SEASONAL INFLUENCE ON FLOWERING AND SEED SET IN THE IDENTIFIED GENOTYPES OF AGGREGATUM ONION (*Allium cepa* L. var. *aggregatum* Don.)

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Thesis submitted in part fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE to the

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CERTIFICATE

This is to certify that the thesis entitled **"SEASONAL INFLUENCE ON FLOWERING AND SEED SET IN THE IDENTIFIED GENOTYPES OF AGGREGATUM ONION (*Allium cepa* L. var. *aggregatum* Don.)"** submitted in part fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** to the Tamil Nadu Agricultural University, Coimbatore is a bonafide research work carried out by **Ms. N. ROHINI** under my supervision and guidance and that no part of this thesis has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

Place : Coimbatore

Date : **(Dr. P. PARAMAGURU)**

Chairman

APPROVED BY

Chairman : **(Dr. P. PARAMAGURU)**

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Co- opted member: **(Dr. S. NATRAJAN)**

(Dr. J. R. KANNAN BAPU)

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- Alexander Graham Bell

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ABSTRACT

SEASONAL INFLUENCE ON FLOWERING AND SEED SET IN THE IDENTIFIED GENOTYPES OF AGGREGATUM ONION

(*Allium cepa* L. var. *aggregatum* Don.)

By

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2011

Field experiment was conducted at experimental farm of Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2010-2011 to study the seasonal influence on flowering and seed set in the identified genotypes of aggregatum onion. The experiment was laid out in a Factorial Randomized Block Design with three replications. The experiment had four different planting seasons *viz*., September, October, November and December as treatments under factor (A) and three genotypes *viz*., CO On 5, Puttarasal type and Santhaipadugai Local as treatments under factor (B).

Observations on growth characters such as, days to first sprouting, days to complete sprouting, plant height, number of leaves, leaf length, leaf girth, shoot girth, tillers per plant and physiological attributes like chlorophyll content were recorded at four different growth stages of crop *viz*., 30th, 60th DAP, at full flowering and at harvest stages respectively. Flowering and yield characters *viz*., days to first flowering, 50 % flowering, full flowering, seed set and seed maturity, length of flower stalk and diameter of umbel at full flowering and at harvest stages,

number of umbels per plant, number of flowers per umbel, number of seeds per umbel, seed weight per umbel, flowering percentage, seed set percentage, seed yield and residual bulb yield were also recorded. In addition, quality traits *viz*., TSS, ascorbic acid content of bulbs and protein content of seeds were also estimated and seedling vigour characters *viz*., germination percentage, root length, shoot length, dry matter production and vigour index were recorded.

Among the four different seasons, September (S_1) season planting recorded the lesser days to sprouting of bulbs in the genotype Santhaipadugai Local. September season planting recorded the maximum of plant height, leaf length, leaf girth and tillers per plant at full flowering and at harvesting in the genotype Puttarasal type. Number of leaves per plant and shoot girth was maximum at 30 and 60 DAP in the genotype Puttarasal type planted during September season.

The flowering characters *viz*., days to first flowering, 50 % flowering, full flowering, and seed set and seed maturity was earlier under Santhaipadugai Local planted during September season. The Puttarasal genotype as September crop recorded significantly higher chlorophyll content at 60 DAP and at full flowering. Whereas length of flower stalk, diameter of umbel, number of umbels per plant, number of flowers per umbel, number of seeds per umbel and seed weight per umbel were the highest under September season in Puttarasal type due to existing favourable climate ie., low temperature and high relative humidity prevailed during flowering period. Among the four different seasons, September season crop recorded the highest seed yield in all three genotypes. Out of three genotypes, Puttarasal type gave significantly higher seed yield (807 kg ha^{-1}) in September season followed by Santhaipadugai local and CO On 5. Among the three seasons, September (S_1) planting recorded the maximum residual bulb yield (8000 kg ha^{-1}) in the Puttarasal type followed by CO On 5 and Santhaipadugai Local planted during September season.

The genotype Santhaipadugai Local recorded significantly higher TSS (14.37° brix) and ascorbic acid content (9.43 mg 100 g^{-1}) of bulbs in September planted crop, while Puttarasal type recorded the highest seed protein content (19 %) in September season.

Seedling vigour characters *viz*., germination percentage (92.76 %), root length (7.20 cm), shoot length (8.80 cm), dry matter production (15.82 mg 10 S_2^{-1}) and vigour index (1484.14) were the highest under September season in Puttarasal type.

Hence, considering the overall performance in terms of growth, flowering and seed set and physiological characters it could be concluded that Puttarasal type planted in September season recorded better yield and quality, followed by Santhaipadugai Local and CO On 5.

CONTENTS

ABBREVIATIONS

@	:	At the rate of	l^{-1}	:	Per litre
/	:	Per	mg	:	Milligram
%	:	Percentage	mg g^{-1}	:	Milligram per gram
°C	:	Degree Celsius	ml	:	Millilitre
<	:	Minimum	MSL	:	Mean Sea Level
>	:	Maximum	m^2	:	Square metre
±	:	Plus or Minus	nm	:	Nano meter
CD (0.05)	:	Critical Difference at 5 per cent level	N	:	Nitrogen and Normality
cm	:	Centimetre	NHB	:	National Horticultural Board
cv.	:	Cultivar	OD	:	Optical density
DAP	:	Days After Planting	plant^{-1}	:	Per plant
DAS		Days After Sowing	ppm	:	Parts per million
DMA	:	Dry matter accumulation	PTC	:	Photo Thermal Conditions
et al	:	Co workers	q	:	Quintals
etc	:	Etcetera	RF	:	Rainfall

°F	**:**	**Degree Fahrenheit**	**RH**	**:**	**Relative Humidity**
Fig.	**:**	**Figure**	**rpm**	**:**	**Round per minute**
g or gm	**:**	**gramme**	**Rs.**	**:**	**Rupees**
G	**:**	**Genotype**	**SEd**	**:**	**Standard Error of mean deviation**
g^{-1}	**:**	**Per gram**	**S**	**:**	**Season**
ha^{-1}	**:**	**Per hectare**	**sp.**	**:**	**Species**
hrs	**:**	**Hours**	**t**	**:**	**Tonnes**
i.e	**:**	**That is**	**TDMP**	**:**	**Total Dry Matter Production**
ISTA	**:**	**Internaional Seed Testing Association**	**TSS**	**:**	**Total soluble solid**
K	**:**	**Potassium**	**Var**	**:**	**Variety**
Kg	**:**	**Kilogramme**	**VI**	**:**	**Vigour Index**
Kg ha^{-1}		**Kilogram per hectare**	**viz.,**	**:**	**namely**
L	**:**	**Litre**	**mg**	**:**	**Milligramme**

ABSTRACT

SEASONAL INFLUENCE ON FLOWERING AND SEED SET IN THE IDENTIFIED GENOTYPES OF AGGREGATUM ONION

(*Allium cepa.* L.var. *aggregatum* Don.)

Student name **Chairman**

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Field experiment was conducted at experimental farm of Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2010-2011 to study the seasonal influence on flowering and seed set in the identified genotypes of aggregatum onion. The experiment was laid out in a Factorial Randomized Block Design with three replications in four different planting seasons *viz.*, September, October, November and December were evaluated as treatments under factor (A) and three genotypes *viz*., CO On 5, Puttarasal type and Santhaipadugai local as treatments under factor (B).

Observations on growth characters such as, day to first sprouting and complete sprouting, plant height, number of leaves, leaf length, leaf girth, shoot girth, tillers per plant and physiological attributes like chlorophyll content etc. were recorded at four different growth stages of crop *viz*., 30, 60 DAP, at full flowering and at harvest stages respectively and flowering and yield characters *viz*., days to first flowering, 50% flowering, full flowering, seed set and seed maturity , length of flower stalk diameter of umbel, number of umbels per plant, number of flowers per umbel, number of seeds per umbel, seed weight per umbel, flowering percentage, seed set percentage, seed yield and residual bulb yield were recorded. In addition, quality traits *viz*., TSS, ascorbic acid content of bulbs and protein content of seeds were also estimated and seedling vigour characters *viz*., germination percentage, root length, shoot length, dry matter production and vigour index were recorded.

Among the four different seasons, September (S_1) season planting recorded the lesser days to sprouting of bulbs in the genotype Santhaipadugai local. September season planting recorded the higher number plant height, leaves per plant, leaf length, leaf girth, shoot girth and tillers per plant in Puttarasal type. Days to first flowering, 50 % flowering, full flowering, and seed set and seed maturity was earlier under Santhaipadugai local planted during September season. The Puttarasal genotype as September crop recorded significantly higher chlorophyll content.

The yield attributes were the highest in Puttarasal type planted September season recorded higher seed yield (807 kg ha^{-1}) and maximum residual bulb yield (8000 kg ha^{-1}). Considering quality and seedling vigour characters September season crop regarded significantly best results.

Hence, considering the overall performance in terms of growth, flowering, physiology character and seed set it could be concluded that Puttarasal type planted in September season gives better yield and quality, followed by Santhaipadugai local and CO On 5.

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) is an important commercial vegetable, being grown in seven lakh hectares in India with an annual production of 12.16 million tonnes of bulbs (NHB, 2010). It accounts for 70 per cent of the vegetable exports from India. The leading onion growing countries are China, India, USA, USSR, Japan, Spain and Italy. In the world, India tops the rank of cultivated area, ranked second in production next only to China and it stands third in export after Netherlands and Spain. Onion is popularly called as "Queen of kitchen" because of its characteristic flavour. It is an indispensable item in every kitchen as condiments and vegetable. The bulb is a source of minerals, carbohydrates, protein and vitamin C. The dehydrated onion bulbs have vast scope in earning foreign exchange.

Two types of onion are commercially grown in India *viz*., common onion (*Allium cepa* L.var. *cepa*) which is most important in commercial trade. The common onion produces single large bulb per plant and propagated through seeds. The next group is the multiplier onion (*Allium cepa* L.var. *aggregatum* Don.) which produces bulbs of small size and they are several in number and form an aggregated cluster and propagated through bulblets.

The area under multiplier onion is being increased in India especially in Tamil Nadu. The total area under onion in Tamil Nadu is 3.53 lakh hectares with a production of 30.55 lakh tonnes (NHB, 2010a). Normally aggregatum onion varieties does not flower and set seed and hence propagated through bulblets. The seed bulb rate per hectare is 1500 kg. On an average one kilogramme of bulblets costs Rs. 20. So the cost of planting material comes around Rs.30,000 per hectare there is a possibility for drastic cut in the planting material and use of seeds as propagation material, the cultivation of aggregatum onion can be achieved successfully. More over, huge quantities of seed bulbs can be made available for consumption.

Production of quality seeds is an important factor in successful onion cultivation (Tomar, 2005) with the growing consciousness about the high yielding varieties among the farmers. The demand for the quality seed is increasing, resulting in more area under seed crops (Singh and Singh, 1976; Sumanaratne and Palipane, 2002).

Cultivar performance and date of planting plays an improtant role in the selection of genotypes for yield improvement and adaptation to particular environmental condition. Vegetables are short duration crops, which are greatly affected by environmental conditions.

Therefore, the effect of time of planting is usually more prominent. Onion, a commercical crop of India is highly sensitive to temperature and photoperiod. Difference in onion yield is caused by different planting times of the year (Verma *et al*., 1971; Joshi *et al*., 1975).

Onion is grown as a rabi season crop in northern plains, while it is grown as both kharif and rabi crops in the southern plains (Gupta *et al*., 1979). The time of planting is the most important factor in seed set (Mishra and Mishra, 1991). Delayed or early planting adversely affects seed yield of onion (Sumanaratne, 2000).

Onion growth in seed production requires vernalization for flowering and cold stimulation for bolting inducement (Rabinowitch, 1990). Mostly, the 'bulb to seed' method is used for seed production, since it permits selection of 'true to type' and healthy bulbs with comparatively very high seed yield.

There are certain ecotypes of aggregatum onion particularly grown near seashores of east coast of Tamil Nadu *viz*., Thengaithittu and Gnanamedu (near Cuddalore), Mutlur and Santhaipadugai Local (near Chidambaram) and Puttarasal type (near Palladam), which exhibits seed setting ability. The major constraint in the cultivation of aggregatum onion is the requirement of large quantity of seed bulbs for planting and cost of planting material. cost of production can be reduced by using seeds as planting material. For production of seeds, genotypes which exhibit good seed setting ability like CO On 5, Puttarasal type and Santhaipadugai Local can be used.

Among the different genotypes tested, the above three genotypes showed both high bulb yield and better seed setting ability. Growing of such seed setting aggregatum onion commercially needs standardized cultural practices. The optimum time of planting and use of proper varieties are important among the growing techniques which could contribute to higher seed yield.

The results also indicated that there were highly significant differences in yield between the planting dates and also between the varieties, also the area where the crop was grown might have contributed for the "bulb to seed" method of seed production in onion.

Taking these aspects into consideration, the present study was undertaken with the following objectives.

1. To determine the optimum time of planting of bulb of seed setting aggregatum onion genotypes for better seed yield.
2. To select a best aggregatum onion genotype for commercial seed production.

CHAPTER II

REVIEW OF LITERATURE

In onion the influence of time of planting on varieties has been studied by several workers. Onion (*Allium cepa* L. var. *aggregatum Don.*) is an important vegetable crop grown in Tamil Nadu. It is cultivated in an area of 3.53 lakh hectares with a production of 30.55 tonnes (NHB, 2010a). The response of different varieties to different environment is reviewed here. Onion is very sensitive to temperature and photoperiod. In early crop growth period a cool weather is favourable, while the crop needs dry atmosphere and moderately high temperature during the maturity. Longer days and high temperature promotes bulb formation (Dhesi *et al*., 1970), it has also been reported that the process of bulbing is controlled by photoperiod and temperature in common onion (Thompson and Kelly, 1978).

2.1. Effect of season of planting on growth characters

2.1.1. Plant height

Joshi *et al*. (1976) observed that onion seedling transplanted on 15th November attained maximum plant height (48.59 cm) under Rudrapur condition. Bhalla *et al*. (1983) reported that onion cv 'Pusa Red' seedling transplanted on 1st December produced increased plant height (74.79 cm) while the height decreased with delay in transplanting. Similar results were reported by Arora *et al. (*1966), Bhargava (1968), Verma *et al.* (1971) and Joshi *et al*. (1976).

Singh and Singh (1984) recorded that planting onion bulbs on 1st November (94.43 cm) proved equally effective with respect to plant height. The lowest plant height (90.07 cm) was noted when bulbs were planted in the middle of November.

The onion variety N-53 bulbs used for planting in kharif season attained maximum plant height (53.80 cm) under Hissar condition (Bhatia and Pandey, 1989). Bhonde *et al*. (1992) observed that the Agrifound Dark Red were associated with better vegetative growth (Plant height and number of leaves per plant). Singh *et al*. (1993) observed that cv. 'Pusa Red' was transplanted on 26th December, the plant height differed significantly with other planting dates during both the years. Maximum plant height of 50.35 cm was recorded when the crop was planted on 26th December.

Bhonde *et al*. (1994) reported that the small onion variety Agrifound Rose cultivated during kharif season attained maximum plant height (36.51cm). Shrivastava *et al*. (1996) observed that onion variety N-2-4-1 attained maximum plant height (58.06 cm) during rabi season (1980-90) under Jabalpur condition.

Maximum plant height 58.10 cm was obtained when bulbs were planted in month of November. The plant height significantly increased from 45th to 60th day of planting and at the time of harvest. And lowest plant height 47. 20 cm in the month of February (Aramirtham, 2000).

The longest plant height (59.81 cm) was observed on the August 25th transplanting date and it was found on a par with August 5th (56.81 cm) transplant. Whereas the shortest plant height (39.70 cm) was recorded on July 25th transplant date (Gautam *et al*., 2006).

Bhatt *et al*. (2007) recorded that the sowing dates significantly influenced the plant height at 45 and 60 DAS. Higher plant height was obtained on18th August (25.46 cm and 32.35 cm) and 28th August (25.38 cm and 32.26 cm) at 45 and 60 DAS respectively over later dates of sowing.

Deen (2008) reported that the October 30th planting produced the longest plants (62.29 cm) compared to other planting, with the delay of planting, plant height growth period were gradually reduced. Anisuzzaman *et al*. (2009) observed that the bulbs of Taher- puri planted on 21st November produced the tallest plants (47.74 cm) while shortest plants (42.95 cm) were those planted on 30th October.

2.1.2. Number of leaves per plant

Kisekva (1963) conducted trail on two onion cultivars and reported that branching and total leaf number were greater in plants grown from sets than in those grown from commercial thinning but the number of leaves per branch was lower in sets than commercial thinning.

Verma *et al*. (1971) observed that the seedling of onion cv. 'Patna Red' transplanted on 1^{st} October gave maximum number of leaves per plant (11.90). While Joshi *et al.* (1976) found that the seedling transplanted on 15^{th} November had produced maximum leaves per plant (11.27).

Bhalla *et al.* (1983) revealed that onion cv. 'Pusa Red' seedling transplanted on 1^{st} December produced maximum number of leaves per plant (13.94) and it decreased with delay in transplanting.

Singh and Korla (1991) has been reported that production of more number of leaves in early transplanting than the later ones. Singh *et al*. (1993) reported that onion variety 'Pusa Red 'gave more leaves when planted on 26^{th} December.

Shrivastava *et al.* (1996) observed that onion variety N-2-4-1 attained maximum leaves per plant (10.58) during rabi season (1980-90) under Jabalpur condition. The maximum number of leaves per plant was recorded (24.00) when bulbs planted in November and minimum number of leaves (15.00) recorded when bulbs were planted in February (Aramirtham, 2000).

Hussain *et al*. (2001) observed that planting on 21^{st} July gave the maximum number (26.07) of leaves per plant. Bhatt *et al*. (2007) found that August 18^{th} planting gave higher number of leaves (5.55) followed by August 28^{th} planting (5.48). Deen (2008) observed that October 30^{th} planting produced the highest number of leaves per plant (16.72) compared to other planting, with the delay of planting, number of leaves were gradually reduced.

Anisuzzaman *et al*. (2009) observed the highest number of leaves per plant (25.73) were counted in 21^{st} November planted crop followed by 10^{th} November (23.12) planting while leaf number was least in 30^{th} October.

2.1.3. Tillers per plant

Anisuzzaman *et al.* (2009) reported that the number of tillers per plant (4.00) was maximum in 2^{nd} November planted onion while minimum number of tillers per plant (3.68) was recorded in 30^{th} October planted onion.

2.2. Effect of season of planting on flowering and seed yield characters

2.2.1. Days to first flowering

Joshi *et al*. (1976) reported that the minimum number of days required for flowering (54.80) was seen when onion bulbs were sown on 15^{th} October under Chaubattia condition. Krishnaveni *et al*. (1990) observed that onion bulbs planted during 2^{nd} week of November recorded minimum number of days to flowering (55.9 days), whereas December 1^{st} week planted bulb recorded (58.00) days to flowering.

The inflorescence in the onion may continue to opening for more than two weeks and the plant may bloom for more than 30-40 days (Naik and Srinivas, 1992). Sumanaratne and Palipane (2002) reported that the flower stalks were initiated at six weeks after the field establishment of mother sets.

2.2.2. Days to 50 % flowering

Gill and Hari Singh (1989) reported that planting of onion postponed from October 1^{st} to November 1^{st} delayed the 50 % flowering by 7 days.

Krishnaveni *et al.* (1990) observed that onion bulbs planted during 3^{rd} week of November recorded minimum number of days to 50 % flowering (75.8 days), whereas January planted takes maximum days to 50 % flowering (78.6).

Earliest flowering (44 days) was noticed when the bulbs were planted in November and it was delayed from the month of December to February (48-54 days) (Aramirtham, 2000).

Anisuzzaman *et al.* (2009) recorded that the onion planted on 30^{th} October captured the longest time (54.04 days) while 21^{st} November, planted onion took the shortest time (50.34 days) for 50 % flowering.

2.2.3. Days to full flowering

The number of days to full flowering was minimum (76 days) in November planting. The flowering was delayed as the planting was delayed from December to February (79.2 to 82.6 days) Krishnaveni *et al*. (1990).

The number of days to full flowering was minimum (62 days) in earliest planting *viz.*, November. The flowering was delayed as the planting delayed from December to February (65-68 days) (Aramirtham, 2000).

Sumanaratne and Palipane (2002) reported that the flower stalks were initiated at six weeks after the field establishment of mother sets. All three varieties *viz*., Agrifound Rose, Vathalan and Jaffna local took another three weeks to complete flowering during October season.

2.2.4. Length of flower stalk

Joshi *et al*. (1976) reported that onion bulbs planted on October 15th produced maximum height of flowering stem under Chaubattia condition. However, it could not affect the length of vegetative phase, size of umbel, and seed per umbel as well as seed weight.

Singh and Singh (1984) observed that planting of onion bulbs on first November and last November proved equally effective with respect to length of flower stalk. The lowest flower stalk height (90.76 cm) was noted when the bulbs were planted in the middle of November.

In an experiment conducted at Katrain, a long day cultivar Brown Spanish onion bulbs planted on 15th December produced minimum length of flower stalk when compared to seed to seed method (Verma *et al*., 1995). Anisuzzaman *et al.* (2009) recorded that the maximum scape length (64.55 cm) was recorded in 21st November planted onion while the minimum length (57.46 cm) was found in 30th October planting.

Seed stem were greatest with those onion transplanted on 5th January 2004. Other treatments with exceptionally high numbers of seed stems included onion transplanted on November and 2nd February 2003 (Boyhan *et al.*, 2009).

2.2.5. Number of umbels per plant

Kisekva (1963) observed that the plant grown to the seed producing stage over a period of three years (i.e., from sets) produced fewer flowering stems (umbels) than those grown over second years (i.e., from seeds).

Nammi *et al*. (1980) who found that the large umbels were produced more seed yield than smaller umbels. November first planted bulbs (10.99) gave maximum number of umbels per plant followed by middle of November (9.32) planted crops. Whereas minimum number of umbels per plant recorded when crop planted during 30th November (Singh and Singh, 1984).

Sidhu *et al.* (1996) concluded that the number seed stalk per plant was the most useful characteristic either independently or in combination with umbel diameter, for selecting for seed yield in onion seed crops.

Bulbs planted in November month recorded more number of umbels per plant (5.00) and it gradually reduced from December and attained a less number of umbel per plant in the month of February (4.00 -3.00) (Aramiratham, 2000). Sumanaratne and Palipane (2002) reported that the onion varieties Vethalan and Agrifound Rose formed more flower stalks. The flower umbels of Agrifound Rose formed was bigger than those of Vethalan during October to January season.

Difference in flower stalk formation from variety is well established (Boyhan *et al*. 2005; Cramer, 2003). Boyhan *et al.* (2008) did not see seed stem difference among varieties but early sowing (5th October) dates influenced seed stems and revealed that the number of seed stems were greater (9.3 number per plot) on the early sowing date (5th October) compared with the middle (or) late sowing date.

Anisuzzaman *et al.* (2009) observed that the Number of umbels per plant was highest (4.21) in 21st November planting date while the lowest was at 30th October planting of mother bulbs. Boyhan *et al*. (2009) reported that the earliest transplant date of 12th November had more seed stem than the 23rd November or 6th December transplanted bulb.

2.2.6. Number of flowers per umbel

Number of flowers per umbel were higher in 1st November planted bulbs (498.47) followed by 15th November (462.91). Whereas lowest number were recorded when bulbs were planted on 30th November (Singh and Singh, 1984).

NHRDF (2005) recommended that last week of October to first fortnight of November month for planting of onion bulbs. If planting is done early, the crop gets damaged from rain which occurs in March or April. If late planting was done, vegetative growth is less and due to this there are lesser number of flowers and also the seeds in umbel were minimum.

Florets per umbel increased progressively with increasing cold duration. The greatest number of florets per umbel was 596 and 578 for cultivars Hygro and Delta, respectively, compared to that of the 20 days treatment which produced 441 and 423 florets per umbel for cultivars of Hygro and Delta respectively. A one day increase in chilling duration equated to 3.47 and 2.76 increase in number of florets per umbel in cultivars of Hygro and Delta respectively (Khokhar *et al*., 2007).

Anisuzzaman *et al*. (2009) reported that the number of flowers per umbel is a very important component contributing to final seed yield. The highest (239.0) number of flowers per umbel was found in 21st November plants while the lowest number (194.6) was recorded in 30th October onion crop.

2.2.7. Number of seeds per umbel

The increase in seed yield was expected since set-to-seed plants had a large umbel diameter, greater number of opened flowers and higher number of seeds per capsule when set planted at November 1998 under Iraq condition (Al-Sahaf, 2002).

Seed yield per umbel increased with increasing chilling durations. Seed yield per umbel following a low temperature treatment (5.8° C) for 90 days was approximately four times greater in both cultivars (5.5 and 4.2 g for cultivars Hygro and Delta, respectively) (Khokhar *et al*., 2007).

Anisuzzaman *et al*. (2009) reported significantly highest (171.1) number of seeds per umbel was recorded in 21st November planted onion. Lowest values for number of seeds per umbel were observed in the 30th October planted onion.

2.2.8. Flowering percentage

Experiment in onion were counted in Punjab with different dates of transplanting and reported that higher yield and flowering percentage in the crop transplanted in October month. Thus the dates of sowing also influenced the yield potential (Singh and Gill, 1980).

Sinclair (1983) conducted experiment with nine onion cultivars sown at low densities between 1st July and 9th September. He observed that bulbs of cv. Prizetaker were the largest at all sowing dates but its flowering percentage was also the highest (up to 41 and 11% for early and late sown bulbs, respectively). Creamgold, spring sowing, Spearwood, Supergba and American also had larger bulbs than the standard cv. Creamgold.

Flowering percentage increased significantly with increasing cool temperature durations. Sets treated for 90 days at 58° C, produced nearly seven times more bolters (56 and 27% for cultivars Hygro and Delta, respectively) than those treated for 20 days (Khokhar *et al*., 2007).

Low temperature during growth period induce flowering. Larger plants are more likely to bolt than smaller plants of the same age. Bolting was observed during rabi season 1997, in V12 due to prolonged rain and cold weather (Jains.com, 2002).

2.2.9. Seed set percentage

Seed set per cent per umbel was maximum in 1st November planting date (70.48 %) followed by 15th November (65.31 %). Whereas minimum seed set percent was recorded when bulbs were planted on 30th November (Singh and Singh, 1984).

Anisuzzaman *et al*. (2009) reported that seed set per cent in each umbel was highest in 21st November planting date (77.38 %), significantly lowest value for percent seed set per umbel were observed in the 30th October planted onion.

2.2.10. Seed yield

Arakeri and Patil (1956) reported that onion bulbs planted on October 14th recorded maximum seed yield per plot under Pune condition. Insitu production of onion seed, nursery may be sown during the last week of August and transplanted in second week of October for getting optimum seed yield (Bhagchandani *et al*.,1970).

Joshi *et al*. (1976) reported that onion bulbs of ‘Pusa Red’ planted on 15th October gave maximum seed yield (295.81 kg ha^{-1}). Dhillon and Arora (1980) reported that the optimum planting time of bulbs for seed production is October - November under Punjab condition.

Mondal (1980) considered last week of October as the best planting time for the highest yield and best quality onion seeds. Gulshan Lal *et al*. (1982) reported that the earliest planting (13th October) of bulbs gave maximum seed yield (3.50 q ha^{-1}). Singh and Singh (1984) observed that bulbs planted during middle of November recorded highest seed yield (17.94 q ha^{-1}). This corroborates the results of Gill *et al.* (1981).

Nehra *et al*. (1989) revealed that maximum seed yield was recorded when the bulbs are planted on October 16th. These finding are in conformity with Mishra *et al.* (1986).

Bhatia and Pandey (1989) recorded that bulbs planted in kharif season recorded maximum seed yield (9.66 q ha^{-1}) which was higher than seed to seed method. Krishnaveni *et al*. (1990) reported that the onion bulbs planted on 2nd week of November gave maximum seed yield (1.28 g $plant^{-1}$).

Verma *et al*. (1995) reported that maximum seed yield was obtained when bulbs were planted on 15th December (27.87g $plot^{-1}$). Ponnuswami and Thumburaj (1996) have reported that shallot onion yielded 250 kg/ha true seeds in Indian condition.

The bulb to seed method planted in March produced the highest yield resulting in good seed quality whereas bulbs planted at the beginning of August produced the lowest seed yield and quality (Gaviola, 1997). El-Aweel and Ghobashi (1999) reported that early planting reduced seed yield by 13.50 per cent but improved the seed germination compared with later planting.

November planted bulbs get more quantity of seeds harvested in January (1.53 g $plant^{-1}$) bulbs planted from December to February recorded less quantity of seed. It ranged from 1.08 to 0.57 g $plant^{-1}$. Bulbs planted in November recorded maximum seed yield (612.50 kg) whose seeds were harvested in January. There after a gradual reduction in seed yield per ha while bulbs planted in December, January and February (432.00, 400.00 and 228.00 kg respectively) Aramiratham (2000).

In general, small onions possess the ability to produce considerable quantity of true seeds (Sumanaratne, 2000). Agrifound Rose recorded 1.2 kg of seeds from six standard beds but Vethalan recorded 1 kg from the same number of bed during May to October season (Sumanaratne and Palipane, 2002).

Whenever the seed crop is planted in first fortnight of October is subjected to the heavy incidence of disease resulting in poor seed yield. Tomar and Negi (2002) has recorded the highest seed yield of 576-800 kg / ha with low incidence of disease and better seed quality in cv. 'Pusa Madhavi' in 15th November planting during rabi 1999. However the higher seed yield (1251.66 kg ha^{-1}) with complete escape from the incidence of disease in cv. 'Pusa Red' was recorded during rabi 2000 (Tomar, 2005).

The highest number of flowers per umbel (226.6), fruit set (71.16 %) and seed yield (383.20 kg ha^{-1}) were found in 30th October planting time, which was significantly higher than other two planting dates (Deen, 2008).

Adagale *et al*. (2010) reported that the under ambient condition, immature or unfilled seed has poor germination and viability. The environment conditions as well as most practices during crop growth stage are found to influence the seed quality.

Anisuzzaman *et al.* (2009) revealed that the Bulb planting dates had significant effects on seed yield per umbel, per plant, per plot, and per hectare. The highest yield was obtained from 21st November planted onion. These were 0.55 g, 2.30 g, 46.40 g and 460.8 kg respectively and the lowest seed yield was recorded in 30th October with respective value of 0.45 g per umbel, 1.74 g per plant, 36.01 g per plot and 355.7 kg ha^{-1}.

2.2.11. 1000 Seed weight

Joshi *et al*. (1976) observed that the average weight of thousand seeds was maximum (4.753 g) when bulbs were planted on 15th October.

Onion variety Hisar-2 gave maximum average weight of thousand seeds when bulbs were planted on 16th October (Nehra *et al*., 1989). Highest test weight of seed was recorded in crops raised during the 2nd week of November (3. 80 g). It decreased gradually registering minimum in January 3rd week planting (Krishnaveni *et al*., 1990).

Anisuzzaman *et al.* (2009) reported that the date of planting had also significant effects on the quality of seed produced. The heaviest seed (3.48 g) was from 21st November, planted onion and the lowest weight (3.07 g) were obtained from 30th October planted bulbs. The maximum weight of hundred seed (0.25 g) was recorded in November while it gradually reduced from December to February it ranged from 0.20 to 0.13 g.

2.3. Varietal influence on growth, flowering, seed and bulb production

Ramtohul and Owadally (1980) reported that maximum bulb production and best time for local Red was the first fortnight of March and maximum yield was given by October sowing. Tropicana F1 was the best of the imported cultivars and Gizeh was least promising.

Buchvarov (1985) observed that early cultivars produced smaller plants than later ones. The dry matter content was highest in Tropicana and Pioneer. The relatively late variety Pioneer produced plant with well developed pseudostem and leaves and was recommended for production.

Khokhar *et al.* (1990) reported that highest mature bulb yield (31.4 t ha^{-1}) was obtained from Jaune Espagnol (bulb weight 41.5 g) followed by Jaune de Hatif and Texas Early Grano.

Attar *et al.* (1991) found that later planting resulted in decrease in the number of leaves, gross yield and net yield. Maximum number of leaves and yield were obtained in Poona Red and Nasik Red. Lallan *et al*. (1991) tested five cultivars during 1984-87 among these Agrifound Dark Red and Pusa Red were the highest yielding in kharif and rabi respectively.

Orlowski and Rekowska (1992) showed that in all cultivar the earliest sowing date gave the highest yield with the other dates giving lower but similar results. With the earlier sowing date Wolska gave the highest average yield of 35. 02 t ha^{-1}.

Kuruppuarachchi (1992) reported that Vethalan flowers and set seeds satisfactorily under Kalipitiya condition. Similar information about the variety has been reported by Kuruppuarachchi (1987), Ragupathi (1984) and Fernando (1983).

Brar *et al*. (1993) observed that in seed crops the line Sel. 102-1 was free from this thrips, while No, 21 IIHR 387, Aflr and Arka Niketan were promising. Sidhu *et al.* (1996) studied that during 1988-89, the seed production potentials of 30 genotypes of onion were investigated at Ludhiana. The maximum seed yield was obtained from the variety Punjab Red Round (1.0 t ha^{-1}), followed by VL - 67 (0.87 t ha^{-1}), Country White (0.89 t ha^{-1}) and

Sel -102-1(0.87 t ha^{-1}). The higher seed in these genotypes was related to higher number of seed stalk per plant and to wider umbel diameter.

Jaiswal *et al*. (1997) reported that the seed production of the onion was investigated at Kundule and Keware, Regal PVP (213 kg ha^{-1}) produced 26.3% more seed than that of Early Red and required 216 days to complete development.

Onion sown on 10th August had greater yield with ‘Agrifound Dark Red’ in Junagadh, India compared with 25th August or 9th September (Movalia *et al*.,1999).

The cultivar Agrifound Dark Red and N-53 recorded significantly higher bulb yield under rabi season. Further Arka Kalyan is recommended for kharif season and Agrifound Dark Red and N-53, Agrifound light Red are recommended for rabi season (Mohanty *et al.,* 2000).

Al- Sahaf (2002) reported that the variety Local White had highest flower set percent (74.9 to 94.0 %) followed by Local Red variety (75.9 to 88.5 %). Whereas the lowest per cent of flower set in was Texas Grano 520 (73.3 to 88.0 %).

In Nasik, Maharashtra, India ‘Agrifound Light’ was found to have the greatest yield from 8th week old transplant harvested 125 days after transplanting compared with 7 or 9th week old transplants and harvest dates of 110 and 140 days after transplanting (Bhonde *et al*., 2001). Although, Jaffna local is not a promising flowering variety its capability of flowering and seeding, could be exploited for varietal development it was reported by Sumanaratne and Palipane, (2002). Improved varieties contribute substantially to enhance crop yield as high as 30 % (Shaikh *et al*., 2002).

Sumanaratne and Palipane (2002) showed that cultivar Agrifound Rose and Vethalan, belonged to multiplier sub group and are suitable for true seed production and those seeds posses ability to substitute the conventional planting material of sets in small onion cultivation. Agrifound Rose and Vethalan are promising cultivar for seed production in small onion under Aralaganwila condition.

In an comprehensive study of onion varieties and sowing dates in New Mexico from 9th to 30th September it was found that delayed sowing results in less bolting greater yield and delayed maturity (Cramer, 2003). Bolting resistance in 'Numex Mesa' played a greater role sowing date on having lower numbers of seed stems regardless of sowing date.

Vaddoria *et al.* (2004) reported that the genotypes 'Agrifound Light Red' and 'JDR -98-144' were found promising with stable performance for bulb yield. Whereas genotypes 'Junagadh Local' and 'Talaja Red' were promising with good stability and higher performance for TSS. Difference in seed stems formation from variety is well established (Boyhan *et al.*, 2005).

The bolting percentage on Red Creole (2.54 %) was found to be maximum compared to Nasik Red which was minimum (1.81 %) but the highest mean diameter of bulb (5.73 cm) was found on N-53 and lowest (4.90 cm)was found on Red Creole reported by Gautam *et al.* (2006).

Bhatt *et al.* (2007) revealed that onion variety 'Agrifound Dark Red' gave more yield under Sardarkkrushinagar condition. Boyhan *et al.* (2009) reported that the variety 'Sweet Vidalia' had increasing yield followed by 'Sugar Belle'. Whereas 'Pegasus' recorded lowest yield.

Low productivity of onion in Bangladesh could be attributed to limited availability of quality seed quality and lack of appropriate hybrids (Tomar *et al.*, 2004; Ali *et al.*, 2007).

Boyhan *et al.* (2008) reported that seed stems differed among varieties, the variety 'Sweet Vadalia' at early planting gave maximum seed stems (25/plot) followed by Pegasus recorded (9/plot). Minimum number of seed stems per plot (7.00) reported in the variety of Nirvana.

Geetharani *et al.* (2008) reported that CO On 5 flowers and seed set satisfactorily under Coimbatore condition along with the growth regulators treatment. Anisuzzaman *et al.* (2009) reported that onion variety 'Taherpuri' is a promising variety under Bangladesh condition.

Onion (*Allium cepa* L.) seed production with variety "Phule Samarth" gave better growth, growth contributing characters and seed yield in onion reported by Adagale *et al*. (2010).

2.4. Effect of season of planting and varietal characters on bulb yield

Planting time of onion varies with locality, type of onion and the method of propagation. For early planting, seedlings are raised between July and August and transplanted from September to October. In plains of Pakistan, October and November sown crops gave increase in the bulb size as well as bulb weight (Rashid and Rashid, 1978).

Ramtohul and Owadally (1980) reported that maximum bulb production and best time for local Red was the first fortnight of March and maximum yield was given by October sowing. Tropicana F1 was the best of the imported cultivars and Gizeh was least promising.

Miccolis and Vitucea (1984) found that planting onion bulbs in early October gave higher yields of salad onion than planting in early September or early November. The variety Doreata Di Parama gave the highest salable plant yield (50 t ha^{-1}).

Lopes (1987) examined the performance of different cultivar in the Rio Grand Valley during two years studies. Each variety produced better yields when associated with specific planting date. In general best yields were obtained with12 October to 16 November planting in 1984-85 and with 17 September planting in 1985-86. The cultivars TG 1015Y, TG 1025Y, as grow Y33 and as grow 429 were recommended for planting in the region between 17^{th} September and 14^{th} November.

Tomar *et al*. (1989) reported that highest bulb yield (448.57 q ha^{-1}) was obtained with earliest sowing compared with 193.43 and 110.99 q ha^{-1} bulb yield in sowing on 15^{th} December and 15^{th} January respectively.

Jadhav *et al*. (1990) tested the performance of 11 cultivars and evaluated for 14 quantitative and qualitative characters during the rabi season of 1990-91. Among the cultivars, Agrifound Light Red and Pusa White Falt had the highest total bulb yields 42.8 and 42.3 t ha^{-1}, respectively. Highest total soluble solid content of 14.8 % was obtained from N257-9-1.

Bednarz and Kadams (1991) reported that high yield were obtained with sowing on 23^{rd} August, 24^{th} September and 1^{st} November, but there was a sharp drop in yield with sowing on 30 November and 28^{th} December.

Katwale and Sarat (1991) evaluated the performance of eight onion cultivars (N-53, N-2-4-1, Local, Nasik Red, Udaipur- 102, Udaipur-103, N-257-9-1 and Udaipur-101) during the rainy season of 1981-84. The N-54 had the highest mean bulb yield (133.99 q ha^{-1}) and the highest percentage (76.1%) of medium size (25-50 mm) bulbs. Bhonde *et al*. (1992) have reported that rabi onion variety if grown in late kharif season can produce equally good bulb yield as that of kharif variety in Nasik area of Maharashtra.

Kachan and Osvald (1992) conducted trail with 2 cultivars, seeds were sown or sets were planted on 14th April, 28th April and 12th May. Onion grown from sets yielded much better than those grown from seeds. Orlowski and Rekowska (1992) carried out a three year trail with the cultivars Rawska, Zyrawska and Wolska. The seeds were sown on 5th, 10th or 15th April. At 6 kg ha^{-1} in rows 30 cm apart. In all cultivars the earliest sowing date gave the highest yield while the other dates giving lower but similar results. With the earliest sowing date, Wolska gave the highest average yield of 35.02 t ha^{-1} followed by Zyrawska and Rawska with 26.21 and 25.96 t ha^{-1}, respectively.

Mingochi and Pande (1992) reported that significant difference among entries for bulb weight (127-218 g) and highest yield in being NIZ 1003 (29 t ha^{-1}) followed by Texas Yellow Grano (28.3 t ha^{-1}) was observed in the later sowing date, bulb quantity and overall mean yield was five times lower than in the earliest trial.

Pakyurek *et al*. (1994) evaluated that autumn sowing produced higher yields than spring sowing. The cultivar SG 936, Ben Semen, Akgun 12 and Corum produced the highest yields. Plants at early planting showed the highest bulb diameter, bulb volume, individual bulb weight and gave the highest bulb yield per ha (Ahmed and Munshi, 1995).

The highest bulb yield 315.22 q / ha was obtained from the variety Agrifound Dark Red, followed by N-53 (302.5 q / ha) it was reported by Mohanty *et al.* (2000) and he noticed that the varieties N-53 produced the tallest plant (58.50 cm), with maximum number of leaves per plant (17.50) whereas the cultivar Arka Pitamber recorded the most dwarf plant (37.40 cm) least diameter of bulb (4.2 cm) and the lowest bulb yield (156.8 q / ha) as compared to the rest of varieties and found that rabi varieties if grown during kharif season can produce equally good bulb yield as that of kharif varieties. Agrifound Dark Red was recommended for cultivation during kharif season for obtaining maximum bulb yield.

Bulb volume, bulb weight per plant was decreased with the delay of planting time. The highest bulb volume (32.69 cm) bulb weight per plant (48.85 g) and bulb yield (13.89 t / ha) were recorded in 30 October planting (Deen, 2008).

2.5. Effect of photoperiod and temperature on growth and development

In onion inflorescence initiation can occur in plants which are not in the bulbed conditions (Heath and Holdsworth, 1943 and Scwlly *et al*., 1945).

Holdsworth and Heath (1950) reported that day length did not affect the inflorescence initiation. They found by dissection that percentage of plants which had initiation of inflorescence were exactly equal in the long and short days at low temperature. But, none of the plants had initiated inflorescence at high temperature i.e. above 20º C in either day length. The complete lack of bolting at high temperature was therefore a temperature effect on initiation at low temperature in the short photoperiod it was a day length effect on the rate of scape elongation. It was evident from result was obtained that day length and temperature determined the number of days a variety might take for bolting. Scientists for shortening the breeding cycle of onion successfully used these two factors.

Photoperiod has little effect on the floral initiation, rather it is induced by exposing to cool temperature (Jones and Mann, 1963). Johns and Mann, (1963) and Kher *et al.* (1999) who stated that lower temperature (<10º C) in the month of December and January expedite premature bolting in rangda season.

Venkampan (1970) working with spring sown bulbs onion delineated three phase in onion inflorescences development namely 'thermo phase' during which inflorescence induction was temperature dependent, the 'competition phase' during onion inflorescence emergence during which factor favoring bulb growth could suppress inflorescence emergence, and the 'completion phase' in which warm temperature long day were beneficial.

High temperature may adversely affect onion seed production. Since the occurrence of physiological damage to umbel, resembling sunscald was associated with a reproduction in the number of viable seed production (Tanner and Goltz, 1972).

Brewster (1982) conducted experiments over several season on inflorescence and seed production by four cultivators of over wintered bulb onion in glass house conditions. Large yields of good quality seed were obtained at temperature of 20-30º C after inflorescence emergence. This temperature regime accelerated seed ripening by 4-5 weeks compared with plants kept at 15- 20º C. Over wintering plants in glass house at 5-10º C rather than outside led to earlier flowering and seed ripening with resultant larger seed yields.

In Indian condition, onion seed production is under taken only during rabi season, while higher temperature of more than 35º C especially during flowering have detrimental effects and cause significant reduction in seed yield and seed viability (Wagh, 1986).

Branca *et al*. (1994) reported that the reproductive response (flowering percentage and date, number of flower stalk and seed production of onion plants) was markedly affected by photo thermal conditions (PTC). The cultivars studied were: Alisa Craig, Alix, Bianc di Giugno, Texas grano 502, Tropicana and Valcorente. Floral induction occurred only in PTC of >1900 hr at < 12º C for all the cultivars tested. Nevertheless, the vernalisation was insufficient when the day length dropped to about 10hr, indicating an interaction between temperature and photoperiod. When the above PTC was given with a day length of 12.9 hr, the yield components of umbel /plant, capsule/umbel, seeds /capsule and 1000 seed weight were optimized. Cultivar differences were more evident in poor PTC for flower initiation, demonstrating that onion has very important intra specific variability in flower induction sensitivity to climatic conditions.

Suitable adjustment in planting dates can help in escaping the physiological damage caused by temperature and variation and result in better bulbing and yield in garlic (Maurya, 1989).

Sowing dates was shown to have an effect on onion production in Louisiana, with the best yields for onion sown on 3rd October, compared with 2nd September or 10th October. With the former planting dates resulting in increased bolting (Mulkey and Talbot, 1991).

The inflorescence in the onion may continue opening for more than two weeks and the plants may bloom for more than 30 - 40 days (Naik and Srinivas, 1992).

Flowering in onion was mainly induced by low atmospheric temperature ranging from 4 to 15º C further, higher temperature after floral initiation sometimes prevent normal development of flower stalks due to abortion of flower initials (Brewster, 1982).

Seed stems are usually greater when cool temperature (<50º F) occur late in the season (March-April) when plants have sufficient leaf number to respond to those condition and enter sexual phase (Boyhan *et al*., 2009).

2.6. Effect of season of planting on quality traits and seedling vigour characters

2.6.1. T.S.S

Bhalla *et al*., (1983) reported that age of seedling and date transplanting had no significant effect on T.S.S and dry matter contents of the onion bulbs. However, maximum T.S.S (15 %) was noted when seven weeks old seedlings were transplanted on 1st December and eight weeks old seedling transplanted on 1st December.

Jadhav *et al*. (1990) tested the performance of 11 cultivars and evaluated 14 quantitative and qualitative during the rabi season of 1990-91. Highest total soluble solid content of 14.8 % was obtained in N257-9-1.

Maximum values of TSS were recorded in the may planting whose bulbs were harvested in the month of July (16.80 %). The planting was taken up in the month of January and bulbs were harvested in March have recorded minimum TSS of 13.49 % recorded by Aramirtham (2000).

2.6.2. Standard germination test

Krishnaveni *et al*. (1990) recorded that seed germination percent was good in November 2nd week (90 %) followed by 3rd week planting (86 %). But germination percent was low in January planting.

Anisuzzaman *et al.* (2009) reported that the germination percent (85.41%) was the highest in the seeds collected from the 21st November planted onion while this value was the lowest (71.87 %) in the 30th October planted onion.

Under ambient condition, however, immature or unfilled seed had poor germination and viability. Environmental conditions as well as management practices during crop growth stage are found to influence the seed quality (Adagale *et al*., 2010).

2.6.3. Root length

Krishnaveni *et al*. (1990) recorded that root length was good in November 2nd week (6.9 cm) followed by 3rd week of planting (6.70 cm) but it was low in January planting (5.8 cm).

2.6.4. Shoot length

Krishnaveni *et al.* (1990) recorded that shoot length was good in November 2nd week (9.5 cm) followed by 3rd week planting (9.0 cm) but it was low in January planting (8.5 cm).

2.6.5. Dry matter content

Maximum dry matter (15.30 %) was recorded in bulbs when five weeks old seedlings were transplanted on 1st December (Krishnaveni *et al.*, 1990).

CHAPTER III

MATERIALS AND METHODS

Investigations were carried out on the "Seasonal influence on flowering and seed set in the identified genotypes of aggregatum onion (*Allium cepa* L.var. *aggregatum* Don.)" at the experimental fields of College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003, during 2010 - 2011. The details of the materials used and the methods adopted for the study and the analytical techniques followed during the present investigation are given in this chapter.

3.1. Meteorological data

3.1.1. Location

The field experiment was conducted at the College Orchard, Tamil Nadu Agricultural University, Coimbatore -3. Geographically, it is located at 11°02' North latitude, 77°03' East longitude and at an altitude of 426.76 m above MSL.

3.1.2. Meteorological parameters

The meteorological parameters such as ambient temperature, relative humidity, rainfall and sunshine hours were collected from Agro-Meteorological Observatory, Agricultural College and Research Institute, Coimbatore. The meteorological data during the crop period are furnished in Fig.1- 4.

3.2. Materials

3.2.1. Collection of genotypes

The seed bulbs of different seed setting aggregatum onion types collected from three different regions of Tamil Nadu such as Santhaipadugai Local (near Chidambaram), Puttarasal type from Palladam (near Coimbatore) and CO On 5 from Dindigul (Ambilikkai) were used as seed materials in this study. The details of the cultivars are furnished below.

Details of the genotypes

Genotypes	Source
CO On 5	Ambilikkai (Dindigul)
Puttarasal type	Palladam (Coimbatore)
SanthaipadugaiLlocal	Santhaipadugai (Chidambaram)

3.3. Methods

3.3.1. Design of experiment

The field experiment was laid out in a Factorial Randomized Block Design with three replications. The field layout plan is presented in Fig. 5.

3.3.2. Treatment details

Factor (A): Seasons

S_1 - September, 2010

S_2 - October, 2010

S_3 - November, 2010

S_4 - December, 2010

Factor (B): Genotypes

G_1 - CO On 5

G_2 - Puttarasal type

G_3 - Santhaipadugai Local

3.3.3. Main field preparation

The soil was brought to fine tilth by giving four deep ploughings. Weeds, stubbles, roots etc., were removed.

3.3.4. Bed preparation

Afterwards, the raised beds were formed at a length of 20 m and width of 1 m, and spacing of each bed is 75 cm.

3.3.5. Planting

The healthy and uniform size bulbs were planted at a spacing of 20 x 15 cm.

3.3.6. Weeding

The experimental plots were kept free of weeds by regular hand weeding depending upon the weed intensity.

3.3.7. Irrigation

The first irrigation was given at the time of planting and followed by life irrigation was given on the third day after transplanting and there after drip irrigations were given daily for 2 hours.

3.3.8. Manures and fertilizers

Manures and fertilizers were applied as per the recommendations given in the Crop Production Techniques of Horticultural Crops (TNAU, 2004).

3.3.9. Plant protection

The plant protection measures were carried out as per the recommendations given in the Crop Production Techniques of Horticultural Crops (TNAU, 2004).

3.3.10. Harvesting

Although all the seed heads did not mature simultaneously, they were harvested in one cutting. Harvesting was made sufficiently early to avoid shattering of seeds. Seeds attained maturity in 40-55 days after flowering. The symptom of harvestable maturity was turning of the skin colour from green to bright yellow. The seed heads were cut with 10-15 cm of stem attached.

3.3.11. Seed extraction

The cut seed heads were dried in the sun. When the seed heads were completely dry they were threshed and seeds collected after cleaning.

3.4. Observations

Ten plants in each replications were randomly selected, tagged and the observations were recorded.

3.4.1. Growth characters

3.4.1.1. Time taken for sprout initiation

The number of days from planting to sprouting of first ten bulbs in each treatment was counted and recorded. Mean values of treatment were calculated and registered.

3.4.1.2. Time taken for completion of sprouting

The number of days taken to complete sprouting was counted and mean value of each treatment was recorded.

3.4.1.3. Plant height

The height of the plant was measured from the neck of the bulb to the tip of the longest leaf by using a scale on 30^{th}, 60^{th} days after planting (DAP), at full flowering and at harvest in ten plants at each stage of the crop growth and the mean value was calculated and expressed in centimetres.

3.4.1.4. Number of leaves per plant

The total number of leaves in each of the ten selected plants on 30^{th}, 60^{th} DAP, at full flowering and at harvest was counted and the average was expressed in number.

3.4.1.5. Leaf length

The length of the longest leaf was measured from the base of attachment to the tip of leaf on 30^{th}, 60^{th} DAP, at full flowering and at harvest and the mean values were calculated and expressed in centimetres.

3.4.1.6. Leaf girth

The girth of leaf was measured using thread at the maximum circumference of the leaf on 30th, 60th DAP, at full flowering and at harvest and the mean values were calculated and expressed in centimetres.

3.4.1.7. Shoot girth

Using flexible nylon tape shoot girth was measured at the collar region of the shoot at 30th, 60th DAP, at full flowering and at harvest and the mean values expressed in centimetres.

3.4.1.8. Tillers per plant

The total number of tillers per plant was counted at 30th, 60th DAP, at full flowering and at harvest randomly selected from ten plants and average number of tillers per plant was registered.

3.4.2. Flowering and seed characters

3.4.2.1. Days to first flowering

The number of days was counted from sowing to start of flowering in ten randomly selected plants in each treatment and average number of days taken to flowering was calculated.

3.4.2.2. Days to 50 % flowering

The total number of days taken from sowing to first flower stalk emergence in 50 % of the population was recorded.

3.4.2.3. Days to full flowering

The total number of days till the completion of flowering was recorded separately in ten randomly selected plants in each treatment and average number of days to complete flowering was calculated.

3.4.2.4. Days to seed set

The number of days was counted from full flowering to seed setting in ten randomly selected plants in each treatment and average number of days taken to seed set was calculated.

3.4.2.5. Days to seed maturity

The number of days was counted till the maturity of seeds in ten randomly selected plants in each treatment and average number of days to seed maturity was calculated.

3.4.2.6. Length of flower stalk

The length of the flower stalk was measured from the collar region of the plant to the base of the umbel for ten plants by using scale during full flowering and at harvest. The mean values were expressed in centimetres.

3.4.2.7. Diameter of umbel

The diameter of umbel was measured from randomly selected ten plant umbels in each treatment during full flowering stage and at harvest stage and average was recorded and expressed in centimetres.

3.4.2.8. Number of umbels per plant

Flowering heads were counted as effective tillers bearing flower heads.

3.4.2.9. Number of flowers per umbel

The number of flowers per umbel was counted by selecting ten umbels and mean was calculated.

3.4.2.10. Number of seeds per umbel

The number of seeds in ten selected umbels from each treatment was counted and converted to number of seeds per umbel.

3.4.2.11. Seeds weight per umbel

The weights of seeds in ten selected umbels were weighed in an electronic balance and the mean weight expressed in gramme.

3.4.2.12. Flowering percentage

Flowering percentage was worked out from the total number of bulbs planted to the number of bulbs flowered in each season using following formula:

$$\text{Flowering percentage} = \frac{\text{Number of bulbs flowered}}{\text{Total number of bulbs planted}} \times 100$$

3.4.2.13. Seed set percentage

Ten umbels were selected at random in each varietal category and the filled and illfilled umbels were counted in each umbel. From the average of filled and illfilled umbellets of the 20 umbels, the seed set was calculated as follows and expressed in percentage.

$$\text{Seed set percentage} = \frac{\text{Number of filled umbellets per umbel}}{\text{Total number of umbellets per umbel}} \times 100$$

3.4.3. Physiological characters

3.4.3.1. Chlorophyll content

Chlorophyll ‘a’, ‘b’ and total chlorophyll content were estimated by following the method of Yoshida *et al*. (1971). A representative sample of leaf tissue 250 mg was weighed and grounded with 10 ml of 80 per cent acetone using a pestle and mortar. The homogenised sample was centrifuged at 3000 rpm for 10 minutes. The supernatant was collected and volume was made up to 25 ml with 80 per cent acetone. The OD value of the extract was measured at 663, 652 and 480 nm using 80 per cent acetone as the blank in the spectrophotometer. The amount of pigments was calculated using the following formula and expressed in mg of pigments g^{-1} of leaf (on fresh weight basis).

$$\text{Chlorophyll a} = [12.7(\text{OD at } 663) – 2.69 (\text{OD at } 645)] \times V/ W \times 1000 \text{ mg g}^{-1}$$

$$\text{Chlorophyll b} = [22.9 (\text{OD at } 645) – 4.68 (\text{OD at } 663)] \times V/ W \times 1000 \text{ mg g}^{-1}$$

$$\text{Total chlorophyll} = [1000 (\text{OD at } 652)/34.5] \times V/ W \times 1000 \text{ mg g}^{-1}$$

Where,

V – Final volume of chlorophyll extract in 80 per cent acetone

W – Fresh weight of leaves extracted (g)

3.4.4. Yield characters

3.4.4.1. Seed yield plant^{-1}

Ten plants from each plot were selected at random and the umbels from each plant were separated, harvested, hand threshed and cleaned, the collected seeds were weighed in an electronic balance and the mean weight expressed in gramme.

3.4.4.2. Seed yield plot^{-1}

The umbels collected from all the plants in each plot were hand threshed, cleaned, weighed separately in a physical balance and the mean weight expressed in g plot^{-1}.

3.4.4.3. Estimated seed yield ha^{-1}

The yield of seed per plot was converted into seed yield ha^{-1} in kg by using the following formula:

$$\text{Seed yield (kg)} = \frac{\text{Weight of seed (g) / plot x Area in hectare (m}^2\text{)}}{\text{Area of plot (m) x 1000}}$$

3.4.4.4. 1000 seed weight

1000 seeds were counted in 10 sample and the mean values were expressed in milligrammes.

3.4.5. Residual bulb yield

3.4.5.1. Residual bulb yield plant^{-1} (after the harvest of seeds)

The fresh weight of the bulbs produced by individual plant after the harvest of seed was taken in an electronic balance and expressed in grammes.

3.4.5.2. Residual bulb yield plot^{-1} (after the harvest of seeds)

The fresh bulbs collected plot^{-1} after the harvest of seed were cleaned and weighed in an electronic balance and the mean value was expressed in kg per plot.

3.4.5.3. Estimated residual bulb yield ha^{-1} (after the harvest of seeds)

The fresh bulbs collected plot^{-1} after the harvest of seed were calculated for one hectare and expressed in kilogrammes.

3.4.6. Quality traits

3.4.6.1. Total soluble solids (TSS)

The total soluble solids of onion bulbs were recorded with hand refractometer and expressed as degree brix.

3.4.6.2. Ascorbic acid

Ascorbic acid content in onion bulbs were estimated by the volumetric method (A.O.A.C., 1975).

A quantity of five grammes of the bulb was taken in 4 % oxalic acid and the volume made up to 100 ml and centrifuged. A quantity of 5 ml of the supernatant was pipetted out into a 100 ml conical flask. 10 ml of 4 % oxalic acid was added and titrated against 2, 6-dichlorophenol indophenol dye. End point was the appearance of pink colour which persists for a few seconds. Ascorbic acid content was calculated and expressed as mg 100 g^{-1} of fresh sample.

3.4.6.3. Seed protein content

The protein content of the seed was estimated by Bradford's method. One gramme sample was macerated with phosphate buffer solution and the volume was made up to five ml. The extract was centrifuged at 3000 rpm for 10 minutes. After centrifugation, supernatant solution was taken and equal volume acetone was added. The supernatant was refrigerated for one hour and centrifuged again at 5000 rpm for 15 minutes. The pellet was collected and stored in 0.1 N NaOH for one day. 0.2 ml of sample was made up to one ml by using 0.8 ml of phosphate buffer and then 5 ml of Bradford's dye was added. Blue color was developed and the optical density of the clear supernatant solution was determined at 595 nm using spectrophotometer against the blank. Protein content was calculated and expressed in mg g^{-1} by using the following formula.

$$\text{Protein content (mg g}^{-1}\text{)} = \frac{\text{OD value of test sample x 0.2 x 1}}{\text{OD value of standard x 5 x 1000}}$$

3.4.7. Seedling vigour characters

3.4.7.1. Standard germination test

The germination test was conducted as per ISTA rules (ISTA, 1993) using roll towel method. Three replications of 75 seeds per genotype were used and the test was carried out in a germination room maintained at 25 ± 2º C temperature and 90 ± 5 % RH. After 21 days the germination test were evaluated and the normal seedling with 'Bent knee' were expressed as germination percentage.

3.4.7.2. Root length

Ten normal seedlings from the standard germination test were randomly selected and the root length was measured from the collar region to the tip of the primary root and the average expressed in centimetres.

3.4.7.3. Shoot length

The length from the collar region to the tip of the shoot was measured as shoot length and the average expressed in centimetres.

3.4.7.4. Dry matter production

The seedlings used for growth measurement were taken in butter paper covers, shade dried initially and subsequently in a hot air oven maintained at 85 ± 1º C for 24 hr and the mean dry weight of the seedling was recorded in mg 10 S_2^{-1}.

3.4.7.5. Vigour index (VI)

The vigour index was calculated using the procedure suggested by Abdul - Baki and Anderson (1973) and expressed as whole number.

$$\text{VI} = \text{Germination percentage x Total seedling length (cm)}$$

3.5. Statistical analysis

The data collected were subjected to the statistical analysis in Factorial Randomized Block Design by the method of Panse and Sukhatme (1985).

CHAPTER IV

EXPERIMENTAL RESULTS

A field experiment was carried out to investigate the seasonal influence on morphological, physiological and biochemical characters, yield components and yield of aggregatum onion genotypes. All the characters were recorded at four different growth stages *viz.*, 30^{th}, 60^{th} DAP, at full flowering and at harvest stages. The experiment was laid out in a Factorial Randomized Block Design with three replications at the experimental farm at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The results were subjected to statistical analysis and pertinent data presented in appropriate tables and suitable figures as here under.

4.1. Morphological characters

4.1.1. Sprouting of bulbs

Sprouting of bulbs was observed as initiation and completion to study the periodical growth rate under four different seasons of planting**.**

4.1.1.1. Time taken for sprout initiation

The results on sprout initiation of bulbs of aggregatum onion genotypes are presented in Table 1. The time taken for sprout initiation was significantly influenced by different planting season. Among four planting season, September season took the least time for sprout initiation (4.23 days) followed by October which took 5.17 days. Late planting i.e. sowing on December took more time for sprouting initiation (7.17 days).

The genotypes differed significantly with regard to time for sprout initiation. The genotype Santhaipadugai local took least time for sprouting initiation (4.57 days) followed by CO On 5. Whereas Puttarasal type took maximum time for sprout initiation i.e. 6.80 days.

Days to sprout initiation were earlier in Santhaipadugai Local under September and October season crop, followed by CO On 5. The interaction between seasons and genotypes were also significant. Days taken for sprout initiation were recorded earlier in Santhaipadugai Local planted during September by 3 days, followed by S_1G_1. S_4G_2 recorded delayed sprouting initiation by 8.20 days, and statistically comparable with CO On 5 planted during December season.

4.1.1.2. Time taken for completion of sprouting

The results regarding the completion of sprouting of bulbs of aggregatum onion genotypes are presented in Table 1. The differences in completion of sprouting among various planting seasons were highly significant. Among four planting season, September season took the least time for completion of sprouting (7.77 days) followed by October season which took 8.68 days. Late planting i.e. sowing on December took more time for completion of sprouting (12.10 days)

Significant differences were recorded with respect to time taken for complete sprouting of bulbs amongst the genotypes. The maximum time taken for complete sprouting of bulbs was recorded in Puttarasal type (10.58 days) which differed significantly from all other genotypes. It was followed by CO On 5 that took 9.91 days for complete sprouting. Whereas Santhaipadugai Local took 8.83 days for this purpose.

Time taken for completion of sprouting was earlier in Santhaipadugai local under September and October season crop, followed by CO On 5. The interaction between season and genotypes were also significant. Days taken for completion of sprouting were recorded earlier in Santhaipadugai Local planted during September by 7.77 days, followed by S_1G_1. S_4G_2 recorded delayed sprouting completion i.e. 13.07 days. But comparable with CO On 5 planted during December season.

4.1.2. Plant height

The total plant height was recorded at four different stages *viz.*, 30, 60 DAP, at full flowering and at harvest of seeds are presented in Table 2 and Fig. 6.

An increasing trend was noticed up to harvest stage for the height of plant. Among the four seasons, September season planted crop has recorded maximum plant height (41.18, 53.47, 57.26 and 61.56 cm followed by October season, which has recorded 35.24, 43.86, 48.48 and 52.44 cm at 30, 60 DAP, at full flowering and at the time of seed harvest respectively, than the other two seasons.

Among the three genotypes, Puttarasal type (G_2) has recorded the maximum plant height at all the four stages of observation (36.70, 45.04, 49.24 and 53.69 cm) and statistically on par with Santhaipadugai Local (G_3) at 30 DAP, but significantly superior to CO On 5.

At the four different stages of observation, the interaction between season and genotypes were significant. Puttarasal type sown during September season recorded higher plant height (43.91, 55.63, 59.20 and 65.61cm) at 30, 60 DAP, at full flowering and at harvest respectively but statistically comparable with Santhaipadugai Local planted during October season at 30 DAP. CO On 5 planted during December season recorded the least plant height (27.20, 33.77, 39.63 and 43.06 cm at 30, 60 DAP, at full flowering and at harvest respectively) but statistically comparable with CO On 5 planted during November season at 30 DAP of observation.

4.1.3. Number of leaves per plant

The number of leaves per plant was observed at four different stages *viz.*, 30, 60 DAP, at full flowering and at harvest of seeds. A decreasing trend was noticed up to harvest stage for the number of leaves per plant. Among the four seasons, September season crop recorded maximum number of leaves (30.93, 25.52, 22.03 and 17.93 at 30, 60 DAP, at full flowering and at harvest respectively) when compared to other three seasons (Table 3 and Fig.7).

Among the three genotypes, Puttarasal type (G_2) recorded maximum number of leaves at all the four stages of observation (30.00, 24.50, 21.84 and 17.45) which was followed by CO On 5.

At all the stages of observation, the interaction between seasons and genotypes were also significant. September season planted Puttarasal type has recorded maximum number of leaves (35.00, 28.40, 24.00 and 20.00) but statistically comparable with CO On 5 planted during September season at 30 DAP. Santhaipadugai Local planted during December season recorded the minimum number of leaves (19.50, 17.50, 16.00 and 11.83 at 30, 60 DAP, at full flowering and at harvest respectively) but statistically comparable with CO On 5 planted during November season at 30 DAP of observation.

4.1.4. Leaf length

The data on leaf length recorded in different seasons and genotypes were presented in Table 4. The averge leaf length recorded during September season was 38.18, 49.88, 53.11 and 57.3 cm at 30, 60 DAP, at full flowering and at harvest respectively. This was followed by October season, with value of 32.51, 40.15, 44.40 and 49.46 cm at 30, 60 DAP, at full flowering and at harvest respectively, than the other two seasons.

The maximum leaf length was found in genotype Puttarasal type with 33.72, 41.04, 46.65 and 50.93 cm at 30, 60 DAP, at full flowering and at harvest stages of crop growth respectively and statistically on par with Santhaipadugai Local at 30 DAP.

At all the stages of observation, the interaction between seasons and genotypes were significant. Puttarasal type sown during September season recorded maximum leaf length (40.58, 52.06, 55.53 and 63.13 cm at 30, 60 DAP, at full flowering and at harvest respectively) but comparable with Santhaipadugai Local planted during September season at 30 DAP. December season planted CO On 5 has recorded the minimum length of leaves (24.83, 31.26, 37.83 and 40.40 cm at 30, 60 DAP, at full flowering and at harvest respectively) but statistically comparable with CO On 5 planted during November season at 30 DAP of observation.

4.1.5. Leaf girth

The data with respect to leaf girth in four different seasons and three different Onion genotypes were presented in Table 5. An increasing trend was observed up to full flowering and then gradual reduction in leaf girth at harvesting stage (1.88 to 2.86 cm). Among the four seasons, September season crop registered significantly the maximum leaf girth of 2.09, 2.40, 3.27 and 2.62 cm at all the four stages of observation *viz*., 30, 60 DAP, at full flowering and at harvest respectively and this was followed by October (S_2) season which recorded 2.01, 2.27, 2.92 and 2.42 cm at the same stages of crop growth, then the other two seasons.

The Puttarasal type has registered significantly higher leaf girth of 1.89, 2.22, 3.03 and 2.45 cm respectively in the same stages. Whereas CO On 5 has recorded lower leaf girth of 1.69, 2.09 2.72 and 2.19 cm at 30, 60 DAP, at full flowering and at harvest respectively.

At 30 and 60 DAP of observation, the interaction between seasons and genotypes were not significant. But it was significant during full flowering and at harvest. Puttarasal type planted during September season recorded significantlly higher leaf girth (2.22, 2.45, 3.56 and 2.86 cm) and statistically comparable with Santhaipadugai Local planted during September-October season at 60 DAP. CO On 5 planted during December season recorded the least leaf girth (1.30, 1.81, 2.33 and 1.88 cm at 30, 60 DAP, at full flowering and at harvest stage respectively) but comparable with CO On 5 planted during November season at 60 DAP of observation.

4.1.6. Shoot girth

The data registered on shoot girth of the different genotypes and seasons were presented in Table 6. An increasing trend was observed up to full flowering stage for the shoot girth and then gradual reduction in shoot girth at harvesting stage (1.97 to 3.05 cm). Among the four seasons, September season crop registered significantly the maximum shoot girth of 2.61, 3.08, 3.41 and 2.93 cm, followed by October (S_2) season which recorded 2.46, 3.01, 3.21 and 2.76 cm ^{at} 30, 60 DAP, at full flowering and at harvest respectively, than the other two seasons.

The higher shoot girth was found in Puttarasal type at 30, 60 DAP, at full flowering and at harvest stages of crop growth with 2.53, 2.60, 3.03 and 2.78 cm respectively, and lesser shoot girth was found in cultivar CO On 5 with 2.23, 2.60, 2.92 and 2.44 cm at the same stages of crop growth.

At all the stages of observation, the interaction between seasons and genotypes were statistically significant. Puttarasal type sown during September season recorded higher shoot girth (2.82, 3.33, 3.66 and 3.05 cm) but comparable with Santhaipadugai Local sown during November season at 30 DAP. CO On 5 planted during December season recorded the least shoot girth (1.97, 2.29, 2.46 and 1.97 cm at 30, 60 DAP, at full flowering and at harvest stage respectively) and statistically comparable with CO On 5 planted during October season at 30 DAP of observation.

4.1.7. Tillers per plant

The observations recorded on the total number of tillers per plant are presented in Table 7. The differences in number of tillers per plant among various planting seasons were statistically significant. The maximum number of tillers per plant was observed in September season planted crop i.e. 6.72, 8.84, 9.67 and 9.05 at 30, 60 DAP, at full flowering and at harvest respectively, followed by other three seasons.

The number of tillers per plant was found higher in Puttarasal genotype at 30, 60 DAP, at full flowering and at harvest stages of crop growth with 7.16, 8.38, 9.04 and 8.50 respectively. The total number of tillers per plant was found lesser in cultivar CO On 5 with 5.38, 7.12, 7.39 and 7.12 at the same stage of crop growth.

The maximum number of tillers per plant was higher in Puttarasal type under September and October season crop, followed by Santhaipadugai Local. At all the stages of observation, the interaction between seasons and genotypes were significant. Puttarasal type sown during September season recorded higher number of tillers per plant (7.80, 9.59, 10.74, and 9.47 at 30, 60 DAP, at full flowering and at harvest respectively) but comparable with Santhaipadugai Local planted during November season at 30 DAP. CO On 5 planted during December season recorded the least number of tillers per plant (5.03, 6.32, 6.60 and 6.55 at 30, 60 DAP, at full flowering and at the harvest stage respectively) but comparable with CO On 5 planted during October season at 30 DAP of observation.

4.2. Flowering and seed characters

4.2.1. Days to first flowering

The number of days taken for the commencement of flowering varied significantly among the genotypes within and also between the seasons (Table 8 and Fig.8). In general, flowering was earlier in all three genotypes in September season. The number of days taken for flowering varied from 31.20 to 39.60 and 33.20 to 40.20 days for S_1 and S_2 respectively. The differences among the genotypes were found to be statistically significant. Flowering was earlier in the Santhaipadugai Local in September and October season followed by CO On 5. Flowering was delayed in Puttarasal type in all the season. The interaction between season and genotypes were significant. Santhaipadugai Local planted during September season recorded earlier flowering by 31.20 days, (S_1G_3) followed by Santhaipadugai Local planted during other three season. Puttarasal type planted during December season (S_4G_2) recorded delayed flowering by 42.40 days.

4.2.2. Days to 50 % flowering

As in the case of the onset of flowering, days taken for 50 per cent flowering was also earlier for the September season planted crops by about 13.63 days when compared to December season planted crop (Table 8, Fig.8 and Plate 6, 8 &10). The difference between the seasons was also found to be significant. The differences among the genotypes were found to be statistically significant.

Days to 50 per cent flowering was earlier in Santhaipadugai Local under September and October, than other two season crop, followed by CO On 5. The interaction between season and genotypes were also significant. Days taken for 50 per cent flowering was recorded earlier in Santhaipadugai Local planted during September by 43.33 days, followed by S_1G_1. S_4G_2 recorded delayed flowering by 60.01 days.

4.2.3. Days to completion of flowering

As in the case of the 50 % flowering, days taken for completion of flowering was also earlier for the September season sown crops by about 17.72 days when compared to December season planted crop (Table 8, Fig. 8 and Plate 6, 8 &10). The difference between the seasons was also found to be significant. The number of days to completion of flowering was minimum (66.65 days) in earliest planting viz. September. The flowering was delayed as the planting delayed from December (73.42 days). The differences among the genotypes were found to be statistically significant.

Days to completion of flowering were earlier in Santhaipadugai Local under September and October, and then November, December season crop, followed by CO On 5. The interaction between season and genotypes were also significant. Days taken for completion of flowering were recorded earlier in Santhaipadugai Local planted during September by 60.30 days, followed by S_1G_1. S_4G_2 recorded delayed flowering by 80.30 days.

4.2.4. Days to seed set

The data recorded on days to set seed are presented in Table 9, Fig. 9 and Plate 7, 9 &11) The number of days taken for the seed setting varied significantly among the genotypes within and also between the seasons. The number of days to set seed was minimum (86.50) in September season planting. Whereas the seed set was delayed in November and December season planting (98.40 and 102.87 days respectively).

There was significant difference in days to seed set between the genotypes. Puttarasal type (G_2) recorded the maximum days to seed set (105.07 days) followed by CO On 5. Whereas the genotype Santhaipadugai Local recorded minimum days to set seed i.e. 87.80 days.

Seasons and genotypes were found significant in days to seed set. Santhaipadugai Local planted during September season recorded minimum days to set seed (79.16 days), followed by CO On 5 planted during S_1 (84.20 days). S_4G_2 recorded maximum days to seed set 112.20 days, which is on par with S_4G_1.

4.2.5. Days to seed maturity

The data on the effect of treatment on days to seed maturity is presented in Table 9 and Fig.9. Considering the season, September season planted crop recorded minimum days required to seed maturity (115.21 days) than the other three seasons.

Among the genotypes, Santhaipadugai Local recorded minimum days need to seed maturity (115.82 days) followed by CO On 5 and the genotypes Puttarasal type recorded maximum days taken to seed maturity i.e. 137.39 days.

The minimum days to seed maturity (104.40 days) was recorded under the treatment combination Santhaipadugai Local sown during September season followed by CO On 5 planted during September season, while the maximum days required to seed set was recorded under the treatment combination Puttarasal type planted during December season (144.23 days).

4.2.6. Length of flower stalk

The length of flower stalk per plant was observed at two different phonological stages *viz.*, at full flowering and at harvest stages. Among the four season, September season crop recorded lengthiest flower stalk (56.32 and 60.23 cm at full flowering and harvest stages, respectively) than other three seasons (Table 10 and Fig. 10).

Significant variation existed between the genotypes with regard to length of flower stalk. The lengthiest flower stalks were found in Puttarasal type which possessed maximum length of 48.14 and 52.39 cm at two stages of observation. It was followed by G_3 and the shortest flower stalk were recorded in genotypes CO On 5 in which the length of flower stalk was 44.92 and 48.64 cm at full flowering and at harvest stages respectively.

The effects of interaction between the seasons and genotypes on flower stalk length were found to be significant. Puttarasal type planted during September season recorded lengthiest flower stalk (58.86 and 63.86 cm at full flowering and at harvest stages respectively), but comparable with G_3 planted during September season at full flowering stage. CO On 5 planted during December season recorded shortest flower stalks (38.80 and 42.03 cm at the same stage of observation).

4.2.7. Diameter of umbel

Considering the seasons, September season crop recorded widest diameter of umbel 6.62 and 5 cm at full flowering and harvesting stages respectively (Table 11). December season crop recorded shortest umbel diameter at same stages of observation.

The diameter of umbel in three onion genotypes differed significantly. The umbels of genotypes Puttarasal had widest diameter (6.00 and 4.86 cm at full flowering and at harvest stages respectively). Whereas CO On 5 umbels had the shortest diameter at the two stage of observation.

Season and genotype interaction was not found significant on umbel diameter. The widest umbel diameter (7.07 and 6.03 cm at full flowering and harvest respectively) was recorded under the treatment combination Puttarasal type planted during September season at two stages of observation. But it was on par with G_3 at the time of harvest. The shortest umbel diameter (4.07 and 3.17 cm) was recorded under CO On 5 planted during December season at same stages of observation.

4.2.8. Number of umbels per plant

The data recorded on number of umbels per plant are presented in Table 12 and Plate 12, 13 & 14. The number of umbels per plant varied significantly due to seasons and genotypes. Bulbs planted in September recorded more number of umbels per plant (6.76), it gradually reduced from October and attained a less number of umbels per plant in the season of December (5.39).

Puttarasal type recorded maximum number of umbels per plant (6.69) followed by Santhaipadugai Local and CO On 5. The interaction between seasons and genotypes were also significant. The higher number of umbels per plant (7.50) was recorded in Puttarasal type planted during September season, followed by S_1G_3. S_4G_1 which recorded lesser number of umbels per plant (4.81).

4.2.9. Number of flowers of per umbel

The number of flowers per umbel varied significantly due to seasons (Table 12, Fig. 11 and Plate 12, 13 & 14). The average number of flowers per umbel ranged from 126.26 to 250.86 being minimum in December planted crop and maximum being in September (S_1) planted crop.

The genotypes under screening differed significantly with regard to number of flowers per umbel. The number flowers per umbel ranged between 167.93 to 209.30. The maximum number of flowers per umbel was noticed in genotype Puttarasal type followed by G_3. Whereas the minimum number of flowers per umbel were recorded in CO On 5.

The interaction between season and genotypes were also significant. The maximum number of flowers per umbel (282.40) was recorded under treatment combination Puttarasal type planted during September season and Santhaipadugai Local planted during September season. While the minimum number of flowers per umbel (114.40) was obtained under treatment combination CO On 5 planted during December season.

4.2.10. Number of seeds per umbel

The influences of treatment on number of seeds per umbel are presented in Table 12 and Fig.11. There was a gradual reduction in number of seeds per umbel from October to December planting season. It ranged from 154.36 and 231.03 in December and October planting season respectively. In September higher number of seeds per umbel (251.04) was recorded.

The genotypes differed significantly with regard to number of seeds per umbel. The significantly greatest number of seeds (219.03) per umbel was recorded in Puttarasal type which differed significantly from G_3 and $G_{1.}$

Interaction effect also exhibited significant variation among all the treatments. Puttarasal type planted during September season significantly increased the number of seeds per umbel (260.03) followed by S_2G_2. CO On 5 planted during December season recorded with minimum number of seeds per umbel (142.03) compared to all other interaction.

4.2.11. Weight of seeds per umbel

The data recorded on weight of seeds per umbel are presented in Table 12. The weight of seeds umbel^{-1} was significantly influenced by seasons and genotypes. The maximum weight of seeds umbel^{-1} (0.306 g) was recorded in September while it gradually reduced from October to December planting season. It ranged from 0.290 to 0.163 g.

Among the three different genotypes, Puttarasal type recorded the highest seed weight umbel^{-1} (0.257 g) followed by Santhaipadugai Local. The lowest seed rate was found in CO On 5. Within the interaction effect, Puttarasal type planted during September season (S_1G_2) increased the weight of seeds umbel^{-1} with the higher value of 0.319 g followed by $S_2G_{2.}$ The lowest weight of seeds umbel^{-1} was recorded in CO On 5 planted during December season (0.146 g).

4.2.12. Flowering percentage

Flowering percentage of genotypes differed significantly due to different planting seasons (Table 13, Fig.12 and 6, 8 &10). The maximum flowering percentage was observed in the bulbs planted on September season (87.82 %) followed by October season. The minimum flowering percentage was observed in bulbs planted on December planting season.

The maximum flowering percentage was counted in Puttarasal type and Santhaipadugai Local (80.37 and 71.00 % respectively). The minimum flowering percentage was recorded in the genotype CO On 5. Seasons and genotypes interaction were found significant on flowering percentage. The highest flowering percentage (97.90 %) recorded under the treatment combination Puttarasal type planted during September season followed by S_2G_2. The lowest flowering percentage (52.00 %) was obtained under CO On 5 planted during December season.

4.2.13. Seed set percentage

As regards seed set percentage of umbels collected from crops of different planting season, the maximum seed set percentage (85.07 %) was observed in umbels obtained from September planting crops followed by October and November planting crops while late planting (December season) gave minimum seed set percentage (Table 13, Fig.12 and 7, 9 &11).

The maximum seed set percentage of umbels were counted in Puttarasal type and Santhaipadugai Local (79.72 % and 75.02 % respectively). The minimum seed set percentage was recorded in the genotype CO On 5. Season and genotype interaction was found significant on seed set percentage. The highest seed set percentage (88.73 %) recorded under the treatment combination Puttarasal type planted during September season followed by S_2G_2. The lowest seed set flowering (58.30 %) was obtained under CO On 5 planted during December season.

4.3. Physiological attributes

4.3.1. Chlorophyll content

4.3.1.1. Chlorophyll 'a' (mg g^{-1})

Chlorophyll 'a'content was found to be increased significantly up to 60 DAP and declined thereafter (Table 14). At all seasons the three genotypes significantly influenced the chlorophyll 'a'content. Higher amount of chlorophyll 'a' was observed in September season crop (0.73, 0.77, 0.64 and 0.59 mg g^{-1} at 30, 60 DAP, at flowering and harvesting respectively) followed by S_2, S_3 and S_4. Among the three different genotypes, Puttarasal type resulted in the highest chlorophyll 'a' content (0.72, 0.75, 0.64 and 0.55 mg g^{-1} at 30, 60 DAP, during flowering and at harvesting respectively) which was followed by G_1 and G_3. The interaction between seasons and genotypes had significant influence on chlorophyll 'a' content. Among interactions, Puttarasal type planted during September season possessed the maximum content of chlorophyll 'a' (0.82, 0.86, 0.74 and 0.70 mg g^{-1}) and Santhaipadugai Local planted during December season possessed the minimum content of chlorophyll 'a' (0.45, 0.47, 0.48 and 0.38 mg g^{-1} at 30, 60 DAP, at full flowering and at harvest stages respectively).

4.3.1.2. Chlorophyll 'b' (mg g^{-1})

Chlorophyll 'b' content showed increased trend up to 60 DAP and declined towards full flowering stage (Table 15). Both seasons and genotypes were significantly influenced the chlorophyll 'b' content. September crop recorded the highest amount of chlorophyll 'b' (0.31 and 0.37 mg g^{-1} at 30 and 60 DAP respectively) followed by October, November and December crop. Considering the genotypes, Puttarasal type recorded the highest value of Chlorophyll 'b'content (0.34 and 0.41 mg g^{-1}) followed by CO On 5 (0.25 and 0.27 mg g^{-1}), and Santhaipadugai Local (0.20 and 0.17 mg g^{-1}) at 30 and 60 DAP respectively. The interaction between seasons and genotypes attained statistical significance on chlorophyll 'b'content. September season planted Puttarasal genotype recorded more chlorophyll 'b' (0.42, 0.60, 0.32 and 0.31 mg g^{-1}) content, irrespective of the stages of observation followed by CO On 5 planted during September season and it was statistically comparable with Puttarasal type planted during September season. Santhaipadugai Local planted during December season recorded lesser chlorophyll 'b' content (0.18, 0.14, 0.18 and 0.13 mg g^{-1}) at all the stages of observation.

4.3.1.3. Total chlorophyll (mg g^{-1})

Total chlorophyll content showed same trend as that of chlorophyll 'a' and 'b' content (Table 16 and Fig.13). Total chlorophyll content was significantly affected by seasons and genotypes. Among the four seasons, September season crop (0.77, 1.01, 0.91 and 0.85 mg g^{-1} at 30, 60 DAP, at full flowering and at harvest respectively) resulted in the highest amount of total chlorophyll content followed by October, November, and December season crop at all the stages of observation. Puttarasal type (0.83, 1.00, 0.91 and 0.79 mg g^{-1} at 30, 60 DAP, at full flowering and at harvest respectively) obtained the highest total chlorophyll content, which was followed by CO On 5 and Santhaipadugai Local. Significant effect on total chlorophyll content was exhibited by the interaction between seasons and genotypes. Puttarasal type planted during September season (S_1G_2) recorded more amount of total chlorophyll (0.91, 1.07, 1.04, and 1.02 mg g^{-1} at 30, 60 DAP, at full flowering, and at harvest respectively).

4.4. Yield characters

4.4.1. Seed yield

4.4.1.1. Seed yield per plant

The data recorded on seed yield plant $^{-1}$ are presented in Table 17 and Fig.14. Among the four season of planting set more quantity of seeds was recorded in September planting (2.07 g plant^{-1}). The bulbs planted from October to December recorded less quantity of seeds. It ranged from 0.83 to 1.79 g plant^{-1}. On average over four season of study, the seed yield plant^{-1} recorded was 1.45 g.

The genotypes differed significantly with respect to seed yield. It ranged from 1.19 to 1.74 g plant^{-1}. The genotype Puttarasal type produced the highest (1.74 g plant^{-1}) seed yield followed by Santhaipadugai Local. The lowest seed yield of 1.19 g plant^{-1} was obtained from genotype CO On 5.The interaction between seasons and genotypes were highly significant on seed yield plant^{-1}. Maximum seed yield was noted from Puttarasal type planted during September season recorded more yield per plant (2.39 g) followed by Puttarasal type planted during October season. CO On 5 planted during December season recorded the lowest yield per plant (0.70 g).

4.4.1.2. Seed yield per plot

Seed yield recorded during the study is depicted in Table 17. The observed data on seed yield kg per plot indicated that the September (S_1) season crop registered significantly higher mean values as compared to October season crop, S_1 recorded with the 0.416 kg plot^{-1} as compared to October season crop which recorded 0.359 kg per plot.

Genotype effect with reference to yield and yield parameters were also differed significantly for CO On 5, Puttarasal type and Santhaipadugai Local. The significant was higher with Puttarasal (G_2) registered the mean value of 0.351 kg plot^{-1} followed by Santhaipadugai Local (G_3) and CO On 5 (G_1). The increase in percent over the G_3 by the G_2 showed that 20.79 in yield per plot. Within the interaction effect, Puttarasal type planted during September season (S_1G_2) gave the maximum seed yield per plot^{-1} with the higher value of 0.484 kg followed by S_2G_2. The lowest seed yield per plot^{-1} was recorded in CO On 5 planted during December season (0.140 kg / plot).

4.4.1.3. Estimated seed yield ha^{-1}

The data recorded on seed yield plant^{-1} are presented in Table 17. Bulbs planted in September season were recorded maximum seed yield (694.30 kg). Thereafter, a gradual reduction in seed yield ha^{-1} while bulbs planted in October, November and December season. On an average over four seasons of study, the seed yield ha^{-1} was 482.22 kg.

The estimated seed yield ha^{-1} varied significantly due to genotypes. The estimated seed yield ha^{-1} ranged from 397.41 to 585.00 kg. The maximum seed yield ha^{-1} was recorded in genotype Puttarasal type (585 kg/ha) followed by Santhaipadugai Local. Whereas the lowest seed yield ha^{-1} were recorded in CO On 5 genotype. The interaction between seasons and genotypes were highly significant on seed yield. Maximum seed yield was noted from Puttarasal planted during September season recorded more yield per ha (807 kg) followed by Puttarasal type planted during October season. CO On 5 planted during December season recorded the lowest yield per plant (233.66 kg/ha).

4.4.1.4. 1000 Seed weight

The influences of treatments on thousand seed weight are presented in Table 17 and Fig. 15. The thousand seed weight was significantly influenced by the seasons and genotypes**.** Among the four seasons, the highest thousand seed weight (1.24 g) was associated with September (S_1) followed by other three seasons.

Puttarasal type showed significant increase in thousand seed weight (1.18g) than the Santhaipadugai Local and CO On 5. Season and genotype interaction was found significant on thousand seed weight. The highest thousand seed weight (1.30 g) recorded under the treatment combination Puttarasal type planted during September season followed by S_1G_3. The lower seed weight (1.03 g) was obtained under CO On 5 planted during December season.

4.4.2. Residual bulb yield

4.4.2.1. Residual bulb yield plant^{-1}

The data pertaining to residual bulb yield plant^{-1} after harvest of seeds are presented in Table 18 & Fig.16. There was gradual reduction in bulb yield plant^{-1} from October to December. It ranged from 14.44 g in October season planting to 9.44 g in December season planting. In September season, the maximum residual bulb yield of 18.00 g was recorded.

The genotypes differed significantly with regard to residual bulb yield per plant. It varied from 10.91 to 17.41 g/plant. The maximum residual bulb yield (17.41 g/plant) was noticed in genotype Puttarasal type followed by CO On 5. The genotype Santhaipadugai Local gave the minimum residual bulb yield of 10.91 g/plant. The interaction between seasons and genotypes was also significant. The maximum residual bulb yield plant^{-1} was recorded under treatment combination Puttarasal type (24.00 g) planted during September season followed by S_2G_2. While the lowest residual bulb yield plant^{-1} was obtained under treatment combination Santhaipadugai Local (7.66 g) planted during December season.

4.4.2.2. Residual bulb yield plot^{-1}

The data recorded on residual bulb yield plot^{-1} are presented in Table 18. The maximum residual bulb yield plot^{-1} of 3.60 kg was recorded in September season. It was gradually reduced from October to December season. It ranged from 2.89 kg in October to 1.88 kg in December season.

The maximum residual bulb yield was achieved from genotype Puttarasal type (3.48 kg/plot) followed by CO On 5 (2.28 kg/plot) which were statistically alike with one other. The minimum residual bulb yield per plot was obtained from Santhaipadugai Local which yielded 2.11 kg/plot produce. Interaction effect also exhibited significant variation among all the treatments. Puttarasal type planted during September season significantly increased the residual bulb yield plot^{-1} (4.80 kg) followed by S_2G_2. CO On 5 planted during December season recorded with minimum number of residual bulb yield compared to all other interaction.

4.4.2.3. Residual bulb yield ha^{-1}

The data recorded on residual bulb yield ha^{-1} are presented in Table 18. Among the four seasons of study, the maximum residual bulb yield of 5999 kg ha^{-1} was recorded in September season. Thereafter, it gradually reduced and minimum residual bulb yield of 2999 kg ha^{-1} was recorded in December season.

Significant variation existed among the genotypes with respect to residual bulb yield ha^{-1}. The genotype Puttarasal type proved superior in this regard by producing 5828 kg/ha bulb yield followed by CO On 5 which produced total yield of 3808 kg / ha. The minimum yield (3524 kg/ha) was obtained by Santhaipadugai Local genotype. Seasons and genotypes interaction was found significant on estimated residual bulb yield ha^{-1}. The estimated residual bulb yield ha^{-1} (8000 kg) recorded under the treatment combination Puttarasal type planted during September season followed by S_2G_2. The lowest residual bulb yield ha^{-1} (3524 kg) was obtained under Santhaipadugai Local planted during December season.

4.5. Quality traits

4.5.1. Total soluble solids (TSS)

The data on total soluble solids (TSS) content of bulbs was significantly influenced by seasons and genotypes which is presented in Table 19. Among the season, September planted crop was observed with higher total soluble solids content of 13.71^o brix which is followed by October season (13.1^o brix), while it was less in December planted crop which has recorded 11.78^o brix.

Among the genotypes, Santhaipadugai Local was observed with higher total soluble solids content of 13.31^o brix followed by Puttarasal type (12.45^o brix), while it was less in CO On 5 which recorded 12.32^o brix. The higher TSS (14.37^o brix) was recorded under treatment combination Santhaipadugai Local planted during September season followed by $S_1G_{1.}$ The lower TSS (11.23^o brix) was obtained under CO On 5 planted during December season.

4.5.2. Ascorbic acid

The ascorbic acid content was also influenced by seasons and genotypes. Considering the season, September season crop recorded higher ascorbic acid content (9.27 mg 100 g^{-1}) than the other three season crops (Table 19).

Santhaipadugai Local recorded higher ascorbic acid content (9.03 mg 100 g^{-1}) followed by Puttarasal type and CO On 5. The interaction between season and genotype was significant. The highest ascorbic acid content (9.43 mg 100 g^{-1}) was recorded under the treatment combination Santhaipadugai Local planted during September season followed by Puttarasal type planted during September season while the lowest ascorbic acid was obtained under the treatment combination CO On 5 planted during December season.

4.5.3. Protein content

The protein content has also influenced by seasons and genotypes. Considering the season, September season crop was recorded higher protein content (18.66 %) than the other three season crop (Table 19 and Fig. 17).

Puttarasal type recorded higher protein content (18.22 %) followed by Santhaipadugai Local and CO On 5. The interaction between seasons and genotypes were statistically significant. The maximum protein content (19.00 %) was recorded under the treatment combination Puttarasal type planted during September season followed by Santhaipadugai Local planted during September season. The minimum protein content (17.20 %) was recorded in the treatment combination CO On 5 planted during December season.

4.6. Seedling vigour attributes

4.6.1. Germination percentage

The germination percentage was also influenced by seasons and genotypes. Considering the season, September season crop recorded higher germination percentage (90.41 %) followed by October season crop than the other two season crop (Table 20 and Fig. 17).

Puttarasal type has recorded maximum germination percentage (86.81 %) followed by Santhaipadugai Local and CO On 5. The interaction between seasons and genotypes were statistically significant. Among different treatment combination, the germination percentage was significantly higher (92.76 %) in combination with Puttarasal type planted during September season followed by S_1G_3 and S_2G_2. The lower germination percentage was recorded in the treatment combination CO On 5 planted during December season.

4.6.2. Shoot length

The data pertaining to the shoot length of various seasons and genotypes were presented in Table 20 and Fig.18. The seedling vigour observation recorded during the study showed that shoot length also recorded the same trend as that of germination percentage. Considering the season, September season crop recorded maximum shoot length (8.40 cm) followed by October season crop than the other two season crop.

Puttarasal type recorded maximum shoot length of (8.21 cm) followed by Santhaipadugai Local and CO On 5. The interaction between seasons and genotype was statistically significant. The higher shoot length (8.80 cm) was recorded under the treatment combination Puttarasal type planted during September season followed by S_2G_2. The shortest shoot length was recorded in the treatment combination CO On 5 planted during December season.

4.6.3. Root length

Observations on root length indicated that almost similar trend as that of the shoot length. September season crop recorded the highest root length (6.53 cm) followed by October (6.2 cm), November (5.96 cm) and lowest in December (5.60 cm) planting season. (Table 20 and Fig.18).

Puttarasal type recorded maximum root length (6.47 cm) followed by Santhaipadugai Local and CO On 5. The interaction between season and genotype were statistically significant. The higher root length (7.20 cm) was recorded under the treatment combination Puttarasal type planted during September season followed by S_2G_2. The least root length was recorded in the treatment combination CO On 5 planted during December season.

4.6.4. Dry matter production

Observation on total dry matter production was significantly influenced by season and genotype (Table 20). The results recorded that the highest dry matter production of 15.37 mg 10 S_2^{-1} was recorded when the crop planted during September followed by other three seasons.

Puttarasal type recorded higher dry matter production (15.08 mg 10 S_2^{-1}) followed by Santhaipadugai Local and CO On 5. The interaction between seasons and genotypes were statistically significant. The higher dry matter production (15.82 mg 10 S_2^{-1}) was recorded under the treatment combination Puttarasal type sown during September season followed by Santhaipadugai planted during September season. The least dry matter production was recorded in the treatment combination CO On 5 sown during December season.

4.6.5. Vigour index

The seedling vigour index also recorded the same trend as that of germination percentage. Considering the season, September season crop recorded higher vigour index (1351.62) followed by October season crop than the other two season crop (Table 20).

Puttarasal type recorded higher vigour index (1279.83) followed by Santhaipadugai Local and CO On 5. The interaction between seasons and genotypes were also significant. The higher vigour index (1484.14) was recorded under the treatment combination of Puttarasal type planted during September season followed by S_2G_2. The least vigour index was recorded in the treatment combination CO On 5 planted during December season.

CHAPTER V

DISCUSSION

Onion (*Allium cepa* L.) is the most important vegetable crop in India. It is used as salad and cooked in various ways in all curries, fried, boiled and or packed. It is also used in processed forms likes flakes, powder and pickles. It has also medicinal uses. In Tamil Nadu, both the types of onion *viz*., cepa onion or bellary onion (*Allium cepa* L. var. cepa) and multiplier or aggregatum onion (*Allium cepa* var. *aggregatum*) are grown. The aggregatum onion genotypes are normally propagated by bulblet as they are non-flowering genotypes. The genotype, CO On 5 developed at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore and Puttarasal type and Santhaipadugai Local are profusely flowering and seed setting under Coimbatore condition where a dry weather prevails.

Onion crop has a very high yield potential if crop receives judicious management practices during crop growth stages. Though every production factor is a limiting factor, yet one of the factors is the proper season of planting which is desirable for higher seed yield. Hence, a study was undertaken to find out the influence of planting season on flowering and seed set in the aggregatum onion genotypes under existing condition of Coimbatore and also to identify the best genotype for commercial onion seed production.

5.1. Growth characters

Influence of planting season of bulbs on flowering and seed setting ability of aggregatum onion genotypes was studied.

The production of quality onion requires different agrotechniques from that of bulb production, and environmental condition such as temperature, relative humidity, rainfall and sunshine hours play a major role in flowering, seed set, seed development and maturation of the resultant seeds. Time of planting and seasonal factors decide the quality of seed production in aggregatum onion genotypes. Certain aggregatum onion genotypes behave like common onion in the aspects of flowering and seed production.

5.1.1. Sprouting of onion bulbs

In the present study, four different seasons of planting of bulbs *viz*., September, October, November and December were compared to assess their influence on flowering and seed setting in aggregatum onion genotypes. Both seasons and genotypes differed significantly with regard to time taken for sprout initiation and completion. September season crop recorded least number of days required to sprout initiation and completion of onion bulbs. This might be due to optimum soil temperature, relative humidity and rainfall prevailed during the initiation and completion of bulbs. The results are in accordance with finding of Jilani (2004).

The Puttarasal type took maximum time for complete sprouting, while CO On 5 and Santhaipadugai Local genotypes were early in completion of sprouting. The difference in sprouting period among the genotypes might be due to difference in morphological and floral characters. The difference in time taken for germination by genotypes has been noted by Habban (1986) and Kimani *et al.* (1993). Similar observations were recorded by Branca *et al.* (1994) and Jilani (2004). The difference in sprouting time can be attributed to genetic variation among the cultivars. Likewise Verma *et al.* (1994) reported difference in number days to 100 per cent sprouting in bulbs of different genotypes.

5.1.2. Plant height

Maximum plant height was obtained when bulbs were planted in September season. The plant height significantly increased from 30th day to full flowering and at the time of harvest. In this entire period the temperature ranged from 18.95 to 31.35° C.

During the September season immediately after sprouting of bulbs, there was cool night (20.4-21.5° C) with bright sunshine during days (10.1-11 hr). This would have encouraged better synthesis of hormones like gibberellins for transformation of terminal bud. After the formation of flowers, anthesis and fertilization, the higher temperature and bright sunshine prevailed would have created a better sink in the developing ovaries by the translocation of cytokinins synthesized in roots. This would have drawn more photo assimilates to the developing seeds to help maturity of seeds.

In early season planting the temperature and day length period prevailed improved the plant height. But the same was significantly reduced in later planting and minimum height was recorded in December planting. In December season, the day temperature ranged from 19.03 to 33.45º C for entire crop growth period and the day length ranged from 7.58-7.65 hr. This combination of temperature and day length mostly suppressed the plant height. The findings of this study are in conformity with the results reported by Joshi *et al*. (1976) and Singh and Singh (1984). A vegetative shoot apex normally develops auxiliary bud to form the inflorescence (Rabinowitch, 1990) and vegetative shoot competes with reproductive phase by developing more rapidly than the inflorescences under a combination of warm temperatures (20º C or higher) and long photoperiod.

The differences in plant height were apparent from early growth stages to final harvest, which are in accordance with reports of Palaniswamy (1980) and Rajasree *et al*. (1994). Among the genotypes studied, Puttarasal type recorded the maximum plant height at 30, 60 DAP, flowering and harvest stages of observation (36.70, 45.04, 49.24 and 49.45 cm respectively). This significant variation may be attributed to the genotypic differences, observed by Jilani (2000). This result is also in accordance with Sidhu *et al*. (1996), Soni *et al*. (1993), Hussain *et al.* (2001), Mohanty (2002), Jogdande *et al*. (2004) and Ananthan (2005).

5.1.3. Number of leaves per plant

The total number of leaves per plant gradually decreased as the age of crop advanced to final harvest. The results observed in the number of leaves at vegetative stage exhibited same as that of plant height. Bulbs planted in September season produced more number of leaves due to low temperature and short photoperiods in entire crop growth period. But the number of leaves decreased when the planting was delayed up to December due to high temperature in its entire crop growth period. The September planted onion was comparatively younger than other three seasons and the senescence started only in the basal leaves. On the other hand more dry leaves were observed in November and December planted onion. The results are in accordance with finding of Anisuzzaman *et al*. (2009). Favourable cool temperature and fully sunny days in the September and October season also promoted the maximum vegetative growth. Moreover raining during November and December also caused excessive soil moisture and damaged vegetative growth. Similar findings were reported by Verma *et al*. (1971), Shrivastava *et al.* (1996), Hussain *et al*. (2001) and Bhatt *et al*. (2007) that onion bulbs planted on early season produced maximum number of leaves.

The maximum number of leaves per plant was recorded in Puttarasal type while minimum in Santhaipadugai Local at all the stages of crop growth. Findings of the present study revealed that there was significant variation exhibited in onion genotype for number of leaves per plant. Similar finding had been reported in onion by Mohanty (2004). Studies on various quantitative and qualitative characters of different genotypes of onion by Habban (1986), Jadhav *et al.* (1990) and Kimani *et al.* (1993) showed difference in number of leaves among the genotypes. Hussain *et al.* (2001) also recorded the maximum number of leaves in July planting of onion.

5.1.4. Leaf length and leaf girth

The interactive effect of planting seasons and genotypes were non- significant in leaf girth. The maximum leaf girth was noted in Puttrasal type planted on September season at all the four stages of observation while minimum was noted in December planting. Jadhav *et al.* (1990), Kimani *et al.* (1993) and Branca *et al*. (1994) reported similar finding while studying various characteristics of onion cultivars.

The characters like leaf length and leaf girth are also important attributes that influence the photosynthesis, which in turn results in flower formation. Significant variation was recorded among the onion cultivars in the present study for leaf length and leaf girth. This has corroborated with the findings of Padmavathy (1995), Singh and Chaure (1999) and Jilani (2004).

5.1.5. Shoot girth and tillers per plant

The shoot girth is an important character to give vigour to the plant. In the present investigations, the shoot girth in onion showed significant difference between the genotypes at all the stages of crop growth in all the cropping seasons. The type Puttarasal, recorded the maximum shoot girth at all the four stages of crop growth whereas CO On 5 recorded minimum shoot girth. The increment in shoot girth may be attributed to the increased number of leaves per plant, which is in synchrony with the results of Rajasree *et al*. (1994).

Number of tillers per plant was gradually increased from 30 DAP to full flowering stages and then declined during final harvest. The maximum number of tillers per plant was counted in September planting season crop while the least in December season. The genotypes varied significantly with respect to tillers per plant. The maximum number of tillers per plant was found in Puttarasal type followed by Santhaipadugai Local. The genotype CO On 5 contained the minimum number of tillers per plant at all the four stages. Similarly Kisekva (1963), Verma *et al.* (1994) and Jilani (2004) documented different number of tillers in different cultivars.

5.2. Flowering characters

5.2.1. Flowering

Bulbs planted in September season was observed to take minimum number of days for 50 per cent flowering. In this period, temperature recorded was between 21.90 and 28.08° C. It mostly favoured the flowering in common onion and so much so in aggregatum onion, which behaves like common onion in respect of flowering. But in later plantings, the days increased to 50 per cent flowering, because the temperature was above 30º C. In December planting more number of days is required for emergence of 50 % flowering due to high temperature in its entire cropping period. Floral initiations in September planted crop coincide with low temperature, while that of November and December planted crop coincide with warm temperature. Hence, temperature seems to have negative influence on earliness to flowering. The results are in accordance with Joshi *et al.* (1976) and Krishnaveni *et al.* (1990).

The results of present investigation have clearly indicated the effects of such external factors at the growing point as demonstrated by the work of Purvis (1934) and Purvis and Gregory (1937) on the vernalization of cereals. The lower temperature prevailed during early crop growth period in September planting would have favoured the production of hormones like gibberellins which could have created an induction in the terminal bud to transform it into reproductive one thereby favoured early flowering. Early flowering is an indicator of early maturity. Sometimes early maturity is good as it can escape from bad weather and diseases.

The date on completion of flowering showed that time of planting significantly altered the flowering behaviour of onion crop. Completion of flowering was earlier in bulbs planted during September season and delayed linearly as the planting of bulbs was delayed. The days to full flowering increased as the bulbs planted from October up to December. Sumarnatne and Palipane (2002) supported that minimum number of days are required for completion of flowering when bellary onion bulbs were planted in October and similar results were also recorded by Krishnaveni *et al*. (1990) and Aramirtham (2000).

Days taken to first, 50 per cent and completion of flowerings were less in Santhaipadugai Local compared to CO On 5 and Puttarasal type. This might be due to the short duration of Santhaipadugai Local than the longer duration of CO On 5 and Puttarasal type. But bulbs planted in December season took more time to flowering, due to unfavourable environmental conditions as reported previously in bellary onion by Anisuzzaman *et al*. (2009) and in French bean (Begum *et al*., 2003) and Jadhav *et al.*(1990). Compared different characters of eleven cultivars and revealed difference in time taken for flowering initiation and completion. Similar observations were recorded by Kimani *et al* (1993), Ambulkar *et al.* (1996), Branca *et al.* (1994) and Jilani (2004).

5.2.2. Length of flower stalk

The data on length of flower stalk revealed gradual increases from full flowering to final harvesting. The present investigation showed that the September season crop recorded the highest flower stalk length followed by October season at full flowering and at harvest. Similar results were also reported by Jilani (2004) in common onion. Aramiratham (2000), Anisuzzaman *et al.* (2009) and Boyhan *et al*. (2009) reported that maximum flower stalk length was observed in the early planted crop of onion which supports the present findings. Abu-Rayyam and Abu-Irmaileh (2004) also reported that onion requires cool weather during inflorescence initiation and seed stalk development. A moderately high temperature and dry weather conditions are favourable for seed maturation.

Planting in different season has significant influence on the formation of flower stalk. The lengthiest flower stalks were found in type Puttarasal at full flowering and at harvest. The shortest flower stalks were recorded in genotype CO On 5. Gil and Hari Singh (1989), Mishra

(1994) and Jilani (2004) found difference in length of flower stalks. Jadhav *et al.* (1990), Kimani *et al.* (1993) and Branca *et al.* (1994) also reported that the difference was due to varietal characters.

5.2.3. Number of umbels per plant

Bulbs planted in September season produced more number of umbels per plant which decreased in late planting from October season to December season. Boyhan *et al*. (2008) revealed that the number of umbels per plant were greater (9.3/plot) on the early sowing date compared with the middle (or) late sowing date. Boyhan *et al*. (2009) reported that the number of umbels per plant is usually greater when cool temperature occur in the early season planting. Singh and Singh (1984), Aramiratham, (2000) and Anisuzzaman *et al.* (2009) reported that maximum number of umbels per plant was observed in the early planted crop in common onion which lend support to the present findings.

The number of umbels per plant plays an important role in the production of seed. Difference in number of umbels per plant has been found amongst genotypes, and ranged from 4.81 to 7.50. The Puttarasal type exceeded in number of umbels per plant, followed by Santhaipadugai Local and the least number of umbels per plant was recorded in CO On 5. All three genotypes were statistically alike. Gill and Hari Singh (1989) and Mishra (1994) reported variability in number of umbels per plant. Jadhav *et al.* (1990), Kimani *et al.* (1993), Branca *et al.* (1994) and Jilani (2004) reported differences due to varietal characters.

5.2.4. Diameter of umbel

The combined effect of seasons and genotypes was non-significant during full flowering but it was significant during harvest. The greatest diameter of umbel was noted in September planting season at two stages of observation. Difference in umbel diameter among various genotypes of onion was documented by Jadhav *et al.* (1990) and Kimani *et al*. (1993).

5.2.5. Number of flowers per umbel

The number of flowers per umbel is a very important component contributing to final seed yield. Seasons had significant influence on the number of flowers per umbel.

Higher number of flowers per umbel was recorded with the September season crop and delayed planting recorded reduction in yield as reported in aggregatum onion (Aramiratham, 2000) and in bellary onion by Jilani (2004) and Anisuzzaman *et al.* (2009).

Planting of onion bulbs during September resulted in more number of flowers per umbel with effective translocation and distribution of photosynthates from source to sink, which in turn resulted in elevated stature of yield attributes possibly due to favourable weather conditions such as rainfall distribution and temperature during the crop growth period (Jilani, 2004; Anisuzzaman *et al.,* 2009; Boyhan *et al*. 2009).

Genotypes also had significant influence on the number of flowers per umbel. Puttarasal type recorded the higher number of flowers per umbel, followed by Santhaipadugai Local and it might be due to favourable environment and genotype variation, and genetic make up which provided more number of flowers per umbel. The findings from the present work are also in line with the report of Aramiratham (2000) and Boyhan *et al*. (2009).

5.2.6. Days to seed set and maturity

The present investigation revealed that both season and genotype had highly significant effect on days taken to seed set and maturity. September season crop took 86.50 days for seed set and 115.21 days for seed maturity as compared to later sown i.e. December season crop, which took about 102.87 days for seed set and 133.80 days for seed maturity.

This implies that the later sown crop required 16.37 days more for seed set and 18.59 days for maturity. This clearly supports the apprehension that the bulbs planted on later dates completed its growth development and differentiation processes in a comparatively quick succession under the influence of optimum temperature and high relative humidity thereby allowing less time for a balanced source: sink relationship development and hence the low yield as compared to September season. Abu-Rayyan and Abu- Irmaileh (2004) also reported that onion requires cool weather during inflorescence initiation and seed stalk development. A moderately high temperature and dry weather conditions are favourable for seed maturation.

Days required for seed set and seed maturity was earlier in Santhaipadugai local compared to CO On 5 and Puttarasal type. This might be due to the shorter duration of Santhaipadugai Local than the of CO On 5 and Puttarasal type. But bulbs planted in December took more days to seed maturation, due to unfavorable environmental conditions which is well in agreement with Anisuzzaman *et al*. (2009).

5.2.7. Flowering and seed set percentage

It is interesting to note that most of yield contributing characters were at their maximum with the crop grown under September planting season. The flowering percentage was highest in the crop grown under September planting season. Flowering percentage was increased due to increasing cool temperature during September planting. There was gradual reduction in flowering percentage with later planting season due to high temperature. This clearly indicated that increase in the flowering percentage as a result of early planting and better environmental condition prevailed during the season. This finding was in conformity with Khokhar *et al*. (2007).

Seed set per cent in each umbel was also highest in September planting season and significant variation was found due to the influence of planting season and genotypes. Different planting seasons and genotypes showed significant effect on flowering and seed set percentage. The maximum seed set percentage was recorded in September planting season and Puttarasal genotype than others. Similar trend was observed in the case of flowering percentage. These results are in accordance with the finding of Singh and Singh (1984), Kuruppuaracachi (1992) and Deen (2008).

5.3. Physiological attribute

5.3.1. Chlorophyll content

Chlorophyll, the pigment responsible for converting light energy into chemical energy, is directly associated with the photosynthetic efficiency of crop plants. The enhancement of chlorophyll content (‘a’, ‘b’ and total) was often observed with the seasons. The time trend of chlorophyll content revealed gradual increases from 30 to 60 DAP. The chlorophyll content declined at later growth stages (flowering & harvest). The Chlorophyll ‘a’ content increased by 27.3 % and 31.1

% at 30 and 60 DAP respectively in September season crop than the December season crop. Similarly, Chlorophyll ‘b’ also showed an increase in S_1 and the increase was 54 % at 30 DAP and 28.3 % at 60 DAP. The total chlorophyll content increased by 21.7 % at 30 DAP and at 16.8 % 60 DAP in September season crop than the December season crop.

September season crop had the highest chlorophyll content, followed by October season crop. Crop planted during December recorded the lowest chlorophyll content due to unfavourable environment i.e. high temperature during flowering and harvesting. Similar results were reported by Sato and Park (1981). Earlier planted crop showed greater increase in the rate of photosynthesis than the late planted crop which may be due to increase in the content of total chlorophyll. Reduction in total chlorophyll content might be due to the accelerated leaf-senescence as a result of ageing. Similar results were reported by Naeem *et al*., (2009). Puttarasal type recorded highest chlorophyll content followed by CO On 5. Differences in leaf chlorophyll content among cultivars observed in several crops (Gopal Singh *et al*., 1985; Chandra Babu *et al*., 1988) lend support to the present findings.

5.4. Yield and yield attributes

5.4.1. Seed yield

The seed yield was recorded periodically after the physiological maturity of the crop. The seed yield declined linearly as the season advanced. The highest seed yield per plant was recorded in September season crop. It ultimately increased the seed yield per plot and hectare. This might be due to more number of umbels per plant recorded during September planting. These results are in accordance with the finding of Singh and Singh, (1984), Boyhan *et al*. (2008) and Anisuzzaman *et al.* (2009).

The seed yield significantly decreased from October to December planting season. Time of planting of bulbs also affected the growth of the plant and seed yield. They were significantly better in earlier planted bulbs than in delayed planting. It is interesting to note that yield attributing characters like plant height, number of leaves, number of umbels per plant and number of flowers per umbel were higher in September season crop than in late planting from

October to December season crop. This might be the reason for increased in the seed yield per plant in September planting season, which ultimately increased the yield per unit area.

The decrease in yield may be due to foliar diseases and poor environment condition as a result of late planting, light, temperature, humidity, etc prevailied in December season resulted in lower seed yield per hectare. These results are in accordance with the finding of Gill *et al*. (1981) in carrot and Singh and Singh (1984), Aramiratham (2000), Boyhan *et al*. (2008) and Anisuzzaman *et al.* (2009) in onion.

The estimated variability in seed yield from plant to plant was least in December planting crop and it was the highest in September planting. These results suggest that there is better uniformity in pollination as well as maturity of seed in the crop raised by planting the bulbs in September season. The yield attributing characters like plant height, number of leaves and number of umbels per plant were higher in September than in late planting from October to December season crop.

The genotypes differed significantly with regard to seed yield. It ranged from 397.41 to 585 kg ha^{-1} amongst the genotypes. The Puttarasal type produced the highest seed yield followed by Santhaipadugai Local. While the lowest seed yield was reaped from genotype CO On 5 and it might be due to increased number of umbels per plant owing to prolonged crop duration compared to CO On 5 and genotype variation. Similar results were reported by Jilani (2004) and Adagale *et al*. (2010) in onion. Seed yield is a cumulative performance of number of flowers per umbel, number of umbels per plant, number of seeds per umbel and 1000 seed weight. Enhancement of yield attributes would have ultimately culminated into seed production of each genotype. Similar studies regarding genotype variation for different attributes were reported earlier, (Nehra *et al*., 1989; Toman *et al*., 1989; Jadhav *et al*., 1990; Krishnaveni *et al*., 1990; Bhatia and Pandey, 1991; Brogo *et al.*, 1993; Kimani *et al.*, 1993; Verma *et al.*, 1994; Sumanaratne and Palipane (2002); Tomar, 2005).

Thousand seed weight was maximum in September planting while it decreased from October to December. Abdalla (1969), who worked with different dates of planting of onion bulbs for seed production in Sudan also got lesser seed weight with late sowing. Similar results were also observed from the finding of Joshi *et al*. (1976) and Nehra *et al*. (1989).

The different genotypes showed significant effect on 1000 seed weight. The heaviest seeds (1.30 g) were recorded in Puttarasal type followed by Santhaipadugai Local, whereas lightest seeds (1.03 g) were found in CO On 5. Amiroddin *et al.* (1988), Jadhav *et al*. (1990), Kimani *et al.* (1993) and Branca *et al.* (1994) found difference in 1000 seed weight due to variable conditions including genetic make of the cultivars.

5.4.2. Residual bulb yield

Blubs planted in September season registered maximum residual bulb yield per plant, per plot, and per hectare whose bulbs were harvested in January. Bulbing has been shown to require continued inductive photoperiods to complete, it seems reasonable to make the assumption that rate of bulbing depends on current photoperiods and temperature alone. In this case, development in changing photoperiods and temperature can be modelled as sum of rate development at a given temperature and photoperiod multiplied by the duration of time during which these condition prevails (Mc Naughton *et al*., 1985).

In the present study, the plant, which were planted during September, were subjected to initial mild temperature of 22.71° C and when they enter into bulbing phase the temperature rose up to 31.07° C and there was further increase as the bulbs were maturing. On the other hand the crops raised in later season during November and December were subjected to heavy rain during early crop growth phase itself. Low night temperature and high day temperature induced more bulb yield in September planted set. Singh and Singh (1976) and Joshi *et al*. (1975) also reported high bulb yield in early planting depending upon the location of experiment. These results are in accordance with Singh *et al*. (1993), Pakyurek *et al*. (1994), Kumar *et al*. (1998) and Mohanty *et al*. (2000). Hussain *et al.* (2001) recorded higher yield in 29^{th} September sowing. Similarly Mingochi and Pande (1992) achieved maximum bulb yields in earlier sown trials.

Bhalla *et al*. (1983) and Deen (2008) supported that increased yield may be because of difference in yield components as bulb volume, average weight of the bulbs and crop stand. Secondly, it may be because of the bulbs planted early in the season got established in field earlier. Consequently, early planting resulted in early continued swelling of the bulbs till the crop matured for harvesting but when flowering and seed set happened bulb size was reduced. During late planting, the bulb size could not be developed, which dependent on temperature and day length. The production assimilates were translocated towards developing sink (seeds) rather bulbs. In want of sufficient metabolites, the bulbs remained under developed.

The variation in bulb yield and yield contributing parameters may be attributed to the difference in genetic make up of the genotypes. The maximum yield was harvested by Puttarasal type as it was significantly different from all other genotypes. Buchvarov (1985) found difference in yield among 110 cultivars. Varietal differences with respect to bulb yield have been reported by Habban (1986), Hochmuth *et al.* (1990), Jadhav *et al.* (1990), Krishnaveni *et al.*(1990), Katwale and Sarat (1991), Kimani *et al.* (1993), Pandey *et al.* (1994) and Vasetskii and Reznik (1995).

5.5. Quality traits

5.5.1. TSS and ascorbic acid

The quality characters, namely TSS and ascorbic acid contents mainly decide the quality and nutritive value of onion bulbs.

Total soluble solids, an important quality criterion for onions, contributes towards flavours (Sharma *et al*., 1996) and processing quality. The soluble solid content would ultimately decide the dry matter that in turn would reflect on the recovery of processed products. In the present investigation, TSS content varied significantly from 11.78 (S_4) to 13.71^o brix (S_1) in seasons and 12.32 (G_1) to 13.31^o brix (G_3) in genotypes. Vadivel (1979) recorded a range of 12.36 to 15.90^o brix for TSS content among the different genotypes of aggregatum onion. Similar findings were also reported by Agarwal and Tiwari (2000) and in garlic Gowda *et al*. (2007).

Ascorbic acid is another important biochemical constituent to assess the quality of onion bulbs. There existed variations among the seasons of planting and genotypes for this constituent. The ascorbic acid content varied from 8.18 to 9.27 mg/100 g in planting season and 8.44 to 9.03 mg/100 g in genotypes. This finding is in conformity with the results of Rumi Borah (1994) and Padmavathy (1995).

5.5.2. Seed protein content

It is an important quality character in onion seeds. The present investigation revealed that both seasons and genotypes had significant effect on protein content of seeds. September season crop recorded higher seed protein content than all other three season crops. The protein content was influenced by growth environment. Again it may be due to high temperature which have aided in conversion of photo assimilate into protein for normal growth of the seeds. Geetharani *et al*. (2008) revealed that early planting of onion bulbs recorded significantly higher seed protein percentage than the later planting.

Sharma *et al*. (1989) also reported that the highest protein content was recorded with early date of planting and there was significant reduction in protein content in successive dates. Seed protein provides a source of amino acid and reduced N necessary for germination and early growth of the seedling (Spencer and Boulter, 1984). Among the genotypes, Puttarasal type recorded higher protein content than the other two genotypes.

5.6. Seedling vigour characters

5.6.1. Standard germination test

Seed germination is used to assess seed quality or viability and to predict the performance of the seed and seedling in the field. Testing the germination in seed is to obtain information about the planting value of the seeds and by inference the quality of the seeds. In addition, germination results are also required for comparing the performance potential or superiority of the different seed lot. The germination percentage of seed was highly influenced by the seasons and genotypes. September season crop seeds achieve more germination percentage followed by October season crop. Similar report was achieved by Anisuzzaman *et al*. 2009. Under ambient condition, however, immature or unfilled seed has poor germination and viability. Environmental conditions as well as management practices during crop growth stage were found to influence the seed quality (Adagale *et al*., 2010).

Among the genotypes, germination percentage was higher in Puttarasal type, followed by Santhaipadugai Local and lower in CO On 5. This might be due to differences in these genotype variations.

5.6.2. Root and shoot length

Root length is important not only to give anchorage to the plants but also its capacity to forage nutrients from deeper layer of the soil strata. There was not much difference in root length between genotypes. Even though Puttarasal type had slightly higher root length than Santhaipadugai local this may be due to the high growth rate of the genotype.

The root and shoot lengths were significantly influenced by season of planting and genotypes. September season crop has recorded the maximum root and shoot length than other three seasons. There was not much difference in root and shoot length between genotypes. Similar findings were also reported by Krishanaveni *et al.* (1990), Geetharani *et al*. (2008) and Anisuzzaman *et al.* (2009).

5.6.3. Dry matter production and Vigour index

The seedling vigour observations such as dry matter production and vigour index were also having the same trend as that of germination percentage and root length due to differences in genotype characters as well as planting seasons. Similar finding were also reported by Krishnaveni *et al.* (1990) and Geetharani *et al.* (2008).

CHAPTER VI

SUMMARY

The influence of season of planting on growth, flowering and seed yield of three aggregatum onion genotypes *viz.*, CO On 5, Puttarasal type and Santhaipadugai Local was studied during four different seasons. The investigations were carried out during 2010-2011, at the experimental farm, Department of Vegetable crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. This experiment was laid out in a Factorial Randomized Block Design and data collected were subjected to statistical scrutiny. The outcomes of research are highlighted.

Growth characters

- The interaction between seasons and genotypes were significant on days to sprouting of onion bulbs.
- Among the four different seasons, September (S_1) planting recorded the lesser days required to initiation of sprouting and completion of sprouting (3 and 7 days respectively) in the genotype Santhaipadugai Local followed by CO On 5 and Puttarasal type than other three seasons.
- Plant height was measured at four different growth stages of crop *viz.*, 30th, 60thDAP, at full flowering and at harvest. September season planting registered the greatest height (59.20 and 65.61 cm) at full flowering and at harvest respectively in Puttarasal type followed by Santhaipadugai Local and lowest in CO On 5 genotype.
- The highest number of leaves per plant was found in bulbs planted in September season (35 and 28.40) at 30 and 60 DAP respectively in the Puttarasal type followed by Santhaipadugai Local and lowest number was recorded in CO On 5 genotypes.
- The leaf length was higher with bulbs planted during September season (55.53 and 63.13 cm) at full flowering and at harvest respectively in the Puttarasal type.
- Maximum leaf girth was observed in September season planting (3.56 and 2.82 cm) at full flowering and at harvest respectively in the Puttarasal type followed by Santhaipadugai Local and CO On 5 genotypes.

- September season planting recorded the largest shoot girth (3.33 and 3.66 cm) at 30 and 60 DAP respectively in the Puttarasal type followed by Santhaipadugai Local and CO On 5 genotypes.
- The total number of tillers per plant was highest in September planting (9.67 and 9.05) at full flowering and at harvest respectively in Puttarasal type.

Flowering characters and yield attributes

- Days required for first flowering (31.20), 50 % flowering (43.33) and full flowering (60.30) was earlier under Santhaipadugai Local planted during September season.
- The number of days taken for seed set (79.16) and seed maturity (104.40) was earlier under Santhaipadugai Local planted during September season.
- The yield attributes *viz*., length of flower stalk at full flowering and at harvest (58.86 and 63.86 cm respectively), diameter of umbel at full flowering and at harvest (7.07 and 6.03cm respectively), number of umbels per plant (7.50), number of flowers per umbel (282.40), number of seeds per umbel (260.03) and seed weight per umbel (0.319 g) were the highest under September season in Puttarasal type due to existing favourable climate ie., low temperature and high relative humidity prevailed during flowering period.

Physiological attributes

- Among the four different seasons, September (S_1) season planting recorded the maximum total chlorophyll content (0.77, 1.01 and 0.91 mg g^{-1}) at 30, 60 DAP and at full flowering respectively.
- The Puttarasal type planted during September season recorded significantly maximum chlorophyll (0.91, 1.07 and 1.04 mg g^{-1} respectively) at 30, 60 DAP and at full flowering respectively.

Seed yield and residual bulb yield

- Among the four different seasons, September season recorded the maximum seed yield in all three genotypes.

- Out of three genotypes, Puttarasal type gave significantly higher seed yield (807 kg ha^{-1}) in September season followed by Santhaipadugai Local (673 kg ha^{-1}) and lower yield in CO On 5 (603 kg ha^{-1}).
- September (S_1) season planting recorded the maximum residual bulb yield (8000 kg ha^{-1}) in the Puttarasal type followed by Santhaipadugai Local and lowest yield was recorded in CO On 5.

Quality traits

- The genotype Santhaipadugai Local planted during September season recorded significantly higher total soluble solid (14.37° brix) content and ascorbic acid content (9.43 mg 100 g^{-1}) followed by Puttarasal type and CO On 5 genotypes.

- The highest seed protein content was recorded in Puttarasal type (19 %) compared to Santhaipadugai Local (18.90 %) and CO On 5 (18.09 %) during September season.

Seedling vigour characters

- Seedling vigour characters *viz*., germination percentage (92.76 %), root length (7.20 cm), shoot length (8.80 cm), dry matter production (15.82 mg 10 S_2^{-1}) and vigour index (1484.14) were the highest under September season grown Puttarasal type followed by Santhaipadugai Local and CO On 5.

The following conclusions were drawn from the results obtained in the present investigation

- Among the four different seasons, there was significant difference in seed yield. The September season favourably increased the growth, flowering and yield attributes resulting in highest seed yield.
- Interaction effect of seasons and genotypes showed that significant influence on growth, flowering, yield attributes and seed yield were obtained in September season crop in Puttarasal type.

- With the background of the above results, it could be concluded that Puttarasal type in September season planting was better to improve the growth, flowering and yield attributing parameters which will ultimately result in increasing the productivity of the crop followed by Santhaipadugai Local and CO On 5.

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Table 1. Influence of planting season on sprouting of bulbs in genotypes of aggregatum onion

	Days to first sprouting				Days to complete sprouting			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	4.00	5.30	3.00	**4.23**	7.95	8.38	7.00	**7.77**
S_2	5.03	6.20	4.25	**5.17**	8.70	9.20	8.00	**8.68**
S_3	6.53	7.06	5.00	**6.20**	10.50	11.70	9.59	**10.59**
S_4	7.30	8.20	6.00	**7.17**	12.50	13.07	10.75	**12.10**
Mean	**5.71**	**6.80**	**4.57**	**5.69**	**9.91**	**10.58**	**8.83**	**9.77**
	S	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.060	0.052	0.104		0.042	0.036	0.073	
CD (P= 0.05)	0.125	0.108	0.216		0.088	0.076	0.152	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 2. Influence of planting season on plant height (cm) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	39.63	43.91	40.00	**41.18**	51.28	55.63	53.50	**53.47**	55.26	59.20	57.39	**57.26**	58.61	65.61	60.48	**61.56**
S_2	32.57	37.39	35.23	**35.24**	41.53	46.93	43.31	**43.86**	45.00	51.54	48.91	**48.48**	50.41	55.53	51.38	**52.44**
S_3	31.86	35.33	32.70	**33.30**	37.06	40.20	38.43	**38.56**	41.43	44.03	42.22	**42.56**	45.73	48.33	47.40	**47.15**
S_4	27.20	29.63	27.53	**28.12**	33.77	37.42	35.23	**35.47**	39.63	42.18	40.55	**40.79**	43.06	45.30	43.90	**44.08**
Mean	**32.81**	**36.70**	**33.86**	**34.46**	**40.91**	**45.04**	**42.57**	**42.84**	**45.33**	**49.24**	**47.27**	**47.28**	**49.45**	**53.69**	**50.79**	**51.31**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.302	0.262	0.524		0.191	0.166	0.332		0.290	0.251	0.502		0.167	0.144	0.289	
CD (P=0.05)	0.628	0.544	1.088		0.398	0.344	0.689		0.602	0.521	1.043		0.346	0.300	0.600	

S_1	Season -1 (September, 2010)	G_1	CO On 5
S_2	Season -2 (October, 2010)	G_2	Puttarasal type
S_3	Season -3 (November, 2010)	G_3	Santhaipadugai Local
S_4	Season -4 (December, 2010)		

Table 3. Influence of planting season on number of leaves in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
S_1	30.00	35.00	27.80	**30.93**	25.06	28.40	23.10	**25.52**	23.10	24.00	19.00	**22.03**	17.90	20.00	15.90	**17.93**
S_2	26.40	33.00	24.40	**27.53**	23.13	27.73	21.53	**24.13**	20.47	24.43	19.10	**21.83**	16.00	19.50	14.53	**16.67**
S_3	23.36	27.83	21.68	**24.94**	19.10	22.26	19.50	**20.28**	19.00	20.46	18.50	**19.32**	14.00	15.70	13.56	**14.42**
S_4	22.10	24.16	19.50	**21.92**	17.80	19.60	17.50	**18.30**	17.50	18.46	16.00	**17.32**	12.80	14.60	11.83	**13.07**
Mean	**25.46**	**30.00**	**23.34**	**26.27**	**21.27**	**24.50**	**20.40**	**22.06**	**20.01**	**21.84**	**18.15**	**20.00**	**15.17**	**17.45**	**13.95**	**15.52**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.235	0.203	0.407		0.782	0.677	1.355		0.215	0.186	0.370		0.205	0.177	0.355	
CD (P=0.05)	0.487	0.422	0.844		1.622	1.405	2.810		0.447	0.387	0.774		0.425	0.368	0.737	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 4. Influence of planting season on leaf length (cm) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	36.56	40.58	37.40	**38.18**	47.53	52.06	49.67	**49.88**	51.80	55.53	52.00	**53.11**	56.43	63.13	57.53	**57.53**
S_2	29.73	34.56	33.23	**32.51**	37.73	42.46	40.27	**40.15**	42.00	48.76	42.43	**44.40**	47.03	52.05	49.23	**49.46**
S_3	28.83	32.50	29.76	**30.36**	32.40	35.59	32.96	**33.76**	39.00	41.73	39.07	**39.93**	42.06	44.50	43.83	**43.83**
S_4	24.83	27.26	25.04	**25.71**	31.26	33.70	32.00	**32.32**	37.83	40.60	38.36	**38.93**	40.40	43.23	40.89	**40.89**
Mean	**29.99**	**33.72**	**31.36**	**31.69**	**37.33**	**41.04**	**38.72**	**39.03**	**42.65**	**46.65**	**42.96**	**44.09**	**46.48**	**50.93**	**47.93**	**48.44**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.062	0.540	0.108		0.113	0.098	0.196		0.149	0.129	0.258		0.045	0.039	0.078	
CD (P=0.05)	0.130	0.113	0.226		0.235	0.203	0.407		0.309	0.268	0.536		0.094	0.081	0.162	

S_1 Season -1 (September, 2010)

S_2 Season -2 (October, 2010)

S_3 Season -3 (November, 2010)

S_4 Season -4 (December, 2010)

G_1 CO On 5

G_2 Puttarasal type

G_3 Santhaipadugai Local

Table 5. Influence of planting season on leaf girth (cm) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	2.00	2.22	2.05	**2.09**	2.35	2.45	2.41	**2.40**	3.16	3.56	3.31	**3.27**	2.46	2.86	2.53	**2.62**
S_2	1.92	2.05	2.01	**2.01**	2.24	2.31	2.26	**2.27**	2.86	3.21	3.06	**2.92**	2.36	2.52	2.38	**2.42**
S_3	1.52	1.75	1.57	**1.62**	1.97	2.16	2.07	**2.06**	2.54	2.84	2.67	**2.68**	2.06	2.30	2.14	**2.16**
S_4	1.30	1.52	1.41	**1.41**	1.81	1.97	1.92	**1.90**	2.33	2.53	2.43	**2.43**	1.88	2.12	1.98	**1.99**
Mean	**1.69**	**1.89**	**1.76**	**1.78**	**2.09**	**2.22**	**2.16**	**2.16**	**2.72**	**3.03**	**2.86**	**2.87**	**2.19**	**2.45**	**2.26**	**2.30**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.047	0.040	0.081		0.027	0.023	0.047		0.030	0.026	0.053		0.028	0.025	0.050	
CD (P=0.05)	0.097	0.084	NS		0.057	0.049	NS		0.064	0.055	0.111		0.050	0.051	0.193	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 6. Influence of planting season on shoot girth (cm) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	2.47	2.82	2.54	**2.61**	2.82	3.33	3.10	**3.08**	3.24	3.66	3.33	**3.41**	2. 86	3.05	2.87	**2.93**
S_2	2.34	2.61	2.44	**2.46**	2.75	3.23	2.92	**3.01**	3.09	3.40	3.12	**3.21**	2.67	2.87	2.72	**2.76**
S_3	2.16	2.48	2.42	**2.35**	2.57	2.95	2.75	**2.70**	2.89	3.16	2.93	**2.99**	2.27	2.76	2.30	**2.44**
S_4	1.97	2.23	2.08	**2.09**	2.29	2.73	2.50	**2.47**	2.46	2.92	2.66	**2.68**	1.97	2.44	2.12	**2.17**
Mean	**2.23**	**2.53**	**2.37**	**2.38**	**2.60**	**3.03**	**2.81**	**2.81**	**2.92**	**3.29**	**3.01**	**3.07**	**2.44**	**2.78**	**2.50**	**2.57**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.022	0.019	0.039		0.013	0.011	0.022		0.013	0.012	0.024		0.015	0.013	0.027	
CD (P=0.05)	0.046	0.040	0.081		0.027	0.023	0.047		0.028	0.024	0.049		0.033	0.028	0.057	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 7. Influence of planting season on number of tillers per plant in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	Days to first flowering				Days to 50 % flowering								Days to full flowering			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
S_1	5.71	7.80	6.65	**6.72**	8.25	9.59	8.67	**8.84**	8.55	10.74	9.72	**9.67**	8.42	9.47	9.26	**9.05**
S_2	5.56	7.38	6.50	**6.48**	7.55	8.56	8.05	**8.05**	6.89	9.32	7.67	**7.96**	6.48	8.97	7.27	**7.57**
S_3	5.20	6.81	5.50	**5.84**	6.39	8.33	7.27	**7.33**	7.46	8.75	7.67	**7.96**	7.03	8.34	7.24	**7.53**
S_4	5.03	6.63	5.11	**5.59**	6.32	7.03	6.65	**6.66**	6.60	7.34	7.00	**7.00**	6.55	7.24	7.00	**6.93**
Mean	**5.38**	**7.16**	**5.94**	**6.16**	**7.12**	**8.38**	**7.60**	**7.72**	**7.39**	**9.04**	**8.01**	**8.15**	**7.12**	**8.50**	**7.69**	**7.77**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.056	0.048	0.097		0.036	0.031	0.062		0.094	0.081	0.162		0.022	0.019	0.038	
CD (P=0.05)	0.116	0.100	0.201		0.074	0.064	0.129		0.195	0.168	0.337		0.045	0.039	0.079	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 8. Influence of planting season on flowering in aggregatum onion genotypes

	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	35.20	39.60	31.20	**35.33**	48.90	54.56	43.33	**48.93**	65.37	74.30	60.30	**66.65**
S_2	35.86	40.20	33.20	**36.42**	51.23	57.27	46.06	**51.52**	69.30	77.50	63.33	**70.04**
S_3	37.93	40.66	35.80	**38.13**	53.50	59.11	49.26	**53.96**	71.56	79.46	66.60	**72.54**
S_4	39.06	42.40	37.06	**38.51**	57.00	60.01	51.00	**56.04**	72.76	80.30	67.20	**73.42**
Mean	**37.01**	**40.71**	**34.31**	**37.35**	**52.65**	**57.74**	**47.41**	**52.60**	**69.75**	**77.89**	**64.35**	**70.66**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.398	0.344	0.689		0.395	0.342	0.684		0.102	0.089	0.178	
CD (P=0.05)	0.825	0.714	1.429		0.819	0.709	1.419		0.213	0.184	0.369	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 10. Influence of planting season on length of flower stalk (cm) in aggregatum onion genotypes

	At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	54.00	58.86	56.11	**56.32**	57.97	63.86	58.86	**60.23**
S_2	46.50	50.50	43.69	**46.89**	49.90	54.73	49.00	**51.21**
S_3	40.40	43.04	41.07	**41.50**	44.66	47.03	46.26	**45.98**
S_4	38.80	40.18	39.17	**39.38**	42.03	43.96	42.60	**42.86**
Mean	**44.92**	**48.14**	**45.01**	**45.02**	**48.64**	**52.39**	**49.18**	**50.07**
	S	**G**	**SG**		**S**	**G**	**SG**	
SEd	1.004	0.870	1.740		0.607	0.525	1.051	
CD (P=0.05)	2.080	1.804	3.609		1.259	1.090	2.181	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 11. Influence of planting season on diameter of umbel (cm) in aggregatum onion genotypes

	At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	6.20	7.07	6.60	**6.62**	4.02	6.03	4.96	**5.00**
S_2	5.03	6.60	5.20	**5.61**	3.85	5.31	4.43	**4.55**
S_3	4.41	5.70	4.70	**4.93**	3.61	4.55	3.93	**4.03**
S_4	4.07	5.59	4.28	**4.64**	3.17	3.56	3.46	**3.39**
Mean	**4.70**	**6.00**	**4.80**	**5.45**	**3.66**	**4.86**	**4.19**	**4.24**
	S	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.453	0.393	0.786		0.387	0.335	0.671	
CD (P= 0.05)	0.941	0.815	NS		0.804	0.696	1.392	

S_1	Season -1 (September, 2010)	G_1	CO On 5
S_2	Season -2 (October, 2010)	G_2	Puttarasal type
S_3	Season -3 (November, 2010)	G_3	Santhaipadugai Local
S_4	Season- 4 (December, 2010)		

Table 12. Influence of planting season on yield components in aggregatum onion genotypes

	Number of umbels/plant				Number of flowers/umbel				Number of seeds/umbel				Seed weight/umbel (g)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	6.21	7.50	6.59	**6. 76**	226.40	282.40	243.80	**250.86**	245.05	260.03	248.04	**251.04**	0.292	0.319	0.308	**0.306**
S_2	5.70	7.03	6.22	**6.32**	191.00	242.00	212.80	**215.26**	190.03	258.02	245.05	**231.03**	0.268	0.315	0.287	**0.290**
S_3	5.15	6.33	5.56	**5.68**	139.93	164.60	135.80	**146.77**	150.02	185.04	165.04	**166.70**	0.158	0.208	0.177	**0.181**
S_4	4.81	5.92	5.45	**5.39**	114.40	148.20	116.20	**126.26**	142.03	173.03	148.03	**154.36**	0.146	0.189	0.153	**0.163**
Mean	**5.47**	**6.69**	**5.95**	**6.04**	**167.93**	**209.30**	**177.15**	**184.79**	**181.78**	**219.03**	**201.54**	**200.78**	**0.216**	**0.257**	**0.231**	**0.235**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.022	0.019	0.039		2.625	2.273	4.546		0.011	0.009	0.019		0.001	0.001	0.002	
CD (P=0.05)	0.046	0.040	0.081		5.444	4.714	9.429		0.023	0.020	0.040		0.003	0.003	0.006	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 17. Influence of planting season on seed yield characters of aggregatum onion genotypes

	Seed yield plant^{-1} (g)				Seed yield plot^{-1} (kg)				Estimated seed yield ha^{-1} (kg)				1000 seed weight (g)			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
S_1	1.81	2.39	2.02	**2.07**	0.360	0.484	0.404	**0.416**	603.00	807.00	673.00	**694.30**	1.19	1.30	1.24	**1.24**
S_2	1.45	2.18	1.76	**1.79**	0.290	0.436	0.352	**0.359**	483.00	726.00	587.00	**599.66**	1.13	1.22	1.17	**1.17**
S_3	0.81	1.31	0.96	**0.96**	0.162	0.262	0.192	**0.205**	270.00	437.00	320.00	**342.33**	1.05	1.12	1.07	**1.08**
S_4	0.70	1.11	0.83	**0.83**	0.140	0.222	0.166	**0.176**	233.66	370.00	277.00	**293.50**	1.03	1.09	1.04	**1.05**
Mean	**1.19**	**1.74**	**1.39**	**1.45**	**0.238**	**0.351**	**0.278**	**0.289**	**397.41**	**585.00**	**464.25**	**482.22**	**1.10**	**1.18**	**1.92**	**1.13**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.018	0.016	0.032		0.002	0.002	0.005		2.350	2.040	4.080		0.004	0.004	0.008	
CD (P=0.05)	0.039	0.033	0.069		0.004	0.005	0.011		4.890.	4.230	8.470		0.010	0.008	0.017	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 13. Influence of planting season on flowering and seed set percentage in aggregatum onion genotypes

	Flowering percentage				Seed set percentage			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	80.56	97.90	85.00	**87.82**	82.50	88.73	84.00	**85.07**
S_2	72.00	86.10	78.00	**78.70**	78.03	84.18	80.68	**80.96**
S_3	59.93	72.00	64.00	**65.31**	71.00	78.50	73.43	**74.31**
S_4	52.00	65.50	57.00	**58.16**	58.30	67.50	62.00	**62.60**
Mean	**66.12**	**80.37**	**71.00**	**72.50**	**72.45**	**79.72**	**75.02**	**75.73**
	S	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.301	0.261	0.522		0.141	0.122	0.245	
CD (P= 0.05)	0.625	0.541	1.082		0.294	0.254	0.509	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 18. Influence of planting season on residual bulb yield in aggregatum onion genotypes

	Residual bulb yield plant^{-1} (g)				Residual bulb yield plot^{-1} (kg)				Estimated residual bulb yield ha^{-1} (kg)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	16.00	24.00	14.00	**18.00**	3.20	4.80	2.80	**3.60**	5333	8000	4666	**5999**
S_2	11.00	20.00	12.33	**14.44**	2.20	4.00	2.47	**2.89**	3667	6664	4116	**4816**
S_3	10.66	13.00	09.66	**11.11**	2.13	2.60	1.93	**2.20**	3550	4434	3733	**3733**
S_4	8.00	12.66	07.66	**09.44**	1.60	2.53	1.53	**1.88**	2682	4216	2100	**2999**
Mean	**11.41**	**17.41**	**10.91**	**13.25**	**2.28**	**3.48**	**2.18**	**2.64**	**3808**	**5828**	**3524**	**4387**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.652	0.565	1.130		0.070	0.061	0.122		135.770	117.580	235.169	
CD (P=0.05)	1.353	1.172	2.344		0.146	0.127	0.254		281.581	243.857	487.714	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 14. Influence of planting season on chlorophyll 'a' content (mg g^{-1}) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	0.71	0.82	0.67	**0.73**	0.76	0.86	0.68	**0.77**	0.62	0.74	0.57	**0.64**	0.56	0.70	0.51	**0.59**
S_2	0.69	0.75	0.59	**0.67**	0.72	0.78	0.61	**0.70**	0.59	0.64	0.54	**0.59**	0.49	0.58	0.42	**0.49**
S_3	0.65	0.72	0.48	**0.61**	0.66	0.73	0.52	**0.63**	0.56	0.61	0.52	**0.56**	0.45	0.52	0.40	**0.45**
S_4	0.54	0.61	0.45	**0.53**	0.55	0.62	0.47	**0.53**	0.56	0.58	0.48	**0.54**	0.39	0.43	0.38	**0.40**
Mean	**0.65**	**0.72**	**0.55**	**0.64**	**0.67**	**0.75**	**0.57**	**0.66**	**0.58**	**0.64**	**0.52**	**0.58**	**0.47**	**0.55**	**0.42**	**0.48**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.006	0.005	0.010		0.006	0.005	0.010		0.012	0.010	0.021		0.004	0.003	0.007	
CD (P=0.05)	0.012	0.010	0.021		0.012	0.012	0.023		0.025	0.022	0.044		0.008	0.007	0.015	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 15. Influence of planting season on chlorophyll 'b' content (mg g^{-1}) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	0.29	0.42	0.23	**0.31**	0.33	0.60	0.17	**0.37**	0.29	0.32	0.24	**0.28**	0.26	0.31	0.19	**0.25**
S_2	0.25	0.37	0.21	**0.27**	0.40	0.56	0.19	**0.38**	0.26	0.28	0.23	**0.26**	0.20	0.26	0.16	**0.20**
S_3	0.24	0.30	0.18	**0.25**	0.19	0.30	0.18	**0.22**	0.24	0.26	0.19	**0.23**	0.18	0.22	0.16	**0.18**
S_4	0.23	0.26	0.18	**0.22**	0.18	0.19	0.14	**0.17**	0.22	0.23	0.18	**0.21**	0.15	0.17	0.13	**0.15**
Mean	**0.25**	**0.34**	**0.20**	**0.26**	**0.27**	**0.41**	**0.17**	**0.28**	**0.25**	**0.27**	**0.21**	**0.24**	**0.20**	**0.24**	**0.16**	**0.20**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.019	0.016	0.033		0.036	0.031	0.063		0.004	0.003	0.007		0.004	0.004	0.008	
CD (P=0.05)	0.040	0.034	0.069		0.075	0.065	0.131		0.008	0.007	0.015		0.009	0.088	0.016	

S_1 Season -1 (September , 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 16. Influence of planting season on total chlorophyll (mg g^{-1}) in aggregatum onion genotypes

	30 DAP				60 DAP				At full flowering				At harvest			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
S_1	0.75	0.91	0.67	**0.77**	1.06	1.07	0.92	**1.01**	0.91	1.04	0.81	**0.91**	0.83	1.02	0.69	**0.85**
S_2	0.70	0.91	0.65	**0.75**	0.88	1.02	0.82	**0.90**	0.87	0.92	0.77	**0.85**	0.66	0.78	0.59	**0.67**
S_3	0.69	0.77	0.55	**0.67**	0.76	0.96	0.73	**0.81**	0.81	0.89	0.75	**0.81**	0.64	0.71	0.57	**0.64**
S_4	0.62	0.75	0.55	**0.64**	0.75	0.93	0.70	**0.79**	0.78	0.83	0.74	**0.78**	0.59	0.66	0.55	**0.60**
Mean	**0.69**	**0.83**	**0.60**	**0.71**	**0.86**	**1.00**	**0.79**	**0.88**	**0.84**	**0.91**	**0.76**	**0.84**	**0.68**	**0.79**	**0.60**	**0.69**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.016	0.014	0.029		0.019	0.016	0.033		0.007	0.006	0.012		0.005	0.004	0.008	
CD (P=0.05)	0.034	0.030	0.060		0.039	0.013	0.026		0.015	0.018	0.036		0.010	0.009	0.018	

S_1 Season -1 (September , 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 19. Influence of planting season on quality traits of aggregatum onion genotypes

	TSS (° brix)				Ascorbic acid (mg100 g $^{-1}$)				Protein content (%)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	13.70	13.08	14.37	**13.71**	9.11	9.26	9.43	**9.27**	18.09	19.00	18.90	**18.66**
S_2	12.78	13.00	13.58	**13.12**	8.53	8.60	9.03	**8.72**	17.80	18.30	18.10	**18.06**
S_3	11.56	12.23	12.65	**12.15**	8.35	8.45	9.00	**8.60**	17.30	17.90	17.50	**17.56**
S_4	11.23	11.50	12.63	**11.78**	7.79	8.10	8.66	**8.18**	17.20	17.70	17.40	**17.43**
Mean	**12.32**	**12.45**	**13.31**	**12.69**	**8.44**	**8.60**	**9.03**	**8.69**	**17.59**	**18.22**	**17.97**	**17.93**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.145	0.125	0.251		0.059	0.051	0.103		0.038	0.033	0.066	
CD (P=0.05)	0.306	0.261	0.522		0.124	0.107	0.215		0.079	0.069	0.138	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 20. Influence of planting season on seedling vigour characters of aggregatum onion genotypes

	Germination (%)				Root length (cm)				Shoot length (cm)				Dry matter production (mg 10 S_2^{-1})				Vigour Index			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
S_1	88.46	92.76	90.00	**90.41**	6.10	7.20	6.30	**6.53**	7.80	8.80	8.60	**8.40**	14.80	15.82	15.50	**15.37**	1229.73	1484.14	1341.00	**1351.62**
S_2	85.06	90.00	87.00	**87.35**	5.90	6.50	6.20	**6.20**	7.70	8.70	7.90	**8.10**	14.30	15.26	14.70	**14.75**	1156.80	1368.00	1226.70	**1250.50**
S_3	80.66	86.50	82.00	**83.05**	5.60	6.30	6.00	**5.96**	7.20	7.80	7.73	**7.57**	14.25	14.85	14.45	**14.51**	1032.44	1219.65	1125.86	**1125.98**
S_4	72.13	78.00	76.00	**75.37**	5.20	5.90	5.70	**5.60**	7.0	7.56	7.30	**7.28**	13.80	14.40	14.00	**14.06**	880.00	1047.54	88.00	**971.84**
Mean	**81.58**	**86.81**	**83.75**	**84.05**	**5.69**	**6.47**	**6.05**	**6.07**	**7.42**	**8.21**	**7.88**	**7.84**	**14.28**	**15.08**	**14.62**	**14.67**	**1074.74**	**1279.83**	**1170.39**	**1174.98**
	S	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.301	0.261	0.521		0.017	0.015	0.030		0.036	0.031	0.063		0.028	0.025	0.050		0.178	0.154	0.308	
CD (P=0.05)	0.625	0.541	1.082		0.036	0.031	0.063		0.076	0.065	0.131		0.060	0.052	0.104		0.369	0.320	0.640	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 9. Influence of planting season on days to seed set and seed maturity in aggregatum onion genotypes

	Days to seed set				Days to seed maturity			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
S_1	84.20	96.13	79.16	**86.50**	112.23	129.00	104.40	**115.21**
S_2	92.10	104.72	86.33	**94.38**	120.70	136.90	113.70	**123.76**
S_3	96.26	107.23	91.70	**98.40**	125.76	139.43	120.60	**128.60**
S_4	102.43	112.20	94.00	**102.87**	132.56	144.23	124.60	**133.80**
Mean	**93.75**	**105.07**	**87.80**	**95.54**	**122.81**	**137.39**	**115.82**	**125.34**
	S	**G**	**SG**		**S**	**G**	**SG**	
SEd	0.453	0.392	0.785		0.092	0.080	0.160	
CD (P: 0.05)	0.940	0.814	1.628		0.192	0.166	0.332	

S_1 Season -1 (September, 2010)
S_2 Season -2 (October, 2010)
S_3 Season -3 (November, 2010)
S_4 Season -4 (December, 2010)

G_1 CO On 5
G_2 Puttarasal type
G_3 Santhaipadugai Local

Table 21. Cost economics of three genotypes of aggregatum onion during September season

Genotypes	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B/C ratio
CO On 5	190970	473250	282280	2.47
Puttarasal type	208970	637250	428280	3.04
Santhaipadugai local	198470	522750	324280	2.63

Data not analyzed statistically

Fig. 5. Layout plan of experimental field

N

RI	RII	RIII
S_1G_2	S_1G_3	S_1G_1
S_1G_3	S_1G_1	S_1G_2
S_1G_1	S_1G_2	S_1G_3
		1.5 m
RI	RII	RIII
S_2G_3	S_2G_1	S_2G_2
S_2G_1	S_2G_2	S_2G_3
S_2G_2	S_2G_3	S_2G_1
RI	RII	RIII
S_3G_1	S_3G_2	S_3G_3
S_3G_2	S_3G_3	S_3G_1
S_3G_3	S_3G_1	S_3G_2
RI	RII	RIII
S_4G_3	S_4G_2	S_4G_1
S_4G_2	S_4G_1	S_4G_3
S_4G_1	S_4G_3	S_4G_2

6.00 m

LIST OF ANNEXURE

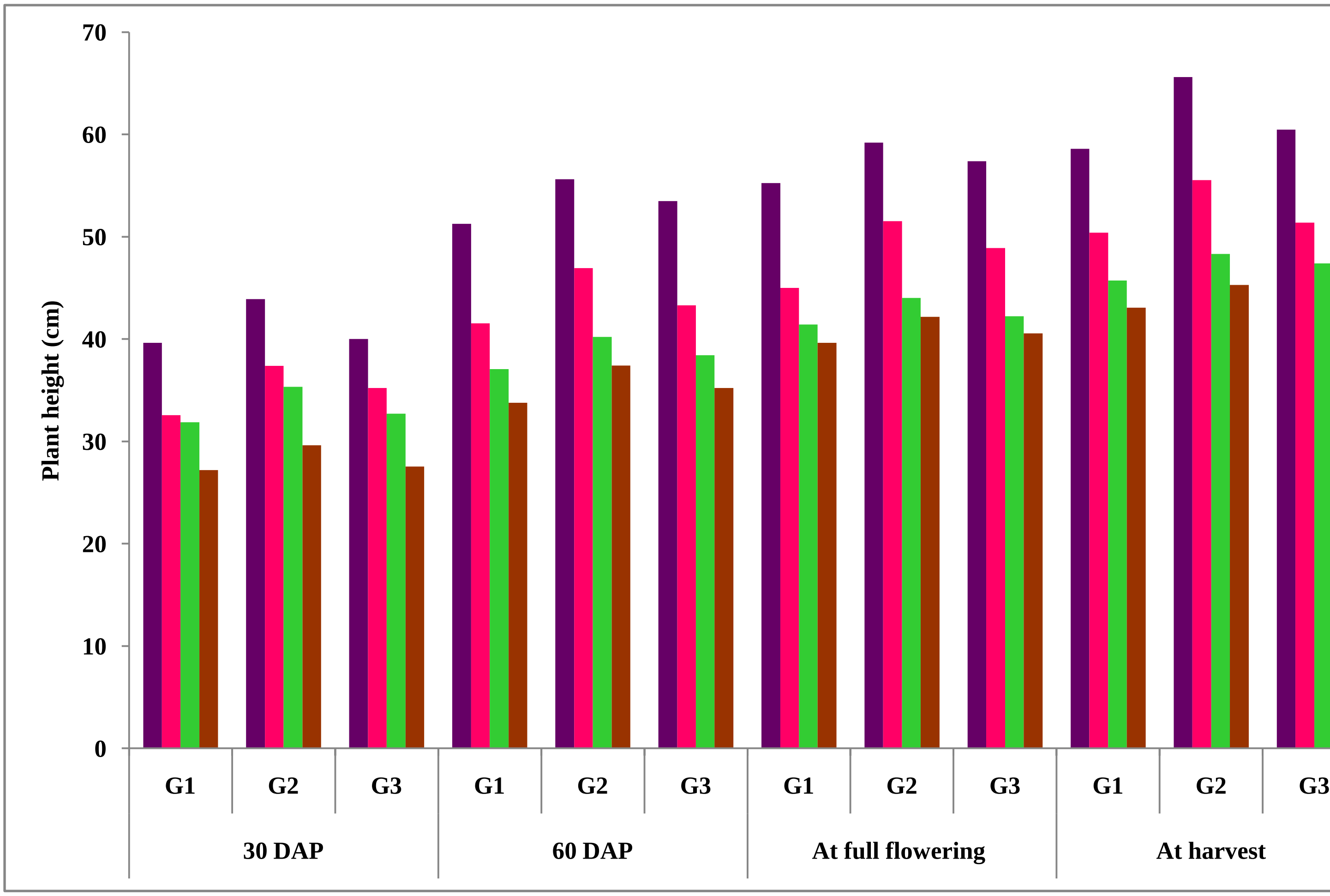


Fig.6. Influence of planting season on plant height in aggregatum onion genotypes

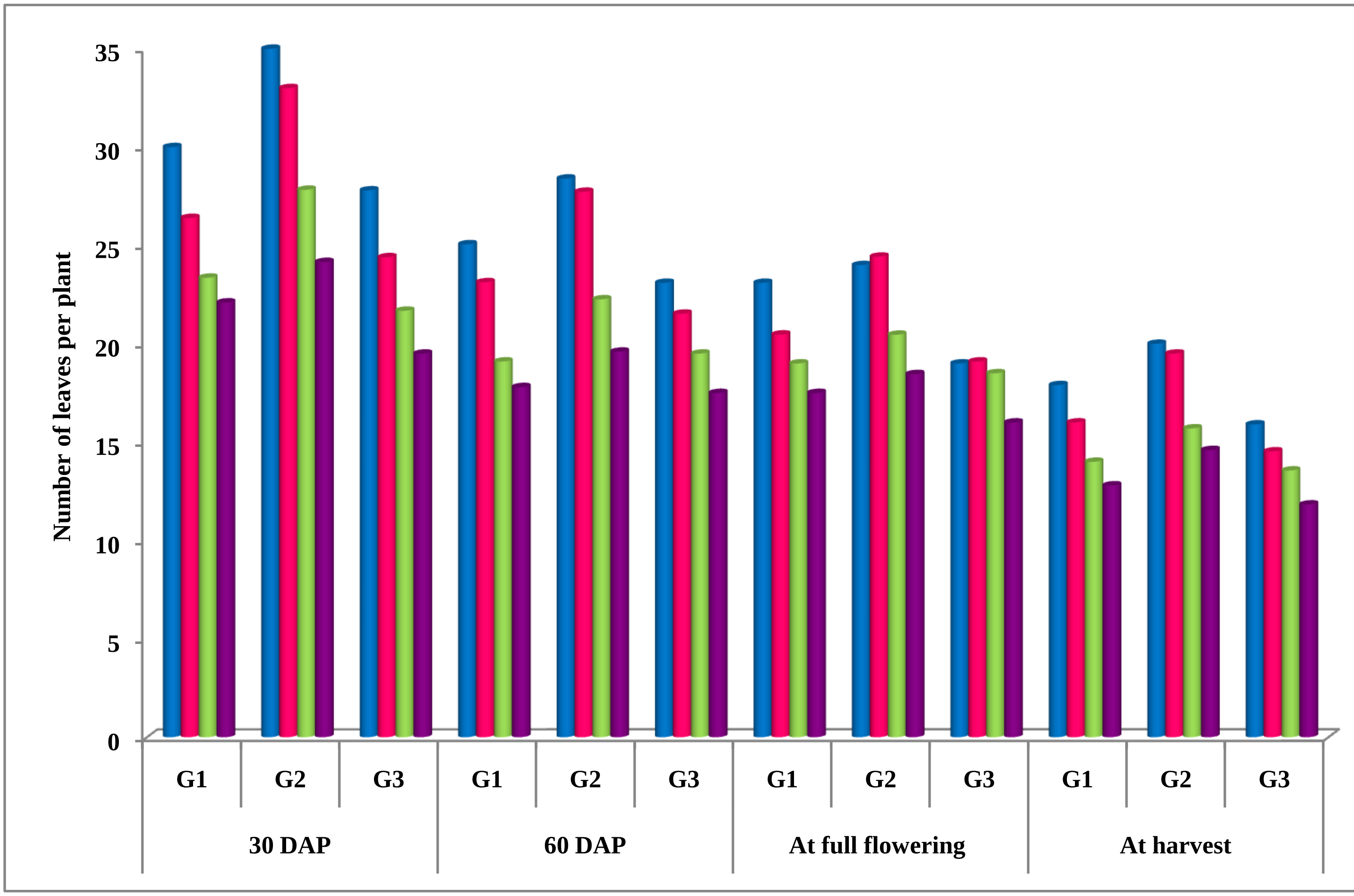


Fig. 7. Influence of planting season on number of leaves per plant in aggregatum onion genotypes

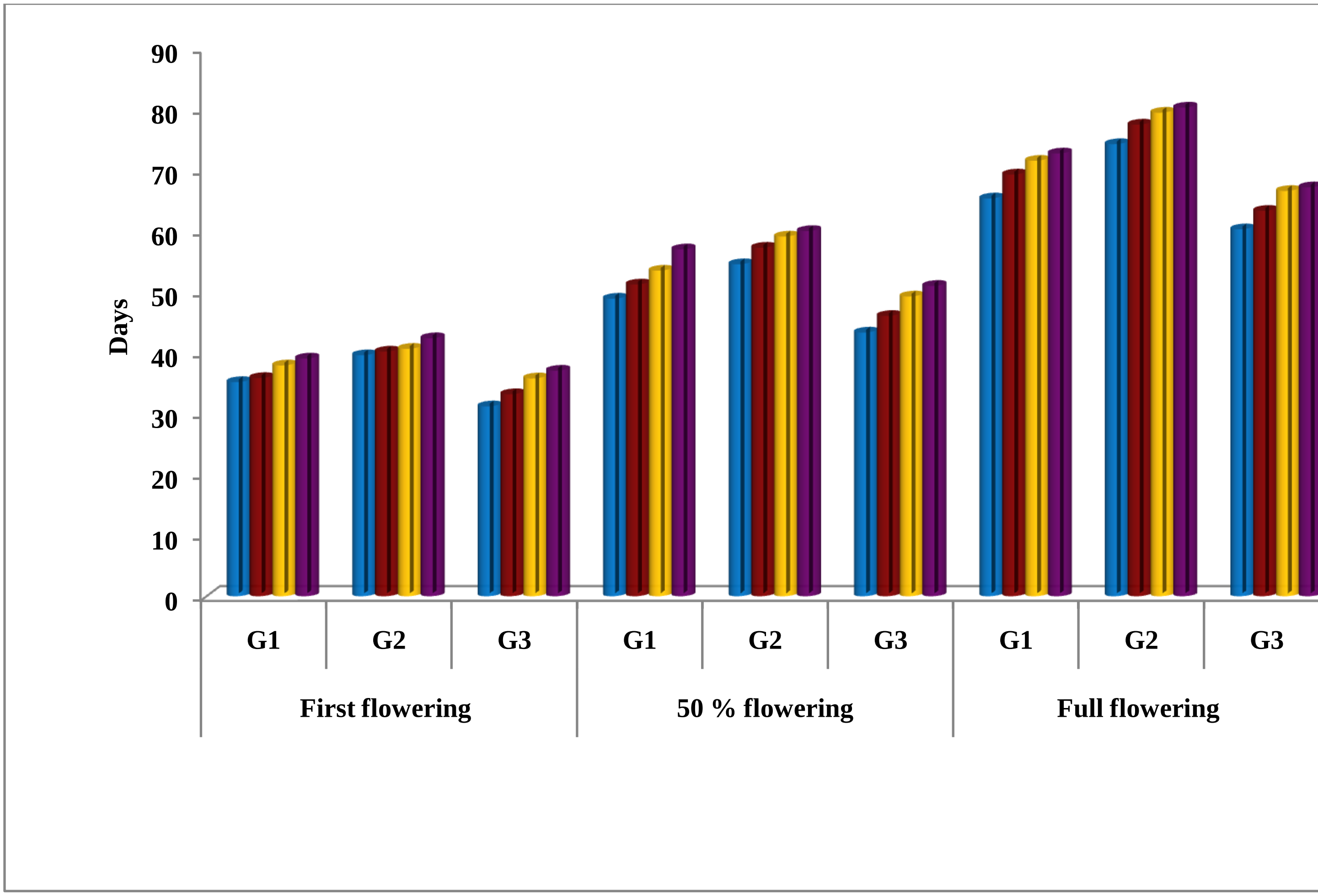


Fig. 8. Influence of planting season on flowering in aggregatum onion genotypes

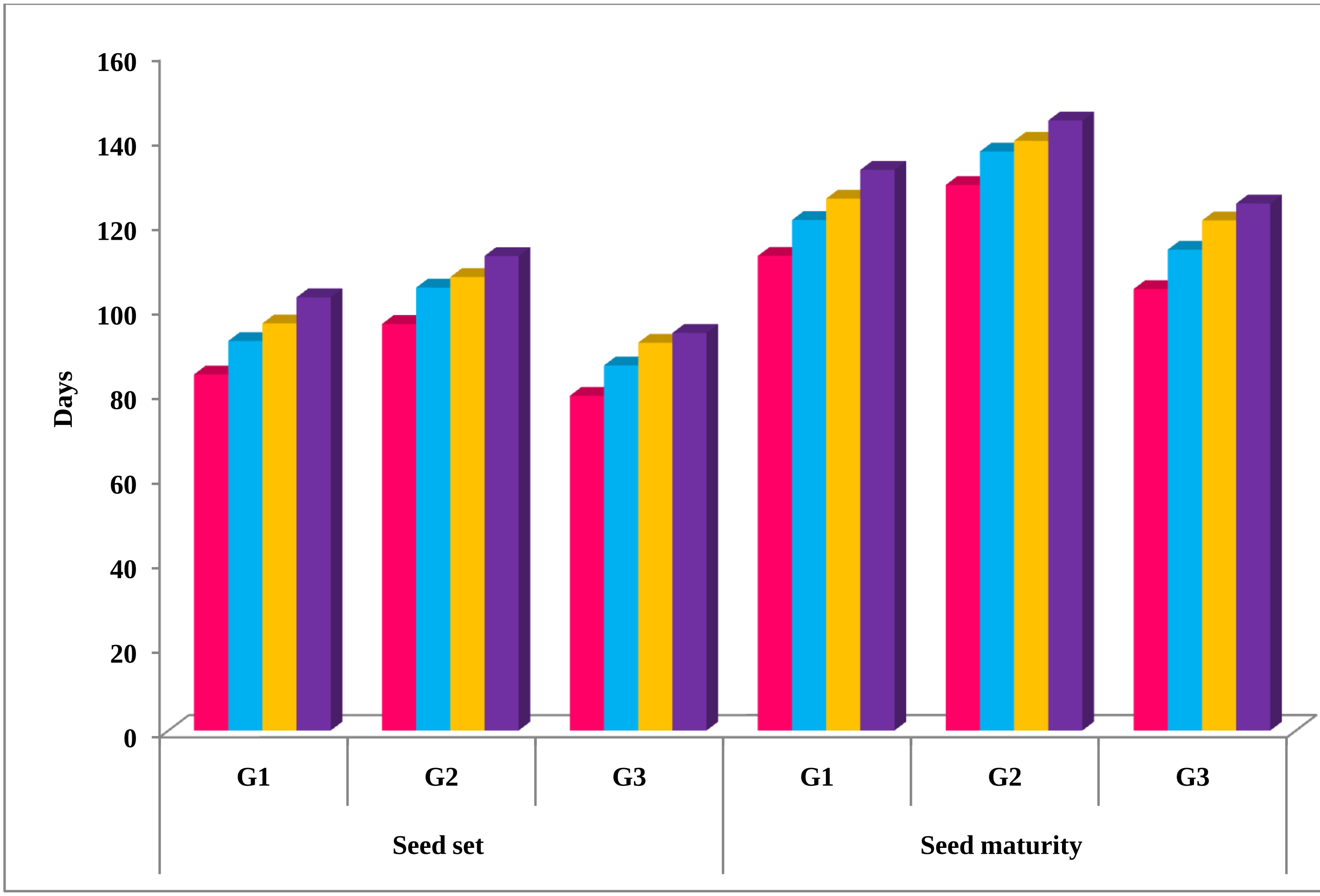


Fig. 9. Influence of planting season on days to seed set and seed maturity in aggregatum onion genotypes

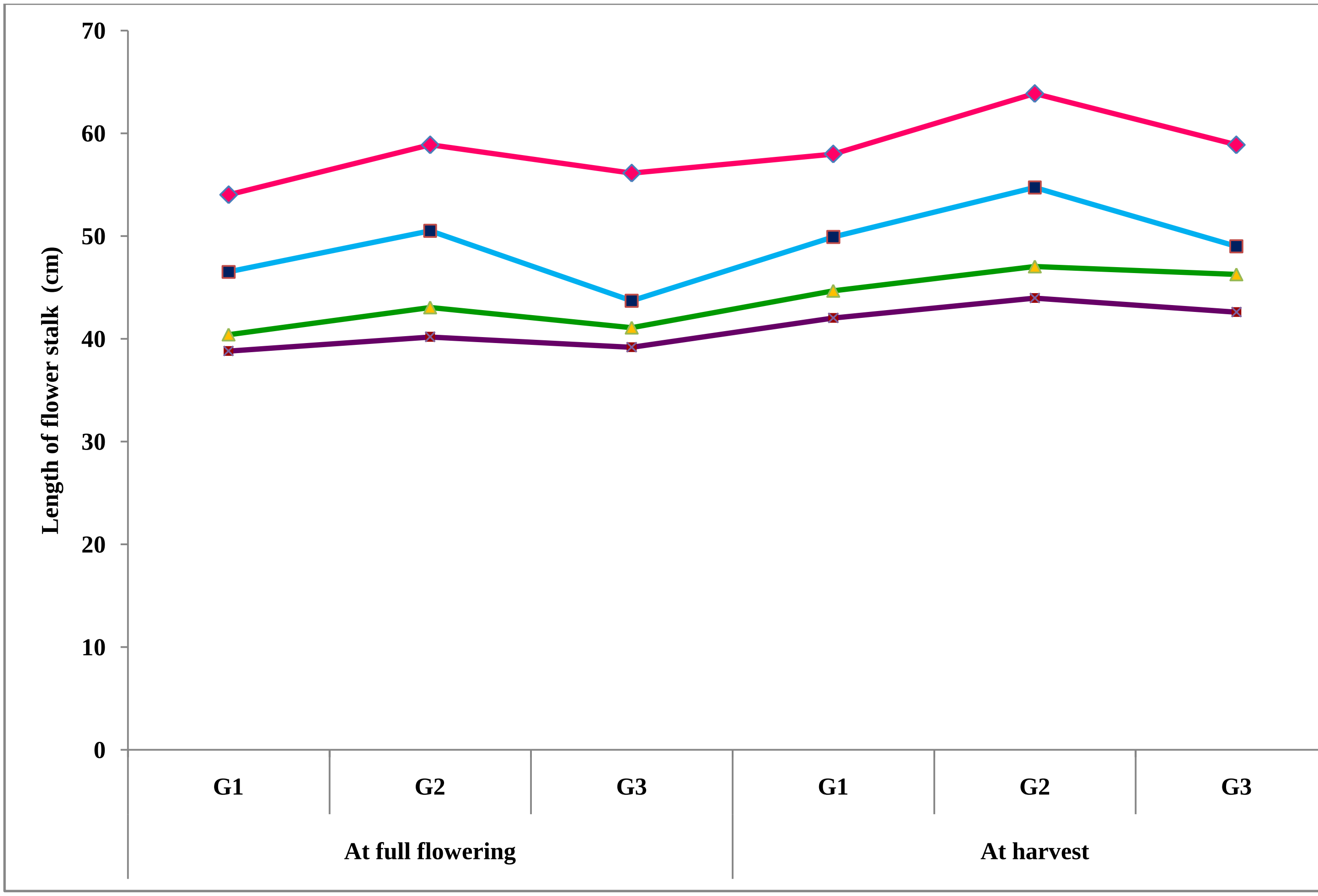


Fig. 10. Influence of planting season on length of flower stalk in aggregatum onion genotypes

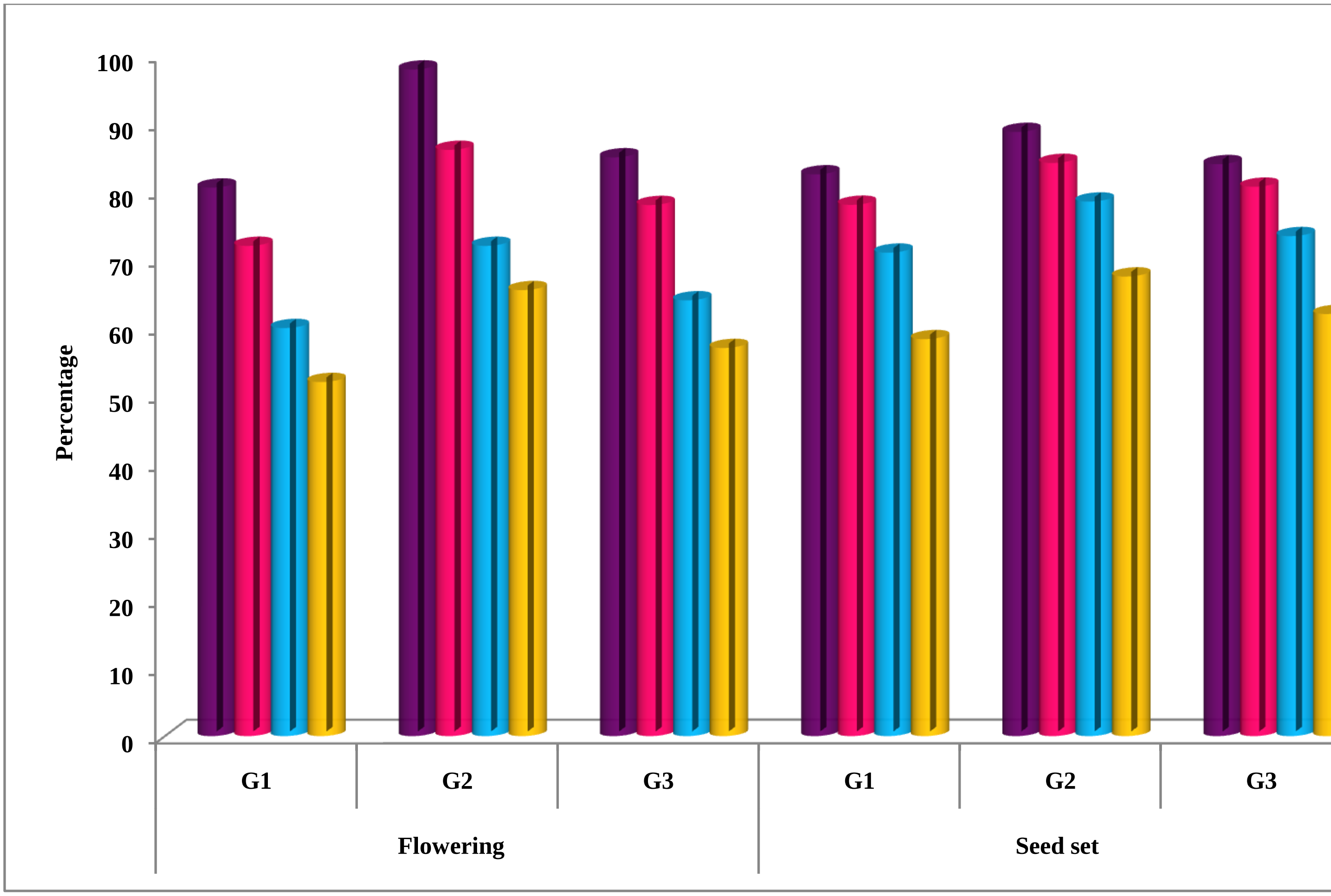


Fig. 12. Influence of planting season on flowering and seed set percentage in aggregatum onion genotypes

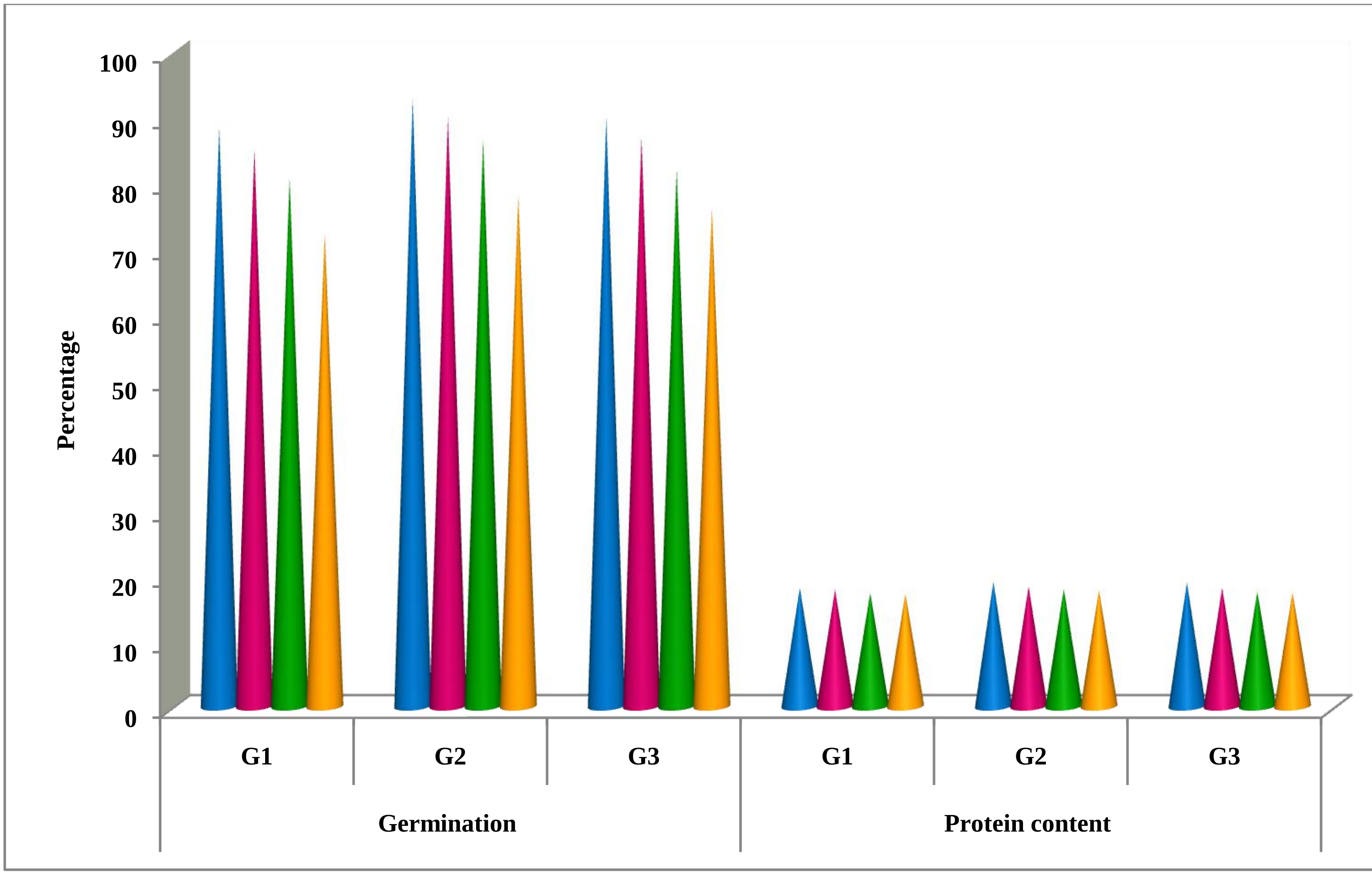


Fig. 17. Influence of planting season on germination percentage and protein content in aggregatum onion genotypes

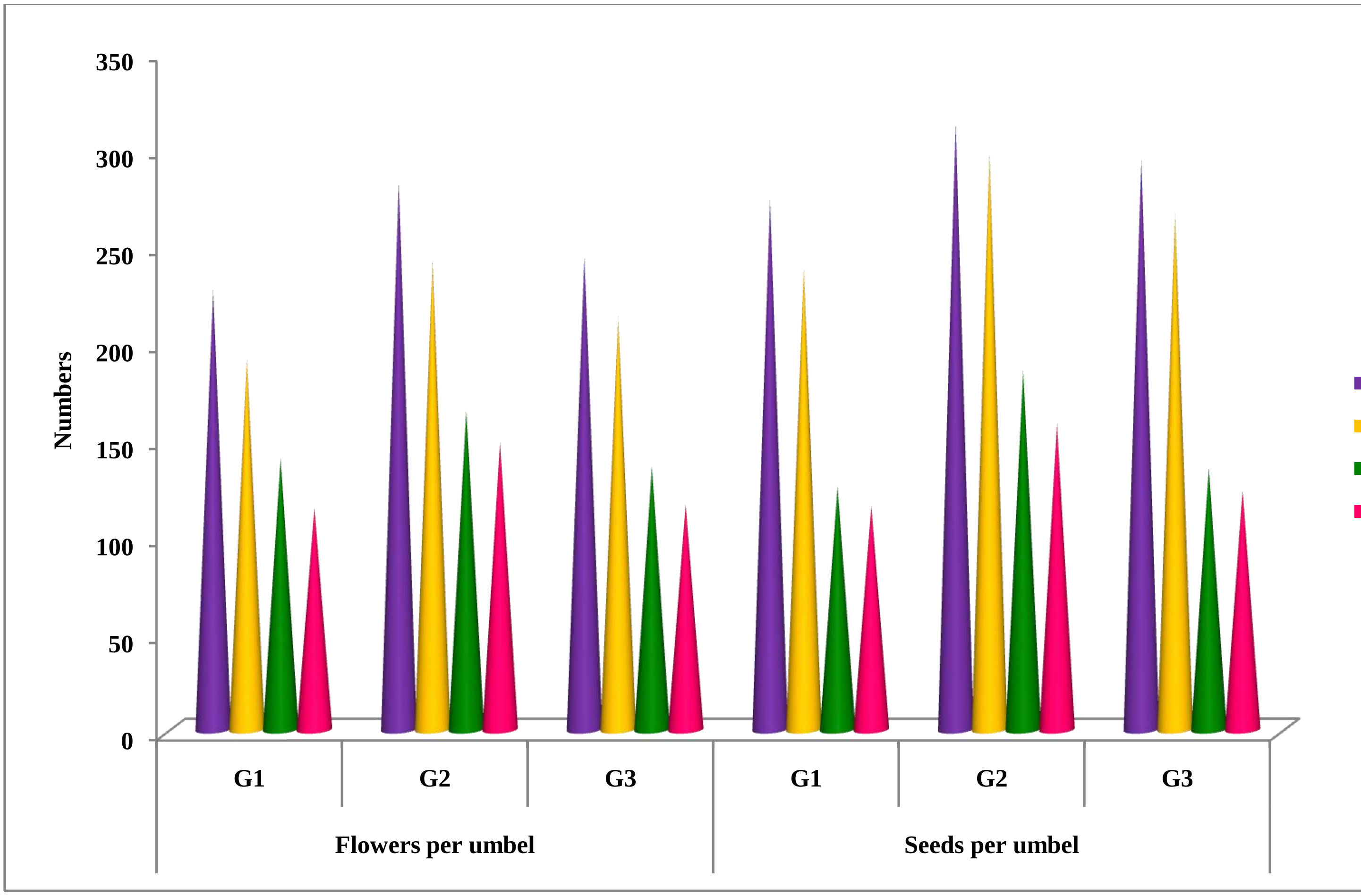


Fig.11. Influence of planting season on number of flowers per umbel and number of seeds per umbel

in aggregatum onion genotypes

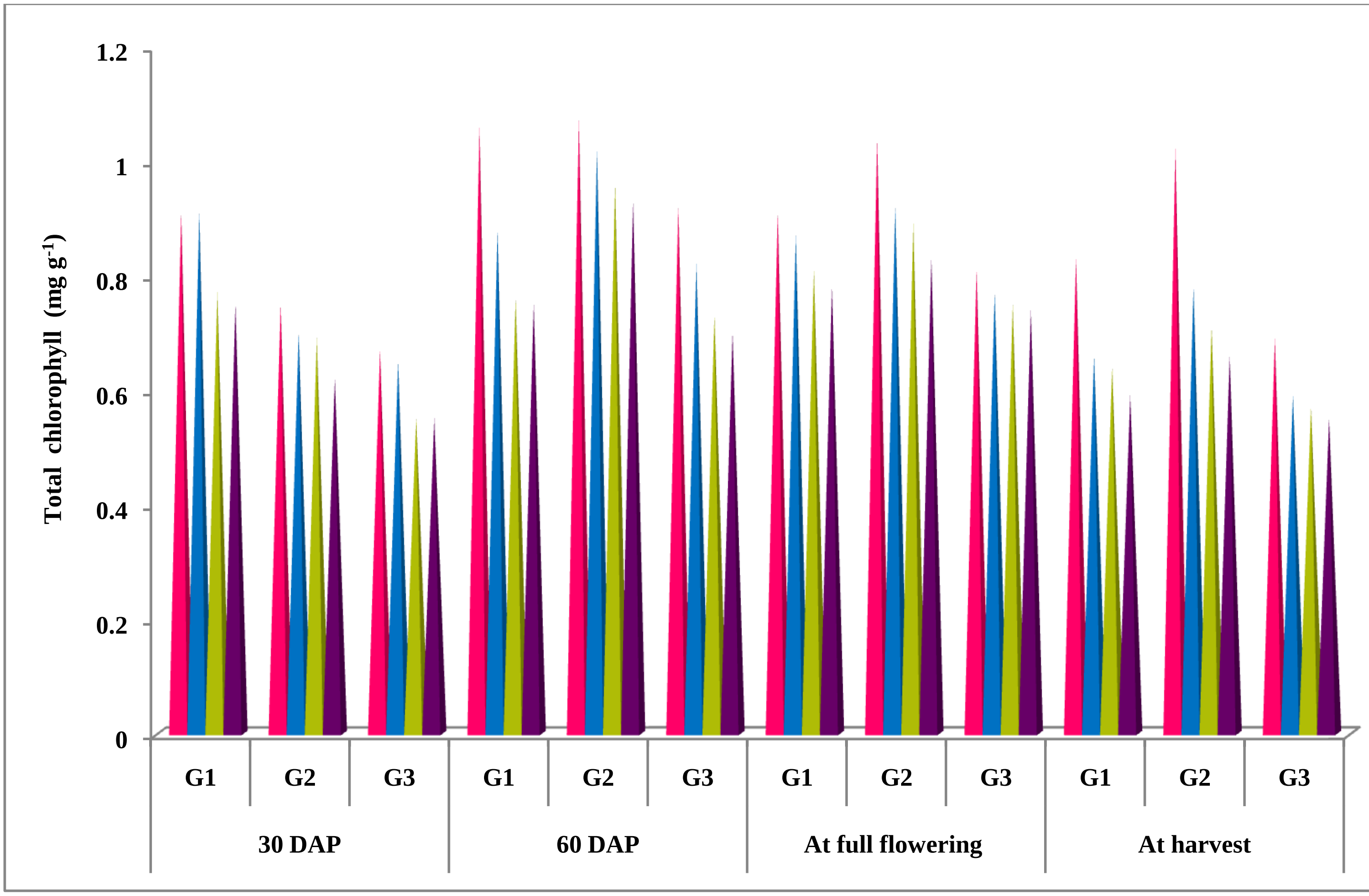


Fig. 13. Influence of planting season on total chlorophyll content in aggregatum onion genotypes

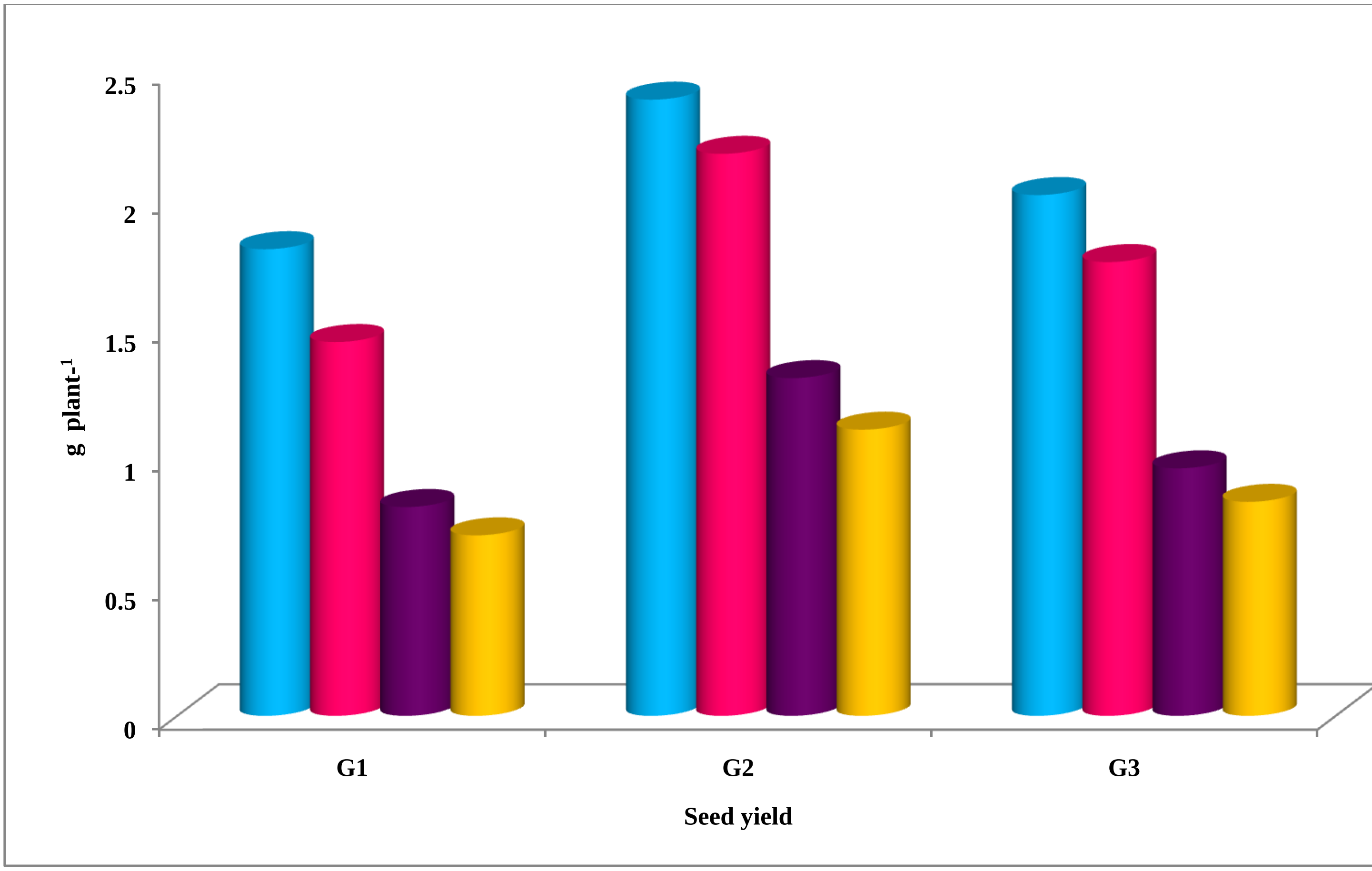


Fig. 14. Influence of planting season on seed yield per plant in aggregatum onion genotypes

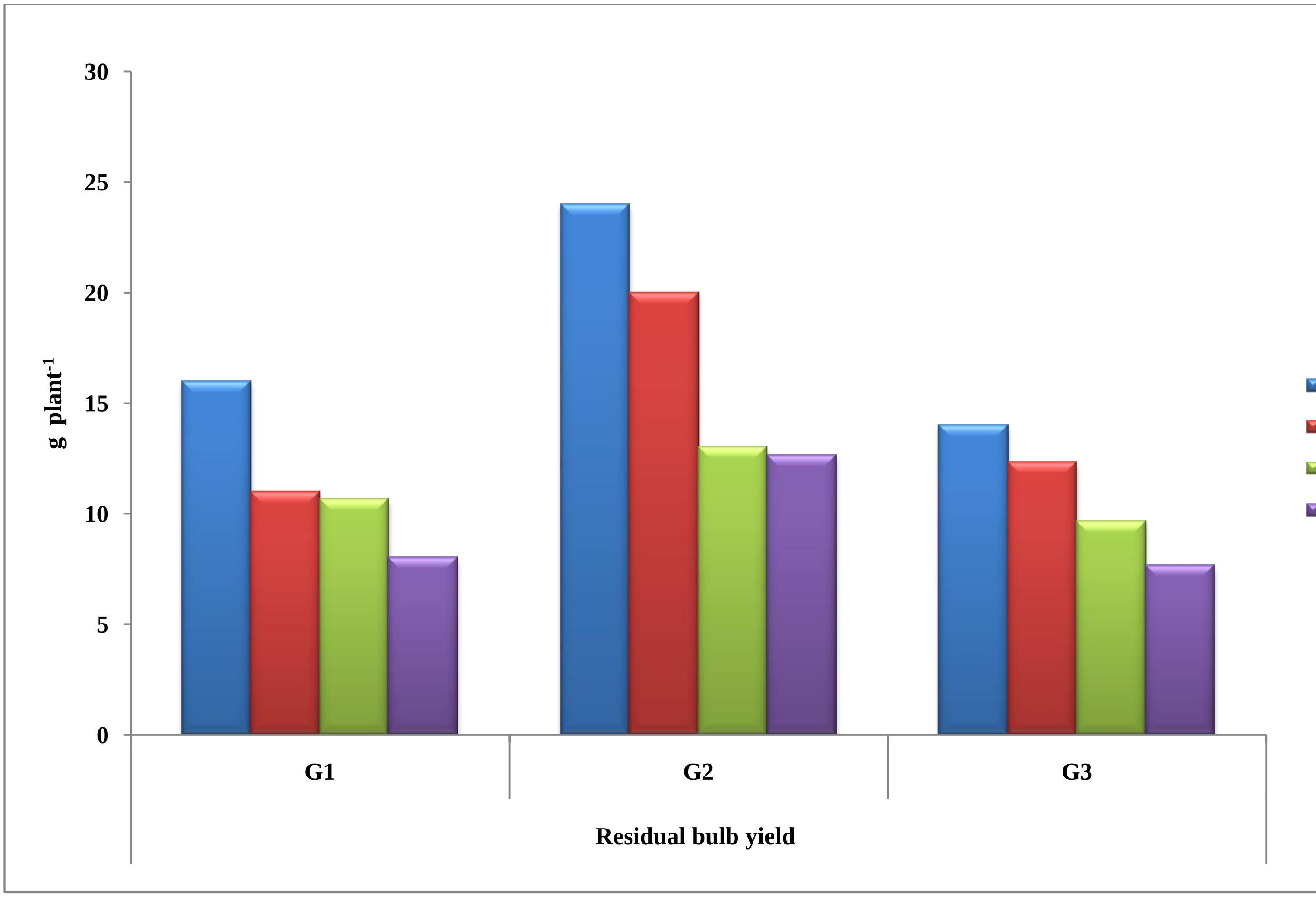


Fig. 16. Influence of planting season on residual bulb yield per plant in aggregatum onion genotypes

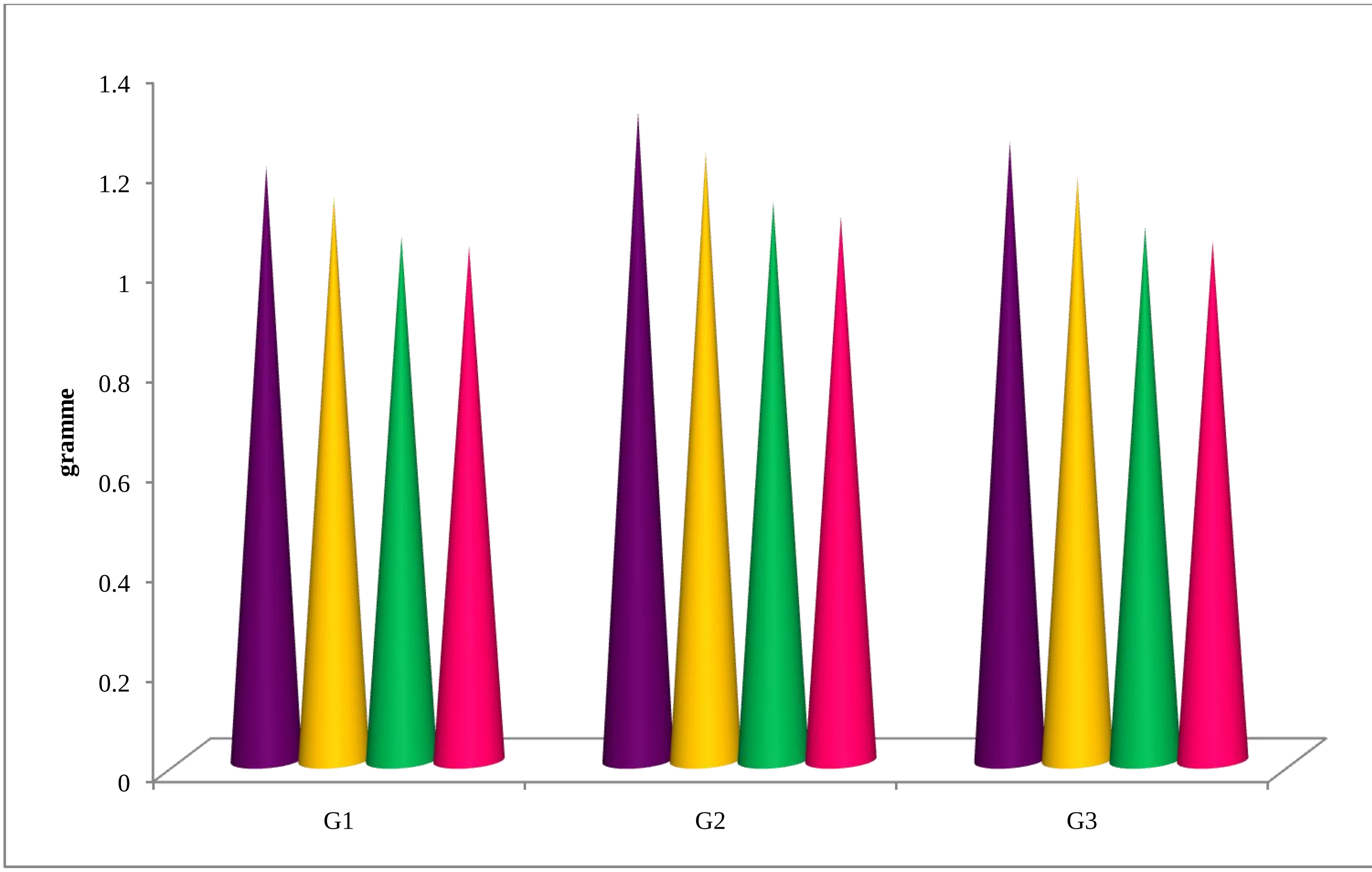


Fig. 15. Influence of planting season on thousand seed weight in aggregatum onion genotypes

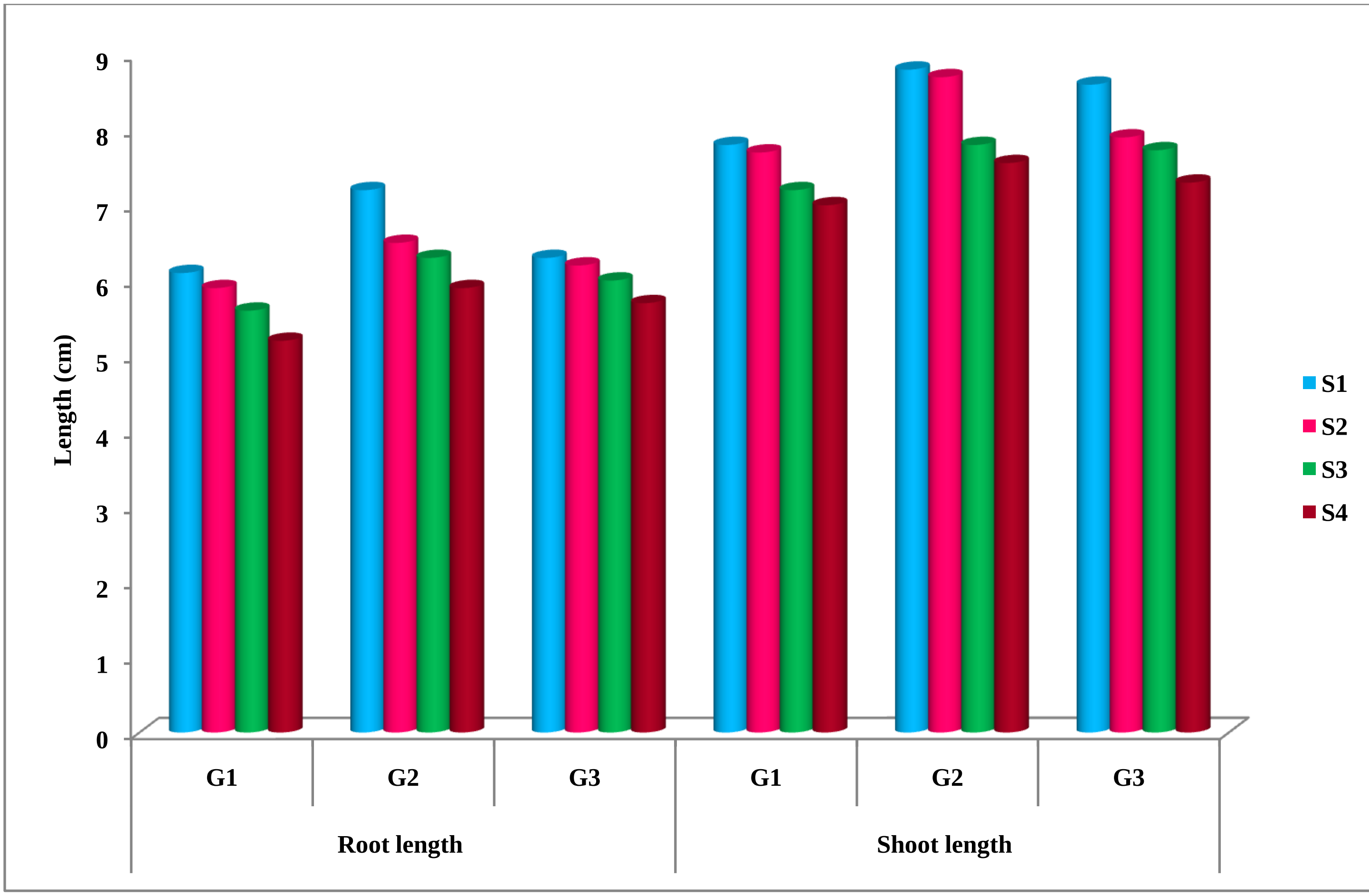
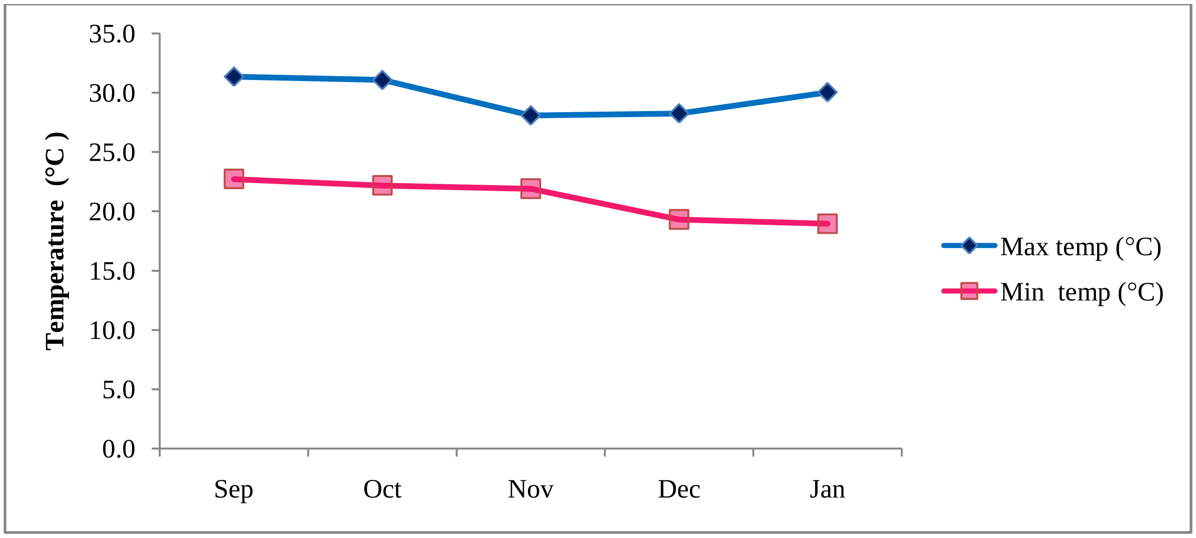
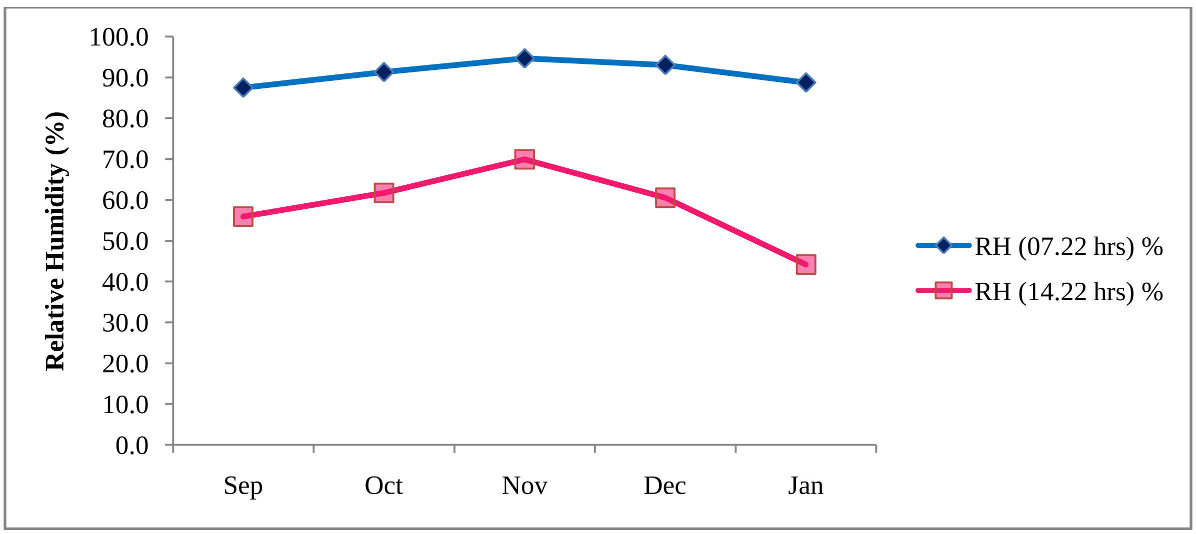


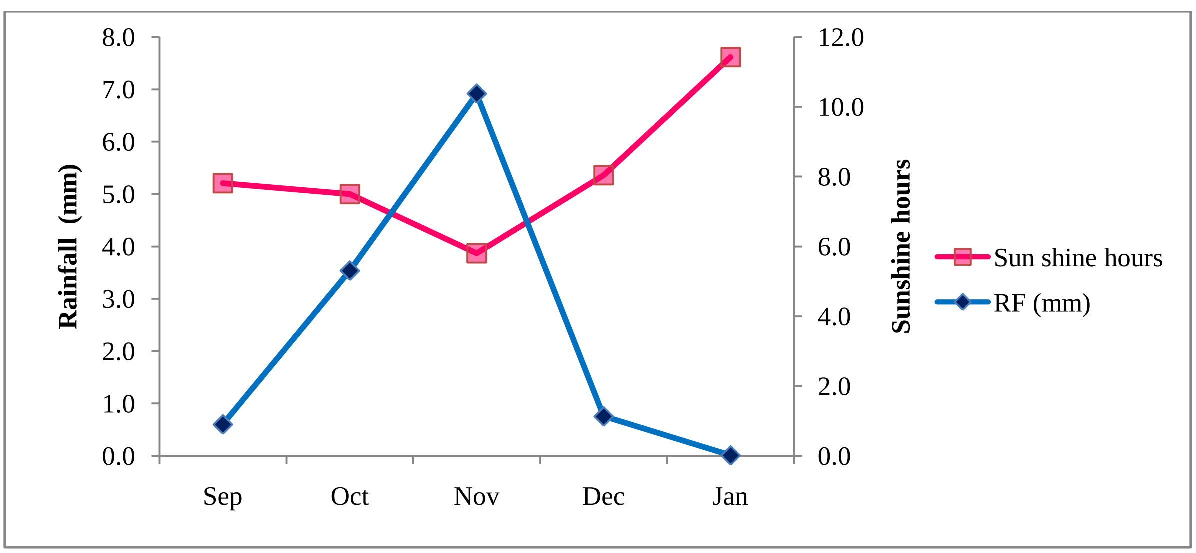
Fig. 18. Influence of planting season on seedling root length and shoot length in aggregatum onion genotypes



Temperature (°C)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Sep
Oct
Nov
Dec
Jan
Max temp (°C)
Min temp (°C)

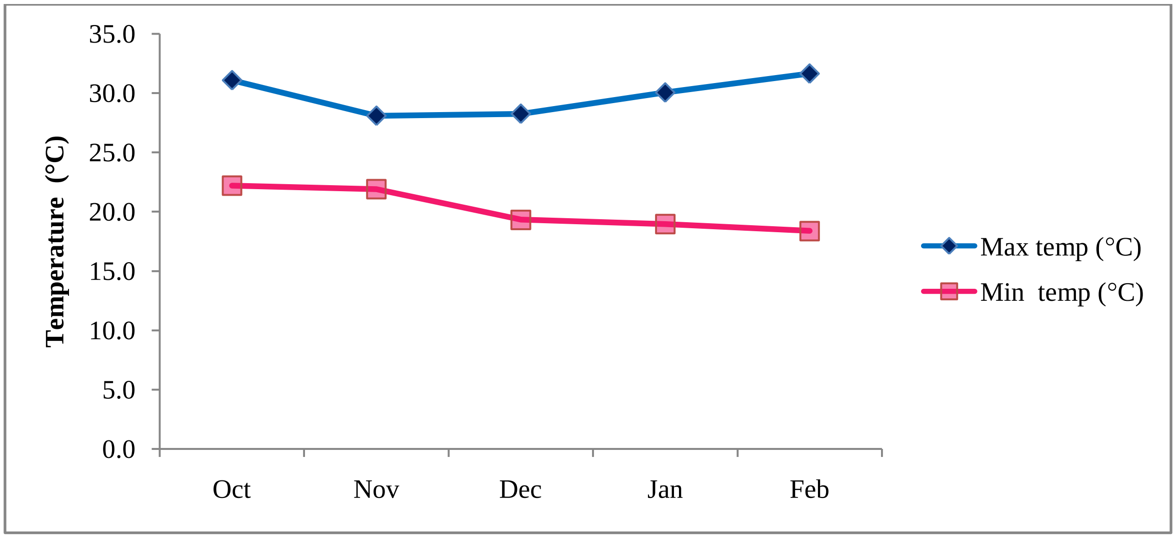


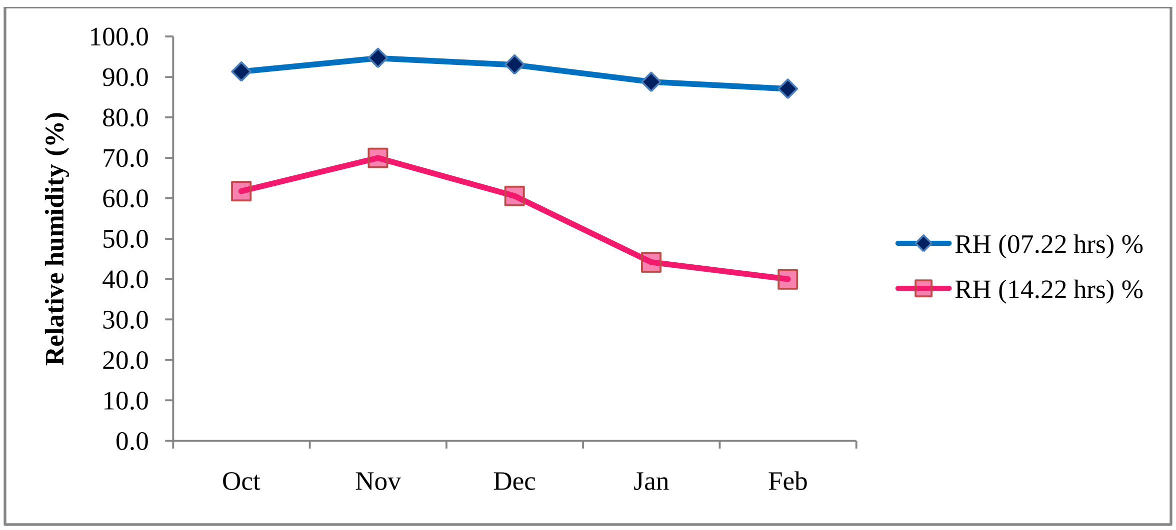
Relative Humidity (%)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Sep
Oct
Nov
Dec
Jan
RH (07.22 hrs) %
RH (14.22 hrs) %



Rainfall (mm)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Sunshine hours
Sep
Oct
Nov
Dec
Jan
Sun shine hours
RF (mm)

Fig. 1. Meteorological data for temperature, relative humidity, rainfall and sunshine hours during S_1 cropping period (September 2010-January 2011)





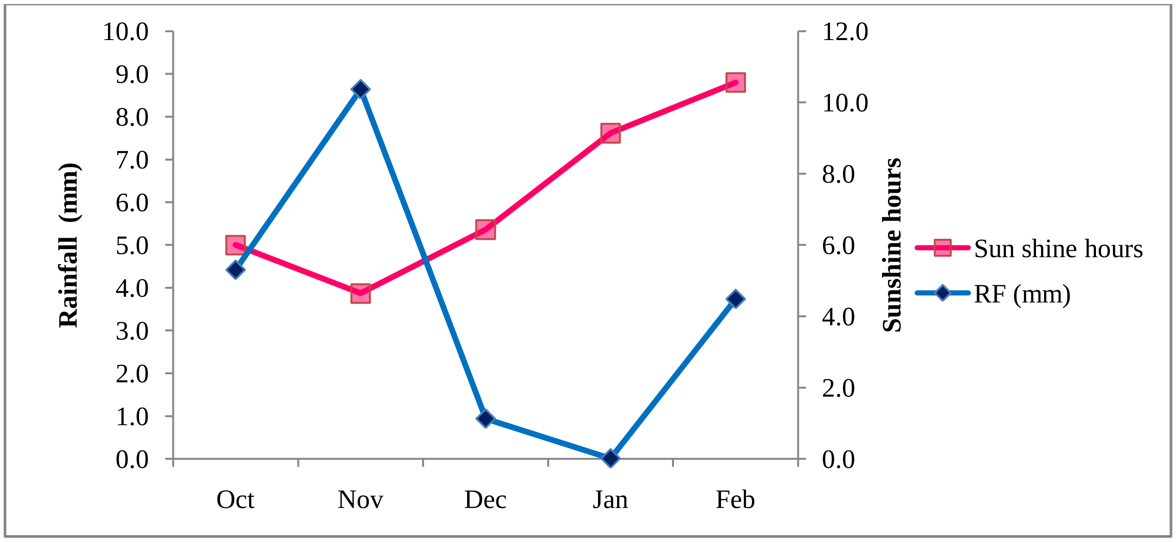
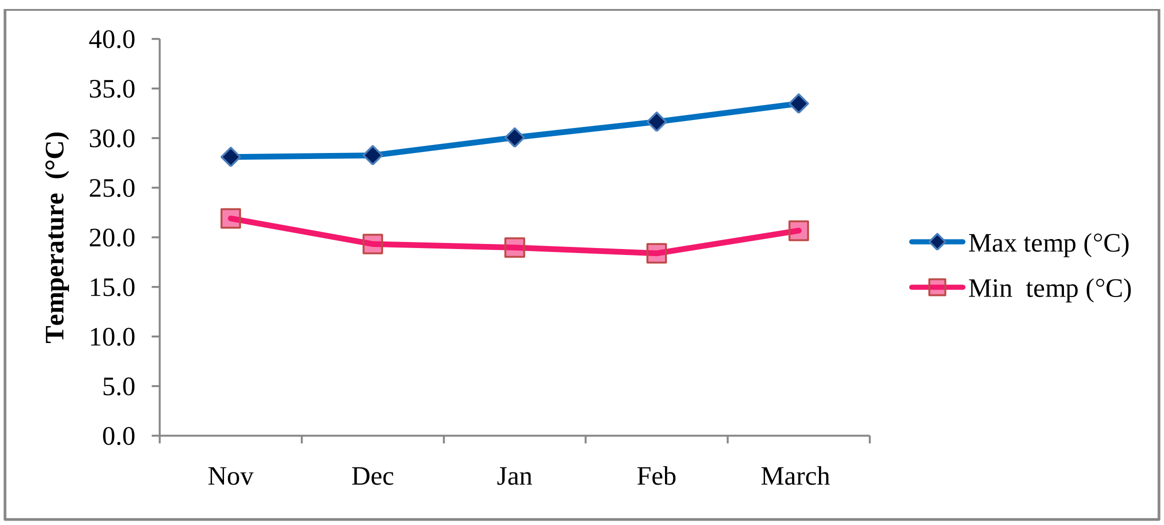
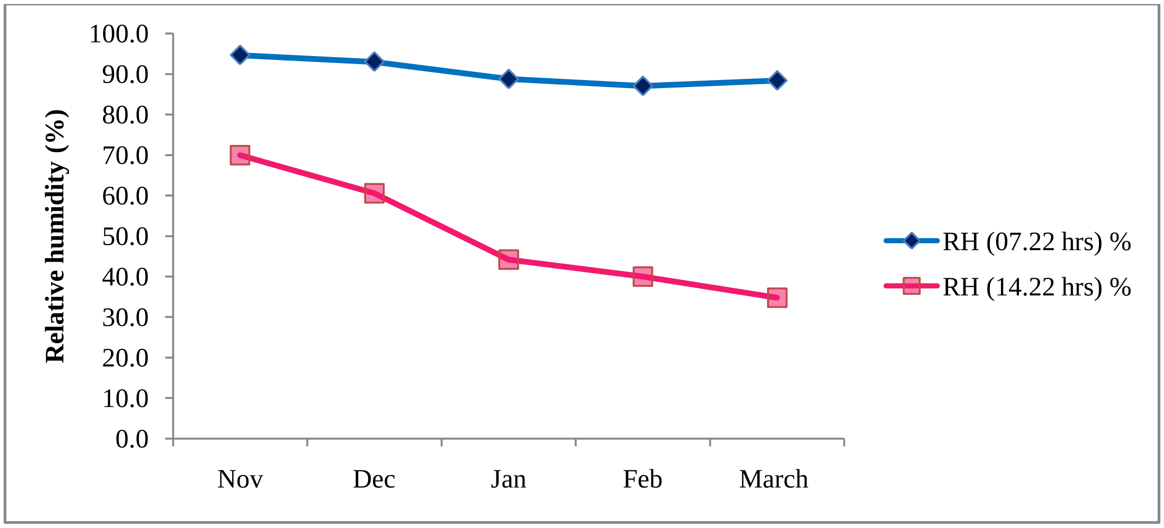


Fig. 2. Meteorological data for temperature, relative humidity, rainfall and sunshine hours during S_2 cropping period (October 2010-February 2011)





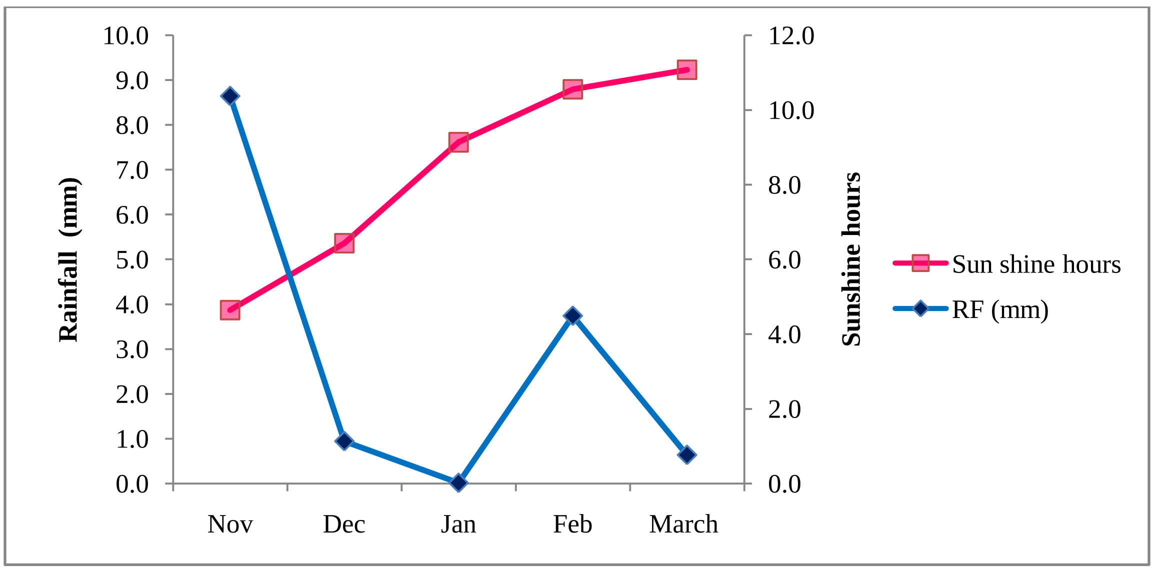
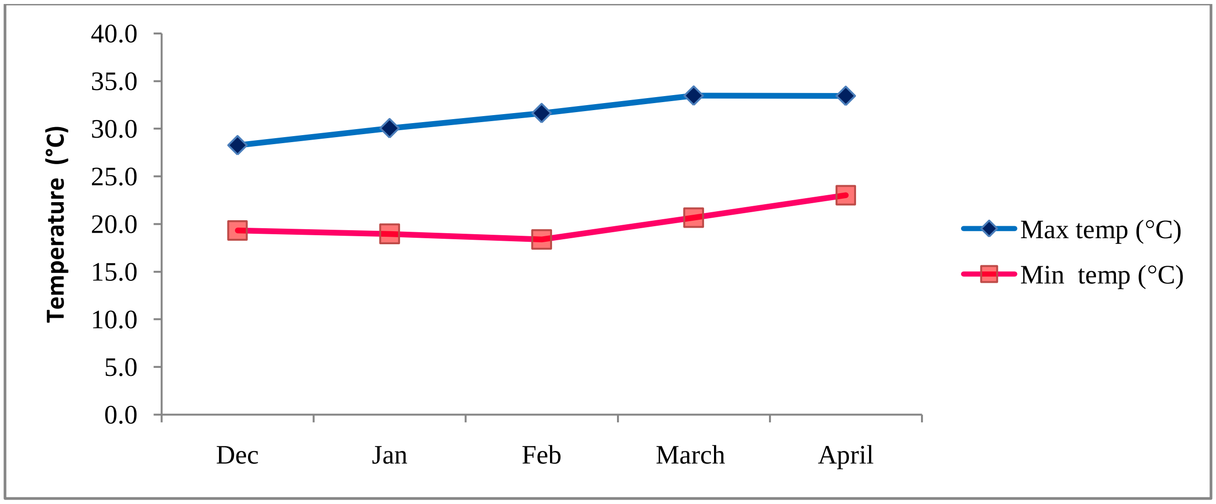
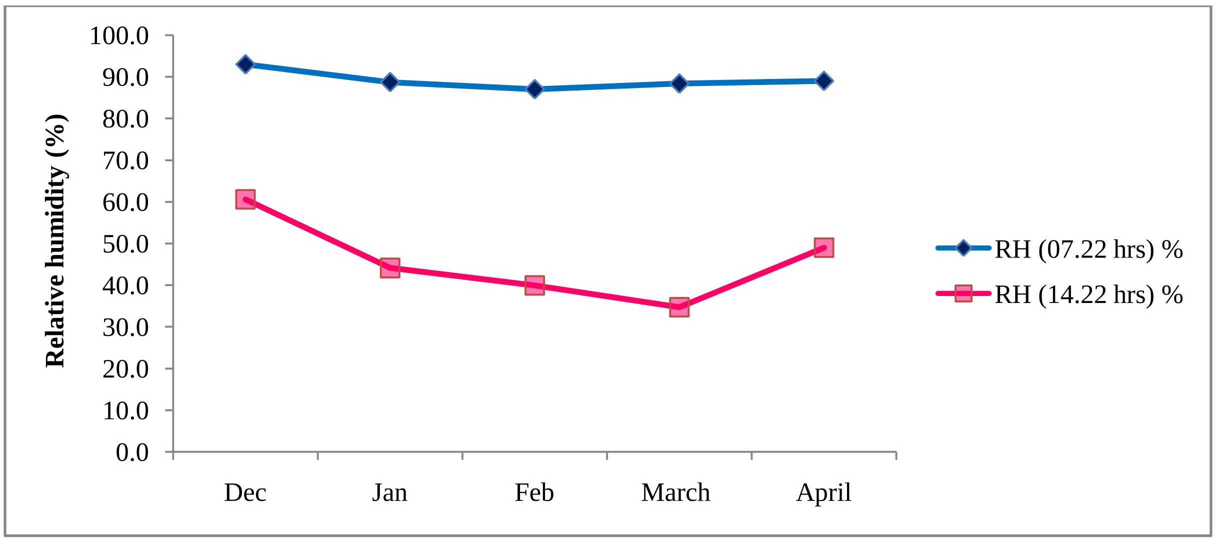


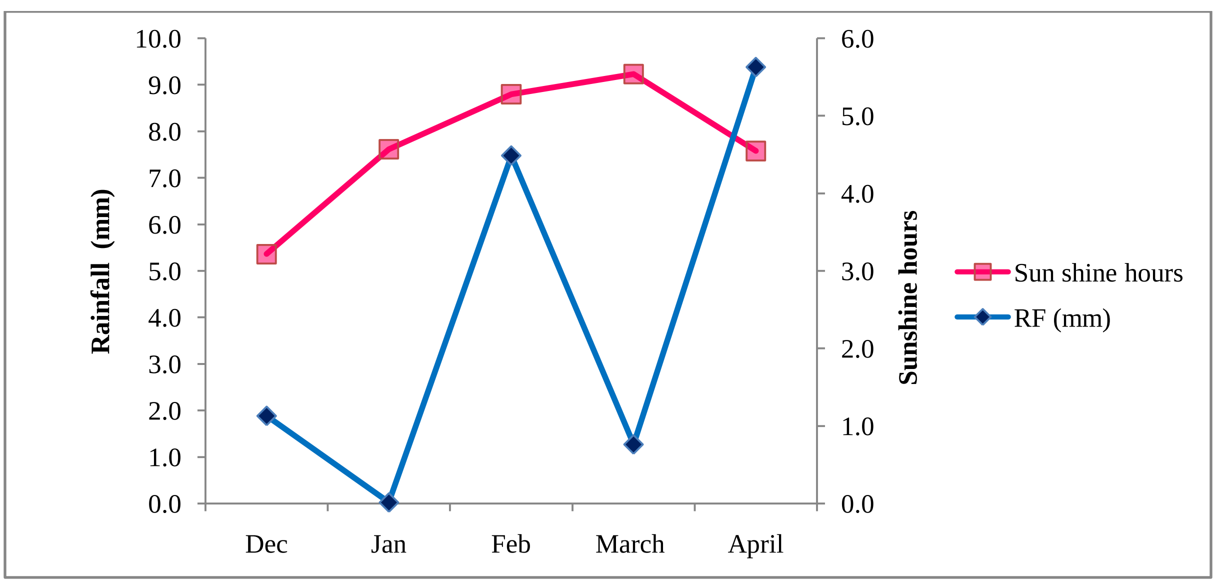
Fig. 3. Meteorological data for temperature, relative humidity, rainfall and sunshine hours during S_3 cropping period (November 2010-March 2011)



Temperature (°C)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Dec
Jan
Feb
March
April
Max temp (°C)
Min temp (°C)



Relative humidity (%)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Dec
Jan
Feb
March
April
RH (07.22 hrs) %
RH (14.22 hrs) %



Rainfall (mm)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Sunshine hours
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Dec
Jan
Feb
March
April
Sun shine hours
RF (mm)

Fig. 4. Meteorological data for temperature, relative humidity, rainfall and sunshine hours during S_4 cropping period (December 2010-April 2011)

REFERENCES

A.O.A.C. 1975. Official and tentative methods of analysis. **Association of Official Agricultural Chemists,** Washington, D.C., U.S.A.12th Ed.

Abdalla, A.A. 1969. Effects of planting date and spacing on yields of onion seed under hot arid conditions in the Sudan**. J. Exp. Agric., 5:**147-149.

Abdul-Baki, A.A. and J.D.Anderson.1973.Vigour deterioration of season seeds by multiple criteria. **Crop Sci., 13:**630-633.

Abu-Rayyam, A.M. and B.E.Abu-Irmaileh. 2004. Onion development and yield responses to manual cultivation, herbicide, or colored mulches. **J. Veg. Crop Prod., 10:**37-49.

Adagale, S.V., S.D. Masalakar and B.S. Pandure. 2010. Effect of integrated nutrient management on growth and yield of onion seed production. **Asian J. Hort., 4:** 482-487.

Ahmed, S.U. and S.K. Munshi. 1995. Effect of different dates and methods of planting on the growth, bulb yield and storage of onion. **Prog. Agric., 6:** 109-116.

Ali M.K., M.F. Alam, M.N. Alam, M.S. Islam and Khandaker. 2007. Effect of nitrogen and potassium level on yield on yield and quality of seed production of onion**. J. Appl. Sci. Res., 3:**1889-1899.

Al-Sahaf, F.H. 2002. Effect of planting method and rose water spray on seed production in onion (*Allium cepa* L.). **Emir. J. Agric. Sci., 14:**14-23.

Ambulkar, M.R., P.B. Kale, P.B. Gonge and V.S. Mahorkor. 1996. Effect of bulb size and spacing on the yield and quality of onion seed (*Allium cepa* L.). **Hort. Absts., 66(12):**10380.

Amiroddin, B. Patel and A.A. Patil. 1988. Effect of spacing and Nitrogen levels on seed quality on onion (*Allium cepa* L.). **Prog. Hort., 20(3-4):**197-199.

Ananthan, M. 2005. Evaluation of bellary onion (*Allium cepa* var. *cepa*) genotypes for yield, processing and export qualities. **Ph.D. Thesis,** Tamil Nadu Agricultural University,Coimbatore.

Anisuzzaman, M., M. Ashrafuzzaman, Razi Ismail., M.K. Uddin and M.A. Rahim. 2009. Planting time mulching effect on onion development and seed production. **Afr.J. Biot., 8:**412-416.

Arakeri, H.R. and S.S. Patil. 1956. Effect of bulb size, spacing and time of planting on the yield of onion seed. **Indian J. Agron., 1:**75-79.

Aramirtham, P. 2000. Studies on certain aspects of growth and development of seed setting aggregatum onion (*Allium cepa* var. *aggregatum*) culture AcSP- 1. **M.Sc.Thesis,** Tamil Nadu Agricultural University, Coimbatore.

Arora, P.S., S.N. Pandey and P.M. Basantani. 1966. Agronomic practices or raising yield of onion bulb. **Indian J. Hort., 23**(**3&4):**127.

Attar, S., B.N. Korla and A. Singh. 1991. Effect of transplanting dates and varieties on number of leaves and yield on onion (*Allium cepa* L.). **Veg. Sci., 18:**24-28.

Bednarz, F. and A. Kadams. 1991. Yield and quality of transplanted onion (*Allium cepa* L.) in Nigeria as influenced by variety, sowing date and other factors. **Hort. Absts., 6:**7880.

Begum, A., A. Ahad, M.O. Kaisar, M.M. Islam and M.K. Anam. 2003. Effect of sowing dates and fertilizer treatments on the reproductive variability of French bean. **Pakistan J. Bio. Sci., 6(22):**1897-1901.

Bhagchandani, P.M., Netra Pal and B. Choudhury. 1970. "Seed to seed" method of production in onion (*Allium cepa* L.). **Prog. Hort., 2:**15-23.

Bhalla, P.L., K. Singh and C.H. Patil. 1983. Significance of age of seedling and dates of transplanting on growth, yield and quality of onion (*Allium cepa* L.) cv. Pusa Red. **Seeds & Farms, 9:**21-25.

Bhargava, K.K. 1968. Effect of age of seedling, date of transplanting and pruning on growth and yield of onion (*Allium cepa* L.). **M.Sc. Thesis,** submitted to JNKVV, Jabalpur.

Bhatia, A.K. and U.C. Pandey. 1989. Response of planting methods, fertility levels and spacing on seed production of kharif onion. **Haryana Agric. Univ. J. Res., XIX (4):**352-357.

Bhatt, V.K., P.T. Patel and R.K. Bhatt. 2007. Effect of methods and dates of sowing on yield of green onion in kharif under north Gujarat conditions. **Indian J. Hort., 64:**475-476.

Bhonde, S.R., J.S. Bhadauria and S.S. Chougle. 1994. Effect of seed rate on yield and quality of direct sown small onions. **Newsl. Natl. Hort. Res. Dev.Foundation15:**3-4.

Bhonde, S.R., A.B. Chougule and N.B. Singh. 2001. Studies on the effect of age of seedling and date of harvesting on yield and quality of onion during late kharif season. **Newsl. Natl. Hort. Res. Dev. Foundation. 21:**27-30.

Bhonde, S.R., Srivaslava, K.J. and U.B. Pandey. 1992. Evaluation of varieties for growing "Rangda" crop of onion *(Allium cepa* L.) in Nasik area of Maharastra. **Maharastra J. Hort., 6(2):**39-42.

Boyhan, E., Reid L. Torrance, Jeff Cook, Cliff Riner and C. Randell Hill. 2009. Sowing date, transplanting date, and variety effect on transplanted short-day onion production. **Hort. Tech., 19:**66-71.

Boyhan, G.E., A.C. Puris, W.M. Randle, R.L. Torrance and C.R. Hill. 2005. Harvest and post harvest quality of short-day onions in variety trails in Georgia. **Hort. Tech., 15:**694-706.

Boyhan, G.E., J.C.D. Perez, Chris Hopkins, R.L. Torrance and C.R. Hill. 2008. Direct seedling short- day onion in southeastern Georgia. **Hort. Tech., 18:**349-355.

Branca, F., A. Ruggeri, and L. Qualiotti. 1994. Reproductive response of onion seed plant to photo- thermal condition. International symposium on agro techniques and storage of vegetable and ornamental seeds, Ban, Italy. **Acta Hort., 326:** 25-34.

Brar, K., S. Sidhu and M.L. Chadha. 1993. Screening onion varieties for resistance to *Thrips tabaci* and *Helicoverpa armigera*. **J. Insect Sci., 6:**123-124.

Brewster, J.L. 1982. Flowering and seed production in over-wintered cultivars of bulbs onions, 1. Effect of different raising environment-temperatures and day lengths. **J. Hort. Sci., 57:**93-101.

Brogo, R., O.M. Stahlschmidt and R.M. Tizio. 1993. Preliminary study on water requirement in onion (*Allium cepa* L.) cv. Valcatorce in relation to seed production. **Agric. Scientia, 10(3-9):**3-7.

Buchvarov, S. 1985. Onion varieties for early spring sowing. **Rasteniev"dni Nauki 22(1):**68-76.

Chandra Babu, R., M. Moosa Sheriff, V. Muralidharan and M. Seetha Rani. 1988. Alternate selection indices for leaf photosynthetic rate in green gram.(*Vigna radiata* L.wilczek) cultivars**. J. Agron. Crop Sci., 161:**353-356.

Cramer,C.S. 2003. Performance of fall-sown onion cultivars using four seedling dates. **J. Amer. Soc. Hort. Sci., 128:**472-478.

Deen, M.U. 2008. Effect of mother bulb size and planting time on growth, bulb and seed yield of onion. **Bangladesh J. Agril. Res., 33(3):**531-537.

Dhesi, N.S., K.S. Nandpuri and J.C. Kumar. 1970. Onion cultivation. **Punjab Agril. University, Ludhiana, Farm Bull., 6:**10.

Dhillon, T.S. and S.K. Arora. 1980. Raise onion seed-The right way. **The Punjab Veg. Grower., XV:**48-50.

El-Aweel, M.A.T., and A.A. Ghobashi. 1999. Seed production in onion as influenced by dates of planting in the sultanate of Oman. **Assiut J. Agr. Sci., 30(2):** 43-53.

Fernando, P.H.D.1983. Production of onion seed. **KRUSHI., 6:** 23-24.

Gautam, P., Bhogendra Khatri and P. Paudel. 2006. Evaluation of different varieties of onion and their transplanting times for off- season production in mid hills of Nepal. **Nepal Agric. Res. J., 7:**21-26.

Gaviola, J.C. 1997. Effect of production method on yield and quality of onion cv. Valcatorce INTA seeds. **Seed Absts., 23:**27.

Geetharani, M., I. Manivannan and A.S. Ponnuswamy. 2008. Seed production of onion as influenced by the application of growth regulators and nutrients. **Asian J. Hort., 3:**301-303.

Gill, S. and Hari Singh. 1989. Effect of bulb size and dates of planting on growth parameters and seeds yield of onion. **Seed Res., 17:**11-15.

Gill, S.S., H. Singh and J. Singh. 1981. Carrot seed production – II Spacing and umbel order on seed yield. **Veg. Sci., 8**(**1):**6-11.

Gopal Singh, B.V., Jagan Mohan Rao, C.A. Suguna and L. Madusudana Rao. 1985. Varietal differences in growth and yield of mungbean. (*Vigna radiata* L.Wilczek) during summer and kharif seasons. **Indian J. Plant Physiol., 38:** 207-214.

Gowda, M.C., B. Madineni and A.P. Gowda. 2007. Evaluation of garlic (*Allium sativum* L.) genotypes for growth, yield and quality. **Crop Res., 33(1, 2 & 3):** 141-143.

Gulshan Lal, D.K. Singh and Babu Ram. 1982. Note on the effect of spacing and time on planting on onion bulbs on seed production. **Prog. Hort., 14:**264-265.

Gupta, R.P., U.B. Pandey, L. Singh and P.H. Srivastava. 1979. Important onion disease and their control. **Seeds & Farms., 5:**17-19.

*Heath, O.V.S. and M. Holdsworth. 1943. Bulb formation and flower production in onion plants from sets. **Nature, 152:**334-335.

Habban, J. 1986. Onion varieties for winter cultivation. **Hort. Absts**.,**055-**05202.

Hochmuth, R.C., S.M. Olson and G.J. Hochmuth. 1990. Short day onion cultivars for North Florida. **Proceedings of the Florida State Horticultural Society. 103:** 96-98.

Holdsworth, M. and O.V.S. Heath. 1950. Studies in physiology of the onion plant, IV. The influence of day - length and temperature on the flowering of the onion plant. **Exp. Bot., 1:** 353-373.

Hussain, W.S., Ishtiaq and A.S. Hussain. 2001. Effect of different bulb size and planting dates on green leaf production of onion (*Allium cepa* L.). **J. Bio. Sci., 1:**345-347.

ISTA. 1993. International rules for seed testing. **Seed Sci. & Technol., 21:**25-30.

Jadhav, R.S., N.N. Shinde and M.B. Sontake. 1990. Performance of onion varieties in rabi season. **Prog. Hort., 22:**84-86.

Jain.com. 2002. Improved cultivation of white dehydrated onion. **Jain irrigation system Ltd.**, Jalgaon.

Jaiswal, J.P., S.P. Bhattarai and P.P. Subed. 1997. Finding of varietal trials on normal season onion and seed production. **Working paper Lumle Regional Agric. Res. Center,** No.97-49, 19 pp.7.

Jilani, M.S. 2004. Studies on the management strategies for bulb and seed production of different cultivars of onion (*Allium cepa* L.). **M.Sc. Thesis,** NWFP Agriculture University, Peshawar. NWFP - Pakistan.

Jogdande, N.D., V.S. Gonge, S.R. Dalal, S.S. Khandagale and A.D. Warde. 2004. Performance of onion varieties. **In: National seminar on opportunities and potentials of spices for crop diversification** held on 19-21, Goa, January, pp. 231-233.

Johns, H.A. and L.K. Mann. 1963. Onion and their allies. **Inter. Sci. Pub. Inc**. New York. pp. 104-105.

Joshi, R.P., R.D. Singh, A.K. Singh and K.P.S. Phogat. 1975. Effect of different sowings on bulb production of onion var. Pusa Red. **Punjab Hort. J., 15(1-2):** 57-58.

Joshi, R.P., R.D. Singh, A.K. Singh and K.P.S. Phogat. 1976. Effect of different dates of transplanting seedling and bulb storage and production of onion. (*Allium cepa* L.) var. Pusa Red. **Veg. Sci., 3:**1-8.

Kachan, N. and J. Osvald. 1992. The effect of sowing and planting dates on the yield and quality of onion. **Hort. Absts.,** 065- 00291.

Katwale, T.R. and R K. Sarat. 1991. Evaluation of onion varieties for rainy season in Satpura zone of Madhya Pradesh, **Orissa J. Hort., (1-2):**6-10.

Kher, A.K., Asha Devi and K.E. Lawande. 1999. Performance studies in released varieties of onion. Ann. Res. **NRC for Onion and Garlic.** Pp. 12-15.

Khokhar, K.M., Hadley and S. Pearson. 2007. Effect of cold temperature durations of onion sets in store on the incidence of bolting, bulbing and seed yield. **Sci. Hort., 112(1):**16-22.

*Heath, O.V.S. and M. Holdsworth. 1943. Bulb formation and flower production in onion plants from sets. **Nature., 155:** 623.

*Purvis, O.N. (1934) An analysis of the influence of temperature during germination on the sussequent development of certain winter cereals and its relation to the effect of length of day. **Ann.Bot., 48, 919.**

*Purvis, O.N. and F.G. Gregory. 1937. Studies in the vernalisation of cereals. I. A comprehensive study of vernalisation in winter rye by low temperature and by short days. **Ann. Bot., N.S.I, 569.**

*Singh, D.P., C.S. Pathak and A.A. Deshpande. 1982. Comparative performance of twenty onion varieties at different stages of growth. **Ibid,** 40 - 41.

*Vekampan, J. and Wiebosch. 1971. Shortening of breeding cycle of onion. Methods Procstal Groent Alkmaar 52:72, **Hort. Absts., 41:** 6767.

A.O.A.C. 1975. Official and tentative methods of analysis. **Association of Official Agricultural Chemists,** Washington, D.C., U.S.A.12th Ed.

Abdalla, A.A. 1969. Effects of planting date and spacing on yields of onion seed under hot arid conditions in the Sudan**. J Exp. Agric., 5:** 147 - 149.

Abdul - Baki, A.A. and J.D. Anderson. 1973. Vigour deterioration of season seeds by multiple criteria. **Crop Sci., 13:** 630 - 633.

Abu - Rayyam, A.M and B.E. Abu - Irmaileh. 2004. Onion development and yield responses to manual cultivation, herbicide, or colored mulches**. J. Veg. Crop Prod. 10:** 37 - 49.

Adagale, S.V., S.D. Masalakar and B.S. Pandure. 2010. Effect of integrated nutrient management on growth and yield of onion seed production**. Asian J. Hort., 4:** 482-487.

Agarwal and R.S. Tiwari. 2000. Correlation and path analysis studies on yield attributes factors in garlic. **National Symposium on Onion, Garlic Production and Post-harvest management, Challenges and Strategies.** 27 - 29.

Ahmed, S.U. and S.K. Munshi. 1995. Effect of different dates and methods of planting on the growth, bulb yield and storage of onion. **Prog. Agric., 6:** 109 - 116.

Al-Abdulsalam, M.A. and A.F. Hamaiel. 2004. Effect of planting dates and compound fertilizers on growth, yield and quality of Hassawi onion under Al-Hassaoasis conditions. **Scientific J. King Faisal Univ. (Basic and Appl. Sci.) 5:** 65 - 79.

Ali M.K., M.F. Alam, M.N. Alam, M.S. Islam. and Khandaker. 2007. Effect of nitrogen and potassium level on yield on yield and quality of seed production of onion**. J. Appl. Sci. Res., 3:** 1889-99.

Al-Sahaf, F.H. 2002. Effect of planting method and rose water spray on seed production in onion (*Allium cepa* L.). **Emir. J. Agric. Sci. 14:** 14-23.

Ambulkar, M.R., P.B. Kale, P.B. Gonge and V.S. Mahorkor. 1996. Effect of bulb size and spacing on the yield and quality of onion seed (*Allium cepa* L.) **Hort. Absts., 66 (12):**10380.

Amin , M.M.U. and M.A. Rahim. 1995. Effect of plant density, planting time and nitrogen on the growth and yield of onion. **Prog. Agric., 6 :** 69-75.

Amiroddin, B. Patel and A.A. Patil. 1988. Effect of spacing and Nitrogen levels on seed quality on onion (*Allium cepa* L.). **Prog. Hort., 20 (3-4):** 197- 199.

Ananthan, M. 2005. Evaluation of bellary onion (*Allium cepa* var. *cepa*) genotypes for yield, processing and export qualities. **Ph.D. Thesis,** Tamil Nadu Agricultural University, Coimbatore.

Anisuzzaman, M., M. Ashrafuzzaman, Razi Ismail., M.K. Uddin and M.A. Rahim. 2009. Planting time mulching effect on onion development and seed production. **Afr.J. Biot., 8:** 412-416.

Arakeri, H.R. and S.S. Patil. 1956. Effect of bulb size, spacing and time of planting on the yield of onion seed. **Indian J. Agron., 1:**75-79.

Aramirtham, P. 2000. Studies on certain aspects of growth and development of seed setting aggregatum onion (*Allium cepa* var. *aggregatum*) culture AcSP- 1. **M.Sc.Thesis,** Tamil Nadu Agricultural University, Coimbatore.

Arora, P.S., S.N. Pandey and P.M. Basantani. 1966. Agronomic practices or raising yield of onion bulb. **Indian J. Hort., 23** (**3&4):** 127.

Attar, S., B.N. Korla and A. Singh. 1991. Effect of transplanting dates and varieties on number of leaves and yield on onion (*Allium cepa* L.). **Veg. Sci., 18:** 24 - 28.

Badaruddin, M. and A. Haque. 1977. Effect of time of planting and spacing on the yield of onion (*Allium cepa* L.) **Bangladesh Hort., 5:** 23-29.

Bednarz, F. and A. Kadams. 1991. Yield and quality of transplanted onion (*Allium cepa* L.) in Nigeria as influenced by variety, sowing date and other factors. **Hort. Absts., 6:** 7880.

Begum, A., A. Ahad, M.O. Kaisar, M.M. Islam and M.K. Anam. 2003. Effect of sowing dates and fertilizer treatments on the reproductive variability of French bean. **Pakistan J. Bio. Sci., 6(22):** 1897-1901.

Bhagchandani, P.M., Netra Pal and B. Choudhury. 1970. "Seed to seed" method of production in onion (*Allium cepa* L.). **Prog. Hort., 2:** 15 - 23

Bhalla, P.L., K. Singh and C.H. Patil. 1983. Significance of age of seedling and dates of transplanting on growth, yield and quality of onion (*Allium cepa* L.) cv. Pusa Red. **Seeds & Farms, 9:** 21-25.

Bhargava, K.K. 1968. Effect of age of seedling, date of transplanting and pruning on growth and yield of onion (*Allium cepa* L.). **M.Sc., thesis submitted to JNKVV, Jabalpur.**

Bhatal, G.S. and J.C. Thakur. 1986. Yield of different cultivars of garlic as affected by planting dates. **Punjab Veg. Grower., 21:** 29 - 31.

Bhatia, A.K. and U.C. Pandey. 1989. Response of planting methods, fertility levels and spacing on seed production of kharif onion. **Haryana Agric. Univ.J. Res., XIX (4):** 352 - 357.

Bhatt, V.K., P.T. Patel and R.K. Bhatt. 2007. Effect of methods and dates of sowing on yield of green onion in kharif under north Gujarat conditions. **Indian J. Hort., 64:** 475 - 476.

Bhonde, S.R., J.S. Bhadauria and S.S. Chougle. 1994. Effect of seed rate on yield and quality of direct sown small onions**. Newsletters -National Horticultural Research and development foundation., 15:** 3 - 4.

Bhonde, S.R., A.B. Chougule and N.B. Singh. 2001. Studies on the effect of age of seedling and date of harvesting on yield an quality of onion during late kharif season. **Nwsl. Natl. Hort. Res. Dev. Foundation. 21:** 27 - 30.

Bhonde, S.R., Srivaslava, K.J. and Pandey, U.B. 1992. Evaluation of varieties for growing "Rangda" crop of onion *(Allium cepa* L.) in Nasik area of Maharastra. **Maharastra J. Hort, 6(2):** 39-42

Boyhan, E., Reid L. Torrance, Jeff Cook, Cliff Riner and C. Randell Hill. 2009. Sowing date, transplanting date, and variety effect on transplanted short-day onion production. **Hort. Tech., 19:** 66-71.

Boyhan, G.E., A.C. Puris, W.M. Randle, R.L. Torrance and C.R. Hill. 2005. Harvest and post harvest quality of short-day onions in variety trails in Georgia. **Hort. Tech., 15:** 694 - 706.

Boyhan, G.E., J.C.D. Perez, Chris Hopkins, R.L. Torrance and C.R. Hill. 2008. Direct seedling short- day onion in southeastern Georgia. **Hort. Tech., 18:** 349 - 355.

Branca, F., A. Ruggeri, and L. Qualiotti. 1994. Reproductive response of onion seed plant to photo- thermal condition. International symposium on agro - techniques and storage of vegetable and ornamental seeds, Ban, Italy. **Acta Hort., 326:** 25 - 34.

Brar, K., S. Sidhu and M.L. Chadha. 1993. Screening onion varieties for resistance to *Thrips tabaci* and *Helicoverpa armigera*. **Journal of Insect Sci., 6**: 123 - 124.

Brewster, J.L. 1982. Flowering and seed production in over- wintered cultivars of bulbs onions, 1. Effect of different raising environment- temperatures and day lengths. **J. Hort. Sci., 57:** 93 - 101.

Brogo, R., O.M. Stahlschmidt and R.M. Tizio. 1993. Preliminary study on water requirement in onion (*Allium cepa* L.) cv. Valcatorce in relation to seed production. **Agric Scientia 10(3-9):** 3 - 7.

Buchvarov, S. 1985. Onion varieties for early spring sowing. **Resteniev dni- Nauki. 22:** 68-76. **Hort. Absts., 1987**. 057-00309.

Chandra Babu, R., M. Moosa Sheriff, V. Muralidharan and M. Seetha Rani. 1988. Alternate selection indices for leaf photosynthetic rate in green gram. (*Vigna radiata* L.wilczek) cultivars**. J. Agron. Crop Sci., 161:** 353-356.

Cramer, C.S. 2003. Performance of fall- sown onion cultivars using four seedling dates. **J. Amer. Soc. Hort. Sci., 128 :** 472 - 478.

Das, A.K., M.K. Sadhu, M.G. Som and T.K. Bose. 1985. Effect of time of planting on growth and yield of multiple clove garlic (*Allium sativum* L.) **Indian. J Agr. Sci., 29:** 177- 181.

Deen, M.U. 2008. Effect of mother bulb size and planting time on growth, bulb and seed yield of onion. **Bangladesh J. Agril. Res. 33 (3):** 531 - 537.

Dhesi, N.S., K.S. Nandpuri and J.C. Kumar. 1970. Onion cultivation. **Punjab Agril. University., Ludhiana, Farm Bull, 6:**10.

Dhillon, T.S. and S.K. Arora. 1980. Raise onion seed - The right way. **The Punjab Veg. Grower., XV:** 48 - 50.

El-Aweel , M.A.T., and A.A. Ghobashi. 1999. Seed production in onion as influenced by dates of planting in the sultanate of Oman. **Seed Abstracts. 23 (5):** 232.

El-Rehim, G.H.A., F.A. Ahmed, G.I Shalaby, and A.A Waly. 1997. Effect of transplanting dates and planting density on bulb yield and quality of Giza 20 onion in Upper Egypt. **Egyptian J. Agr. Res., 75:** 681-695.

Fernando, P.H.D.1983. Production of onion seed. **KRUSHI., 6 :** 23-4.

Gautam, P., Bhogendra Khatri and P. Paudel. 2006. Evaluation of different varieties of onion and their transplanting times for off- season production in mid hills of Nepal. **Nepal Agric. Res. J., 7 :** 21 - 26.

Gaviola, J.C. 1997. Effect of production method on yield and quality of onion cv. Valcatorce INTA seeds. **Seed Absts., 23 :** 27.

Geetharani, M., I. Manivannan and A.S. Ponnuswamy. 2008. Seed production of onion as influenced by the application of growth regulators and nutrients. **Asian J. Hort., 3:** 301-303.

Gill, S. and Hari Singh. 1989. Effect of bulb size and dates of planting on growth parameters and seeds yield of onion. **Seed Res., 17:** 11-15.

Gill, S.S., H. Singh and J. Singh. 1981. Carrot seed production – II Spacing and umbel order on seed yield. **Veg. Sci., 8** (**1**)**:** 6-11.

Globerson Ahura Sharir, D. and R. Elies. 1981. The nature of flowering and seed maturation of onions as a basis for mechanical harvesting of the seed. **Acta. Hort., 111:** 99-108.

Gopal Singh, B.V., Jagan Mohan Rao, C.A. Suguna and L. Madusudana Rao. 1985. Varietal differences in growth and yield of mungbean. (*Vigna radiata* L.Wilczek) during summer and kharif seasons. **Indian J. Plant Physiol., 38:** 207 - 214.

Gowda, M.C., B. Madineni and A.P. Gowda. 2007. Evaluation of garlic (*Allium sativum* L.) genotypes for growth, yield and quality. **Crop Res. 33(1, 2 & 3):** 141 - 143.

Grevsen, K. 1989. Effect of sowing dates on different varieties of Walsh onion (*Allium fistulosum* L.) under temperate coastal climate. **Acta Hort., 242:** 319 - 324.

Gulshan Lal, D.K. Singh and Babu Ram. 1982. Note on the effect of spacing and time on planting on onion bulbs on seed production. **Prog. Hort., 14:** 264 - 265.

Gupta, R.P., U.B. Pandey, L. Singh and P.H. Srivastava. 1979. Important onion disease and their control. **Seeds & Farms., 5:** 17-19.

Habban, J. 1986. Onion varieties for winter cultivation. **Hort. Absts**.**055-** 05202.

Hassan, W.S. and F.M. Malik. 2001. Efficacy of cultural and chemical weed control in transplanted onion. **J.Bio. Sci., 1(9):** 825 - 827.

Hochmuth, R.C., S.M. Olson and G.J. Hochmuth. 1990. Short day onion cultivars for North Florida. **Proceedings of the Florida State Horticultural Society. 103:** 96 - 98.

Holdsworth, M. and O.V.S. Heath. 1950. Studies in physiology of the onion plant, IV. The influence of day - length and temperature on the flowering of the onion plant. **Exp. Bot., 1 :** 353-373.

Hussain, W.S., Ishtiaq and A.S. Hussain. 2001. Effect of different bulb size and planting dates on green leaf production of onion (*Allium cepa* L.). **J. Bio. Sci., 1:**345-347.

ISTA. 1993. International rules for seed testing. **Seed Sci. & Technol., 21:**25-30.

Jadhav, R.S., N.N. Shinde, and M.B. Sontake. 1990. Performance of onion varieties in rabi season. **Prog. Hort., 22 :** 84-86.

Jain.com. 2002. Improved cultivation of white dehydrated onion. **Jain irrigation system Ltd.**, Jalgaon.

Jaiswal, J.P., S.P. Bhattarai and P.P. Subed. 1997. Finding of varietal trials on normal season onion and seed production. **Working paper Lumle Regional Agric. Res. Center**.No.97-49, 19 pp.7.

Jilani, M.S. 2004. Studies on the management strategies for bulb and seed production of different cultivars of onion (*Allium cepa* L.). **M.Sc. Thesis,** NWFP Agriculture University, Peshawar. NWFP – Pakistan.

Jogdande, N.D., V.S. Gonge, S.R. Dalal, S.S. Khandagale and A.D. Warde. 2004. Performance of onion varieties. **In: National seminar on opportunities and potentials of spices for crop diversification** held on 19-21, Goa, January, pp: 231-233.

Johns, H.A. and L.K. Mann. 1963. Onion and their allies. **Inter. Sci. Pub. Inc**. New York. pp. 104-105.

Joshi, R. P. 1975. Effect of different sowing dates on bulbs production of onion var. Pusa Red. **The Punjab Hort. J., 15:** 57-58.

Joshi, R.P., R.D. Singh, A.K. Singh and K P.S. Phogat. 1975. Effect of different sowings on bulb production of onion var. Pusa Red. **Punjab Hort. J., 15(1-2):** 57 - 58.

Joshi, R.P., R.D. Singh, A.K. Singh and K.P.S. Phogat. 1976. Effect of different dates of transplanting seedling and bulb storage and production of onion. (*Allium cepa* L.) var. Pusa Red. **Veg Sci., 3:** 1 - 8.

Kachan, N. and J. Osvald. 1992. The effect of sowing and planting dates on the yield and quality of onion. **Hort. Absts**. 065 - 00291.

Katwale , T.R. and R K. Sarat. 1991. Evaluation of onion varieties for rainy season in Satpura zone of Madhya Pradesh, **Orissa J. Hort ., (1-2):** 6 - 10.

Kher, A.K., Asha Devi and K.E. Lawande. 1999. Performance studies in released varieties of onion. Ann. Res. **NRC for Onion and Garlic**. Pp. 12 - 15.

Khokhar, Hadley and S. Pearson. 2007. Effect of cold temperature durations of onion sets in store on the incidence of bolting, bulbing and seed yield. **Sci. Hort., Volume 112 (1) :** 16 - 22.

Khokhar, K.M., N. Kaska, S.I. Hussain, K.M. Qureshi and T. Mahmood. 1990. Effect of different sowing dates, direct seeding transplanting of seedling maturation, bulb weight and yield in onion (*Allium cepa* L.) cultivars. **Indian J. Agri. Sci. 60(10):** 668-671.

Kimani, P.M., J.W. Karinki, R. Peters, H.D. Rabinowitch and D.J. Midomore. 1993. Potential of onion seed production in a tropical environment. International symposium on alliums for the tropics. **Acta. Hort., 358:** 341 - 348.

Kimani, P.M., J.W. Karinki, R.Peters and H.D. Rabinowitch. 1993. Influence of the environment on the performance of some onion in Kenya. **African Crops Sci. J., 1 (1):**15 -23.

Kisekva, V.I. 1963. The influence of the age of planting material on branching in onions. **Hort. Absts. 34(4):** 712.

Krishnaveni, K., K.S. Subramanian, M. Bhaskaran and K.N. Chinnasamy. 1990. Effect of time of planting bulbs on the yield and quality of Bellary onion seeds. **South Indian Hortculture., 38(5):** 258 - 261.

Kumar, H., J.V. Singh, Ajaykumar and Mahak Singh. 1998. Influence of time transplanting on growth and yield of onion (*Allium cepa* L.) cv. Patna Red. **Indian J. Agric. Res., 32(1):** 6 - 10.

Kuruppuarachchi, D.S.P. 1987. Bombay onion seed production experience at kalpitiya. **KRUSHI, 9 (3-4):**37 -3 9.

Kuruppuarachchi, D.S.P. 1992. True seed production of large onion at kalpitiya in the north western dry zone of Sri Lanka. **Onion news letter for the tropics, No 4:** 36 – 38.

Kuruppuarachchi, D.S.P.1992. True seed production of large onion at Kalpaitiya in the north western dry zone of Sri Lanka. **Onion Newsletters for the Tropics., 4:** 36-38.

Lallan, S., S.P. Singh, P.K. Mishra and L. Singh. 1991. Evaluation of onion varieties at karnal. Newsletter Associated Agricultural Development Foundation. **Hort Absts., 11 (3) :** 3 - 4.

Lopes, J.F. 1987. Effects of dates and spacing on several characteristics of short day onion varieties grown in south Texas. **Dissertation Abstracts International (Science and engineering) 48 (6) :**1564.

Maurya, K.R. 1989. Effect of transplanting on yield of garlic. **Prog. Hort., 19 (2):** 132-134.

Mc Naughton, K.G., P.W. Gandar and H.G. Mc Pherson. 1985. Estimating the effects of varying temperature on the rate of development of plants. **Ann. Bot., 56:**579 - 595.

Miccolis, V. and S. Vitucea. 1984. The effect of time of planting and the bulb size on the yield of salad onion from three onion cultivars. **Informatore Agraio. 43 (18):** 93-99.

Mingochi, D.S. and E.K.M. Pande. 1992. Evaluation of some short- day onion cultivars in Taiwan. **Onion Newsletter for the Tropics., 4:** 45-48.

Mishra, H.N., S. Sahoo, A K. Mohanpatra and Arya K.B. Mahapatra. 1997. Effect of different dates of planting on growth and yield of garlic (*Allium sativum* L.) under high altitude condition of southern Orissa. **The Orissa J. Hort., 25:** 53 - 54.

Mishra, H.P 1994. Effect of Nitrogen and Potassium on onion seeds production in calcareous soil. **Hort. Absts. 65(9):** 8898.

Mishra, H.P. 1986. Effect of bulb size on the seed yield of onion. **Ind. J. Hort., 43 (1/2):** 140 - 143.

Mishra, H.P. and B. Mishra. 1991. Effects of planting dates and bulb size on the yield components of onion seed crops. **Ind. J. agric. Res., 25 (2):** 107-112.

Mohanty, B.K. 2002. Variability, Heritability, Interrelationship and Path analysis in onion**.** **Haryana J. Hort. Sci., 31(1&2):** 84-87.

Mohanty, B.K. 2004. Genetic variability and Path analysis in onion. **Indian J. Agric. Res., 38(1) :** 65 - 68

Mohanty, B.K., M.M. Hossin and A.M. Pursti. 2000. Varietal assessment of common onion for horticultural traits during kharif season. **The Orissa J. Hort. Vol. 28(2):** 8 - 10.

Mondal, M.F. 1980. Effect of time of planting of onion bulbs on the yield and quality of seeds. **Bangladesh J.Agric., 5(3):**131 - 134.

Mondal, M.F., L. Brewster and H.A. Butter. 1986. Effect of plant density and sowing date in field condition. **Ann. Bot. 58:** 187 - 195.

Movalia, A.G., B.B. Kaneria, V.D. Khanpara, K.V. Jadav and R.K. Mathukia. 1999. Response of direct seeded a transplanted onion *(Allium cepa* L.) transplanted dates of swing and nitrogen levels. **Gujarat Agr. Univ. Res. J.25:** 90 - 93.

Mulkey, W.A. and T.P. Talbot. 1991. Sweet bulbing onion varieties and planting dates for northern. **Louisiana Agr. 35:** 3 - 5.

Naeem, M., M. Masrooor, A. Khan and J.B. Morris. 2009. Agrobotanical attributes nitrogen-fixation, enzyme activities and nutraceuticals of Hyacinth bean. A bio functional medicinal legume. **Amer. J. Plant Physiol., 4(2):** 58 - 69.

Naik, L.B., and K. Srinivas. 1992. Seed production in vegetable crops II. A review. **Agric. Rev., 13(2):** 59 - 80.

Nammi, F., H.D. Rabinowitch and N. Kedar. 1980. The effect of GA_3 application on flowering and seed production in onion. **J. Amer. Soc. Hort. Sci., 105:**164 - 167.

Nehra, B.K., Y.S. Malik, and A.C. Yadav. 1989. Seed production in onion as influenced by time of bulb planting and cut treatments. **Haryana Agric. Univ.J. Res., XIX (3):**225 -229.

NHB. 2010. Selected state wise are and production of onion in India. **National Horticultural Board,** New Delhi.

NHB. 2010. State wise estimates of area and production for onion India. **National Horticultural Board,** New Delhi.

NHRDF. 2005. Onion seed technology. **National Horticultural Research and Development Foundation.** Nasik, Maharashtra.

Orlowski, M. and E. Rekowska. 1992. Effect of sowing date of date onion seeds on the yield of important cultivars grown in western. **Hort. Absts**., 064-07824.

Padda, D.S. and J. Singh. 1981. Seed production of vegetable crops. Second edition. **Pani printing press, Ludhiana:** 22-25.

Padmavathy. 1995. Evaluation of half - sib and irradiated progenies of seed setting aggregatum onion types (*Allium cepa* L. var. *aggregatum* Don.). **M.Sc. Thesis, Tamil Nadu Agricultural University,** Coimbatore.

Pakyurek, Y., K. Abak, N. Sari, H.Y. Guler, I. Babik and J. Rumpel. 1994. Effect of sowing dates and plant densities on the yield and quality of some varieties in South East Anatolia. **Acta- Horticulture**. **7th Inter. Symp**. On timing field production of vegetables, Skierniewice, Pland.

Palaniswamy, K.P. 1980. Studies on growth development and storage of CO 2 onion (*Allium cepa* L. var. *aggregatum*, Don.) **Ph.D. Thesis**, Tamil Nadu Agricultural University, Coimbatore.

Panda, S.C., and B.K. Mohanty. 2002. Response of onion to time of planting. **The Orissa J. Hort., Vol. 30:** 78 - 79.

Pandey, U.B., D.S. Panwar and V.P. Sharma. 1994. Effect of spacing and levels of nitrogen on growth and seed yield of kharif onion. **Seed Res., 20:** 147 - 148.

Panse, K.V. and P.V. Sukhatme. 1985. **Statistical Methods for Agricultural Workers.** ICAR, New Delhi.

Ponnuswami, V. and S.Thumburaj. 1996. Shallots seed production, TVIS, Volume 1, No.1, January- June, **AVRDC**. 18 p.

R.S. Patil, V. Sood , V. K. Garande, S. D. Masalkar and S. B. Desale. 2003. Study of premature bolting in rangda (Late kharif) onion (*Allium cepa* L.) **The Orissa J. Hort., 31:** 62 - 64.

Ragupathi, R. 1984. Onion seed production feasible in kalpitiya. **KRUSHI.6 (4):**38 - 43.

Rajasree, V., K.P. Palanisamy and S. Thamburaj. 1994. Evaluation of genotypes of *Allium cepa* var. *aggregatum* propagated through seeds. **South Indian Horticulture, 42:** 89-92.

Ramtohul, M. and A.L. Owadally. 1980. Effect of monthly time of sowing on the yield of bulb of five onion cvs. (*Allium cepa* L.) **Revue Agricole Sucriere et Delille Maunca, 58:** 171- 179.

Rashid, M.A. and M.M. Rashid. 1978. The effect of spacing on the yield of onion. **Hort. Absts., 48 (6):** 481.

Reddy, K.C. and K.M. Reddy. 2005. Differential levels of vermicompost and nitrogen on growth and yield in onion (*Allium cepa* L.) – radish (*Raphanus sativus* L.) cropping system. **J. Res., ANGRAU, 33**: 11-17.

REFERENCES

Robinowicth, H.D. 1990. Physiology of flowering. In : Rabinowicth, H. D. and Brewster, J. L. (eds). **Onions and allied crops, Vol. 1**. CRC Prees, Boca Raton, Florida, pp. 113- 134.

Rumi Borah. 1994. Diallel analysis in aggregatum onion (*Allium cepa* L. var. *aggregatum* Don.). **M.Sc. Thesis, Tamil Nadu Agricultural University**, Coimbatore.

Scwlly, N., M.N. Perker and H.A. Bonlhwick. 1945. Interaction of nitrogen nutrition and photoperiod as expressed in bulbing flower stalk development of onion. **Bot. Gas., 107:** 52

Shaikh, A.M., B.S. Vyakaranahal, M. Shekhargouda, P.R. Dharmatti. 2002. Influence of bulb size and growth regulators on growth, seed yield and quality of onion cv. Nasik Red. **Seed Res. 30:** 223- 229.

Sharma, M.L., G.S. Bharadwaj, Y.S. Chauhan, S.D. Sharma and M. S. Sharma. 1989. Response of green gram to sowing dates under rainfed conditions**. Indian J. Agron., 34(2):** 252 - 254.

Sharma, S., S.S. Bal and K.L. Bajaj. 1996. Chemical composition of some important varieties of onion (*Allium cepa* L.). **Veg. Sci., 23(1):** 48 - 51.

Shrivastava, R.K., B.K. Verma., S.K. Dwivedi and Y.C. Dwivedi. 1996. Response of onion (*Allium cepa* L.) varieties to plant spacing in relation to yield attributes and bulb productivity. **Veg. Sci., 23(1):** 26 - 29.

Sidhu, A.S., J.S. Kanwar and M.L. Chada. 1996. Seed production potential of different genotypes of onion. **Onion newsletters for the tropics, 7:** 38 - 41.

Sinclair, P. 1983. Onion varieties for late sowing. **Farmer's newsletter. 158:** 16 - 19. **Hort. Absts**. 054-02311.

Singh, Attar and B.N. Korla. 1991. Effect of transplanting dates and varieties on number of leaves and yield in onion. (*Allium cepa L.*) **Veg.Sci., 18(1):** 24-28.

Singh, D.P. and R.P. Singh. 1976. Studies on the effect of time of sowing and age of seedling on growth and yield onion (*Allium cepa* L.). **Ind. J. Hort., 31:** 69 - 73

Singh, H. and S.S. Gill. 1980. An approach to insitu seed production in onion. **Seed Res 8(1):**38 - 41.

Singh, J. and N.K. Chaure. 1999. Effect of age of seedling and nitrogen levels on growth and yield of onion (*Allium cepa* L.). **Adv. Hortic., 6:** 73-77.

Singh, J.P. and R.K. Singh. 1984. Effect of spacing and planting time on seed production in onion. **South Indian Horticulture., 32:**284 - 287.

Singh, J.P., M.K Singh and R.D. Singh. 1993. Growth and yield of onion (*Allium cepa* L.) bulbs as influenced by date of transplanting, nitrogen and potash fertilization. **Veg. Sci., 20(1) :**14 - 17.

Singh, R.V and K.P.S. Phogat. 1989. Effect of different sowing time on growth and bulb yield of garlic. **Prog. Hort**. **21(2):**145 - 147.

Soni, D.S., R.K. Saraf and S.K. Lodh. 1993. Performance of eight onion varieties in Madhya Pradesh - A note. **Haryana J. Hort. Sci., 22(3):**240 -241.

Spencer, D. and D. Boulter. 1984. The Physiological Role of Storage Proteins in Seeds. **Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences.**Vol.304:275 - 285.

Sumanaratne, J.P. 2000. True seed production, Red onion. Chapter 3, Other Field crops, Department of Agriculture at the turn of the country, **DOA**, Peradeniya.20 p.

Sumanaratne, J.P., W.M.U. Palipane. 2002. Feasibility of small onion (*Allium cepa* L. *Aggregatum*) cultivation from true seeds. **Annals of the Sri Lanka Department of Agriculture., (4):**39 - 46.

Tanner, C.B. and S.M. Goltz. 1972. Excessive high temperature of seed onion seed umbels. **J. Amer. Soc. Hort. Sci., 97:**5 - 9.

Thompson, H.C. and W.C. Kelly. 1978. **Vegetable crops (5th ed).** Tata Mc Grew Hill publishing co. Ltd. New Delhi.

TNAU. 2004. **Crop Production Techniques of Horticultural Crops**, Tamil Nadu Agricultural University, Coimbatore and Directorate of Horticulture and Plantation Crops, Chennai. pp. 289.

Toman, S.I., L.V. Pavlov, N.O. Gorcha Kovaand and V.I. Rudenok. 1989. Optimum size of onion mother bulbs. Kartofel- i- Ovoshchi. 6: 20-21.

Tomar S.P.S., T.P. Singh and G.S. Tomar. 1989. Effect of planting date and hormone on onion (*Allium cepa* L.) yield. **Indian J. Agri. Sci. 58(2):** 136-138.

Tomar, B.S. and Negi, H.C.S. 2002. Effect of planting time on seed yield, quality characters and disease incidence in onion (*Allium cepa* L.). In; **Processing of XI National seed seminar on quality enhances agricultural profitability held at UAS Dharwad January 18-20, 2002**

Tomar, B.S., 2005. **Quality seed production of onion**. Seed production unit, New Delhi-110012.

Tomar, B.S., Singh, Balraj, M. Hassan. 2004. Effect of irrigation methods on seed yield and seed quality in onion. cv. Pusa Madhavi. **Seed Res., 32 (1).**

Vaddoria, M.A., I.J. Golani, D.R. Mehta, K.L. Dobariya and R.H. Gohil. 2004. Phenotypic stability in onion. **The Orissa J. Hort., 32 (1):** 26 - 29.

Vadivel, B. 1979. Heterosis and combining ability studies in onion. (*Allium cepa* L. var. *aggregatum Don*). **M.Sc. Thesis**, Tamil Nadu Agricultural University, Coimbatore.

Vadivel, B., C.R. Muthukrishnan and I. Irulappan. 1976. Association of characters between yield and yield components in aggregatum onion (*Allium cepa* L. var. *aggregatum* Don.). **South Indian Horticulture 28 :** 227 - 229.

Vasetskii, V.F. and N.G. Reznik. 1995. Onions for mechanized harvesting and drying. **Hort. Absts., 065- 01174.**

Venkampan, J. 1970. Shortening the breeding cycle in onion. Mothods Procfetal. Groent Alkmeer. **Hort Abstr., 41 :** 52-72.

Verma, J.P., S.V.S. Rathore and B.S. Yadav. 1971. Performance of bulb crop of onion as affected by sowing dates and age of transplant. **Prog. Hort., 3:** 29 - 33.

Verma, T.S., Amar Singh and K.D. Lakhanpal. 1995. Comparative study of seed to seed and bulb to seed production methods in onion cv. Brown Spanish **Veg. Sci., 1 :** 30 - 32.

Verma, T.S., Ramesh Chand, P.C. Thakur, K.D. Lalkhanpal, Amer Singh. 1994. Effect of bulb size and plant spacing on seed yield of onion. **Hort. Absts., 66(12)** : 10379.

Wagh, R.S. 1986. Effect of different growth substances on seed yield and seed quality of onion (*Allium cepa* L.) **M.Sc. (Ag.) Thesis**. Mahatma Phule Kristi Vidypeeth, Raguri (M.S.)

Yoshida, S.D., A. Foron and J.H. Cock. 1971. **Laboratory Manual for Physiological Studies of Rice.** IRRI, Philippines. 36 - 37.

Khokhar, K.M., N. Kaska, S.I. Hussain, K.M. Qureshi and T. Mahmood. 1990. Effect of different sowing dates, direct seeding transplanting of seedling maturation, bulb weight and yield in onion (*Allium cepa* L.) cultivars. **Indian J. Agri. Sci., 60(10):**668-671.

Kimani, P.M., J.W. Karinki, R. Peters, H.D. Rabinowitch and D.J. Midomore. 1993. Potential of onion seed production in a tropical environment. International symposium on alliums for the tropics. **Acta. Hort., 358:**341-348.

Kimani, P.M., J.W. Karinki, R. Peters and H.D. Rabinowitch. 1993. Influence of the environment on the performance of some onion in Kenya. **African Crops Sci. J., 1(1):**15-23.

Kisekva, V.I. 1963. The influence of the age of planting material on branching in onions. **Hort. Absts., 34(4):**712.

Krishnaveni, K., K.S. Subramanian, M. Bhaskaran and K.N. Chinnasamy. 1990. Effect of time of planting bulbs on the yield and quality of Bellary onion seeds. **South Indian Horticulture, 38(5):**258-261.

Kumar, H., J.V. Singh, Ajaykumar and Mahak Singh. 1998. Influence of time transplanting on growth and yield of onion (*Allium cepa* L.) cv. Patna Red. **Indian J. Agric. Res., 32(1):**6-10.

Kuruppuarachchi, D.S.P. 1987. Bombay onion seed production experience at Kalpitiya. **KRUSHI, 9(3-4):**37-39.

Kuruppuarachchi, D.S.P.1992. True seed production of large onion at Kalpaitiya in the north western dry zone of Sri Lanka. **Onion Newsletters for the Tropics, 4:**36-38.

Lallan, S., S.P. Singh, P.K. Mishra and L. Singh. 1991. Evaluation of onion varieties at karnal. Newsletter Associated Agricultural Development Foundation. **Hort Absts., 11(3):**3-4.

Lopes, J.F. 1987. Effects of dates and spacing on several characteristics of short day onion varieties grown in south Texas. **Dissertation Abstracts International (Science and engineering), 48(6):**1564.

Maurya, K.R. 1989. Effect of transplanting on yield of garlic. **Prog. Hort., 19(2):** 132-134.

Mc Naughton, K.G., P.W. Gandar and H.G. Mc Pherson. 1985. Estimating the effects of varying temperature on the rate of development of plants. **Ann. Bot., 56:**579-595.

Miccolis, V. and S. Vitucea. 1984. The effect of time of planting and the bulb size on the yield of salad onion from three onion cultivars. **Informatore Agraio., 43 (18):**93-99.

Mingochi, D.S. and E.K.M. Pande. 1992. Evaluation of some short- day onion cultivars in Taiwan. **Onion Newsletter for the Tropics, 4:**45-48.

Mishra, H.P. 1986. Effect of bulb size on the seed yield of onion. **Ind. J. Hort., 43 (1/2):** 140 - 143.

Mishra, H.P 1994. Effect of Nitrogen and Potassium on onion seeds production in calcareous soil. **Hort. Absts., 65(9):**8898.

Mishra, H.P. and B. Mishra. 1991. Effects of planting dates and bulb size on the yield components of onion seed crops. **Indian. J. Agric. Res., 25 (2):**107-112.

Mohanty, B.K. 2002. Variability, Heritability, Interrelationship and Path analysis in onion**. Haryana J. Hort. Sci., 31(1&2):**84-87.

Mohanty, B.K., M.M. Hossin and A.M. Pursti. 2000. Varietal assessment of common onion for horticultural traits during kharif season. **The Orissa J. Hort., 28(2):** 8-10.

Mohanty, B.K. 2004. Genetic variability and Path analysis in onion. **Indian J. Agric. Res., 38(1):**65-68.

Mondal, M.F. 1980. Effect of time of planting of onion bulbs on the yield and quality of seeds. **Bangladesh J.Agric., 5(3):**131-134.

Movalia, A.G., B.B. Kaneria, V.D. Khanpara, K.V. Jadav and R.K. Mathukia. 1999. Response of direct seeded a transplanted onion *(Allium cepa* L.) transplanted dates of swing and nitrogen levels. **Gujarat Agr. Univ. Res. J., 25:**90-93.

Mulkey, W.A. and T.P. Talbot. 1991. Sweet bulbing onion varieties and planting dates for northern. **Louisiana Agr., 35:**3-5.

Naeem, M., M. Masrooor, A. Khan and J.B. Morris. 2009. Agrobotanical attributes nitrogen-fixation, enzyme activities and nutraceuticals of Hyacinth bean. A bio functional medicinal legume. **Amer. J. Plant Physiol., 4(2):**58-69.

Naik, L.B., and K. Srinivas. 1992. Seed production in vegetable crops II. A review. **Agric. Rev., 13(2):**59-80.

Nammi, F., H.D. Rabinowitch and N. Kedar. 1980. The effect of GA_3 application on flowering and seed production in onion. **J. Amer. Soc. Hort. Sci., 105:** 164-167.

Nehra, B.K., Y.S. Malik and A.C. Yadav. 1989. Seed production in onion as influenced by time of bulb planting and cut treatments. **Haryana Agric. Univ.J. Res., XIX (3):**225-229.

NHB. 2010. Selected state wise area and production of onion in India. **National Horticultural Board,** New Delhi.

NHB. 2010a. State wise estimates of area and production for onion in India. **National Horticultural Board,** New Delhi.

NHRDF. 2005. Onion seed technology. **National Horticultural Research and Development Foundation.** Nasik, Maharashtra.

Orlowski, M. and E. Rekowska. 1992. Effect of sowing date of date onion seeds on the yield of important cultivars grown in western. **Hort. Absts.,** 064-07824.

Padmavathy. 1995. Evaluation of half - sib and irradiated progenies of seed setting aggregatum onion types (*Allium cepa* L. var. *aggregatum* Don.). **M.Sc. Thesis,** Tamil Nadu Agricultural University, Coimbatore.

Pakyurek, Y., K. Abak, N. Sari, H.Y. Guler, I. Babik and J. Rumpel. 1994. Effect of sowing dates and plant densities on the yield and quality of some varieties in South East Anatolia. **Acta- Horticulture**. **7th Inter. Symp**. On timing field production of vegetables, Skierniewice, Pland.

Palaniswamy, K.P. 1980. Studies on growth development and storage of CO 2 onion (*Allium cepa* L. var. *aggregatum*, Don.) **Ph.D. Thesis**, Tamil Nadu Agricultural University, Coimbatore.

Pandey, U.B., D.S. Panwar and V.P. Sharma. 1994. Effect of spacing and levels of nitrogen on growth and seed yield of kharif onion. **Seed Res., 20:**147-148.

Panse, K.V. and P.V. Sukhatme. 1985. **Statistical Methods for Agricultural Workers.** ICAR, New Delhi.

Ponnuswami, V. and S. Thumburaj. 1996. Shallots seed production, TVIS, Volume 1, No.1, January- June, **AVRDC**. 18 p.

*Purvis, O.N. 1934. An analysis of the influence of temperature during germination on the subsequent development of certain winter cereals and its relation to the effect of length of day. **Ann. Bot., 48, 919.**

*Purvis, O.N. and F.G. Gregory. 1937. Studies in the vernalisation of cereals. I. A comprehensive study of vernalisation in winter rye by low temperature and by short days. **Ann. Bot., N.S.I, 569.**

Ragupathi, R. 1984. Onion seed production feasible in Kalpitiya. **KRUSHI, 6(4):** 38-43.

Rajasree, V., K.P. Palaniswamy and S. Thamburaj. 1994. Evaluation of genotypes of *Allium cepa* var. *aggregatum* propagated through seeds. **South Indian Horticulture, 42:**89-92.

Ramtohul, M. and A.L. Owadally. 1980. Effect of monthly time of sowing on the yield of bulb of five onion cvs. (*Allium cepa* L.). **Revue Agricole Sucriere et Delille Maunca, 58:**171-179.

Rashid, M.A. and M.M. Rashid. 1978. The effect of spacing on the yield of onion. **Hort. Absts., 48(6):**481.

Rabinowicth, H.D. 1990. Physiology of flowering. In: Rabinowicth, H. D. and Brewster, J. L. (eds). **Onions and Allied Crops, Vol. 1**. CRC Prees, Boca Raton, Florida, pp.113-134.

Rumi Borah. 1994. Diallel analysis in aggregatum onion (*Allium cepa* L. var. *aggregatum* Don.). **M.Sc. Thesis,** Tamil Nadu Agricultural University, Coimbatore.

Sato, K. and K.B. Park. 1981. On the low temperature damage in rice seedlings. 2^{nd} varietal differences in discolouration of leaves under low temperature and their restoration to change in pigment compositions. **Japan. J. Crop. Sci., 50:**401-406.

Scwlly, N., M.N. Perker and H.A. Bonlhwick. 1945. Interaction of nitrogen nutrition and photoperiod as expressed in bulbing flower stalk development of onion. **Bot. Gas., 107:**52.

Shaikh, A.M., B.S. Vyakaranahal, M. Shekhargouda and P.R. Dharmatti. 2002. Influence of bulb size and growth regulators on growth, seed yield and quality of onion cv. Nasik Red. **Seed Res., 30:**223-229.

Sharma, M.L., G.S. Bharadwaj, Y.S. Chauhan, S.D. Sharma and M. S. Sharma. 1989. Response of green gram to sowing dates under rainfed conditions**. Indian J. Agron., 34(2):**252-254.

Sharma, S., S.S. Bal and K.L. Bajaj. 1996. Chemical composition of some important varieties of onion (*Allium cepa* L.). **Veg. Sci., 23(1):**48-51.

Shrivastava, R.K., B.K. Verma., S.K. Dwivedi and Y.C. Dwivedi. 1996. Response of onion (*Allium cepa* L.) varieties to plant spacing in relation to yield attributes and bulb productivity. **Veg. Sci., 23(1):**26-29.

Sidhu, A.S., J.S. Kanwar and M.L. Chada. 1996. Seed production potential of different genotypes of onion. **Onion Newsletters for the Tropics, 7:**38-41.

Sinclair, P. 1983. Onion varieties for late sowing. **Farmer's Newsletter. 158:** 16-19. **Hort. Absts.,** 054-02311.

Singh, and B.N. Korla. 1991. Effect of transplanting dates and varieties on number of leaves and yield in onion (*Allium cepa L.*). **Veg. Sci., 18(1):**24-28.

Singh, D.P. and R.P. Singh. 1976. Studies on the effect of time of sowing and age of seedling on growth and yield onion (*Allium cepa* L.). **Indian J. Hort., 31:** 69 -73.

Singh, H. and S.S. Gill. 1980. An approach to insitu seed production in onion. **Seed Res., 8(1):**38-41.

Singh, J. and N.K. Chaure. 1999. Effect of age of seedling and nitrogen levels on growth and yield of onion (*Allium cepa* L.). **Adv. Hortic., 6:** 73-77.

Singh, J.P. and R.K. Singh. 1984. Effect of spacing and planting time on seed production in onion. **South Indian Horticulture, 32:**284-287.

Singh, J.P., M.K. Singh and R.D. Singh. 1993. Growth and yield of onion (*Allium cepa* L.) bulbs as influenced by date of transplanting, nitrogen and potash fertilization. **Veg. Sci., 20(1)**:14-17.

Singh, R.V and K.P.S. Phogat. 1989. Effect of different sowing time on growth and bulb yield of garlic. **Prog. Hort., 21(2):**145-147.

Soni, D.S., R.K. Saraf and S.K. Lodh. 1993. Performance of eight onion varieties in Madhya Pradesh - A note. **Haryana J. Hort. Sci., 22(3):**240 -241.

Spencer, D. and D. Boulter. 1984. The Physiological Role of Storage Proteins in Seeds. **Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 304:**275-285.

Sumanaratne, J.P. 2000. True seed production, Red onion. Chapter 3, Other Field crops, Department of Agriculture at the turn of the country, **DOA**, Peradeniya.20 p.

Sumanaratne, J.P. and W.M.U. Palipane. 2002. Feasibility of small onion (*Allium cepa* L. *Aggregatum*) cultivation from true seeds. **Annals of the Sri Lanka Department of Agriculture, (4):**39-46.

Tanner, C.B. and S.M. Goltz. 1972. Excessive high temperature of seed onion seed umbels. **J. Amer. Soc. Hort. Sci., 97:5**-9.

Thompson, H.C. and W.C. Kelly. 1978. **Vegetable crops (5th ed).** Tata Mc Grew Hill publishing co. Ltd. New Delhi.

TNAU. 2004. **Crop Production Techniques of Horticultural Crops**, Tamil Nadu Agricultural University, Coimbatore and Directorate of Horticulture and Plantation Crops, Chennai. pp.289.

Toman, S.I., L.V. Pavlov, N.O. Gorcha Kovaand and V.I. Rudenok. 1989. Optimum size of onion mother bulbs. **Kartofel-I-Ovoshchi, 6:**20-21.

Tomar S.P.S., T.P. Singh and G.S. Tomar. 1989. Effect of planting date and hormone on onion (*Allium cepa* L.) yield. **Indian J. Agri. Sci., 58(2):**136-138.

Tomar, B.S. and Negi, H.C.S. 2002. Effect of planting time on seed yield, quality characters and disease incidence in onion (*Allium cepa* L.). In; **Processing of XI National seed seminar on quality enhances agricultural profitability held at UAS Dharwad January 18-20, 2002.**

Tomar, B.S. 2005. **Quality seed production of onion**. Seed production unit, New Delhi-110012.

Tomar, B.S., Singh, Balraj and M. Hassan. 2004. Effect of irrigation methods on seed yield and seed quality in onion. cv. Pusa Madhavi. **Seed Res., 32(1):**25-30.

Vaddoria, M.A., I.J. Golani, D.R. Mehta, K.L. Dobariya and R.H. Gohil. 2004. Phenotypic stability in onion. **The Orissa J. Hort., 32(1):**26-29.

Vadivel, B. 1979. Heterosis and combining ability studies in onion (*Allium cepa* L. var. *aggregatum Don*). **M. Sc. Thesis**, Tamil Nadu Agricultural University, Coimbatore.

Vasetskii, V.F. and N.G. Reznik. 1995. Onions for mechanized harvesting and drying. **Hort. Absts., 065-01174.**

Venkampan, J. 1970. Shortening the breeding cycle in onion. Mothods Procfetal. Groent Alkmeer. **Hort. Absts., 41:**52-72.

Verma, J.P., S.V.S. Rathore and B.S. Yadav. 1971. Performance of bulb crop of onion as affected by sowing dates and age of transplant. **Prog. Hort., 3:**29-33.

Verma, T.S., Amar Singh and K.D. Lakhanpal. 1995. Comparative study of seed to seed and bulb to seed production methods in onion cv. Brown Spanish. **Veg. Sci., 1:**30-32.

Verma, T.S., Ramesh Chand, P.C. Thakur, K.D. Lalkhanpal and Amer Singh. 1994. Effect of bulb size and plant spacing on seed yield of onion. **Hort. Absts., 66(12)**:10379.

Wagh, R.S. 1986. Effect of different growth substances on seed yield and seed quality of onion (*Allium cepa* L.) **M.Sc. Thesis**, Mahatma Phule Kristi Vidypeeth, Raguri (M.S.).

Yoshida, S.D., A. Foron and J.H. Cock. 1971. **Laboratory Manual for Physiological Studies of Rice.** IRRI, Philippines.36-37.

*Originals not seen

CO On 5

Puttarasal type

Santhaipadugai local

Plate 1. Onion genotypes used in the study

Plate 2. Field view of September season crop

Plate 3. Field view of October season crop

Plate 4. Field view of November season crop

Plate 5. Field view of December season crop

Plate 6. Flowering in CO On 5 planted during September season

Plate 7. Seed setting in CO On 5 planted during September season

Plate 8. Flowering in Puttarasal type planted during September season

Plate 9. Seed setting in Puttarasal type planted during September season

Plate 10. Flowering in Santhaipadugai local planted during September season

Plate 11. Seed setting in Santhaipadugai local planted during September season

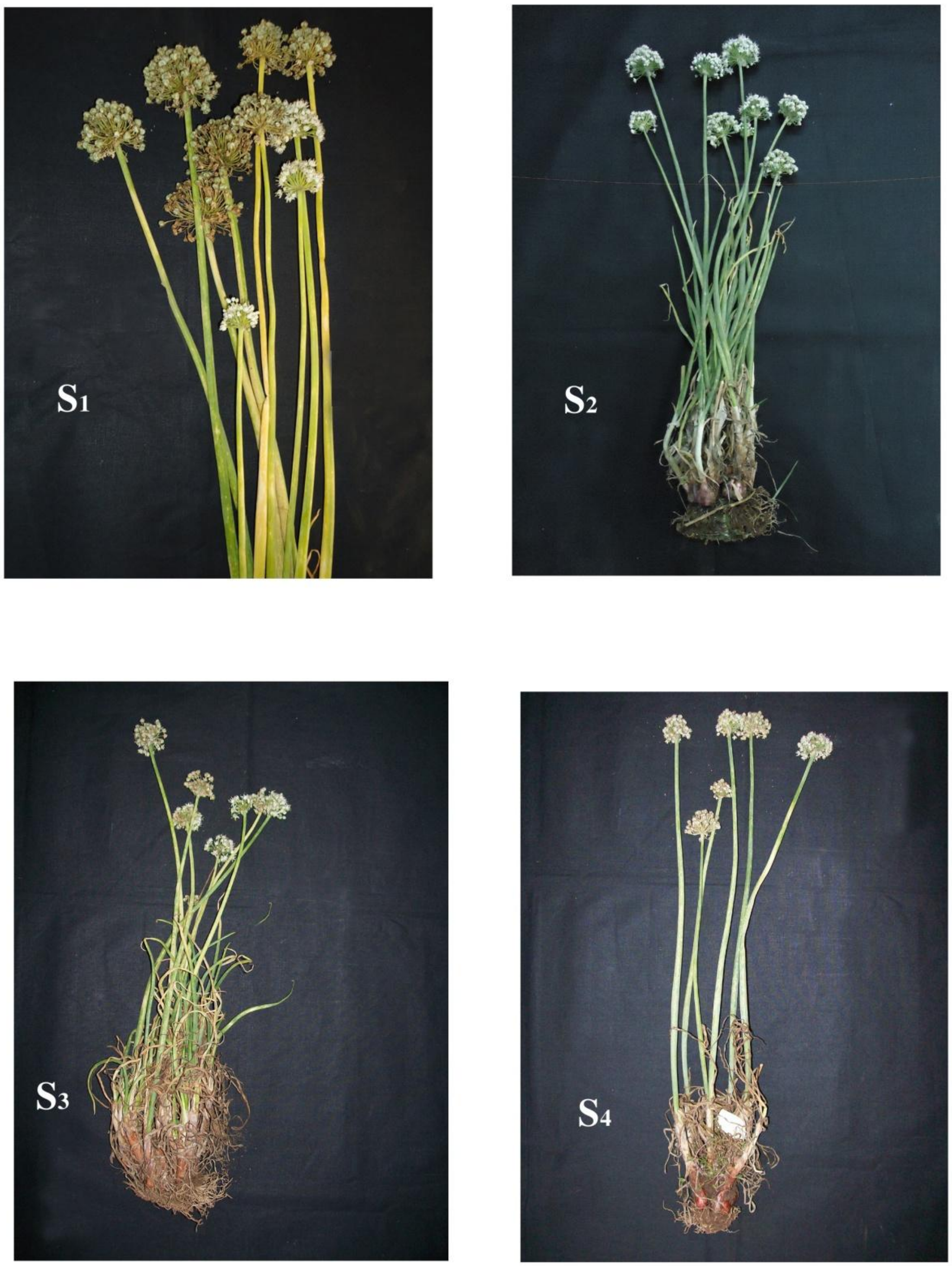


Plate 12. Influence of planting season on number of umbels per plant in CO On 5

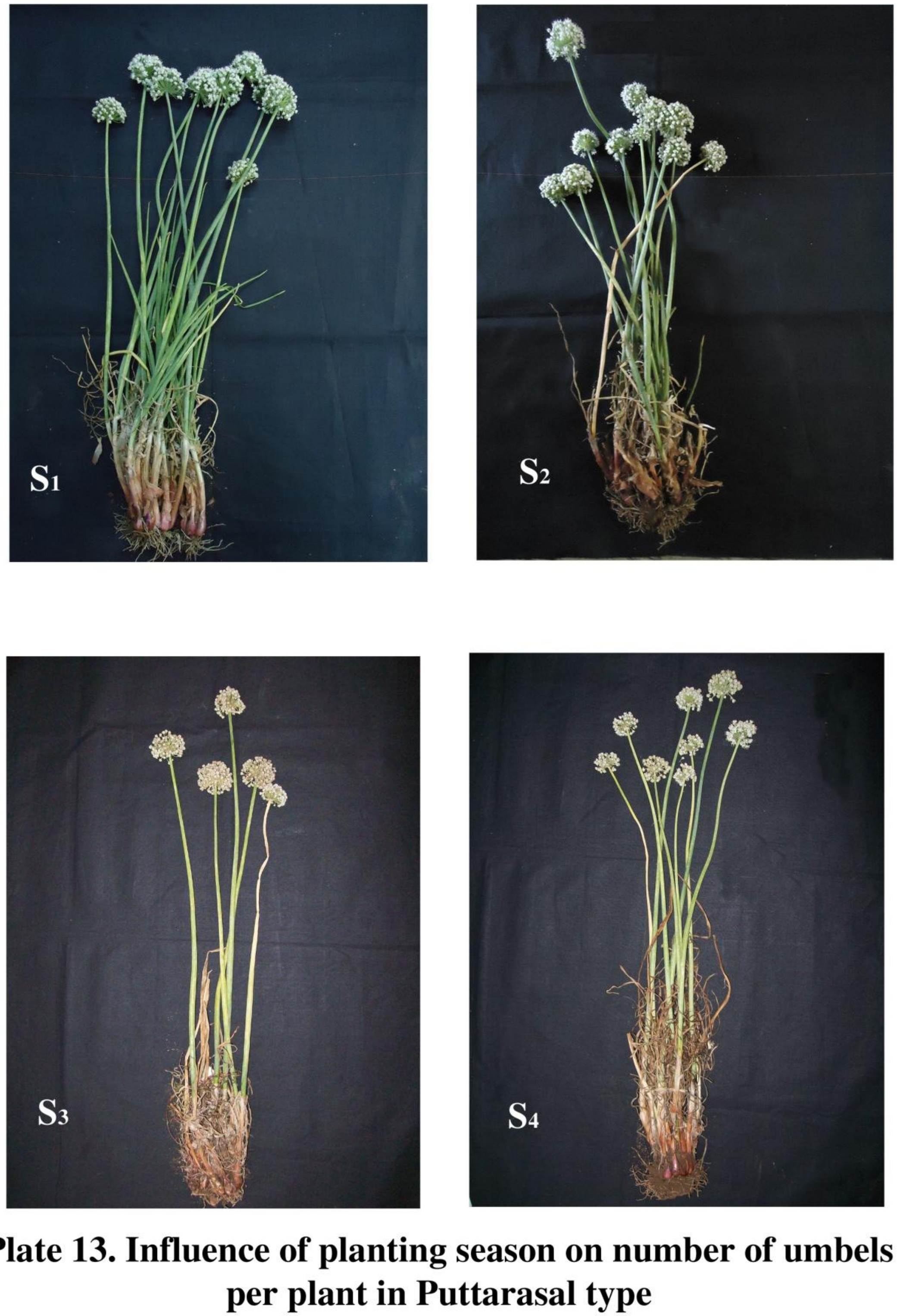


Plate 13. Influence of planting season on number of umbels per plant in Puttarasal type

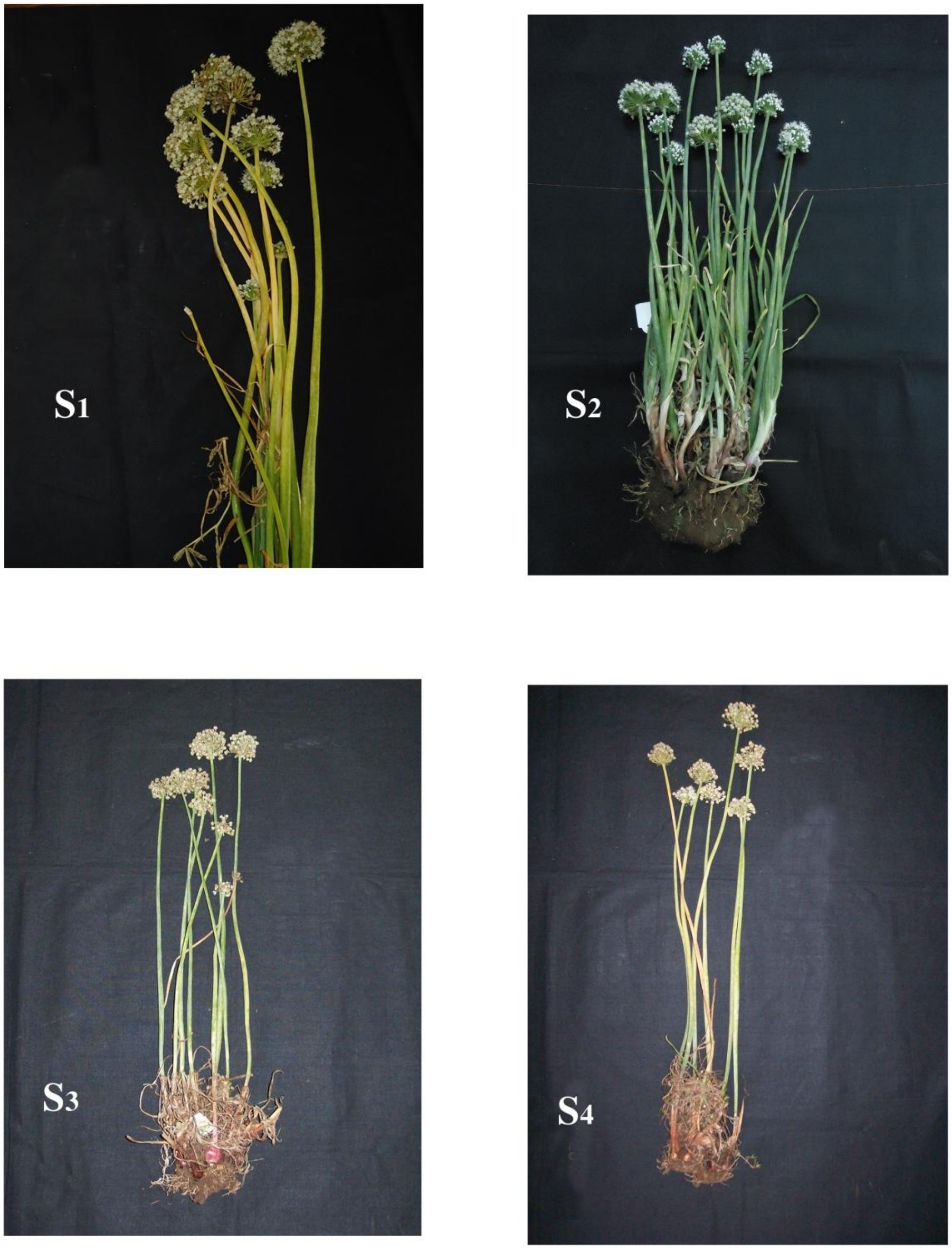


Plate 14. Influence of planting season on number of umbels per plant in Santhaipadugai local

CO On 5

Puttarasal type

Santhaipadugai local

Plate 1. Onion genotypes used in the study

Plate 2. Field view of September season crop

Plate 3. Field view of October season crop

Plate 4. Field view of November season crop

Plate 5. Field view of December season crop

Plate 6. Flowering in CO On 5 planted during September season

Plate 7. Seed setting in CO On 5 planted during September season

Plate 8. Flowering in Puttarasal type planted during September season

Plate 9. Seed setting in Puttarasal type planted during September season

Plate 10. Flowering in Santhaipadugai local planted during September season

Plate 11. Seed setting in Santhaipadugai local planted during September season

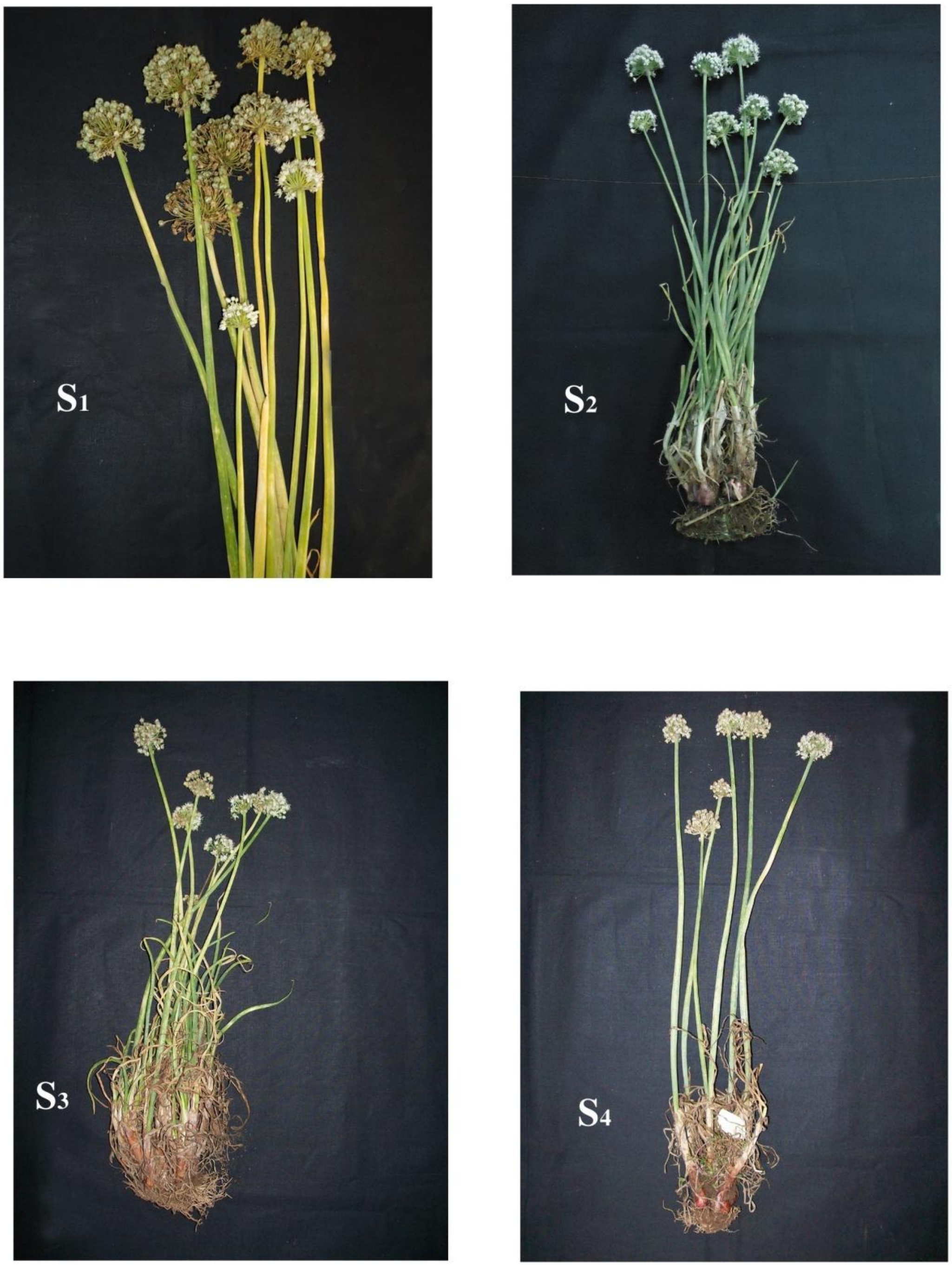


Plate 12. Influence of planting season on number of umbels per plant in CO On 5

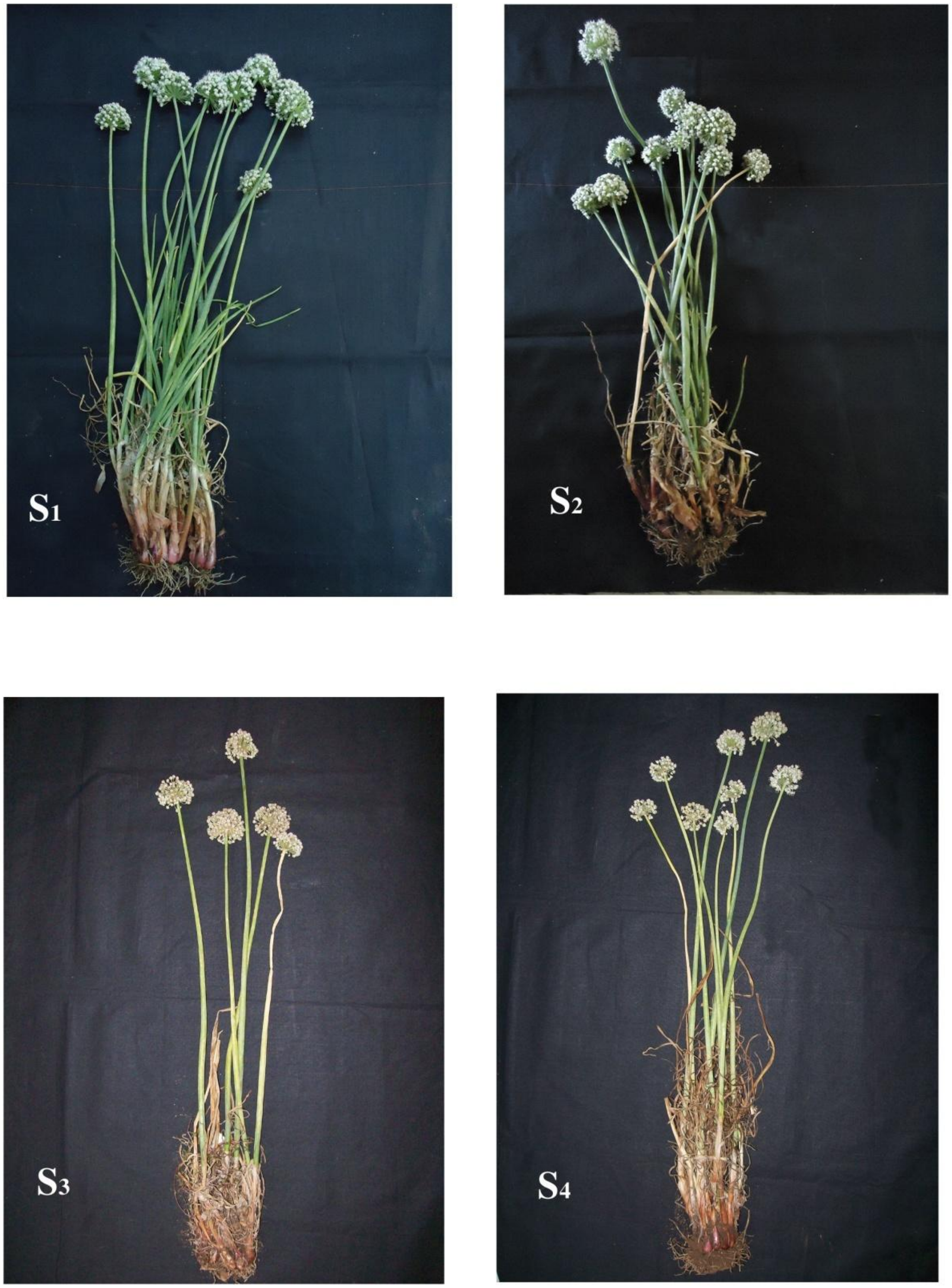


Plate 13. Influence of planting season on number of umbels per plant in Puttarasal type

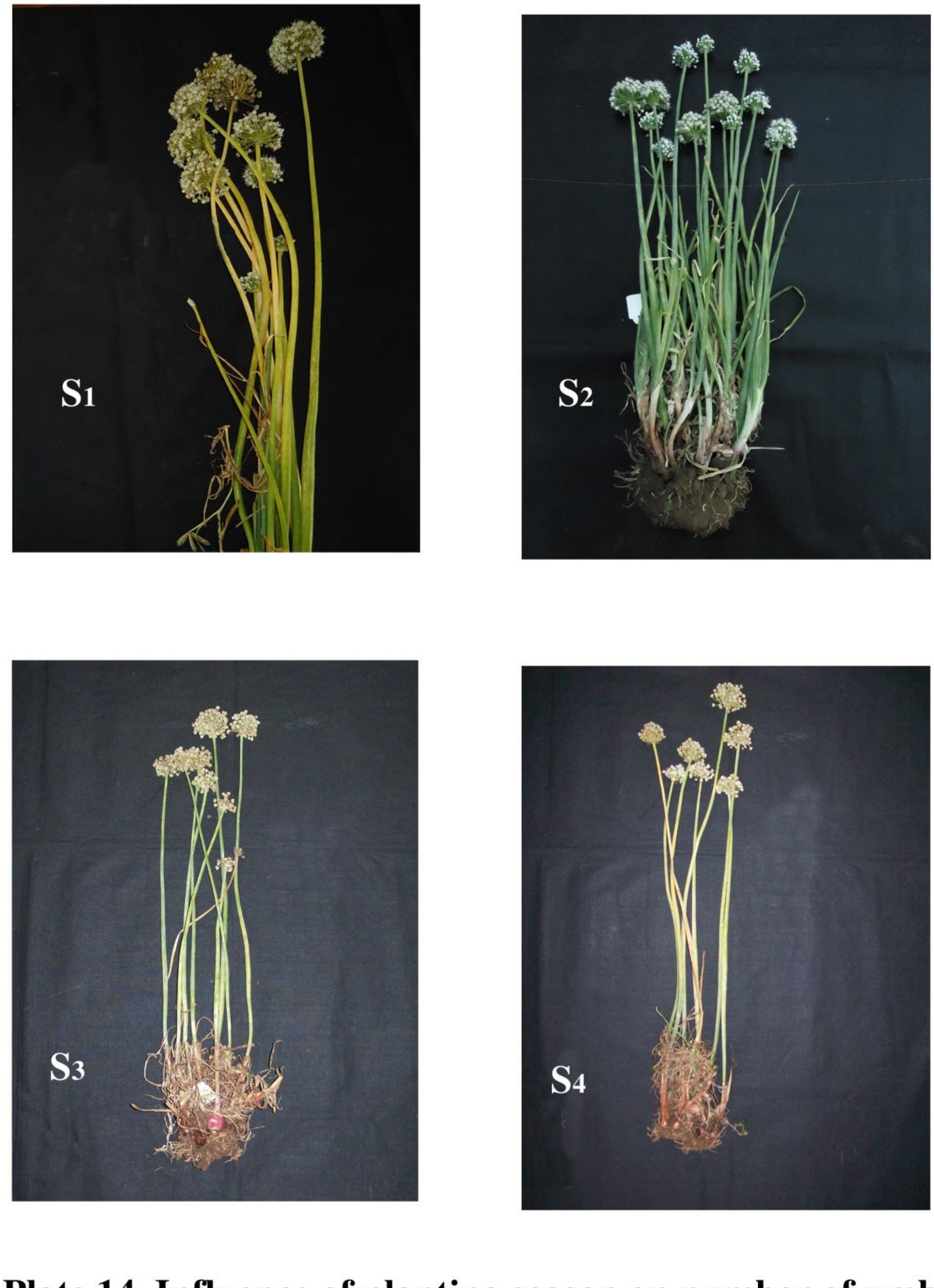


Plate 14. Influence of planting season on number of umbels per plant in Santhaipadugai local

RESEARCH FINDINGS

SEASONAL INFLUENCE ON FLOWERING AND SEED SET IN THE IDENTIFIED GENOTYPES OF AGGREGATUM ONION (*Allium cepa* L. var. *aggregatum* Don.)

Student name
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The influence on season of planting on growth, flowering and seed yield of three aggregatum onion genotypes *viz.*, CO On 5, Puttarasal type and Santhaipadugai local in bulb to seed and flowering, maturity of seed and seed yield were studied during four different seasons. The investigations were carried out during 2010-2011, at the experimental farm, Department of Vegetable crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. This experiment was laid out in a Factorial Randomized Block Design and data collected were subjected to statistical scrutiny. The outcomes of research were highlighted.

Observations on growth characters such as days to first and complete sprouting, plant height, number of leaves, leaf length, leaf girth, shoot girth, tillers per plant, and physiological characters like chlorophyll content etc. were recorded at four different stages of crop growth *viz.*, 30^{th}, 60 DAP at full flowering and at harvest stages respectively and flowering and yield characters *viz.*, days to first flowering, 50 % flowering, full flowering, seed set, and seed maturity, length of flower stalk, diameter of umbel, number of umbels per plant, number of flowers per umbel, number of seeds per umbel, seed weight per umbel, flowering percentage, seed set percentage, seed yield and residual bulb yield were recorded. In addition, quality traits like, TSS, ascorbic acid content of bulbs and protein content of seeds were also estimated and seedling vigour characters *viz.*, germination percentage, root length, shoot length, dry matter production and vigour index were recorded.

Present research results showed that Puttarasal type in September season planting was better to improve the growth, flowering and yield attributing parameters which will ultimately result in increasing the productivity of the crop.

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Growth characters

- The interaction between seasons and genotypes were significant on days to sprouting of onion bulbs.
- Among the four different seasons, September (S_1) planting recorded the lesser days required to initiation of sprouting and completion of sprouting (3 and 7 days respectively) in the genotype Santhaipadugai local followed by CO On 5 and Puttarasal type than other three seasons.
- Plant height was measured at four different growth stages of crop *viz*., 30th, 60thDAP, at full flowering and at harvest. September season planting registered the greatest height (59.20 and 65.61 cm) at full flowering and at harvest respectively in Puttarasal type followed by Santhaipadugai local and lowest in CO On 5 genotype.
- The highest number of leaves per plant was found in bulbs planted in September season (35 and 28.40) at 30 and 60 DAP respectively in the Puttarasal type followed by Santhaipadugai local and lowest number was recorded in CO On 5 genotypes.
- The leaf length was higher with bulbs planted during September season (55.53 and 63.13 cm) at full flowering and at harvest respectively in the Puttarasal type.
- Maximum leaf girth was observed with plant planted during September season (3.56 and 2.82 cm) at full flowering and at harvest respectively in the Puttarasal type followed by Santhaipadugai local and CO On 5 genotypes.
- September season planting recorded the largest shoot girth (3.33 and 3.66 cm) at 30 and 60 DAP respectively in the Puttarasal type followed by Santhaipadugai local and CO On 5 genotypes.
- The total number of tillers per plant was highest in September planting (9.67 and 9.05) at full flowering and at harvest respectively in Puttarasal type.

Flowering characters and yield attributes

- Days required for first flowering (31.20), 50 % flowering (43.33) and full flowering (60.30) was earlier under Santhaipadugai local planted during September season.
- The number of days taken for seed set (79.16) and seed maturity (104.40) was earlier under Santhaipadugai local planted during September season.
- The yield attributes *viz*., length of flower stalk at full flowering and at harvest (58.86 and 63.86 cm respectively), diameter of umbel at full flowering and at harvest (7.07 and

6.03cm respectively), number of umbels per plant (7.50), number of flowers per umbel (282.40), number of seeds per umbel (260.03) and seed weight per umbel (0.319 g) were the highest under September season in Puttarasal type due to existing favourable climate ie., low temperature and high relative humidity prevailed during flowering period.

Physiological attributes

- Among the four different seasons, September (S_1) season planting recorded the maximum total chlorophyll content (0.77, 1.01 and 0.91 mg g^{-1}) at 30, 60 DAP and at full flowering respectively.
- The Puttarasal type planted during September season recorded significantly maximum chlorophyll (0.91, 1.07 and 1.04 mg g^{-1} respectively) at 30, 60 DAP and at full flowering respectively.

Seed yield and residual bulb yield

- Among the four different seasons, September season recorded the maximum seed yield in all three genotypes.
- Out of three genotypes, Puttarasal type gave significantly higher seed yield (807 kg ha^{-1}) in September season followed by Santhaipadugai local (673 kg ha^{-1}) and lower yield in CO On 5 (603 kg ha^{-1}).
- September (S_1) season planting recorded the maximum residual bulb yield (8000 kg ha^{-1}) in the Puttarasal type followed by Santhaipadugai local and lowest yield was recorded in CO On 5.

Quality traits

- The genotype Santhaipadugai local planted during September season recorded significantly higher total soluble solid (14.37° brix) content and ascorbic acid content (9.43 mg 100 g^{-1}) followed by Puttarasal type and CO On 5 genotypes.

- The highest seed protein content was recorded in Puttarasal type (19 %) compared to Santhaipadugai local (18.90 %) and CO On 5 (18.09 %) during September season.

Seedling vigour characters

- Seedling vigour characters *viz*., germination percentage (92.76 %), root length (7.20 cm), shoot length (8.80 cm), dry matter production (15.82 mg 10 S_2^{-1}) and vigour index (1484.14) were the highest under September season grown Puttarasal type followed by Santhaipadugai local and CO On 5.

The following conclusions were drawn from the results obtained in the present investigation

- Among the four different seasons, there was significant difference in seed yield. The September season favourably increased the growth, flowering and yield attributes resulting in highest seed yield.
- Interaction effect of seasons and genotypes showed that significant influence on growth, flowering, yield attributes and seed yield were obtained in September season crop in Puttarasal type.
- With the background of the above results, it could be concluded that Puttarasal type in September season planting was better to improve the growth, flowering and yield attributing parameters which will ultimately result in increasing the productivity of the crop followed by Santhaipadugai local and CO On 5.