onion have been obtained and the efforts are on to deliver the same results in garlic. Moreover, different media are still being tried to increase the rate of induction frequency and number of shoots per explant.

Experiment 2 DNA Fingerprinting in onion and garlic

In order to conserve our biodiversity and maintain the identity of our germplasm, DNA fingerprinting of germplasm, elite lines and cultivars is of importance. We have started DNA fingerprinting of onion and garlic varieties through RAPD. DNA isolation was done by modified CTAB method and the quantification of DNA was done by spectrophotometric estimation with lambda DNA. Operon primers OPA 1-20, OPC 1-20, OPD 1-20, OPE 1-20 and OPF 1-20 were used to detect polymorphism. At present 100 primers have been screened and the primers showing polymorphism are being again tested to check the veracity of the polymorphism and the primers. A total of 35 primers were found to show polymorphism.

IV. CROP PRODUCTION

MAIN PROJECT : ONION BASED CROPPING SYSTEM

The crop sequence has a considerable effect on crop yield, soil fertility and occurrence of diseases and pests etc. In recent years soil fertility-fertilizer use research is focused on cropping sequences. Fertilizer recommendations are made for cropping sequence as a whole taking into account the yield of preceding crop and their residual effect. Studies on sequential cropping of well-delineated agro ecological zone would help for optimization of nutrient inputs, thereby, minimizing the external inputs. However, the available information on these aspects of onion is very less. Thus a long-term trial was started in 2000 to find out best cropping sequence for onion. Various experiments were conducted during 2002-2003 Out of 12 sequences, 7 sequences gave cost: benefit ratio of more than 2.The highest cost benefit ratio of 1: 2.12 was found in Soybean (kharif): onion (Rabi) sequence. This sequence produced 2.40 t/ha yield of soybean in kharif and 3.30 t/ha yield of onion in rabi season. This sequence is closely followed by Aster (kharif) and onion (Rabi) sequence. These sequences were found better over traditional crop sequences of Bajra: Onion, Potato: Onion and Potato: Wheat (Table 25).

Table 25 : Comparative yield (t/a) performance, total return and C: B ratio of different cropping sequences

Sequence	Summer season (t/ha)	Kharif season	Late kharif	Rabi season	Total Return Rs/ha)	C: B ratio
		Yield (t/ha)				
S1	-	Aster (212500 Bundles)	-	Onion (29.40)	75997	1:2.12
S2	-	Marigold (10.7)	-	Onion (29.1)	62071	1:2.05
S3	-	Potato (18.4)	-	Wheat (4.030)	47236	!:2.04
S4	-	Potato (18.6)	-	Onion (29.6)	64926	1:2.03
S5	-	Groundnut (2.21)	-	Onion (31.1)	44196	1:1.98
S6	-	Soybean (2.40)	-	Onion (33.0)	49948	1:2.16
S7		Bajra(2.47)	-	Wheat (4.29)	30756	1:2.05
S8		Bajra(2.37)	-	Onion (30.9)	43625	1:1.89
S9		Onion (20.9)	-	Wheat (4.36)	40985	1:1.91
S10	Groundnut (4.49)	-	Onion (33.6)	-	61053	1:2.03
S11	Cucumber (14.3)	-	Onion (32.8)	-	56576	1:2.03
S12	-	Onion (20.3)	-	Potato (17.7)	50441	1:1.91

MAIN PROJECT: IRRIGATION STUDIES IN ONION AND GARLIC

Flood or surface irrigation method is widely practiced in India which results in inefficient use of irrigation water due to loses in evaporation, deep percolation and distribution, while water use efficiency of properly designed and well managed micro irrigation system is about 90 per cent. Hence more emphasis should be given to irrigation method to get the higher productivity and reduce the consumption of water.

ONION : The pooled results of the 3 years study conducted on effect of irrigation methods and level of irrigation on growth, yield and water use efficiency (WUE) in onion reveals that highest yield (40.2 t/ha) was obtained in drip irrigation method with 100% (PE) level of irrigation. This treatment produced 23.1% higher yield over surface irrigation. As far as the water saving was concerned there was 37.8 % saving of water in best treatment (100%PE with drip irrigation) over surface irrigation. Among the irrigation methods drip was found far superior in term of yield, quality, and water saving over sprinkler and surface irrigation methods (Table 26).

Table 26 : Effect of irrigation methods and level of irrigation on yield and water use efficiency in onion

Treatments	Marketable yield (t/ha)	% Increase in yield over surface irrigation	% Water saving over surface	WUE (Kg/ha.cm)
Drip irrigation50% PE	26.3	-19.0	63.6	1084.8
Drip irrigation75% PE	34.4	6.6	50.1	968.7
Drip irrigation100% PE	40.2	23.1	37.8	877.2
Sprinkler irrigation 50% PE	23.1	-28.0	63.1	836.2
Sprinkler irrigation 75% PE	25.4	-20.9	44.1	616.7
Sprinkler irrigation 100% PE	28.7	-9.9	32.5	532.0
Surface irrigation on 50 mm CPE at 7cm depth	32.6	-	-	422.7

GARLIC

The pooled results of the 3 years study conducted on effect of irrigation methods and level of irrigation on growth, yield and water use efficiency (WUE) in garlic reveals that highest yield (13.2 t/ha) was obtained in drip irrigation method with 100% (PE) level of irrigation. This treatment produced 13.0% higher yield over surface irrigation with 37.9 percent water saving. Although there was 63.7 and 50.7 per cent water saving in 50% and 75% PE irrigation levels of drip system but 50% PE treatments produced lower yield than surface irrigation while in 75% PE it was at par with surface irrigation . The sprinkler irrigation produced lower yield than drip irrigation at all levels.

The 50 and 75 % PE level in sprinkler produced lower yield than surface irrigation. The percentage of A grade bulbs were also higher in drip irrigation than other treatments. Overall the drip irrigation was found far superior in term of yield, quality, and water saving over sprinkler and surface irrigation methods (Table 27).

Table 27 : Effect of irrigation methods and irrigation levels on yield and water use efficiency in onion

Treatments	Marketable yield (t/ha)	% increase in yield over Surface Irrigation	% Water Saving over surface	WUE (Kg/ha.cm)
Drip irrigation50% PE	9.07	-21.2	63.7	343.1
Drip irrigation75% PE	11.9	1.64	50.7	318.8
Drip irrigation100% PE	13.2	13.0	37.9	274.6
Sprinkler irrigation 50% PE	7.31	-37.4	63.6	256.0
Sprinkler irrigation 75% PE	10.4	-7.78	50.1	269.0
Sprinkler irrigation 100% PE	12.3	7.01	36.4	246.5
Surface irrigation on50 mm CPE at 7cm depth	11.6	-	-	147.4

MAIN PROJECT : PRODUCTION TECHNOLOGY FOR KHARIF ONION

Preamble : Onion is grown all over the country. The main season for onion is rabi (winter) season, but it is also grown in substantial area in kharif and late kharif (rangda) seasons. The productivity in kharif season is lower than the rabi and late kharif seasons. The reasons of low productivity are non-availability of package of practices for these seasons, higher infestation of diseases, pests etc., and failure of attaining maturity of the vegetative parts. This leads to low productivity of quality bulbs. The low productivity of kharif onion is associated with the failure in timely production of nursery seedling. This causes delay in planting of kharif crop. The peak vegetative growth period coincides with high rainfall, as a result the incidence of diseases is high which leads to low yield. Further vegetative growth phase continues even after maturity and the neck remains wide and thick and that influences the quantity and quality of bulb.

Experiment 1 Effect of shading on nursery production in kharif

Different shading materials i.e. Agro shade net 50% and75%, hessian cloth, and nylon net were used for shading from top and western and southern sides in nursery sown in flat beds with surface irrigation and broad base furrow (BBF) with drip irrigation during summer season 2002. The results show that the number of transplantable seedlings was higher than control in all

treatments. The seedlings produced in drip irrigation were superior to those produced in surface irrigation in terms of seedling girth and number of roots/seedling. The girth of seedlings in hessian cloth treatment was significantly higher than agro shade nets. As far as irrigation was concerned, drip irrigation was found better than surface irrigation (Table 28). There was water saving of 40 % in drip irrigation than surface irrigation.

Table 28 : Percent transplantable seedlings

Treatments	Per cent transplantable seedlings	
	Drip irrigation	Surface irrigation
Control (No shading)	47.55	31.85
Shading with Hessian cloth	68.63	65.95

Experiment 2 Effect of date and method of planting on yield of kharif onion

An experiment was conducted to find out the suitable date and method of planting in kharif season. Onion cv. Baswant-780 was planted by four methods i.e. flat bed, raised bed, ridge, furrow and broad based furrow on four dates i.e. June 1, June 15, July 1, and July 15, 2002.The results revealed that bulb yield was higher in first and last date of planting. Among different methods, flat bed and bbf with drip irrigation produced higher yield than other methods (Table 29 & 30).

Table 29 : Effect of date of planting on yield of kharif onion cv.Baswant-780

Date of planting	1st June	15th June	1st July	15 th July
Marketable yield (t/ha)	12.45	10.05	10.36	12.53

Table 30 : Effect of date of planting on yield of kharif onion cv.Baswant-780

Method of planting	Flat bed	Raised bed	Ridge and furrow	Broad base furrow (bbf)
Marketable yield (t/ha)	16.04	10.07	8.99	18.25

Experiment 3 Effect of Pre harvest treatment for forced maturity

Various growth regulators, herbicides, metal salts etc. were tried in kharif season for the leaf desiccation, forced maturity enhancing storability. Among them foliar application of various concentrations of copper sulfate at 90 days after transplanting was found successful in leaf desiccation and forced maturity. There was 100 % drying of leaves with in 24 hours of spraying 10% CuSO4.The other concentration viz.4, 6,8% CuSO4 were also found successful in leaf desiccation within 4days of spray. These forced matured bulbs were kept in storage studies. The results revealed that there was significantly higher sprouting in forced matured bulbs. The rotting was also higher in these treatments (Table 31).

Table 31 : Effect of chemical desiccants on storage losses in onion cv. Baswant-780

Chemical	% Losses after 30 days		
	PLW	Rot	Sprout
Control	12.87	3.31	0.92
2% $CuSO_4$	4.61	18.23	1.77
4% $CuSO_4$	4.76	10.71	7.26
6% $CuSO_4$	5.58	11.92	12.69
8% $CuSO_4$	9.0	7.33	10.33
10% $CuSO_4$	13.5	10.56	4.0
CD (0.05)	5.5	6.73	3.61

Experiment 4 Effect of direct seeding on growth and yield of onion

Onion is grown as direct sown crop all over the world except few southern Asian countries including India. The direct sowing of crop is beneficial to eliminates the problem of production of nursery during summer, Keeping this point in view, experiments were conducted during kharif 2002 on direct sowing of onion. Seeds of onion cv. Baswant-780 were sown and seedlings were transplanted in bbf with drip irrigation during second week of July. The growth and yield parameters were recorded. The results revealed that there was no significant differences in growth of direct sown and transplanted onion. The yield in direct sown onion was 30 tonnes/ha, which was almost double as compared to transplanted onions (16 tonnes/ha). There was more percentage of A and B grade bulbs in direct sown crop. The total duration taken from seed to bulb was five months in direct sown crop, which was less than the combined duration of nursery and transplanted crop.

MAIN PROJECT : ORGANIC CULTIVATION IN ONION (CENTRAL SECTOR SCHEME)

The environmental problems aggravated by intensive use of pesticides, insecticides and inorganic fertilizers and over utilization of natural resources have leads to many problems. Thus the concept of sustainable farming with organic production system is gaining acceptability. The demand of organic products has created new export opportunities in fruits and vegetables crops. Onions being a first ranking fresh vegetable in export needs production technology for organic production to maintain its export market.

The experiment on organic cultivation of onion cv. Baswant-780 was started in Kharif 2001 comprising of 9 treatments of various organic manures and their combinations with two irrigation systems i.e. drip and surface. The control plot was given recommended dose of fertilizers and pesticides. In organic manure treatments, three sprays of Verticillium lacane were given at 30,45 and 60 days after transplanting. This experiment was repeated in same piece of land during rabi 01-02 and kharif 02. The result shows that the RDF showed higher yield than all the organic manure treatments except poultry manure treatment .The yield in drip irrigated bed was higher than flat beds in all the treatments The over all, the yield of onion under organic treatments was lower in first season but showed an increasing trend in second and third season. The yield of kharif onion was lower than the rabi season as the disease infection was higher in kharif. Further the drip irrigation system was found superior over surface irrigation in respect of yield and quality of bulbs (Table 32 & 33).

Table 32 : Yield of onion as influenced by different manures under surface irrigation

Treatments	Marketable yield (t/ha)			
	Kharif		Rabi	
	2001	2002	2001	2002
Recommended NPK	12.9	12.86	23.9	23.9
FYM (20t/ha)	4.5	5.31	11.9	10.05
FYM (10t+NC 1t/ha)	5.0	7.04	11.9	9.45
Poultry manure (10t/ha)	3.0	6.86	16.9	16.21
Control	5.9	6.35	9.0	9.05

Table 33 : Yield of onion as influenced by different manures under drip irrigation

Treatments	Marketable yield (t/ha)			
	Kharif		Rabi	
	2001	2002	2001	2002
Recommended NPK	16.9	27.2	32.6	26.88
FYM (20t/ha)	8.0	18.9	22.8	20.33
FYM (10t+NC 1t/ha)	9.0	17.8	20.9	17.76
Poultry manure (10t/ha)	7.4	22.5	26.4	25.57
Control	7.5	17.9	21.0	13.64

MAIN PROJECT : INTERCROPPING OF ONION AND GARLIC IN SUGARCANE WITH MODERN IRRIGATION SYSTEMS (CENTRAL SECTOR SCHEME)

Preamble : The concept of intercropping in sugarcane with vegetables is gaining popularity among the farmers to get additional income in initial months and to maximize the use of all available resources. The crops like onion and garlic are very much suited to intercropping in sugarcane (Nov.-Dec planting). Since these crops are shallow rooted bulb crops having low canopy, thus they do not compete with deep-rooted long duration crop like sugarcane. The emphasis is now being given on the paired row planting of sugarcane for better cane thickness and sugar recovery. Further the use of micro irrigation particularly drip irrigation is now becoming essential to save water and increase the water use efficiency. These factors provide opportunities for intercropping of short duration vegetable crops in sugarcane during initial months.

Considering these points in view, an experiment was planned and laid out on intercropping of onion and other vegetables in sugarcane during Dec. 2001 with four methods of irrigation/ planting i.e. i) Surface irrigation with sugarcane paired row planting, ii) Surface irrigation with sugarcane planting in ridges and furrows iii) Drip irrigation with sugarcane paired row planting, iv) Sprinkler irrigation with sugarcane paired row planting, and four intercrops i.e. i) Onion ii) Garlic, iii) Potato , iv) Cabbage .The result revealed that irrespective of irrigation methods, marketable yields of intercrops was higher in paired row planning than ridge and furrows. Onion and garlic yields were four and two times higher in paired row than ridge and furrows, respectively. Onion performed well in all treatments except ridges and furrows where the doubles were very

high(72%)(Table 34) Sugarcane yield was at par in all treatments(Table 35). There was 23 % water saving in pair row with surface than ridges and furrows. while paired row planting with drip irrigation recorded 38 percent water saving than ridge and furrows(Table36). Paired row planting of sugarcane with drip and onion as intercrop appeared to be most economically profitable combination, which recorded 247 tonnes of sugarcane yield and 23 tonnes of onion yield per hectare.

Table 34 : Yield of sugarcane

Treatments	Yield (t/ha)	No.of milleable canes/ha (In lakhs)
Drip irrigation with paired row planting	247	2.08
Sprinkler irrigation with paired row planting	271	2.09
Surface irrigation with paired row planting	219	1.63
Surface irrigation with ridge & furrow planting	259	1.82

Table 35 : Marketable yield of intercrops (t/ha)

Treatments	Intercrops			
	Onion	Garlic	Potato	Cabbage
Drip irrigation with paired row planting	23.5	4.1	6.9	28.6
Sprinkler irrigation with paired row planting	20.7	5.5	13.4	35.3
Surface irrigation with paired row planting	21.5	2.4	9.3	21.4
Surface irrigation with ridge & furrow planting	7.9	2.7	18.4	45.3

Table 36 : Water requirement of sugarcane along with intercrops

Treatments	Amount of water applied (ha cm)	% water saving over ridge & furrow method
Drip irrigation with paired row planting	115	39
Sprinkler irrigation with paired row planting	143	24
Surface irrigation with paired row planting	145	23
Surface irrigation with ridge & furrow planting	189	-

MAIN PROJECT: DEVELOPMENT OF INTEGRATED NUTRIENT MANAGEMENT MODULE IN ONION AND GARLIC

Experiment 1 Combined effect of organic manures and fertilizers on onion and garlic

The objective of this experiment was to come out with the best treatment effect due to combined application of farmyard manure, vermi-compost and poultry manure with different levels of recommended dose of fertilizer (RDF) on yield, quality and stroability of onion and garlic. The experiment was continued for the third year during rabi 2002-03. The results revealed that the application of either FYM or Vermi - compost or Poultry manure @ 5t/ha along with 50% RDF produced at par yield in comparison with the treatment receiving 100% RDF. Application of poultry manure @10t/ha along with 50% RDF produced significant increase in yield over recommended dose of fertilizer application in onion and garlic. The above treatment reduced the storage losses to 21% and 12% in onion and garlic, respectively when compared with RDF application. Application of organic manures along with reduced levels of chemical fertilizers improved the keeping quality of bulbs. The improvement in yield due to application of organic manures with reduced doses of NPK might have been due to improved nutrient use efficiency in above crops (Table 37).

Table 37 : Influence of organic manures and fertilizer levels on the yield, storage losses and nutrient content of onion and garlic

Treatment	Yield (t/ha)	Storage Losses (%)	N (%)	P (%)	K (%)	Yield (t/ha)	Storage Losses (%)	N (%)	P (%)	K (%)
RDF	42.06	58.17	3.12	0.30	3.01	9.70	31.67	3.51	0.33	3.18
50% RDF +FYM 10t/ha	44.80	37.43	3.18	0.33	2.90	10.60	21.00	3.23	0.33	3.16
50% RDF +VC 10t/ha	45.13	51.00	3.03	0.30	2.18	9.50	29.33	3.20	0.22	2.30
50% RDF +PM 5t/ha	45.46	28.67	2.93	0.31	2.53	9.43	21.07	2.81	0.29	3.06
50% RDF +PM 10t/ha	50.70	37.0	3.40	0.34	3.42	11.10	19.17	3.53	0.35	3.33
75% RDF +PM 10t/ha	53.80	40.13	3.53	0.36	3.66	11.30	24.00	3.72	0.38	3.66
CD (0.05)	05.62	1.94	0.20	0.03	0.15	0.49	3.54	0.27	0.02	0.23

FYM= Farmyard manure, VC: Vermi-compost and PM: Poultry manure

Experiment 2 Effect of potassium sources and levels on onion and garlic yield and storage quality

Potassium plays important role in the quality improvement of vegetables. Response to the application of higher doses of potassium to soils already having medium to high potash has been recorded. These observations provoked to conduct studies on the quality aspects of onion and garlic. Muriate of potash (MOP i.e. KCl) is the most common used potash fertilizer. Since, onion and garlic are sulphur loving crops the additional sulphur requirement cannot be met through complex fertilizers, Therefore, Sulphate of potash (SOP i.e. K2SO4) was tried in the study for third year during rabi 2002-03 to compare its effect with MOP and their levels on both the crops.

Potassium was applied in 3 levels i.e. 50, 75 and 100 Kg/ha through MOP and SOP. Each level was applied as whole (basal) or in one split (50% of level) 30 days after transplanting. The yield of onion and garlic increased with increasing the potassium levels due to either sources. The rate of increase in yield due to potassium levels was greater in SOP treatments than MOP. This might be due to the increased availability of sulphur along with potassium to the crops, as it is corroborated with the findings that the content of K and S in the bulbs was increased due to SOP (Table 38). Application of potassium significantly reduced the storage losses in both onion and garlic when compared with K0 (No K) treatment. The minimum storage losses in onion (24%) and garlic (20%) was recorded due to application of SOP @100Kg K/ha as basal and basal +1 split, respectively.

Table 38 : Effect of potassium and levels on the yield, storage quality and nutrient content of onion and garlic

Treatment	Onion (var. N-2-4-1)				Garlic (var. G-41)			
	Yield (t/ha)	Storage Losses	K (%)	S (%)	Yield (t/ha)	Storage Losses	K (%)	S (%)
K0	40.43	62.67	1.20	0.17	6.43	34.33	1.34	0.20
MOP 50 (b)	46.17	45.67	2.44	0.21	8.07	27.67	2.56	0.31
MOP 100 (b)	49.00	31.67	3.39	0.30	10.08	24.67	3.13	0.32
MOP 100 (1s)	46.50	35.00	3.52	0.30	8.13	27.67	3.46	0.33
SOP 50 (b)	48.23	35.33	3.37	0.40	9.48	26.33	2.73	0.37
SOP 75 (b)	50.37	31.33	3.07	0.47	10.28	25.00	2.87	0.50
SOP 100 (b)	51.60	24.00	3.44	0.54	10.58	24.33	3.34	0.56
CD (0.05)	3.39	4.04	0.27	0.03	1.12	1.18	0.11	0.03

Experiment 3 Effect of bio-fertilizers and nitrogen levels on onion & garlic

Free living nitrogen fixing bacteria play important role in nutrient management of non-legume crops. The study to evaluate the effect of Azospirillum and Azotobacter along with reduced doses of nitrogen on the yield and storability of onion and garlic was continued for the

third year during rabi 2002-03. It is evident from the results that increasing the level of nitrogen from 50% RDF to 100% RDF, the corresponding nitrogen content increased in both onion and garlic and thereby, the storage losses of bulbs also increased from 34.1% and 25.1% (N= 50% RDF) to 54.8% and 37.9% (N=100% RDF) in onion and garlic, respectively (Table 39). Further, the experimental results revealed that, application of Azospirillum @ 4kg/ha along with 50% recommended dose of nitrogen recorded significant minimum storage losses in onion (31%) over a period of six months. Similarly, in garlic, the minimum storage losses (29%) were also recorded.

Table 39 : Effect of bio-fertilizers and nitrogen level on the yield (t/ha) and storability of onion and garlic

	Onion (var. N-2-4-1)			Garlic (var. G-41)		
Treatment	Yield (t/ha)	Storage losses (%)	% N	Yield (t/ha)	Storage Losses (%)	% N
N0	29.25	28.19	1.30	5.44	24.53	1.39
N50	38.82	34.16	2.15	6.93	25.18	1.98
N75	42.34	44.91	2.51	7.63	35.94	2.26
N100	49.88	54.89	2.90	9.20	37.93	2.77
N50+ Azotobacter	39.44	32.43	2.29	7.93	31.71	2.21
N50+ Azospirillum	44.71	31.61	2.43	8.53	29.00	2.26
CD (0.05)	1.67	1.14	0.20	1.49	1.95	0.12

Experiment 4 Effect of sulphur levels on the yield, quality and storability of onion and garlic bulbs

In order to know the effect of sulphur on the yield, quality and storability of onion and garlic, the experiment was repeated for second year during late Kharif and rabi season in 2002-03. The results obtained were in accordance with the previous year, showing the response to increasing level of sulphur application (0, 15, 30, 45, 60 &75 Kg/ha). Yield of onion and garlic increased from 33 and 11t/ha due to only NPK to 39 and 13 t/ha respectively due to NPK + sulphur @ 75 Kg/ha (Table 40).

The sulphur application in S deficient soil might have increased the nutrient use efficiency of other major nutrients and as result of balanced nutrient application the yield might have increased. Reduction of storage losses to the extent of 12% in both onion and garlic was observed when 45 Kg sulphur was applied along with recommended NPK. In addition, significant increase in sulphur content of bulbs might have resulted into significant increase in quality components such as pyruvic acid and TSS of onion.

Table 40 : Effect of levels of sulphur on the yield, quality and storability of onion and garlic

Treatment	Onion (var. B-780)		Sulphur (%)	Pyruvic acid (umol/ml)	TSS (^{0}Brix)	Garlic (var. G-41)		Sulphur (%)
	Yield (t/ha)	Storage Losses (%)				Yield (t/ha)	Storage Losses (%)	
NPK	33.37	62.67	0.33	3.13	11.8	13.03	31.1	0.45
NPK+S15	34.47	55.33	0.38	3.40	11.9	13.23	29.3	0.51
NPK+S45	38.27	51.00	0.45	3.67	12.6	14.37	22.1	0.60
NPK+S75	39.10	53.33	0.53	4.27	13.2	14.57	23.3	0.89
CD (0.05)	1.71	4.54	0.07	0.39	0.46	1.32	1.74	0.09

Experiment 5 Effect of zinc treatment on the yield and shelf life of onion and garlic

The study on micronutrient application was initiated in the year 1999-2000. It was found that foliar application of micronutrients (Fe, Zn, Mn & Cu) had no significant effect on the yield of onion and garlic. This might be due to reason that the soil had these micronutrients in the sufficient range of availability. Further, response to micronutrient application on yield is observed only when the soil is deficient for them. However, as the application of zinc improved the shelf life of bulbs, this provoked to continue the study on different zinc treatments separately. The research results of rabi 2002-03 were in confirmation with findings of previous year. Various zinc treatments viz., basal application of zinc sulphate @ 20 and 40Kg/ha, soaking of seedling in solution of zinc sulphate, application of zinc sulphate along with vermicompost and foliar sprays of zinc sulphate @ 100 and 500 ppm had no effect on yield of bulbs. However, foliar sprays of zinc sulphate @ 500ppm at 30, 45 and 60 days after transplanting reduced the storage losses in onion to extent of 6 per cent when compared with only NPK treatment. In case of garlic, the reduction in storage loss was 13 per cent (Table 41).

Table 41 : Effect of Zinc application on the yield and storability of onion and garlic

Treatment	Onion (var. N-2-4-1)		Garlic (var. G-41)	
	Yield (t/ha)	Storage losses (%)	Yield (t/ha)	Storage losses (%)
NPK	40.33	53.60	10.13	36.75
NPK+spray1	37.00	49.26	9.67	25.26
NPK+spray2	38.83	47.94	9.03	23.48
CD (0.05)	NS	1.48	NS	1.69

Spray 1 : 100 ppm Zinc Sulphate at 30, 45 and 60 DAT
Spray 2 : 500 ppm Zinc Sulphate at 30, 45 and 60 DAT

V. CROP PROTECTION

MAIN PROJECT : INTEGRATED PEST MANAGEMENT IN ONION

Experiment 1 Effect of date of planting on thrips infestation during 2002

Onion is grown through out the year in Maharashtra. Therefore an appropriate date of transplanting of onion in relation to thrips infestation needs to be studied to obtain higher bulb yield. An experiment was conducted in RBD with 14 dates of planting covering all the three seasons. Seedlings were transplanted at 15 day interval from 1st June to15th December. Significantly higher numbers of thrips were found in a 1st December (58.52/plant) planting followed by 15th November (52.27/plant), 1st June (38.68/plant) and 15 th June (36.84/plant) plantings (Table 42). Lowest numbers of thrips were seen in 15 th August and 1st August with 5.24 and 5.85 thrips/plant respectively. Highest marketable yield was observed in 15 th September planting (45.89 t/ha) followed by 1st October and 1st September which recorded 41.92 and 41.14 t/ha respectively. The bulb yield in kharif season were very low because of severe rotting of bulbs. Total yield was highest in 1st October and 15 th September plantings.

Table 42 : Effect of date of planting on thrips infestation in onion during the year 2002

Date of planting	Thrips/plant	Marketable yield (t/ha)	Total yield (t/ha)
1 June	38.68 c*	1.81 i	7.80 hi
15 June	36.84 cd	2.79 i	3.54 j
1 July	22.65 ef	6.43 h	6.68 i
15 July	10.17 h	16.40 g	16.45 g
1 Aug	5.85 i	33.60 c	34.07 d
15 Aug	5.24 i	39.83 b	40.28 c
1 Sep	8.52 h	41.14 b	43.59 b
15 Sep	13.39 g	45.87 a	47.77 a
1 Oct	21.71 ef	41.92 b	43.14 b
15 Oct	24.1 e	32.90 c	34.09 d
1 Nov	34.22 d	19.32 f	25.11 f
1 Dec	58.52 a	22.82 d	28.03 e
15 Dec	20.88 f	19.82 ef	10.1 h

* means with same alphabet does not differ significantly. DMRT (0.05)

Experiment 2 Barrier cropping for the management of onion thrips

Thrips are weak fliers and are carried by wind very easily from one field to the other. Blocking of thrips movement through some barriers may reduce the thrips population. In this connection three kinds of barriers were employed to study their blocking efficiency.

Lowest numbers of nymphs (6.5/plant) were recorded in the barrier with outer row of maize and inner row of wheat (MW) and 2 rows of maize (2M) (6.67/plant) compared to control (22.24/plant) (Table 43). Similarly, lowest numbers of adults were found in 2M and MW. 2M blocked adult thrips to 71.1% whereas MW blocked 68.55% of adult thrips (Table 44). However the bulb yield was low in 2M compared to control (NB) (Table 45).

Table 43 : Thrips population under different barrier crops

Average number/plant	Nymphs per plant			
	2W	MW	2M	NB
Nymphs	16.94 ± 6.39	6.50 ± 2.83	6.67 ± 2.83	22.24 ± 11.08
Adults	3.44 ±1.15	2.27 ± 0.95	1.94 ± 0.71	6.26 ± 1.87

Table 44 : Blocking efficiency of different barrier crops against thrips in onion during rabi, 2002

	% blocking of adult thrips		
	2W	MW	2M
Mean ± S.E.	41.61± 6.75	68.55 ± 3.68	71.10 ± 3.14

Table 45 : Bulb yield (t/ha) under different barrier crops

Yield (t/ha)	Barrier crop			
	2W	MW	2M	NB
Marketable	23.92	23.13	19.1	22.83
Total	28.9	25.97	20.9	27.82

Experiment 3 Management of thrips based on critical growth stages of onion

Thrips attack onion at all the stages of the crop growth. It is important to identify the critical stages in onion with respect to thrips so that suitable control measures could be taken during that period, thereby, minimizing the pesticide load as well as frequency of application.

Higher CB ratios were realized when plant protection measures were taken during bulbing stage. Highest CB ratio (1:5.14) was obtained when 2 sprays were done at 60 and 75 DAP followed by sprays at 45 and 60 DAP (1:4.25) and 45, 60 and 75 DAP (1:3.43). The study suggested that the insecticide load on onion could be considerably decreased if plant protection measures were taken during bulbing stage (45-75 DAP) of onion crop.

Experiment 4 Combined effect of neem and insecticides against thrips in onion

Present pest management in onion is chemo-intensive. To bring down the pesticide usage in onion a trial was conducted in rabi season to evaluate the efficacy of neem, insecticides like, profenofos, acephate, cypermethrin applied alone as well as combined application of neem with above insecticides.

Overall efficacies of profenofos applied in combination with neem both at half the doses (3.70 thrips/plant) and when applied alone (4.68 thrips/plant) were found significantly superior over other treatments. Significantly higher marketable yield was recorded in plots sprayed with Profenofos + neem, profenofos alone which recorded 42.2 and 41.75 t/ha compared to 27.56 t/ha in control. However, highest total yield was observed in profenofos; Profenofos + neem; carbosulfan and acephate when compared with control that recorded 29.63t/ha.

Experiment 5 Evaluation of some insect pathogens against thrips in onion

Many insect pathogens were reported effective against different sucking pests in field and laboratory. In this direction, insect pathogen formulations namely, Verticilium lecani, Beauveria bassiana, Paecilomyces at different doses along with insecticide carbosulfan as check were evaluated in the field during rabi season for the control of thrips.

All the treatments were found significantly superior over control. However all the insect pathogens at both the doses did not differ significantly among themselves and were inferior to carbosulfan sprays. Higher marketable yield was obtained with the carbosulfan sprays (42.06 t/ha).

SUB-PROJECT : SCREENING ONION AND GARLIC GERMPLASM FOR RESISTANCE TO THRIPS AND ERIOPHYID MITES

Experiment 1 Screening onion germplasm for resistance to thrips

Host plant resistance is relatively safe and ecologically safer. In onion and garlic no promising resistant variety to thrips is available at present. A large number of germplasm lines of onion and garlic were screened.

During kharif : 259 lines of onion that include 245 white and 14 red were screened. High incidence of thrips occurred at the early stage of the crop resulting in curling and twisting of plants. Later on, thrips population decreased and plants recovered from the damage. As a result sufficient leaf injury was not noticed on plants. The lines were screened based on Leaf Curl Rating (LCR) only.

Based on the LCR, the entries viz., W040, W259, W100 and W225 recorded the lowest rating (<2). Among white onion, 25 lines recorded significantly superior marketable yield and 179 lines on par with check variety Phule safed. With regard to total yield, 2 lines were found superior and 13 lines at par with P. Safed. Among red onion, no line was found superior over check B-780 in respect of marketable yield, but 8 lines were at par. However, in case of total yield 2 lines namely W069 and W408 were found significantly superior over B-780.

During rabi : Around 293 lines of red (102) and white (191) onion lines were screened for thrips resistance. Thrips attack was severe during initial stages of the crop and as a result many lines of onion were died. Around 23 lines of white and 58 lines of red onion recorded >70% survival. These lines will be screened further for thrips resistance.

Experiment 2 Screening of garlic germplasm for eriophyid mite resistance

42 lines of garlic that were found resistant to eriophyid mite in earlier trials, were confirmed resistant during rabi 2002. All the 42 lines recorded <1 rating on a 0-4 scale. The susceptible check G-50 recorded a rating of 4.

VI. POST HARVEST TECHNOLOGY
MAIN PROJECT : POST HARVEST STUDIES IN ONION

Preamble : Onion is one of the most important vegetable crops grown in almost all over the country. India annually produces an average of 44.28 lakh tones of onion on an area of 4.09 lakh hectare. The crop has the export value, around 10% of the total production is exported to different countries. The major onion producing states are Maharashtra, Tamil Nadu, Gujarat, Bihar, A.P. and Karnataka. Onion is an essential part of our traditional daily diet. This creates a relatively constant year round demand of onion. Although onions are grown almost all round the year in our country, major produce comes from rabi season crop. Thus it becomes necessary to store the produce to make it available in the lean period. The storage losses in onion are very high as compared to other crops. It has been estimated that 40 to 50 per cent of the production never reaches to consumer due to post harvest losses. These losses are weight losses (20-25%), losses due to sprouting (8-10%) and losses due to decay (10-12%). The storage life of the onion is considerably affected by the choice of cultivars, agronomic practices, harvesting time, curing techniques and storage conditions etc. The post harvest losses in onion are very high and there is an urgent need to develop a package of post harvest handling and storage to reduce the losses.

Experiment 1 Assessment of storage losses:

1.1 Seasonal variation

1.1.1 Late Kharif

Onion cv. Baswant-780 produced during late kharif season was stored to assess the storage losses during February to June 02 .The total losses after 150 days of storage were 76.1%. The weight loss during 90 to 105 days was highest. As far as sprouting is concerned it was only 5.5% up to 135 days but it steeply increased to16.4% in next 15 days.

1.1.2 Rabi

Onion cv. N-2-4-1 produced during rabi season was stored to assess the storage losses during May to Dec.02 .The physiological loss of weight after 150 days of storage was 36.47%. Rotting and sprouting during above period was 3.62% and 6.82 %, respectively. The percentage of

bulbs affected by black mould were very high as shade curing could not be performed effectively due to rains during harvesting period.

1.1.3 Kharif

Onion cv. Baswant -780 produced in Kharif season was stored under ambients condition to assess the storage loss during Oct.-Dec.02.The losses due to physiological weight loss after 90 days of storage were highest during this season followed by sprouting. This is probably due to physiological immaturity of bulbs and lack of proper curing during the kharif season.

1.1.4 Evaluation of onion samples collected from farmers field during late Kharif

The onion samples were collected from various farmers of Pune districts during February 2002 to study their storage behaviour. The PLW, Rotting, Sprouting was significantly lower in sample collected from Nimgaon. The sprouting losses in all samples were significantly lower than onion cv. B-780 after 4 month of storage (Table46).

Table 46 : Storage losses (%) in late Kharif onions collected from farmers field

Source	Storage losses(%)		
	PLW	Rot	Sprout
B-780	27.35	14.4	11.7
Bhose-I	29.07	15.71	1.65
Kharpudi-II	25.99	13.24	1.52
Nimgaon-I	25.52	8.94	2.14

1.2 Effect of neck length of bulb

Bulbs of onion cv. N-2-4-1 having different neck length i.e., 0 cm, < 2cm, 2-3 cm and intact leaves were stored for 7 months under ambient conditions. The results of the experiment reveal that there was no effect of neck length on physiological weight loss and black mould. The rotting and sprouting was less in intact leaves treatment.

1.3 Effect of bulb size and neck thickness

Onion bulbs cv.N-2-4-1 were graded according to size and neck thickness and stored for four months to study the storage losses. No significant difference was found in different sizes and neck thickness of onion with respect storage losses.

Experiment 2 Effect of pre harvest treatments

2.1 Late Kharif

Various concentrations of Lihocil, MH-40 Gramaxone, Glyphosate,Goal and. Atrazine. etc. were sprayed during late kharif season to kill the foliage and to induce forced ripening. The gramaxone concentrations killed all the foliage within 72 hours of the spray while glyphosate treatments showed slight yellowing of the leaves. The gramaxone sprays caused heavy rotting in the storage and the losses were up to 100%. The different combinations of gramaxone and MH40 were also sprayed in combinations at 15 days before harvesting but these combinations failed to reduce the storage losses caused by gramaxone.

2.2 Rabi

Various chemicals, growth regulators, fungicides, phenols, amino acids such as ethrel, carbaryl, TIBA, bavistin ,Paclobutrazol ,Trichoderma, sulphate, salicyclic acid, sodium piruvate, phenols,glycine and MH 40 were applied as pre harvest sprays to study their effect on storage losses in onion cv. N-2-4-1. None of these chemicals were found effective in reducing the losses . The higher concentrations of paclobutrazol showed reduction in sprouting during storage.

Experiment 3 Effect of curing treatments

Various curing methods such as curing under various types of polyethylene tunnels, curing in pits and conventional method were tried during rabi season. The curing in polyethylene tunnel having one end open was found significant in reducing rotting.

Experiment 4 Description of the onion storage structures designed and constructed at NRCOG

Various types of onion storage structures were constructed during last year at NRCOG. These structures are either bottom ventilated or without ventilation. These structures are constructed keeping in view all type of farmers' i.e. small, marginal and big farmers /traders. Various types of roofing materials were used for these structures depending on cost of construction and life span. The details of the dimensions, capacity and various types of material used are given in Table 47.

Table 47 : Details of onion storage structures designed and constructed at NRCO&G, Rajgurunagar

Particulars	Tradition double row storage structure with asbestos roofing	Modified bottom ventilated double row storage structure with asbestos roofing	Mud plastered Top and bottom ventilated storage structure with asbestos roofing	Bottom Ventilated storage structure with asbestos roof and chain links on sides	Bottom ventilated single row storage structure with Mangalore tile roofing	Tradition single row structure with Mangalore tile roofing	Bottom ventilated low cost thatched roof storage structure
Storage capacity (By weight tones)	38(Excluding gangway)	42(Excluding gangway)	31(Excluding gangway)	25(Excluding gangway)	5	5	5
Expected life (years)	20	20	20	20	20	20	5
Cost of storage (Rs. /Kg)	7.50	4.5	5.96	5.0	8.0	7.0	1.0
Cost of storage (Rs. /Kg/year)	0.38	0.23	0.30	0.25	0.40	0.35	0.20
Construction material							
Roof	Asbestos	Asbestos	Asbestos	Asbestos	Mangalore tiles	Mangalore tiles	Sugarcane leaves/ thatch
Side wall	Wooden bantam	Wooden bantam	Split bamboo plastered with mud	Chain link	Split Bamboo	Split Bamboo	Split Bamboo
Floor	PCC	Wooden bantam with C channel support	Wooden bantam with C channel support	Wooden bantam with C channel support	Split bamboo bantam with C channel support	PCC	Split bamboo bantam
Bottom Ventilation gap	NO	75cm	75cm	75cm	75cm	NO	25cm

Experiment 5 Performance of onion storage structures

5.1 Late Kharif

Three-onion storage structures i.e. Bottom Ventilated Storage structure with Asbestos Roof and chain links on sides, Mud plastered Top and bottom ventilated storages structure with asbestos roof, Modified bottom ventilated double row storage structure with asbestos roofing were evaluated for their performance for the storage of late kharif onion during Feb to June 02.The results show that the mud plastered top and bottom ventilated storage structures showed lower physiological weight losses (19.09%) as compared to others while the rotting losses were lower in modified bottom ventilated storage structure(1.29 %), whereas the sprouting was highest in Bottom Ventilated Storage structure with Asbestos roof and chain links on sides(25.44 %).The black mould infection was higher (8.01%) in Mud plastered top and bottom ventilated storage structure with asbestos roof. The highest weight loss and lower rotting in modified bottom ventilated double row storage structure with asbestos roofing may be attributed to more aeration. Overall, the mud plastered top and bottom ventilated storage structure was found better over others.

5.2 Rabi

Among the double row type of onion storage structures, bottom cum top ventilated mud plastered was found more efficient in reducing physiological loss of weight (PLW) and rotting as compared to modified bottom ventilated storage structure. The highest weight loss was in traditional double row storage structure (33.69 %) and bottom ventilated storage structure with asbestos roof and chain links on sides (34.4 %). while the lowest weight loss was recorded in mud plastered top and bottom ventilated storage structure with asbestos roof (14.7 %)followed by low cost bottom ventilated structure (21.9 %). The rotting was highest in traditional double row storage structure (28.8 %) while sprouting was highest (8.4 %) in bottom ventilated storage structure with asbestos roof and chain links on sides In general the storage losses were lowest in mud plastered top and bottom ventilated storage structure with asbestos roof and highest in traditional type of storage structure. Among single row type storage structures, low cost thatched roof structure was found better over bottom ventilated Mangalore tiled storage structure and traditional Mangalore tiled storage structure.

Experiment 6 Economics of storage structures

6.1 Late Kharif

The Benefit: cost ratio of onion storage from February to June in different onion storage structures reveal that the net profit was highest Rs.875/ton in mud plastered top and bottom ventilated storage structure. While the net profit was Rs.674/ton in modified bottom ventilated onion storage structure and Rs.579/ton in bottom ventilated storage structure with asbestos roof

and chain links on sides. Thus mud plastered top and bottom ventilated onion storage structure was found more profitable than others.

6.2 Rabi

The Benefit: cost ratio of onion storage from May to September in different onion storage structures reveals that among the double row storage structures, net profit was highest (Rs 1739/ton) in mud plastered top and bottom ventilated storage structure with asbestos roof while the net profit in modified bottom ventilated storage structure and traditional onion storage structure was Rs 968/ton and Rs 211/ton, respectively. Among the single row storage structure, the low cost bottom ventilated storage structure gave highest net profit of Rs. 1542 per ton. The net profit in bottom ventilated single row storage structure having mangalore tiles was Rs. 814/ton, which was almost double than the net profit (Rs.372/ton) of traditional single row storage structure having mangalore tiles. Overall, the mud plastered bottom ventilated storage structure and low cost bottom ventilated storage structure were found profitable than the others.

Experiment 7 Effect of packaging material

The bulbs of onion cv. N-2-4-1 were packed in different packing materials i.e. staking, hessian cloth bags, netlon bags and plastic crates from May to September 02 and observations of various types of losses were recorded. The results reveal that PLW was more in crates but rotting was more in staking and Hessian cloth bags .

Experiment 8 Performance of onion grader

8.1 Capacity

The results of the testing of onion grader reveal that it can grade 1.0 tone per hour. Two persons are required to perform grading. The efficacy of the grader may vary from person to person but to get a required capacity the grader should run at an average speed of 50-60 rpm. The performance of the grader was tested with two onion varieties i.e. Baswant-780 and N-2-4-1. The results revealed that the grader works efficiently with both type of varieties. The range difference was only1.8 % in A grade when onion cv. N-2-4-1 was graded with grader in 10 replications while range difference in manual grading was 21.4 % in 10 replication. Similarly the range difference for B grade bulbs was 9.8% in grader and 35% in manual grading. Similar results were obtained with onion cv. Baswant-780.

8.2 Precision

The difference between repeated grading by grader was very less as compared to manual grading. The accuracy of grading was 95 to98% as compared to 75 to 80 % in manual grading. The machine was also able to found different grades in manually graded onions When the manually

graded A grade onion was passed through the grader it was found that it contained only 27.31 % A grade and remaining were 62.73%B grade and 6.31% C grade onions. Similarly B grade contained 70.3% B grades and 30.65 % C grade onions. In C grade onion there were16.91% B grade onions. Almost similar results were obtained from onion cv. Baswant 780.

8.3 Economics

The comprehensive production cost of the gadget as per the specifications should be around Rs. 15,000/-. The working life of grader should be at least ten years. During main harvesting season assuming 60 working days, the grader can grade 500 tonnes annually. The calculation of interest on capital, depreciation and labour charges for running the grader reveals that the grading charges would be around Rs. 26/ton as compared to Rs. 80/ton in manual grading (Table 48).

Table 48 : Comparison of cost of manual and machine grading (in Rs.)

Sl.No	Description	Onion grader	Manual grading
1	Cost of onion grader	15,000.00	-
2	Working life	10 years	-
3	Annual average grading (Tonnes)	500	500
Annual cost			
1	Interest on Capital@5%	750.00	0.0
2	Depreciation	1500.00	0.0
3	Repair and Maintenance	750.00	0.0
Operating cost			
1	Labour charges (Rs./ Ton)	20.00	80.00
Total cost (If grading 500 tonnes /year)		13,000.00	40,000.00
Cost of grading (Rs./tonnes)		26.00	80.00

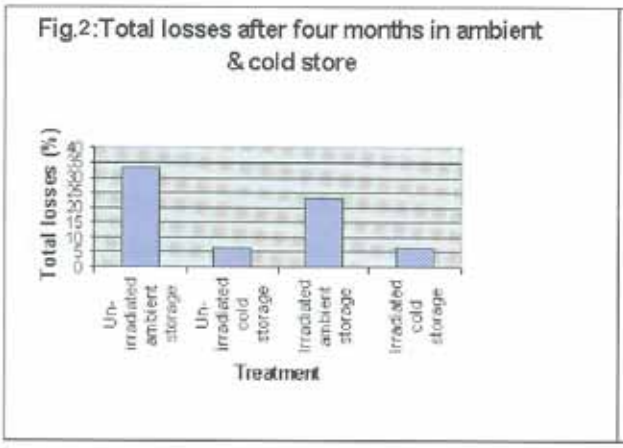
Experiment 9 Studies of morphological and biochemical changes during growth, development and storage

Studies on morphological changes in onion reveals that rapid weight increase in rabi onion cv. N-2-4-1 starts after 9 week of transplanting when the increase in plant height almost stops. The weight increase in bulbs corresponds to equatorial and polar diameter of bulbs. The neck thickness of the bulbs increased initially but decreased at the time of maturity. The total soluble solids in the bulbs increased continuously up to harvesting but the pyruvic acid content increased up to 105 days but decreased at the time of maturity. The pattern of bulb growth in kharif onion cv. Baswant 780 was similar to rabi season variety but the bulb initiation in kharif variety started after two week .The weight of bulb and diameter was also less in kharif season. The kharif season bulbs have thicker neck as compare to rabi season variety. Further the total soluble solids and pyruvic acid was also lower in kharif season crop.

MAJOR PROJECT : COMPARISON OF CHEMICAL SPROUT SUPPRESSANT AND IRRADIATION ON STORAGE LIFE OF ONION UNDER DIFFERENT STORAGE CONDITIONS (CENTRAL SECTOR SCHEME)

Preamble : A large quantity of onion is stored under ambient conditions during June to October to fulfill the demand of this period. There is no control of humidity and temperature. Under such conditions, the storage losses are up to 50 per cent. Among them, the physiological loss in weight and sprouting contributes 20-25 and 10-12 per cent respectively, while 10-12 per cent losses are due to rotting. There are several factors such as varietal response, cultural practices, high temperature and high humidity during storage, etc. which affect its storability. The low temperature storage provides considerable decrease of weight loss and rotting. But low temperature stored onion show very high incidence of sprouting after taking out of cold store. The irradiation of onion has reported to reduce sprouting in onions.

An experiment was undertaken to study the effect of -irradiation (60 gy dose from cobalt-60 source) and low temperature storage (0-20C and 65-70% respectively) on post harvest losses The results reveal that total losses in cold stored onions at the time of taking out were only 6.41 per cent as compared to 33.35 and 22.87 per cent in un-irradiated and irradiated onions stored under bottom ventilated storage structure, respectively. As far as the post cold storage behaviour is concerned; the total losses after one-month room temperature storage were high in un-irradiated cold stored onions (57.58%) followed by un-irradiated ambient-stored onions (52.3%), while lowest losses were recorded in irradiated cold-stored onion (23.65%). The total losses after four months of taking out from cold store were only 50.3 per cent in irradiated cold stored onion as compared to 87.12 per cent in un-irradiated ambient-stored onions (Fig2 and 3).



VII. EDUCATION AND TRAINING

Lectures / Talks

Dr. K.E. Lawande delivered lecture on

- 'Onion and Garlic Production, Problems and Management' at Manchar organized by Deepak Fertilizers & Petrochemicals Ltd., Pune on 6th January 2003.
- 'Onion and Garlic' at Ahmednagar Sahakar Sabhagriha organized by Ahmadnagar Onion Growers Society on 24th January 2003.
- 'Onion and Garlic' in farmers rally at Pimpalgaon Baswant (Nashik) organized by Nirmal Seeds Pvt. Ltd., Pachora, Dist. Jalgaon on 12th April 2003.
- 'Onion and Garlic Cultivation, Problems and Management' at Pune organized by Jansewa Foundation, Pune on 28th April 2003.
- 'Research Activities in Onion and Garlic of NRCOG' at NRCOG, Rajgurunagar organized by MBAMB, Pune on 30th June 2003.
- 'Onion and Garlic Production and Management' organized by Jansewa Foundation, Pune at Village Baripada, District Dhulia on 22nd October 2003.

Dr. V. Mahajan delivered lecture on

- 'Onion & Potato cultivation and problems' organized by Ambegaon Taluka Shetmal Prakriya Sahakari Sanstha Maryadit, Manchar and IFFCO, Pune at Manchar on 11th June 2003.
- 'Kanda Lagwad' organised by MPKV, College of Agriculture, Pune for RAWE students at vill. Kelgaon on 9th September, 2002.
- 'Rabi hangamatil peek niyojan' organised by Shri Bhairavnath Sahakari Pani Watap Sanasthan, Pune, Ganhians group at village Kadus on 2nd Oct., 2002.
- 'Kanda va lasoon utpadan tantra' organised by Pune District Sahakari Board Ltd., during Akhil bhartiya sahakari saptah at Rajgurunagar on 16th Nov., 2002.
- 'Onion production technology' at Agri. Training centre, khapoli to the extension officers of the Maharshtra State at Khapoli on 26th Nov., 2002.

TRANSFER OF TECHNOLOGY

- NRCOG organized three-day farmers training programme under Central Sector Scheme of NHRDF, Nashik from 26.12.2002 to 28.12.2002.

PARTICIPATION IN EXHIBITIONS

NRCOG participated in Agri-Exhibition at

- Bhimashankar organized by Deptt. of Agriculture, Pune from 28th February 1st March 2003.
- Lasalgaon organized by NHRDF, Nashik from 22-23rd March 2003.
- Captain Shivrampant Damle Sports Ground, Pune organized by SDAO, Rajgurunagar on 6th April 2003.
- Vishal Junnar Nagar Dyaneshwar Grammonnati Mandal High School Ground, Aale, Tal. Junnar, Dist. Pune organized by Vishal Junnar Sahakari Patpedhi Maryadit, Mumbai and Srijan Marketing, Sinnar from 12-14th April 2003.
- Ganesh Kala Krida Manch, Pune organized by Global Exhibitors, Pune from 10-13th October 2002.
- Rahuri organized by MPKV, Rahuri on 21st December 2002.

VIII. PUBLICATIONS/PRESENTATION

Sankar, V., K. E. Lawande, A. Khar and Asha Devi. 2001. Evaluation of onion varieties during late kharif season under different dates of planting. Allium Improvement Newsletter. vol. 11

Sankar, V., A. Khar, Asha Devi, V. Mahajan and K.E.Lawande. 2002. Evaluation of exotic hybrids for storage quality during Rabi season. Allium Improvement Newsletter. vol. 11

Srinivas, P.S. and K.E. Lawande. Barrier cropping a new method for management of thrips in onion. Paper presented in International Conference on Vegetable Crops at Bangalore from 11-14th November 2002. pp. 301-303

Srinivas, P.S., Mahajan V., Anil Khar and K.E. Lawande. Reaction of onion germplasm to thrips during Rangda (late kharif). Ibid. pp. 34.

Chandra Prakash, M.K., K.E. Lawande and V. Sankar. Market Information System for onion and garlic. Ibid.pp

Sankar, V., A. Aziz Qureshi, P.C. Tripathi and K.E. Lawande. Studies on onion based cropping system. Ibid. pp 177.

Khar, A., Asha Devi, Vijay Mahajan and K.E. Lawande. Evaluation of indigenous collection of tropical onion (Allium cepa L.) germplasm. Ibid. Pp 16.

Khar, A., Asha Devi, Vijay Mahajan, K.E. Lawande and S.B. Kadam. Evaluation of exotic onion hybrids during late kharif. Ibid. Pp 53.

Asha Devi, Anil Khar, S.K. Chakrabarthy, D. Pattanayak and K.E. Lawande. Preliminary studies on Random Amplified Polymorphic DNA (RAPD) markers for genetic analysis of tropical and

temperate onion varieties/hybrids. Ibid. Pp148

Mahajan, V., K.E. Lawande, P.C. Tripathi, Asha Devi and Anil Khar. Reduction in breeding cycle of rabi onion by producing seeds during kharif. Ibid. Pp 224.

Mahajan, V., A. Khar, Asha Devi and K.E. Lawande. Evaluation of white onion germplasm during kharif. Ibid. Pp14.

Mahajan, V., K.E. Lawande, Asha Devi, Anil Khar and S.B. Kadam. Performance of indigenous white onion germplasm during late kharif (Rangda). Ibid. Pp14.

Tripathi, P.C., S.S. Dhumal, V. Sankar, A.A. Qureshi, V. Mahajan and K.E. Lawande. Survey of onion storage structures in Maharashtra. Ibid. Pp 288.

Lawande , K.E. 2003. Potential for export and value addition in onion and garlic. In 'Regional Agrowealth : Opportunities for Value Addition and Exports' BARC, Mumbai, 28-29th March 2003.

POPULAR ARTICLES

Sankar V., Qureshi A.A., Tripathi, P.C. and K.E. Lawande. Drip Irrigation in Garlic. Spice India, April 2002.

Lawande, K.E., Vijay Mahajan, S.B. Kadam and S.S. Dhumal. Kandhyanche Sudharit Padhatine Sathwanuk. Shetkari, April 2002, 17.

Tripathi, P.C., Sankar V. and K.E. Lawande. Agrifound Parvati A high yielding garlic variety for hills. Spice India. May 2002.

V. Sankar, V. Mahajan and K.E. Lawande. Improved Varieties of Garlic. Spice India, August 2002, pp.19-20.

K.E. Lawande. Niryatsham Kanda Utpadan. Shetkari Masik, October 2002, pp.9-12.

Mahajan,V. Niryatshyamya Lasoon Utpadan. Shetakari Masik, October, 2002, pp 23-26 & 29.

K..E. Lawande. Jagatik Spardhesathi Darja Avashyak. Sakal, 24th January 2003, p 8.

INSTITUTIONAL ACTIVITIES

MoU signed

- The marketing right of the hand operated 'Onion Grader' developed by NRCOG were given to M/s. Pune District Onion Growers Cooperative Purchase & Sale Society Limited, Pune. A MoU was signed on 5th April 2003.

IX. INSTITUTIONAL MEETINGS

- Sixth SRC meeting was conducted from 19-21st March 2003 under chairmanship of Dr. K.E. Lawande, Director, NRCOG. Scientists presented progress of work and future programme, which were thoroughly discussed.
- QRT final meeting of NRCOG from 20-21st May 2002 at this Centre under the chairmanship of Dr. M.R. Thakur, Ex-Vice Chancellor, Dr. Y.S. Parmar University of Horticulture & Forestry, Solan. The member were Dr. H.S. Gill, Ex-Head, Division of Vegetable Crops, Dr. Narendra Singh, Ex-Head, Division of Vegetable Crops, IARI, New Delhi, Dr. C.D. Mayee, Director, CICR, Nagpur, Dr. B.B. Lal Kaushal, Professor and Head, Dr. Y.S. Parmar University of Horticulture & Forestry, Solan and Dr. U.B. Pandey, Director, NHRDF, Nashik and Member Secretary, QRT. The team reviewed ongoing work and expressed full satisfaction about the progress made by the Centre and suggested measures for further strengthening of NRCOG.
- Fifth SRC meeting was conducted on 12-14th June 2002 under chairmanship of Dr. K.E. Lawande, Director, NRCOG. Scientists presented progress of their work and future programme, which were thoroughly discussed.

- Fifth RAC meeting was held on 17th June 2002. Dr. Vishnu Swarup, Director, Indo-American Hybrid Seeds, New Delhi chaired the meeting. The members were Dr. B.S. Dhankhar, ADG (VC), ICAR, New Delhi, Dr. K.E. Lawande, Director, NRCOG, Rajgurunagar, Dr. O.P. Dutta, Ex-Head, Dept. of Vegetable Crops, IIHR, Bangalore, Dr. S.S. Kadam, Head, Dept. of Biotechnology, MPKV, Rahuri, Dr. S.H. Shinde, Dean, College of Agriculture, Kolhapur, Dr. S.J. Singh, Head, IARI Regional Station, Pune, Prof. R.P. Singh, Nalanda (Bihar), Mr. Dhananjaya Kumar, Patna and Dr. V. Mahajan, Sr. Scientist & Member Secretary. All the scientists presented their findings and the programmes were critically discussed. The committee appreciated the concerned efforts of the scientists and gave appropriate suggestions for future research programmes.
- Fifth IMC meeting was held on 18th June 2002 under the chairmanship of Dr. K.E. Lawande, Director, NRCOG. The committee reviewed and approved the agenda items accordingly.

HINDI PAKHAWARA

The centre organised three days farmers training programme in Hindi sponsored by the Department of Horticulture, Government of Madhya Pradesh from 26.12.02 to 28.12.02. Around 50 farmers from Madhya Pradesh were trained on improved varieties, production, protection, post harvest handling and marketing of onion and garlic through audio-visuals and field visits.

Our New Colleague

Dr. V.S.R. Krishnaprasad joined this centre as Principal Scientist (Horticulture) on 27th March, 2003. Prior to this, he worked for two decades in IIHR, Bangalore and its regional station at Central Horticultural Experiment Station (IIHR) Ranchi. He has the credit of developing 16 improved varieties/hybrids in vegetables such as pointed gourd, cucumber, ridge gourd, brinjal, tomato and French Bean. Out of these, the Central variety release committee and state variety release of Bihar and Jharkhand has identified 8 varieties each. He has published 152 research papers in various national and international journals. He is working on the improvement of red and light red onion

X. PERSONNEL

Staff Postion

S. No.	Category	Sanctioned Post	Filled	Vacant
1	RMP	01	01	00
2	Scientific	10	08	02
3	Technical	08	07 + 01*	01
4	Administrative	09	07+01*	02
5	Supporting	07	07	00
	Total	35	30+02*	05

* The above category-wise posts tranferred along with post from DWMR, Patna

Name	Designation
Dr. K. E. Lawande	Director
Dr. V. S. R. Krishnaprasad	Pr. Scientist (Horticulture)
Dr. P. C. Tripathi	Sr. Scientist (Horticulture)
Dr. V. Mahajan	Sr. Scientist (Horticulture)
Dr. A. A. Qureshi	Scientist (Soil Science)
Ms. Asha Devi, A.	Scientist (Genetics)
Dr. Anil Khar	Scientist (Horticulture)
Dr. P. S. Srinivas	Scientist (Entomology)
Mr. V. Sankar	Scientist (Horticulture)
Mr. M.K. Chandraprakash	Scientist (Computer Application)
Mr. N. Gopal	Assistant Administrative Officer
Mrs. S. S. Joshi	Assistant
Mr. V. V. Patil	Technical Officer (T-5)
Mr. D. B. Mundharikar	PA to Director
Mr. N. L. Gore	T-4 Tech. Asstt. (Field/Farm)
Mr. A. P. Trivedi	T-4 Tech. Asstt. (Field/Farm)
Mr. H.S.C. Shaikh	T-4 (Computer Programmer)
Mr. S. P. Kandwal	Sr. Clerk
Mr. P. S. Tanwar	Sr. Clerk
Mrs. M. S. Salve	Sr. Clerk
Mrs. N. R. Gaikwad	Hindi Typist
Mr. R. K. Dedge	Jr. Clerk
Mr. D. M. Panchal	T-2 Tech. Asstt. (Field/Farm)
Mr. R. B. Baria	T-2 Tech. Asstt. (Field/Farm)
Mr. B. A. Dahale	T-2 Tractor Driver
Mr. S. P. Yeole	T-2 Jeep Driver
Mr. S. K. Said	S. S. Gr. III (Beldar)
Mr. P. R. Sonawane	S. S. Gr. II (Lab Attendent)
Mr. P. E. Tadge	S. S. Gr. II (Lab Attendent)
Mr. M. S. Kale	S. S. Gr. II (Lab Attendent)
Mr. R. S. Kulkarni	S. S. Gr. I (Lab Attendent)
Mr. S. D. Waghmare	S. S. Gr. I (Watchman)
Mr. N. H. Sheikh	S. S. Gr. I (Messenger)

XI. DISTINGUISHED GUESTS

Mr Ben Wright, Mr. Visut Chompradit	Seminis Woodland, USA	07.04.2003
Dr. R. N. Pal	Ex. DDG (Hort.), ICAR	30.04.2003
Dr. M. Mahadevappa	Chairman,ASRB, New Delhi	15.05.2002
Dr. Vishnu Swarup	Director, Indo-American Hybrid Seeds	17.06.2002
Lt. Gen. R.S. Nagar,	Director General of Artillery Army Headquarters, New Delhi	15.11.2002
Dr. Tsou, Samson. C.S.	Director-General AVRDC, Taiwan	17.11.2002
Dr. S. Shanmugasundaram	AVRDC, Taiwan	17.11.2002

Total number of farmers visited - 2500

XII. BUDGET

Financial Statement for the Year 2002-2003

Head of Accounts	Rupees in Lakhs	
	Budget Grant	Expenditure
Non-Plan	65.00	50.80
Plan	88.25	84.71
KVK	NIL	NIL
NATP	25.70	22.32
AP Cess Fund Schemes	NIL	NIL
Pension & Retirement benefits	9.41	9.40
"P" Loans & Advances	8.10	0.95
"R" Deposit Schemes	3.46	1.24
Revolving Fund Scheme	8.46	6.35
Total	208.38	175.77
Revenue Receipt	3.50	-

XIII. ANNEXURE 1

Meteorological data for the year 2002-03 at NRC for Onion and Garlic, Rajgurunagar

Month	Average				Total Rain Fall (mm)	Average Sunshine (Hr day^{-1})
	Max. Temp (^{0}C)	Min. Temp (^{0}C)	Max. RH (%)	Min. RH (%)		
Apr 2002	38.0	19.0	69	21	32.5	8.37
May 2002	37.1	23.1	70	34	8.5	9.20
Jun 2002	28.7	21.4	80	60	256.7	4.05
Jul 2002	28.9	22.0	83	68	30.0	3.15
Aug 2002	27.3	20.0	85	91	115.2	2.12
Sept 2002	29.7	19.3	89	58	80.5	4.30
Oct 2002	34.0	17.9	83	35	0	7.26
Nov 2002	30.2	10.9	62	31	1.0	9.23
Dec 2002	30.5	11.6	77	36	0	8.43
Jan 2003	29.2	12.1	77	39	4.0	8.02
Feb 2003	28.0	11.3	63	20	0	9.47
Mar 2003	35.7	14.3	66	20	0	10.14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