EFFECT OF SET-PLANTING ON *KHARIF* ONION (*Allium cepa* L.) BULB-PRODUCTION CV. BASWANT-780 AND S-1 (PHULE SAMARTH)

By

Miss. Hemlata Vilas Yevale
(Reg. No.02114)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARASHTRA, INDIA

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

HORTICULTURE

DEPARTMENT OF HORTICULTURE

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
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2004

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

(Hemlata V. Yevale)

Place : MPKV, Rahuri

Dated : 28 / 6 /2004.

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Professor of Horticulture,
Department of Horticulture,
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Maharashtra State (INDIA)

CERTIFICATE

This is to certify that the thesis entitled, "**Effect of set-planting on *kharif* onion (*Allium cepa* L.) bulb-production cv. Baswant-780 and S-1 (Phule Samarth)**", submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri for the award of the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **HORTICULTURE**, embodies the results of a *bona fide* research carried out by **Miss. HEMLATA VILAS YEVALE**, under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and help received during the course of this investigation have been acknowledged.

Place : MPKV, Rahuri

Dated : 28 / 6 /2004.

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Place : MPKV, Rahuri (D.M. Sawant)

Dated : 30 /06 /2004.

ACKNOWLEDGEMENTS

I am very happy to have this opportunity to express my deep and sincere feeling of indebtedness to my research guide Dr. R.S. Patil, Professor and Onion Breeder, Department of Horticulture, Rahuri for suggesting an interesting topic of research, planning the programme, expert guidance and constant encouragement throughout the investigation and also for his help in final shaping of manuscript in present form.

I am highly greatful to Dr. S.D. Warade, Professor and Senior Vegetable Breeder, Department of Horticulture, M.P.K.V., Rahuri, Dr. M.N. Bhalekar, I/C Tomato Improvement Scheme, Department of Horticulture, M.P.K.V., Rahuri and Dr. A.V. Solanke, Associate Professor, Department of Agronomy, M.P.K.V., Rahuri for being members of my advisory committee and for their keen interest, encouragement and timely suggestions on various aspects of the research.

I also express my esteemed regards to Dr. U.T. Desai, Head, Department of Horticulture, M.P.K.V., Rahuri for his timely and valuable help and encouragement.

Thanks are due to Dr. S.D. Masalkar, Dr. D.P. Waskar, Dr. A.R. Karale, Dr. A.M. Musmade, Prof. S.N. Gohil, Prof. V.S. Garande, Prof. D.B. Pawar, Shri. B.M. Ilhe, K.G. Shinde and all staff of Department of Horticulture for valuable guidance during period of post graduation.

I sincerely extend my thanks with deep sense of regards to Shri. S.B. Desale, Shri. R.H. Kolse, Shri. S.J. Shinde and Shri. N.S. Gupta for their suggestions and providing the facilities for carrying out this investigation.

I highly greatful to all field staff including Moti mama and Dudhat Mawashi for kind co-operation during the period of my field studies.

With great honour, pride and friendliness, I wish to express to all my friends and well whishers specially to Anjali didi and Jijaji for their encouragement, help and co-operation.

I am very much thankful to Jindal Medical Relief Society, Banglore for awarding me fellowship for the master programme and for financial assistance.

I am also thankful to the authors past and present whose literature has been cited and SUYOG COMPUTERS for neat and tidy word processing of this dissertation.

My humble support towards the completion of studies entirely owes its origin to the divine inspiration, I always derived from my family. I herby find no words to express my heartiest gratitude and immense indebtedness to my parents (Papa and Aai).

It is beyond my capacity to express my feelings for Tai and Jijaji, brothers Pradeep and Sandeep for their overwhelming affection upon me which encouraged my spirits every time.

Place : M.P.K.V., Rahuri

(H.V. Yevale)

Date : 28/ 6 /2004.

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LIST OF ABBREVIATIONS

^{0}C	:	Degree celsius
C.D.	:	Critical difference
cm	:	Centimeter (s)
DAP	:	Days after planting
DAS	:	Days after sowing
FYM	:	Farm yard manure
g	:	Gramme (s)
ha	:	Hectare (s)
i.e.	:	That is
I.U.	:	International unit (s)
kg	:	Kilogramme (s)
m	:	Meter (s)
mg	:	Miligramme (s)
mm	:	Milimeter (s)
N.S.	:	Non-significant
Rs.	:	Rupees
S.E.	:	Standard error
Sig.	:	Significant
t	:	Tonne (s)
viz.	:	Namely
%	:	Per cent
/	:	Per
$<$	:	Less than
$>$	:	Grater than

ABSTRACT

EFFECT OF SET-PLANTING ON *KHARIF* ONION (*Allium cepa* L.) BULB PRODUCTION

By

Hemlata Vilas Yevale

A candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)
in
Horticulture
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722
2004

Research Guide	:	Dr. R.S.Patil
Department	:	Horticulture

The present investigation was conducted during the years 2002-2004 at onion storage scheme, Department of Horticulture, M.P.K.V., Rahuri, Dist. Ahmednagar (Maharashtra) with a view to assess the possibility of early *kharif* onion cultivation by set-planting technique.

The experiment constituted of two onion *kharif* varieties [Baswant-780 (V_1) and Phule Samarth (V_2) i.e. S-1], three seed sowing dates [1st January (D_1), 15th January (D_2) and 1st February (D_3)] and four sizes of sets [2.1 to 2.5 (S_1), 1.6 to 2.0 cm (S_1), 1.1 to 1.5 (S_3) and 0.5 to 1.0 cm (S_4)]. Thus, 24 treatment combinations replicated four times in Factorial Randomized Block Design.

The experiment for set production was carried out during *rabi* 2002-03 while bulb crop was evaluated during *kharif* 2003 and seed crop in *rabi* 2003-04.

The results obtained in respect of set production, bulb production, bulb storage and seed production influenced by various treatments are briefed as follows.

The most noticeable result obtained in present investigation was by use of set plantation, early *kharif* (*Halwa*) onion cultivation can be undertaken in Maharashtra with good yield potential (183 to 243 q/ha), high marketability (> 80 %) and short duration (60-75 days).

The experiment on set production revealed that both onion cultivar (i.e. B-780 and S-1) were effective by seed sowing at 1-15th January. A good set yield (400/m^2) was recorded with 90 days. However, percentage of smaller set size (S_4) was maximum (> 50 %) which showed maximum storage losses (upto 50 %) and recorded least bulb yields. The maximum set yield recorded by individual factors viz cv. Phule Samarth (V_2) and 1st January sowing date (D_1) while best combination was cv. Baswant-780 sown at 1st January (V_1D_1).

The experiment on bulb crop raised by set plantation during *kharif* season revealed that three factors i.e. variety (V) seed sowing date for set production (D) and set size (S) significantly influenced growth and bulb characters individually as well as by two way or three way interactions. The best significantly superior treatments for total bulb yields were seed sowing date at 1st February (D_3), medium large set size (S_2) and interaction of medium sized sets raised by seed sowing at 1st February of cv. B-780 ($V_1D_3S_3$) while highest marketable bulb yield (85.89 %) was recorded by treatment combination with medium sized set of cv. Phule Samarth raised by seed sowing at 1st February ($V_2D_3S_2$). The least bulb storage losses (24.94 total loss) were obtained by treatment $V_2D_2S_2$ i.e. cv. Phule Samarth with seed sowing date 15th January and medium large set size. For seed production significant results were obtained by large seed-bulbs (S_1) in combination with both the cultivars (V_1S_1 or V_2S_2).

However, by considering overall performance of set production, set storage, bulb production and seed production, it was concluded that both onion cultivars can be used for set plantation by seed sowing at 15th January and by use of medium sized sets (1-2 cm in diameter).

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Introduction

1. INTRODUCTION

Onion (*Allium cepa* L.) originated from central Asia is one of the most important commercial vegetable crops grown through out the world. It contributes about 5 per cent share in total vegetable production (Economic survey of India-2002-03). It is valued for its distinctive pungent flavour due to allyl propyl disulphide and is an essential ingredient of cuisine of many regions. Recent reports suggest that onions play a vital part in preventing heart disease and other aliments (Augusti, 1976). According to Watt and Merill (1950) onion contains eleven of the common amino acids. In 100 g of row onion bulb tissues, there are about 50 I.U. of vitamin A, 0.03 mg of thiamin, 0.04 mg riboflavin, 0.02 mg of niacin and 0.9 mg of ascorbic acid. Rest are carbohydrates which make-up dry matter of bulb.

Onion is being extensively cultivated all over the world, especially in China, India, Netherlands, Pakistan, Bangladesh and Australia. India is second largest producer of onion with an area of 410.25 thousand ha and production 5451.45 thousand MT. India's recent export of onion in various forms is to the tune of 545.211 thousand MT worths Rs 394.52 crores to the countries like Saudi Arebia, Singapore, Malaysia, UAE, Bangladesh etc. (Anonymous, 2003).

In India, Maharashtra is largest producer of onion in the country with about 65.00 thousand ha area and 1375 thousand MT production. Out of which 8.50 thousand ha in *kharif*, 25.00 thousand ha in late *kharif* and 31.50 thousand ha in *rabi* seasons. In case of production *kharif*, late *kharif* and *rabi* seasons contributes 200.00 thousand MT, 525.00 thousand MT and 650.00 thousand MT, respectively. (Anonymous, 2003).

Onion cultivation : In Indian continent, onion is prominently *rabi* season crop. However, in Maharashtra the onion bulb-crop is cultivated through out the year in different seasons like early *kharif*, *kharif*, late *kharif*, *rabi* and late *rabi* (i.e. summer). However for onion seed-crop, *rabi* is the only season in India.

In Maharashtra, onion bulb-crop is cultivated in three regular seasons i.e. 10-15 per cent cultivation in *kharif* season, 20-40 per cent cultivation in late *kharif* and 50-60 per cent cultivation in *rabi* season.

Onion cultivation in *kharif* season

Kharif onion cultivation is monopoly of Maharashtra state due to availability of extreme short-day cultivars (*viz.*, N-53, B-780, Agrifound Dark Red and local strains) and favorable climatic conditions.

Normally *kharif* onion cultivation initiates with sowing of seeds in nursery in second fortnight of June, upon onset of monsoon and lowering down of temperatures. Transplanting of seedlings is done in the month of August and crop is harvested in the month of November. However, this *kharif* crop oftenly affected severely by cloudy atmosphere, late rains and incidence of various pests and diseases. Therefore at present *kharif* onion cultivation is restricted to certain area with low yield potential and poor keeping quality.

Onion cultivation in early-*kharif* season

To overcome the problems of *kharif* onion cultivation an early *kharif* onion cultivation is followed in certain areas of sub-mountain zone of Maharashtra (i.e. Akole and Sangamner Taahsils of Ahmednagar Dist., Maval region of Pune Dist., Phaltan, Khatav, Man and Wai tahsils of Satara Dist.) for early *kharif* onion cultivation, seeds are sown in the month of mid-April under mild climatic conditions (temp. 30-34^{0}C) seedlings are transplanted in first fortnight of June and bulbs are harvested in August-September, when normally market prices are relatively high and gets benefit of off-season cultivation. However, this cultivation is not possible in rest of Maharashtra due to severe hot summer when temperatures are above 40^{0}C in the month of April and May which adversely affects seed germination and seedling growth.

Early *kharif* cultivation with onion set-planting

Even though early *kharif* onion cultivation is not possible in plains of Maharashtra, some farmers are undertaking early *kharif* cultivation with onion-set-planting.

In this regard general practice followed by farmers is set-raising from December to March and planting of 1-3 cm dia. sets in June. The bulbs are harvested in August-September. However big sized sets mostly associated either with twin bulbs or premature bolting and low keeping quality. However meagre efforts were carried out and no systematic research work has been undertaken in Maharashtra to develop suitable agro-technique for production of onion-sets. Furthermore additional information is needed for optimum time of seed sowing for set-production, effect of set-size on production, storage and quality of *kharif* onion.

Therefore to develop suitable agro-techniques for early *kharif* onion cultivation through set-plantation, a present investigation was undertaken with two *kharif* onion cultivars [i.e. Baswant-780 and S-1 (Phule Samarth)] with following objective.

1. To assess the possibility of onion cultivation in early *kharif* season (i.e. Transplanting in 1st week of June) with set-planting.
2. To standardize time of seed sowing for onion set-production
3. To know the seasonal effect on vegetative growth and set development of onion seedlings
4. To estimate storage losses of onion-sets
5. To observe the effect of set planting on growth and yield of onion bulb-crop during early *kharif* season (June to September)
6. To estimate storage losses of onion bulbs and use as seed-bulb for seed production.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Importance of set-planting

• The *kharif* season onion crop is raised mostly from seedlings and to some extent from onion-sets (Singh and Singh, 2000). The production of *kharif* onion through sets has several advantages such as surety of production through escape from diseases and pests incidence and adverse climatic conditions at latter growth stages, as it matures early compared to the crop raised by seedlings and also fetch better market prices as an off-season crop (Singh and Sharma, 2002).

• The crop from sets comes onto market quite early and meets the demand for several months starting from August to November. The crop from sets is almost entirely for fresh and immediate consumption (Rahim, *et al.,* 1992). They further reported that about 30 per cent of onion grown in Bangladesh are produced from sets which are available from November onwards especially for the fresh market.

• Krawiec, *et al.* (1998) found that onions grown from sets, matured four weeks earlier than that the ones from seeds and gives 38 per cent more yield.

2.2 The important parameters in onion-set-production

2.2.1 Sowing of seeds

In most of the vegetable crops, good seed germination observed within temperature range of 8-12°C. At high temperatures seed germination affected drastically (Gur, 1980).

The study on the production of onion-sets was carried out under protective environment in trays with different number of cells per tray i.e. 288 (1 plant/cell), 128 (5 plants/cell) and 12 cells (9 plants/cell), it showed that the higher plant density resulted in smaller set size (diameter and weight) furthermore, good quality onion set production (i.e. 1.3 cm diameter and 2 g set-weight) was noticed in a tray with 128 cells and 5 plants/cell (Cardoso, 1999).

For onion set-production in India under field condition mid-January to mid February is ideal period for seed sowing (Chaddha, 2001).

Singh and Sharma (2002) reported successful *kharif* onion cultivation through set-plantation where sets produced during early summer, stored for 2 to 3 months and planted in field after receiving rains.

2.2.2 Duration of set-nursery

Gupta, *et al.* (2000) reported that onion set yield was significantly increased with increase in set-nursery duration (i.e. 90-100 days). They further observed that such a long duration not only increased the total yield of onion sets but also yield of medium to large (1.5 cm to 2.5 cm respectively) sets, increased. Furthermore, they observed better crop stand from medium to large . . 1.5 to 2.5 cm dia. sets than small sized i.e. < 1.5 cm dia. sets.

2.2.3 Storage of onion sets

Smith, *et al.* (1959) recorded minimum sprouting losses (i.e. 12 % by number and 10.25 % by weight) of onion sets during storage with medium to large sized (1.25 to 1.87 cm) onion sets when stored at 27-28°C with high humidity.

Genkow (1959) reported cold storage of onion sets where medium to large onion sets (i.e. 1.5-2.0 cm and 2.0 to 3.0 cm diameter respectively) were stored under two storage temperatures *viz.,* at cold attic (1 to 2°C) and at 10°C. However, more onion bulb yield was observed with sets stored in cold attic than those stored at 10°C.

Ior Dachescu, *et al.* (1979) studied two cold storage temperatures i.e. 0-1.5°C and 1-3°C along with ambient temperatures (16-24°C) for storage of onion-sets. The minimum (1.4 to 3.7 %) storage losses were observed at cold storage (0-1.5°C) than control storage, also tendency to sprout suppressed most by storage at 0-1.5°C (cold storage).

The effect of different physiological maturity stages of onion seedlings on storage of onion sets was reported by Singh and Sharma (2002). The onion sets were harvested at three stages i.e. 25, 50 and 100 per cent foliage drying. The least storage losses (i.e. 10.52 % total loss which include 9.33 % physiological loss in weight and 1.20 % rotting) was observed from treatment of carbendazim spraying at 100 days after seed sowing and sets harvested at 100 per cent foliage drying.

2.3 Effect of onion-sets on plant growth, yield and quality of bulb crop

2.3.1 Set-planting methods

An effect of two mechanical planting methods i.e. precision seeder and pneumatic seed drill was evaluated along with manual method in multiplier onion set planting (Onal, *et al.*, 1992). They observed the most uniform planting depth with precision seeder furthermore, satisfactory set emergence was noticed with precision seeder (70 %) and also by manual method (80 %). However, it was poor with *pneumatic* seed drill (57 %).

Onal, *et al.* (1991) studied set-position and soil conditions for mechanical set plantation in onion. They noticed that normal and horizontal set positions were critical for set emergence while smaller soil particles in dry conditions and larger soil aggregates in moist conditions were beneficial for mechanical onion set-plantation.

2.3.2 Effect of size of sets and spacing

2.3.2.1 On bulb yield and quality

Krickl (1962) reported that larger onion sets gives higher yield than smaller sets, specifically in those strains which had been selected for non-bolting.

However, in multiplier onions Chetepova (1972) observed that even-though larger sets recorded higher bulb yield but lower-down the quality. The higher percentage of mother bulbs was recorded in small sets than in larger sets. Furthermore, mother bulbs obtained from small sets produced more seed yield than from medium to large sets.

Shalaby, *et al.* (1991) studied effect of plant density (spacing) and set-size on bulb yield of onion. They reported that the highest total, marketable and exportable yields were observed at *density of 160 sets/m^2 (i.e. area of 625 cm^2/ plant) from 0.3 to 1.6 cm* set-size. However, set size of 1.6 to 2.4 cm was the best ~~for~~ all density (i.e. spacing) treatments to record the higher total yield.

Size of planting material has profound effects on yield and quality of onion bulbs. Ahmed (1994) reported that yield of onion bulbs grown from dry sets was higher than that from seedlings. Further he also noted that medium sized sets yielded better than big sets.

Ryu-Youngwoo, *et al.* (1998) compared yield performance of shallot by planting different bulbs (i.e. 30 + 3, 20 + 3 and 10 + 3g) and noticed that yield levels were reduced as per bulb size (i.e. 41.3, 39.8 and 23.1 t/ha respectively). They observed that medium bulb size was the best planting material in shallot.

2.3.2.2 On doubling and bolting

Bulbs from the larger sets produced more shoots per bulb and were more prone to doubling than bulbs from smallest sets, especially when bulbs from smallest sets, ~~especially when bulbs~~ were planted on the latest date (*Rabi*nowitch, 1979).

Krawiec, *et al.* (1998) studied sensitivity to bolting of onion grown from sets and found that storing onion sets at 0-1^{0}C stimulated the occurrence of generative sprouts. The highest share of the bolts was noted in the onions grown from sets of 21-25 mm in diameter and in the ones stored at the temperature of 0-1°C.

Ryu-Youngwoo, *et al.* (1998) studied bolting in shallot by planting various sized sets (i.e. 30 + 3, 20 + 3 and 10 + 3 g) and found maximum bolting i.e. 98.2 per cent in large sized (30 + 3 g) followed by 92.5 per cent in medium sized (20 + 3 g) sets. However, less bolting was found in small sized sets (10 + 3 g) i.e. 85.4 per cent.

2.4 Storage quality of onion bulbs

2.4.1 Effect of curing

Curing of onion bulbs in the field for 4 days by the windrow method followed by shed curing for 21 days improves the storage life of onion bulbs. Kale, *et al.* (1991) recorded lower storage losses (38.7 %) compared with non-cured bulbs (47.8 %).

Bhattarai and Subedi, (1998) examined the effect of curing on storage of onion and reported lower losses (31.9 %) with curing than without curing (43.9 %). However, non-cured onion showed greater loss in strings and hanging baskets also.

Mie dema (1994) found lowest sprouting losses (i.e. 50.47 %) with curing in sun with foliage and storage with dried foliage than other treatments.

2.4.2 Effect of neck-length

The effect of cutting to various neck-lengths (0 to entire tops) on storage losses of onion bulbs revealed that the fully cured bulbs with 4 cm neck-length, recorded the lowest (38.7 %) storage losses (Kale, *et al.*, 1991).

2.5 Seed production

2.5.1 Effect of size of seed bulbs

Singh and Sachan (1999) reported that largest bulb size (4-5 cm) gave highest seed yield/plant, although the smallest bulb (2.5-3 cm) produced the biggest umbel on an average.

Seed bulbs obtained from small sets formed more scapes per bulb and gave a greater seed yield than seed bulbs formed from medium and large sets (Cherepova and Yakubskaya, 1972). They also reported that set size had no effect on seed quality.

Material and Methods

3. MATERIAL AND METHODS

The present investigation entitled "Effect of set-planting on *Kharif* onion (*Allium cepa.* L.) bulb-production" was carried out at AICRP Farm Onion Storage Scheme, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment on set plantation was undertaken during *rabi* 2002-03, while experiments on bulb and seed crop were carried out during *kharif* 2003 and *rabi* 2003-04 respectively.

3.1 Materials

The seed of both the cultivars i.e. B-780 and S-1 was obtained from onion breeder, onion storage scheme, M.P.K.V., Rahuri. All other facilities, required were provided by Instruction cum Research Orchard, Department of Horticulture, M.P.K.V., Rahuri in nick of time.

3.1.1 Experimental site

Mahatma Phule Krishi Vidyapeeth is situated at 19^0 47' North latitude and 74^0 19' East longitude. The plot selected for experiment had uniform soil and fertility. The soil was sandy clay loam in texture (Entisole) and well drained.

3.2 Methods

3.2.1 Set-production

For set-production in onion an experiment was undertaken with three sowing dates i.e. 1^{st} January (D_1), 15^{th} January (D_2) and 1^{st} February (D_3), 2003.

Two onion cultivars, i.e. Baswant-780 (B-780) and S-1 (P. Samarth), the former variety has been especially developed for *kharif* season by M.P.K.V., Rahuri and has well adopted in Ahmednagar and Nashik districts. The salient features of B-780 are pink red globular-round bulbs resistant for twin bulbs and premature bolting, 110-120 days maturity period, yield potential upto 250 q/ha. with good keeping quality (2-3 months) while S-1 (i.e. Phule Samarth) is recently developed onion cultivar by M.P.K.V., Rahuri especially for *kharif* and *rangda* season. The salient features of S-1 are dark-red, lusterious, globular, round bulbs, thin bulb neck, natural top-fall, early maturity i.e. 75-80 days in *kharif* and 85-88 days in *rangda* season, resistant for twin bulbs and premature bolting, yield potential upto 250-300 q/ha. for *kharif* and 300-400 q/ha for *rangda* season, good keeping quality (2-3 months).

3.2.1.1 Experimental design

An experiment was conducted with two onion cultivars (V_1 and V_2) and three sowing dates (D_1, D_2 and D_3) i.e. in total 6 treatment combinations in factorial randomized block design with three replications.

The seeds were sown in lines (10 cm apart) on raised bed of 3 x 1m^2 size and 20 g seed rate per raised bed was applied 5 to 6 kg FYM, 250 g fertilizer (15:15:15) & 25 g of cupper oxychloride were well mixed in soil before seed sowing. Plant protection sprays were given at 15 days interval. The sets were harvested after three months period.

3.2.2 Storage of onion sets

The sets were field cured by windrow method for 3 days until complete drying of foliage. Then sets were graded in four categories according to sizes i.e. S_1 (2.1 to 2.5 cm), S_2 (1.6 to 2.0 cm), S_3 (1.1 to 1.5 cm) and S_4 (0.5 to 1.0 cm).

The sets were stored along with dried foliage in a bundle in hanging condition in well ventilated shade (ambient temperature 30^{0}C) until may, 2003.

3.2.3 Bulb production

3.2.3.1 Experimental design

An field experiment was carried out in *kharif* season along with 2 onion cultivars [B-780 and S-1], 3 dates of seed sowing for set production (1st January, 15th January and 1st February) and 4 set-sizes (2.1 - 2.5 cm, 1.6 - 2.0 cm, 1.1 - 1.5 cm and 0.5 - 1.0 cm). An experiment with 24 treatment combinations (2 x 3 x 4) was conducted in Factorial Randomized Block Design with four replications.

3.2.3.2 Planting

The sets were planted at 15 cm distance in ridges and furrows (on both sides of ridge) in a plot of 3 x 2m^2 with plant population of 1600 plants in each plot. The planting was done in 1st week of June (7th June) 2003.

3.2.3.3 Cultural operations

All required cultural operations i.e. irrigation, weeding, plant-protection, fertilizer application etc. were followed as per the recommendations of M.P.K.V., Rahuri (Appendix-II).

3.2.3.4 Harvesting

Harvesting of crop was done at 50 per cent top-fall stage.

3.2.3.5 Post harvest operations

Harvested bulbs were kept in field for 5-7 days for field curing (windrow method). After field curing shade curing was done for 21 days in partial shade along with leaf-tops. Upon shade curing the tops were cut by giving twist and leaving 4 cm bulb neck, then bulbs were kept for storage.

3.2.4 Storage of onion bulbs

5 kg bulb per treatment were stored at ambient temperatures for 105 days (i.e. 7th September-21st December, 2004) and per cent rotting, sprouting physiological loss in weight and total losses were estimated as storage losses.

3.2.5 Seed production

After 3.5 month storage, the dormant bulbs with good keeping quality were selected as seed bulbs.

3.2.5.1 Experimental design

An experiment was conducted with 2 cultivars and 3 bulb sizes with an objective to use bulbs harvested from set plantation for seed production programme.

2 cultivars (V_1 : B-780 and V_2 : S-1) and 3 bulb sizes (S_1 : 5.5 cm, S_2 : 4.5 cm and S_3 : 3.5 cm) total, six treatment combinations (2 x 3) were studied in factorial randomized block design with 5 replications .

3.3 Observations

3.3.1 Set production

3.3.1.1 Average seedling height (cm)

The height was recorded in centimeters for randomly selected 10 seedlings from plot. It was recorded from ground level to the tip of leaves.

3.3.1.2 Average number of leaves

Average number of leaves was obtained by counting the number of functional leaves for randomly selected 10 seedlings at 85 DAS crop stage.

3.3.1.3 Average bulb-diameter (cm)

The diameter of bulbs of randomly selected 10 seedlings was measured by uprooting the seedlings at 85 DAS crop stage. The instrument vernier caliper was used for the purpose.

3.3.1.4 Yield of sets

After harvesting number of sets in each bed was counted and set yield in terms of number of sets/m^2 was calculated.

By sorting the sets in various sizes (i.e. S_1, S_2, S_3 and S_4). Per cent yield of each sized set was recorded.

3.3.2 Storage of sets

3.3.2.1 Storage losses (%)

The sorted sets were stored upto end of May 2003. Percent rotting losses of each sized sets was calculated by

$$\% \text{ loss} = \frac{\text{Initial count-final count}}{\text{Initial count}} \times 100$$

3.3.3 Bulb-production

3.3.3.1 Average plant height (cm)

Five plants of each treatment were selected randomly and labeled and plant height was recorded in cm at 50 DAP crop stage.

~~was calculated. Plant height was recorded at the end of 50 days after planting.~~

3.3.3.2 Average number of leaves

Number of leaves were counted for the same plants selected for plant height and average was calculated. Average number of leaves were also recorded at 50 days after planting.

3.3.3.3 Average bulb diameter (cm)

Bulb diameter was also recorded for five plants, randomly selected. For the purpose, the soil around the bulbs was removed carefully without disturbing the bulbs or root-system and diameter was measured by vernier caliper and soil was replaced. Averages were calculated. Observation was taken at 25 days, 50 days and at 65 days to know the bulb development.

3.3.3.4 Percent bulb development

Average bulb diameter in cm was recorded as above and percent bulb development was calculator. For that percentage of developed bulb diameter was calculated over average diameter of planted sets (% increase in bulb diameter).

$$\% \text{ increase in bulb diameter} = \frac{Y - X}{X} \times 100$$

Where X = Bulb diameter at particular stage (cm)

Y = Initial bulb diameter (cm)

3.3.3.5 Percent premature bolting

Plants showing premature bolts were counted and percentage was calculated over total number of plants in each treatment. The observation was taken at 60 DAP (Days after planting).

3.3.3.6 Days required for 50 per cent top/leaf bending as a maturity index

Different maturity sings were observed in two onion cultivars. It was 50 per cent top fall in cv. S-1 while 50 per cent leaf bending in cv. B-780.

3.3.3.7 Percent twin bulbs

Number of twin bulbs was counted and percentage was calculated over total number of bulbs in each treatment. The observation was taken after harvesting.

3.3.3.8 Bulb diameter (equatorial and polar) cm

Randomly five bulbs were selected from harvested bulbs and equatorial as well as polar diameters (cm) were measured by using vernier caliper.

3.3.3.9 Neck thickness (cm)

Neck thickness was measured by vernier caliper after field curing but before shade curing. Randomly selected five bulbs were used for average calculation.

3.3.3.10 Bulb yield

The bulb yield per plot was recorded and converted in quintal per hectare.

3.3.3.11 Marketable yield (%)

The weight of bolted bulbs, twin bulbs and undesired bulbs was substracted from total weight and weight of marketable bulbs was calculated. Further more percentage of marketable yield was calculated by following formula.

$$\text{Marketable yield (\%)} = \frac{\text{Marketable bulb weight}}{\text{Total bulb weight}} \times 100$$

3.3.4 Storage of bulbs

Medium sized, graded and cured bulbs (5 kg/treatment) were selected for storage studies. Observations were recorded at monthly interval, for the storage losses due to rotting, sprouting, PLW and total losses.

3.3.4.1 Rotting losses (%)

The rotted bulbs were separated and weighed. Per cent loss over initial weight due to rotting was calculated.

3.3.4.2 Sprouting loss (%)

The sprouted bulbs were separated and weighed. Percentage loss over initial weight due to sprouting was calculated.

3.3.4.3 Total loss (%)

The weight of only healthy bulbs was recorded which was subtracted from the initial weight and converted in percentage to get total loss.

3.3.4.4 PLW (%)

Per cent PLW was calculated by subtracting per cent sprouting and rotting losses from per cent total loss with following formula.

Per cent PLW = Per cent total loss – (Per cent rotting loss + Per cent sprouting loss)

3.3.5 Seed-production

3.3.5.1 Number of umbels/plant

Number of umbels were counted of five randomly selected plants and average was calculated.

3.3.5.2 Weight of seeds/umbel

Five umbels were selected randomly one from each plant from randomly selected 5 plants in each treatment. After weighing seeds of each umbel average was calculated.

3.4 Statastical analysis

The observations were taken. The data were tabulated and computed by using standard methods of statistical analysis as described by Sukhatme and Panse.

Results

4. EXPERIMENTAL RESULTS

The present investigation was conducted during ~~*rabi*~~ 2002-2004 ~~and~~ ~~*kharif*~~ ~~2003~~ to evaluate the effect of set-planting on onion-bulb production and quality, mainly influence of sowing dates, size of sets and varieties on *kharif* onion cultivation. The observations were recorded on plant growth and bulb development of onion sets and bulb crop, during storage and seed crop. The possibility of use of bulbs obtained from set-planting as seed bulbs for improvement of keeping quality of *kharif* onion was studied. The results obtained are presented in this chapter.

4.1 Onion set-production

The data regarding the effect of two varieties, three sowing dates and their interactions are presented under appropriate sub-headings.

Table 1. Average seedling height (cm) influenced by varying varieties seed sowing dates and their interaction (50 DAP stage)

Table 1a. V x D

Variety (V)	*Sowing dates (D)*			Mean
	D_1 (1st January)	D_2 (15th January	D_3 (1st February)	
V_1 : B-780	28.81	32.31	30.86	30.66
V_2 : S-1	29.42	34.80	33.60	32.60
Mean	29.11	33.55	32.23	

Table 1b. ANOVA

	SE	CD (5 %)
V	0.472	1.489
D	0.578	1.824
V x D	0.818	2.579

4.1.1 Average seedling height (cm)

From Table 1b it is observed that ~~character~~ seedling height was significantly influenced by both the factors i.e. variety and seed sowing date (V and D) and their interaction (V x D).

Table 1a revealed that cv. S-1 recorded significantly higher seedling height (32.60 cm) over cv. B-780 (30.66 cm). Among the sowing dates, the maximum seedling height (33.55 cm) was noticed at 15th January, which was at par with 1st February (32.23 cm) but significantly superior over 1st January (29.11 cm) furthermore, interaction of cv. S-1 with seed sowing at 15th January (V_2D_2) recorded the significantly highest seedling height (34.80 cm) which was ~~only~~ at par with cv. S-1 sowing at 1st February (V_2D_3) i.e. 33.60 cm.

Table 2. Average number of leaves of seedlings as influenced by varying varieties, seed sowing dates and their interactions

Table 2a. V x D

Variety (V)	Sowing dates (D)			Mean
	D_1 (1st January)	D_2 (15th January)	D_3 (1st February)	
V_1 : B-780	6.33	6.33	6.33	6.33
V_2 : S-1	6.33	6.00	6.00	6.11
Mean	6.33	6.16	6.16	

Table 2b. ANOVA

	SE	CD (5 %)
V	0.144	NS
D	0.177	NS
V x D	0.250	NS

4.1.2 Average number of leaves per seedling

The Table 2b revealed that the character, number of leaves of seedlings was neither significantly influenced by two factors (i.e. variety and sowing dates) nor by their interaction. The average 6 to 6.33 leaves ~~were~~ was recorded by different treatments and their combinations (Table 2a).

Table 3. Average diameter (cm) of sets as influenced by varying varieties, seed sowing dates and their interactions

Table 3a. V x D

Variety (V)	Sowing dates (D)			Mean
	D_1 (1st January)	D_2 (15th January)	D_3 (1st February)	
V_1 : B-780	0.92	0.94	0.95	0.93
V_2 : S-1	0.88	0.98	0.90	0.92
Mean	0.90	0.96	0.92	

Table 3b. ANOVA

	SE	CD (5 %)
V	0.044	NS
D	0.054	NS
V x D	0.076	NS

4.1.3 Average set diameter (cm)

Like number of leaves, the character diameter of sets was neither significantly influenced by the two factors nor by their interaction (Table 3b).

A average of 0.9 to 0.98 cm diameter of sets was recorded by different treatment combinations. However, maximum set bulb diameter (0.98 cm) was recorded by V_2D_2 (cv. S-1 with seed sowing at 15th January).

Table 4. Yield of onion sets (no. of sets/m²) as influenced by varying varieties, seed sowing dates and their interactions

Table 4a. V x D

Variety (V)	Sowing dates (D)			Mean
	D_1 (1st January)	D_2 (15th January	D_3 (1st February)	
V_1 : B-780	406	358	283	349
V_2 : S-1	405	368	289	354
Mean	405	363	286	

Table 4b. ANOVA

	SE	CD (5 %)
V	11.657	NS
D	14.277	44.98
V x D	20.191	63.62

4.1.4 Set yield per square meter (number of sets/m^2)

Table 4b showed that the set yield was significantly influenced by the factor sowing dates while no significant difference was found in varieties. However interaction of variety and sowing date showed significant influence on set yield per m^2.

Table 4a revealed that sowing date D_1 (1st January) recorded significantly superior set yield (405 sets/m^2) over D_2 i.e. 15th January (363/m^2) and D_3 i.e. 1st February (286/m^2). Thus, late seed sowing resulted in linear decrease in set-yield. The sowing date D_1 also performed best in interaction with V_1 (cv. B-780) i.e. 406 sets/m^2, that other interactions. While significantly lower set-yield was recorded in interaction V_1D_3 (cv. B-780, with seed sown at 1st February) i.e. only 283 sets/m^2

Table 5 Percentage of various set sizes as influenced by various varieties, seed sowing dates and their interactions

(Figures in the paranthesis indicates arc sin transformed values).

Table 5a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	21.7 (27.79)	23.3 (28.83)	20.6 (26.99)	21.9 (27.87)
V_2 : S-1	22.8 (28.53)	23.6 (28.83)	23.4 (28.95)	23.3 (28.84)
Mean	22.3 (28.16)	23.4 (28.94)	22.0 (27.97)	

Table 5b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	11.1 (19.41)	12.5 (20.73)	14.7 (22.56)	58.6 (49.93)	22.3 (28.16)
D_2 : 15th Jan	11.4 (19.70)	13.1 (21.23)	17.2 (24.48)	59.3 (50.37)	23.4 (28.94)
D_3 :1st Feb.	11.2 (19.50)	12.8 (20.93)	16.9 (24.26)	53.8 (47.19)	22.0 (27.97)
Mean	11.2 (19.54)	12.8 (20.96)	16.2 (23.77)	57.2 (49.16)	

Table 5c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1	11.6 (19.95)	12.2 (20.44)	15.9 (23.49)	54.6 (47.62)	21.9 (27.87)
V_2	10.7 (19.13)	13.4 (21.49)	16.6 (24.04)	59.9 (50.71)	23.3 (28.84)
Mean	11.2 (19.54)	12.8 (20.96)	16.2 (23.77)	57.2 (49.16)	

Table 5d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	11.5 (19.81)	11.4 (19.76)	12.0 (20.27)	10.6 (19.02)	11.3 (19.63)	10.3 (18.74)	11.2 (19.54)
S_2 : 1.5-2.0 cm	13.0 (21.17)	12.4 (20.63)	11.2 (19.52)	12.0 (20.29)	13.8 (21.83)	14.5 (22.35)	12.8 (20.96)
S_3 : 1-1.5 cm	14.3 (22.22)	16.0 (23.59)	18.4 (24.64)	15.1 (22.90)	18.3 (25.36)	16.4 (23.88)	18.2 (23.77)
S_4 : 0.5-1 cm	55.2 (47.96)	61.0 (51.35)	57.5 (43.54)	61.9 (51.90)	57.6 (49.39)	60.1 (50.83)	57.2 (49.16)
Mean	21.7 (27.79)	23.3 (28.83)	20.6 (26.99)	22.8 (28.53)	23.6 (28.83)	23.4 (28.95)	

Table 5e. ANOVA

Variety	SE	CD (5 %)
V	0.574	NS
D	0.703	NS
S	0.812	2.31
V x D	0.995	NS
D x S	1.407	4.00
V x S	1.148	3.27
V x D x S	2.814	7.99

4.1.5 Percent yield of various set sizes

According to bulb diameter of set (i.e. set size) the onion sets were graded into four categories *viz.*, large (S_1 : 2.1 to 2.5 cm), medium large (S_2 : 1.6-2.0 cm), medium (S_3 : 1.0-1.5 cm) and small (S_4 : 0.5-1.0 cm).

The effect of three factors i.e. set size (S), variety (V) and seed sowing date (D) and their interaction were studied on grades of onion sets.

The data of Table 5e revealed that significant yield differences were recorded by factor set-size (S) and interaction DS, VS and VDS. In general the significantly higher yield of smaller sets (S_4 : 0.5-1.0 cm) i.e. 57.2 per cent was recorded over medium (S_3 : 1.0-1.5 cm) i.e. 18.2 per cent, medium large (S_2 : 1.5-2.0 cm) i.e. 12.8 per cent and large (S_1 : 2.1-2.5 cm) i.e. 11.2 per cent (Table 5d).

Similarly, in interaction of sowing date and set size i.e. D x S (Table 5b) it was observed that sowing date D_2 (15th January) recorded the highest yield of small (S_4) sized sets (59.3 %) than other sowing dates *viz.*, D_1 and D vield (53.8 %) of small sized

(S_4) sets was observed with sowing date D_3 (1st February). However, lower yield (11.1-11.4 %) of S_1 sized sets was recorded with all three sowing dates.

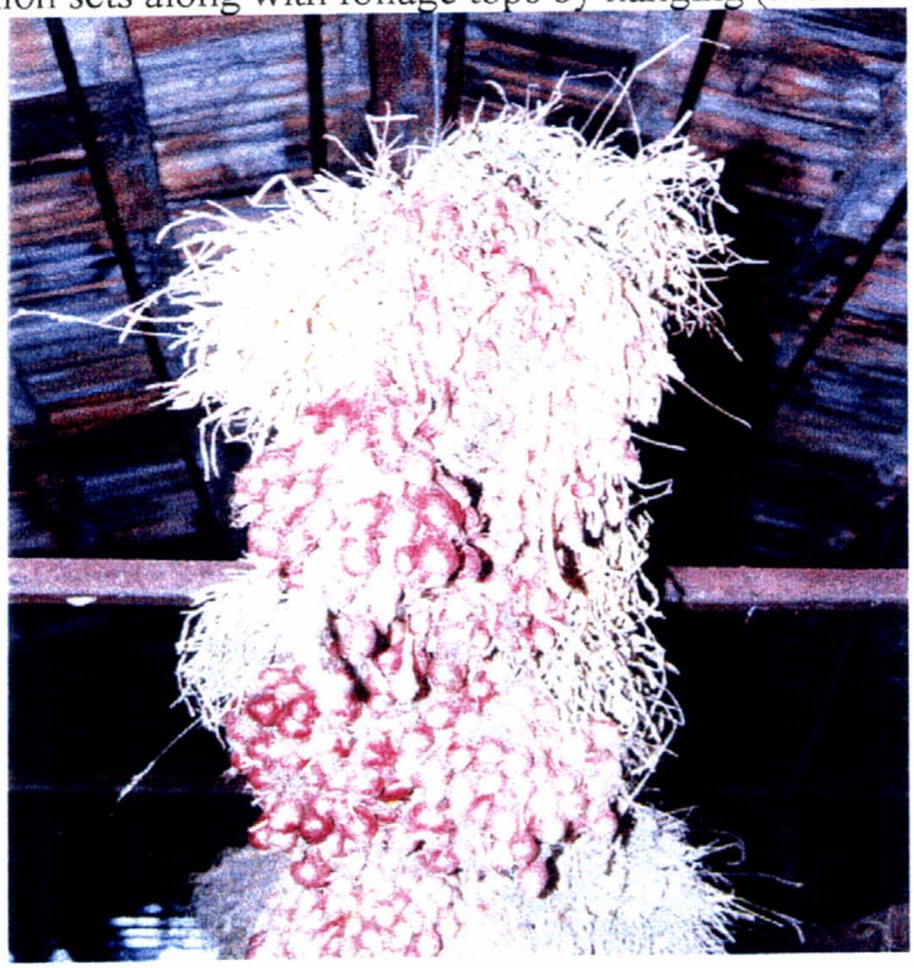
In interaction of variety and set size i.e. V x S (Table 5c) the highest set yield was recorded by small sized sets (S_4) with cv. B-780 (59.9 %) followed by with cv. S-1 (54.6 %) which were at par with each other. However the smaller sized (S_4) set yield of these two treatment were significantly higher than rest of treatments the set yield of medium (S_3), medium-large (S_2) and large (S_1) sets were ranged 15.9 to 16.6 per cent, 12.2 to 13.4 per cent and 10.7 to 11.6 per cent, respectively.

In three way interaction of variety, date of seed sowing and set-size i.e. V x D x S (Table 5d), the significantly higher set-yields were recorded in smaller set-size by treatment combinations $V_2 D_1 S_4$ (61.9 %) followed by $V_1 D_2 S_4$ (61.0 %) and $V_2 D_3 S_4$ (60.1 %).

All treatment combinations with smaller set size (S_4) were recorded set-yield (55.2-61.9 %) at par with each other. However, set yields of treatment combinations with other set sizes were significantly lower than treatment combinations with small set size. The lowest set yield was recorded by treatment $V_2 D_3 S_1$ (10.3 %).

Plate-1. Storage and grading of onion sets

A) Storage of onion sets along with foliage tops by hanging (March -1st week of June)



B) Four grades of onion set used for storage studies (Cv. Baswant-780)

a

b

a) Upper line: Onion sets with good keeping quality used for bulb production

b) Lower line: Onion sets with displaying rotting losses during storage

Table 6. **Per cent storage (rotting) losses of onion sets as influenced by varying varieties and seed sowing dates**

Table 6a. **V x D** (Figures in the paranthesis indicates arc sin transformed values)

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	32.4 (34.73)	28.3 (32.16)	31.5 (34.14)	30.7 (33.68)
V_2 : S-1	34.7 (36.08)	30.3 (33.38)	25.2 (30.16)	30.0 (33.21)
Mean	33.6 (35.41)	29.3 (32.77)	28.3 (32.15)	

Table 6b. **D x S**

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	7.9 (16.29)	35.3 (36.48)	35.0 (36.24)	63.2 (52.63)	33.6 (35.41)
D_2 : 15th Jan	6.4 (14.64)	26.1 (30.72)	29.9 (33.12)	63.1 (52.60)	29.3 (32.77)
D_3 :1st Feb.	5.9 (14.11)	26.7 (31.09)	32.3 (34.63)	56.6 (48.76)	28.3 (32.15)
Mean	6.6 (51.01)	29.3 (32.76)	32.3 (34.66)	61.0 (51.33)	

Table 6c. **V x S**

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	6.2 (14.43)	31.5 (34.12)	34.8 (36.13)	58.7 (50.04)	30.7 (33.68)
V_2 : S-1	7.2 (15.59)	27.2 (31.41)	30.0 (33.19)	61.5 (52.62)	30.0 (33.21)
Mean	6.6 (15.01)	29.3 (32.76)	32.3 (34.66)	61.0 (51.33)	

Table 6d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	6.8 (15.17)	5.9 (14.04)	5.9 (14.77)	8.9 (17.41)	6.9 (15.24)	6.0 (14.14)	6.6 (15.01)
S_2 : 1.5-2.0 cm	31.9 (34.39)	31.8 (34.35)	30.7 (33.61)	38.8 (38.56)	20.7 (27.09)	22.9 (28.58)	29.3 (32.76)
S_3 : 1-1.5 cm	33.0 (35.04)	26.0 (30.64)	46.1 (42.72)	37.0 (37.44)	33.9 (35.60)	20.0 (26.55)	32.3 (34.66)
S_4 : 0.5-1 cm	66.0 (54.33)	58.0 (49.63)	52.0 (46.16)	60.3 (50.93)	68.0 (55.58)	61.0 (51.36)	61.0 (51.33)
Mean	32.4 (37.3)	28.3 (32.16)	31.5 (34.14)	34.7 (36.08)	30.3 (33.38)	25.2 (30.16)	

Table 6e. ANOVA

Variety	SE	CD (5 %)
V	1.072	NS
D	1.313	NS
S	1.517	4.31
V x D	1.858	5.28
D x S	2.627	7.48
V x S	2.145	6.10
V x D x S	5.255	14.93

4.1.6 Storage (rotting) losses of onion sets

The data of Table 6e revealed that percent rotting losses of onion sets were significantly influenced by factor set size and interactions VD, DS, VS and VDS.

For the factor set size significantly higher rotting losses were recorded in small sized sets (S_4) i.e. 61.0 per cent while it was least in large sized sets (S_1) i.e. only 6.6 per cent (Table 6d). It was noticed that storage losses were reduced as set-size increases.

Moderate storage losses were recorded in medium large and medium set sizes (i.e. 32.3 and 29.3 % respectively).

For the factor sowing date (Table 6a) it was worthy to note that eventhough storage period was different for three sowing dates, the storage losses were non significant and showed narrow range variation i.e. (28.3 to 33.6 %). Furthermore, two varieties recorded almost similar rotting losses (i.e. about 30 %) during set storage and showed their equal potential for good keeping quality.

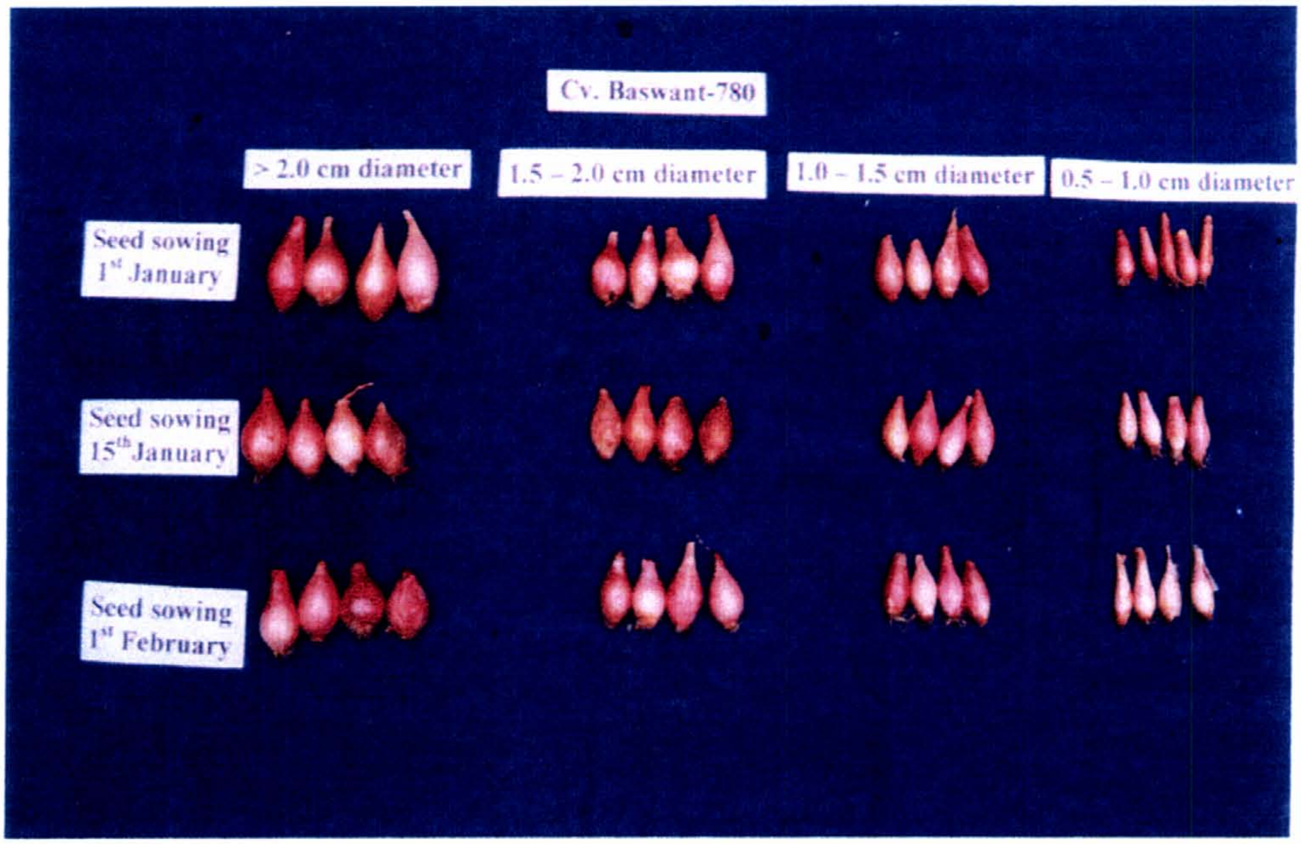
Eventhough individual factor influence of variety and sowing dates was non significant on storage losses but the interaction between these two factors recorded significant differences (Table 6c showed that the treatment V_2D_1 (cv. S-1 with sowing date 1st January) recorded the maximum storage loss i.e. 34.7 % while same variety with 1st February sowing (V_2D_3) recorded minimum loss i.e. 25.3 per cent. Ingeneral the storage losses increased with early sowing dates.

In interaction of sowing dates and set size (D x S) the significantly minimum storage losses (5.9-7.9 %, Table 6b) recorded by treatment combination of large sets with three sowing dates (i.e. S_1D_1, S_2D_2 and S_1D_3).

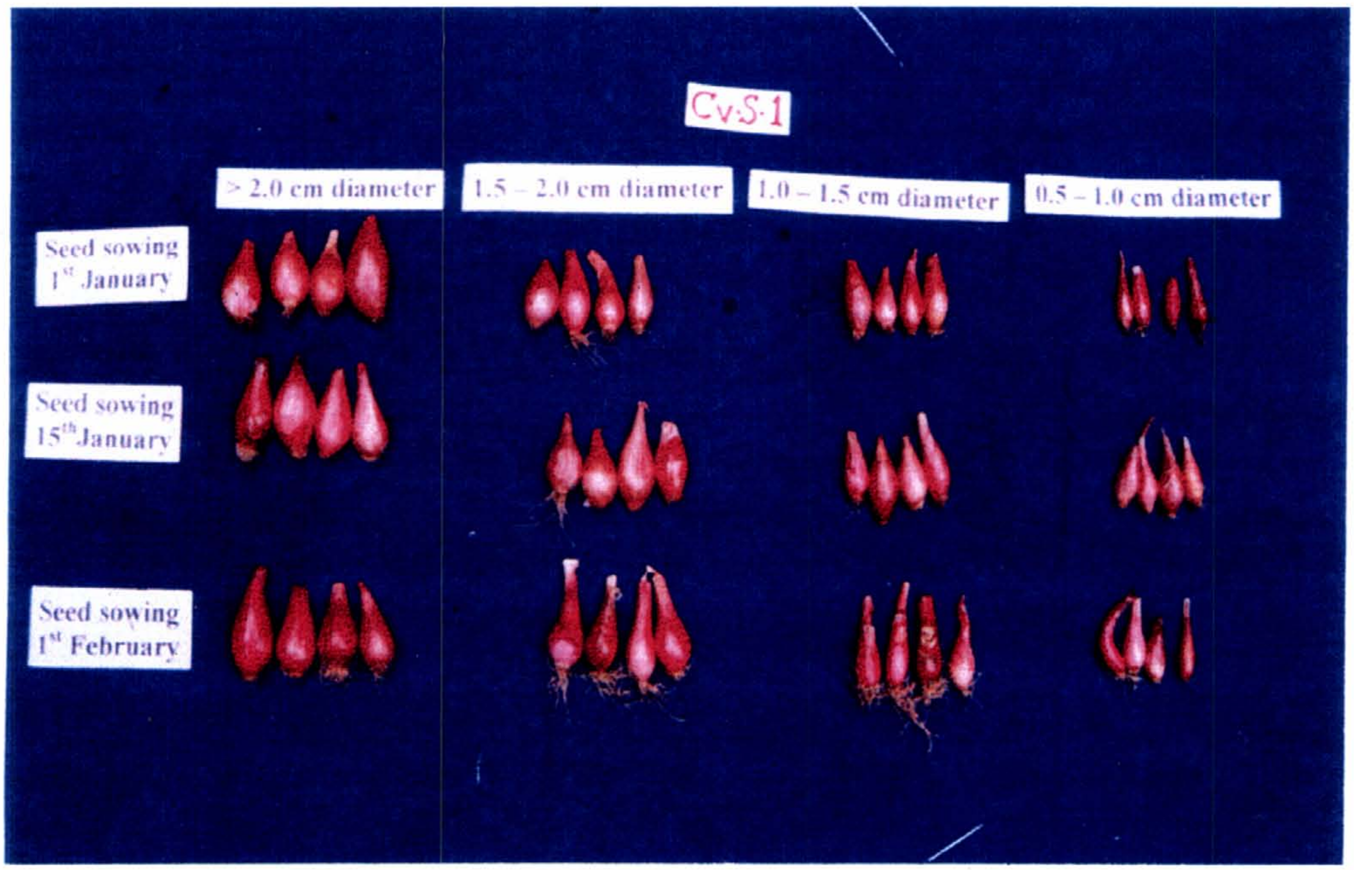
In interaction of variety and set-size (V x S, Table 6c) the significantly lower storage losses were recorded by large sets of cv. b-780 (6.2 %) followed by cv. S-1 (7.2 %) over other sizes of sets of two varieties. The significantly higher storage losses were recorded in smaller set-sizes of cv. S-1 (61.5 %) and cv. B-780 (58.7 %) over rest of treatment combinations.

Plate-2. Onion seeds used for bulb production

A) Cv. B-780 with four grades of onion sets obtained by three sowing dates



B) Cv. S-1 (Phule Samarth) with four grades of onion sets obtained by three sowing dates



In interaction of three factors (V x D x S, Table 6d), it was noticed that large set size (S_4) combined with other two factors recorded significantly lower storage losses (5.9-8.9 %) than rest of treatment combinations. Furthermore it was observed that storage losses were proportionally increased with smaller set size when combined with other two factors. Accordingly the higher storage losses were recorded (52.0-66.0 %) in treatment combination where small set-size (S_4) combined with other two factors.

4.2 Bulb production

The effect of set planting on *kharif* onion bulb production was studied with three factors i.e. varieties (2), sowing dates (3) and set-sizes (4). The results are presented under appropriate subheadings.

Table 7. Average plant height (cm) as influenced by varying varieties, seed sowing dates, set sizes and their interactions

Table 7a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	57.58	58.89	59.64	58.70
V_2 : S-1	58.41	58.39	58.94	58.58
Mean	57.99	58.64	59.29	

Table 7b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1[st] Jan.	58.90	57.66	58.83	56.58	57.99
D_2 : 15[th] Jan	60.94	57.07	59.37	57.19	58.64
D_3 :1[st] Feb.	59.87	58.84	59.94	58.51	59.29
Mean	59.90	57.86	59.38	57.42	

Table 7c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	59.56	58.04	59.51	57.71	58.70
V_2 : S-1	60.25	57.68	59.25	57.14	58.58
Mean	59.90	57.86	59.38	57.42	

Table 7d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	58.90	61.03	58.75	58.91	60.85	61.00	59.90
S_2 : 1.5-2.0 cm	58.41	57.90	57.81	56.92	56.25	59.87	57.86
S_3 : 1-1.5 cm	57.77	58.75	62.01	59.89	59.99	57.87	59.38
S_4 : 0.5-1 cm	55.25	57.90	60.00	57.92	56.48	57.02	57.42
Mean	57.57	58.89	59.64	58.41	58.39	58.94	

Table 7e. ANOVA

Variety	SE	CD (5 %)
V	0.498	NS
D	0.610	NS
S	0.704	1.98
V x D	0.862	NS
D x S	0.996	NS
V x S	1.219	NS
V x D x S	1.724	NS

4.2.1 Average plant height (cm)

The data of Table 7c revealed that plant height was only significantly influenced by the factor set-size while other factors and interactions were non-significant.

The maximum plant height was recorded by big sized sets i.e. S_1 (59.90 cm) which was at par with medium sized sets i.e. S_3 (59.38 cm) but significantly more than other two set sizes i.e. S_2 and S_4 (57.86 and 57.42 cm, respectively).

Ingeneral, variation was noticed in narrow range and the highest plant height (61.03 cm) was recorded by treatment combination V_1 D_2 S_1 (i.e. cv. B-780, sowing date 15th January and set size 2.1-2.5 cm).

Table 8. Average number of leaves/plant as influenced by varying varieties, seed sowing dates, set sizes and their interaction

Table 8a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	16.62	16.43	18.62	17.22
V_2 : S-1	18.93	18.25	18.50	18.56
Mean	17.78	17.34	18.56	

Table 8b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	17.75	17.50	17.37	18.50	17.78
D_2 : 15th Jan	18.50	17.50	17.50	15.87	17.34
D_3 :1st Feb.	19.37	16.00	20.37	18.50	18.56
Mean	18.54	17.00	18.41	17.62	

Table 8c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	17.50	15.00	19.50	16.91	17.22
V_2 : S-1	19.58	19.00	17.33	18.33	18.56
Mean	18.54	17.00	18.41	17.62	

Table 8d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	17.75	17.00	17.75	17.75	20.00	21.00	18.54
S_2 : 1.5-2.0 cm	15.00	16.00	14.00	20.00	19.00	18.00	17.00
S_3 : 1-1.5 cm	17.75	17.00	23.75	17.00	18.00	17.00	18.41
S_4 : 0.5-1 cm	16.00	15.75	19.00	21.00	16.00	18.00	17.62
Mean	16.62	16.43	18.62	18.93	18.25	18.50	

Table 6e. ANOVA

Variety	SE	CD (5 %)
V	0.289	0.81
D	0.354	0.99
S	0.409	1.15
V x D	0.501	1.41
D x S	0.708	1.99
V x S	0.578	1.63
V x D x S	1.415	3.98

4.2.2 Average number of leaves

The data of Table 8e revealed that number of leaves per plant of bulb crop was significantly influenced by all factors and all interactions.

Among the factor variety (V), the cv. S-1 produced significantly more i.e. 18.56 leaves/plant than cv. B-780, which produced 17.22 leaves/plant (Table 8a). Among the factor, sowing date, D_3 (1st February) was the superior date (18.56 leaves/plant) over remaining two dates. D_1 and D_2 i.e. 17.78 and 17.34 leaves/plant respectively) while among the factor set size, large set size produced the highest number of leaves (18.53) than S_2 set size and it was at par with S_3 and S_4.

The first order interaction i.e. VD, DS and VS also significantly influenced the character number of leaves/plant. In VD interaction more number of leaves i.e. 18.93 leaves/plant were noticed in V_2D_1, followed by V_1D_3 (18.62) and V_2D_3 (18.50) (Table 8a).

Data pertaining to DS interaction (Table, 8b) revealed that, D_3S_3 recorded significantly more leaves (i.e. 19.37 leaves/plant), over combination D_2S_4 and D_3S_2 (15.87 and 16.00, respectivly).

VS interaction revealed that significantly higher number of leaves were recorded by treatment V_2S_1 (19.58) followed by V_1S_3 (19.60) and V_2S_2 (19.00) which were at par with other (Table 8c).

In second order interaction i.e. VDS the data of Table 8d revealed that significantly highe number of leaves per plant were recorded by treatment $V_1D_3S_3$ (23.75) followed by $V_2D_1S_4$ and $V_2D_3S_1$ (21.00) over rest of treatment but at par with each other.

Table 9. Per cent premature bolting as influenced by varying *varieties, seed sowing dates, set-sizes and interactions*

(Figures in the paranthesis indicates arc sin transformed values)

Table 9a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	2.22 (8.27)	1.03 (5.84)	2.45 (8.16)	1.90 (7.42)
V_2 : S-1	0.84 (5.38)	0.97 (5.91)	2.20 (8.10)	1.34 (6.46)
Mean	1.53 (6.83)	1.00 (5.87)	2.33 (8.13)	

Table 9b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	2.93 (9.11)	1.99 (7.76)	0.37 (4.79)	0.82 (5.65)	1.53 (6.83)
D_2 : 15th Jan	0.94 (5.83)	1.93 (7.26)	0.86 (5.80)	0.27 (4.60)	1.00 (5.87)
D_3 :1st Feb.	4.79 (11.91)	0.65 (5.34)	2.74 (9.20)	1.12 (6.06)	2.33 (8.13)
Mean	2.89 (8.95)	1.52 (6.79)	1.32 (6.60)	0.74 (5.44)	

Table 9c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	3.30 (9.71)	2.03 (7.57)	1.73 (7.31)	0.55 (5.11)	1.90 (7.42)
V_2 : S-1	2.48 (8.19)	1.01 (6.01)	0.92 (5.89)	0.93 (5.76)	1.34 (6.46)
Mean	2.89 (8.95)	1.52 (6.79)	1.32 (6.60)	0.74 (5.44)	

Table 9d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	3.45 (10.65)	0.73 (5.50)	5.71 (12.98)	2.41 (7.57)	1.16 (6.15)	3.87 (10.84)	2.89 (8.95)
S_2 : 1.5-2.0 cm	3.02 (9.65)	2.27 (7.42)	0.80 (5.62)	0.96 (5.86)	1.59 (7.11)	0.50 (5.07)	1.52 (6.79)
S_3 : 1-1.5 cm	0.75 (5.54)	1.14 (6.38)	3.29 (10.00)	0.50 (4.05)	0.58 (5.23)	2.20 (8.40)	1.32 (6.60)
S_4 : 0.5-1 cm	1.65 (7.24)	0.50 (4.05)	0.50 (4.05)	0.50 (4.05)	0.54 (5.15)	2.25 (8.07)	0.74 (5.44)
Mean	2.22 (8.27)	1.03 (5.84)	2.45 (8.16)	0.84 (5.38)	0.97 (5.91)	2.20 (8.10)	

Table 9e. ANOVA

Variety	SE	CD (5 %)
V	0.526	NS
D	0.645	NS
S	0.745	2.10
V x D	0.912	NS
D x S	1.290	3.64
V x S	1.053	2.97
V x D x S	2.580	7.26

4.2.3 Percentage premature bolting

Data of table revealed that premature bolting was significantly influenced by the factor size of sets and interaction DS, VS and VDS (Table 9e).

Large sized sets (S_1) recorded significantly higher premature bolting (2.89 %) than other three sizes, while small sized sets (S_4) showed least bolting (0.74 %) (Table 9d). It was noticed that percentage of premature bolting was decreased as the size of sets decreased and vice versa.

Among the interactions significantly more premature bolting was observed in D_3S_1 interaction (4.79 %, table 9b) followed by D_1S_1 (2.93 %), while the interaction D_2S_4 and D_1S_4 showed significantly lower bolting i.e. 0.27 per cent and 0.82 per cent respectively.

However in the three way interaction (Table 9d) $V_1S_1D_3$ showed maximum (5.71 %) premature bolting while minimum bolting (0.5 %) was observed in $V_2D_2S_2$, $V_2D_1S_3$, $V_1D_2S_4$, $V_1D_3S_4$ and $V_2D_1S_4$ interactions.

Table 10. Per cent twin bulbs as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 10a. V x D (Figures in the paranthesis indicates arc sin transformed values)

Variety	Sowing dates			Mean
	D_1 (1[st] Jan.)	D_2 (15[th] Jan.)	D_3 (1[st] Feb.)	
V_1 : B-780	0.93 (5.44)	0.72 (4.80)	0.18 (2.50)	0.61 (4.44)
V_2 : S-1	2.93 (9.80)	0.14 (1.81)	0.29 (3.14)	1.12 (6.02)
Mean	1.93 (7.92)	0.43 (3.63)	0.24 (2.50)	

Table 10b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1[st] Jan.	6.26 (14.42)	0.64 (4.44)	0.48 (3.63)	0.34 (3.14)	1.93 (7.92)
D_2 : 15[th] Jan	0.36 (3.14)	0.72 (4.80)	1.21 (6.29)	0.97 (5.44)	0.43 (3.63)
D_3 :1[st] Feb.	0.59 (4.05)	0.00 (0.00)	0.00 (0.00)	0.36 (3.14)	0.24 (2.50)
Mean	2.40 (8.91)	0.45 (3.63)	0.37 (3.14)	0.23 (2.50)	

Table 10c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	0.72 (4.80)	0.50 (4.05)	0.75 (4.80)	0.47 (3.63)	0.61 (4.44)
V_2 : S-1	4.09 (11.54)	0.40 (3.63)	0.00 (0.00)	0.00 (0.00)	1.12 (6.02)
Mean	2.40 (8.91)	0.45 (3.63)	0.37 (3.14)	0.23 (2.50)	

Table 10d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	1.42 (3.63)	0.73 (4.80)	0.00 (0.00)	1.51 (4.05)	0.00 (0.00)	1.18 (6.29)	2.40 (8.91)
S_2 : 1.5-2.0 cm	0.64 (4.44)	0.86 (5.13)	0.00 (0.00)	0.64 (4.44)	0.58 (4.05)	0.00 (0.00)	0.45 (3.63)
S_3 : 1-1.5 cm	0.96 (5.44)	1.30 (6.55)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.37 (3.14)
S_4 : 0.5-1 cm	0.69 (4.44)	0.00 (0.00)	0.73 (4.80)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.23 (2.50)
Mean	0.93 (5.44)	0.72 (4.80)	0.18 (2.50)	2.93 (9.80)	0.14 (1.81)	0.29 (3.14)	

Table 10e. ANOVA

Variety	SE	CD (5 %)
V	0.160	NS
D	0.197	NS
S	0.227	NS
V x D	0.278	0.78
D x S	0.394	1.11
V x S	0.321	0.90
V x D x S	0.787	NS

4.2.4 Percent twin bulbs

Data of Table 10e revealed that no any factor individually influenced the character percent twin bulbs but first order interactions of them influenced significantly.

In interaction VD (Table 10a), treatment V_2D_1 showed significantly higher twin bulb (2.93 %) over rest of treatments. Ingeneral early sowing dates recorded higher twin bulbs than late dates. Later sowing recorded minimum twin bulbs i.e. combinations, V_2D_2 and V_1D_3 showed least doubling (i.e. 0.14 and 0.18 %, respectively).

In interaction of set size and twin bulbs (D x S, Table 10b) the significantly higher twin bulbs (6.26 %) was recorded by treatment D_1S_1 over rest. No twin bulbs were observed in combinations D_3S_2 and D_3S_3 (i.e. 0.00 %).

In three factor interaction, treatment $V_2D_1S_1$ recorded higher twin bulbs (1.52 %), while no twin bulbs were observed in treatments $V_1D_3S_1$, $V_2D_2S_1$, $V_1D_3S_2$, $V_2D_3S_2$, $V_1D_3S_3$, $V_2D_1S_3$ $V_2D_2S_3$, $V_2D_3S_3$, $V_1D_2S_4$, $V_2D_1S_4$, $V_2D_2S_4$ and $V_2D_3S_4$ (Table 10d).

Table 11. Days required for 50 % top fall (i.e. days for maturity) as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 11a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	73.25	73.81	71.31	72.79
V_2 : S-1	62.87	63.62	63.43	63.31
Mean	68.06	68.71	67.37	

Table 11b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	69.25	67.12	68.25	67.62	68.06
D_2 : 15th Jan	70.50	68.87	68.12	67.37	68.71
D_3 :1st Feb.	67.87	68.25	67.75	65.62	67.37
Mean	69.20	68.08	68.04	66.87	

Table 11c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	73.91	72.66	72.91	71.66	72.79
V_2 : S-1	64.50	63.50	63.16	62.08	63.31
Mean	69.20	68.08	68.04	66.87	

Table 11d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	74.25	75.00	72.50	64.25	66.00	63.25	69.20
S_2 : 1.5-2.0 cm	72.25	73.50	72.25	62.00	64.25	64.25	68.08
S_3 : 1-1.5 cm	73.25	74.25	71.25	63.25	62.00	64.25	68.04
S_4 : 0.5-1 cm	73.25	72.50	69.25	62.00	62.25	62.00	66.87
Mean	73.25	73.81	71.31	62.87	62.62	63.43	

Table 11e. ANOVA

Variety	SE	CD (5 %)
V	0.320	0.90
D	0.393	1.10
S	0.453	1.28
V x D	0.555	1.56
D x S	0.786	2.21
V x S	0.641	1.81
V x D x S	1.560	4.39

Plate-3. Top fall of bulb crop at harvesting stage (sing of physiological maturity)

A) Cv. B-780 at 70-75 DAP

Cv. Baswant-780 not showing symptoms of regular top-fall but bending of individual leaf (70-75 days)

B) Cv. S-1 (Phule Samarth) at 60-65 DAP

Cv. S-1 (Phule Samarth) display peculiar symptoms of top fall at 60-65 DAP crop stage

4.2.5 Days required for 50 per cent top-fall (i.e. Days for maturity)

This character is prime important character in onion as it is sign for physiological maturity.

Days required for 50 per cent top-fall was significantly influenced by all factors as well as all interactions (Table 11e). In case of cv. B-780 instead of ~~instead~~ of foliage top-fall individual leaf bending was noticed. However cv. S-1 displayed distinguished foliage top-fall as sign of physiological maturity in *kharif* season.

Cultivar S-1 required significantly less days for maturity (i.e. 63.31 days) than the cv. B-780 (i.e. 72.79 days) (Table 11a).

Eventhough the factor date of seed sowing (d) showed significant variation for days to maturity, it was narrow ranged i.e. 67.51 (D_3) to 68.71 (D_2) days.

Similarly, factor set size displayed narrow ranged variation (66.87 by S_4 to 69.20 days by S_1, Table 11d) among the four set sizes.

In variety and seed sowing dates interaction (i.e. V x D, Table 11a) the significantly minimum days to maturity (62.87) was recorded by treatment V_2D_1 which was at par with V_2D_3 and V_2D_2 (63.43 and 63.62 days, respectively). Thus, it showed clear idea about cv. S-1 for earliness.

Similarly in DS and VS interactions, significantly early maturity was found in D_3S_4 (Table 11b) and V_2S_4 (Table 11c) treatment combinations i.e. 65.62 and 62.08 days respectively, while late maturity was observed in combinations D_2S_1 and V_1S_1 i.e. 70.50 and 73.91 days respectively.

However when VDS interaction was considered, it was found that $V_1D_1S_1$ recorded maximum (i.e. 74.25 days for maturity), while combinations of cv. S-1 i.e. $V_2D_1S_2$, $V_2D_1S_4$ and $V_2D_3S_4$ showed 50 per cent top fall quite early i.e. within 62 days only.

Table 12 Total yield of bulbs (q/ha) as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 12a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	146.73	180.23	180.23	168.84
V_2 : S-1	153.43	169.51	178.22	166.83
Mean	150.08	174.87	178.89	

Table 12b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 : 1st Jan.	158.79	166.16	146.06	128.64	150.08
D_2 : 15th Jan	196.98	162.14	179.56	161.47	174.87
D_3 : 1st Feb.	194.97	175.54	215.07	131.32	178.89
Mean	183.58	168.17	180.23	140.70	

Table 12c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	186.93	170.18	188.27	131.32	168.84
V_2 : S-1	180.90	165.49	172.19	149.41	166.83
Mean	183.58	168.17	180.23	140.70	

Table 12d. V x D x S

Set size	*Variety and sowing dates (V x D)*						*Mean*
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	163.48	201.00	194.97	154.43	192.29	194.97	183.58
S_2 : 1.5-2.0 cm	182.04	164.82	164.15	150.75	159.46	186.93	168.17
S_3 : 1-1.5 cm	126.63	194.97	243.88	166.16	163.48	186.93	180.23
S_4 : 0.5-1 cm	113.90	160.80	119.26	143.38	162.81	142.71	140.70
Mean	146.73	180.23	180.23	153.43	169.51	178.22	

Table 12e. ANOVA

Variety	SE	CD (5 %)
V	5.829	NS
D	7.102	20.10
S	8.241	23.24
V x D	10.050	NS
D x S	14.271	40.26
V x S	11.658	32.89
V x D x S	*28.542*	*80.26*

4.2.6 Total yield (q/ha)

The data of Table 12 (e) revealed that total yield of bulbs (q/ha) was greatly influenced by the factor sowing dates (D) and size of sets (S) and interactions i.e. DS, VS and VDS, while no significant difference was observed in yields of two varieties.

Among the factors sowing date (Table 12a) D_3 and D_2 (i.e. 1st February and 15 January) recorded significantly higher yields over D_1 (1st January) (ie. 150.80 q/ha) and were at par with each other (178.89 and 174.87 q/ha respectively).

Among the factors set-size (Table 12b) generally maximum yields were recorded with larger set sizes and reduction in yield was noticed with smaller set size. The higher bulb yield

(183.58 q/ha) was recorded with S_1 (2.1-2.5 cm) set sized followed by S_3 (180.23 q/ha) and S_2 (168.17 q/ha) which were at par with each other but significantly superior over S_4 set size (140.70 q/ha).

Among the interaction, D x S showed significantly higher yields with treatment combinations D_3S_3 (215.07 q/ha) followed by D_2S_1 (196.98 q/ha) and D_3S_1 (194.97 q/ha) over rest but at par with each other (Table 12b).

In VS interaction (Table 12c) significantly higher yields were obtained with V_1S_3 (188.27 q/ha) and V_1 S_1 (186.93 q/ha) over V_1S_4 (131.32 q/ha).

In three way interaction (Table 12d) the maximum yield was recorded with combination of $V_1D_3S_3$ (243.88 q/ha) followed by $V_1D_2S_1$ (201.0 q/ha) which was at par with each other but $V_1D_3S_3$ was significantly superior over $V_2D_2S_2$, $V_2D_1S_1$, $V_2D_1S_4$, $V_2D_3S_4$, $V_1D_1S_3$ and $V_1D_1S_4$ where yields were lower than 163 q/ha.

Table 13. Marketable yield of bulbs (%)as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 13a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	76.97	79.81	81.31	79.36
V_2 : S-1	77.01	78.09	80.54	78.54
Mean	76.99	78.95	80.92	

Table 13b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 : 1st Jan.	76.83	76.52	77.90	76.70	76.99
D_2 : 15th Jan	79.98	78.32	82.39	75.11	78.95
D_3 : 1st Feb.	79.76	85.43	78.63	79.89	80.92
Mean	78.86	80.09	79.64	77.23	

Table 13c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	78.61	82.23	79.45	77.17	79.36
V_2 : S-1	79.10	77.95	79.83	77.30	78.54
Mean	78.86	80.09	79.64	77.23	

Table 13d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	77.90	79.10	78.84	75.77	80.87	80.68	78.86
S_2 : 1.5-2.0 cm	78.40	83.34	84.97	74.65	73.31	85.89	80.09
S_3 : 1-1.5 cm	75.42	81.41	81.52	80.38	83.38	75.75	79.64
S_4 : 0.5-1 cm	79.17	75.42	79.93	77.24	74.81	79.85	77.23
Mean	76.97	79.81	81.31	77.01	78.09	80.54	

Table 13e. ANOVA

Variety	SE	CD (5 %)
V	0.477	NS
D	0.584	1.64
S	0.674	1.90
V x D	0.826	2.33
D x S	1.168	3.29
V x S	0.954	2.69
V x D x S	2.336	6.57

4.2.7 Percent marketable yield

Data presented in Table 13e revealed that percent marketable yield was significantly influenced by factors, seed sowing date (D) and size of sets (S) & also by all interactions, while factor variety didn't show any influence.

Among the factor date of seed sowing, (Table 13a) significant yield increase was observed as date proceeding from D_1 to D_3. The maximum yield was noticed at D_3 (80.92 %) while minimum at D_1 (76.99 %).

Among the factor, set size (Table 13b) S_2, S_3 and S_1 were at par and recorded marketable bulb yield of 80.09, 79.64 and 78.86 per cent respectively, while least marketable bulb yield was obtained with size S_4 (small sized sets) i.e. 77.23 per cent which was at par with S_1 set size.

Among the interactions, the best, significantly superior treatment for marketable bulb yields were D_3S_2 (85.43 %, Table 13b) V_1S_2 (82.23 %, Table 13c), V_1D_3 (81.31 %, Table 13a) and $V_2D_3S_2$ (85.89 %, Table 13d).

Table 14. Average bulb neck thickness (cm) as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 14a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	1.86	1.75	1.62	1.74
V_2 : S-1	0.81	0.91	0.90	0.87
Mean	1.33	1.33	1.26	

Table 14b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1[st] Jan.	1.33	1.34	1.32	1.34	1.33
D_2 : 15[th] Jan	1.37	1.28	1.38	1.29	1.33
D_3 :1[st] Feb.	1.24	1.29	1.07	1.44	1.26
Mean	1.31	1.30	1.26	1.35	

Table 14c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	1.71	1.72	1.68	1.86	1.74
V_2 : S-1	0.91	0.80	0.84	0.85	0.87
Mean	1.31	1.30	1.26	1.35	

Table 14d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	1.73	1.77	1.64	0.93	0.97	0.84	1.31
S_2 : 1.5-2.0 cm	1.95	1.62	1.61	0.74	0.95	0.97	1.30
S_3 : 1-1.5 cm	1.86	1.90	1.28	0.79	0.86	0.87	1.26
S_4 : 0.5-1 cm	1.91	1.72	1.96	0.78	0.86	0.92	1.35
Mean	1.86	1.75	1.62	0.81	0.91	0.90	

Table 14e. ANOVA

Variety	SE	CD (5 %)
V	0.034	0.09
D	0.042	NS
S	0.048	NS
V x D	0.059	0.16
D x S	0.084	0.23
V x S	0.068	0.19
V x D x S	0.168	0.47

4.2.8 Average bulb-neck thickness (cm)

Data of table 14 (e) revealed that character bulb-neck thickness was significantly influenced by factor variety and all interactions.

Among the factor variety, the cv. S-1 recorded significantly thin bulb neck (0.87 cm) over cv. B-780 (1.74 cm) (Table 14a).

Among the interactions V x D (Table 14a) the treatment V_2D_1 (cv. S-1 and sowing date 1st January) showed the most thin bulb neck (0.81 cm) followed by V_2D_3 and V_2D_1 (0.90 and 0.91 cm, respectively) which were at par with each other but recorded significantly thin bulb neck over three other combinations with cv. B-780 (i.e. V_1).

In VS interaction (Table 14c) the significant bulb neck was recorded with combinations of cv. S-1 i.e. V_2S_2, V_2S_3, V_2S_4 and V_2S_1 (0.80, 0.84, 0.85, 0.89 cm respectively) over four other combinations of cv. Baswant-780).

In DS interaction (Table 14b) the significantly minimum neck-thickness was observed with D_3S_3 (i.e. 1.07 cm), followed by D_3S_1 (1.24 cm) over rest.

In three way interaction (Table 14d) also clear cut difference was noticed with the factor variety. Ingeneral combination with cv. S-1 showed bulb thickness less than 1.0 cm however most of treatment combinations with cv. S-1 showed bulb neck-thickness less than 1.0 cm however most of that with cv. B-780 recorded bulb neck thickness above 1.50 cm. In particular the most thick neck (0.74 cm) was noticed with $V_2D_1S_2$ while the most thick bulb neck was recorded with $V_1D_3S_4$ (1.96 cm) followed by $V_1D_1S_2$ (1.95 cm).

Table 15. Average bulb weight (g) as influenced by varieties, seed sowing dates, set sizes and their interactions

Table 15a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	67.24	75.48	75.19	72.64
V_2 : S-1	68.75	71.02	79.14	72.97
Mean	68.00	73.25	77.17	

Table 15b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	72.68	67.47	64.18	67.66	68.00
D_2 : 15th Jan	78.51	75.38	72.32	66.80	73.25
D_3 :1st Feb.	79.55	76.81	79.27	73.03	77.17
Mean	76.91	73.22	71.92	69.17	

Table 15c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	81.32	79.13	68.48	61.61	72.64
V_2 : S-1	72.50	67.31	75.36	76.72	72.97
Mean	76.91	73.22	71.92	69.17	

Table 15d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	83.55	81.78	78.63	61.81	75.24	80.46	76.91
S_2 : 1.5-2.0 cm	71.87	87.70	77.82	63.07	63.05	75.80	73.22
S_3 : 1-1.5 cm	53.36	73.23	78.86	75.00	74.41	79.68	71.92
S_4 : 0.5-1 cm	60.19	59.20	65.45	75.14	74.41	80.62	69.17
Mean	67.24	75.48	75.19	68.75	71.02	79.14	

Table 15e. ANOVA

Variety	SE	CD (5 %)
V	1.715	NS
D	2.101	5.92
S	2.426	6.84
V x D	2.971	NS
D x S	3.431	NS
V x S	4.202	11.85
V x D x S	8.404	23.65

4.2.9 Average bulb-weight (g)

From the data recorded in Table 15e showed that significant differences were observed in average bulb weight by the factors seed sowing dates (D) and set-sizes (S). Also the interactions VS and VDS significantly influenced the character.

Among the factor seed sowing dates (D, Table 15a) it was noticed that bulb weight showed increasing trend along with sequential sowing dates. Thus, the highest bulb weight was recorded with D_3 (77.17 g) followed by D_2 (73.25 g) and D_1 (68.0 g) where D_3 was at par with D_2 but significantly superior over D_1.

Among the factor set-size (S_1 table 15b) it was noticed that bulb weight reduced as set size got smaller. The highest bulb-weight was recorded with S_1 (76.91 g) followed by S_2 and S_3 (73.22 and 71.92 g) which were at par with each other.

Among the interactions, the significantly superior treatments in VS combination (Table 15c) was V_1S_1 (81.32 g); while $V_1D_2S_2$ (87.70 g) in VDS interaction (Table 15d).

Table 16. Average equatorial diameter of bulb (cm) as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 16a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	5.23	5.14	5.44	5.27
V_2 : S-1	4.93	4.99	5.38	5.10
Mean	5.08	5.07	5.41	

Table 16b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	5.42	5.30	4.72	4.88	5.08
D_2 : 15th Jan	5.23	5.15	5.17	4.73	5.07
D_3 :1st Feb.	5.42	5.45	5.66	5.11	5.41
Mean	5.36	5.30	5.18	4.91	

Table 16c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	5.52	5.48	5.18	4.91	5.27
V_2 : S-1	5.20	5.11	5.18	4.91	5.10
Mean	5.36	5.30	5.18	4.91	

Table 16d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	5.78	5.32	5.46	5.07	5.15	5.39	5.36
S_2 : 1.5-2.0 cm	5.50	5.53	5.42	5.10	4.77	5.47	5.30
S_3 : 1-1.5 cm	4.74	5.04	5.78	4.69	5.30	5.55	5.18
S_4 : 0.5-1 cm	4.91	4.69	5.12	4.86	4.77	5.11	4.91
Mean	5.23	5.14	5.44	4.93	4.99	5.38	

Table 16e. ANOVA

Variety	SE	CD (5 %)
V	0.069	NS
D	0.084	0.23
S	0.097	0.27
V x D	0.119	0.33
D x S	0.139	0.47
V x S	0.138	0.38
V x D x S	0.338	0.95

4.2.10 Equatorial bulb diameter (cm)

The data pertaining to equatorial diameter influenced by various treatmentsare presented in Table 16.

The data of Table 16 (e) showed that equatorial diameter was significantly influenced by factor sowing dates (D), size of sets (S) and interactions VD, DS, VS and VDS.

Among the factor D (Table 16a) the maximum equatorial diameter (5.42 cm) was observed with sowing date 1st February (D_3) over sowing date 1st January (D_1, 5.08 cm)§ 15th January (D_2 5.07 cm).

Among the factor size of sets (Table 16b) the larger set-size (S_1) recorded significantly more equatorial diameter i.e. (5.36 cm) over smaller set-size i.e. S_4 (4.91 cm). Decreasing trend in equatorial diameter was observed with decrease in set-size which was recorded minimum in small sized (S_4) sets.

In VD interactions (table 16a), maximum equatorial diameter was recorded with V_1D_3 (5.45 cm) followed by V_2D_3 (5.38 cm).

DS interaction (Table 16b) significantly influenced equatorial diameter of bulb. The maximum diameter was recorded in D_3S_3 (5.66 cm); while the interaction D_1S_3 recorded least (i.e. 4.72 cm)

In VS interaction (Table 16c) the combination V_1S_2 was the most superior (5.48 cm) over all other interactions.

Data presented in three way interaction reveals that maximum equatorial diameter was obtained in interactions $V_1D_1S_1$ and $V_1D_3S_3$ (i.e. 5.78 cm) which was significantly superior over $V_2D_1S_3$ and $V_1D_2S_4$ (i.e. 4.69 cm).

Table 17. Average polar diameter of bulbs (cm) as influenced by varying varieties sowing dates, set-sizes and their interactions

Table 17a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	4.75	5.13	5.27	5.05
V_2 : S-1	5.13	5.30	5.45	5.30
Mean	4.94	5.22	5.36	

Table 17b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	5.23	5.14	4.50	4.91	4.94
D_2 : 15th Jan	5.23	5.29	5.30	5.05	5.22
D_3 :1st Feb.	5.40	5.41	5.66	4.97	5.36
Mean	5.29	5.28	5.15	4.98	

Table 17c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	5.24	5.25	4.95	4.77	5.05
V_2 : S-1	5.33	5.31	5.36	5.18	5.30
Mean	5.29	5.28	5.15	4.98	

Table 17d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_3	V_2D_1	V_1D_2	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	5.27	5.17	5.30	5.20	5.30	5.50	5.29
S_2 : 1.5-2.0 cm	5.18	5.33	5.25	5.10	5.25	5.58	5.28
S_3 : 1-1.5 cm	3.92	5.18	5.43	5.08	5.43	5.58	5.15
S_4 : 0.5-1 cm	4.66	4.86	5.25	5.15	5.25	5.15	4.98
Mean	4.75	5.13	5.30	5.13	5.30	5.45	

Table 17e. ANOVA

Variety	SE	CD (5 %)
V	0.071	0.20
D	0.087	0.24
S	0.100	0.28
V x D	0.123	0.34
D x S	0.174	0.49
V x S	0.142	0.40
V x D x S	0.349	0.98

4.2.11 Average polar bulb diameter (cm)

The data of Table 17e revealed that the significant differences were noticed by all factorsand their interactions.

Among the factor V (Table 17a) it was observed that cv. S-1 recorded significantly more polar diameter (5.3 cm) than the cv. B-780 (5.05 cm). However among the sowing date D_3 (1st February) showed maximum polar diameter (5.36 cm), followed by 15th January (5.22 cm), which were at par with each other.

Among the factor set size, the larger sets (S_1) recorded significantly more polar diameter (5.29 cm) over smaller sets i.e. S_4 (4.98 cm). It was noticed that polar diameter get reduced with smaller set size (Table 17b).

Among the interactions, the significantly superior treatments were V_2S_3 (5.36 cm, table 17c) D_3S_3 (5.66 cm, table 17b), V_2D_3 (5.45 cm, table 17a) and $V_2D_3S_2$ and $V_2D_3S_3$ (5.58 cm, table 17d).

Plate-4. **Plant growth and bulb development at 30 DAP and 60 DAP crop stage**

A) At 30 DAP

Cv. Baswant-780

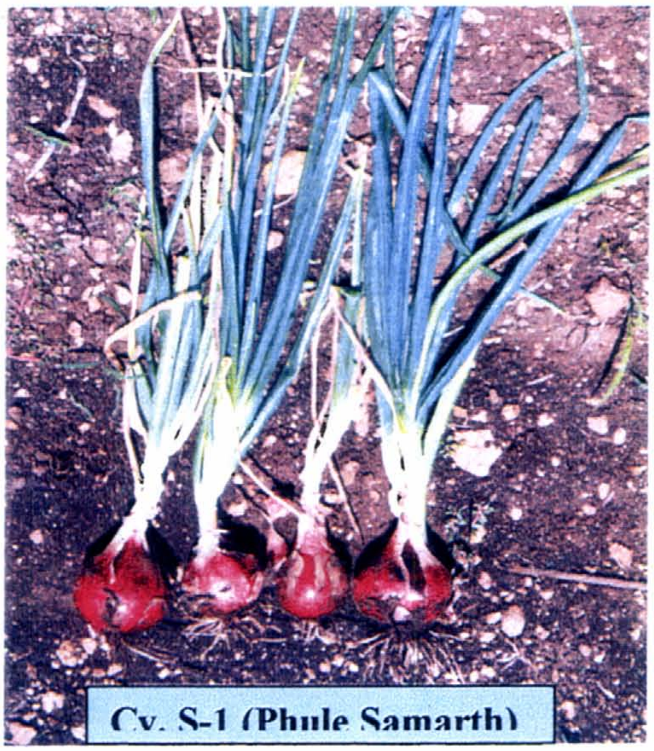
Cv. S-1 (Phule Samarth)

a. Seedling growth (control)
b. Growth of (S_1) onion sets (> 2 cm dia.)
c. Growth of medium large (S_2) onion sets (1.5-2 cm)
d. Growth of medium (S_3) onion sets (1-1.5 cm dia)
e. Growth of small (S4) onion sets (0.5-1 cm dia.)

B) At 60 DAP

Seedling growth (60 DAS)

Set development (60 DAP)



4.2.12 Periodical percent increase in bulb development of onion sets (basis : equatorial diameter)

A percent increase in bulb development of onion set was estimated on the basis of equatorial diameter. A formula given on page 17 was used for estimation. The observations were recorded at 25, 50 and 65 DAP i.e. at vegetative, bulb development and bulb maturation stages. At each stage the bulbs of four grades i.e. S_1 (2.3 cm), S_2 (1.7 cm), S_3 (1.3 cm) and S_4 (0.7 cm) of onion sets were used for estimation of bulb development.

Table 18. Per cent increase in bulb development of onion sets at 25, 50 and 65 DAP

Table 18a. At 25 days

	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)
V_1 : B-780	15.93	19.70	3.97	71.42
V_2 : S-1	18.83	22.81	46.15	90.47

Table 18b. At 50 days

	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)
V_1 : B-780	95.64	114.81	187.17	404.76
V_2 : S-1	92.30	105.83	283.51	433.33

Table 18c. At 65 days

	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)
V_1 : B-780	138.54	207.03	304.86	600.94
V_2 : S-1	126.22	194.01	298.45	582.85

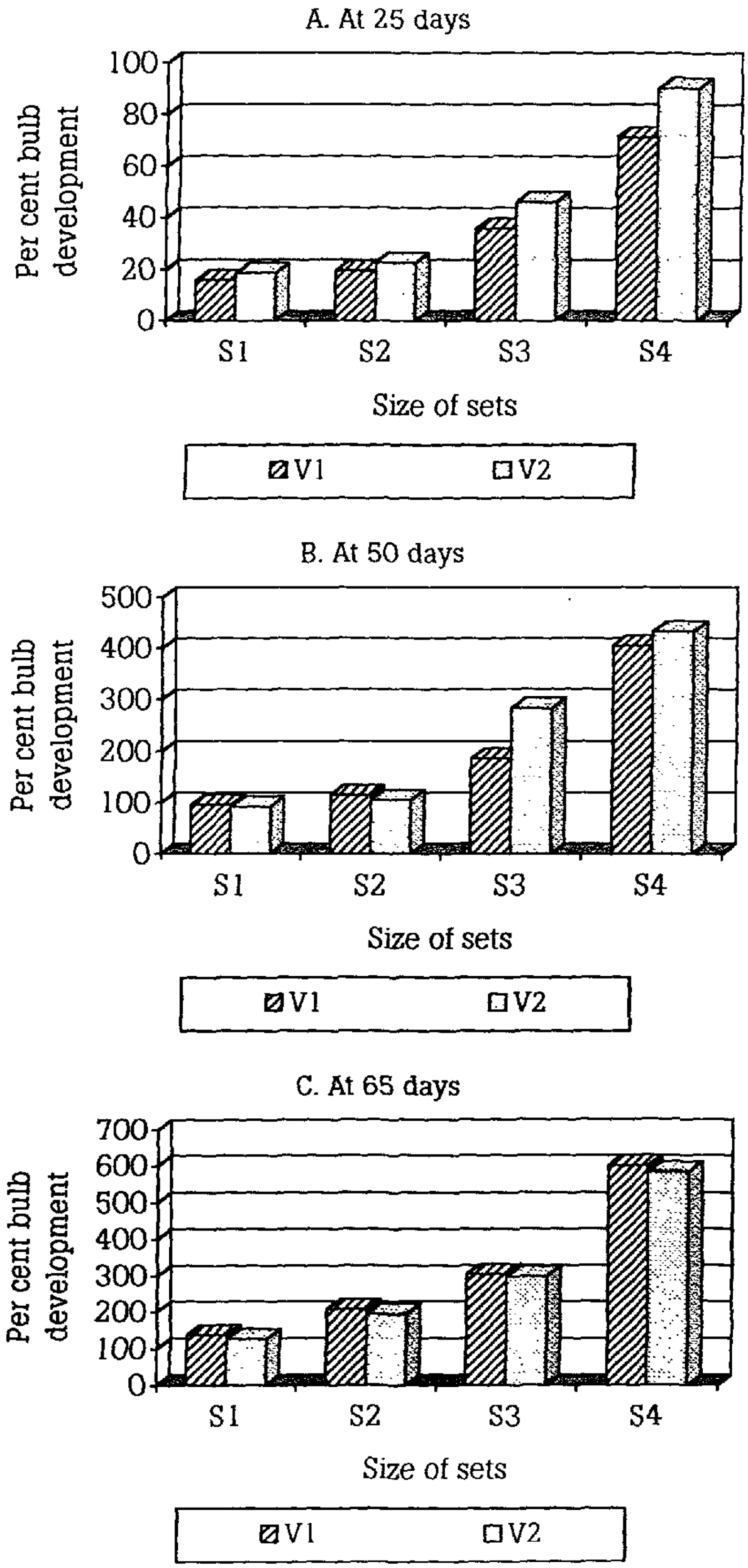


Fig. 1. Periodical per cent increase in bulb development (equatorial diameter) over initial size of sets

4.2.12.1 At 25 DAP (i.e. at vegetative growth stage)

Among the four grades of onion set, the most speedy bulb development was recorded in smaller sets i.e. S_4 size (71.42-90.47% increase) while it was gradually slow down with bigger bulb sets. The minimum increase in bulb development was observed in large (S_1) sized onion sets (15.93-18.83 %).

In initial period, the growth of cv. S-1 bulbs was faster than the cv. B-780.

4.2.12.2 At 50 DAP (i.e. at bulb development stage)

During this particular period bulb development was acutely increased with four times than the earlier stage. In particular the increase in bulb development was within range of 407.76 to 433.33 per cent with smaller (S_4) set size while it was 92.3 to 95.64 per cent with longer (S_1) set size. The similar trend was noticed for effect of set size on bulb development but similar bulb development noticed between two varieties for S_1 and S_2 set sizes but bulb development of cv. S-1 was faster than cv. B-780 for S_3 and S_4 set sizes.

4.2.12.3 At 65 DAP (Bulb maturation stage)

As bulbs of cv. S-1 showed maturity symptom at 65 DAP, the observation were recorded at 65 DAP instead of 75 DAP.

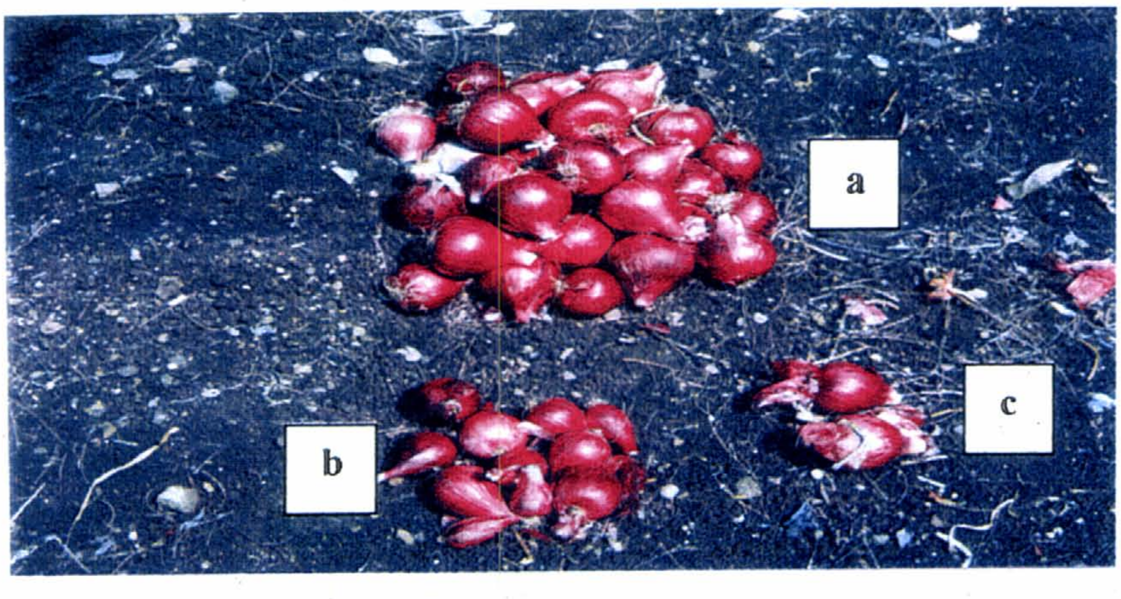
At this stage, progressive increase in bulb development was noticed with 582.85-600.94 per cent increase with S_4 set size and 126.22-138.34 per cent with S_4 set size. However, with S_1 and S_2 set sizes the growth rate of cv. S-1 was reduced than cv. B-780

Plate-5. Curing & grading of bulbs under shade

A) Prolong bulb curing (10-12 days) of Cv. B-780 due to profuse foliage growth

B) Fast bulb curing (7-9 days) of Cv. S-1 (Phule Samarth) due to controlled vegetative growth

C) Grading of onion bulbs Cv. S-1 (Phule Samarth)



a) Grade I (Large medium bulbs)

b) Grade II (Small bulb)

c) Grade III (Bulbs with premature bolts) indicating the bulb maturity of cv. S-1. While with S-3 and S-4 set sizes the more or less similar increase in bulb development of two cultivars was observed showing active growth of onion bulbs.

4.3 Effect of set-planting on storage of onion bulbs

The data pertaining to different storage losses (i.e. rotting, sprouting, PLW and total) are presented in Table 18 to 21 in percent values as well as arc sin conversions.

Table 19. Per cent rotting losses in storage as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 19a. V x D (Figures in the paranthesis indicates arc sin transformed values)

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	13.10 (20.51)	13.19 (20.37)	11.38 (18.76)	12.55 (19.88)
V_2 : S-1	8.88 (16.12)	9.74 (17.33)	11.48 (18.61)	10.04 (17.35)
Mean	10.99 (18.32)	11.47 (18.85)	11.43 (18.68)	

Table 19b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	9.66 (16.37)	11.99 (19.99)	10.15 (17.41)	12.17 (19.50)	10.99 (18.32)
D_2 : 15th Jan	11.42 (18.84)	11.08 (18.44)	11.47 (18.81)	11.91 (19.32)	11.47 (18.85)
D_3 :1st Feb.	14.31 (21.98)	10.88 (18.41)	6.91 (12.79)	13.62 (21.55)	11.43 (18.68)
Mean	11.79 (19.06)	11.31 (18.95)	9.51 (16.34)	12.56 (20.12)	

Table 19c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	14.07 (21.11)	12.44 (20.03)	12.15 (19.66)	11.56 (18.73)	12.55 (19.88)
V_2 : S-1	9.52 (17.02)	10.19 (17.87)	6.87 (13.01)	13.57 (21.51)	10.04 (17.35)
Mean	11.79 (19.06)	11.31 (18.95)	9.51 (16.34)	12.56 (20.12)	

Table 19d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	14.69 (21.87)	12.69 (19.20)	14.84 (22.25)	4.64 (10.87)	10.15 (18.49)	13.78 (21.70)	11.79 (19.06)
S_2 : 1.5-2.0 cm	12.79 (20.84)	15.76 (23.32)	8.78 (15.92)	11.19 (19.13)	6.40 (13.57)	12.99 (20.90)	11.31 (18.95)
S_3 : 1-1.5 cm	13.33 (21.13)	13.45 (21.33)	9.67 (16.53)	6.97 (13.68)	9.49 (16.30)	4.16 (9.06)	9.51 (16.34)
S_4 : 0.5-1 cm	11.59 (18.22)	10.87 (17.66)	12.23 (20.32)	12.75 (20.79)	12.95 (20.97)	15.02 (22.77)	12.56 (20.12)
Mean	13.10 (20.51)	13.19 (20.37)	11.38 (18.76)	8.88 (16.12)	9.74 (17.33)	11.48 (18.61)	

Table 19e. ANOVA

Variety	SE	CD (5 %)
V	0.958	NS
D	1.173	NS
S	1.355	NS
V x D	1.660	NS
D x S	2.347	6.62
V x S	1.917	5.40
V x D x S	4.695	13.21

4.3.1 Rotting losses (%)

Data given in Table 19e revealed that significant differences were noticed only by interactions e.g. DS, VS and VDS. While, no any individual factor influenced the rotting losses.

Significantly least rotting losses were recorded with treatment combination V_2D_3 (6.87 %, Table 19a), D_3S_3 (6.91 %, Table 19b) and $V_2D_3S_3$ (4.16 %, Table 19d).

Table 20. Percent sprouting losses in storage as influenced by varying varieties, seed sowing dates, set-sizes and interactions

Table 20a. V x D (Figures in the paranthesis indicates arc sin transformed values)

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	1.99 (7.89)	2.06 (8.02)	2.42 (8.71)	2.16 (8.21)
V_2 : S-1	5.77 (13.18)	3.67 (9.88)	4.47 (11.73)	4.63 (11.60)
Mean	3.87 (10.54)	2.86 (8.95)	3.44 (10.22)	

Table 20b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	4.17 (10.66)	2.70 (9.28)	6.47 (13.95)	2.17 (8.26)	3.87 (10.54)
D_2 : 15th Jan	2.20 (8.16)	3.29 (9.53)	3.61 (9.80)	2.36 (8.31)	2.86 (8.95)
D_3 :1st Feb.	3.47 (10.32)	2.25 (8.46)	5.27 (12.74)	2.80 (9.35)	3.44 (10.22)
Mean	3.28 (9.71)	2.74 (9.09)	5.12 (12.17)	2.44 (8.64)	

Table 20c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	1.37 (6.74)	2.09 (8.16)	2.56 (8.89)	2.60 (9.03)	2.16 (8.21)
V_2 : S-1	5.19 (12.68)	3.40 (10.02)	7.68 (15.45)	2.28 (8.24)	4.63 (11.60)
Mean	3.28 (9.71)	2.74 (9.09)	5.12 (12.17)	2.44 (8.64)	

Table 20d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	1.12 (6.18)	1.25 (6.57)	1.75 (7.48)	7.23 (15.15)	3.15 (9.74)	5.19 (13.16)	3.28 (9.71)
S_2 : 1.5-2.0 cm	1.80 (7.65)	2.37 (8.67)	2.12 (8.17)	3.60 (10.91)	4.22 (10.39)	2.38 (8.75)	2.74 (9.09)
S_3 : 1-1.5 cm	3.40 (10.42)	1.42 (6.80)	2.87 (9.44)	9.54 (17.48)	5.81 (12.81)	7.68 (16.05)	5.12 (12.17)
S_4 : 0.5-1 cm	1.62 (7.32)	3.23 (10.04)	2.97 (9.74)	2.72 (9.20)	1.50 (6.58)	2.63 (8.95)	2.44 (8.64)
Mean	1.98 (7.89)	2.06 (8.02)	2.42 (8.71)	5.77 (13.18)	3.67 (9.88)	4.47 (11.73)	

Table 20e. ANOVA

Variety	SE	CD (5 %)
V	0.519	1.46
D	0.636	NS
S	0.735	2.07
V x D	0.900	2.54
D x S	1.273	3.59
V x S	1.039	2.93
V x D x S	2.546	7.16

4.3.2 Sprouting losses (%)

From the data in Table 20e it was revealed that except factor sowing dates all other factors and interactions influenced the character significantly.

Among the individual factors significantly superior treatment for least sprouting losses were cv. B-780 (2.16 %, Table 20a) and smaller set size i.e. S_4 (2.44 %, Table 20b).

Among the first order interactions, the significantly superior treatments were V_1D_1 (1.99 %), D_1S_4 (2.17 %) and V_1S_1 (1.37 %) given in table 20a, 20b and 20c respectively. While in second order interaction $V_1D_1S_1$ (1.12 %) was significantly superior (Table 20d) which was at par with some other interaction.

Table 21. Percent physiological loss in weight in storage as influenced by varying varieties, seed sowing dates, set-sizes and their interactions

(Figures in the paranthesis indicates arc sin transformed values)

Table 21a. V x D

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	16.20 (23.60)	23.89 (28.41)	17.89 (24.88)	19.32 (25.63)
V_2 : S-1	12.93 (20.89)	14.23 (22.12)	11.73 (19.85)	12.96 (20.95)
Mean	14.57 (22.25)	19.06 (25.27)	14.81 (22.36)	

Table 21b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1[st] Jan.	15.82 (23.43)	14.34 (22.11)	12.23 (20.14)	15.89 (23.41)	14.57 (22.25)
D_2 : 15[th] Jan	16.01 (23.43)	15.99 (23.51)	15.61 (23.19)	28.62 (30.93)	19.06 (25.27)
D_3 :1[st] Feb.	14.17 (21.89)	16.30 (23.69)	15.50 (22.90)	13.27 (20.98)	14.81 (22.36)
Mean	15.33 (22.88)	15.54 (23.11)	14.45 (22.07)	19.26 (25.10)	

Table 21c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	17.67 (24.74)	17.22 (24.43)	17.23 (24.39)	26.18 (28.96)	19.32 (25.63)
V_2 : S-1	12.99 (21.02)	13.87 (21.78)	11.66 (19.76)	13.33 (21.25)	12.96 (20.95)
Mean	15.33 (22.88)	15.54 (23.11)	14.45 (22.07)	19.26 (25.10)	

Table 21d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	16.60 (23.90)	18.65 (25.63)	17.82 (24.89)	15.05 (22.75)	13.41 (21.43)	10.52 (18.89)	15.33 (22.88)
S_2 : 1.5-2.0 cm	14.93 (22.62)	17.75 (24.81)	19.06 (25.87)	13.75 (21.61)	14.32 (22.21)	13.55 (21.51)	15.54 (23.11)
S_3 : 1-1.5 cm	14.93 (22.54)	17.61 (24.78)	19.17 (25.85)	9.53 (17.73)	13.62 (21.62)	11.83 (19.95)	14.45 (22.07)
S_4 : 0.5-1 cm	18.36 (25.34)	41.67 (38.63)	15.52 (22.91)	13.42 (21.48)	15.57 (23.23)	11.02 (19.05)	19.26 (25.10)
Mean	16.20 (23.60)	23.89 (28.41)	17.89 (24.88)	12.93 (20.89)	14.23 (22.12)	11.73 (19.85)	

Table 21e. ANOVA

Variety	SE	CD (5 %)
V	0.994	2.80
D	1.218	NS
S	1.407	3.96
V x D	1.720	NS
D x S	2.437	6.87
V x S	1.989	5.61
V x D x S	4.873	13.71

4.3.3 Physiological loss in weight (%)

Data pertaining to percent PLW is presented in Table 21 which revealed that PLW was influenced significantly by the factors variety (V), set-sizes (S) and interactions VD_1, DS, VS and VDS (Table 21e).

For least PLW the significant treatments among individual factors were cv. S-1 (12.96 %, Table 21a) and smaller set-size i.e. S_4 (19.26 %, Table 21b). Significantly superior interaction combinations were observed as V_2D_3, D_3S_4 and V_2S_3 (i.e. 11.73, 13.27 and 11.66 % respectively in Tables 21a, 21b and 21c) for first order interaction and $V_2D_1S_3$ (9.53 % Table 21d) for second order interaction.

Table 22. Percent total storage losses as influenced by varying varieties, seed sowing dates, set-sizes and their interactions

Table 22a. V x D (Figures in the paranthesis indicates arc sin transformed values)

Variety	Sowing dates			Mean
	D_1 (1st Jan.)	D_2 (15th Jan.)	D_3 (1st Feb.)	
V_1 : B-780	31.29	39.15	31.70	34.04
	(33.86)	(37.70)	(34.12)	(35.23)
V_2 : S-1	27.60	27.65	27.68	27.64
	(31.55)	(31.60)	(31.57)	(31.58)
Mean	29.44	33.40	29.69	
	(32.71)	(34.65)	(32.85)	

Table 20b. D x S

Sowing dates	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
D_1 :1st Jan.	29.66 (32.90)	29.03 (32.47)	28.85 (32.23)	30.23 (33.22)	29.44 (32.71)
D_2 : 15th Jan	29.63 (32.83)	30.37 (33.32)	30.70 (33.49)	42.89 (38.96)	33.40 (36.65)
D_3 :1st Feb.	31.95 (34.35)	29.44 (32.71)	27.69 (31.49)	29.69 (32.84)	29.69 (32.85)
Mean	30.41 (33.36)	29.61 (32.84)	29.08 (32.41)	34.27 (35.01)	

Table 22c. V x S

Variety	Set sizes (S)				Mean
	S_1 (2.1-2.5)	S_2 (1.6-2.0)	S_3 (1.1-1.5)	S_4 (0.5-1.0)	
V_1 : B-780	33.12 (35.01)	31.76 (34.21)	31.95 (34.33)	39.35 (37.37)	34.04 (35.23)
V_2 : S-1	27.70 (31.71)	27.46 (31.47)	26.21 (30.48)	29.19 (32.64)	27.64 (31.58)
Mean	30.41 (33.36)	29.61 (32.84)	29.08 (32.41)	34.27 (35.01)	

Table 22d. V x D x S

Set size	Variety and sowing dates (V x D)						Mean
	V_1D_1	V_1D_2	V_1D_3	V_2D_1	V_2D_2	V_2D_3	
S_1 : > 2.0 cm	32.41 (34.56)	32.55 (34.62)	34.41 (35.84)	26.92 (31.24)	26.71 (31.03)	29.49 (32.85)	30.41 (33.36)
S_2 : 1.5-2.0 cm	29.52 (32.87)	35.80 (36.72)	29.96 (33.03)	28.54 (32.08)	24.94 (29.93)	28.92 (32.40)	29.61 (32.84)
S_3 : 1-1.5 cm	31.66 (34.06)	32.48 (34.73)	31.71 (34.21)	26.89 (30.41)	28.92 (32.26)	23.67 (28.78)	29.08 (32.41)
S_4 : 0.5-1 cm	31.57 (33.96)	55.77 (44.73)	30.72 (33.42)	28.89 (32.49)	30.02 (33.18)	28.67 (32.26)	34.27 (35.01)
Mean	31.29 (33.86)	39.15 (37.70)	31.70 (34.12)	27.60 (31.55)	27.65 (31.60)	27.68 (31.57)	

Table 22e. ANOVA

Variety	SE	CD (5 %)
V	1.023	2.88
D	1.253	NS
S	1.447	NS
V x D	1.713	5.00
D x S	2.507	7.07
V x S	5.047	15.77
V x D x S	5.014	14.11

4.3.4 Total storage losses (%)

Data of Table 22e revealed that total storage losses were significantly influenced by only individual factor variety and interactions VD, DS, VS and VDS.

Among the individual factors cv. S-1 recorded significantly lower total losses (27.64 %, Table 22a) over cv. B-780 (34.04 %).

Among the first order interaction significantly superior treatments were V_2D_2, D_3S_3 and V_2S_3 (27.65, 27.69 and 26.21 %, respectively in Table 22a, 22b and 22c); while treatment $V_2D_3S_3$ (23.67 %) was significantly superior ~~treatment~~ for second order interaction (Table 22d).

4.4 Effect of seed bulbs from set planting on seed production

The stored bulbs were utilized for seed production by grading into three sizes i.e. large, medium and small i.e. S_1, S_2 and S_3 (5.5 cm, 4.5 cm and 3.5 cm, respectively). Effect of two factor i.e. variety (V) and bulb-size (S) was studied on seed production. Two parameters such as number of umbels and seed weight were evaluated for seed production studies (Table 23 and 24, respectively).

Table 23. Number of umbels per plant as influenced by varieties, size of seed bulb and their interactions

Table 23a. V x S

Variety	Size of seed bulb (cm)			Mean
	S_1 (5.5)	S_2 (4.5)	S_3 (3.5)	
V_1 : B-780	11.80	6.20	6.00	8.00
V_2 : S-1	9.00	8.00	9.00	8.66
Mean	10.40	7.10	7.50	

Table 23b. ANOVA

	SE	CD (5 %)
V	0.627	NS
S	0.768	2.24
V x D	1.086	3.17

4.4.1 Number of umbels per plant

The data of Table 23b showed that the number of umbels per plant was significantly influenced by size of seed bulb and interaction of variety and bulb size.

Large sized seed bulbs produced significantly more umbels per plant (10.40) over medium and small sized bulbs (7 and 8 respectively, Table 23a).

Among the interactions (V x S, Table 23b) the treatment combination V_1S_1 recorded significantly higher number of umbels per plant (11.80) over rest of combinations, except V_2S_1 and V_2D_3 (9.0) which were at par with each other.

Table 24. Weight of seeds/umble (g) as influenced by varieties, size of seed bulb and their interactions

Table 24a. V x S

Variety	Size of seed bulb (cm)			Mean
	S_1 (5.5)	S_2 (4.5)	S_3 (3.5)	
V_1 : B-780	2.48	2.42	2.37	2.42
V_2 : S-1	2.51	2.47	2.29	2.42
Mean	2.49	2.44	2.33	

Table 23b. ANOVA

	SE	CD (5 %)
V	0.026	NS
S	0.031	0.09
V x D	0.045	0.13

4.4.2 Average seed weight per plant (g)

Data of Table 24b revealed that weight of seeds per umble was significantly influenced by size of seed-bulb and interaction of variety and seed-bulb size. The factor variety didn't show any influence on seed weight.

Significantly, more seed weight (2.49 g/umbel) was recorded from large sized bulbs (S_1) over small sized bulbs S_3 (2.33 g) but it was at par with medium sized bulbs (S_2). While interaction V_2S_1 (cv. S-1 with large bulb size) recorded significantly more seeds (2.51 g; Table 24b) than V_1S_3 (2.37 g) and V_2S_3 (2.29 g).

Discussion

5. DISCUSSION

Eventhough onion is one of the main cash crop of medium, small and marginal farmers of Maharashtra. Day by day importance of onion cultivation is increasing especially on background of draught prone conditions prevailed in MS during last 3-4 years. In such scinario the trend for year round onion cultivation is increasing fast. Accordingly the onion crop is being undertaken for *kharif* and *rabi* season as main season but additionally early *kharif* (*Halwa*) and late *kharif* (*Rangada*) are taken as an off-season cultivation. However, early *kharif* crop is restricted to certain packets where summer season is mild i.e. particularly areas of Nasik, Ahmednagar (Sangamner and Akole) and Pune (Rajguru nagar or Khed) districts, where seedling growth is possible during April and May months. However, in rest of Maharashtra, it is not possible due to hot climate.

To overcome the difficulty of nursery management of early *kharif* (*Halwa)* crop during summer months, an alternative measure was studied with onion set plantation. The *kharif* onion production has been reported by onion set plantation from South India and Bangladesh for multiplier onion. Therefore in this context, an attempt was made in present investigation through production and storage of onion sets and further their effect was studied on bulb and seed crops.

In present investigation, two onion cultivars, three seed sowing dates, four set sizes were included and their effect on set production and storage, bulb production and storage, seed production etc. was studied by employing factorial randomized block design (FRBD). The results obtained in present investigation are discussed below, under appropriate headings and subheadings.

5.1 Set production

5.1.1 Effect of variety on set production

Two onion cultivars were used for set production during *rabi* (January-March) season. Furthermore, cv. Phule Samarth showed superiority over cv. Baswant-780 for seedling growth (32.60 and 30.66 cm height, respectively) and yield of sets (354 to 349 sets/m^2). However set diameter of both varieties remained more or less similar. On the basis, it is concluded that both the onion cultivars are equally compatible and can be effectively used for onion set production during *rabi* season (Jan-March).

5.1.2 Effect of seed sowing dates on set production

Three seed sowing dates (i.e. 1^{st} Jan., 15^{th} Jan. and 1^{st} Feb.) were tried for onion set production. On the basis of average seedling height, number of leaves and bulb diameter. The sowing date on 15^{th} January (D_2) proved the best one. However, in terms of set yield, the sowing at 1^{st} January found the better one. Therefore, period of first fortnight (i.e. 1^{st} to 15^{th}) of January is suggested to be prime important period of seed sowing for onion set production.

These results are in agreement of findings of Chaddha (2001) who reported mid January to mid February is the ideal time of onion seed sowing for set production.

Furthermore, in present study it is observed that progressive set yield reduction from 1st January to 1st February. It is mainly due to adverse effect of higher temperature on seed germination and plant growth. Thus these results confirmed the findings of Gur (1980). In this context, it is observed that seed germination was adversely affected by seed sowing after 15th February 2003 when day temperatures recorded more than 35 °C.

5.1.3 Effect of interaction of variety and seed sowing dates on set production

From the significant results it is observed that combination of V_2D_2 (cv. S-1 and sowing date 15th January) was superior combination in case of vigour and quality of sets. However, higher set yield (406 and 405/m^2) was observed for both the onion cultivars at 1st January (i.e. D_1V_1 and D_1V_2).

Thus, more or less similar reactions have been noticed by both the cvs with sowing date 1st January.

5.2 Effect on grading of onion sets

5.2.1 Effect of variety on set grades

From the results it is noticed that Cv. S-1 gave significantly higher yield of large (S_1), medium large (S_2) and medium (S_3) sized sets which found better for set planting. On the other hand cv. B-780 produced more number of S_4 (small) sized sets in which maximum losses were recorded during storage and also lower productive for bulb production. The fast bulb development in cv. S-1 might ~~may~~ be associated with earliness of the variety.

5.2.2 Effect of sowing date on set grading

Significantly higher yield of S_2 and S_3 sized i.e. (1 to 2 cm diameter) sets was obtained with sowing at 15th January. As 1 to 2 cm diameter sets are good for set planting storage and bulb production, 15th January is the best date for the sowing the onion seeds under Maharashtra condition~~s~~.

5.2.3 Effect of variety and sowing date interaction on set grading

The results showed that the combination V_2D_2 (cv. S-1 with 15th January sowing) was the best combination for good yield of S_2 and S_3 sets.

Generally yield of small sized sets i.e. S_4 (0.5 to 1 cm) was more (above 50 %) than other set sizes. Therefore, to improve the desirable set size ~~(i.e.~~(S_2 or S_3 with 1-2 cm diameter). Further study should be undertaken on seed rate, spacing and fertilization. It is of prime important to obtain good yield of medium sized sets (1 to 2 cm) which are considered best for set planting storage and bulb production.

5.3 Storage of sets

5.3.1 Effect of variety on set storage

As moderate storage losses (30.0 and 30.7 %) were recorded by both the onion cvs (i.e. S-1 and B-780, respectively), it showed good keeping quality of both the cultivars.

5.3.2 Effect of sowing date on set storage

The least storage losses were found in sets obtained from D_3 (1st Feb.) date of sowing than two other dates. These results are obvious as sets of D_3 were stored for shorter period than other two dates.

5.3.3 Effect of size of sets on set storage

Distinguish results were obtained with different set sizes. It showed that significantly higher storage losses were noticed in small sized (S_4) sets i.e. (upto 50-60 %). While storage potential of large sized (S_1) sets has been noticed to be most promising (6-10 % storage loss) followed by medium sized sets S_2 (29.30 %) and S_3 (32.30 %).

The high storage losses in small sized sets (S_4) are mainly due to rapid dessication of water from undeveloped and unmatured bulbs associated with high temperatures (upto 40 ^{0}C) during the months April-May.

5.3.4 Effect of interactions on set storage

a. Variety x sowing date

From the significant results obtained, it is concluded that V_2D_3 (i.e. seed sowing of cv. S-1 at 1st February) is best combination for storage quality of sets.

b. Sowing date x set size

D_3S_1 (large sized sets obtained from 1st February sowing) proved to be the best treatment combination for good storage quality with minimum storage loss (5.9 %).

c. Variety x set size

Combination of large sized sets (S_1) with both the varieties (V_2S_1 and V_1S_1) were recorded minimum storage losses. Hence, it is concluded that good keeping quality is positively associated with bulb development of sets.

d. Variety x sowing date x set size

Among three way interaction, the least storage losses were recorded by $V_1D_2S_1$ and $V_1D_3S_1$ (5.9 %) followed by $V_1D_1S_1$ (6.8 %). It means that large sized sets of cv. B-780 has better keeping quality for all three seed sowing dates. However, more or less similar trend was also noticed with cv. S-1 (6.0 to 8.9 % storage loss). Hence, ultimately it is observed that size of the bulb is the most crucial factor than the other two for storage of onion sets.

5.4 Effect of onion set plantation on bulb production

The most distingwish result has been noticed with onion set planting that the bulb crop can be harvested within 60-75 days (i.e. upto 9-24th August) along with good bulb development. These results are not only promising due to catch of off-season markets but also for increasing production potential of *kharif* onions. Normally, heavy monsoon in the month of September, affects the plant growth and bulb development of *kharif* onion. Also pest and disease incidence is normally more in this period. These parameters are responsible for low yield levels of *kharif* onion. But with set planting, onion bulb development takes place during period of July to first fortnight of August when monsoon is moderate with clear sunlight. Such situation is most congenial for bulb development as it provides high temperatures (25-30 °C), long and clear photoperiod (12-13 hrs) with moderate humidity (70-80 %). Nevertheless, these results especially with cv. S-1 are so much impressive as bulb can be harvested in 60 days than, a period otherwise required for normal raising of seedlings by sowing the seeds in the month of June.

Thus, with use of set planting, it is now possible to undertake early *kharif* (*Halwa*) season as on off-season onion cultivation very successfully in rest of Maharashtra where it cannot be possible due to hot summer climate detrimental for nursery growth. However, there results in present investigation are of preliminary nature and required further study with fine modifications for standardization of technology for early *kharif* (*Halwa*) onion cultivation in Maharashtra via onion set plantation. But the results of present investigation are pioneer and certainly directive for future research.

5.4.1 Effect of variety on bulb production

The significant results showed that cv. S-1 performed better over cv. B-780 in studies of average number of leaves, days required for maturity, bulb neck thickness, bulb polar diameter and storage losses. cv. S-1 recorded significantly more leaves (i.e. 18.56 per plant), the functional leaves which contributes in photosynthesis and bulb development. Earliness was shown by the cultivar with requirement of only 63.31 days for 50 per cent top fall. Minimum bulb neck thickness (0.87 cm) was recorded which has role in occurrence of top fall and minimizing the storage losses. Maximum polar diameter (5.30 cm) was recorded in cv. S-1.

However, for the remaining important characters like bulb yield and marketable bulbs, bulb weight, equatorial diameter and rotting losses, cv. B-780 recorded best results but at par with cv. S-1.

Thus, it indicates that both onion cultivars can be used for onion set plantation having distinct and certain advantages with each of the variety.

5.4.2 Effect of sowing dates on bulb production

From the results obtained it was observed that date of seed sowing of onion sets significantly influenced bulb crop and D_3 seed sowing date found significantly superior over D_1 (1 January) for characters like average number of leaves, days required for maturity, total yield, marketable yield, average bulb weight, equatorial diameter and polar diameter of bulb. The significant results of above characters showed that D_3 i.e. 1st February is the best seed sowing date for onion sets to have successful bulb production.

However, eventhough D_3 seed sowing date (1st February) emerge as the best date for bulb production, the set production was certainly hampered with this date. On the other hand, D_1 (1st January) date was superior for set production but inferior for set storage and bulb production. It is therefore essential to have optimal balance in between set and bulb production. In this regard, sowing date D_2 (i.e. 15th January) certainly recorded good yield of sets as well as bulbs. The bulb characters of D_3 date were at par with D_2. Hence, by considering overall performance of set and bulb production, finally it is concluded that D_2 (i.e. 15th January) is the best seed sowing date for set plantation of early *kharif* (*Halwa*) onion cultivation.

The results obtained are similar to Chaddha (2001) who reported the sowing period mid January to mid February is the best for set production.

5.4.3 Effect of size of sets on bulb crop

i. Growth characters of bulb crop

Results obtained showed that size of sets noticed significant effect on growth characters like average plant height and average number of leaves. Large sized sets i.e. S_1 (2.1 to 2.5 cm) produced significantly maximum average plant height i.e. 59.90 cm than any other set size, also maximum number of leaves i.e. 18.54 functional leaves/plant were noticed in large sized sets. These both characters significantly contributes in growth, vigour and yield ~~hence are important~~.

These results are found similar to that of Gupta *et al.* (2000) who reported that better crop stand and vigour. From large sized onion sets (1.5 to 2.5 cm) than small sized (< 1.5 cm).

ii. Premature bolting and twin bulbs in bulb crop

~~From the results~~ it was observed that significantly minimum percentage premature bolting as well as twin bulbs was recorded in small sized sets i.e. S_4. Percentage of both premature bolting and twin bulbs increased with increase in size of sets. Maximum premature bolting and doubling (twin bulbs) were observed in large sized sets i.e. S_1. Above results are in agreement with Rabinowitch (1979), Krawiec *et al.* (1988) and Ryu-Youngwoo *et al.* (1998).

Premature bolting and twin bulbs are certainly undesirable characters in bulb production which reduces marketable bulb yield and eventually the monitary returns. Hence, planting of medium sized sets is desirable to minimize the problem of premature bolting and doubling with increasing total yield and marketable bulb yield levels.

iii. Yield characters of bulb crop

Yield characters like total yield and marketable yield were significantly influenced by size of sets. The results obtained showed that in total yield the large set size i.e. S_1 performed best (183.58 q/ha) while in marketable yield medium large set size i.e. S_2 was best with 80.06 per cent marketable yield.

In other characters like ~~average~~ bulb weight, equatorial diameter and polar diameter S_1 (large sized sets) recorded significantly higher ~~average~~ values i.e. average bulb weight (76.91 g), equatorial diameter (5.36 cm) and polar diameter (5.29 cm).

These results confirmed the finding of Krickl (1962), Chetepova (1972), Shalaby *et al.* (1991) and Ryu-Youngwoo *et al.* (1998).

Ingeneral results showed that yields were increased with increase in set size but it promoted the problem of premature bolting and twin bulbs. While small sized sets were good for showing minimum premature bolting and doubling but were poor in yielding ability. In such critical situation, medium sized sets i.e. S_2 and S_3 (1 to 2 cm) showed moderate performance in all bulb characters, hence medium size set are used ~~recommended~~ for set plantation of onions during *kharif* season.

5.4.4 Effect of interactions on bulb crop

a. Variety x sowing date

Significant results showed that V x D interaction significantly influenced various characters of bulb crop i.e. average number of leaves were maximum ~~(upto/plant)~~ with combinations V_2D_1 and V_2D_3. Minimum twin bulbs (0.14 %) were observed in V_2D_2 combination. With the combination V_2D_1 days to maturity were decreased (62.87 days) and bulb neck thickness was also minimized i.e. 0.81 cm. Total bulb yield was increased by treatments V_1D_2 and V_1D_3 (180.23 q/ha). However, marketable yield was significantly more with V_1D_3 (81.31 %). Significantly larger equatorial diameter and potal diameter were recorded with combinations V_1D_3 (5.44 cm) and V_2D_3 (5.45 cm), respectively.

b. Sowing date x size of sets

Sowing date and set size interaction significantly influenced the bulb crop characters *viz.*, average number of leaves, premature bolting per cent twin bulbs, days required for maturity, per cent marketable yield bulb neck thickness, bulb equatorial diameter and polar diameter.

Average number of leaves increased (20.37 leaves/plant) by use of D_3S_3 combination. Premature bolting was minimized with D_2S_4 combination (0.27 %) and the combination D_3S_2 and D_3S_3 recorded no twin bulbs (0.00 %). Days required for maturity decreased significantly with D_3S_4 combination to 66 days. D_3S_2

combination recorded more marketable yield i.e. 85.43 per cent. Bulk neck thickness was significantly reduced by D_3S_3 combination (1.07 cm). Equatorial and polar diameter also increased by D_3S_3 combination (5.66 and 5.66 cm, respectively).

From above results performance of treatment combination D_3S_3 (1st February sowing and 1-1.5 cm diameter set) found best regarding various characters.

c. Variety x set size

Interaction of variety and set size influenced significantly all bulb crop characters including average number of leaves, bolting and doubling, maturity, yield characters and quality characters, except ~~significant difference was not found in~~ plant height. The combination V_2S_1 showed well performance in maximum average number of leaves per plant (19.58), maximum average bulb weight (81.32 g), maximum equatorial diameter (5.33 cm). The minimum percentage of premature blotting was observed at V_1S_4 combination (0.55 %), while twin bulb percentage reduced to 0.00 per cent at V_2S_3 and V_2S_4 combinations. Days required for maturity minimized at V_2S_4 combination to 62.08 days. ~~Maximum~~ while ~~total~~ ~~yield~~ V_2S_2 recorded at V_2S_3 i.e. 188.27 q/ha ~~and~~ per cent marketable yield was combination recorded significantly thin bulb neck diameter (neck-thickness) i.e. 0.80 cm which is desirable character for storage quality.

d. Variety x sowing date x set size

From results on effect of three way interaction of VDS on bulb production, it was observed that except average plant height and twin bulb percentage, the interaction significantly influenced all the characters under study. Maximum number of leaves obtained from the combination $V_1D_3S_3$ i.e. 23.75 leaves/plant. Minimum premature bolting (0.50 %) was observed in 4 combinations *viz.,* $V_1D_2S_4$, $V_1D_3S_4$, $V_2D_1S_3$ and $V_2D_1S_4$ having either medium or small sized sets (S_3 and S_4). The crop obtained from set combinations $V_2D_1S_2$, $V_2D_1S_3$, $V_2D_1S_4$, $V_2D_2S_3$, $V_2D_2S_4$ and $V_2D_3S_4$ matured quite early than rest of the combinations i.e. within 62 days. Significantly more total yield (201 q/ha) and marketable yield (85.89 %) were recorded with combinations $V_1D_2S_2$ and $V_2D_3S_2$, respectively. Significantly more average bulb weight was obtained with $V_1D_2S_2$ combination i.e. 87.70 g. Maximum equatorial diameter i.e. 5.78 cm was noticed in two combinations *viz.,* $V_1D_1S_1$ and $V_1D_3S_1$. The combination $V_1D_3S_3$ recorded significantly more polar diameter (5.75 cm).

5.5 Storage of bulbs

5.5.1 Effect of variety on bulb storage

Significant influence of variety was observed on sprouting PLW and total losses while totting did not have any influence of variety. Significantly less sprouting losses (2.42 %) recorded in cv. B-780 while cv. S-1 showed minimum losses regarding physiological loss in weight (12.96 %) and total losses (27.64 %).

5.5.2 Effect of sowing dates on bulb storage

Sowing date did not have any influence on storage losses i.e. rotting, sprouting, PLW and total losses.

5.5.3 Effect of set size on bulb storage

Results showed that only sprouting losses were significantly influenced by the set size while rotting losses, PLW and total losses were not influenced by this factor. Minimum sprouting losses (2.44 %) were recorded in bulbs obtained from small sized sets (S_4).

5.5.4 Effect of interactions on bulb stage

a. Variety x sowing date

From the results it was observed that except rotting losses the interaction significantly influenced the other i.e. sprouting losses, PLW and total losses. The interaction V_1D_1 recorded minimum sprouting losses (1.99 %) than rest of the interactions, while the PLW and total losses were decreased with combinations V_2D_3 (11.73 %) and V_2D_1 (27.60 %) respectively.

In this interaction, as the factor sowing date didn't have any influence individually, the influence of combination is only due to presence of variety V_2 (cv. S-1) performed best in minimizing the storage losses due to picular characters like thin neck, medium size etc.

b. Sowing dates x set size

Interaction of sowing date and set size significantly influenced the storage characters, the effect was only due to presence of factor 'S'. Minimum rotting losses were recorded at combination D_3S_3 (6.91 %), sprouting losses at D_2S_1 (2.20 %), PLW at D_1S_3 (12.23 %) and total losses at D_3S_3 (27.69 %). From above results it can be explained that sowing date, D_3 (1^{st} Feb.) and set size, S_3 (1-1.5 cm) are crucial factors for improving keeping quality of onion bulbs.

c. Variety x set size

From the results of VS interaction on storage it is observed that the interaction significantly influenced all storage losses i.e. rotting, sprouting, PLW and total losses. The combination V_2S_3 found superior for minimum losses in respect of rotting (6.87), PLW (11.66

%) and total loss (26.21 %). While V_1S_1 proved best for sprouting losses (1.37 %).

d. Variety x sowing dates x size of sets

Results on effect of VDS interaction on storage losses showed that interaction significantly influence rotting, sprouting, PLW and hence total losses. Minimum average values of rotting losses recorded with $V_2D_3S_3$ (4.16 %), ~~that~~ ~~of~~ sprouting losses with $V_1D_1S_1$ (1.12 %), PLW with $V_2D_3S_1$ (10.52 %) and total losses with $V_2D_2S_2$ (24.94 %).

5.6 Seed production

5.6.1 Effect of variety

Results obtained showed that the variety factor did not influenced the characters of seed production i.e. number of umbels/plant and weight of seed/umbel. Both varieties remained at par with each other for seed parameters.

5.6.2 Effect of seed bulb size

From results obtained it was noticed that size of seed bulbs significantly influenced number of umbels/plant and weight of seeds/umbel. As the size of seeds bulb increased the number of umbels per plant as well as weight of sees/umbel increased. The larger bulb size i.e. S_1 recorded maximum number of umbels (10.40) per plant and maximum seed weight (2.49 g) per umbel.

The results are found similar to those of Singh and Sachan (1999) who reported that largest bulb size (4-5 cm) gives more seed yield per plant.

5.6.3 Effect of interaction on seed parameters

Interaction of variety and size significantly influenced the number of umbels per plant and weight of seed per umbel.

Significantly more umbels per plant were observed with interaction V_1S_1 (11.80 umbels per plant) while more seed weight was recorded with combination V_2S_1 i.e. 2.51 g.

5.6.4 Modified seed production programme for *kharif* onion : Future strategy

For improvement in *kharif* onion cultivars regarding keeping quality some modification are necessary in usual seed production programme. Normally freshly harvested onion bulbs of *kharif* season are immediately used for seed production in the month of November without evaluating the keeping quality. It is only possible with undertaking early *kharif* cultivation, in which crop should be harvested in mid September and upon bulb caring and storage in the month of October finally only dormant bulbs should be used in seed production during second fortnight of November. This strategy will be certainly useful for improving keeping quality of *kharif* onion. However, it is prerequisite for maintenance of keeping quality of any onion cultivar to first evaluate the keeping quality of seed bulbs and then utilized in seed production programme. But it is not happed for seed production programme of *kharif* onions. Thus, such improved seed production programme in onion can be undertaken by use of set plantation for early *kharif* (*Halwa*) cultivation.

Summary and Conclusions

6. SUMMARY AND CONCLUSIONS

The present investigation was conducted during year 2002-2004 at Onion Storage Scheme, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri with a view to assess the possibility of early *kharif* cultivation by set planting and to study the effect ~~of it~~ on *kharif* onion crop.

The treatments consisted of two varieties (cv. B-780 and cv. S-1), three seed sowing dates (1^{st} January, 12^{th} January and 1^{st} February) and four sizes of sets (large, medium large, medium and small). Thus, there were 24 treatments replicated four times in a Factorial Randomised Block Design. Along with bulb-production, effect on set production, storage and seed production was also studied.

The results obtained in respect of set-production and set storage influenced by various treatments are summarized below. Both the varieties (V_1 and V_2) are at par in respect of set yield, set storage potential. 15^{th} January is best period for seed sowing for optimum set and bulb production.

Results obtained in respect of growth, yield contributing and quality characters of bulb production influenced by various treatments are summarized as cv. B-780 was best for yield potential while cv. S-1 was best of earliness and other characters. However, both varieties are suitable for set planting.

Planting small sets resulted in low yield which increased linearly with increase in set size (From S_4 to S_1). In the contrast the problems like premature bolting and twin bulbs decreased from large to small sets (S_1 to S_4). Hence planting of medium to medium large (S_3 and S_2) set sizes should be used for successful bulb production with more marketable bulb yield.

Results obtained in respect of storage of onion bulbs summarized as both the onion cvs showed good keeping quality but the cv. S-1 was best with comparatively less total losses. The bulbs obtained from planting medium large (S_3) sets recorded less storage losses followed by medium (S_2) sets.

Results obtained from seed production studies showed that bulbs obtained from set planting can be used as seed bulb by applying selection pressure for good storage quality for variety improvement of *kharif* onion cultivars.

The best results obtained in present study are shown in tabular form (Table 25).

On the basis of result obtained in the present study, following conclusions are made :

1. Early *kharif* (*Halwa*) onion crop can be undertaken successfully by onion set plantation within 60-75 days.
2. Onion Cv. Basawant-780 or Phule Samarth (S-1) can be utilized for set plantation with specific advantages.
3. Best time for seed sowing is 15th January.
4. To increase the set yield for medium size (1-2 cm diameter) further study is necessary.

5. Use of medium sized sets was found useful for good set storage higher total and marketable bulb yields.
6. Bulbs obtained from set plantation can be used for seed production programme ~~for~~ improving keeping quality of *kharif* onions.

Table 25. Best treatments

Table 25a. Best treatments for set-production

Treatments	Characters					
	Average seedling height (Max.) cm	Average no. of leaves (Max.) No.	Average bulb diameter (Max.)	Yield of sets per sq.m. (max.) No./sq.m.	Yield of various sized sets (Max.) %	Rotting losses of onion-sets (Min.) %
V	V_2 (32.60)*	V_1 (6.33)	V_1 (0.93)	V_2 (354)	V_2 (23.4)	V_2 (30.0)
D	D_2 (33.55)*	D_1 (6.33)	D_2 (0.96)	D_1 (405)**	D_2 (23.4)	D_3 (28.3)
S					S_4 (55.5)**	S_1 (6.6)**
VD	V_2D_2 (34.80)*	V_1D_1, V_1D_2, V_1D_3 and V_2D_1 (6.33)	V_2D_2 (0.98)	V_1D_1 (406)*	V_2D_2 (23.6)	V_2D_3 (25.3)*
DS					D_2S_4 (59.3)*	D_3S_1 (5.9)*
VS					V_2S_4 (59.9)*	V_1S_1 (6.2)
VDS					$V_2D_1S_4$ (61.9)*	$V_1D_1S_1$ and $V_1D_3S_1$ (5.9)*

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 25b. Best treatments for bulb production

Treatments	Characters										
	Average plant height (max.) cm	Average no. of leaves (max.) No.	Premature bolting (min.)	Twin bulbs (min) %	Days for 50 % top/leaf fall (min.) No.	Total yield of bulbs (max.) q/ha	Per cent marketable bulb yield (max.) %	Bulb neck thickness (min.)	Average bulb wt. (max.) g	Bulb Eq. diameter (max.) cm	Bulb polar diameter (max.) cm
V	V_1 (58.70)	V_1 (19)**	V_2 (1.34)	V_1 (0.61)	V_2 (63)**	V_1 (168.84)	V_1 (79.36)	V_2 (0.87)**	V_2 (72.97)	V_1 (5.27)	V_2 (5.30)*
D	D_3 (59.29)	D_3 (19)*	D_2 (1.00)	D_3 (0.24)	D_3 (67)*	D_3 (178.89)*	D_3 (80.92)*	D_3 (1.26)**	D_3 (77.17)*	D_3 (5.41)**	D_3 (5.36)**
S	S_1 (50.90)*	S_1 (19)*	S_4 (0.74)*	S_4 (0.23)*	S_4 (66)**	S_1 (183.58)**	S_2 (80.06)**	S_3 (1.26)	S_1 (76.91)*	S_1 (5.36)**	S_1 (5.29)*
VD	V_2D_3 (58.94)	V_1D_1 & V_2D_3 (19)*	V_2D_1 (0.84)	V_2D_2 (0.14)*	V_2D_1 (63)*	V_1D_2 & V_1D_3 (180.23)*	V_1D_3 (81.31)*	V_2D_1 (0.81)*	V_2D_3 (79.14)	V_1D_3 (5.44)*	V_2D_3 (5.45)*
DS	D_2S_1 (60.94)	D_3S_3 (20)**	D_2S_4 (0.27)*	D_3S_2, D_3S_3 (0.00)*	D_3S_4 (66)*	D_3S_3 (215.07)	D_3S_2 (85.43)**	D_3S_3 (1.07)*	D_3S_1 (79.55)	D_3S_3 (5.66)*	D_3S_3 (5.66)*
VS	V_2S_1 (60.25)	V_2S_1 (20)**	V_1S_4 (0.55)*	V_2S_3, V_2S_4 (0.00)*	V_2S_4 (62)*	V_2S_3 (188.27)*	V_1S_2 (82.23)*	V_2S_2 (0.80)*	V_1S_1 (81.32)**	V_1S_1 (5.52)*	V_2S_1 (5.33)*
VDS	$V_1D_3S_3$ (62.01)	$V_1D_3S_3$ (24)**	$V_1D_2S_4$, $V_1D_3S_4$, $V_2D_1S_3$, $V_2D_1S_4$ (0.50)*	$V_1D_2S_1$, $V_1D_3S_1$, $V_1D_3S_2$, $V_1D_3S_3$, $V_2D_1S_3$, $V_2D_1S_4$, $V_2D_2S_1$, $V_2D_2S_3$, $V_2D_2S_4$, $V_2D_3S_2$, $V_2D_3S_3$, $V_2D_3S_4$ (0.0)	$V_2D_1S_2$, $V_2D_1S_3$, $V_2D_1S_4$, $V_2D_2S_3$, $V_2D_2S_4$, $V_2D_3S_4$ (62)*	$V_1D_3S_3$ (243.88)*	$V_2D_3S_2$ (85.89)**	$V_2D_1S_2$ (0.74)*	$V_1D_2S_2$ (87.70)*	$V_1D_2S_1$, V_1D_3S (5.78)	$V_1D_3S_3$ (5.75)*

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 25c. Best treatment for bulb storage

Treatment	Characters			
	Rotting losses (min.) %	Sprouting losses (min.) %	PLW (min.) %	Total losses (min.) %
V	V_2 (10.04)	V_1 (2.42)**	V_2 (12.96)**	V_2 (27.64)*
D	D_1 (10.99)	D_2 (2.86)	D_1 (14.57)	D_1 (29.44)
S	S_3 (9.51	S_4 (2.44)**	S_1 (15.33)	S_3 (29.08)
VD	V_2D_1 (8.88)	V_1D_1 (1.99)*	V_2D_3 (11.73)*	V_2D_1 (27.60)*
DS	D_3S_3 (6.91)*	D_2S_1 (2.20)*	D_1S_3 (12.23)*	D_3S_3 (27.69)*
VS	V_2S_3 (6.87)*	V_1S_1 (1.37)**	V_2S_3 (11.66)*	V_2S_3 (26.21)*
VDS	$V_2D_3S_3$ (4.16)*	$V_1D_1S_1$ (1.12)*	$V_2D_3S_1$ (10.52)*	$V_2D_2S_2$ (24.94)*

Table 25d. Best treatments for seed production

Treatments	Characters	
	No. of umbels (max.) no.	Wt. of seed/umbel (max.) g
V	V_2 (9)	V_1 and V_2 (2.42)
S	S_1 (10)*	S_1 (2.49)**
VS	V_1S_1 (12)*	V_2S_1 (2.51)*

* Significant at 5 per cent level ** Significant at 1 per cent level

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7. LITERATURE CITED

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* **Originals not seen**

Appendix

8. APPENDIX

Appendix I. Meteorological data

Week No.	Temperature (°C)		Humidity (%)		Rainfall (mm)
	Max.	Min.	Morn.	Even.	
Jan.					
1	27.9	11.6	87.0	35.6	0.0
2	29.8	12.7	91.1	38.1	0.0
3	27.9	7.3	72.7	28.4	0.0
4	31.8	10.8	73.4	27.6	0.0
Feb.					
5	13.6	11.4	73.9	28.0	0.0
6	32.1	12.1	81.4	29.1	0.0
7	33.3	11.6	82.7	26.7	0.0
March					
8	32.4	12.2	82.7	26.9	0.0
9	35.0	14.1	78.3	23.7	0.0
10	33.6	11.2	83.4	21.3	0.0
11	35.2	12.8	86.1	19.4	0.0
12	36.4	16.7	62.6	21.0	0.3
13	38.0	15.4	45.6	24.7	0.2
April					
14	37.9	17.2	69.1	49.9	0.3
15	38.2	19.0	68.7	51.3	0.0
16	39.4	18.8	72.7	50.6	0.0
17	40.5	21.4	79.7	47.3	0.0
May					
18	40.2	19.2	60.9	24.6	0.0
19	40.0	19.6	68.4	16.9	0.0
20	40.6	22.4	68.1	18.9	0.2
June					
22	39.4	21.6	74.6	20.3	0.0
23	39.2	23.0	77.4	24.9	0.0
24	35.5	23.4	89.0	51.3	1.3
25	33.1	23.1	85.3	49.7	4.3
26	32.2	23.4	87.7	49.4	0.0

Appendix I contd...

Week No.	Temperature (°C)		Humidity (%)		Rainfall
	Max.	Min.	Morn.	Even.	(mm)
July					
27	32.1	22.5	88.4	58.7	3.9
28	32.3	22.7	88.6	55.3	4.2
29	32.0	23.1	86.6	52.0	0.0
30	29.9	22.7	86.0	67.0	3.2
Aug.					
31	31.2	21.5	86.3	56.0	1.5
32	30.7	21.7	89.6	58.7	0.9
33	32.0	21.0	87.7	50.3	0.7
34	29.9	21.2	90.3	61.7	8.3
35	30.3	21.0	85.7	59.1	0.0
Sept.					
36	31.0	20.0	86.6	52.4	0.4
37	31.6	18.7	87.0	53.0	0.7
38	32.9	19.4	86.3	55.7	0.4
39	28.8	21.1	91.4	71.1	8.5
Oct.					
40	31.8	18.9	87.1	53.4	3.0
41	33.3	19.8	88.4	43.3	0.0
42	33.2	15.3	82.1	35.9	0.0
43	32.5	12.1	85.1	29.4	0.0
Nov.					
44	32.1	19.5	87.1	51.3	0.4
45	32.1	12.8	72.4	30.3	0.0
46	31.0	13.8	69.6	37.9	0.0
47	32.0	13.5	64.7	33.1	0.0
48	32.0	13.4	79.3	33.6	0.0
Dec.					
49	30.8	10.0	84.1	28.7	0.0
50	31.0	9.0	76.7	27.3	0.0
51	28.1	8.2	75.6	27.3	0.0
52	30.1	8.6	83.1	41.0	0.0

Appendix I contd...

Week No.	Temperature (°C)		Humidity (%)		Rainfall
	Max.	Min.	Morn.	Even.	(mm)
Jan.					
1	29.9	10.5	73.6	31.1	0.0
2	28.4	8.4	83.4	32.1	0.0
3	31.6	10.1	75.9	27.7	0.0
4	28.0	10.2	84.9	36.1	0.0
Feb.					
5	29.2	11.0	85.1	35.0	0.0
6	30.6	7.5	84.3	26.3	0.0
7	32.6	12.9	84.1	27.1	0.0
8	34.1	11.5	85.9	25.6	0.0
March					
9	35.4	13.3	86.5	22.5	0.0
10	36.0	12.8	85.3	20.9	0.0
11	37.2	14.7	85.0	17.3	0.0
12	39.1	14.7	82.9	16.0	0.0
13	37.1	16.9	82.3	21.6	0.0

Appendix-II : Calendar of operation

Sr. No	Details	Set production	Bulb production	Seed production
1.	Season	*Rabi* 2002-03	*Kharif* 03	*Rabi* 2003-04
2.	Date of seed sowing	1st January, 15th January and 1st February (Three sowings)	7.6.2003 (Set planting)	26.12.2003 (Bulb planting)
3.	Basal dose of fertilizer			
a.	NPK (kg/ha)	50:50:50	50:50:50	50:50:50
b.	FYM (t/ha)	20	20	20
4.	Date of weeding	Two weedings at 30 and 60 days	8.7.2003, 10.8.2003	28.1.2004, 2.3.2004
5.	Date of top dressing (i.e. 50 kg N per ha)	30 days after seed sowing i.e. 1st February, 15th February and 1st March, 2003	9.7.2003	29.1.2004
6.	Interval for irrigation	6-8 days	8-10 days	8-10 days
7.	Number of irrigations	12	6-8	15
8.	Number of plant protection sprays on 10th, 25th, 40th and 55th day*	4	4	4
9.	Date of harvesting	90 days after seed sowing i.e. 1st April, 15th April and 1st May, 2003	for cv. S-1, 7-12 August 2003 for cv. B-780, 17-23, August, 2003	16.5.2004
10.	Storage	Upto 6.6.2003	7.9.2003 to 21.12.2003	-

For plant protection spray fungicides Dithan M-45 (0.03 %) or Bavistin (0.01 %) and insecticides Monocrotophos (0.015 %) or Cypermethrin (0.008 %) were used alternatively with sticker.

Vita

9. VITA

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A candidate for the degree

of

MASTER OF SCIENCE (AGRICLTURE)

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Major field	:	Horticulture (Olericulture)

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