Performance of onion (*Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting

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DEDICATED

My Respected Parents

…who sacrificed their today for my tomorrow

Mata Prasad……

DECLARATION

I, **Mata Prasad,** Enrolment No.-865/17, hereby declare that I am a candidate for the degree of **Doctor of Philosophy in Horticulture,** Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae Bareli Road, Lucknow-226025 (U.P.), India and have carried out my research work entitled **"Performance of onion (*Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting"**. This submitted for the award of the degree of Doctor of Philosophy in Horticulture is my original research work. I also declare that the thesis is essentially free from all kinds of plagiarism.

Date: 04/03/2022

Place: Lucknow

(Mata Prasad)

CERTIFICATE

This is to certify that the thesis entitled **"Performance of onion (*Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting"** Submitted by **Mr. Mata Prasad**, Enrolment No.-865/17 is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

The thesis submitted to Babasaheb Bhimrao Ambedkar University, Lucknow satisfies all the requirements as stipulated in the Doctor of Philosophy (Ph.D.) regulations- 1999 as amended in 2008/2010/2013 and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

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Place, Lucknow
Date 07./03./2022

(Mata Prasad)

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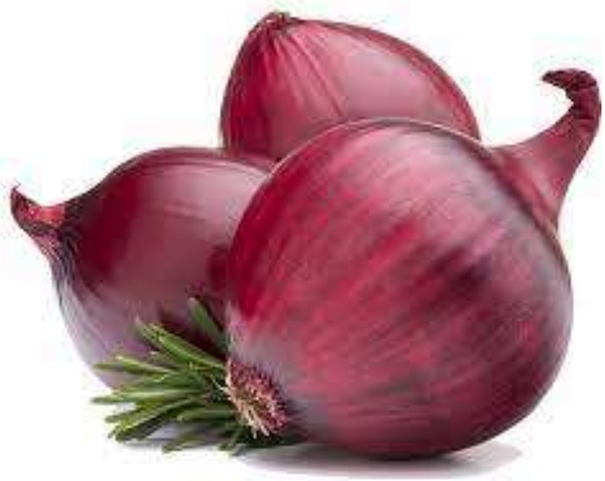
LIST OF ABBEREVITION

Anon.	:	Anonymous
B: C	:	Benefit cost ratio
$CaSO_4$	:	Calcium sulphate
CD	:	Critical Difference
cm	:	Centimeter
cv.	:	Cultivar
D.F.	:	Degrees of freedom
etal.	:	Etalii
Fig.	:	Figure
FYM	:	Farmyard manure
g	:	Gram
ha	:	Hectare
ha^{-1}	:	Perhectare
HCl	:	Hydrochloric acid
i.e	:	that is
I.U.	:	InternationalUnit
K	:	Potassium
kg	:	Kilogram
km	:	Kilometer
ml	:	Milliliter
M.S.S.	:	Mean Sum of Square
mm	:	Millimeter
mg	:	Milligram
Mg	:	Micro gram
µm	:	Micromole
HPO_3	:	Metphosphoric acid
L.	:	Linnaeus
Lt	:	liter
MT	:	Metric ton
t	:	tons

N	:	Normality
N	:	Nitrogen
nm	:	Nanometer
$NaHCO_3$	:	Sodium bicarbonate
NaOH	:	Sodiumhydroxide
No.	:	Number
O.P	:	Optical Density
P	:	Phosphorus
pH	:	Potential of hydrogen
P.pp.	:	Page/pages
ppm	:	parts per million
RBD	:	Randomized block design
R.H.	:	Relative humidity
Rs.	:	Rupees
S	:	Sulphur
S.E.	:	Standard error difference
Soln.	:	Solution
SO_4^{2-}	:	Sulphate ion
sp.	:	Species
S.S.	:	Sum of square
TSS	:	Total Soluble Solids
viz.	:	videlicet
wt.	:	Weight
^{0}	:	Degree
'	:	Minute
%	:	Per cent
/	:	per
µ	:	micro
^0C	:	Degree Celsius
^0B	:	Degree Brix

Chapter-I



INTRODUCTION

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable bulb crops cultivated extensively in India and it belongs to family Alliaceae, having chromosome number 16 (2n = 2 x = 16). It is one of the most important crops grown in rabi season in India and world. It is a bulb vegetable crop used in daily diet of people in the whole world. India ranks second in area and production of onion followed by China. In India, major onion growing states are Maharashtra, Karnataka, Madhya Pradesh, Bihar and Gujarat. Onion is cultivated in an area of 1320130 hectare with a production of 20931250 MT and productivity 15.86 tonnes/ha in India. In Uttar Pradesh, it is grown in about 24.96 ha area with a production of 422.75 MT and productivity 16.94 tonnes/ha. The maximum area (433.46 ha) and production (6510.86 MT) is under Maharashtra state. The Karnataka ranks second with 207.15 ha area and 5331.59 MT production. The maximum productivity of 25.48 MT/ha recorded in Gujarat after that 24.09 MT/ha in Madhya Pradesh and 16.94 MT/ha in Uttar Pradesh **(Anon., 2019)**.The present level of productivity of onion of the country is very low as compared to major producers like USA, China, Netherlands and Korea Republic. Onion crop can generate income to farmer and can be exported to obtain foreign exchange needed by many developing countries. Available statistics indicate that about 30% of the world production of onion is produced in tropical countries in an area estimated as nearly 0.9 million hectares. The leaves of onion are tubular and the bulbs are formed by the attachment of swollen leaf bases to underground part of stem which is small and rudimentary. Flowers are produced during second phase after formation of bulbs. Flowering structure is called an umbel, which is an aggregate of many small inflorescences (cymes) of 5-10 flowers. Length of peduncle commonly known a scape varies with variety, though, individual flowers are hermaphrodite, they are cross pollinated due to protandry. Cross pollination is achieved by honey bees when they visit flowers for nectar. Stigma becomes receptive 3-4 days after shedding of pollen grains. Artificial selfing is done by covering all umbels of a plant together and by shaking or rubbing each other or by introducing flies. Onion is valued for its bulbs having characteristic odour, flavour and pungency, which is due to the presence of a volatile oil – allyl-propyl disulphide. Pungency is formed by enzymatic reaction when tissues are broken. Bulbs are suited for storage for a long period and for long distance transport. Onion is slow growing, shallow rooted crop with narrow, upright leaves and non-branching habit. A fairly high concentration of nutrient should normally be maintained at the surface of the soil for its optimum growth and yield **(Anon., 2012)**. Onion bulb is rich in minerals like phosphorus (50 mg / 100 g) and calcium (180 mg / 100 g). Many medicinal uses are reported for bulbs and is commonly used as diuretic and applied on wounds and boils. Onion greens are also used by harvesting crop at pencil thickness and when small bulb is formed. It becomes a major cash crop with higher market demand and price due to its culinary, dietary and medicinal values. Onion oil, which is extracted by steam distillation, is used for flavouring. Recently there has been more demand for dehydrated products for use primarily in the food industry while, in some instances onions may be given as feed to livestock, but this may result in tainted milk. Onions also have a place in the folklore of many countries and their extracts have antibacterial properties **(Anon., 1985).**

The production of *kharif* onion has several advantages i.e. increases total production per annum to fulfill the demand for fresh onion in the market. *Kharif* onion provides a high price as compared to rabi season onion. There are very few varieties which are known to farmers as *kharif* varieties. Although there are so many varieties of onion available in the local market, but their performance have not been tested under Lucknow conditions and there is a great confusion regarding the selection of the right variety of onion for *Kharif* season. Due to lack of technical knowledge on this aspect, the onion growers of these regions are suffering up to a great extent, not only due to low bulb production but also problems in keeping quality of bulb in *kharif* season cultivation. Besides, the traditional rabi crop (winter season), the *kharif* crop (rainy season) and late *kharif* crop are now being grown successfully in the north and eastern parts of the country, which has revolutionized the onion production and marketing in the country. The *rabi* crop harvested in April-May is stored all over the country and slowly made available for domestic supply as well as export up to September-October. There is a critical gap in the supply of onions in the country from October to March and, as a result, the prices shoot up. A good harvest in *kharif* season can bridge the gap between demand and supply of onions during this dearth period. Further, production of onions during the *kharif* season offers a good alternative to farmers for obtaining higher returns.

In view of the above aspects, the present investigation entitled, **"Performance of onion *(Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting"** was carried out with the following objectives-

Objectives of the study-

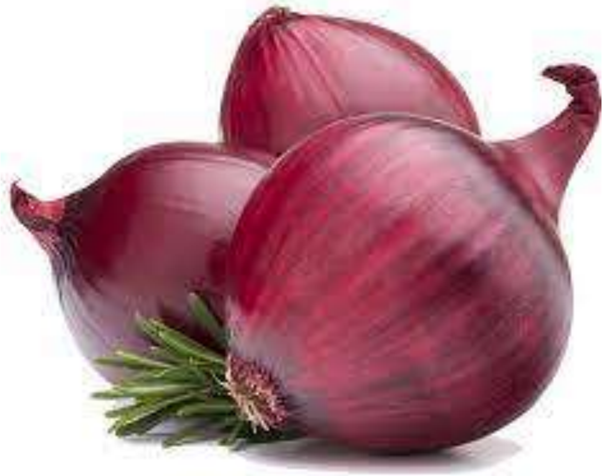
1. To find out the effect of different dates of transplanting on vegetative growth of onion cultivars.

2. To study the yield response of onion cultivars under different dates of transplanting.

3. To assess the quality parameters of onion cultivars as influenced by different dates of transplanting.

4. To calculate the economics of *kharif* onion production.

Chapter-II



REVIEW OF LITRATURE

REVIEW OF LITERATURE

The review of literature obtained during the investigation entitled **"Performance of onion (*Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting"** was undertaken to evaluate the programme in using different dates of transplanting independently and in combination. The literature pertaining to the topic of study has been reviewed in the present chapter for reference to draw suitable conclusions from the observations recorded.

2.1 Effect of planting dates on vegetative growth of onion:

Singh and Singh (2000) studied the effect of different planting dates (21^{st} August, 1^{st} September and 11^{th} September) on growth and yield characters of onion cultivar (N-53) during *kharif* season in Agra, Uttar Pradesh. They obtained maximum gross yield and marketable bulb yield with early planting date i.e., 21^{st} August.

Sharma *et al*. (2009) studied on optimum date of planting in *kharif* onion under Himachal Pradesh condition. They planted Agrifound Dark Red, a known *kharif* onion variety, on five different dates (1^{st} July, 16^{th} July, 1^{st} August, 16^{th} August and 1^{st} September). Highest plant height, maximum number of leaves, maximum polar diameter of bulbs were observed in 1^{st} August planting whereas average bulb weight and total marketable bulb yield was found maximum in 16^{th} August planting. However, further delay in planting towards 1^{st} September resulted into a significant decline in bulb production.

Nayee *et al*. (2010) conducted an experiment to investigate the effect of varied planting dates on yield and quality of *kharif* onion cv. Agrifound Dark Red under Gujarat condition. Out of three dates of planting (10^{th}, 20^{th} and 30^{th} July), highest plant population was found in 30^{th} July planting while maximum plant height and neck thickness of plant was recorded with 20^{th} July planting.

Khodadadi (2012) observed significant effect of the planting date on plant emergence, final height of plant and seed yield per hectare in onion. They reported that 6th November planting with mother bulb size of 65 to 80 mm recorded maximum seed yield/ ha.

Bosekeng and Coetzer (2013) studied the response of different onion cultivars to various sowing dates. They reported that cultivars differed with respect to growth bulb size, neck diameter and bolting due to their difference in genotype, however, did not differ in bulb fresh mass weight and yield. Sowing date did not significantly influence plant growth, the study on the effect of planting time on yield of onion variety Agrifound Dark Red in *kharif* season under Nasik condition revealed that 20th August planting gave higher bulb yield due to higher harvest index (NHRDF, 2013).

Das *et al.* (2015) suggested planting of *kharif* onion cultivars in between second week of August and second week of September in the gangetic plains of West Bengal.

Patil *et al.* (2016a) advocated planting of onion set of size 1.6- 2.0 cm on 15th June for getting maximum total yield of *kharif* onion cultivar Baswant- 780 as early production. As regards marketable bulb yield, the set planting on 1st July with 1.6- 2.0 cm set size was advocated for getting maximum yield.

2.2 Effect of planting dates on yield of onion:

Masthanareddy and Sulikeri (1998) evaluated five onion varieties during summer in Karnataka. They recorded significantly higher number of leaves in Arka Pragathi. On the other hand, cultivar N 53 recorded significantly higher bulb yield over Arka Pragathi and Arka Kalyan.

Rajalingam and Haripriya (2000) stated that the yield components, including plant height, leaf length, leaf breadth, number of leaves, weight of plant, and number of bulbs, bulb length, bulb diameter and volume of bulb exhibited significant positive association with yield. The path coefficient analysis indicated that plant height, leaf breadth, weight of plant, bulb length, shape index, days to maturity and harvest index, had direct positive effect on yield. Mohanty and Prusty (2001) suggested onion cultivars Arka Nikeatn and Pusa Madhavi for large scale cultivation in *kharif* season under Odisha condition keeping in view of their higher yield, better storage quality and medium bulb.

Mohanty and Prusty (2002) also evaluated twelve onion varieties under Odisha condition. They reported that highest yield was obtained from N 53 which was at par with Arka Kalyan, Agrifound Dark Red and Arka Niketan, while moderate yield was realized from Agrifound Light Red and Pusa Madhavi. They recommended N 53, Arka Kalyan and Agrifound Dark Red for cultivation in rainy season and rest in winter season. The experiment showed the possibilities of growing the *rabi* varieties during *kharif* season as they produce bulbs equally in both the season. Arka Niketan showing better keeping quality, medium bulb and higher yield was also advocated for commercial cultivation in rainy season.

Gautam *et al.* (2006) observed significant effect of transplanting dates on the plant height, plant stand at maturity and marketable bulb production of onion. The longest plant and highest bulb yield was observed on 15^{th} August transplanting date. Out of four transplanting dates (25^{th} July, 5^{th} August, 15^{th} August and 25^{th} August), they recommended 15^{th} August as the best time for transplanting of seedling.

Supe *et al.* (2008) evaluated eight onion genotypes in *rangda* (*Late kharif*) season under Nasik conditions. Among the different genotypes, outstanding performance of the genotype S-1 in bulb yield/ ha was recorded by them.

Das (2008) studied the effect of age of seedling and cultivars on the yield of onion during *kharif* season at Keonjhar. He observed that maximum bulb yield was produced by the cultivar Nasik Red when 45 days old seedlings were planted.

Sharma (2009) evaluated different onion cultivars during *kharif* season at sub mountain low hill of Himachal Pradesh and recorded Baswant-780 as the top yield followed by Agrifound Dark Red and N-53.

Giri *et al*. (2009) studied the performance of different onion cultivars during *kharif* season in the plains of new alluvial zone of West Bengal. They reported that Agrifound Dark Red, Baswant -780 and N53 showed better potentialities. They obtained highest bulb yield in Agrifound Dark Red followed by Baswant-780. They also supported the potentiality of *kharif* onion in the State particularly in the new alluvial and red and Laterite zone of West Bengal.

Singh *et al.* (2011) carried out an investigation to study the genetic variability in late *kharif* germplasm of onion at Nashik, Maharashtra. They observed that a wide range of variability was present in gross yield (19.65 to 41.17 t/ha), marketable yield (10.05 to 39.13 t/ha) and plant height (54.95 to 71.80 cm). Significant and positive correlation was also observed by them in marketable yield with plant height, neck thickness, bulb diameter, bulb size index, weight of 20 bulbs, and gross yield at genotypic and phenotypic levels. However, negative correlation was found in marketable yield with bolters, doubles and days for bulb initiation at genotypic and phenotypic levels, they reported. It was revealed from the experiment that there is ample scope for development of improved onion cultivars suitable under Maharashtra condition as the germplasm consisted a wide range of variability for important characters.

Sharma (2012) studied the effect of planting geometry on growth and yield of *kharif* onion (*Allium cepa* L.) under Madhya Pradesh condition. He concluded that among the four varieties tested, Agrifound Dark Red was the best variety followed by Bhima Super with respect to growth and yield.

Patil *et al.* (2012) reported that the transplanting date had significant effect on yield of onion under Maharashtra condition. They observed that cultivar 'JWO807' gave highest bulb yield when transplanted on 15^{th} November.

Kandil *et al.* (2013) opined that determination of suitable date of planting is very much important for obtaining maximum bulb yield and desirable quality of onion.

Ketema *et al*. (2013) observed significant effect of different planting methods on maturity and dry bulb yield of onion in two different seasons in 2008/09. Data on days to maturity, dry bulb yield, bulb weight and bulb diameter were collected. Planting methods and cultivars showed statistically significant difference ($P<0.01$) both for earliness and dry bulb yield. However, their interaction was not significant. Sets planting resulted in higher yield (39.1 t/ha) followed by transplants (36.3 t/ ha) and direct seeding (19.5 t/ha). The cultivar 'Bombay Red' (33.3 t ha-1) gave significantly higher yield than 'Adama Red' (31.1 t/ha) and 'Nasik Red' (30.2 t /ha). Sets matured earlier (94 days) than transplants (104 days) and direct sown (135 days).

The overall result indicated that in addition to the current transplanting practice onion establishment from set may also be a good option for dry bulb production in the Central Rift Valley areas of Ethiopia where earliness and high yield are important parameters considered by onion growers.

Ashok *et al.* (2013) conducted an experiment with ten varieties/lines of onion. They reported significant differences in growth and yield parameters among the varieties/lines and noted Early Grano as the highest yield.

Mohanta and Mandal (2014) observed significant differences in growth and yield parameters of onion with different dates of planting (15th and 30th August and 15th and 30th September) at Horticulture Farm of Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal). They recorded increased value in growth and yield parameters of onion as planting dates progressed from August to September. The highest yield was produced from 30th September planting.

Tripathy *et al.* (2014) evaluated twenty two onion cultivars during *kharif* season under Odisha condition. They observed that VG-18, Bhima Super, NRCRO-3, VG-19, RO-282, HOS 4 produced bulb of above 70 gm. In commercial cultivation of onion, marketable bulb yield plays a vital role than total bulb yield. They recorded that the cultivars like NRCWO-3, Bhima Red, NRCWO-4, NRCWO-2 and NRCWO-1 produced both total and marketable bulb yield greater than 200 q/ha. However, Bhima Super and NRCRO-3 recorded only total bulb yield of more than 200 q/ha. In onion, neck thickness of harvested bulbs play key role towards shelf life and rate of rotting under storage condition. Usually bulbs with relatively thin neck have better storage life than that of bulbs with thick neck. They reported that VG-19 recorded significantly minimum neck thickness which was at par with NRCRO-1, NRCRO-4, VG-18, Col 652, HOS – 4 and Pusa White Round. Onion, being basically a winter crop and when cultivated during *kharif* or *late kharif*, the crop is exposed to adverse weather condition and act as an off season crop. Therefore, the percent of plant establishment is also considered an important factor to screen out the cultivars suitable for off season cultivation. They reported that NRCWO-3, Bhima Super, NRCWO-1, NRCWO-2, NRCWO-4 and VG-19 showing more than 80% of plant establishment would definitely perform better during *kharif* and *late kharif* season.

Mohanta and Mandal (2014) observed significant differences in growth and yield parameters of onion with different cultivars (Agrifound Dark Red, Arka Kalyan, Arka Niketan, Indam Marshal and Red Stone) in *kharif* season at Horticulture Farm of Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal). They recorded highest yield in Agrifound Dark Red and suggested the cultivar to grow in *kharif* season in lateritic belt of West Bengal.

Jatav (2014) studied the effect of spacing and varieties on growth and yield of *late kharif* onion (*Allium cepa* L.) under Gwalior condition. He found significantly maxim

um plant height and number of leaves in Agrifound Dark Red which was at par with Bhima Super. Agrifound Dark Red also recorded highest total yield of bulbs per ha followed by Bhima Super and Bhima Red, he reported.

Utagi *et al.* (2015) recommended the cultivars like Bhima Super, Bhima Red and Bhima Shakti for profitable crop in central dry zone of Karnataka. These cultivars produced higher yield attributes as well as yield, they reported.

Prasad *et al.* (2016) observed that among twenty three cultivars of onion, Bhima Raj maintained its superiority over all other varieties during late kharif season in relation to growth, yield and quality of onion in central dry zone of Karnataka. In a performance study with ten different kharif onion varieties.

Kumar *et al.* (2016) received higher yield from the onion variety NHRDF Red during *rabi* season when planted during first fortnight of December at Haryana condition.

Rajpurohit (2016) observed that the onion variety Agrifound Dark Red responded well in terms of growth, growth analytical and yield parameters. He recommended the variety for commercial onion production in Malwa plateau condition during *kharif* season. Onion is highly sensitive to temperature and photoperiod. Cultivar performance and date of planting play an important role in the selection of genotypes for yield improvement and adaptation to particular environmental conditions.

Prasad *et al*. (2017) revealed that there were significant effects of all treatments on vegetative growth, yield and quality attributes of onion. Plant height

(65.34 cm), number of leaves per plant (8.89), length of leaves (56.07 cm), neck thickness (18.75 mm), yield (5.166 kg/plot and 387.46 q/ha) were found maximum at 1^{st} December planting with wheat straw mulching (T_7). The best quality bulb in respect of maximum neck thickness (12.35 mm), basal diameter (13.61.mm), diameter of bulb (54.41 mm polar and 64.15 mm equatorial), length of bulb (65.17 mm), number of scales per bulb (9.24), bulb moisture (85.06 %) T.S.S. (13.84 ^{o}Brix), ascorbic acid (10.47 mg/100g), total sugars (10.39 %) etc. were also obtained when mulching was done with wheat straw and transplanted on 1st December followed (planted on 1^{st} December and mulching with rice husk). The study clearly concluded that i.), mulching is good for production of onion, late transplanting on 30^{th} December showed very poor performance irrespective of mulching and i transplanting on 1^{st} December and mulching with wheat straw was the best combination for getting good quality yield of onion.

Sharma and Jarial (2017) recorded significant differences in the plant height and bulb yield among four cultivars of onion (N-53, Nasik Red, Agrifound Dark Red and Agrifound Light Red) under low hill conditions of Himachal Pradesh. They observed maximum plant height in the cultivar Nasik Red followed by Agrifound Dark Red which was statistically at par with each other. The highest average bulb yield was observed in cultivar Agrifound Dark Red as they reported.

Santra *et al.* (2017) evaluated ten onion genotypes during *kharif* season in two locations, Kalyani and Bankura of West Bengal, India. They observed significant differences among genotypes for all traits. Pooled mean performances showed that Agrifound Dark Red had highest plant height, maximum average bulb weight, and maximum total bulb yield and highest marketable bulb yield. They also reported that Agrifound Dark Red and Gota exhibited high total yield in both the locations, Kalyani and Bankura of West Bengal.

Sharma and Jarial (2017) studied the effect of dates of planting with four onion cultivars under low hill conditions of Himachal Pradesh at six dates of planting at ten days interval starting from 5^{th} July to 25^{th} August. They recorded continuous decrease in plant height with delay in planting. Planting date also produced significant effect on bulb yield. The highest average yield was obtained from 25^{th} July planting.

Rugi (2017) studied the effect of varieties and transplanting dates on growth, yield and quality of *kharif* onion (*Allium cepa* L.) under Madhya Pradesh condition. He reported that, between two transplanting dates (10^{th} and 25^{th} August), 25^{th} August proved as the best for growth, yield and economic returns.

Rugi (2017) studied the effect of varieties and transplanting dates on growth, yield and quality of *kharif* onion (*Allium cepa* L.) under Madhya Pradesh condition. He reported that, among different varieties tested (Agrifound Dark Red, Arka Kalyan, Arka Bheem, Bhima Red, Bhima Raj, Bhima Super, Bhima Dark Red and Bhima Shubhra), Agrifound Dark Red was superior with respect to higher growth attributes, higher bulb yield and yield attributes as well as quality followed by the variety Bhima Shubhra, Bhima Super and Bhima Red which were at par to each other.

Abou Khadrah *et al.* (2017) suggested transplanting of onion at 15^{th} December in wide furrows maintaining the plant density of 45 plants/m^2 for maximum economic yield at North Delta of Egypt.

Rugi *et al*. (2018) reported that the fresh and dry weight of shoots increased upto 90 DAT followed by a reduction at harvest. On the other hand, fresh and dry weight of bulb increased upto harvest, irrespective of various treatments. There was a significant effect of transplanting dates on all the parameters studied. Transplanting date D_2 (25^{th} August) recorded maximum fresh weight of shoot, dry weight of shoot, fresh weight of bulb, dry weight of bulb, average weight of bulb, yield of marketable bulb, bolting and B:C ratio. Among the varieties, V8 (Agrifound Dark Red) recorded maximum fresh weight and dry weight of shoot, fresh weight and dry weight of bulb, average weight of bulb, yield of marketable bulb and B:C ratio. Combined effect of treatment D2V7 (Bhima Shubhra with 25th August transplanting) recorded maximum fresh weight and dry weight of shoot, fresh weight and dry weight of bulb, average weight of bulb, yield of marketable bulbs and B:C ratio.

Walle *et al*. (2018) carried out an significant differences in plant height and leaf length at maturity, bolting percentage, shoot fresh and dry weights, weight of marketable and total bulb yields, biological fresh and dry matter yields, average bulb fresh and dry weights, and neck diameter due to the main effects of cultivar and population density. Cultivars had significant main effects on harvest index, days to maturity, and biomass yield. Bombay Red was found to be superior to Adama Red in most parameters measured. Similarly, the main effects of plant population density had significant influences on the number of leaves per plant, number of marketable bulbs, and percent dry matter. The highest plant population density (200 plants m-2) resulted in the highest weights of marketable bulbs (47540 kg ha-1), total bulb yield (51137.2 kg ha-1), and the lowest bulb fresh weight (45.89 g). Moreover, additional research on the cultivars for more seasons and under different agro-ecological conditions is suggested to draw a conclusive recommendation.

Misu *et al.* (2018) observed significant influence of different varieties (BARI Piaj-1, BARI Piaj-4 and Taherpuri) under Bangladesh condition. They reported that highest yield was obtained from the variety BARI Piaj-4.

2.3 Effect of planting dates on morphological characteristics of onion:

Dev *et al*. (2005) conducted a study to standardize the planting time of growing *kharif* onion in lower hills of Himachal Pradesh. Seedlings of onion cultivar N-53 were transplanted on five dates at 15 days interval starting from 1st July to 1st September. They obtained maximum bulb yield from 16th July planting. They observed that delayed planting markedly reduced the bulb yields. However, crop planted earlier by one fortnight *i.e*., on 1st July showed lesser reductions. They noticed similar trend for bulb weight also. A continuous decrease in plant height was also recorded with every delay in planting. Review of Literature 6 In an experiment at the agro-ecological research site (AER site) of the Regional Agricultural Research Station, Lumle, at Deurali in Palpa, Nepal during rainy season.

Mahanthesh *et al.* (2009a) suggested that onion varieties nemaly Baswant–780, Arka Kalyan and Agrifound Light Red, which gave higher dry matter and bulb yield, can be cultivated for better return in *kharif* season under irrigated condition in central dry zone of Karnataka.

Dhotre *et al.* (2010) studied genetic diversity in 14 *kharif* onion (*Allium cepa* var. *cepa* L.) genotypes. They grouped the genotypes into 5 clusters based on genetic affinity. They recorded fresh bulb weight ranging from 31.89 to 93.86 g, polar diameter ranging from 3.53 to 4.64 cm, equatorial diameter from 3.9 to 4.83 cm and range of bulb yield from 10.74 to 21.12 tons /ha.

Singh and Bhonde (2011) suggested the growers and exporters of onion in Nashik area to consider onion hybrids Mercedes, Linda Vista, Cougar and Colina in respect of yield and yield contributing traits and the variety Agrifound Light Red in respect of total soluble solids, dry matters and pyruvic acid content.

Dewangan and Sahu (2014) evaluated 23 genotypes of onion during *kharif* season in Chhattisgarh plains. They found onion variety BKHO-1002 as superior for total yield of bulb, average weight of bulb, polar and equatorial diameter of bulb. They observed maximum plant height and neck thickness in onion variety BKHO-1004 whereas, maximum number of leaves per plant in BKHO-1005.

Das *et al*. (2015) conducted an experiment at Mondouri (West Bengal), during 2010-11 and 2011-12 to find out the suitable varieties and to standardize the date of planting for *kharif* onion production in the Gangetic plains. During first year, eight varieties namely Agrifound Dark Red, Agrifound Light Red, N-53, Baswant -780, Arka Kalyan, Pusa Red, Nasik Red and Bombay Red were evaluated. After evaluation, three best performing varieties namely, Baswant -780, N -53 and Agrifound Dark Red were selected and transplanted on four different dates of planting (28^{th} July, 18^{th} August, 8^{th} and 29^{th} September) to identify the most suitable planting date for *kharif* onion cultivation. Results indicated that maximum yield of 152.50 q/ha was obtained from Baswant-780. In the second experiment highest plant height, neck diameter, weight of fresh bulb, diameter of bulb and maximum yield of 167.48 q/ ha was also obtained from Baswant-780 where the seedlings were transplanted on 8 September. Amongst the three varieties with different dates of planting, it revealed that the variety Baswant-780 followed by Agrifound Dark Red were found as the most suitable *kharif* onion should be planted in between the second week of August and second week of September.

Umamaheswarappa *et al.* (2015) observed significant differences for growth, yield and quality parameters among 22 onion genotypes during an evaluation study under central dry zone of Karnataka. They suggested that Bhima Shakti, being the highest total bulb yield with higher polar and equatorial diameter of bulb and having highest ten bulb weight can be taken up for profitable crop during late kharif season.

Hirave *et al.* (2015) evaluated eight red onion varieties during kharif season under Akola condition and reported that the varieties Bhima Red and Bhima Raj showed better performance. The study revealed that Bhima Red recorded significantly maximum average fresh weight of bulb, diameter of bulb and marketable yield per ha.

Das (2017) evaluated twelve onion varieties for their growth, yield and quality parameters during *rabi* season under Gwalior, Madhya Pradesh, condition. He observed that the variety Agrifound Dark Red was superior in plant height, number of leaves per plant, leaf length and equatorial bulb diameter. Agri Found Dark Red also recorded significantly maximum total and marketable bulb yield which was found at par with Bhima Raj, Gulmohar, Bhima Super, Ceylon and Gourang.

Sharma and Dogra (2017) evaluated four *kharif* onion varieties under five different transplanting times at Chamba, Himachal Pradesh. They observed significant effect of varieties, transplanting dates and their interaction on bulb diameter, bulb weight and yield. Among the varieties Agrifound Dark Red transplanted around second fortnight of August produced the highest bulb yield.

Ketema *et al.* (2018) conducted an experiment at Melkassa Centre of the Ethiopian Institute of agricultural Research for two seasons to investigate the effect of different onion planting methods on growth parameters and canopy development of onion cultivars. The experiment consisted of three planting methods of onion, namely direct seeding to the field, transplanting of seedlings and planting sets, and three onion cultivars (Adama Red, Bombay Red and Nasik Red). The experimental design was split plot with three replications; cultivars were assigned to the main plot and planting methods to sub-plot. Data were collected at 55, 70, 85 and 100 days after planting. Leaf area index were significantly ($P<0.05\%$) higher on sets and transplants at all dates of observation. The correlation analysis results show highly significant ($P<0.001$) association between plant height, leaf area, LAI and shoot fresh and dry weight, with correlation coefficient ranging between 0.89 and 0.99. This indicates that any one of these parameters can be used for yield estimator depending on the condition and the facilities available. Regression analysis of total yield on leaf area index showed stronger dependence at 85 days after planting than the other dates as observed by a higher value of coefficient of determination (R2 = 0.80). This study indicated that planting method has significant effect on the growth and performance of onion cultivars.

Ahmed *et al*. (2020) carried out an experiment at Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October2018 to March 2019 to examine the effects of different bulb size viz.,large size bulb (15±1 g), medium size bulb (10±1 g), small size bulb(7±1 g) on seed production of two onion varieties (Taherpuri and Kalash Nagari). Significant variation observed in both varieties for most of the parameters based on onion bulb size. The variety Kalash Nagari showed better performances compared to variety Taherpuri. After 60 days of planting, Kalash Nagari variety gave the highest plant height (55.07 cm), number of leaves (20.62), stalk length (100.78 cm),and total seed yield (630 kg ha-1), while in Taherpuri plant height, leaf number, stalk length and total seed weight were 32.21 cm, 6.93, 61.47 cm and 270 kg/ha, respectively. Large sized bulb gave better performance compared to small sized bulb. The large sized bulb gave highest plant height (49.83 cm) and highest total seed yield (490 kg/ ha). Medium size bulb gave the seed yield (460 kg /ha) and lowest in small size bulb (390 kg /ha). Seed yield was significantly affected by the combined effects of variety and bulb size.

2.4 Effect of planting dates on chemical quality of onion.

Bajaj *et al.* (1980) analysed the pyruvic acid content of five white and seven red varieties of onion. The range of pyruvic acid content was from 6.18 to 13.27 micro moles/g (fresh wt basis), they reported.

Masthanareddy and Sulikeri (1998) evaluated five onion varieties during summer in Karnataka and they found the cultivar Arka Niketan and Arka Pragathi recorded highest and lowest TSS, respectively.

Masalkar *et al.* (2005) investigated the effect of potash levels (50- 250 kg / ha) and planting seasons (*kharif* and *rabi*) on physico-chemical composition of ‘Phule Safed’ onion variety. They reported that pyruvic acid showed a considerable increase (9.54 µmoles/g) during *rabi* season with application of potash up to 200 kg/ha.

Yoo *et al.* (2006) reported that over 80% of onion pungency depends on genetic factors, while the remaining part is related to external factors, such as the habitat and cultivation practices. According to the sweet onion industry guidelines, onions are classified on the basis of pungency as low pungency / sweet (0–3 μmol / g FW), medium pungency (3–7 μmol / g FW), and high pungency (above 7 μmol / g FW).

Leja *et al.* (2008) stated that the balance between pungency and sweetness results from the volatile sulphur compounds and sugar level. The final taste of fresh onion depends on the mutual relation between carbohydrates and pyruvic acid. They evaluated nutritional composition in bulbs of ten onion cultivars and found that higher level of pyruvate corresponded in most cases with higher sugar content but was not correlated with that of ascorbic acid.

Mahanthesh *et al.* (2009b) tested 13 different onion genotypes for yield and storage qualities during *kharif* season in Karnataka and recorded significant differences in TSS content among the genotypes. They recorded highest TSS in Bellary Red which was at par with Arka Pragati and H -3, while Agrifound Dark Red recorded the minimum TSS.

Dalamu *et al.* (2010**)** observed that in red genotype with highest levels of phenolics, the anti-oxidant activity was roughly threetimes higher than that of commercial white genotype. They reportedrange of pungency levels from 3.12 to 10.48 μmoles pyruvic acid /g. In an experiment under Dharwad condition on genetic diversitystudies in *kharif* onion (*Allium cepa* var. *cepa* L.) with fourteen genotypes,

Dhotre *et al.* (2010) recorded range of total soluble solids of onion bulb from 10.4% to 18.73%. During evaluation of different onion genotypes under West Bengal condition,

Denre *et al.* (2011) observed that pyruvic acid content ranged from 6.86 to 15.33 μmol/g, with an average value of 11.11 μmol/g.

Singh and Bhonde (2011) recorded significantly highest total soluble solids and pyruvic acid content in Agrifound Light Red which was at par with BSS-442 for both the quality parameters. Department of Agriculture & Cooperation, Ministry of

Agriculture, Government of India (2012) recommended onion variety Agrifound Dark Red for *kharif* season, which produces moderately pungent bulb having pyruvic acid content of 10.07 micro mole/g.

Patil *et al.* (2012) reported that the different planting date and genotype had significant effect on Total Soluble Solids (TSS) content of onion under Maharashtra condition. Among the planting dates (15^{th} November, 1^{st} and 15^{th} December, 1^{st} and 15^{th} January) and genotypes ('JWO807', 'JWO605' and 'JWO16B') studied, they recorded highest TSS content in the genotype 'JWO807' with 1^{st} January planting. They also observed that there is inverse correlation between yield and TSS content.

Sharma (2012) studied the effect of planting geometry on growth and yield of four *kharif* onion varieties. He recorded maximum TSS in bulbs of Agrifound Dark Red which was found at par with Bhima Super. Regarding pyruvic acid content in bulbs, he reported that Bhima Red showed highest value followed by Bhima Super and Agrifound Dark Red.

Ashok *et al.* (2013) studied the character association among bulb yield and related traits with ten varieties/lines of onion. They reported significant differences in quality parameters like TSS ranging from 9.1 °Brix (Early Grano) to 14.5 °Brix (Sel 126), total sugar from 7.0 % (Sel 383) to 12.2 % (Sel 126), reducing sugar from 2.1 % (Sel 383) to 3.61 % (Early Grano) and non-reducing sugar from 4.28 % (Early Grano) to 9.94 % (Sel 126).

Dewangan and Sahu (2014a) evaluated 23 genotypes of onion under *kharif* season in Chhattisgarh plains and they recorded the highest total soluble solids in onion variety BKHO- 1007.

Anon (2014) conducted a biochemical diversity study of thirty four onion varieties at Rajgurunagar, Pune, India which revealed that after three months storage, total sugars decreased significantly. They reported that Bhima Kiran recorded highest value of total sugars in fresh bulbs whereas lowest value was found in Palam Lohit after three months storage.

Steen and Benkeblia (2014) studied variation of reducing and total sugars during growth of onion tissues and the data revealed that total and reducing sugars accumulate in the leaves and translocation massively when bulbs formed.

Tripathy *et al.* (2014) observed significant differences in TSS among twenty two onion cultivars during *kharif* season under Odisha condition. They reported that bulbs of the line, Col-652 showed highest TSS which was statistically at par with Bhima Super, NRCRO-1, NRCRO-3, NRCWO- 1, NRCWO-3, NRCWO-4, RO-282, L-28 and PKV White.

Ali *et al.* (2015) evaluated eight varieties of onion (*Allium cepa* L.) at Tunisia. They found the highest value of total soluble sugars content as 4.72% where as the lowest value was 2.62 % they concluded that onion varieties having higher total soluble sugars content could be considered important to human by supplying energy whereas the variety having lowest value would be a better food source at least for diabetic persons

González–Pérez *et al.* (2015) evaluated seventeen onion landraces from North-West Spain and observed that the pyruvic acid content ranged from 1.16 to 8.35 μmol / g FW, with an average value of 4.47 μmol / g FW.

Hirave *et al.* (2015) evaluated eight red onion varieties in *kharif* season under Akola conditions. They observed significant genotypic influence on TSS content of onion bulb. They recorded maximum TSS in Agrifound Dark Red variety which was found at par with the variety Phule Samarth. The increased total soluble solids were due to enhanced physiological activity and availability of nutrients and development of strong source and sink relationship, they assumed.

Kale and Ajjappalavara (2015) analyzed 44 performance of onion genotypes at Haveri (Devihosur), Karnataka during *rabi* season for total soluble solids, dry matter content, pyruvic acid, calcium, fiber, magnesium and vitamin C content. They recorded ranges of TSS of onion bulb from 8.36 °Brix (OG-42) to 22.60 °Brix (OG-3) and the range for pyruvic acid from 4.15 μmoles/g (OG- 24) to 6.10 μmoles/g (OG-3).

Kallai *et al.* (2015) observed that combined effect of gamma irradiation and short storage time up to 64 days had significant impact on increase in pyruvic acid content of both onion and shallot as compared to their non-irradiated ones with better retention of other quality attributes (texture, color) and with no significant losses of nutrients.

Kandoliya *et al.* (2015) studied seven varieties of onion at Junagadh and revealed that pyruvic acid content varied from 1.09 to 1.33 mg /g with the lowest value in GWO-1 and highest in AGFL-Red. They observed that total soluble sugar content varied significantly in the onion varieties raging from 8.2 to 12.2 mg /g on fresh weight basis. In general, total soluble sugars remained higher in red type of onion and reducing sugars also followed the same trend ranged from 2.21 to 3.62 mg /g of fresh tissues, they noted.

Anon. (2016) evaluated seven onion varieties for storability and nutritional changes during storage at Rajgurunagar, Pune, India. This study revealed that pyruvic acid content increased up to 30 days of storage and then started decreasing. In the beginning of storage, pyruvic acid content was maximum in Bhima Shubhra and minimum in Bhima Super. At 90 days of storage, pyruvic acid content was highest in Bhima Red and lowest in Bhima Shubhra.

Navaldey *et al.* (2016) observed significant increase in onion pungency as planting dates progressed from November to January with higher sulphur dose. On the contrary, reducing and total sugar content of the bulb were highest at low sulphur dose applied at early transplanting, while non-reducing sugar was maximum in December transplanting, they reported.

Rohini and Paramaguru (2016) investigated influence of growing season on bulb, seed yield and quality of aggregatum onion (*Allium cepa* var *aggregatum*) under Coimbatore condition. They observed that September planted crop recorded the higher total soluble solids (TSS) content and that was significantly decreased as planting dates progressed from September to December.

Suhas *et al.* (2016) studied the performance of twenty five onion genotypes for growth, yield and quality attributes under eastern dry zone of Karnataka. They concluded that Super Flare and Super Red could be recommended for commercial onion bulb production as they performed extremely well under *kharif* season.

Behera *et al.* (2017a) assessed the growth, yield and quality of twenty four short day onion genotypes under red and laterite zone of West Bengal. They suggested onion cultivars Bhima Shakti and Bhima Shweta along with Sukhsagar to the onion grower of red and laterite zone of West Bengal during *rabi* season for higher productivity.

Behera *et al.* (2017b) studied the growth, yield and quality of twenty four short day onion genotypes under red and laterite zone of West Bengal. They recorded maximum TSS in Sel-126 followed by NHRDF Red 2 and Arka Niketan which were found statistically at par with each other. They noted maximum total sugars in NHRDF Red 3 followed by Sel-126, Pusa Madhavi, Agrifound Light Red, NHRDF Red, Pusa Ridhi, Sukhsagar, Agrifound Dark Red, Bhima Kiran, N53, Bhima Shakti, Superior Light Red, NHRDF Red 2 and Bhima Shweta, which were found statistically at par with each other. Regarding reducing sugar, Bhima Shakti recorded highest value followed by Sukhsagar, Bhima Kiran, Pusa Ridhi, Arka Niketan, NHRDF Red 2, NHRDF Red 3 and Pusa White Round which were found statistically at par with each other.

Das (2017) studied the growth, yield and quality parameters of twelve onion varieties during *rabi* season under Gwalior, Madhya Pradesh, condition and he recorded significant differences in TSS content of the bulbs. He reported that Pusa Red recorded highest TSS.

Anon. (2017) reported that in red *kharif* onion varieties grade and their interaction had significant effect on the biochemical constituents except the pyruvic acid content where only variety had significant effect. However, white varieties had significantly higher pyruvic acid content compared to red varieties with exception in Bhima Dark Red. Analysis of dried skin of these onion varieties revealed that variety colour had significant effect on biochemical content of onion skin. White varieties had significantly lower biochemical constituents compared to red. Pyruvic acid content was significantly more in white varieties (0.023 to 0.024 μmolespyruvat /g) compared to red varieties (0.020-0.021 μmoles pyruvate/g).

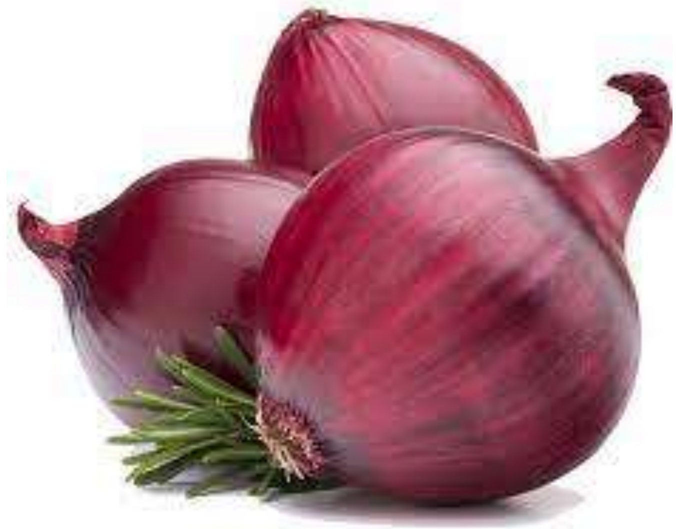
Khan *et al* (2020) a study was conducted by at Spices Research Sub-Centre (SRSC), Bangladesh Agricultural Research Institute (BARI), Faridpur, Bangladesh during the winter season of 2018-2019 to investigate the influences of transplanting times of seedlings and the varieties on the yield and quality of onion bulbs. They reported that insignificantly incensement in Total soluble solid and acidity content from first transplanting to third one and the lower TSS and acidity content of bulbs from earlier transplanting might be due to bearing profuse hard centres. While, the reduced TSS and acidity content from late transplanting was due to occurring rainfall at the maturity stages of bulbs.

2.5 Effect of planting dates on benefit: cost ratio of onion

Singh *et al.* (2011) conducted experiment on "Effect of organic manures and inorganic fertilizers on growth and yield of onion (*Allium cepa* L.) cv. Agrifound Light Red" and reported that the maximum net return up to Rs 72000 per ha was found in RDF application followed by 75% RDF + BF (Rs 64701 ha) and then 75% RDF alone (Rs 59107 ha). The highest B: C ratio obtained by RDF (N100 P60 K50) was 2.45. This was closely followed by 75% RDF + BF (2.33) and then 75% RDF alone (2.21).

Singh *et* al. (2015) conducted farm trials and front line demonstrations during *kharif* 2013–14 and 2014–15 on "Evaluation of Improved Variety of Onion in Kharif Season" at Rajgarh District under Malwa Plateau Zone. Krishi Vigyan Kendra Rajgarh carried out on farm trials and front line demonstrations on different farmer's fields through easily technology adopting farmers. On the basis of all farmer's average results, it indicated that higher yield (161.77 q/ha.) and net monetary return (1,44, 930Rs/ha) of *kharif* onion was obtained under recommended package of practices, which was 22.69% higher as compared to farmer's practices. Where as in farmer's practice, yield of onion was 131.85 q/ha and net profit was 90540 Rs/ha only.

Chapter-III



MATERIALS AND METHODS

Chapter-III

MATERIALS AND METHODS

An investigation entitled **"Performance of onion *(Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting"** was conducted during 2018-2019 and 2019-2020.The experiment was carried out at Horticulture Research Farm of the Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow. This chapter provides a detailed overview of the materials used and the experimental methods adopted during the course of the study. The climatic and edaphic conditions prevailing therein during the crop period have also been presented at an appropriate place with suitable tables and diagrams. Details of the methodologies and materials used in this study are given under the following headings:

3.1 Experimental site:

The field experiment was carried out at the Horticultural Research Farm of the Department of Horticulture, School of Agricultural Science and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow 226025 (UP), India during rabi season. Geographically, Lucknow is located at 26^0 50′ N latitude, 80^0 52′ E longitude and at 123 meters above mean sea level (MSL).

3.2 Climatic and weather conditions

The Lucknow region of Uttar Pradesh has a subtropical climate, as does the majority of the state, with both cold winter and hot summer. District's climate is influenced by the presence of dry air of the continental type throughout the majority of the year. From the end of November to the beginning of March, the cold season persists and from April to June, the hot season is in effect. The climate of the region is subtropical, with summer maximums temperature of 29.3 °C to 45 °C, minimum temperatures of 3.5 °C to 12 °C, and relative humidity (RH) of 50-77% throughout the year. 700 mm of annual rainfall is spread over about 100 days, mainly from July to mid-September, with peak periods occurring between July and August. There are also some showers in winter. Generally, the temperature is between 5 °C and 42 °C. The coldest month of the year is January.

3.3 Edaphic study of experimental site

Following seedling transplantation, a composite soil sample was taken at random from the onion field at the Horticulture Research Farm-up to a depth of 0-15 cm. These samples were completely mixed, dried in the air, and then pulverized before being mixed again. Representative samples of 5 g soil were taken for each analysis and evaluated in the Laboratory of the Regional Research Station of the Central Soil Salinity Research Institute, Lucknow, to assess the soil's original fertility level. The salient data on soil analysis and methods employed are furnished in Table 3.1.

Table 3.1: Physical and chemical properties of soil of experimental field.

A.	**Physical properties of soil**		
Sr. No.	**Soil status**	**Percentage (%)**	**Method of determination**
1	Sand	34.50	Hydrometer meter method (Block, 1965)
2	Silt	50.20	
3	Clay	15.30	
4	Texture class	Sandy loam	Triangular method (Sigmoid, 1928)
B.	**Chemical properties of soil**		
	Component	**Amount**	**Method of determination**
1	Available N_2	110.50 (Kg/ha)	Kjeldahl’s method (A.O.A.C., 1980)
2	Available P_2O_5	40.50 (Kg/ha)	Olsen’s method (Jackson, 1983)
3	Available K_2O	190.40 (Kg/ha)	Flame photometer (Jackson, 1983)
4	Organic carbon	0.12 (%)	Rapid titration method (Jackson, 1983)
5	pH	8.2	Glass electrode, pH meter (Jackson, 1983)
6	E.C (1:1)	0.26	Conductivity meter (Jackson, 1983)
7	E.S.P.	14.80	Conductivity meter (Jackson, 1983)

Meteorological observations:

Meteorological information was recorded at some point of the duration of the experimentation from Indian Institute of Sugarcane Research (IISR), Lucknow, (UP). Observations are presented in Table 3.2.

Table 3.2: Meteorological observation (weekly) during the investigation period (2018-20).

Period		Mean Temperature (^oC)		Relative humidity (%)		Wind velocity (km/hr.)	Rainfall (mm)/annum
Weekly	Date	Max.	Min.	Max.	Min.		
1	27/08/18 to 02/09/18	33.1	25.3	95	78	1.6	22.45
2	03/09/18 to 09/09/18	30.8	24.2	96	85	2.1	20.91
3	10/09/18 to 16/09/18	33.3	24.6	86	61	5.9	0
4	17/09/18 to 23/09/18	33.9	23.4	89	58	3.2	0.65
5	24/09/18 to 30/09/18	34.2	23.1	87	50	3.1	0.028
6	01/10/18 to 07/10/18	33.3	24.6	86	61	5.9	0
7	08/10/18 to 14/10/18	33.9	23.4	89	58	3.2	0
8	15/10/18 to 21/10/18	34.2	23.1	87	50	3.1	0
9	22/10/18 to 28/10/18	33.1	21.1	85	54	2.8	0
10	29/11/18 to 04/11/18	32.2	20.2	86	52	2.5	0
11	05/11/18 to 11/11/18	34.3	22.7	85	53	3.1	0
12	12/11/18 to 18/11/18	29.5	12.7	97	43	2.8	0
13	19/11/18 to 25/11/18	26.5	9.6	83	35	2.5	0
14	26/11/18 to 02/12/18	26.3	7.0	96	34	1.3	0
15	03/12/18 to 09/12/18	27.2	6.5	89	32	1.1	0
16	10/12/18 to 16/12/18	25.1	5.7	85	33	2.2	0
17	17/12/18 to23/12/18	24.2	5.4	78	32	1.2	0
18	24/12/18 to 30/12/18	23.8	4.6	75	31	1.1	0

19	31/12/18 to 07/01/19	22.7	4.9	97	45	1.5	0
20	08/01/19to 14/01/19	22.6	5.8	93	37	1.8	0
21	15/01/19to 21/01/19	22.9	4.5	96	40	2.3	0
22	22/01/19 to 28/01/19	21.8	10.3	90	65	2.0	0.78
23	29/01/19 to 04/02/19	22.3	7.0	94	45	2.7	0
24	05/02/19 to 11/02/19	22.5	9.5	97	58	2.5	2.65
25	12/02/19 to 18/02/19	23.6	10.4	94	53	2.3	0.2
26	19/02/19 to 25/02/19	26.4	11.3	93	42	3.6	0
27	26/02/19 to 04/03/19	23.6	9.5	91	51	2.9	0.82
28	05/03/19 to 11/03/19	27.5	10.9	88	38	4.4	0
29	12/03/10 to 18/03/19	30.5	13.1	78	30	4.1	0
30	19/03/19 to 25/03/19	32.1	15	71	27	5.5	0
31	27/08/19 to 02/09/19	34.7	24.8	92	65	1.4	0.77
32	03/09/19 to 09/09/19	35.1	24.9	90	67	1.5	0.8
33	10/09/19 to 16/09/19	33.8	23.6	94	77	1.7	6.6
34	17/09/19 to 23/09/19	30.2	22.2	96	90	1.3	15.06
35	24/09/19 to 30/09/19	27.8	19.6	97	89	2.0	26.97
36	01/10/19 to 07/10/19	31.0	19.2	95	63	1.3	0.71
37	08/10/19 to 14/10/19	33.1	17.1	95	55	1.3	0
38	15/10/19 to 21/10/19	32.0	16.8	95	58	0.6	0
39	22/10/19 to 28/10/19	30.0	11.6	94	53	1.3	0
40	29/10/19 to 04/11/19	30.0	15.2	94	55	1.2	0
41	05/11/19 to 11/11/19	29.5	14.9	92	53	1.8	0
42	12/11/19 to 18/11/19	29.4	13.0	90	38	1.9	0
43	19/11/19 to 25/11/19	27.7	11.9	94	44	2.1	0
44	26/11/19 to 02/12/19	26.5	12.5	97	55	1.4	0

45	03/12 19 to 09/12/19	24.9	8.2	96	44	1.2	0
46	10/12/19 to 16/12/19	22.2	10.4	96	63	1.5	3.08
47	17/12/19 to 23/12/19	17.9	7.9	93	67	3.2	0
48	24/12/19 to 30/12/19	15.2	5.7	92	66	2.1	0
49	01/01/20 to 07/01/20	20.4	8.3	95.4	55.3	1.9	0.65
50	08/01/20 to 14/01/20	17.7	7.1	96.7	72.3	2.5	1.74
51	15/01/20 to 21/01/20	17.7	10.2	98.7	87.6	2.0	9.68
52	22/01/20 to 28/01/20	20.8	6.6	93	49.7	3.1	0
53	29/01/20 to 04/01/20	22.3	7.2	92.1	50.4	3.6	0
54	05/02/20 to 11/02/20	22.9	5.3	92.9	73.6	2.1	0
55	12/02/20 to 18/02/20	25.6	9.5	88.1	36.1	4.3	0
56	19/02/20 to 25/02/20	26.5	12.1	93.4	57.6	2.5	1.31
57	26.02/20 to 04/03/20	26.7	12.7	95.8	51.5	1.9	0.2
58	05/03/20 to 11/03/20	26.3	13.2	89	55.3	4.1	3.54
59	2/03/20 to 18/03/20	27.0	14.0	89.4	57.9	2.5	2.57
60	19/03/20 to 25/03/20	31.2	16.5	87.7	36.9	2.7	0
61	26/03/20 to 01/04/20	31.8	18.1	74.9	35.4	7.4	0.68

3.4. Soil status of experimental area:

The soil in the experimental field is sandy loam that is slightly alkaline in character, with a pH of 8.2. Table 3.1 showed the physical and chemical properties of soli.

3.5 Experimental details

The experimental details are listed under the following headings:

3.5.1 Design and layout

The experiment used a Factorial Randomized Block Design with 16 main plots that were replicated three times.

3.5.2 Treatment details

There were two factors comprising 8 dates of transplanting (factor A) and 2 varieties (factor B).

Details of experiment:

Crop	:	Onion (*Allium cepa* L.)
Cultivars	:	(i) Agrifound Dark Red (ii) L- 883
Experimental design	:	Factorial RBD (Two factors)
Factor 1	:	Date of transplanting (Eight)
Factor 2	:	Variety (Agri Found Dark Red, L-883)
Number of treatments	:	16
Number of replication	:	3
Total number of plots	:	48
Row to row distance		15 cm
Plant to plant distance	:	10 cm
Net plot size	:	1.95 m X 2 m
Gross plot size		2.20 m X 2.25 m
Length of field	:	22 meter
Width of field	:	9 meter
Total area	:	22 m X 9 m= 198 m^2

Treatment combination

Sl. No.	Symbol	Treatment code	Treatment combinations (Date of transplanting + Variety)
1	T_1	D_1V_1	Transplanting on 30th August + Agrifound Dark Red
2	T_2	D_1V_2	Transplanting on 30th August + L- 883
3	T_3	D_2V_1	Transplanting on 10th September + Agrifound Dark Red
4	T_4	D_2V_2	Transplanting on 10 September + L- 883
5	T_5	D_3V_1	Transplanting on 20th September + Agrifound Dark Red
6	T_6	D_3V_2	Transplanting on20th September + L- 883
7	T_7	D_4V_1	Transplanting on 30th September + Agrifound Dark Red
8	T_8	D_4V_2	Transplanting on 30th September + L- 883
9	T_9	D_5V_1	Transplanting on 10th + October Agrifound Dark Red
10	T_{10}	D_5V_2	Transplanting on 10th October + L- 883
11	T_{11}	D_6V_1	Transplanting on 20th October + Agrifound Dark Red
12	T_{12}	D_6V_2	Transplanting on 20th October + L- 883
13	T_{13}	D_7V_1	Transplanting on 30th October + Agrifound Dark Red
14	T_{14}	$D7V_2$	Transplanting on 30th October + L- 883
15	T_{15}	D_8V_1	Transplanting on 10th November + Agrifound Dark Red
16	T_{16}	D_8V_2	Transplanting on 10th November + L- 883

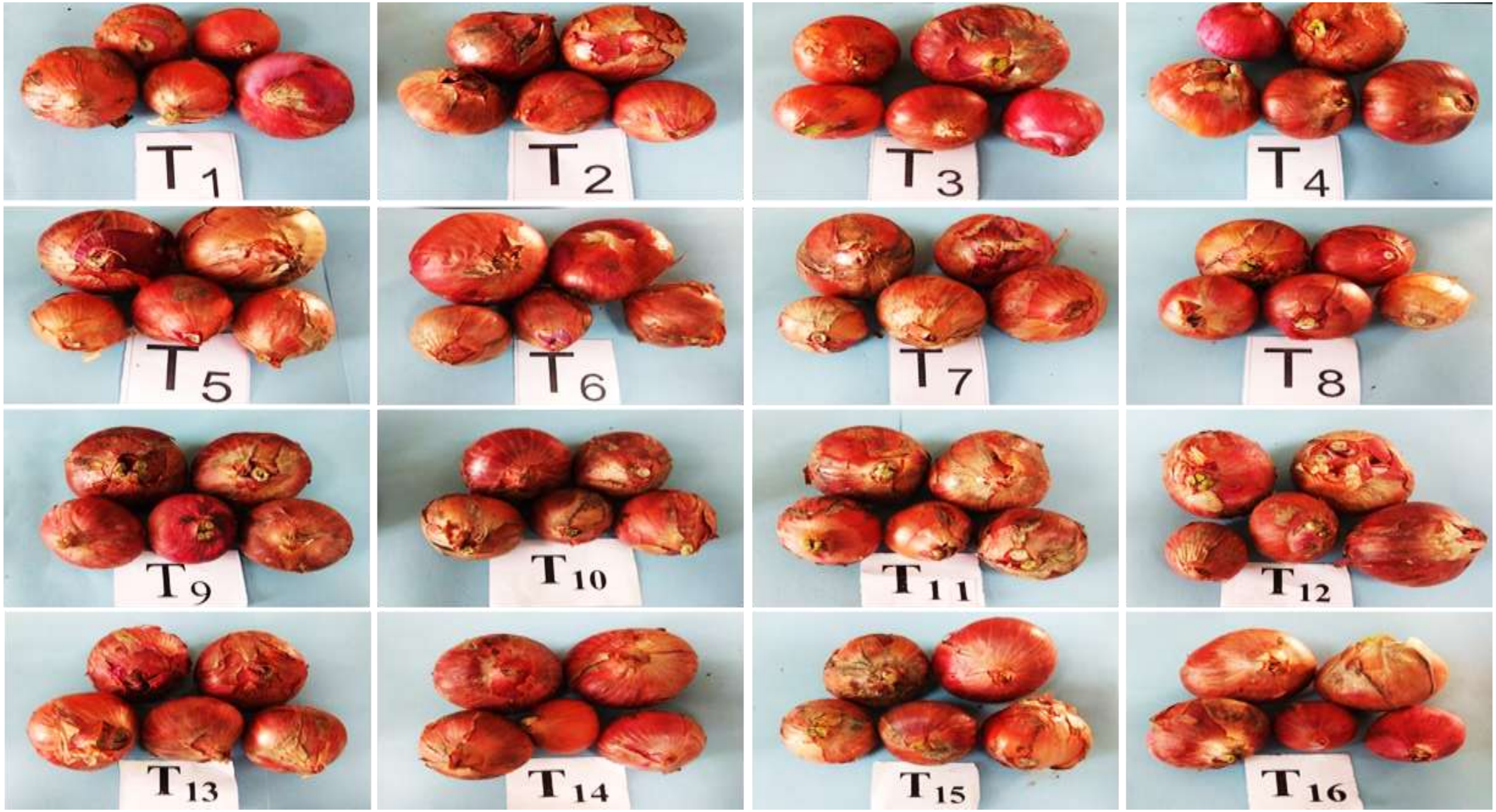


Plate 1: A general view of treatment details

3.6 Spacing

The seedlings were transplanted at standardized spacing of 15cm x 10cm.

3.7. Planting materials

In the current study, the onion cultivar Agri Found Dark Red has a dark red bulb, has globular spherical bulb, a size of 4-6 cm, a tight skin, and has a fairly pungent odour. After transplantation, the crop matures around 90-100 days. Bulbs have 11-12^{0}B total soluble solids, 13-14 percent dry matter, and an average yield of 300q/ha. The Government of India has approved it for cultivation during the *kharif* season. In case of L-883, bulbs are dark red in colour with shiny skin, round in shape and 4.50 – 5.50 cm in diameter. The crop matures in 85-90 days after transplanting. In the case of direct seeding, maturity comes after 80-85 days. Bulbs contain 12-13 ^{0}B TSS, 13-14% dry matter and it gives an average yield of 300-325 q/ha.The line is recommended for cultivation in *kharif* and early *kharif* seasons. The variety also has a good keeping quality. Seeds were collected from the Seed Production Unit of the National Horticultural Research and Development Foundation (NHRDF), Deoria Centre, U.P.

3.8 Cultural operations

3.8.1 Land preparations

A piece of land measuring 22 m in length and 9 m in width was at the experimental farm of Babasaheb Bhimrao Ambedkar, University. After crushing the clods, the field was ploughed three times, harrowed and has leveled appropriately. The plots were then placed out according to the experiment's plan.

3.8.2 Nursery raising and transplanting

Onion seeds were planted in nursery beds to grow seedlings for transplantation into the main field. 10 days before seed sowing fine and fully decomposed farmyard manures were mixed with soil at a rate of 3-4 kg/m^2. To avoid damping off, the seeds were treating with thiram at a rate of 2g/kg of seeds prior to sowing. Seeds were sown in lines 5 cm apart and coated with finely sieved compost before being lightly watered with a rose can. The seed beds were covered with straw until seed germination occurred, and water was poured on a daily basis. Carbendazim was applied to seedlings twice, 15 days and 30 days after sowing, at a rate of 2 g/liter of water.

Nursery of the crop was raised at Horticulture Research Farm under the shade net house to protect the seedlings from high sunlight and heat intensity. Seed beds of 3.0m x 1.0m were prepared and were properly sterilized by drenching with fungicide (Captan @ 5 g/lit. of water) to protect the seedlings from soil born diseases. Seeds were sown on eight different dates, namely on 1^{th} July, 10^{th} July, 20^{th} August, 30^{th} August, 10^{th} August, 20^{th} September, 30^{th} September, in single bed followed by transplanting at eight different dates *i.e.* on 30 August, 10^{th} August, 20^{th} August, 30th August, 10^{th} September, 20^{th} September, 30^{th} September, 10^{th} November, Seedlings were transplanted after two months of seed sowing.

The experimental land was prepared by repeated ploughing and clearing the weeds followed by harrowing and leveling. The soil was then pulverized to make it loose and friable condition. Whole weeds and stubbles were removed. The field was properly leveled and divided by the irrigation channels into 48 plots of 1.95 m x 2 m size. The experiment, which included 16 treatment combinations, was set up in a factorial randomized block design with three replications and was assigned to all plots at random. FYM @ 25 t/ha was applied 10 days before transplanting. The seedlings were transplanted in the main field in the afternoon hours when they were 45 to 50 days old.

3.8.5 Irrigation

When necessary, the experimental area was irrigated. Just after transplanting, a light irrigation was given. There after the field is regularly irrigated at interval about 10-15 days. All the irrigation was very light. The irrigation was ceased 15 days before harvesting.

Plate 2: Preparation of nursery bed

Plate 3: Sowing of seed in nursery bed

Plate 4(A)

Plate 4(A) and 4(B) : A general view of onion seedlings ready for transplanting

Plate 5: Preparation of main field

Plate 6: Transplanting in main field during August

3.8.6 Fertilizer application

FYM (20 t/ha) was incorporated into the field during field preparation. Each treatment received a recommended dose of NPK (120:60:80 kg/ha) in the form of urea, single super phosphate, and muriate of potash. At the time of final field preparation, one-third of the nitrogen dose, full doses of phosphate and potash were applied as a basal dose, while two-thirds of the nitrogen dose was applied in two-split doses at one month intervals.

3.8.7 Gap filling

Even after complete care in the field, about 2% of mortality was observed, especially on the first date of transplanting. The seedlings, which could not perform well, were replaced by the new healthy ones to ensure optimum plant population.

3.8.8 After care

Six hand weedings were performed to keep the plots weed-free, and other plant protection measures were implemented during the experiments in accordance with the package of practices.

3.8.9 Harvesting

Bulbs were pulled out of each plot of different treatments at the neck-fall stage after complete development of the bulbs. The bulbs were separated from the rest of the plant and carefully dried in the shade. Starting of dry appearance of leaves from tip indicated maturity indices for *kharif* onion.

3.9 Observations recorded

Ten plants was chosen at random and tagged in each plot to collect data on various factors. Before and after harvesting, the observations on the following traits were recorded.

3.10 Vegetative growth parameters

3.10.1 Plant height (cm)

3.10.2 Number of leaves/plant

3.10.3 Leaf length (cm)

3.10.4 Neck thickness (mm)

3.11. Yield parameters

3.11.1 Days to harvesting of bulbs (days)

3.11.2 Average fresh weight of bulb (g)

3.11.3 Average weight of bulb after curing (g)

3.11.4 Yield per plot (kg)

3.11.5 Yield per ha (q)

3.12 Morphological characteristics of bulb

3.12.1 Length of bulb (cm)

3.123.2 Bulb equatorial diameter (mm)

3.12.3 Bulb polar diameter (mm)

3.12.4 Number of fresh scales/bulb

3.12.5 Dry matter content (%)

3.13 Chemical quality parameters

3.13.1 TSS (^{0}Brix)

3.13.2 Ascorbic acid (mg/100g)

3.13.3 Total sugars (%)

3.13.4 Reducing sugar (%)

3.13.5 Non- reducing sugar (%)

3.13.6 Titratable acidity (%)

3.13.7 Sulphur content (%)

Plate 7: A general view of experimental field

Plate 8: Ready to harvesting

3.14 Calculation of Benefit: cost ratio

3.14.1 Plant height (cm)

The height of random selected plants was measured from the ground level of the plant at 30, 60, 90, and 120 days after transplanting (DAT) using a measuring scale, and the average height of these plants was computed and the mean results were finally reported in centimeters.

3.14.2 Number of leaves per plant

Total number of leaves of each selected plants under various treatments were recorded at 30, 60, 90 and 120 DAT by counting them manually and the average was calculated for further statistical analysis and reporting.

3.14.3 Leaf length (cm)

The leaf lengths of the studied plants were measured using measuring tape at 30, 60, 90, and 120 DAT and expressed as centimeters.

3.14.4 Neck thickness (cm)

Neck thickness was measured at 30, 60, 90 and 120 DAT by using Digital Vernier Calipers (Mitutoyo Corporation Model) and the means were expressed in cm.

3.14.5 Number of day taken for bulb formation (days)

Numbers of day taken for bulb formation from days of transplanting were calculated and expressed as days.

3.14.6 Number of day taken to maturity (days)

The stage of maturity was determined on random selected plants from each plot and observations were taken very carefully. The maturity of bulb under different treatments was differed and after necessary records was maintained. It was worked out in days after transplanting till the fifty per cent neck fall were recorded as number of days required for maturing the bulb. However, in *kharif* onion starting of dryness of leaf tip indicated maturity.

3.15 Physical quality of bulbs chemical quality of bulb

3.15.1 Volume of bulb (ml)

This was measured by water displacement method.

3.15.2 Number of fresh scales/bulb

The sampling onion bulbs were cut horizontally with a sharp knife, and the number of fresh scales was counted.

3.15.3 Bulb length (cm)

After harvesting, the polar lengths of the 10 bulbs were measured with Digital Vernier Calipers, and the means were calculated and expressed in cm.

3.15.4 Bulb diameter (cm)

After harvesting, the equatorial and polar diameters of the 10 bulbs were measured using Digital Vernier Calipers, and the means were calculated and provided in cm.

3.15.5 Bulb size (cm)

The size of each of the ten single bulbs was recorded, and the average of the ten bulbs was represented as mean bulb size cm.

3.15.6 Bulb weight (g)

Weight was obtained from ten separate bulbs, and the average of ten bulbs was expressed as mean bulb weight (g) as fresh weight.

3.15.7 Bolting percentage (%)

The percentage of plants that bolted was calculated based on the total number of plants in each plot.

3.15.8 Yield per plot (kg)

The bulbs from the net plot were dug out, and the weight of five bulbs from each plot was recorded and expressed in kg per hectare.

3.15.9 Total yield per hectare (q/ha)

The yield per plot were computed in total yield per hectare was expressed in q/ha. Marketable yield per hectare was computed after taking weight after short curing, it was further calculated by deducting > 20% production area due to road irrigation channel etc.

3.16 Bio-chemical parameters

Onion bulb samples were analyzed for the biochemical parameters after harvesting.

3.16.1 Total soluble solids (TSS ^{0}Brix)

The TSS content in the juice of onion bulb of different treatment was recorded with the help of digital refractometer. (model)The digital refractometer was set at zero with distilled water. A small amount of onion juice was taken in moist muslin cloth. A drop of juice of the crusted onion bulb was taken on the refractometer and the value was read against light. Values thus obtained were explained in ^{0}Brix (AOAC, 2000).

3.16.2 Ascorbic acid (mg/100g)

The ascorbic acid in fresh bulb juice of onion was estimated by using 2, 6-Dichloro-Indophenol dye by visual titration method (Ranganna, 2007). 1. Indophenols dye: 0.04%, weight 40 mg sodium 2, 6-dichlorophenolindophenol was taken. 150 ml of hot distilled water was added. Then 42 ml sodium bicarbonate was added. The contents were cooled and 200ml volume makeup with water and kept in refrigerator.

2. Metaphosphoric acid: 3%, 30g MPA was dissolved in water and volume make-up to 1000ml.

3. Standard ascorbic acid: 100mg ascorbic acid was dissolves in 100ml of oxalic acid. 10ml was added with MPA (1ml=0.mg ascorbic acid)

Standardization of dye:

5ml ascorbic acid and 5ml HPO3 were added. Dye was placed in the micro burette. Titrated against dye solution to achieve a pale pink colour and titration value and dye factor (dye equivalents) was calculated.

Dye equivalents =0.5/Titer value

Preparation of sample

10g of sample was taken and 3% MPA was added to make volume 100ml. thoroughly mixed in case of solids or and filtered. Centrifuge when it was needed.

Procedure

A 10ml sample was obtained, and the filtrate was titrated against the dye sodium 2, 6 dichlorophenol indophenol. Titer readings were taken.

Calculation

$$\textbf{Ascorbic acid (mg/100g)} = \frac{\textbf{Titer} \times \textbf{dye equivalent.} \times \textbf{dilution} \times \textbf{100}}{\textbf{Weight of sample}}$$

Analysis for Total sugars, Reducing sugar & Non reducing sugar

a) Total sugars (%)

Flow sheet for estimation of sugars

↓

Sugar weight to (90.g)

↓

Crush to take

↓

Add 5 ml conc. HCl+ Distil water

↓

Heat > 30 min

↓

Cool to room temperature

↓

Neutralized to pH 7.0

↓

Volume makeup

↓

Filter

↓

10 ml was taken in 250 ml flask

↓

About 100 ml water was taken

↓

1drop of phenolphthalein indicator was added

↓

25 ml (43%) lead acetate solution was added

↓
Kept for 30 minutes
↓
25 ml (20%) potassium oxalate was added
↓
Volume makeup up to 250 ml
↓
Filtered through Whatman filter paper no.4
↓
Titrated against Fehlings A & B solution
↓
Adding methyl blue indicator under heat brick red precipitation indicated end point.

$$\textbf{Total sugars (\%)} = \frac{\textbf{Factor} \times \textbf{dilution}}{\textbf{Titer} \times \textbf{weight of sample}} \times \textbf{100}$$

b) Reducing sugar (%)

Reducing sugar was the measured through following flowchart.

20 ml in 250 ml flask was taken
↓
About 100 ml water was added
↓
1 drop of phenolphthalein indicator was added
↓
25 ml (43%) lead acetate solution was added
↓
Kept for 30 minutes
↓
25 ml (20%) potassium oxalate solution was added
↓
250 ml volume makeup
↓
Filtered through Whatman filter paper no 4
↓
Reducing sugar
↓
Filtrate was titrated against 10 ml Fehling's solution A &B using methylene blue indicator and the volume of sugar solution used was recorded

Calculations

$$\textbf{Reducing sugars (\%)} = \frac{\text{Factor } (0.052) \times \text{dilution}}{\text{Titer} \times \text{weight of sample}} \times 100$$

C. Non Reducing sugar (%)

Non –reducing sugar is the measured in three samples with the help of numerical formula in the reducing sugar and total sugar.

Non –reducing sugar (%) = (Total sugars- reducing sugar) × 0.95

3.17 Analysis of various elements present in onion through SEM

Scanning Electron Microscopy (SEM) was calculated at the BBAU's University Science Instrumentation Centre (USIC). Attempts to adapt IR technology to biology date back to the 1910s, when the use of IR spectroscopy for biological sample analysis was first proposed. By the late 1940s, the technique had been effectively applied to the study of materials, and IR spectroscopy has since become a widely used tool for the characterization of bimolecular.

Collection of plant materials

The onion bulbs were collected from the plants which are harvested from the field experiment.

Preparation of the plant materials

The onion bulbs were shade dried at room temperature in a clean environment for 14 days before being ground in a household grinder. After 40 days, the forests were maintained in over drier at 50^0 degrees Celsius for 4-5 hours. The powered samples were kept at room temperature in airtight glass vials for subsequent examination.

Final sample preparation

The materials are ground again with a mortar and pestle to obtain a fine powder. The powdered plant material is mixed with fully dried potassium bromide (1/100 ratio), and the mixture is subjected to a pressure of 5 × 106 Pa in a vacuum mold to form Kbr pellets for use in the FTIR spectrometer.

Scanning Electron Microscopy analysis

Scanning Electron Microscopy (SEM) Analysis of Synthesized Sulphur NanoparticlesThe Scanning Electron Microscopy (SEM) analysis of the synthesized sulphur nanoparticles was done using a Quanta SEI 450 SEM machine at 15kV, with the magnifications at 5.000 and 10.000x.

3.18 Statistical analysis

The statistical analysis of the data gathered in the various sets of experiments was calculated in the manner proposed by Panse and Sukhantme (1985).The standard error (SEm±) for the difference of treatments means were computed as follows:

a) **SEm ± = √EMSS/V**
Where,
EMSS is error mean sum of squares
r = Total number of experimental units / Levels of factor

b)

$$CD = t\ \frac{\sqrt{2EMSS}}{r}$$

Where,
t (5%) = value from (±) table (Fisher's table) for error degree of freedom at 5% of lavel.

E- Economic analysis

Treatment-specific input and output costs were computed using current market prices, and other economic indicators such as net return and cost benefit ratio were calculated.

Cost of cultivation:

The cost of cultivation (Rs. per hectare) of an onion crop was computed using the local market price of various inputs used in production.

Gross income:

Using the on farm market price, the monetary return of onion bulb yield was calculated in rupees. The gross income (Rs. per hectare) was calculated by adding the monetary value of the onion bulb. Gross income (Rs. per hectare) is bulb yield (q per hectare) multiplied by price (Rs per quintal).

Net return:

The net return (Rs. per hectare) of each treatment was computed by subtracting the cost of cultivation from the specific treatment's gross income.

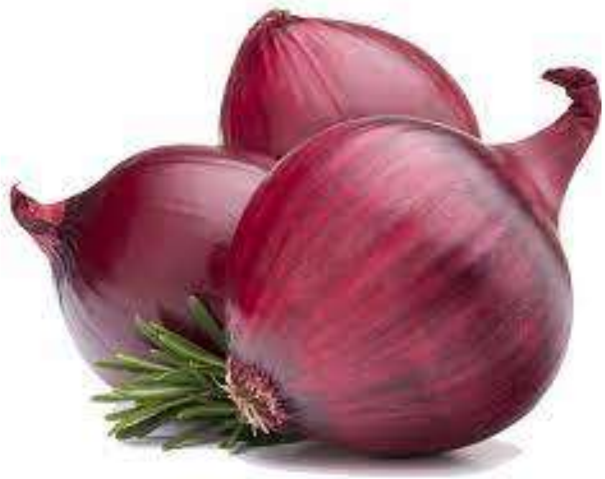
Net return= Gross income (Rs) - cost of cultivation (Rs)

Benefit: cost ratio

The benefit: Cost ratio (B: C) was worked out by dividing the net return of a treatment by the expenditure incurred. Benefit: Cost ratio for each treatment was calculated by using the following formula.

$$\text{B:C ratio} = \frac{\text{Net return obtained (Rs/ha)}}{\text{Expenditure incurred (Rs/ha)}}$$

Chapter-IV



RESULTS AND DISCUSSION

Chapter- IV

RESULTS AND DISCUSSION

4.1 Results

This chapter deals with the experimental findings obtained during the course of investigations. The experiments were conducted as per methods elaborated in the preceding chapter of materials and methods The experiment involved eight transplanting dates, namely the 30th of August, 10th September, 20th September, 30th September, 10th October, 20th October, 30th October, and 10th November during 2018-19 and 2019-20, transplanted two cultivars (Agrifound Dark Red and L-883) laid out in a factorial randomized block design. The response of the onion varieties to different treatments has been illustrated by using tables and graphs in appropriate places in this chapter.

4.1.1. Effect of dates of transplanting and varieties on plant height of *kharif* onion (30, 60, 90 & 120 DAT)

The data of plant height are presented in Table 4.1 and graphically illustrated in Fig. 4.1 the both year of investigation (2018-19 and 2019-20) showed that the plant height at 30 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

This is clear from Table 4.1 that at 30 DAT, the maximum plant height (22.43 cm and 22.39 cm) during 2018-19 and 2019-20 respectively was recorded under the moderate transplanted date D_4. It was followed by transplanted date D_3 (21.47 cm and 21.22 cm) and D_6 (22.39 cm and 22.31 cm) while, the minimum plant height (19.62 cm and 19.67 cm) was recorded under the early transplanted date D_1during the both years of investigation (2018-19 and 2019-20).

In case of two varieties data showed that the maximum plant height (21.37 cm and 21.23 cm during 2018-19 and 2019-20, respectively) was recorded with the cultivar V_2 and minimum plant height was recorded under the cultivars V_1 (20.83 cm and 20.65 cm during 2018-19 and 2019-20).

The interaction effect between dates of transplanting and cultivars were noted significant on plan height at 30 DAT. The treatment D_4 xV_2 produced significantly tallest plant (24.42 cm during 2018-19 and 23.64 cm during 2019-20). However, the lowest plant height (20.62 cm during 2018-19 and 20.23 cm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of data showed that during the first year of the experiment, height of plant was marginally higher than the second year.

As mentioned in Table 4.1 and Fig. 4.2 that at 60 DAT, plant height was significantly influenced by different dates of transplanting and varieties. At 60 DAT, the maximum plant height (32.09 cm and 31.78 cm) during first and second year, respectively was recorded under the transplanting date D_4.Followed by transplanting date D_3 (30.81cm and 30.46 cm) and D_6 (31.57 cm and 31.24 cm) while, the minimum plant height (30.23 cm and 29.85 cm) was recorded under the early transplanting date D_1during both years of investigation (2018-19 and 2019-20).

Data showed that the maximum plant height (31.33 cm and 30.48 cm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and minimum plant height was recorded under the cultivars V_1 (30.75 cm and 29.96 cm during 2018-19 and 2019-20).

The interactive treatment D_4 x V_2 produced significantly tallest plant (33.19 cm during 2018-19 and 32.74 cm during 2019-20). However, the smallest plants (30.56 cm during 2018-19 and 30.10cm during 2019-20) where observed under D_1 x V_2.

similar pattern was also observed at 90 DAT where, the maximum plant height (51.82 cm and 51.77 cm) was recorded when plants were transplanted on (D_4) followed by transplanting date D_3 (50.35 cm and 50.14 cm) and D_6 (51.34 cm and 51.33 cm) while, the minimum plant height (49.53 cm and 49.56 cm) was recorded under the early transplanting date D_1 during 2018-19 and 2019-20 respectively). (Table 4.2 and Fig. 4.3)

Variety V_2 showed that the maximum plant height (50.93 cm and 50.96 cm during 2018-19 and 2019-20) was recorded with the cultivar V_2 and minimum plant height was recorded under the cultivar V_1 (50.22 cm and 50.28 cm during 2018-19 and 2019-20).

The combined treatment $D_4 x V_2$ produced significantly tallest plant at 90 DAT (53.19 cm during 2018-19 and 53.88 cm during 2019-20). However, the lowest plant height (51.93 cm during 2018-19 and 50.76 cm during 2019-20) was recorded under D_1 xV_2. Significant effect of dates of transplanting and varieties was also observed on plant height at 120 DAT.

Whereas, at 120 DAT the maximum plant height (66.75 cm and 66.93cm) was recorded under the transplanting date D_4 (Table 4.2 and Fig. 4.4). It was followed by transplanted date D_3 (64.07 cm and 63.96 cm) and D_6 (66.65 cm and 66.49 cm) while, the minimum plant height (62.40 cm and 62.22 cm) was recorded when early transplanting was done D_1 during the both years of investigation (2018-19 and 2019-20).

In term of performance of varieties the presented data at 120 DAT showed that the maximum plant height (65.80 cm and 65.36 cm during 2018-19 and 2019-20) was recorded with the cultivar V_2 and minimum plant height was recorded under the cultivars V_1 (64.98 cm and 64.69 cm during 2018-19 and 2019-20).

Interaction effect of date of transplanting and varieties D_4 xV_2 showed significantly highest plant height (68.78 cm during 2018-19 and 67.98 cm during 2019-20). However, the lowest plant height (63.60 cm during 2018-19 and 63.83 cm during 2019-20) was recorded under D_1 x V_2. A comparative analysis of data showed that the first year of the experiment, height of plant was higher in first year of experiment as compared to second year.

Table 4.1: Effect of dates of transplanting and varieties on plant height of *kharif* onion.

Variety / Dates of transplanting	Plant height (cm) at 30 DAT							Plant height (cm) at 60 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1- 30th August	18.63	20.62	19.62	19.27	20.23	19.75	19.67	29.90	30.56	30.23	28.46	30.10	29.28	29.85
D_2-10th September	19.77	21.53	20.65	19.66	21.68	20.67	20.66	30.71	31.13	30.92	29.51	30.58	30.04	30.57
D_3-20th September	21.33	21.60	21.47	20.94	20.74	20.84	21.22	30.60	31.03	30.81	29.76	30.11	29.94	30.46
D_4-30th September	20.44	24.42	22.43	21.02	23.64	22.33	22.39	30.99	33.19	32.09	29.88	32.74	31.31	31.78
D_5-10th October	21.30	19.71	20.50	22.08	21.33	21.71	20.98	30.80	31.56	31.18	30.16	30.05	30.10	30.75
D_6- 20th October	23.33	21.45	22.39	22.92	21.45	22.19	22.31	31.73	31.41	31.57	31.40	30.09	30.75	31.24
D_7- 30th October	19.78	20.34	20.06	19.78	20.34	20.06	20.06	30.82	30.98	30.90	29.99	30.34	30.17	30.61
D_8- 10th November	22.09	21.26	21.68	19.53	20.44	19.99	21.00	30.47	30.75	30.61	30.53	29.80	30.16	30.43
Mean	20.83	21.37		20.65	21.23			30.75	31.33		29.96	30.48		
SEm (±)	D	0.33			0.28				0.27			0.31		
	V	0.17			0.14				0.13			0.15		
	D×V	0.47			0.40				0.39			0.43		
CD (P= 0.05)	D	0.96			0.82				0.80			0.89		
	V	0.48			0.41				NS			0.45		
	D×V	1.36			1.16				1.13			1.26		

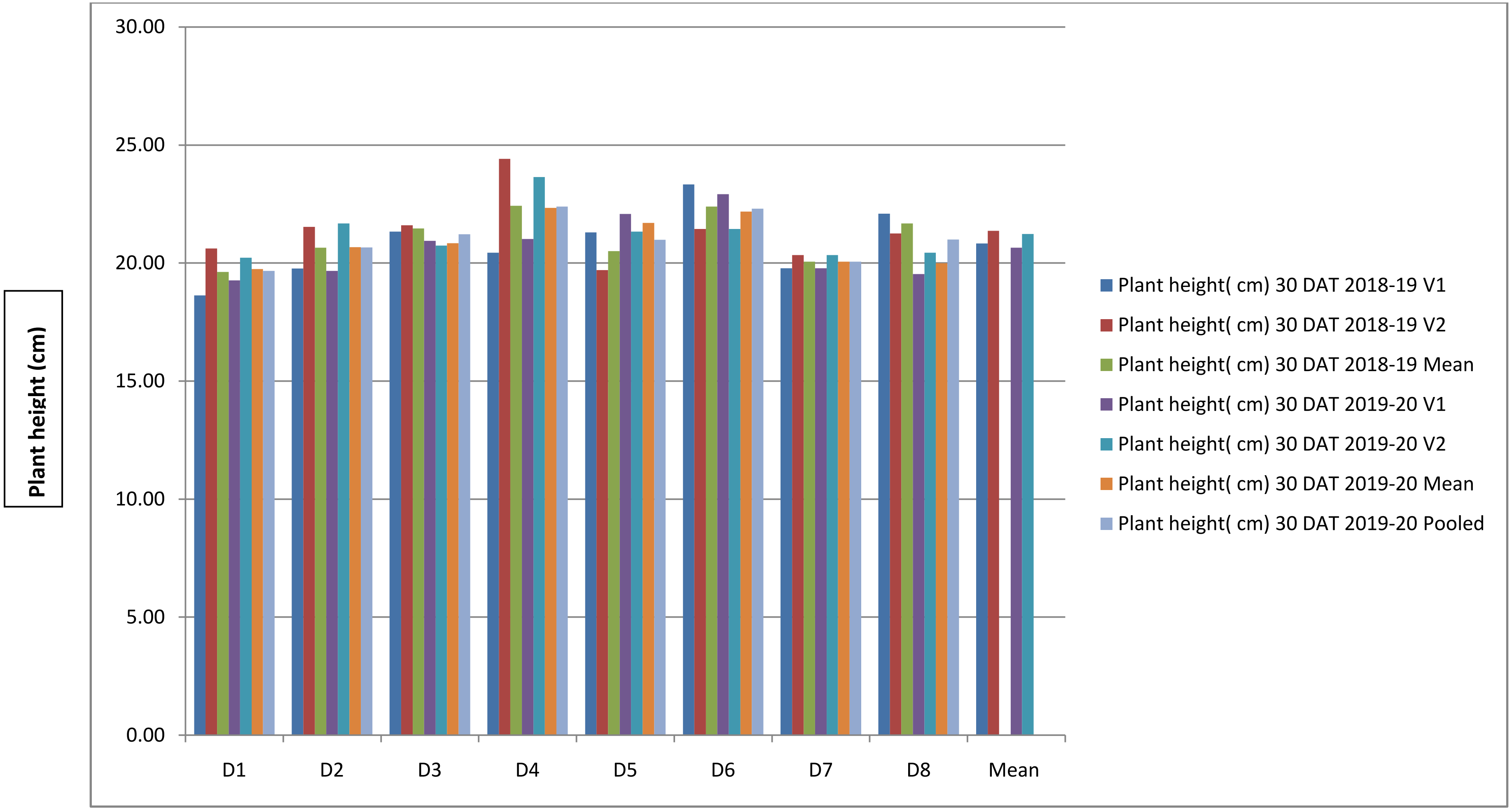


Fig 4.1: Effect of dates of transplanting and varieties on plant height of *Kharif* onion at 30 DAT.

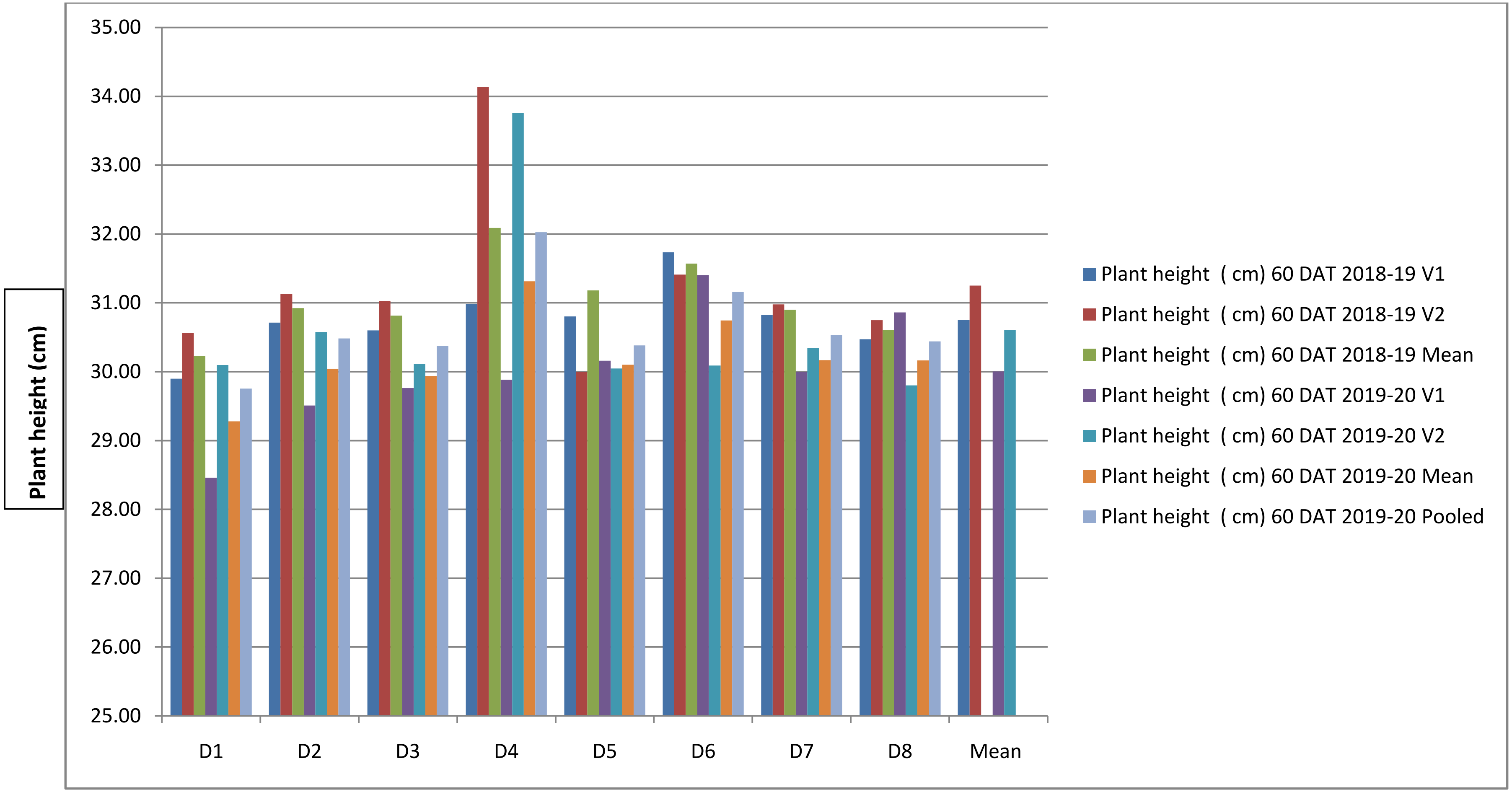


Fig 4.2: Effect of dates of transplanting and varieties on plant height of *Kharif* onion at 60 DAT.

Plate 9: Collection of data in experimental field

Plate 10: A general view of collection of data of trial crop in experimental field

Table 4.2: Effect of dates of transplanting and varieties on plant height of *kharif* onion.

Variety / Dates of transplanting	Plant height (cm) at 90 DAT							Plant height (cm) at 120 DAT						
	2018-19			2019-20				2018-19			2019-20			Pooled
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**		**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	
D_1- 30th August	47.14	51.93	49.53	48.45	50.76	49.60	49.56	61.20	63.60	62.40	60.08	63.83	61.95	62.22
D_2- 10th September	50.54	49.24	49.89	49.40	51.26	50.33	50.07	64.74	66.05	65.40	63.71	65.99	64.85	65.18
D_3- 20th September	50.41	50.28	50.35	50.00	49.68	49.84	50.14	64.85	63.29	64.07	63.59	64.01	63.80	63.96
D_4- 30th September	50.45	53.19	51.82	49.50	53.88	51.69	51.77	64.72	68.78	66.75	66.42	67.98	67.20	66.93
D_5- 10th October	51.44	50.78	51.11	50.98	51.20	51.09	51.10	66.18	65.94	66.06	65.86	64.11	64.99	65.63
D_6- 20th October	52.31	50.38	51.34	52.63	49.98	51.30	51.33	67.04	66.25	66.65	66.91	65.63	66.27	66.49
D_7- 30th October	50.33	51.45	50.89	50.59	51.01	50.80	50.85	65.70	66.27	65.98	65.70	65.77	65.74	65.88
D_8- 10th November	49.15	50.23	49.69	50.65	49.96	50.31	49.94	65.44	66.20	65.82	65.24	65.59	65.41	65.66
Mean	50.22	50.93		50.28	50.96			64.98	65.80		64.69	65.36		
SEm (±)	D	0.30			0.29				0.44			0.42		
	V	0.15			0.14				0.22			0.21		
	D×V	0.43			0.40				0.63			0.59		
CD (P= 0.05)	D	0.88			0.83				1.29			1.22		
	V	0.44			0.42				0.65			0.61		
	D×V	1.25			1.17				1.82			1.72		

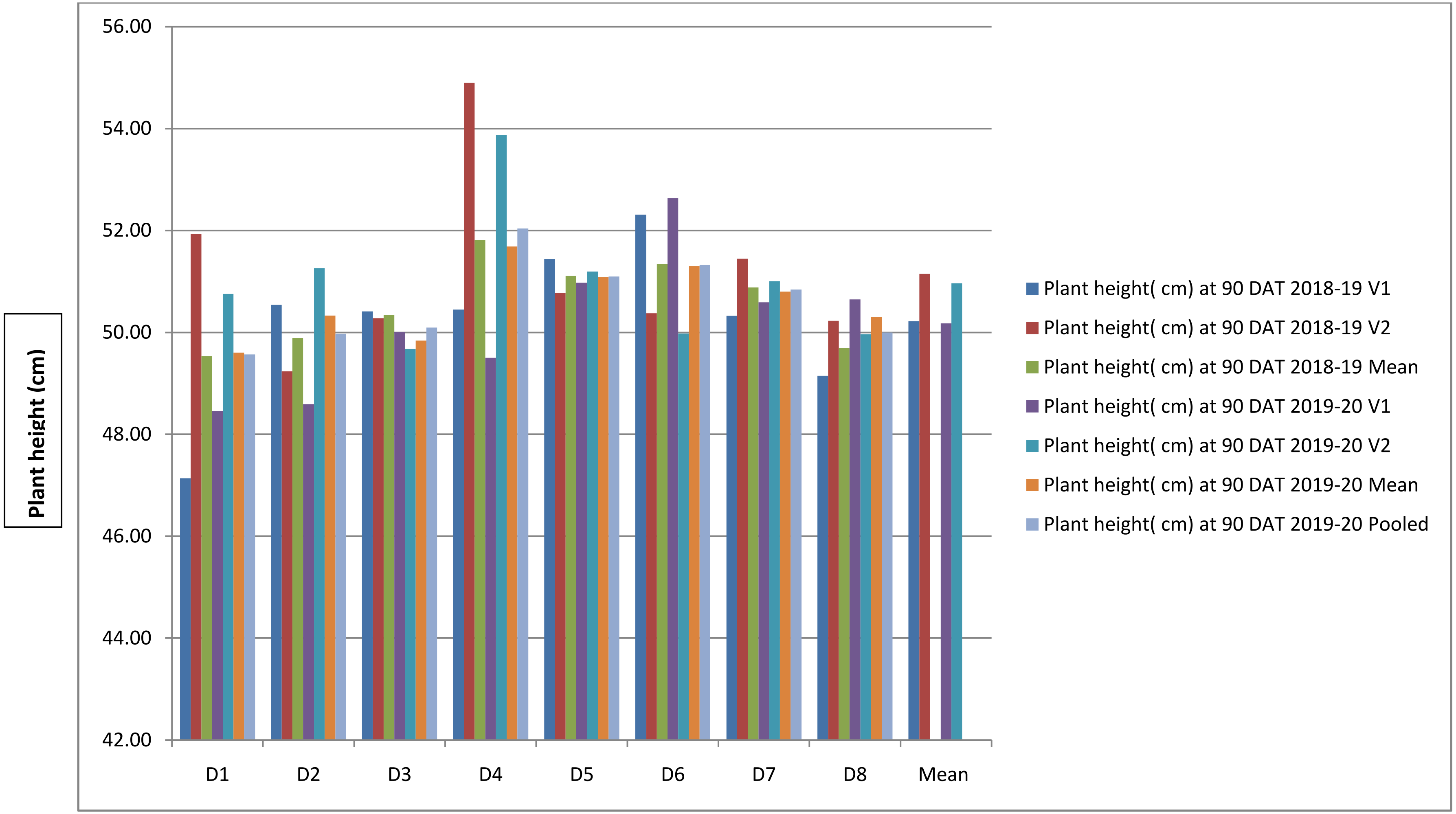


Fig 4.3: Effect of dates of transplanting and varieties on plant height of *Kharif* onion at 90 DAT.

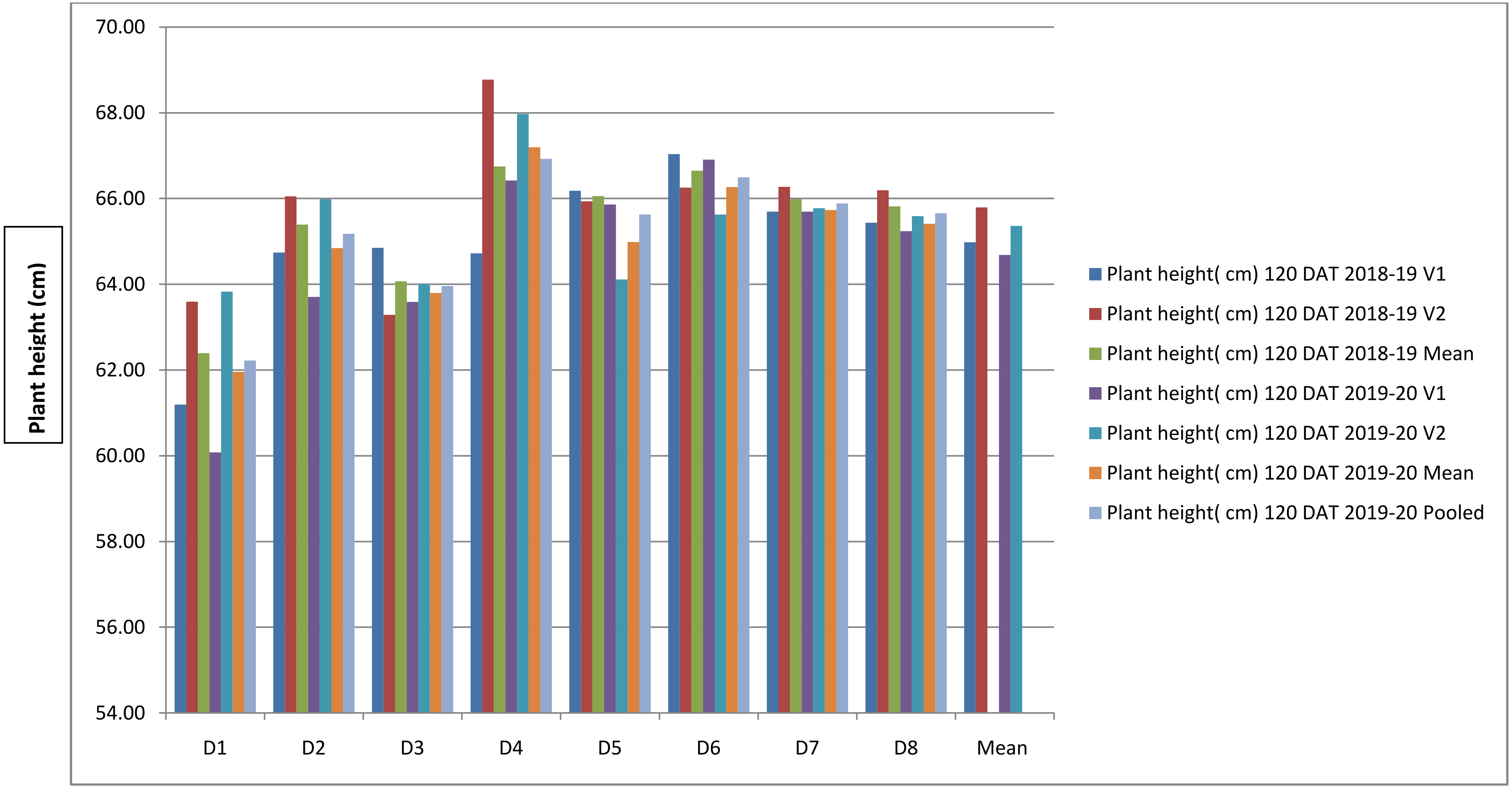


Fig 4.4: Effect of dates of transplanting and varieties on plant height of *kharif* onion at 120 DAT.

4.1.2. The effect of transplanting dates and varieties on number of leaves per plant for *kharif* onion production (30, 60, 90 and 120 DAT)

Table 4.3 presents data on the number of leaves per plant, which is graphically illustrated in Fig. 4.5 subjected to statistical analysis. Both years of investigation (2018-19 and 2019-20) showed that the number of leaves per plant at 30 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

The result showed that at 30 DAT; the maximum number of leaves per plant (3.31 and 3.33) was recorded under the moderate transplanted date of D_4. It was followed by transplanted dates D_3 (3.23 and 3.27) and D_6 (3.28 and 3.30) while, the minimum number of leaves per plant (2.39 and 2.56) was recorded under the early transplanted date D_1during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on the number of leaves. The given data showed that the maximum number of leaves (3.11 and 3.13 during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum number of leaves per plant was recorded under the cultivars V_1 (2.89 and 3.12 during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and cultivars was noted to be significant on the number of leaves. The interactive treatment D_4 xV_2 produced the highest number of leaves (3.64 during 2018-19 and 3.59 during 2019-20). However, the lowest number of leaves per plant (2.65 during 2018-19 and 2.88 during 2019-20) was recorded under D_1 xV_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the number of leaves per plant was marginally higher in 2018-19 than in the second year.

Table 4.3 presented data on the number of leaves per plant, which is graphically illustrated in Fig. 4. Both years of investigation (2018-19 and 2019-20) showed that the number of leaves per plant at 60 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

It is obvious that at 60 DAT the maximum number of leaves per plant (5.69 cm and 5.71 cm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted dates D_3 (5.41 and5.39) and D_6 (5.48 and 5.47) while, the minimum number of leaves per plant (4.59 and 4.58) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on the number of leaves. The given data showed that the maximum number of leaves (5.39 cm and 5.37 cm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum number of leaves per plant was recorded under the cultivars V_1 (5.20 and 5.17 during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and cultivars was noted to be significant on the number of leaves. The interactive treatment D_4 x V_2 produced the highest number of leaves (6.13 during 2018-19 and 6.04 during 2019-20). However, the lowest number of leaves per plant (4.68 during 2018-19 and 4.63 during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the number of leaves per plant was marginally higher in 2018-19 than in the second year.

Table 4.4 presents data on the number of leaves per plant, which is graphically illustrated in Fig. 4.7 the data was subjected to statistical analysis and analysis of variance as given in. Both years of investigation (2018-19 and 2019-20) showed that the number of leaves per plant at 90 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties. It is clear from Table 4.7 that at 90 DAT, the maximum number of leaves per plant (11.08 and 10.82) was recorded under the moderate transplanted date of D_4. It was followed by transplanted dates D_3 (10.01 and 9.98) and D_6 (10.45 and 10.43) while, the minimum number of leaves per plant (9.40 and 9.39) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The maximum number of leaves (10.30 and 10.08 during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum number of leaves per plant was recorded under the cultivars V_1 (9.93 and 10.00 during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and cultivars was noted to be significant on the number of leaves. The interactive treatment D_4 x V_2 produced the highest number of leaves (12.17 during 2018-19 and 11.77 during 2019-20). However, the lowest number of leaves per plant (9.75 during 2018-19 and 9.62 during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the number of leaves per plant was marginally higher in 2018-19 than in the second year.

Table 4.4 presents data on the number of leaves per plant, which is graphically illustrated in Fig. 4.8. Both years of investigation (2018-19 and 2019-20) showed that the number of leaves per plant at 120 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

Whereas, at 120 DAT; the maximum number of leaves per plant (15.19 and 14.99) was recorded under the moderate transplanted date of D_4. It was followed by transplanted dates D_3 (14.14 and 14.04) and D_6 (14.93 and 14.89) while, the minimum number of leaves per plant (12.86 and 12.74) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on the number of leaves. The given data showed that the maximum number of leaves (14.44 cm and 14.16 cm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum number of leaves per plant was recorded under the cultivars V_1 (13.90 and 13.99 during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and cultivars was noted to be significant on the number of leaves. The interactive treatment D_4 x V_2 produced the highest number of leaves (15.91 during 2018-19 and 15.64 during 2019-20). However, the lowest number of leaves per plant (13.58 cm during 2018-19 and 12.43 during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the number of leaves per plant was marginally higher in 2018-19 than in the second year.

Table 4.3: Effect of dates of transplanting and varieties on number of leaves of *kharif* onion

Variety / Dates of transplanting	Number of leaves/plant at 30 DAT							Number of leaves/plant at 60 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	2.13	2.65	2.39	2.59	2.88	2.73	2.56	4.51	4.68	4.59	4.50	4.63	4.56	4.58
D_2-10th September	2.14	3.08	2.61	2.83	3.08	2.96	2.79	5.16	5.42	5.29	5.14	5.39	5.26	5.28
D_3-20th September	3.15	3.30	3.23	3.29	3.33	3.31	3.27	5.29	5.52	5.41	5.26	5.48	5.37	5.39
D_4-30th September	2.97	3.64	3.31	3.13	3.59	3.36	3.33	5.33	6.13	5.69	5.33	6.04	5.73	5.71
D_5-10th October	3.22	3.11	3.16	3.25	3.12	3.18	3.17	5.18	5.17	5.17	5.13	5.16	5.15	5.16
D_6-20th October	3.45	3.12	3.28	3.50	3.11	3.31	3.30	5.58	5.38	5.48	5.55	5.38	5.46	5.47
D_7-30th October	2.89	2.92	2.91	3.19	2.92	3.05	2.98	5.25	5.55	5.40	5.21	5.52	5.37	5.38
D_8-10th November	3.18	3.04	3.11	3.21	3.04	3.13	3.12	5.31	5.37	5.34	5.24	5.27	5.26	5.30
Mean	2.89	3.11		3.12	3.13			5.20	5.39		5.17	5.37		
SEm (±)	D	0.95			0.10				0.10			0.09		
	V	0.05			0.05				0.05			0.04		
	D×V	0.13			0.14				0.13			0.12		
CD (P= 0.05)	D	0.27			0.29				0.28			0.25		
	V	0.13			0.15				0.14			0.13		
	D×V	0.28			0.41				0.39			NS		

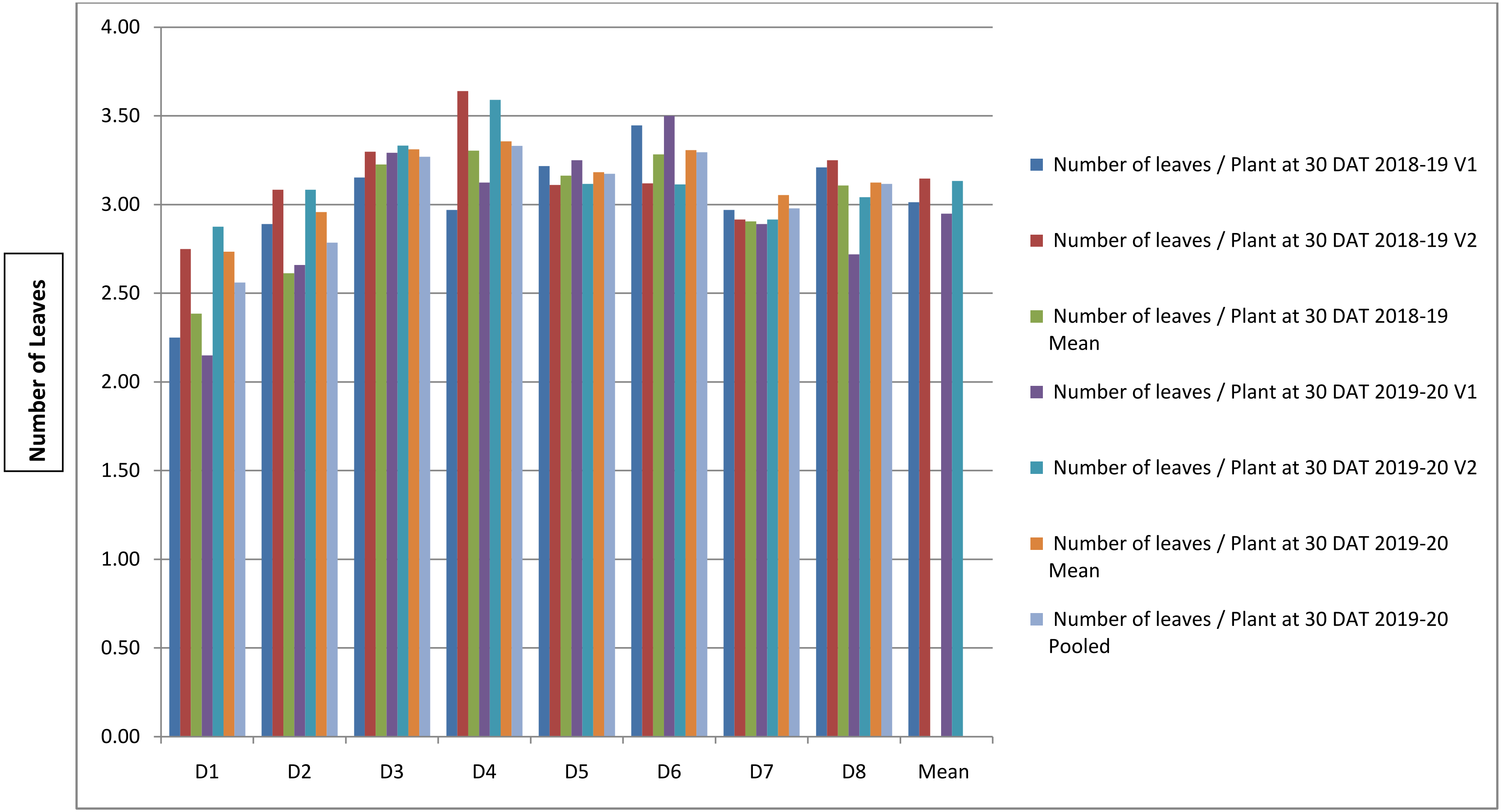


Fig 4.5 Effect of dates of transplanting and varieties on number of leaves of *kharif* onion at 30 DAT.

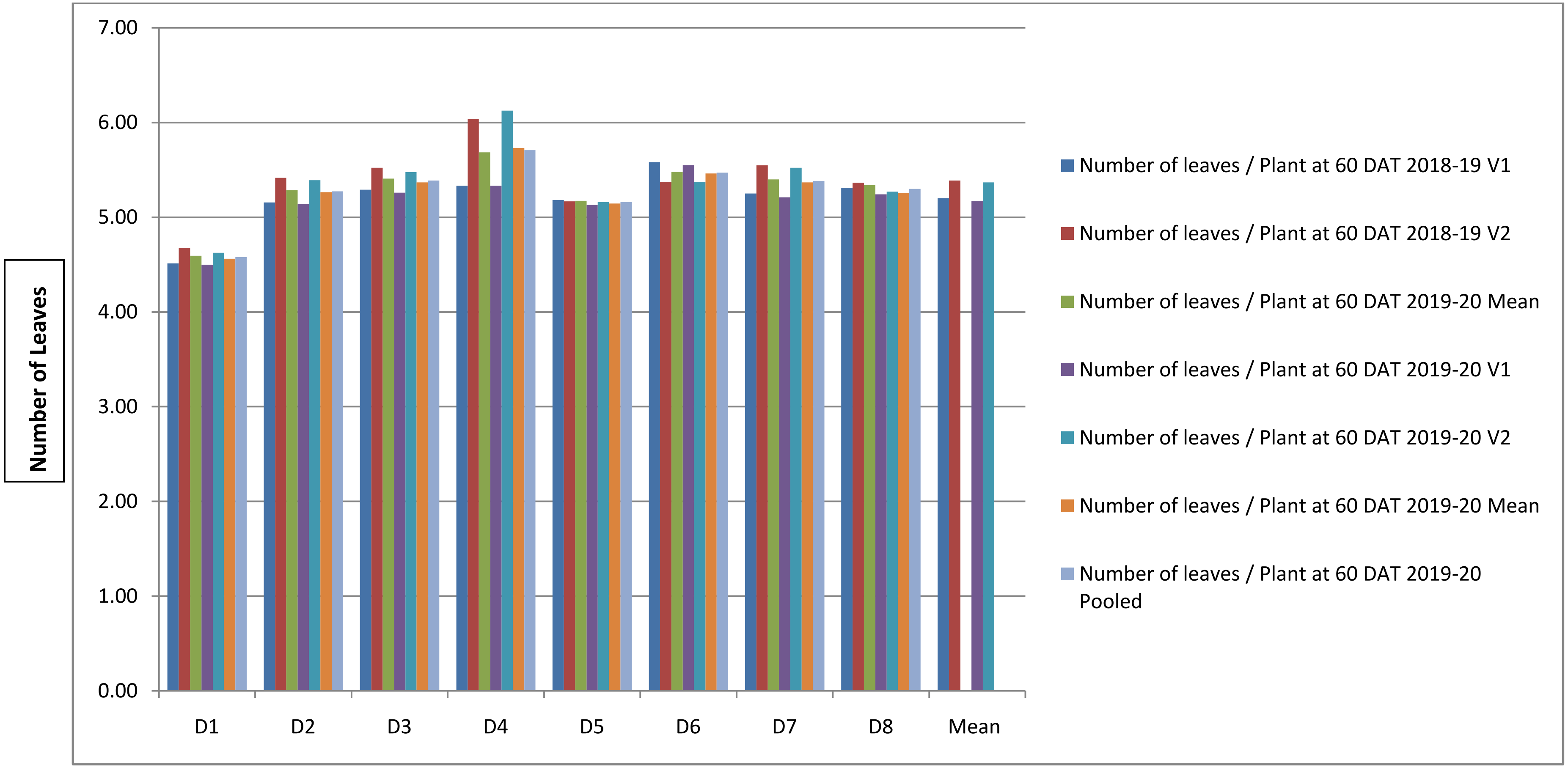


Fig 4.6 Effect of dates of transplanting and varieties on number of leaves of kharif onion at 60 DAT.

Table 4.4: Effect of dates of transplanting and varieties on number of leaves of *kharif* onion.

Variety / Dates of transplanting	Number of leaves/plant at 90 DAT							Number of leaves/plant at 120 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	9.04	9.75	9.40	9.16	9.62	9.39	9.39	12.14	13.58	12.86	12.43	12.80	12.62	12.74
D_2-10th September	9.30	10.22	9.76	9.32	9.93	9.62	9.69	13.14	14.63	13.89	13.46	13.70	13.58	13.73
D_3-20th September	10.11	9.91	10.01	10.24	9.68	9.96	9.98	13.81	14.46	14.14	13.50	14.37	13.94	14.04
D_4-30th September	9.98	12.17	11.08	9.37	11.77	10.57	10.82	14.47	15.91	15.19	13.93	15.64	14.78	14.99
D_5-10th October	10.08	10.55	10.32	9.97	10.52	10.24	10.28	13.81	15.00	14.40	14.67	14.82	14.74	14.57
D_6-20th October	10.61	10.29	10.45	11.27	10.43	10.85	10.65	15.84	14.03	14.93	15.25	14.44	14.84	14.89
D_7-30th October	9.63	10.01	9.82	10.12	9.54	9.83	9.83	13.81	13.86	13.84	14.38	13.81	14.10	13.97
D_8-10th November	10.70	9.50	10.10	10.60	9.13	9.87	9.98	14.17	14.07	14.12	14.34	13.67	14.00	14.06
Mean	9.93	10.30		10.00	10.08			13.90	14.44		13.99	14.16		
SEm (±)	D	0.21			0.22				0.23			0.22		
	V	0.11			0.10				0.12			0.11		
	D×V	0.31			0.30				0.32			0.31		
CD (P= 0.05)	D	0.63			0.62				0.67			0.64		
	V	0.32			NS				0.33			0.32		
	D×V	0.89			0.88				0.94			0.90		

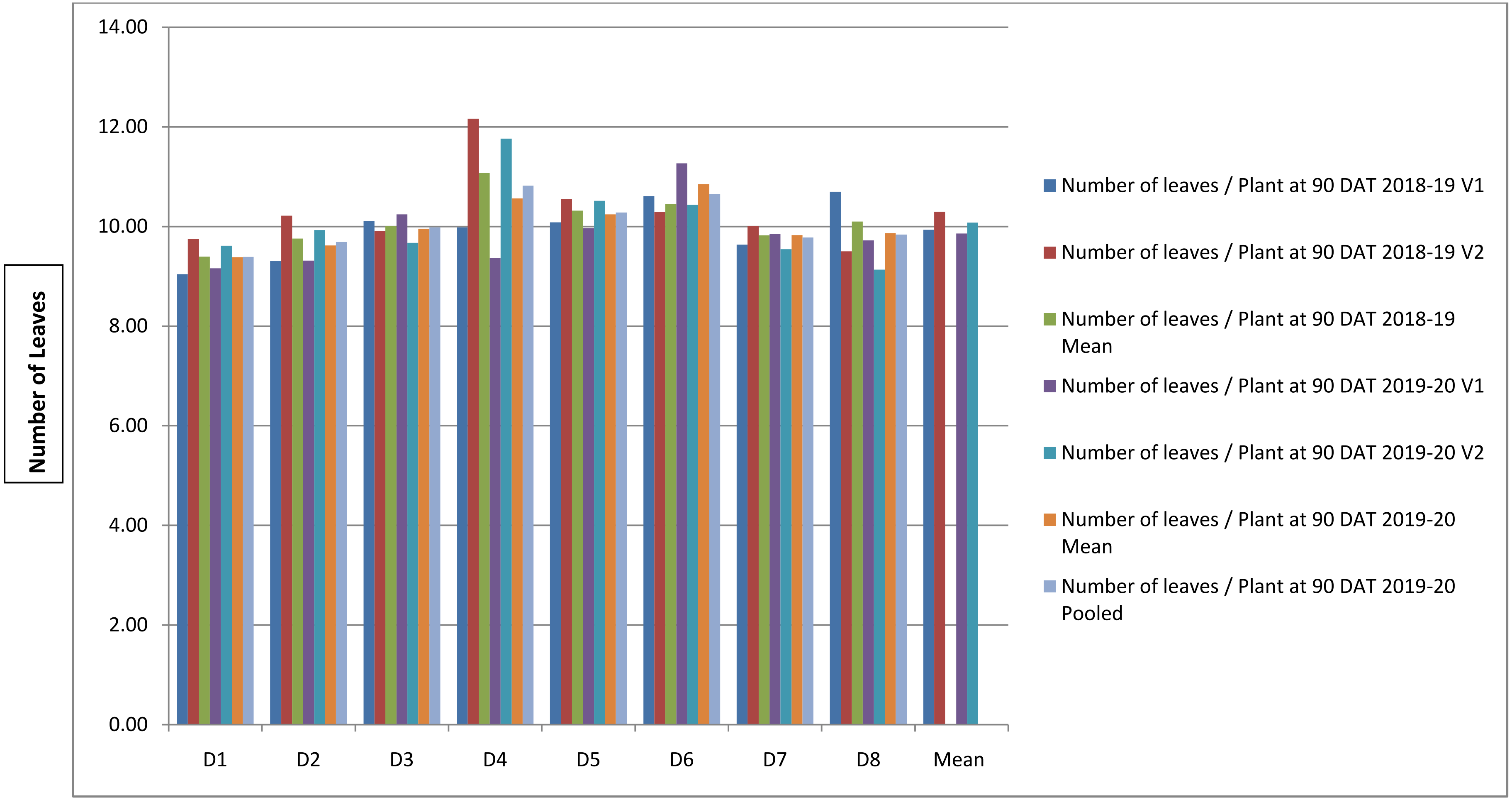


Fig 4.7 Effect of dates of transplanting and varieties on number of leaves of *kharif* onion at 90 DAT.

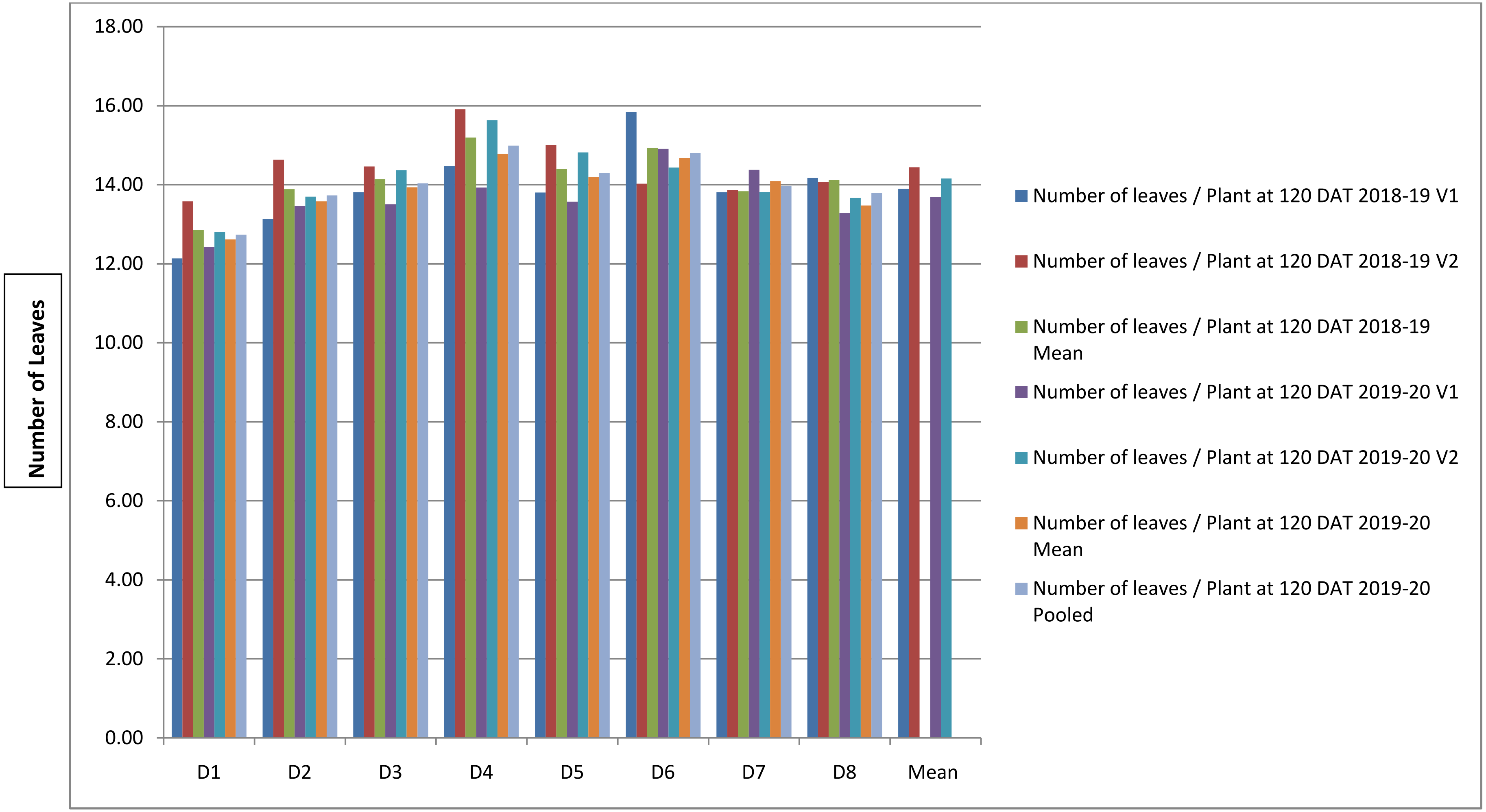


Fig 4.8 Effect of dates of transplanting and varieties on number of leaves of *kharif* onion at 120 DAT.

4.1.3. The effect of transplanting dates and variety on leaf length of *kharif* onion at 30, 60, 90 and 120 DAT

The data on leaf length were shown in Table 4.5 and were presented in Fig. 4.9. Both years of investigation (2018-19 and 2019-20) showed that the leaf length at 30 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

The result showed in the Table 4.1 that at 30 DAT, the maximum leaf length (22.16 cm and 22.06 cm) was recorded under the moderate transplanted date D_4. It was followed by transplanted date D_3 (19.24 cm and 19.47 cm) and D_6 (21.48 cm and 21.40 cm) while, the minimum leaf length (18.19 cm and 17.93 cm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The onion cultivars also had a significant effect on leaf length. The given data showed that the maximum leaf length (20.52 cm and 20.43 cm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and minimum leaf length was recorded under the cultivar V_1 (19.95 cm and 19.89cm during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on leaf length. The interactive treatment D_4 xV_2 showed the significantly highest leaf length (24.21 cm during 2018-19 and 23.69 cm during 2019-20). However, the lowest leaf length (19.00 cm during 2018-19 and 18.29cm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height leaf length was marginally higher in 2018-19 than in the second year.

The data on leaf length are presented Table 4.5and in Fig 4.10. It showed that the leaf length at 60 (DAT) was significantly influenced by different dates of transplanting and varieties.

It is obvious that at 60 DAT, that the maximum leaf length (29.29 cm and 29.24 cm) was recorded under the moderate transplanted date D_4. It was followed by transplanted date D_3 (27.29 cm and 27.29 cm) and D_6 (28.91cm and 28.80 cm) while, the minimum leaf length (25.11 cm and 24.56 cm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The given data showed that the maximum leaf length (27.57cm and 27.16 cm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and minimum leaf length was recorded under the cultivars V_1 (27.14 cm and 26.61 cm during 2018-19 and 2019-20).

The treatment D_4 x V_2 produced significantly highest leaf length (30.36 cm during 2018-19 and 29.94 cm during 2019-20). However, the lowest leaf length (25.34 cm during 2018-19 and 24.67 cm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height of the plant was marginally higher in 2018-19 than in the second year.

The data on leaf length are shown in Table 4.6 and are presented in Fig. 4.11, both years of investigation (2018-19 and 2019-20) showed that the leaf length at 90 (DAT) was significantly influenced by different dates of transplanting and varieties.

At 90 DAT; the maximum leaf length (42.85 cm and 42.89 cm) was recorded under the moderate transplanted date D_4. It was followed by transplanted date D_3 (41.55 cm and 41.60 cm) and D_6 (42.35 cm and 42.28 cm) while, the minimum leaf length (38.57 cm and 38.18cm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

Significantly highest leaf length was recorded with treatment D_4 xV_2 (44.17 cm during 2018-19 and 45.03 cm during 2019-20). Lowest leaf length (39.82 cm during 2018-19 and 38.72 cm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height of the plant was marginally higher in 2018-19 than in the second year.

Both years of investigation (2018-19 and 2019-20) showed that the leaf length at 120 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.(Table 4.6 and Fig. 4.12)

At 120 DAT the maximum leaf length (47.80 cm and 47.60 cm) was recorded under the moderate transplanted date D_4. It was followed by transplanted date D_3 (47.18 cm and 46.82 cm) and D_6 (47.40 cm and 47.16 cm) while, the minimum leaf length (43.81 cm and 43.34 cm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars also had a significant effect on leaf length. The given data showed that the maximum leaf length (46.70 cm and 45.69 cm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and minimum leaf length was recorded under the cultivars V_1 (45.62 cm and 45.20 cm during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars showed that D_4 xV_2 produced the significantly highest leaf length (49.58 cm during 2018-19 and 48.89 cm during 2019-20). However, the lowest leaf length (44.37 cm during 2018-19 and 43.61 cm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height of the plant was marginally higher in 2018-19 than in the second year.

Table 4.5: Effect of dates of transplanting and varieties on length of leaf of *kharif* onion.

Variety / Dates of transplanting	Length of leaves at 30 DAT							Length of leaves at 60 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	17.37	19.00	18.19	16.81	18.29	17.55	17.93	24.87	25.34	25.11	22.81	24.67	23.74	24.56
D_2-10th September	19.82	20.15	19.99	19.63	20.00	19.81	19.92	25.79	26.19	25.99	25.27	26.04	25.66	25.86
D_3-20th September	19.26	19.22	19.24	19.60	20.01	19.81	19.47	26.91	27.67	27.29	26.58	27.13	26.85	27.29
D_4-30th September	20.11	24.21	22.16	20.11	23.69	21.90	22.06	28.22	30.36	29.29	28.38	29.94	29.16	29.24
D_5-10th October	19.60	20.08	19.84	19.93	20.28	20.11	19.94	27.95	27.85	27.90	27.80	26.70	27.25	27.64
D_6-20th October	23.03	19.92	21.48	22.13	20.46	21.30	21.40	29.49	28.32	28.91	28.97	28.32	28.65	28.80
D_7-30th October	19.53	21.15	20.34	19.72	20.53	20.12	20.25	27.34	28.06	27.70	27.10	27.76	27.43	27.59
D_8-10th November	20.87	20.47	20.67	21.21	20.20	20.71	20.68	26.53	26.76	26.64	25.99	26.76	26.38	26.54
Mean	19.95	20.52		19.89	20.43			27.14	27.57		26.61	27.16		
SEm (±)	D	0.36			0.28				0.27			0.26		
	V	0.18			0.14				0.14			0.13		
	D×V	0.51			0.39				0.38			0.36		
CD (P= 0.05)	D	1.04			0.82				0.79			0.76		
	V	0.52			0.41				0.39			0.38		
	D×V	1.48			1.15				1.12			1.07		

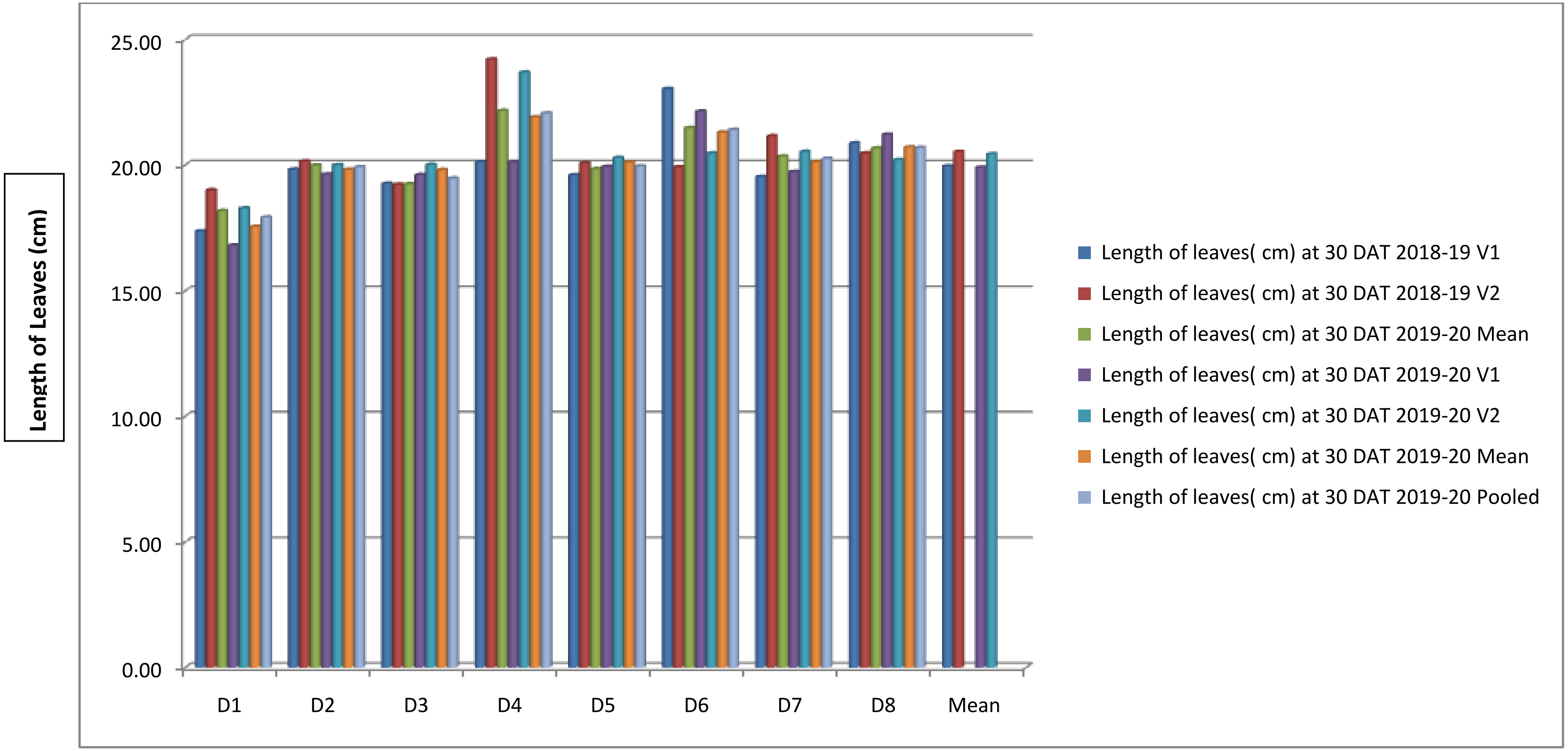


Fig 4.9 Effect of dates of transplanting and varieties on length of leaves of *kharif* onion at 30 DAT.

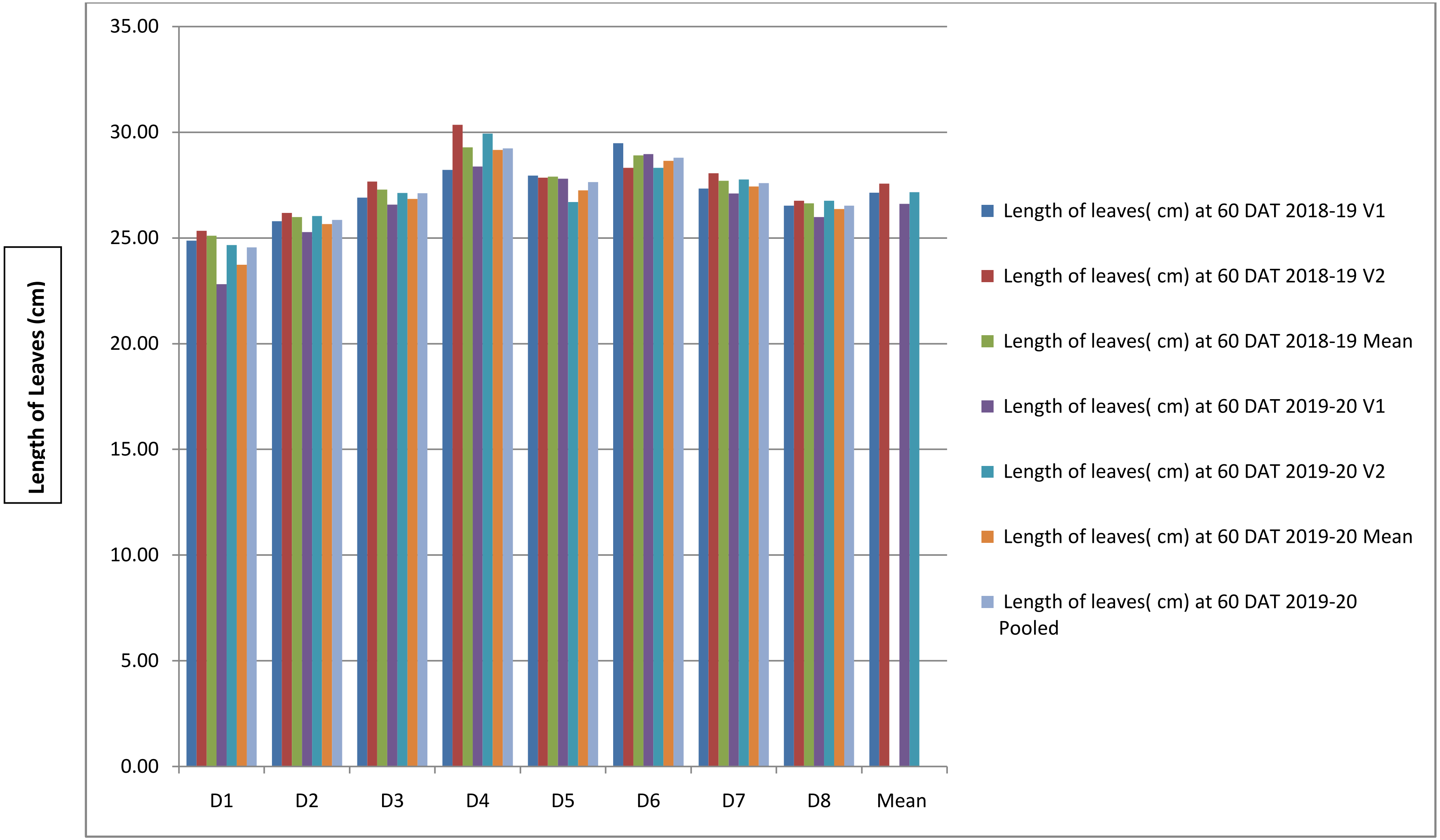


Fig 4.10 Effect of dates of transplanting and varieties on length of leaves of *kharif* onion at 60 DAT.

Table 4.6: Effect of dates of transplanting and varieties on length of leaf of *kharif* onion.

Variety / Dates of transplanting	Length of leaves at 90 DAT							Length of leaves at 120 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	37.32	39.82	38.57	36.48	38.72	37.60	38.18	43.26	44.37	43.81	41.68	43.61	42.64	43.34
D_2-10th September	38.51	40.78	39.65	40.84	41.12	40.98	40.18	44.70	46.12	45.41	44.16	44.87	44.51	45.05
D_3-20th September	41.44	41.66	41.55	42.13	41.24	41.68	41.60	46.99	47.37	47.18	45.83	46.70	46.27	46.82
D_4-30th September	41.52	44.17	42.85	40.87	45.03	42.95	42.89	46.03	49.58	47.80	45.70	48.89	47.29	47.60
D_5-10th October	40.90	40.70	40.80	41.27	40.19	40.73	40.77	45.42	45.53	45.48	46.10	44.92	45.51	45.49
D_6-20th October	43.28	41.42	42.35	43.18	41.19	42.18	42.28	46.61	48.19	47.40	47.49	46.11	46.80	47.16
D_7-30th October	40.54	41.28	40.91	40.88	41.96	41.42	41.11	45.27	45.33	45.30	44.97	43.68	44.33	44.91
D_8-10th November	41.70	40.69	41.20	40.83	41.09	40.96	41.10	46.69	47.09	46.89	45.68	46.75	46.22	46.62
Mean	40.65	41.31		40.81	41.32			45.62	46.70		45.20	45.69		
SEm (±)	D	0.32			0.31				0.29			0.26		
	V	0.16			0.16				0.15			0.13		
	D×V	0.46			0.45				0.41			0.36		
CD (P= 0.05)	D	0.94			0.92				0.85			0.74		
	V	0.47			0.46				0.42			0.37		
	D×V	1.33			1.29				1.19			1.05		

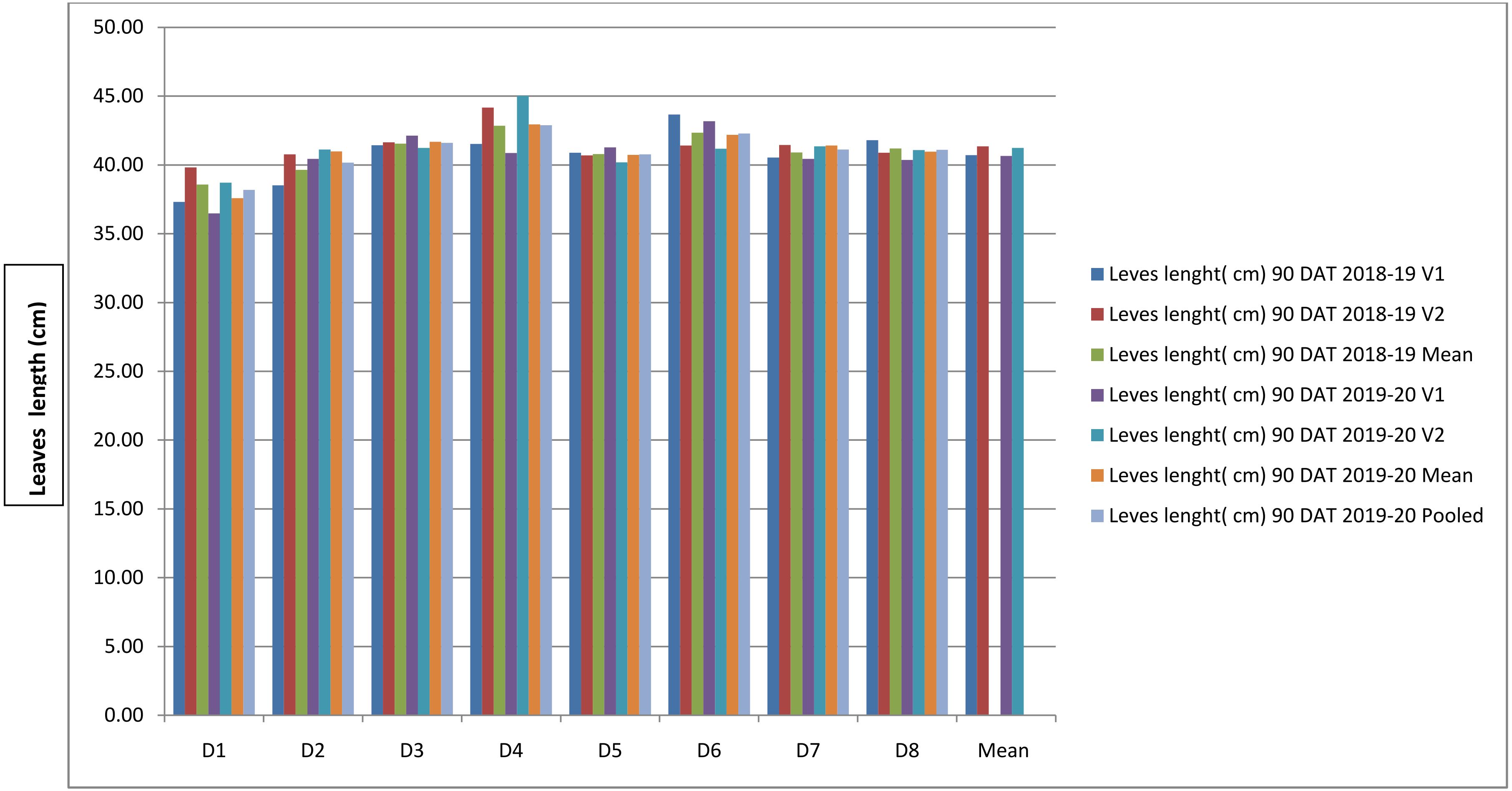


Fig 4.11 Effect of dates of transplanting and varieties on length of leaves of *kharif* onion at 90 DAT.

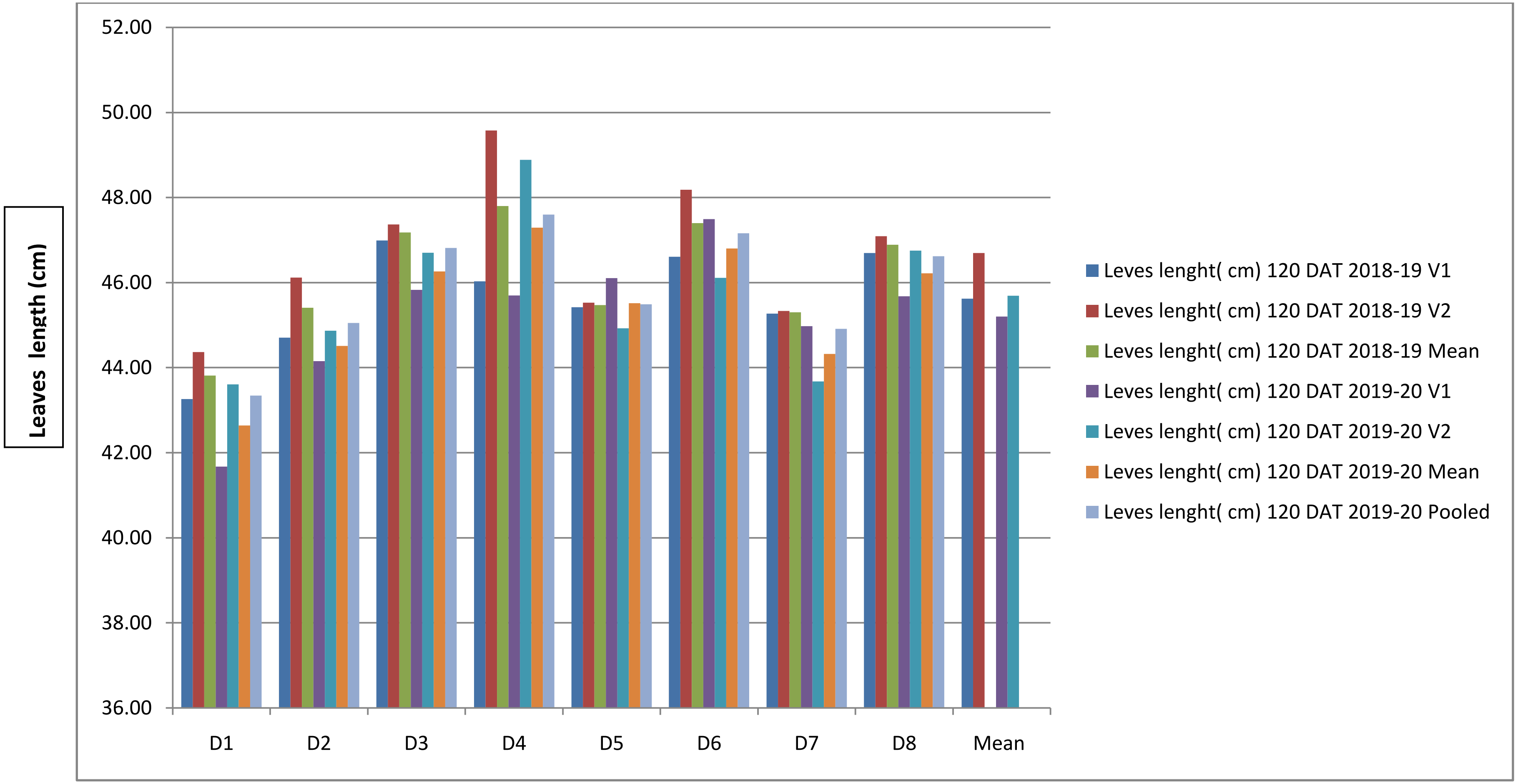


Fig 4.12 Effect of dates of transplanting and varieties on length of leaves of *kharif* onion at 120 DAT.

4.1.4. The effect of dates of transplanting and varieties on neck thickness of *kharif* onion at 30, 60, 90, & 120 DAT

Table 4.7 and Fig- 4.13 showed that the neck thickness at 30 days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

At 30 DAT the maximum neck thickness (10.35 mm and 10.95 mm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (10.35 mm and 10.23 mm) and D_6 (10.77 mm and 10.73 mm) while, the minimum neck thickness (9.55 mm and 9.33 mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on neck thickness. The given data showed that the maximum neck thickness (10.45 mm and 10.36 mm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum neck thickness was recorded under the cultivars V_1 (10.18 mm and 10.09 mm during 2018-19 and 2019-20).The interaction effect between the date of transplanting and the cultivars was noted to be significant on leaf length. The interactive treatment D_4 xV_2 produced the significantly highest neck thickness (11.54 mm during 2018-19 and 11.83 mm during 2019-20). However, the lowest neck thickness (9.91 mm during 2018-19 and 9.53mm during 2019-20) was recorded under D_1xV_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height neck thickness plant was marginally higher in 2018-19 than in the second year.

The data on neck thickness is shown in Table 4.7 and is presented in Fig. 4.14 both years of investigation (2018-19 and 2019-20) showed that the neck thickness at 60 DAT was significantly influenced by different dates of transplanting and varieties.

The data revealed that at 60 DAT, the maximum neck thickness (13.45 mm and 13.36 mm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (12.63 mm and 12.32 mm) and D_6 (13.28 mm and 13.12 mm) while, the minimum neck thickness (11.89 mm and 11.45 mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The recorded data showed that the maximum neck thickness (12.91 mm and 12.47 mm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum neck thickness was recorded under the cultivars V_1 (12.72 mm and 12.08 mm during 2018-19 and 2019-20).The interaction effect between the date of transplanting and the cultivars was noted to be significant on leaf length. The interactive treatment D_4 x V_2 produced the significantly highest neck thickness (14.26 mm during 2018-19 and 14.05 mm during 2019-20). However, the lowest neck thickness (12.31 mm during 2018-19 and 11.91 mm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height neck thickness plant was marginally higher in 2018-19 than in the second year.

Both years of investigation (2018-19 and 2019-20) showed that the neck thickness at 90 DAT was significantly influenced by different dates of transplanting and varieties. (Table 4.8 and Fig 4.15)

The maximum neck thickness (18.39 mm and 18.51 mm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (18.02 mm and 17.97 mm) and D_6 (18.45 mm and 18.44 mm) while, the minimum neck thickness (16.91 mm and 16.41 mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

In case of varietal influence the given data showed that the maximum neck thickness (18.11 mm and 17.63 mm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum neck thickness was recorded under the cultivars V_1 (17.67 mm and 17.09 mm during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on leaf length. The interactive treatment D_4 xV_2 produced the significantly highest neck thickness (20.00 mm during 2018-19 and 19.07 mm during 2019-20). However, the lowest neck thickness (17.47 mm during 2018-19 and 16.35 mm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height neck thickness was marginally higher in 2018-19 than in the second year.

The data on neck thickness is shown in Table 4.8 and Fig. 4.16. Both years of investigation (2018-19 and 2019-20) showed that the neck thickness at 120 DAT was significantly influenced by different dates of transplanting and varieties.

Whereas, at 120 DAT; the maximum neck thickness (23.38 mm and 23.19 mm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (22.54 mm and 22.22 mm) and D_6 (23.27 mm and 23.03mm) while, the minimum neck thickness (21.62 mm and 21.45mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

It was showed that the maximum neck thickness (22.97 mm and 22.48 mm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum neck thickness was recorded under the cultivars V_1 (22.47 mm and 21.98 mm during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on leaf length. The interactive treatment D_4 xV_2 recorded the significantly highest neck thickness (24.11 mm during 2018-19 and 23.87 mm during 2019-20). However, the lowest neck thickness (22.74 mm during 2018-19 and 21.79 mm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the height neck thickness plant was marginally higher in 2018-19 than in the second year.

Table 4.7: Effect of dates of transplanting and varieties on neck thickness of *kharif* onion.

Variety / Dates of transplanting	Neck thickness (mm) at 30 DAT							Neck thickness (mm) at 60 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	9.19	9.91	9.55	8.71	9.53	9.12	9.33	11.47	12.31	11.89	10.13	11.91	11.02	11.45
D_2-10th September	10.22	10.33	10.28	10.00	10.23	10.11	10.19	13.02	12.47	12.75	11.80	11.62	11.71	12.23
D_3-20th September	10.18	10.52	10.35	9.90	10.34	10.12	10.23	12.55	12.71	12.63	11.86	12.16	12.01	12.32
D_4-30th September	10.16	11.54	10.85	10.27	11.83	11.05	10.95	12.65	14.26	13.45	12.49	14.05	13.27	13.36
D_5-10th October	10.25	10.28	10.26	10.44	10.21	10.32	10.29	13.09	12.69	12.89	12.46	12.69	12.57	12.73
D_6-20th October	10.98	10.56	10.77	10.96	10.40	10.68	10.73	13.44	13.11	13.28	13.49	12.44	12.97	13.12
D_7-30th October	10.19	10.11	10.15	10.10	10.07	10.09	10.12	12.95	13.02	12.99	12.71	12.65	12.68	12.83
D_8-10th November	10.25	10.37	10.31	10.33	10.25	10.29	10.30	12.56	12.67	12.61	11.67	12.23	11.95	12.28
Mean	10.18	10.45		10.09	10.36			12.72	12.91		12.08	12.47		
SEm (±)	D	0.12			0.15				0.09			0.10		
	V	0.06			0.07				0.04			0.09		
	D×V	0.17			0.21				0.12			0.28		
CD (P= 0.05)	D	0.35			0.44				0.26			0.57		
	V	0.17			0.22				0.13			0.28		
	D×V	0.49			0.62				0.37			0.81		

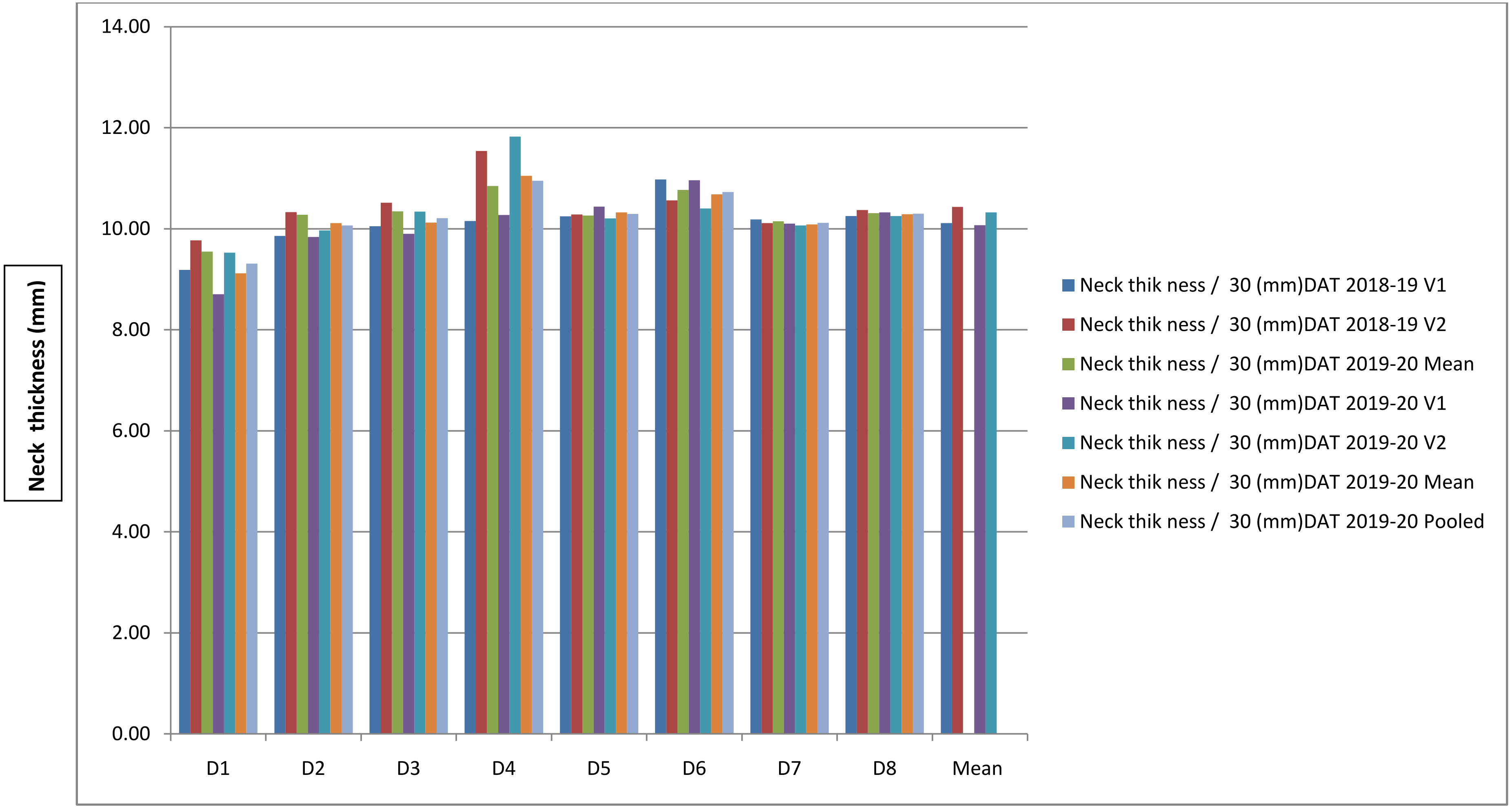


Table 4.13 Effect of dates of transplanting and varieties on neck thick ness of *kharif* onion at 30 DAT.

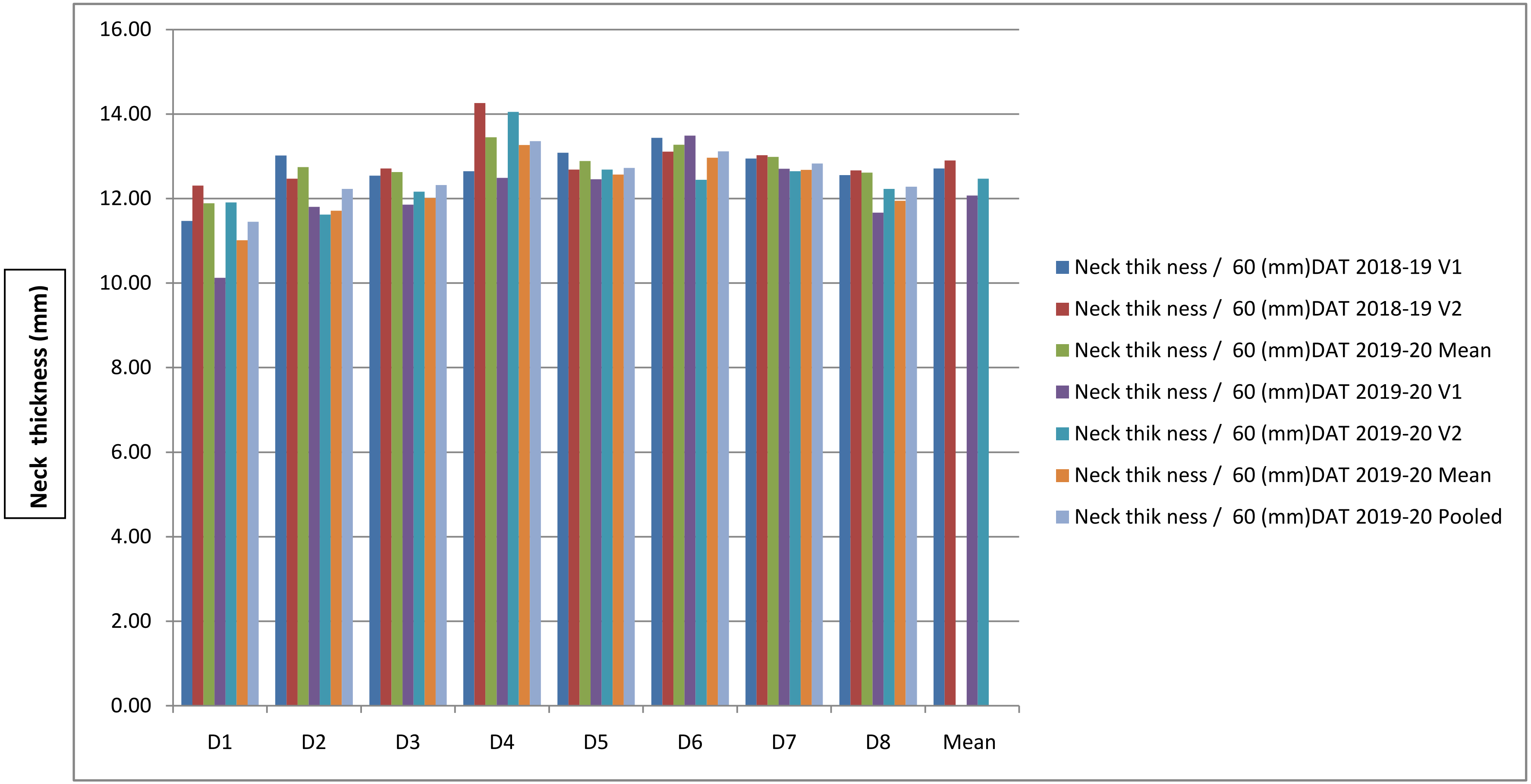


Fig 4.14 Effect of dates of transplanting and varieties on neck thick ness of *kharif* onion at 60 DAT.

Plate 11: Measurement of neck thickness

Plate 12: Spraying of insecticide in experimental field

Table 4.8: Effect of dates of transplanting and varieties on neck thickness of *kharif* onion.

Variety / Dates of transplanting	Neck thickness (mm) at 90 DAT							Neck thickness (mm) at 120 DAT						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	16.35	17.47	16.91	15.47	16.35	15.91	16.41	20.50	22.74	21.62	20.76	21.79	21.27	21.45
D_2-10th September	16.97	17.64	17.30	16.19	17.16	16.68	16.99	21.58	22.77	22.18	21.81	23.04	22.42	22.30
D_3-20th September	17.85	18.18	18.02	17.82	18.04	17.93	17.97	22.50	22.59	22.54	21.87	21.91	21.89	22.22
D_4-30th September	17.72	19.07	18.39	17.26	20.00	18.63	18.51	22.66	24.11	23.38	22.15	23.87	23.01	23.19
D_5-10th October	18.33	17.87	18.10	17.52	16.86	17.19	17.64	23.21	22.85	23.03	22.83	21.72	22.28	22.65
D_6-20th October	18.63	18.26	18.45	19.01	17.86	18.43	18.44	23.78	22.75	23.27	22.84	22.75	22.80	23.03
D_7-30th October	17.89	18.24	18.07	16.81	16.92	16.86	17.46	23.00	22.80	22.90	22.14	21.85	22.00	22.45
D_8-10th November	17.60	18.13	17.86	16.67	17.83	17.25	17.56	22.51	23.13	22.82	21.47	22.93	22.20	22.51
Mean	17.67	18.11		17.09	17.63			22.47	22.97		21.98	22.48		
SEm (±)	D	0.18			0.30				0.15			0.24		
	V	0.09			0.15				0.07			0.12		
	D×V	0.26			0.42				0.21			0.34		
CD (P= 0.05)	D	0.54			0.86				0.44			0.70		
	V	0.27			0.43				0.22			0.35		
	D×V	0.77			1.22				0.63			0.99		

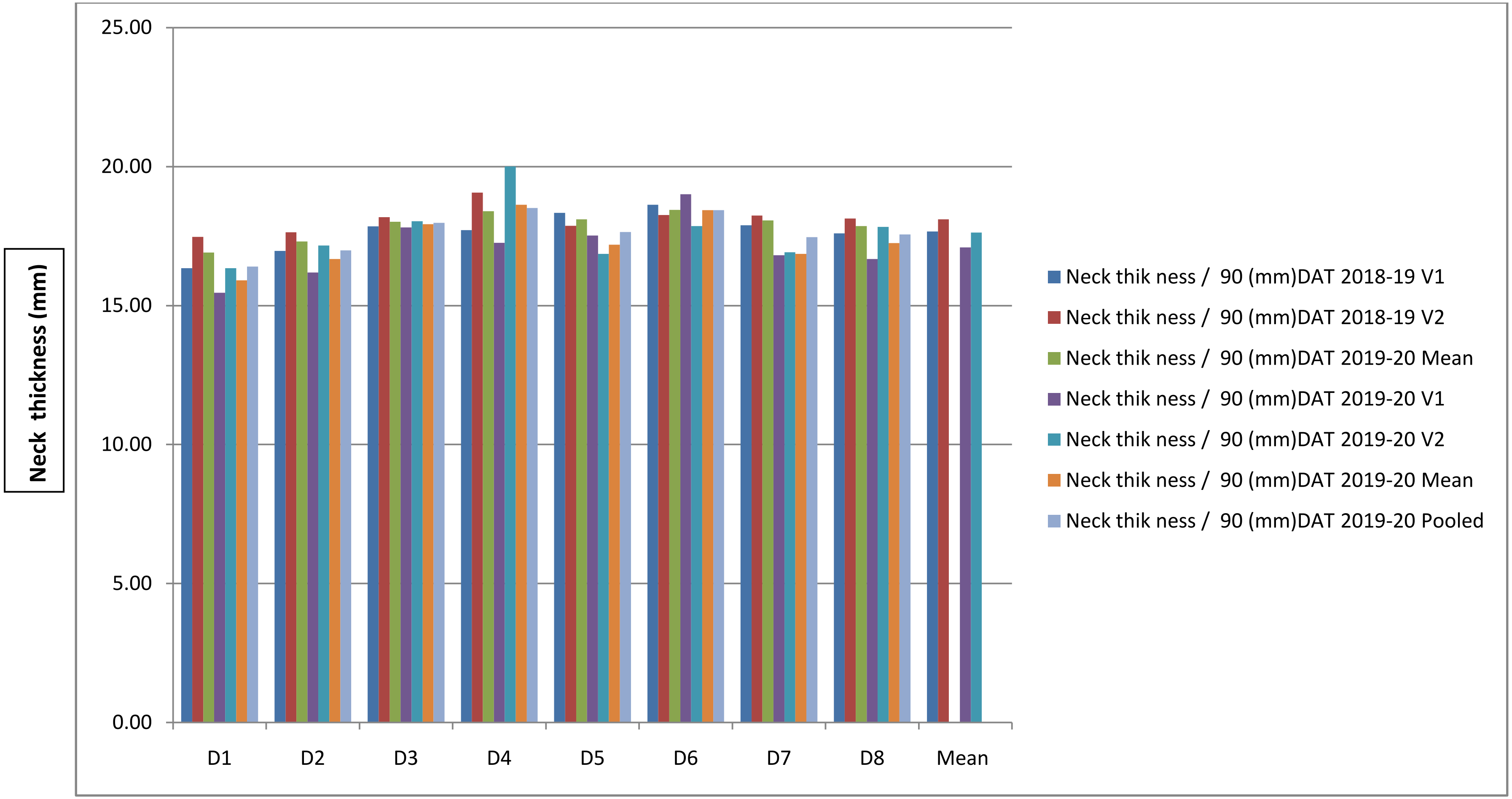


Fig 4.15 Effect of dates of transplanting and varieties on neck thick ness of *kharif* onion at 90 DAT.

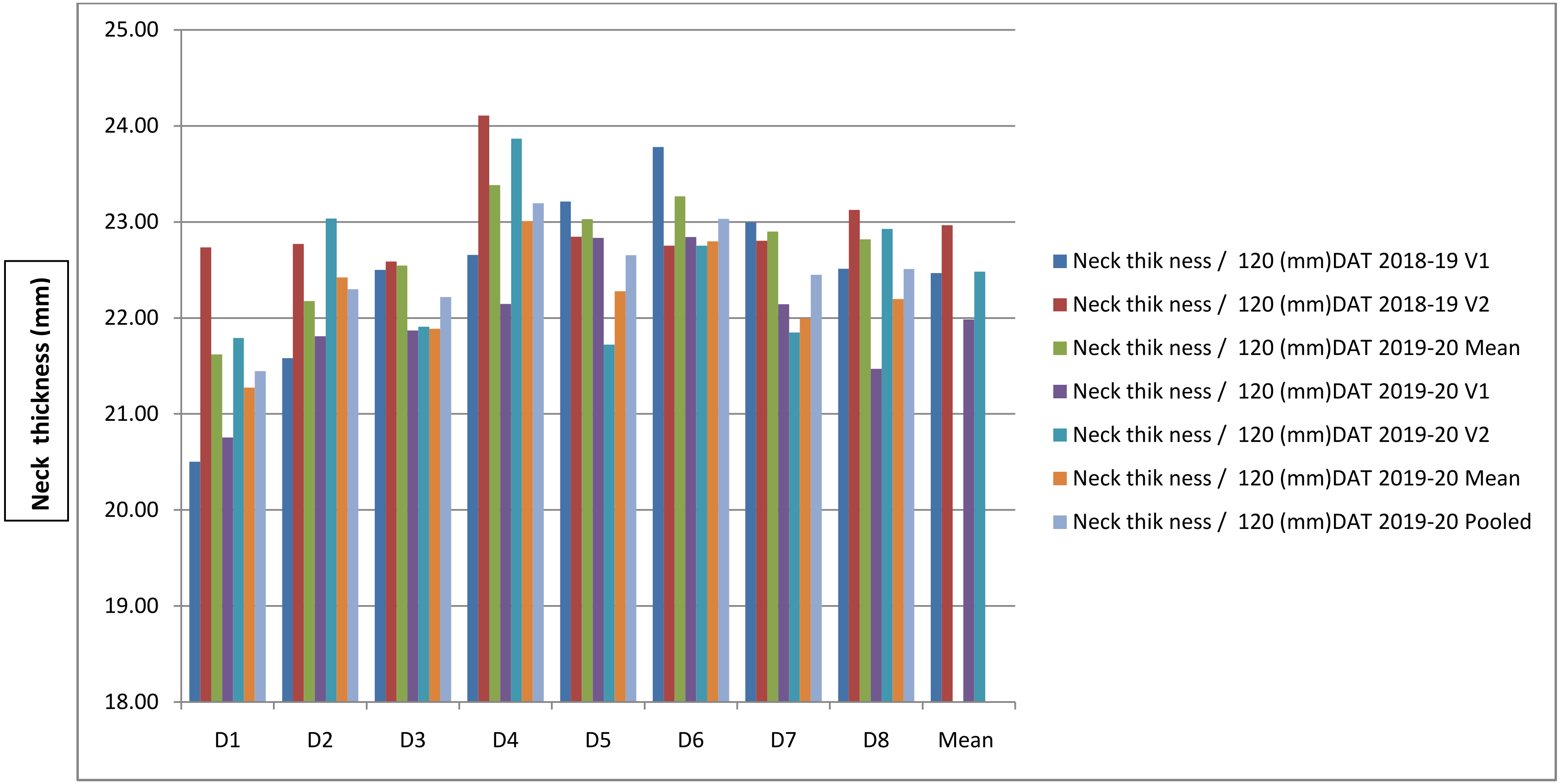


Fig 4.16 Effect of dates of transplanting and varieties on neck thick ness of *kharif* onion at 120 DAT.

4.1.5. The effect of dates transplanting and varieties on days to harvesting of *kharif* onion.

The data on day to harvesting from transplanting is shown in Table 4.9 and is presented in Fig. 4.17 and showed that the day to harvesting at days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

Maximum days taken (131.50 and 131.43 day) was recorded under the moderate transplanted date of D_4, followed by transplanted date D_3 (126.17 day and 126.17 day) and D_6 (139.50 day and 138.00 day) while, the minimum days to harvesting (122.83 day and 123.08 day) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on day to harvesting. The given data showed that the maximum day to harvesting (133.04 day and 132.67 day during 2018-19 and 2019-20) was recorded with the cultivar V_2 and the minimum day to harvesting was recorded under the cultivar V_1 (131.67 day and 131.54 day during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on day to harvesting. The combined treatment D_4 x V_2 produced the significantly highest day harvesting (133 day during 2018-19 and 132day during 2019-20). However, the lowest day to harvesting (124 day during 2018-19 and 123 day during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the day to harvesting was marginally higher in 2018-19 than in the second year.

Table 4.9: Effect of dates of transplanting and varieties on days to harvesting of *kharif* onion.

Dates of transplanting \ Variety	Days to harvesting						
	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	122	124	122.83	123	124	123.33	123.08
D_2-10th September	125	123	124.17	126	123	124.67	124.42
D_3-20th September	127	125	126.17	127	125	126.17	126.17
D_4-30th September	130	133	131.50	130	133	131.50	131.50
D_5-10th October	135	132	133.50	144	142	142.67	138.08
D_6-20th October	134	145	139.50	131	142	136.50	138.00
D_7-30th October	137	140	138.50	137	140	138.50	138.50
D_8-10th November	144	142	142.67	135	132	133.50	138.08
Mean	131.67	133.04		131.54	132.67		
SEm (±)	D	0.51			0.50		
	V	0.25			0.25		
	D×V	0.72			0.70		
CD (P= 0.05)	D	1.47			1.44		
	V	0.73			0.72		
	D×V	2.07			2.03		

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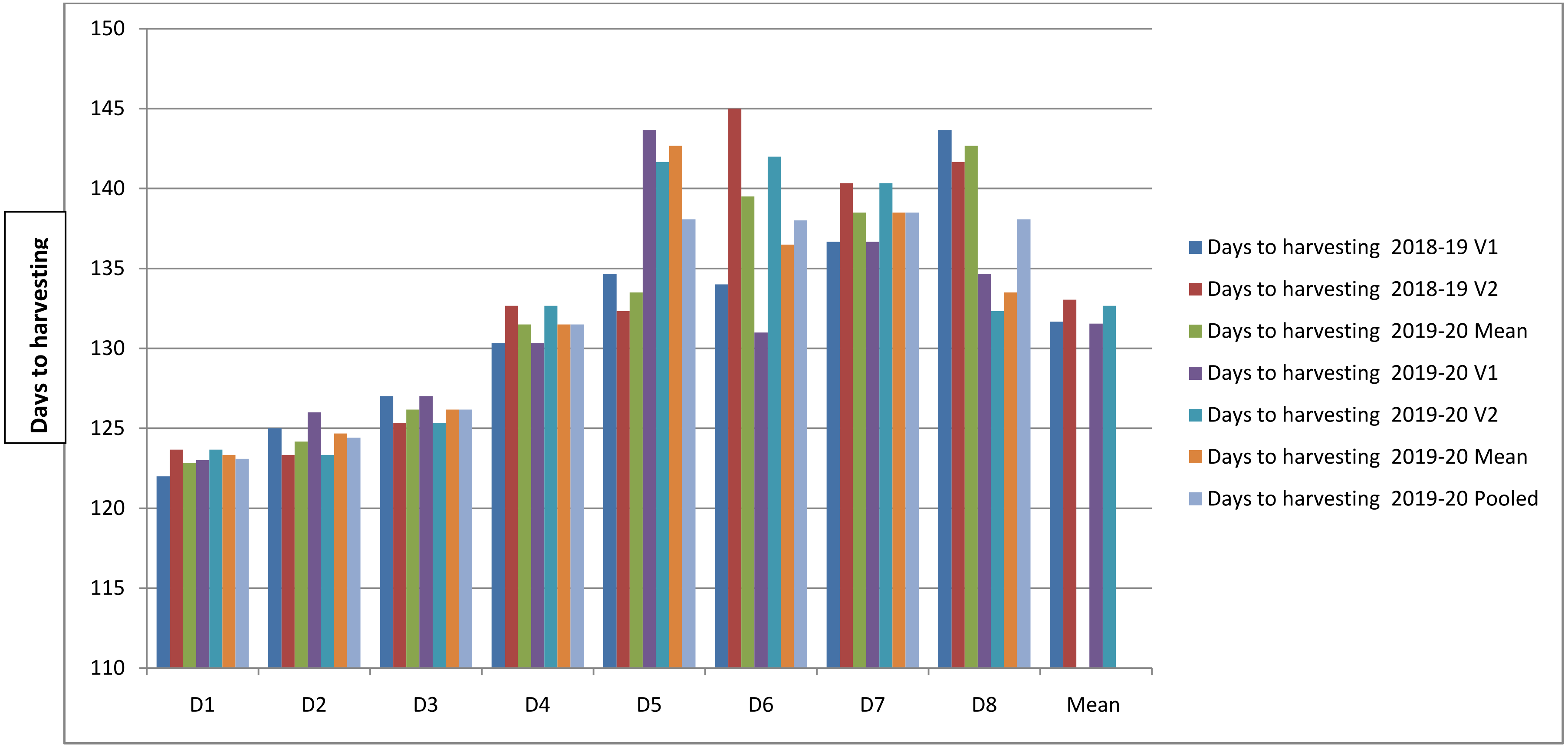


Fig 4.17 Effect of dates of transplanting and varieties on days to harvesting of *kharif* onion

4.1.6. The effect of transplanting date and variety on *kharif* onion fresh weight of bulb

The data on fresh weight of bulb is shown in Table 4.10 and is presented in Fig. 4.18. Data on both years of investigation (2018-19 and 2019-20) showed that the fresh weight of bulb days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

This is clear from Table 4.10 the fresh weight of bulb (117.08 g and 116.26 g) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (93.22 g and 93.01 g) and D_6 (114.14 g and 114.14 g) while, the minimum fresh weight of bulb (79.45 g and 79.16 g) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The onion cultivars also had a significant effect on fresh weight of bulb. The given data showed that the maximum fresh weight of bulb (103.11 g and 101.26 g during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum fresh weight of bulb was recorded under the cultivars V_1 (70.11 g and 69.22 g during 2018-19 and 2019-20).

There was a significant effect on fresh bulb weight due to interaction of dates of transplanting and variety. The interactive treatment $D_4 x V_2$ produced the significantly fresh weight of bulb (80.36 g during 2018-19 and 77.39 g during 2019-20). However, the lowest fresh weight of bulb (63.69 g during 2018-19 and 62.21 g during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the day to harvesting was marginally higher in 2018-19 than in the second year.

4.1.7. The effect of transplanting dates and varieties on average weight of bulb of *kharif* onion.

Table 4.10 and Fig 4.19 showed that the average weight of bulb was significantly influenced by different dates of transplanting and varieties.

The average weight of bulb (80.36 g and 77.27 g) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (72.49 g and 71.70 g) and D_6 (78.13 g and 75.22 g) while, the minimum average weight of bulb (61.93g and 61.49 g) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The presented also the showed that the maximum average weight of bulb (71.67 g and 70.17 g during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum average weight of bulb was recorded under the cultivars V_1 (70.11 g and 69.22 g during 2018-19 and 2019-20respectively).

The dates of transplanting variety also had a significant effect on average bulb weight. The interactive treatment D_4 x V_2 produced the significantly higher average weight of bulb (80.36 g during 2018-19 and 77.39 g during 2019-20). However, the lowest average weight of bulb (63.69 g during 2018-19 and 62.21 g during 2019-20) was recorded under D_1 x V_2.

Table 4.10: Effect of dates of transplanting and varieties on fresh weight of bulb and average weight of bulb (g) after curing of *kharif* onion.

variety / Dates of transplanting	Fresh weight of bulb (g)							Average weight of bulb (g) after curing						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	74.33	84.57	79.45	73.87	83.87	78.87	79.16	60.17	63.69	61.93	59.91	62.21	61.06	61.49
D_2-10th September	87.63	93.13	90.38	86.73	92.47	89.60	89.99	65.53	67.13	66.33	64.83	66.17	65.50	65.92
D_3-20th September	96.37	90.07	93.22	95.37	90.23	92.80	93.01	70.21	74.78	72.49	69.43	72.39	70.91	71.70
D_4-30th September	110.40	123.77	117.08	109.47	121.40	115.43	116.26	74.98	80.36	80.36	75.27	77.39	75.27	77.27
D_5-10th October	103.60	107.07	105.33	104.47	107.07	105.77	105.55	71.83	73.47	72.65	70.67	69.17	69.92	71.28
D_6-20th October	116.80	111.47	114.14	117.17	100.27	108.72	114.14	78.13	69.17	78.13	76.20	73.47	76.20	75.22
D_7-30th October	109.67	106.43	108.05	97.30	106.43	101.87	104.96	72.50	68.37	70.44	71.80	68.37	70.08	70.26
D_8-10th November	98.50	108.37	103.43	99.00	108.37	103.68	103.56	67.57	76.40	71.98	65.67	72.19	68.93	70.46
Mean	99.66	103.11		97.92	101.26			70.11	71.67		69.22	70.17		
SEm (±)	D	0.53			0.48				0.65			0.52		
	V	0.26			0.24				0.32			0.26		
	D×V	0.75			0.68				0.92			0.73		
CD (P= 0.05)	D	1.54			1.40				1.88			1.50		
	V	0.77			0.70				0.94			0.75		
	D×V	2.18			1.98				2.67			2.12		

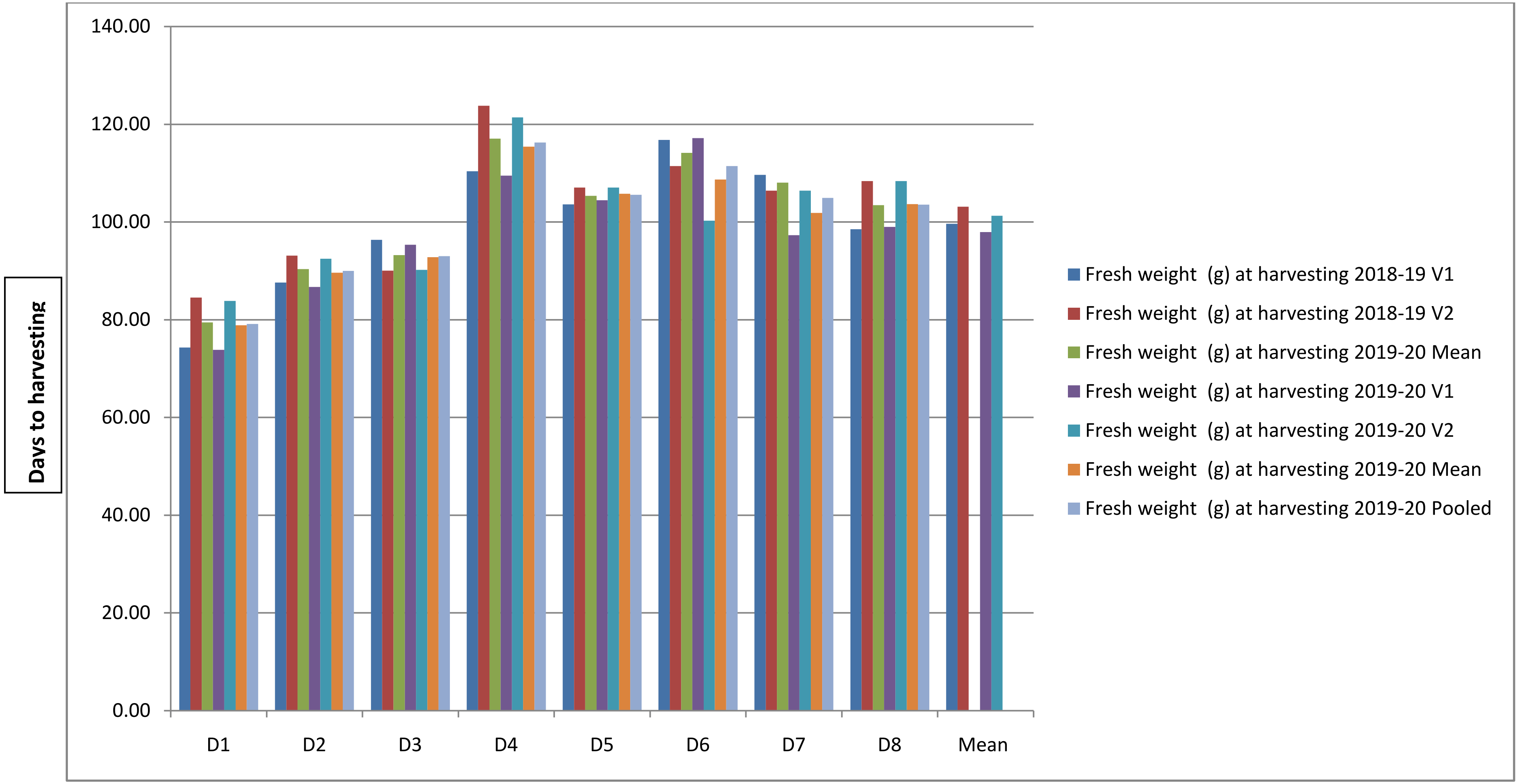


Fig 4.18 Effect of dates of transplanting and varieties on fresh weight (g) of *kharif* onion.

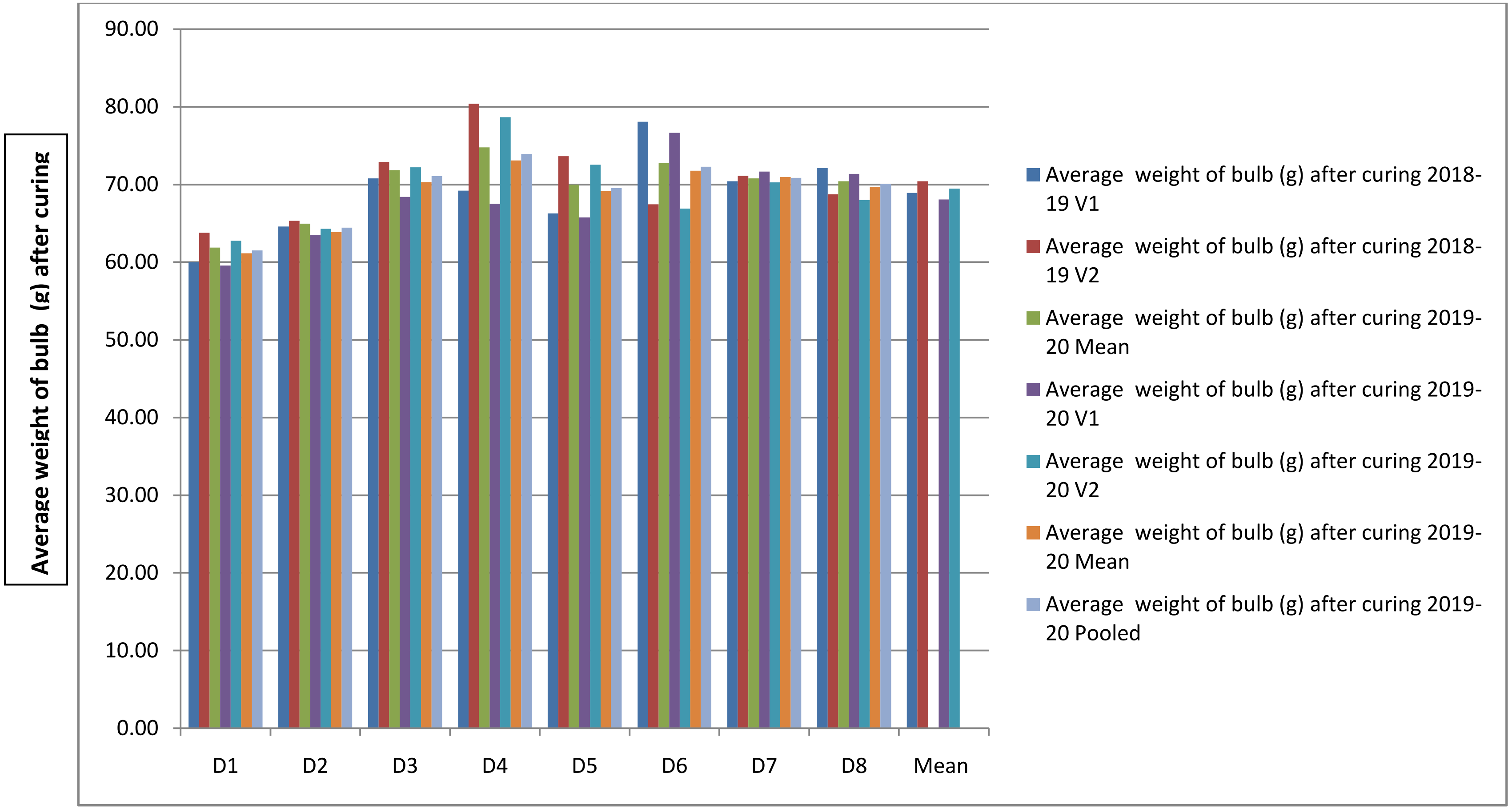


Fig 4.19 Effect of dates of transplanting and varieties on average weight of bulb (g) after curing of *kharif* onion.

4.1.8. The effect of varieties and dates of transplanting on bulb yield of *kharif* onion

Both years of investigation (2018-19 and 2019-20) showed that the yield kg/plot days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties. (Table 4.11 and Fig 4.20)

Maximum yield per plot (10.1 kg and 10.02 kg) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (9.32 kg and 9.31 kg) and D_6 (9.55 kg and 9.46 kg) while, the yield kg/plot (8.05 kg and 7.99 kg) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

Variety V_2 showed the maximum yield (9.29 kg and 9.16 kg during 2018-19 and 2019-20) and the minimum yield was recorded under the cultivars V_1 (9.11 kg and 8.97 kg during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on yield (kg/plot). The interactive treatment D_4 xV_2 produced the significantly yield kg/plot (10.45 kg during 2018-19 and 10.19 kg during 2019-20). However, the lowest yield (8.28 kg during 2018-19 and 8.09 kg during 2019-20) was recorded under D_1 x V_2.

4.1.9. The effect of transplanting dates and variety on *kharif* onion yield (q/ha)

The data on yield similar results were also recorded for yield (q/ha) and presented Table 4.11and Fig 4.21 both years of investigation (2018-19 and 2019-20) showed that the yield quintal per hectare days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

The data revealed at DAT, the yield quintal per hectare (383.29 q/ha and 382.68q/ha) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (354.05 q/ha and 355.80 q/ha) and D_6 (371.84 q/ha and 365.89 q/ha) while, the minimum yield quintal per hectare (309.65 q/ha and 307.49 q/ha) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

Obtained the data showed that the maximum length of bulb (357.84 q/ha and 351.98 q/ha during 2018-19 and 2019-20) was recorded with the cultivars $V_2$and the minimum yield quintal was recorded under the cultivars V_1 (350.21 q/ha and 344.96 q/ha during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant and treatment D_4 x V_2 produced the significantly yield quintal (395.87 q/ha during 2018-19 and 391.95 q/ha during 2019-20). However, the lowest yield quintal (318.42 q/ha during 2018-19 and 311.07 q/ha during 2019-20) was recorded under D_1 x V_2.

Table 4.11: Effect of date of transplanting and varieties on bulb yield (kg per plot and q/ha) of *kharif* onion.

Variety / Dates of transplanting	Kg/plot							Bulb Yield (q /ha)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	7.82	8.28	8.05	7.79	8.09	7.94	7.99	300.87	318.42	309.65	299.57	311.07	305.32	307.49
D_2-10th September	8.52	8.73	8.63	8.43	8.60	8.52	8.57	327.65	335.67	331.66	324.15	327.82	325.98	328.82
D_3-20th September	9.13	9.51	9.32	9.03	9.57	9.30	9.31	351.02	357.07	354.05	347.15	367.97	357.56	355.80
D_4-30th September	9.75	10.45	10.1	9.68	10.19	9.93	10.02	370.71	395.87	383.29	372.20	391.95	382.07	382.68
D_5-10th October	9.34	9.55	9.45	9.15	9.38	9.26	9.35	374.42	362.31	368.37	351.97	360.67	356.32	362.34
D_6-20th October	10.11	8.99	9.55	9.82	8.91	9.36	9.46	379.50	364.18	371.84	377.35	342.55	359.95	365.89
D_7-30th October	9.43	8.89	9.16	9.33	8.76	9.05	9.10	360.02	347.21	353.62	359.00	336.85	347.92	350.77
D_8-10th November	8.78	9.93	9.36	8.54	9.80	9.17	9.26	337.50	381.97	359.73	328.32	376.97	352.65	356.19
Mean	9.11	9.29		8.97	9.16			350.21	357.84		344.96	351.98		
SEm (±)	D	0.08			0.07				5.42			2.94		
	V	0.04			0.04				2.71			1.47		
	D×V	0.12			0.10				7.66			4.16		
CD (P= 0.05)	D	0.24			0.21				15.73			8.54		
	V	0.12			0.11				NS			4.27		
	D×V	0.34			0.30				22.24			12.08		

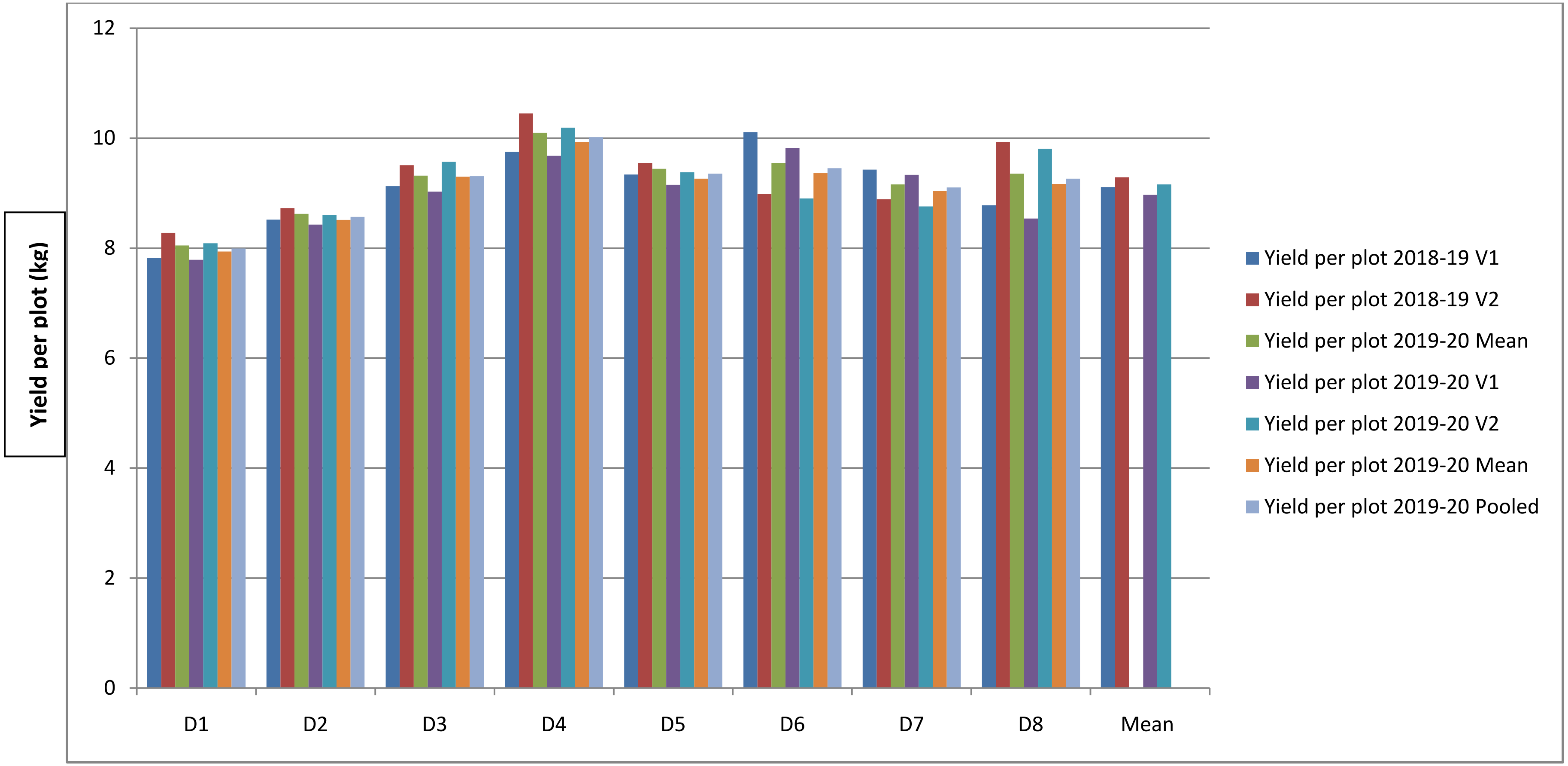


Fig 4.20 Effect of dates of transplanting and varieties on yield (kg/plot).

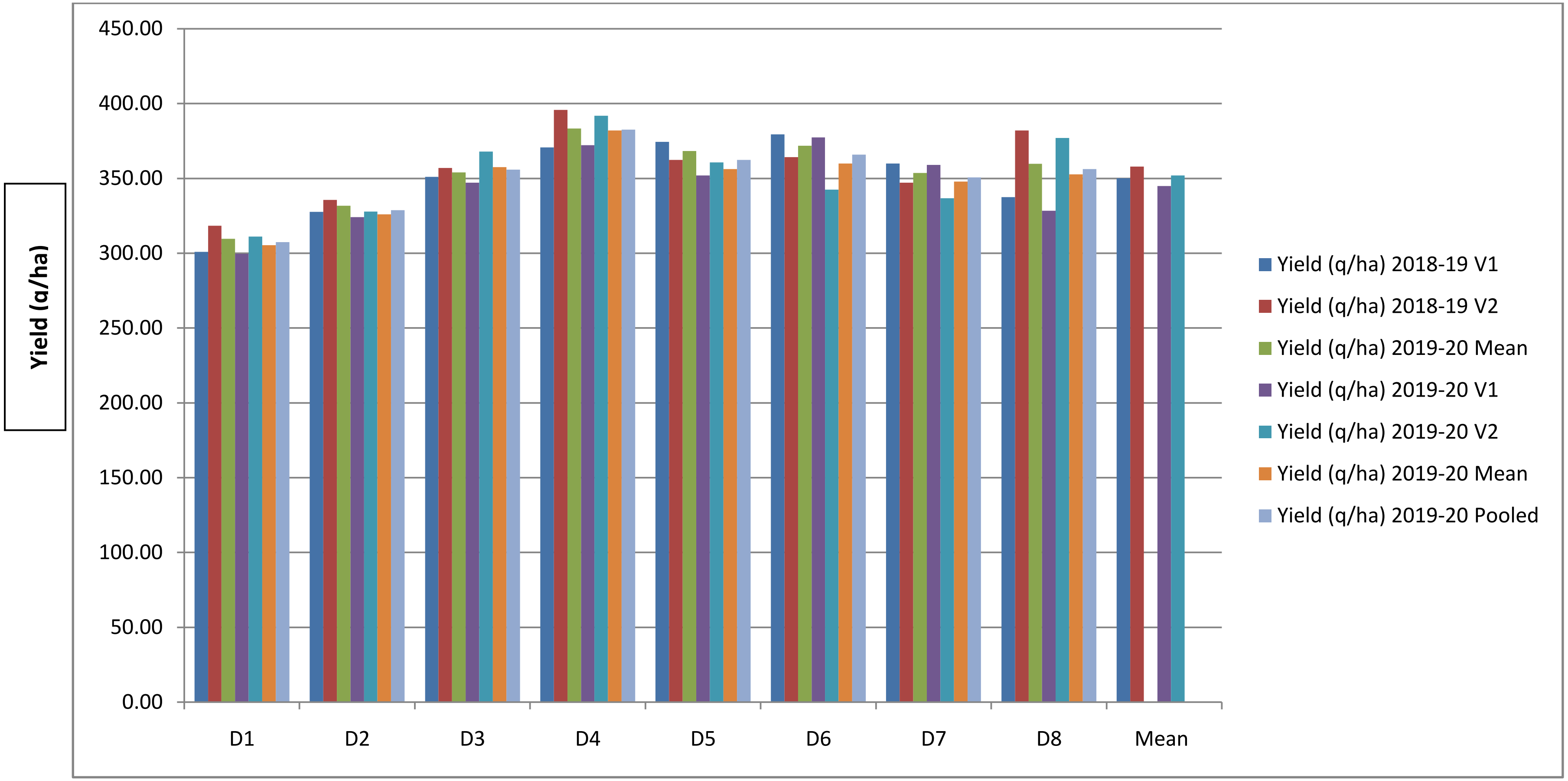


Fig 4.21 Effect of dates of transplanting and varieties on yield (q/ha) of *kharif* onion.

4.1.10. The effect of transplanting dates and variety on dry matter content of *kharif* onion bulb

The data on dry matter content is shown in Table 4.12 and is presented in Fig. 4.22. It showed that the dry matter content days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

The dry matter content (15.74 % and 15.22 %) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (12.46% and 12.38 %) and D_6 (14.53% and 14.29 %) while, the minimum dry matters content (10.21 % and 10.08 %) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).However, the onion cultivars had a significant effect on dry matter content**.**

The given data showed that the maximum dry matter content (13.10 % and 12.79 % during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum dry matter was recorded under the cultivars V_1 (12.60 % and 11.99 % during 2018-19 and 2019-20).The interaction effect between the date of transplanting and the cultivars was noted to be significant on dry matter contain.

The interactive treatment $D_{4\,x}$ V_2 produced the significantly dry matter contain (17.45 % during 2018-19 and 16.45 % during 2019-20). However, the minimum dry matter contain (10.46% during 2018-19 and 10.10 % during 2019-20) was recorded under D_1 xV_2. A comparative analysis of the data showed that in the first year of the experiment, the dry matter contain was marginally higher in 2018-19 than in the second year.

4.1.11. The effect of transplanting dates and varieties on volume of bulb (ml)

Both years of investigation (2018-19 and 2019-20) showed that the volume of bulb days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties(Table 4.12 and Fig 4.23).

The volume of bulb (78.17 ml and 75.82 ml) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (69.17 ml and 66.16ml) and D_6 (76.33 ml and 74.50 ml) while, the minimum volume of bulb (62.00

ml and 60.75 ml) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on volume of bulb. The given data showed that the maximum volume of bulb(72.08 ml and 68.19 ml during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum volume of bulb was recorded under the cultivars V_1 (70.29 ml and 65.88 ml during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on volume of bulb and D_4 xV_2 produced the significantly volume of bulb (85.00 ml during 2018-19 and 80.31 ml during 2019-20). However, the minimum volume of bulb (62.67 ml during 2018-19 and 61.84 ml during 2019-20) was recorded under D_1 x V_2.

Table 4.12: Effect of date of transplanting and varieties on dry matter content in bulb and volume of bulb of *kharif* onion.

Variety / Dates of transplanting	Dry matter content (%)							Volume of bulb (ml)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	9.96	10.46	10.21	9.80	10.10	9.95	10.08	61.33	62.67	62.00	57.17	61.84	59.50	60.75
D_2-10th September	10.78	11.20	10.99	10.40	10.86	10.63	10.81	65.00	71.67	68.33	64.28	69.15	66.72	67.52
D_3-20th September	11.32	13.60	12.46	11.12	13.46	12.29	12.38	69.67	68.67	69.17	65.16	61.16	63.16	66.16
D_4-30th September	14.04	17.45	15.74	12.96	16.45	14.71	15.22	71.33	85.00	78.17	66.65	80.31	73.48	75.82
D_5-10th October	13.86	13.78	13.82	12.88	13.71	13.29	13.56	73.33	77.67	75.50	65.63	73.66	69.65	72.57
D_6-20th October	16.27	12.80	14.53	15.43	12.66	14.05	14.29	82.00	70.67	76.33	75.16	70.19	72.68	74.50
D_7-30th October	12.94	12.14	12.54	11.84	12.07	11.96	12.25	66.67	72.33	69.50	62.17	56.66	59.41	64.46
D_8-10th November	11.62	13.34	12.48	11.49	13.01	12.25	12.37	73.00	68.00	70.50	70.83	72.58	71.70	71.10
Mean	12.60	13.10		11.99	12.79			70.29	72.08		65.88	68.19		
SEm (±)	D	0.29			0.24				0.77			0.46		
	V	0.15			0.12				0.38			0.23		
	D×V	0.41			0.34				1.09			0.65		
CD (P= 0.05)	D	0.85			0.69				2.24			1.34		
	V	0.42			0.34				1.12			0.67		
	D×V	1.20			0.97				3.16			1.89		

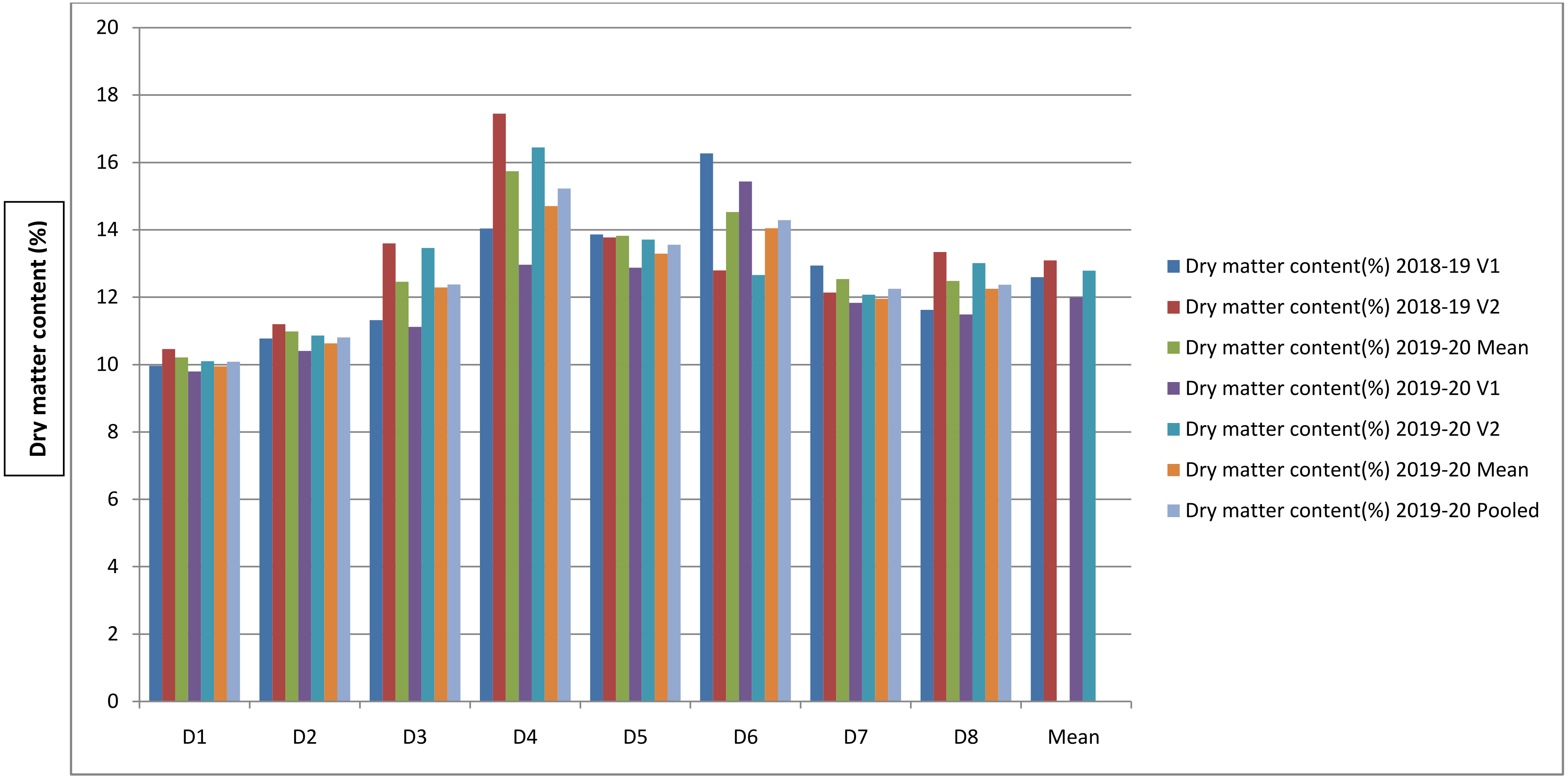


Fig 4.22 Effect of dates of transplanting and varieties on dry matter content (%) in bulb of *kharif* onion.

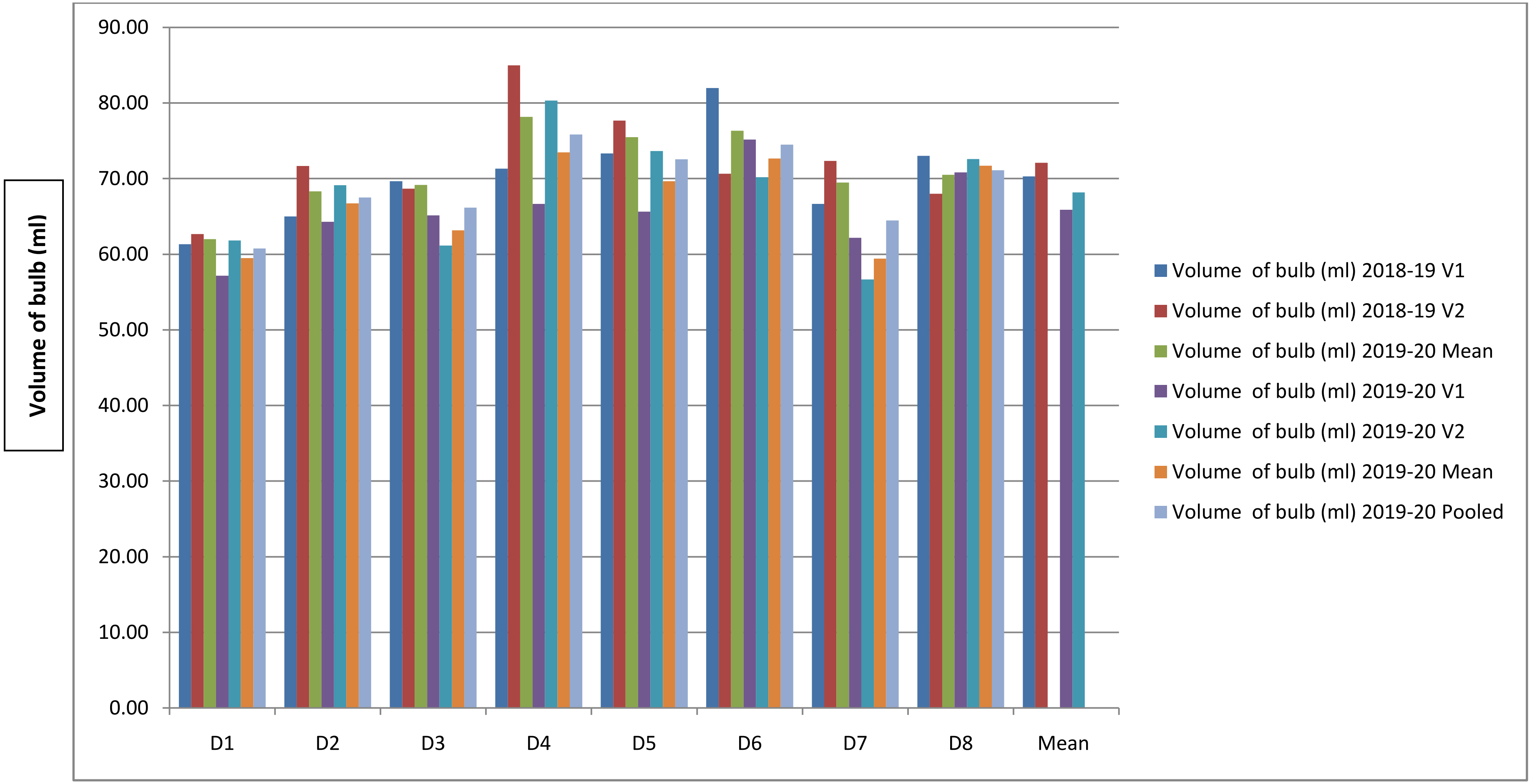


Fig 4.23 Effect of dates of transplanting and varieties on volume of bulb of *kharif* onion

Plate 13 : Harvesting of onion bulb

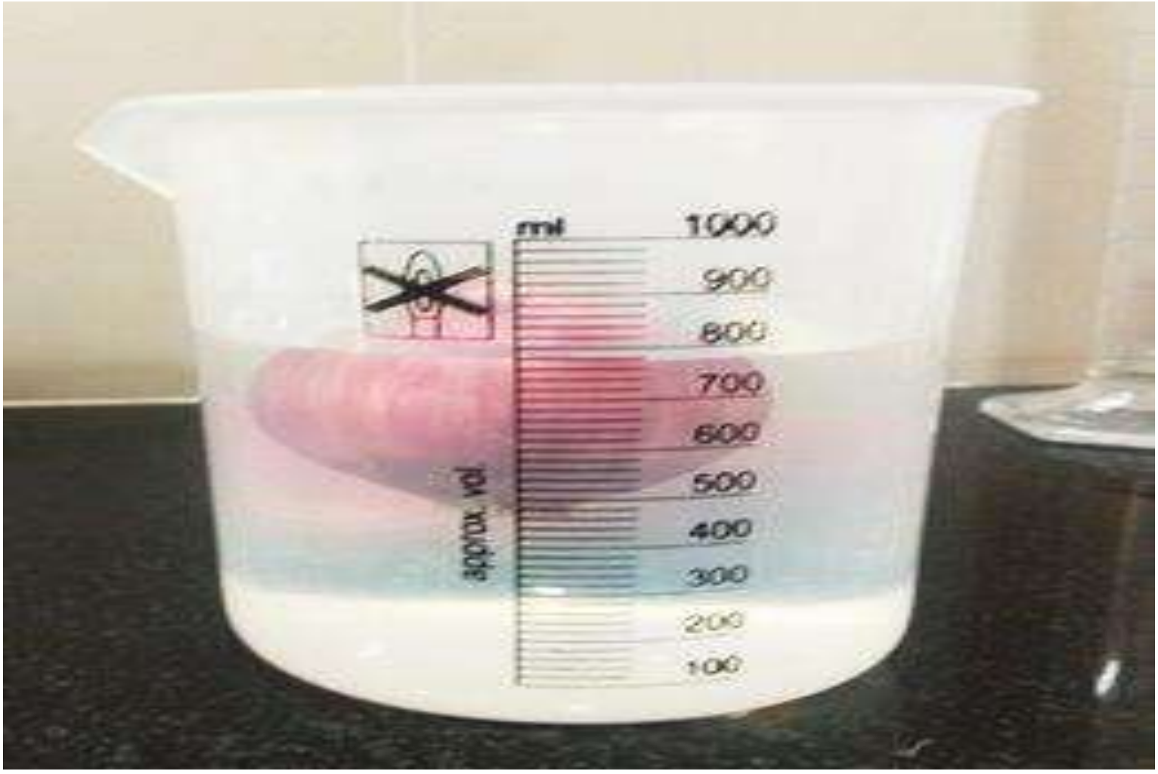


Plate 14 : Estimation of volume of onion bulb

4.1.12. The effect of transplanting dates and varieties on specific gravity of onion bulb

Both years of investigation (2018-19 and 2019-20) showed that the specific gravity days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.(Table 4.13 and Fig 4.24).

The specific gravity (1.18 g/cc and 1.17 g/cc) was recorded under highest the moderate transplanted date of D_4, followed by transplanting date D_3 (1.14 g/cc and 1.12 g/cc) and D_6 (1.18 g/cc and 1.16 g/cc) while, the minimum specific gravity(1.06 g/cc and 1.04 g/cc) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The given data showed that the maximum specific gravity (1.13 g/cc and 1.11 g/cc during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum specific gravity was recorded under the cultivars V_1 (1.11 g/cc and 1.10 g/cc during 2018-19 and 2019-20).The interaction effect between the date of transplanting and the cultivars was noted to be significant on specific gravity. The interactive treatment D_4 xV_2 produced the significantly specific gravity (1.23 g/cc during 2018-19 and 1.20 g/cc during 2019-20). However, the minimum specific gravity (1.19 g/cc during 2018-19 and 1.17 g/cc during 2019-20) was recorded under D_1 x V_1. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the specific gravity was marginally higher in 2018-19 than in the second year.

4.1.13. The effect of transplanting dates and variety on length of bulb of *kharif* onion.

Table 4.13 and Fig. 4.25 showed that the length of bulb days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

This is clear from Table 4.13 that the maximum length of bulb **(**64.66 mm and 63.91 mm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (57.33 mm and 56.16 mm) and D_6 (63.80 mm and 62.65 mm) while, the minimum length of bulb(49.84 mm and 49.61 mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on length of bulb. The given data showed that the maximum length of bulb(59.81 mm and 58.50 mm during 2018-19 and 2019-20) was recorded with the cultivar V_2 and the minimum length of bulb was recorded under the cultivar V_1 (58.09 mm and 57.76 mm during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on length of bulb. The treatment D_4 x V_2 produced the significantly length of bulb (66.53 mm during 2018-19 and 65.53 mm during 2019-20). However, the minimum length of bulb (48.46 mm during 2018-19 and 47.79 mm during 2019-20) was recorded under D_1 x V_1. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the length of bulb was marginally higher in 2018-19 than in the second year.

Table 4.13: Effect of date of transplanting and varieties on specific gravity and length of bulb of *kharif* onion.

Variety / Dates of transplanting	Specific gravity (g/cc)							Length of bulb (mm)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	1.04	1.06	1.06	1.01	1.03	1.02	1.04	48.46	51.22	49.84	47.79	50.98	49.39	49.61
D_2-10th September	1.07	1.08	1.08	1.05	1.09	1.07	1.07	52.20	52.80	52.50	51.86	52.14	52.00	52.25
D_3-20th September	1.12	1.15	1.14	1.08	1.11	1.10	1.12	53.43	61.22	57.33	52.77	57.22	54.99	56.16
D_4-30th September	1.11	1.23	1.17	1.15	1.20	1.18	1.17	62.79	66.53	64.66	60.79	65.53	63.16	63.91
D_5-10th October	1.16	1.13	1.15	1.14	1.13	1.14	1.14	62.07	60.31	61.19	61.73	60.64	61.19	61.19
D_6-20th October	1.19	1.17	1.18	1.17	1.10	1.14	1.16	64.66	62.94	63.80	63.99	58.99	61.49	62.65
D_7-30th October	1.09	1.14	1.12	1.07	1.10	1.09	1.10	59.66	63.74	61.70	61.48	62.41	61.95	61.82
D_8-10th November	1.11	1.10	1.11	1.16	1.15	1.16	1.13	61.46	59.74	60.60	61.67	60.07	61.10	60.77
Mean	1.11	1.13		1.10	1.12			58.09	59.81		57.76	58.50		
SEm (±)	D	0.06			0.05				0.40			0.45		
	V	0.03			0.02				0.10			0.22		
	D×V	0.08			0.07				0.56			0.63		
CD- (P= 0.05)	D	0.17			0.16				1.16			1.20		
	V	0.08			0.06				0.58			0.65		
	D×V	0.24			0.23				1.64			1.84		

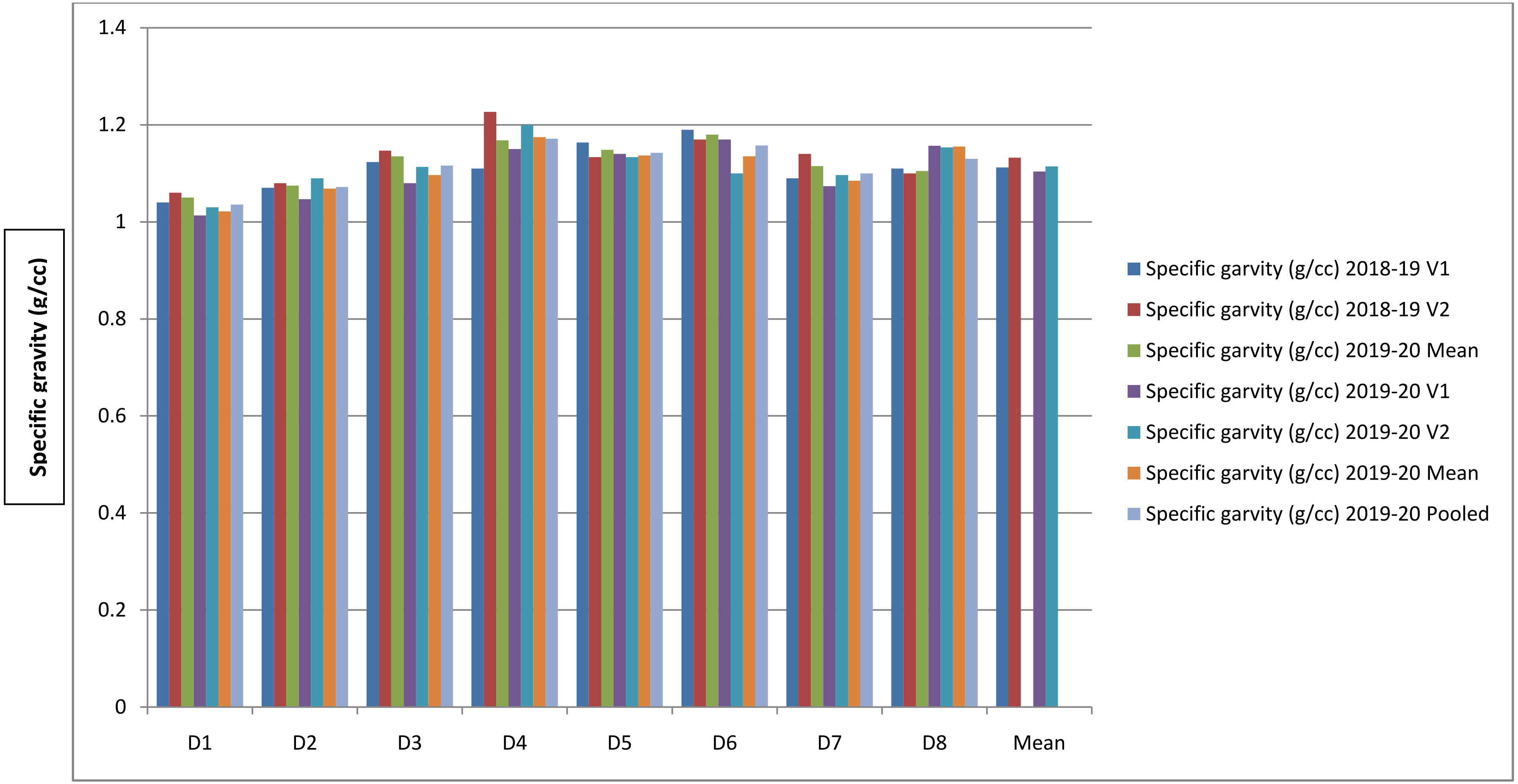


Fig 4.24 Effect of dates of transplanting and varieties on specific gravity (g/cc) of *kharif* onion.

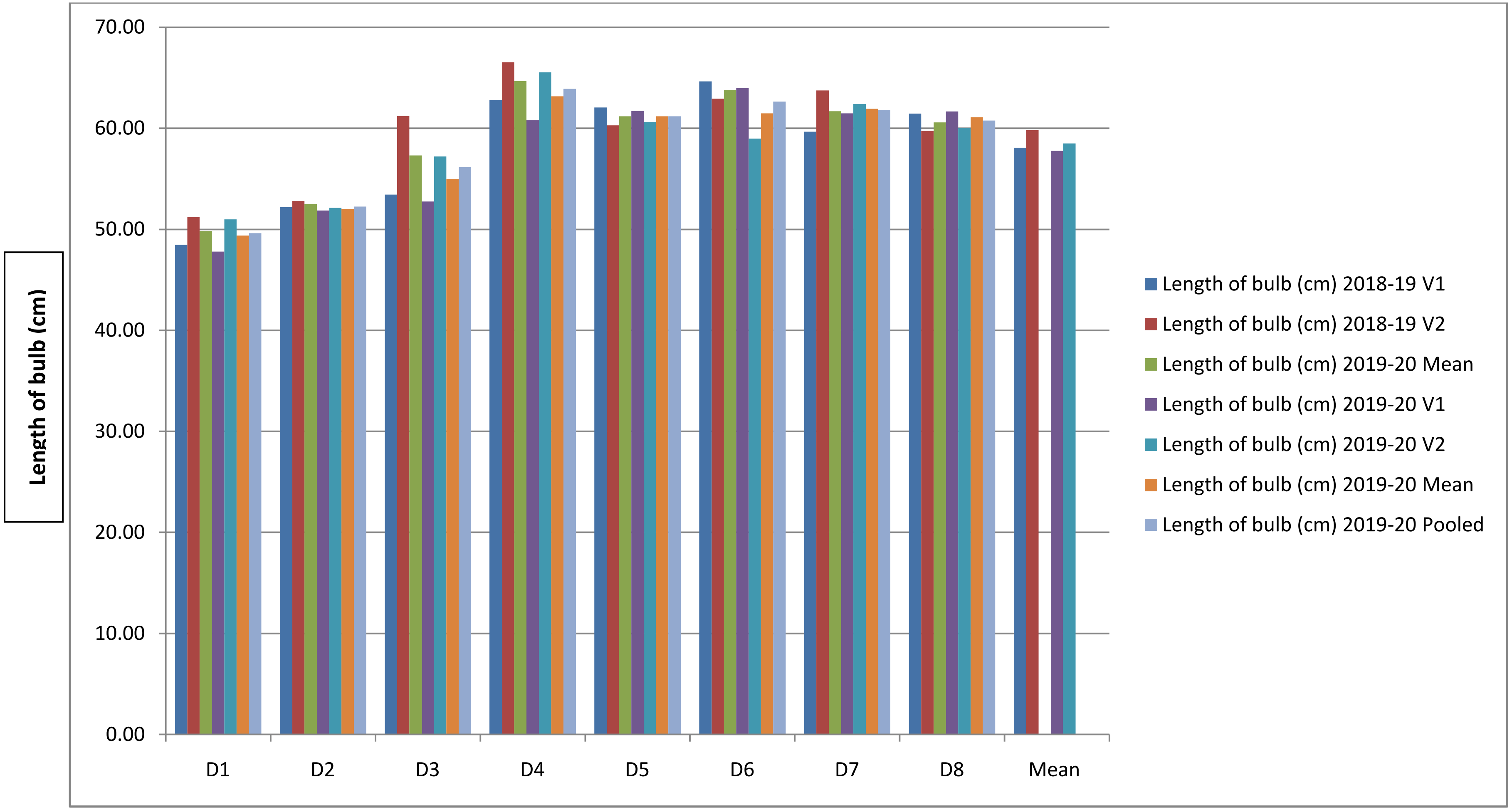


Fig 4.25 Effect of dates of transplanting and varieties on length of bulb (cm) of *kharif* onion.

4.1.14. The effect of transplanting dates and varieties on polar diameter (mm) of onion bulb.

The data on polar diameter is shown in Table 4.14 and in Fig 4.26. It showed that the polar diameter days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

The maximum polar diameter (55.68 mm and 53.98 mm) was recorded under the moderate transplanted date of D_4. It was followed by transplanted date D_3 (46.08 mm and 47.26 mm) and D_6 (52.27 mm and 51.60 mm) while, the minimum polar diameter(42.03 mm and 41.57 mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

Regarding effect of cultivars, it was seen that the maximum polar diameter (48.43 mm and 47.37 mm during 2018-19 and 2019-20) was recorded with the cultivar V_2 and the minimum polar diameter was recorded under the cultivar V_1 (46.84 mm and 45.94 mm during 2018-19 and 2019-20).

The combined treatment D_4 x V_2 produced the significantly higher polar diameter (58.68 mm during 2018-19 and 55.47 mm during 2019-20). However, the minimum polar diameter (42.73 mm during 2018-19 and 41.49 mm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the polar diameter was marginally higher in 2018-19 than in the second year.

4.1.15. The effect of transplanting dates and variety on equatorial diameter of onion

Similarly Table 4.14 and Fig 4.27 showed that the equatorial diameter days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties. The equatorial diameter (69.58 mm and 69.06 mm) was recorded as maximum under the moderate transplanting date of D_4, followed by transplanting date D_3 (63.15 mm and 62.89 mm) and D_6 (68.94 mm and 68.63 mm) while, the minimum equatorial diameter (54.02 mm and 53.70 mm) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The given data showed that the maximum equatorial diameter(64.17 mm and 63.75 mm during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum equatorial diameter was recorded under the cultivars V_1 (63.22 mm and 62.51 mm during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on equatorial diameter**.** The interactive treatment D_4 x V_2 produced the significantly equatorial diameter (74.50 mm during 2018-19and 73.43mm during 2019-20). However, the minimum equatorial diameter (56.73 mm during 2018-19 and 56.03 mm during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the equatorial diameter was marginally higher in 2018-19 than in the second year.

Table 4.14: Effect of date of transplanting and varieties on polar diameter and equatorial diameter of *kharif* onion.

Variety / Dates of transplanting	Polar diameter (mm)							Equatorial diameter (mm)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	41.33	42.73	42.03	40.70	41.49	41.10	41.57	51.31	56.73	54.02	50.71	56.03	53.37	53.70
D_2-10th September	44.66	48.61	46.63	42.77	43.51	43.14	44.89	57.83	59.23	58.53	57.37	58.90	58.13	58.33
D_3-20th September	45.00	47.16	46.08	45.40	51.50	48.45	47.26	61.10	65.20	63.15	60.80	64.47	62.63	62.89
D_4-30th September	52.68	58.68	55.68	49.12	55.47	52.29	53.98	64.65	74.50	69.58	63.67	73.43	68.55	69.06
D_5-10th October	47.81	44.31	46.06	46.50	47.47	46.99	46.52	69.21	66.67	67.94	67.63	66.07	66.85	67.39
D_6-20th October	53.14	51.40	52.27	53.44	48.43	50.94	51.60	70.81	67.07	68.94	69.91	66.73	68.32	68.63
D_7-30th October	46.67	48.17	47.42	44.63	43.75	44.19	45.80	68.40	60.39	64.40	66.87	60.39	63.63	64.01
D_8-10th November	43.43	46.41	44.92	44.95	47.33	46.14	45.53	62.41	63.60	63.01	63.11	64.00	63.56	63.28
Mean	46.84	48.43		45.94	47.37			63.22	64.17		62.51	63.75		
SEm (±)	D	0.74			0.57				0.71			0.61		
	V	0.37			0.28				0.35			0.3		
	D×V	1.05			0.8				1.01			0.87		
CD (P= 0.05)	D	2.15			1.65				2.07			1.78		
	V	1.08			0.82				NS			0.89		
	D×V	3.05			2.33				2.93			2.52		

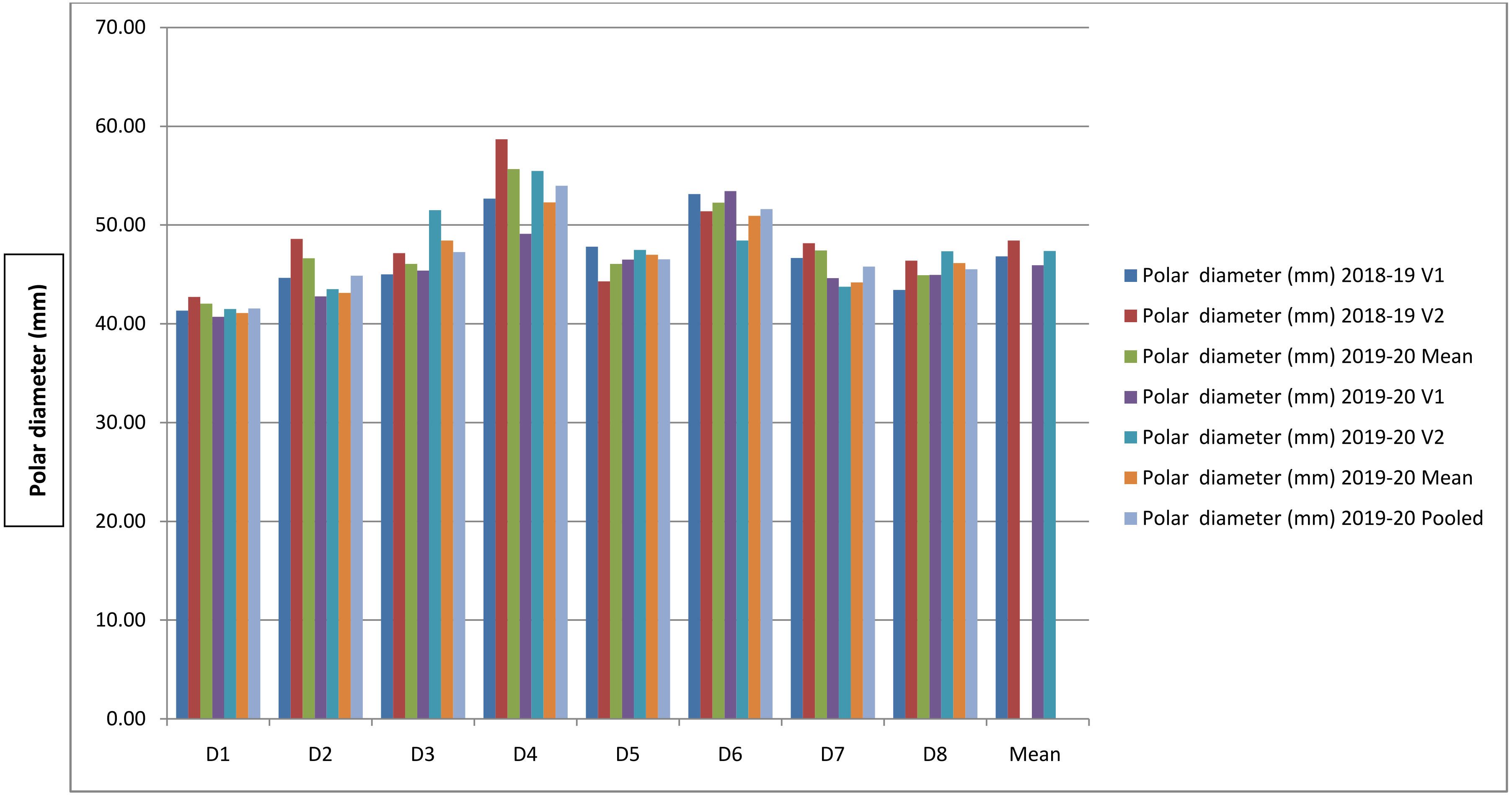


Fig 4.26 Effect of dates of transplanting and varieties on polar diameter (mm) of *kharif* onion.

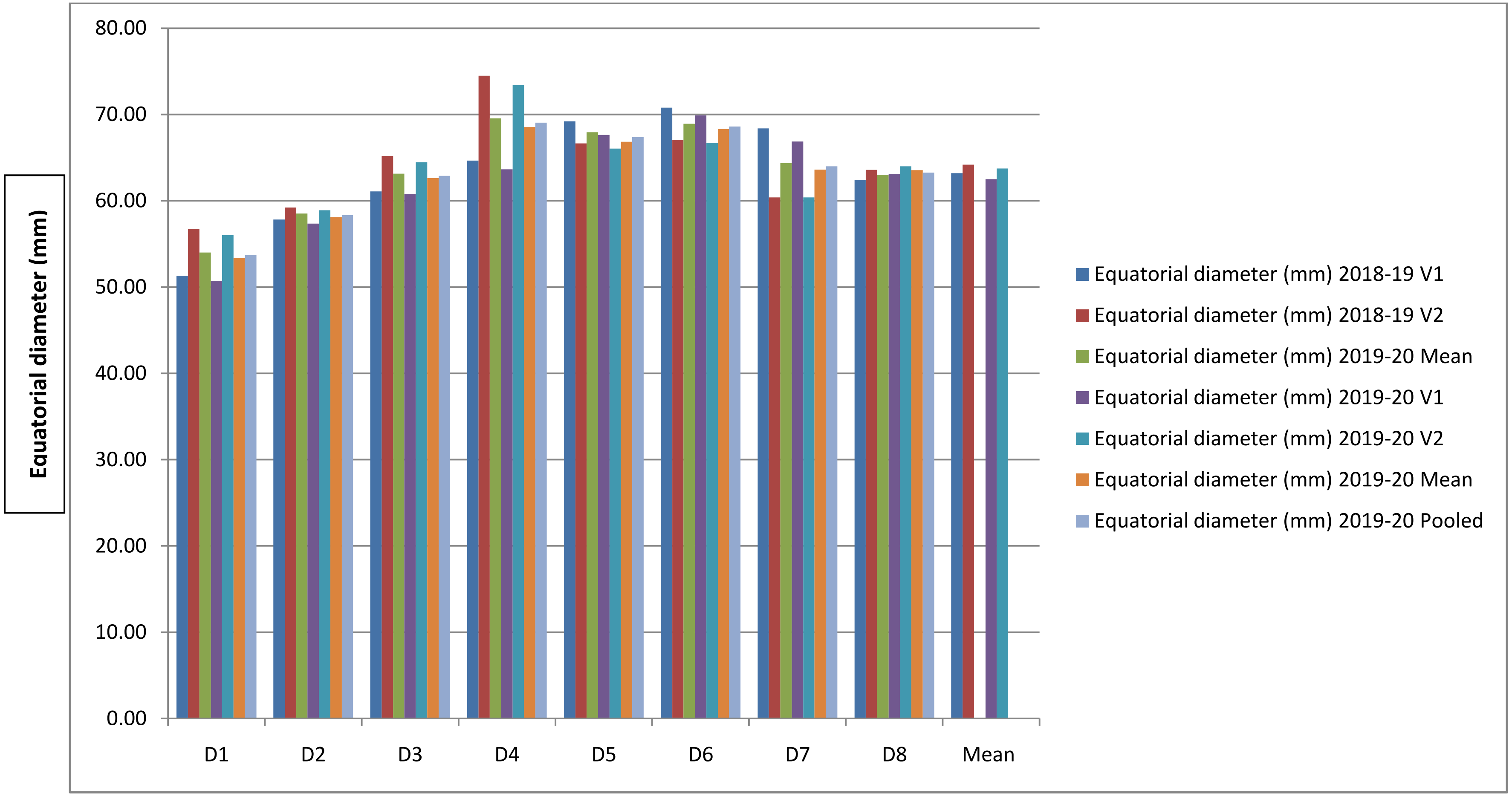


Fig 4.27 Effect of dates of transplanting and varieties on equatorial diameter (mm) of *kharif* onion.

Plate 15 : Estimation of bulb weight

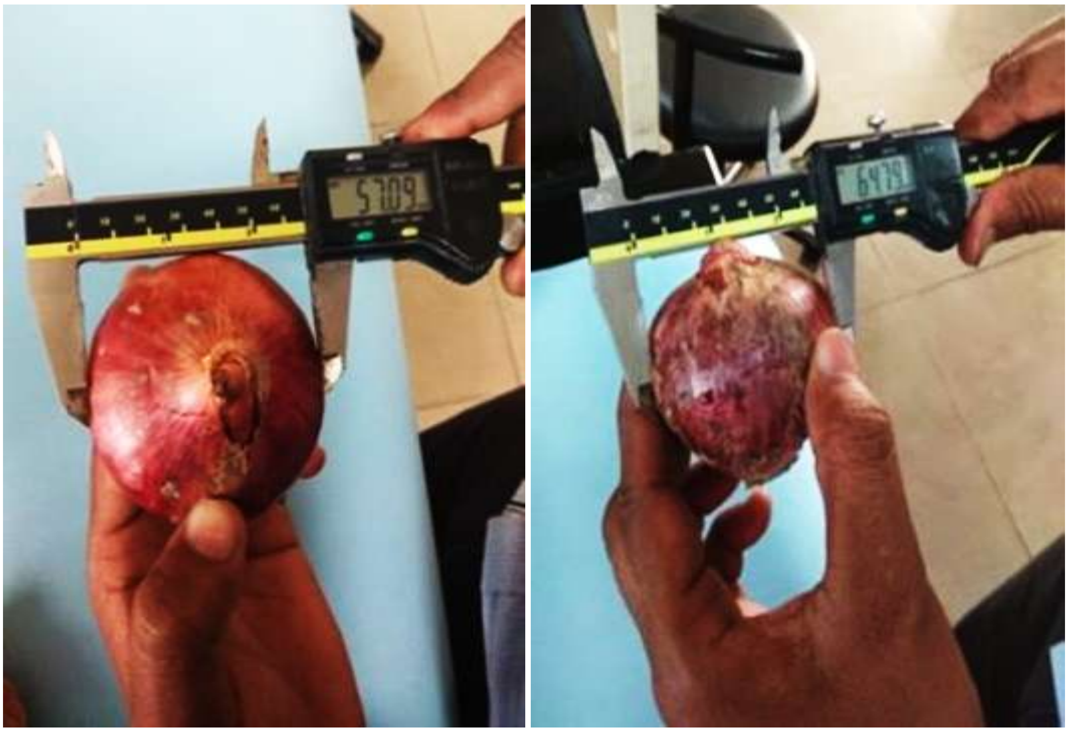


Plate 16: Measurement of Polar and Equatorial diameter of bulb

4.1.15. The effect of transplanting dates and varieties on number of fresh scale per bulb

The data on number of scale is shown in Table 4.15 and is presented in Fig. 4.28 and showed that the number of scale was significantly influenced by different dates of transplanting and varieties.

It showed that maximum the number of scale, per bulb (12.17 and 11.75) was counted under the moderate transplanting date of D4. It was followed by transplanted date D3 (9.17 and 9.12) and D6 (11.17 and10.83) while, the minimum number of scale (6.83 and 6.17) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on number of scale. The given data showed that the maximum number of scale (10.00 and during 2018-19 9.12 and 2019-20) was recorded with the cultivars V_2 and the minimum number of scale was recorded under the cultivars V_1 (9.46 and 8.54during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on number of scale. The interactive treatment D_4 x V_2 produced the significantly number of scale (13.00 during 2018-19 and 12.33 during 2019-20). However, the minimum number of scale (7.33 during 2018-19 and 5.67 during 2019-20) was recorded under D_1 x V_2.

Table 4.15: Effect of transplanting dates and varieties on number of fresh scale per bulb.

Variety / Dates of transplanting	Number of scale per bulb						
	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	6.33	7.33	6.83	5.33	5.67	5.50	6.17
D_2-10th September	8.33	9.67	9.00	6.67	7.33	7.00	8.00
D_3-20th September	9.00	9.33	9.17	8.33	10.00	9.17	9.17
D_4-30th September	11.33	13.00	12.17	10.33	12.33	11.33	11.75
D_5-10th October	10.00	11.00	10.50	7.67	9.00	8.33	9.42
D_6-20th October	12.00	10.33	11.17	11.67	9.33	10.50	10.83
D_7-30th October	8.67	10.67	9.67	10.67	8.00	9.34	9.50
D_8-10th November	10.00	8.67	9.33	7.67	11.33	9.50	9.42
Mean	9.46	10.00		8.54	9.12		
SEm (±)	D	0.34			0.31		
	V	0.17			0.15		
	D×V	0.48			0.44		
CD (P= 0.05)	D	0.99			0.91		
	V	0.57			0.45		
	D×V	1.41			1.28		

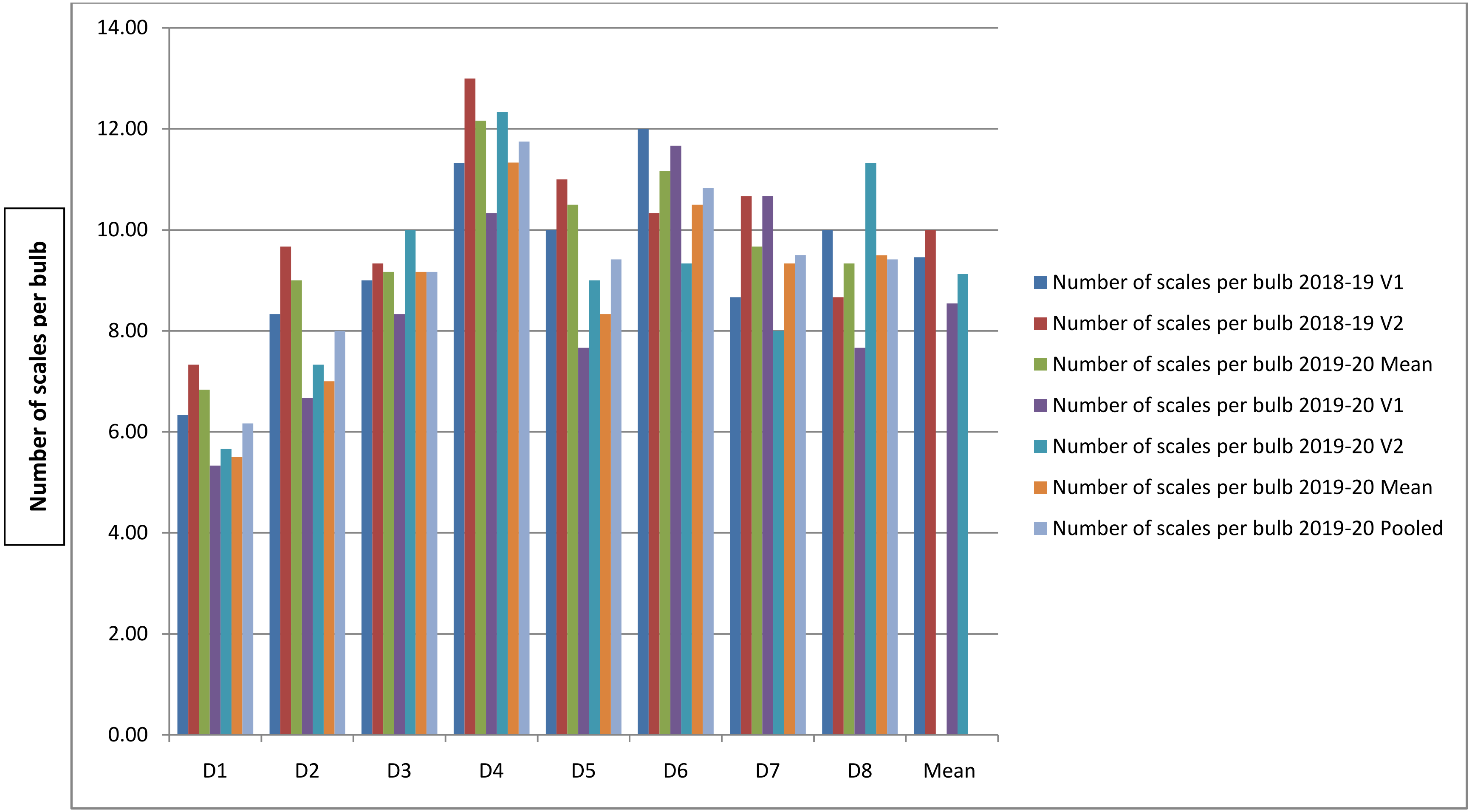


Fig 4.28 Effect of dates of transplanting and varieties on number of scale per bulb of *kharif* onion.

4.1.16 The effect of transplanting date and variety on total soluble solids (^{0}Brix) present in *kharif* onion bulb.

Both years of investigation (2018-19 and 2019-20) showed that the total soluble solids (^{0}Brix) was significantly influenced by different dates of transplanting and varieties.

The maximum total soluble solids (12.23 ^{0}Brix and 12.10 ^{0}Brix) was recorded under the moderate transplanting date of D_3.It was followed by transplanted date D_2 (10.46 ^{0}Brix and 10.37 ^{0}Brix) and D_7 (12.15 ^{0}Brix and 12.06 ^{0}Brix) while, the minimum total soluble solids (9.39 ^{0}Brix and9.24 ^{0}Brix) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

Among the cultivars, presented data showed that the total soluble solid (11.25 ^{0}Brix and 10.84 ^{0}Brix during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum total soluble solids (^{0}Brix) was recorded under the cultivars V_1(11.41^{0}Brix and 11.40^{0}Brix during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant. The interactive treatment D_3 xV_2 produced the significantly total soluble solids (13.23 ^{0}Brix and 13.04 ^{0}Brix during 2018-19 and 2019-20). However, the minimum total soluble solids (9.92 ^{0}Brixand 9.43 ^{0}Brix during 2018-19 and 2019-20) was recorded under D_1xV_2. It was also seen that in the first year of the experiment, the total soluble solids was higher than in the second year.

4.1.17 The effect of transplanting dates and varieties on total sugars of *kharif* onion bulb

Table 4.16 and Fig 4.30 showed that the total sugars were significantly influenced by different dates of transplanting and varieties.

Transplanting date D3 produced highest total sugars (10.18 % and 10.17 %). It was followed by transplanted date D_2 (9.22 % and 9.21 %) and D_7 (10.02 % and 9.99 %) while, the minimum total sugar (8.84% and 8.81 %) was recorded under the early transplanted date D_1during both years of investigation 2018-19 and 2019-20.

The given data showed that the total sugar (9.72 % and 9.69 % during 2018-19 and 2019-20.Was recorded with the cultivars V_2 and the minimum total sugar was recorded under the cultivars V_1 (9.14 % and 9.10 % during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars were noted to be significant on total sugar. The interactive treatment D_3 xV_2 produced the significantly total sugar (11.10 % and 11.04 % during 2018-19 and 2019-20). However, the minimum total sugar (9.65 % during 2018-19 and 9.59 % during 2019-20) was recorded under D_1 x V_2.

Table 4.16: Effect of dates of transplanting and varieties on total soluble solids and total sugars of *kharif* onion.

Variety / Dates of transplanting	Total soluble solids (^{0}Brix)							Total sugars (%)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	8.86	9.92	9.39	8.76	9.43	9.09	9.24	8.03	9.65	8.84	7.95	9.59	8.77	8.81
D_2-10th September	10.30	10.62	10.46	10.14	10.42	10.28	10.37	8.99	9.44	9.22	8.94	9.47	9.21	9.21
D_3-20th September	11.23	13.23	12.23	13.04	10.91	11.97	12.10	9.26	11.10	10.18	9.26	11.04	10.15	10.17
D_4-30th September	11.97	11.58	11.78	11.76	11.45	11.61	11.69	8.86	9.77	9.31	8.88	9.72	9.30	9.31
D_5-10th October	12.86	11.06	11.96	12.13	11.11	11.62	11.79	8.99	9.78	9.38	8.95	9.72	9.34	9.36
D_6-20th October	12.39	11.11	11.75	12.03	11.37	11.70	11.72	9.89	9.33	9.61	9.85	9.29	9.57	9.59
D_7-30th October	12.89	11.40	12.15	12.75	11.22	11.98	12.06	10.26	9.78	10.02	10.19	9.75	9.97	9.99
D_8-10th November	10.78	11.07	10.93	10.67	10.78	10.73	10.83	8.86	8.94	8.90	8.81	8.92	8.87	8.89
Mean	11.41	11.25		11.41	10.84			9.14	9.72		9.10	9.69		
SEm (±)	D	0.12			0.61				0.18			0.17		
	V	0.06			0.08				0.09			0.09		
	D×V	0.17			0.23				0.26			0.25		
CD (P= 0.05)	D	0.35			0.47				0.52			0.5		
	V	NS			0.23				0.26			0.25		
	D×V	0.50			0.66				0.74			0.71		

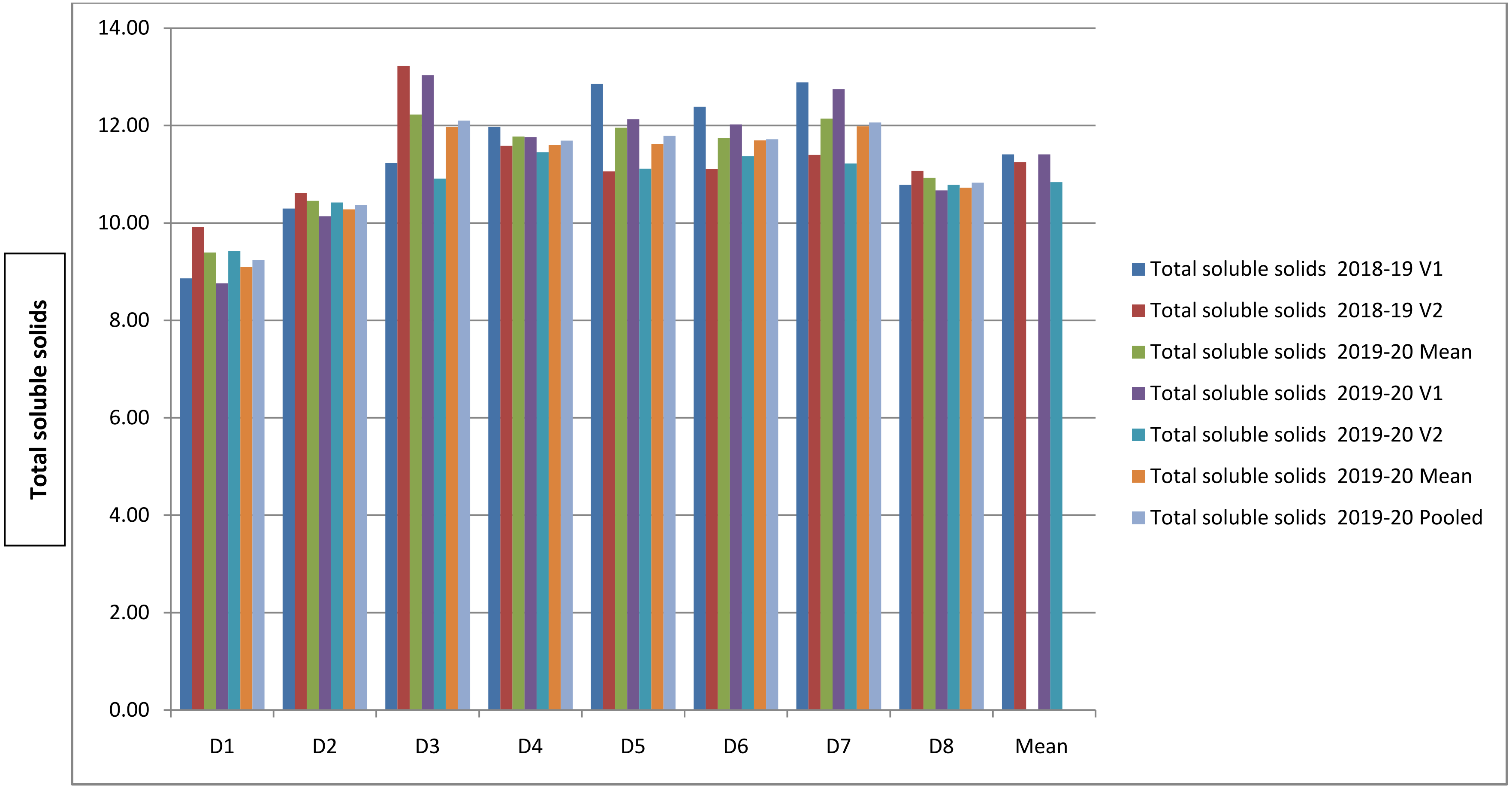


Fig 4.29 Effect of dates of transplanting and varieties on total soluble solids (^{o}Brix) of *kharif* onion.

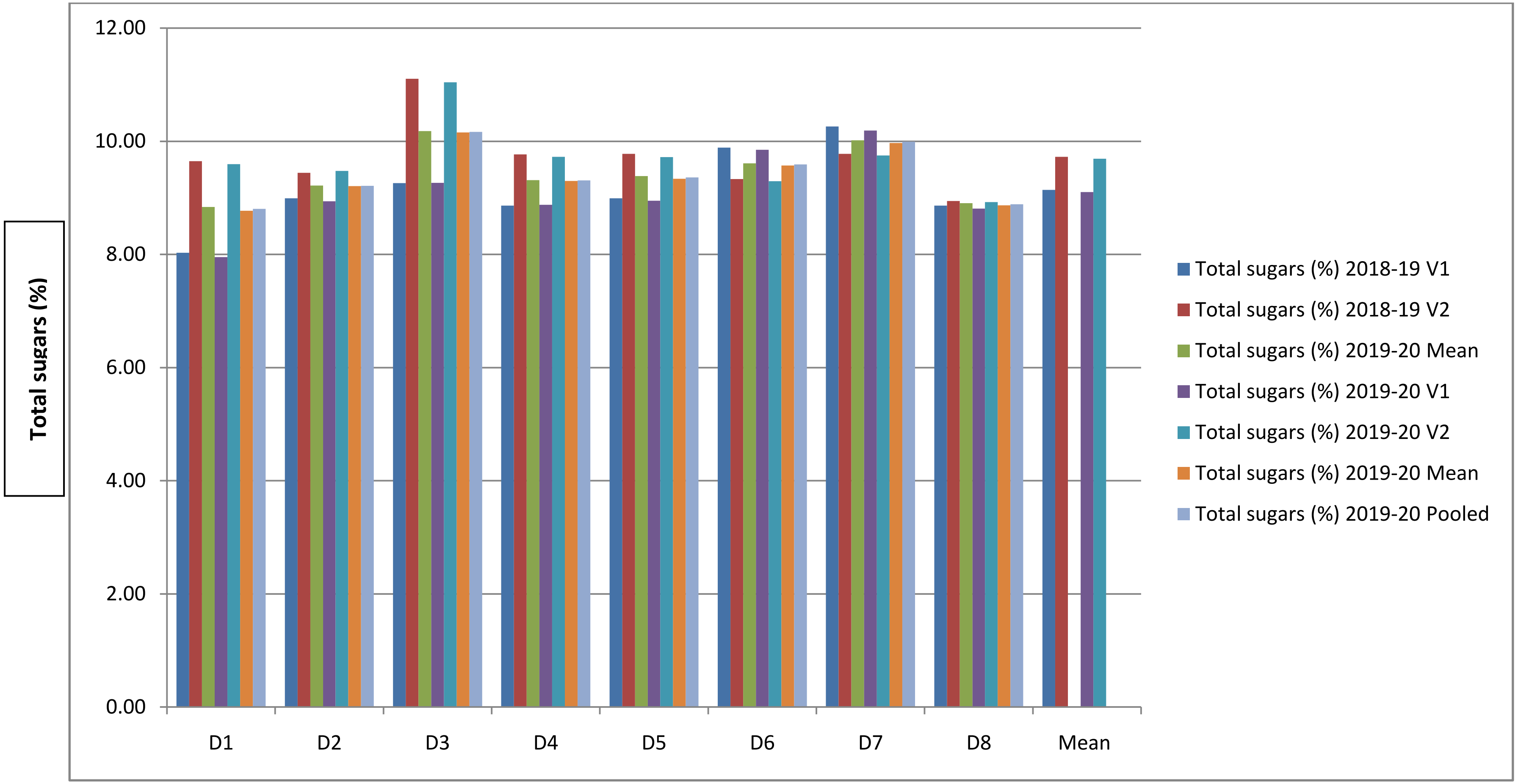


Fig 4.30 Effect of dates of transplanting and varieties on total sugars (%) of *kharif* onion.

Plate 17 : Measurement of total soluble solids by digital refractrometer

Plate 18: Titration for sugar analysis

4.1.18 The effect of transplanting dates and varieties on reducing sugar (%) content in kharif onion bulb

The both years of investigation (2018-19 and 2019-20) showed that the reducing sugar days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.(Table 4.17 and Fig 4.31).

The reducing sugar (5.57 % and 5.58 %) was recorded maximum under the moderate transplanting date of D_3, followed by the transplanting date D_2 (5.03 % and 5.02 %) and D_7 (5.60 % and 5.58 %) while, the minimum reducing sugar (4.82 % and 4.80 %) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

Cultivar V2 showed the maximum reducing sugar (5.47 % and 5.44 % during 2018-19 and 2019-20) and the minimum reducing sugar was recorded under the cultivars V_1 (5.09 % and 5.07 % during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on reducing sugar**.** The interactive treatment D_3 x V_2 produced the significantly reducing sugar (6.19 % and 6.17 % during2018-19 and 2019-20). However, the minimum reducing sugar (5.20 % and 5.18 % during 2018-19 and 2019-20) was recorded under D_1 x V_2.

4.1.19 The effect of transplanting dates and varieties on non- reducing sugar (%) of onion bulb

Similar pattern was also seen in case of non- reducing sugar both years of investigation (2018-19 and 2019-20) showed that the non-reducing sugar days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.(Table 4.17 and Fig 4.32).

The non-reducing sugar (4.61 % and 4.59 %) was recorded under the moderate transplanted date of D_3. It was followed by the transplanted date D_2 (4.22 % and 4.21%) and D_7 (4.43 % and 4.42 %) while, the minimum non-reducing sugar (4.02 % and 4.00 %) was recorded under the early transplanted date D_1 (%) during both years of investigation (2018-19 and 2019-20).

The given data showed that the highest non-reducing sugar (4.27 % and 4.25 % during 2018-19 and 2019-20) was recorded with the cultivar V_2 and the minimum non-reducing sugar was recorded under the cultivar V_1 (4.05 % and 4.03 % during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on non-reducing sugar**.** The interactive treatment D_3 x V_2 produced significantly high non-reducing sugar (4.92 % and 4.87 % during 2018-19 and 2019-20). However, the minimum non-reducing sugar (4.45 % and 4.41 % during 2018-19 and 2019-20) was recorded under D_1 x V_2.

Table 4.17: Effect of dates of transplanting and varieties on reducing sugar and non-reducing sugar of *kharif* onion bulb.

Variety / Dates of transplanting	Reducing sugar (%)							Non reducing sugar (%)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	4.43	5.20	4.82	4.40	5.18	4.79	4.80	3.59	4.45	4.02	3.55	4.41	3.98	4.00
D_2-10th September	4.79	5.28	5.03	4.76	5.26	5.01	5.02	4.20	4.23	4.22	4.18	4.21	4.20	4.21
D_3-20th September	4.96	6.52	5.74	4.98	6.17	5.58	5.66	4.30	4.92	4.61	4.28	4.87	4.58	4.59
D_4-30th September	5.34	5.42	5.38	5.34	5.40	5.37	5.38	3.52	4.34	3.93	3.53	4.32	3.93	3.93
D_5-10th October	4.91	5.62	5.27	4.89	5.59	5.24	5.25	4.08	4.15	4.12	4.06	4.13	4.09	4.11
D_6-20th October	5.67	5.40	5.54	5.65	5.38	5.52	5.53	4.22	3.93	4.08	4.20	3.91	4.06	4.07
D_7-30th October	5.75	5.45	5.60	5.71	5.43	5.57	5.58	4.51	4.34	4.43	4.48	4.32	4.40	4.42
D_8-10th November	4.89	5.16	5.03	4.86	5.13	4.99	5.01	3.97	3.81	3.89	3.95	3.79	3.87	3.88
Mean	5.09	5.51		5.07	5.44			4.05	4.27		4.03	4.25		
SEm (±)	D	0.14			0.12				0.15			0.14		
	V	0.07			0.06				0.08			0.07		
	D×V	0.19			0.18				0.21			0.2		
CD (P= 0.05)	D	0.39			0.37				0.44			0.42		
	V	0.19			0.18				0.22			0.21		
	D×V	0.55			0.52				0.62			0.59		

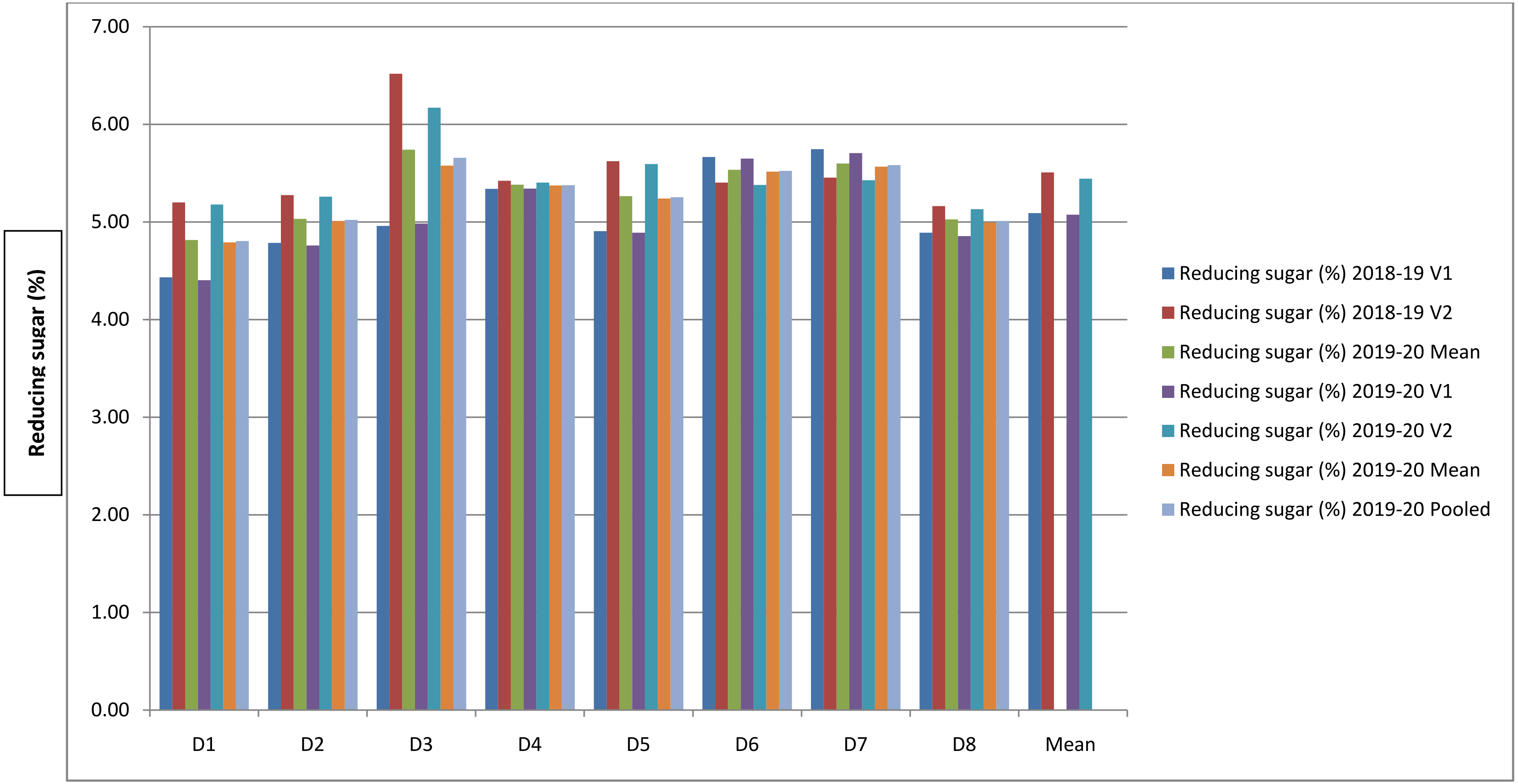


Fig 4.31 Effect of dates of transplanting and varieties on reducing sugar (%) of *kharif* onion

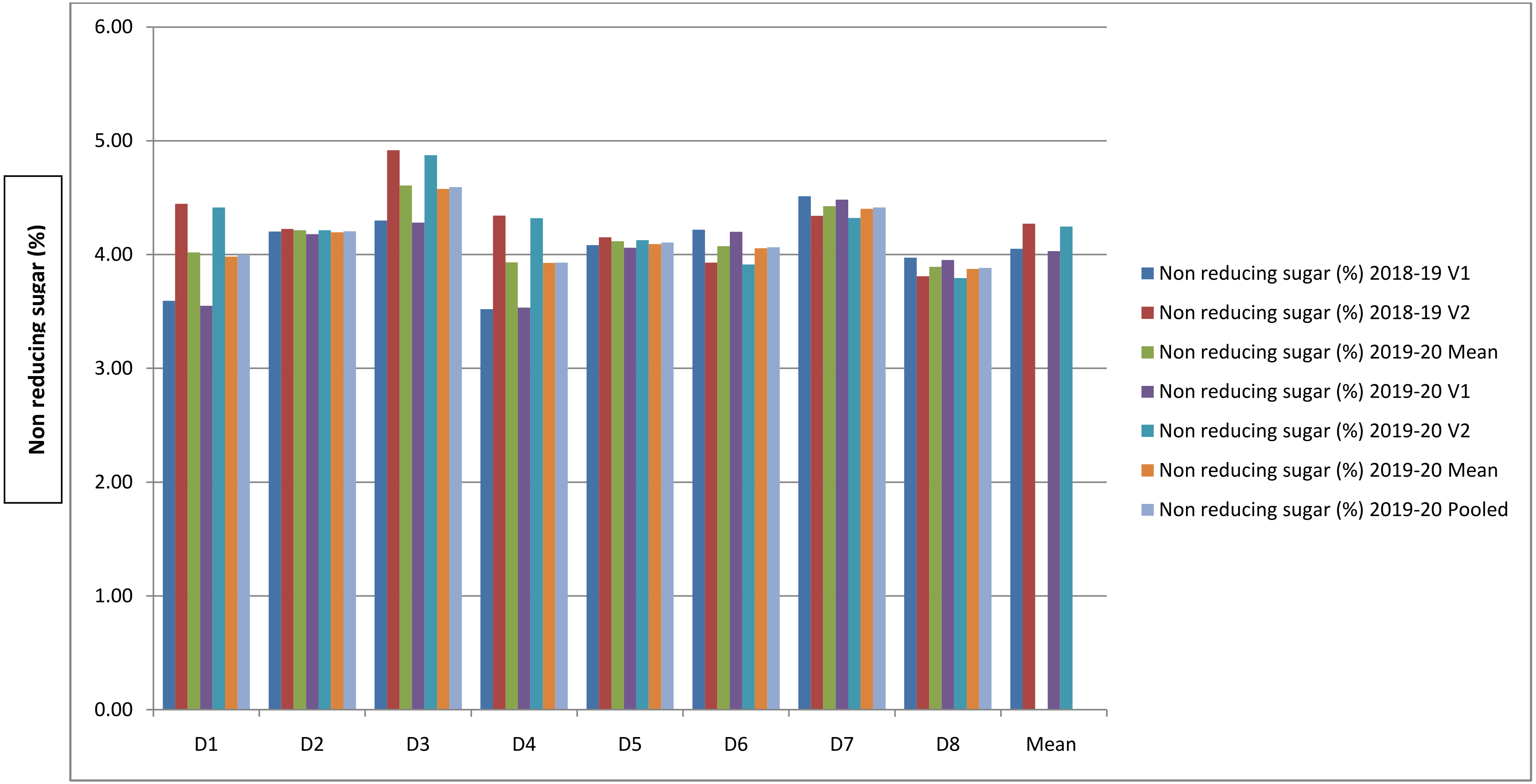


Fig 4.32 Effect of dates of transplanting and varieties on non-reducing sugar (%) of *kharif* onion.

Plate 19: Determination of reducing sugar of onion bulb

Plate 20 : Determination of Ascorbic acid by titration method

4.1.20 Effect of transplanting dates and varieties on ascorbic acid content in *kharif* onion bulb.

Table 4.18 and Fig 4.33 showed that the ascorbic acid was significantly influenced by different dates of transplanting and varieties.

Statistical analysis showed that maximum ascorbic acid (10.16 mg/100g and 10.12 mg/100g) was recorded under the moderate transplanting date of D_3. It was followed by the transplanted date D_2 (8.74 mg/100g and 8.99 mg/100g) and D_7 (9.84 mg/100g and 9.81 mg/100g) while, the minimum ascorbic acid (8.36 mg/100g and 8.33 mg/100g) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

However, the onion cultivars had a significant effect on ascorbic acid. The given data showed that the ascorbic acid (9.28 mg/100g and 9.27 mg/100g during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum ascorbic acid was recorded under the cultivars V_1 (9.25 mg/100g and 9.18 mg/100g during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on ascorbic acid. The interactive treatment D_3 x V_2 produced the significantly ascorbic acid (10.47 mg/100g and 10.32 mg/100g during 2018-19 and 2019-20). However, the minimum ascorbic acid (8.43 mg/100g during 2018-19 and 8.43 mg/100g during 2019-20) was recorded under D_1 x V_2. Moreover, a comparative analysis of the data showed that in the first year of the experiment, the ascorbic acid was marginally higher in 2018-19 than in the second year.

4.1.21 The effect of transplanting dates and varieties on titratable acidity of onion bulb.

Both years of investigation (2018-19 and 2019-20) showed that the acidity days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties. (Table 4.18 and Fig 4.34).

Highest acidity (0.52 % and 0.51%) was recorded under the moderate transplanted date of $D_{1.}$ It was followed by the transplanted date D_8 (0.46 % and 0.45 %) and D_2

(0.49 % and 0.48 %) while, the minimum acidity (0.37 % and 0.36 %) was recorded under the early transplanted date D_3 during both years of investigation (2018-19 and 2019-20).

Cultivar V_2 recorded the highest the acidity (0.42 % and 0.40 % during 2018-19 and 2019-20) and the minimum ascorbic acid was recorded under the cultivars V_1 (0.44 % and 0.40% during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on acidity. The interactive treatment D_1 x V_1 produced the significantly ascorbic acid (0.54 % during 2018-19 and 0.53 % during 2019-20). However, the minimum acidity (0.48 % during 2018-19 and 0.46 % during 2019-20) was recorded under D_1 x V_2.

Table 4.18: Effect of dates of transplanting and varieties on ascorbic acid and titratable acidity of *kharif* onion.

Variety / Dates of transplanting	Ascorbic acid (mg/100g)							Titratable acidity (%)						
	2018-19			2019-20			Pooled	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean		V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	8.29	8.43	8.36	8.17	8.43	8.30	8.33	0.54	0.50	0.52	0.53	0.50	0.52	0.52
D_2-10th September	8.64	8.85	8.74	8.63	9.82	9.23	8.99	0.52	0.46	0.49	0.49	0.48	0.49	0.49
D_3-20th September	9.85	10.47	10.16	9.98	10.32	10.15	10.16	0.45	0.28	0.37	0.45	0.25	0.35	0.36
D_4-30th September	9.13	9.34	9.23	9.04	9.32	9.18	9.21	0.37	0.42	0.39	0.33	0.42	0.38	0.38
D_5-10th October	9.69	9.06	9.37	9.67	9.11	9.39	9.38	0.38	0.43	0.41	0.37	0.41	0.39	0.40
D_6-20th October	9.25	8.67	8.96	9.23	8.93	9.08	9.02	0.40	0.36	0.38	0.38	0.35	0.37	0.37
D_7-30th October	10.29	9.39	9.84	10.19	9.37	9.78	9.81	0.35	0.49	0.42	0.29	0.40	0.35	0.38
D_8-10th November	8.89	10.01	9.45	8.49	8.84	8.67	9.06	0.48	0.44	0.46	0.47	0.40	0.43	0.45
Mean	9.25	9.28		9.18	9.27			0.44	0.42		0.41	0.40		
SEm (±)	D	0.024			0.025				0.006			0.005		
	V	0.012			0.012				0.003			0.002		
	D×V	0.033			0.035				0.009			0.007		
CD (P= 0.05)	D	0.068			0.072				0.019			0.014		
	V	NS			0.036				0.009			0.007		
	D×V	0.097			0.102				0.027			0.020		

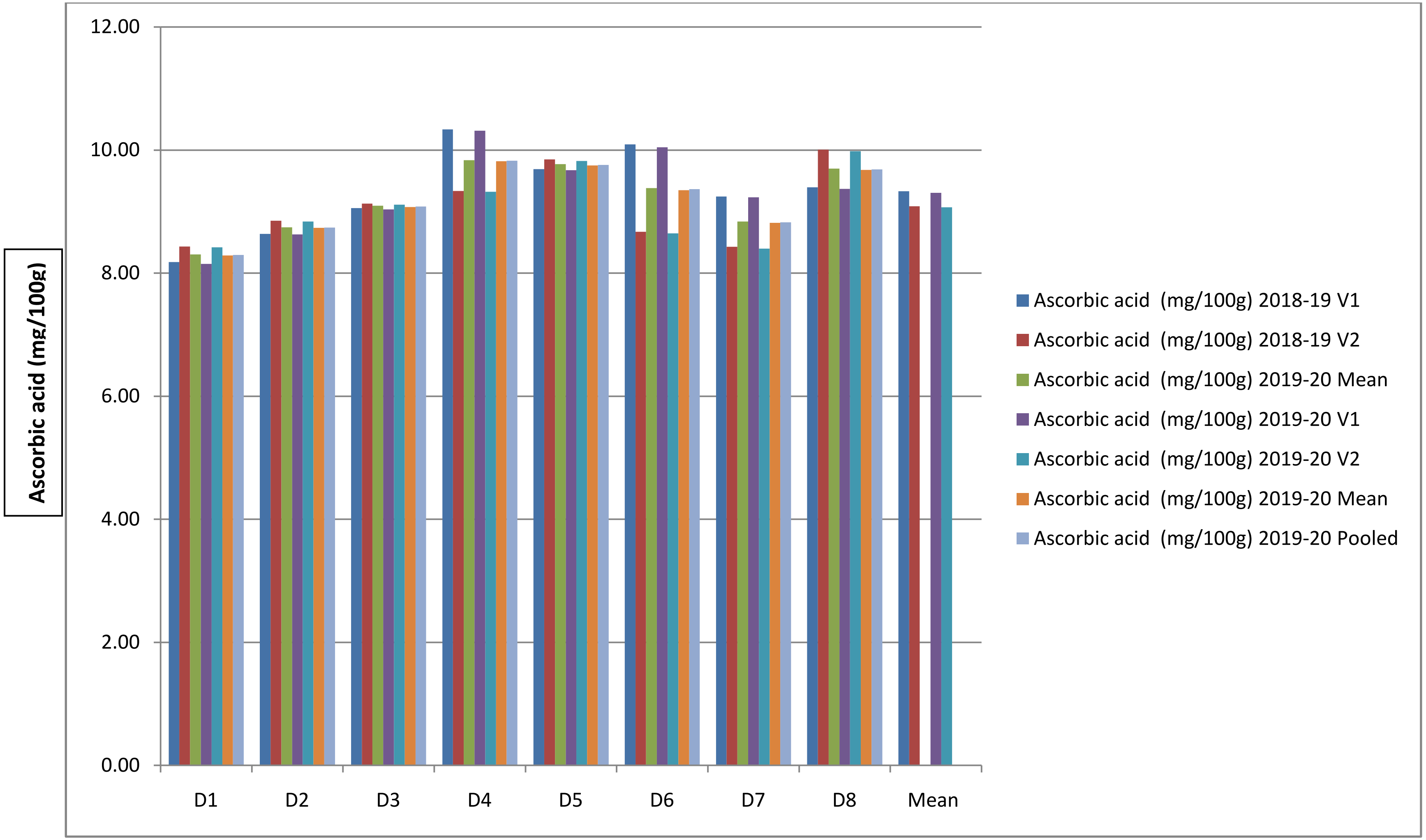


Fig 4.33 Effect of dates of transplanting and varieties on ascorbic acid of *kharif* onion.

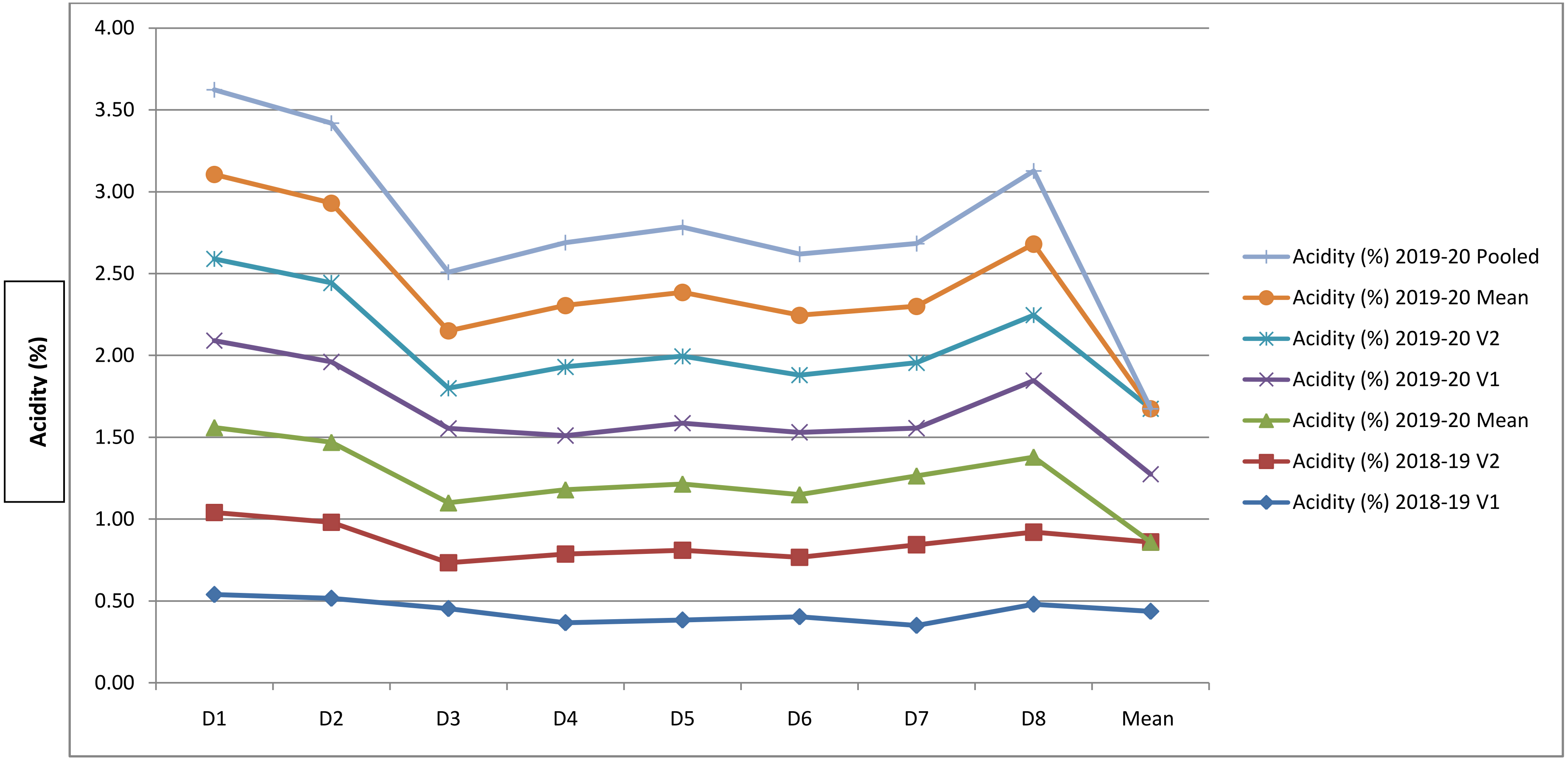


Fig 4.34 Effect of dates of transplanting and varieties on acidity (%) of *kharif* onion.

4.1.22 Effect of transplanting dates and varieties on sulphur content (%) in *kharif* onion bulb

The data on sulphur content was presented in Table 4.19 and in Fig. 4.35 both years of investigation (2018-19 and 2019-20) showed that the sulphur content days after transplanting (DAT) was significantly influenced by different dates of transplanting and varieties.

Maximum sulphur content (0.39 % and 0.27 %) was recorded under the moderate transplanting date of D_6, followed by the transplanting date D_3 (0.32% and 0.25 %) and D_2 (0.23 % and 0.19 %). While the minimum sulphur content (0.29 % and 0.27 %) was recorded under the early transplanted date D_1 during both years of investigation (2018-19 and 2019-20).

The given data showed that the sulphur (0.32 % and 0.26 % during 2018-19 and 2019-20) was recorded with the cultivars V_2 and the minimum sulphur content was recorded under the cultivars V_1 (0.29 % and 0.20 % during 2018-19 and 2019-20).

The interaction effect between the date of transplanting and the cultivars was noted to be significant on sulphur content. The interactive treatment D_6 x V_2 produced the significantly sulphur content (0.27 % and 0.51 % during 2018-19 and 2019-20). However, the minimum sulphur content (0.31 % and 0.16 % during 2018-19 and 2019-20) was recorded under D_1 xV_1.

Table 4.19: Effect of dates of transplanting and varieties on sulphur content of *kharif* onion.

Variety / Dates of transplanting	Sulphur (%)						
	2018-19			2019-20			Pooled
	V_1	V_2	Mean	V_1	V_2	Mean	
D_1-30th August	0.31	0.32	0.31	0.16	0.32	0.24	0.28
D_2-10th September	0.17	0.29	0.23	0.00	0.29	0.15	0.19
D_3-20th September	0.53	0.23	0.38	0.18	0.23	0.21	0.29
D_4-30th September	0.43	0.48	0.45	0.00	0.22	0.11	0.28
D_5-10th October	0.26	0.32	0.29	0.13	0.27	0.20	0.25
D_6-20th October	0.25	0.29	0.27	0.65	0.37	0.51	0.39
D_7-30th October	0.11	0.22	0.17	0.26	0.28	0.27	0.22
D_8-10th November	0.29	0.37	0.33	0.21	0.11	0.16	0.25
Mean	0.29	0.32		0.20	0.26		
SEm (±)	D	0.008			0.004		
	V	0.004			0.002		
	D×V	0.012			0.006		
CD (P= 0.05)	D	0.024			0.013		
	V	0.012			0.006		
	D×V	0.034			0.018		

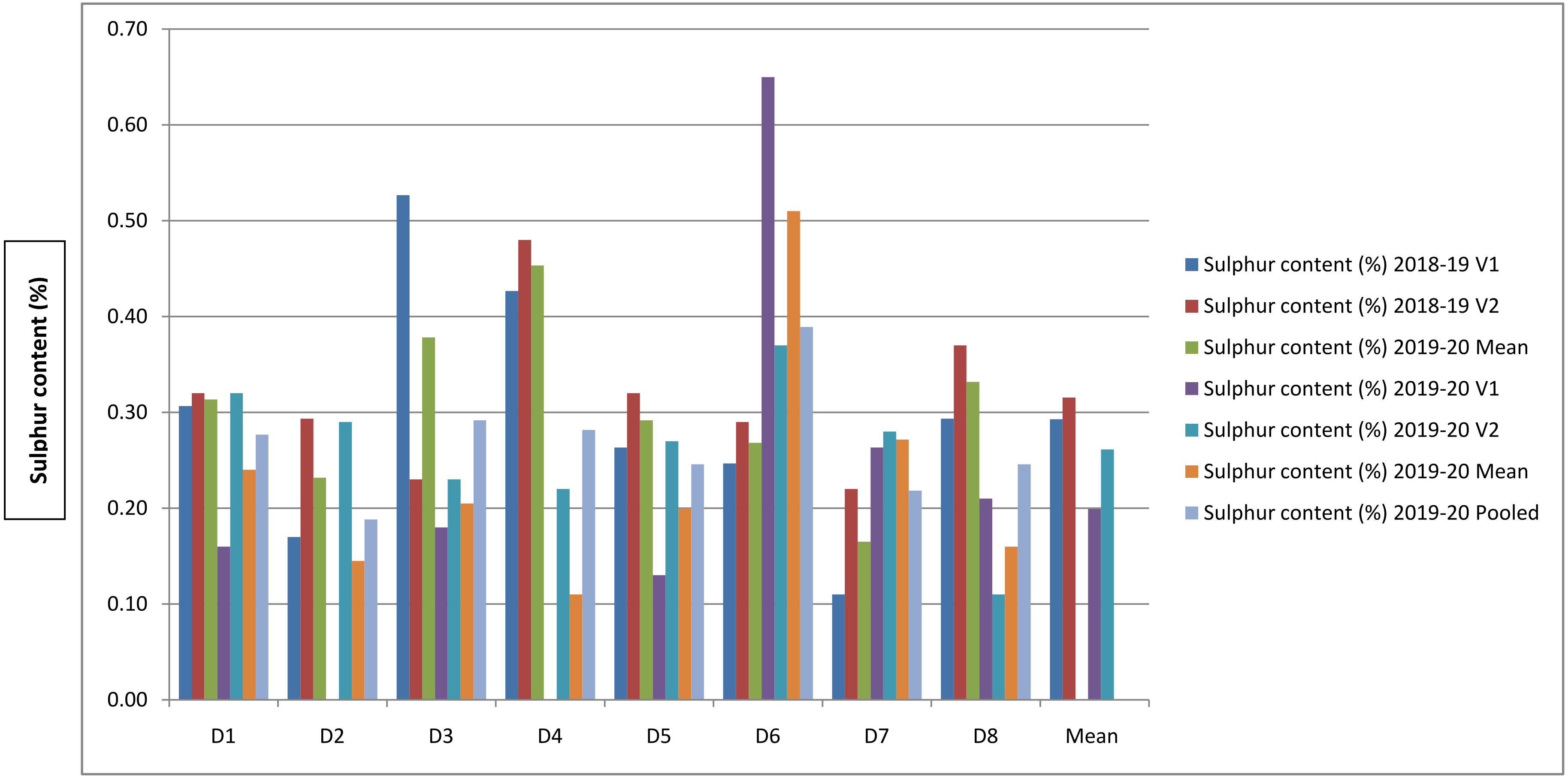


Fig 4.35 Effect of dates of transplanting and varieties on sulphur content (%) of *kharif* onion.

Plate 21: Sample preparation for determination of sulphur

4.1.23 The effect of transplanting dates and varieties on economic assessment of *kharif* onion.

The cost of cultivation, gross and net income in addition to benefit: cost under different dates of transplanting treatments were calculated on hectare basis and presented in Table No. 4.20

Cost of cultivation:

The total expenditure with respect to different dates of transplanting treatments was divided into two parts, i.e., fixed cost and variable cost. At the Uttar Pradesh condition, the minimum fixed cost of all treatments in first year (Rs.108305), and in second-year (Rs.107210), respectively, whereas the variable cost varied depending on the inputs used in that particular treatment. The total of these two costs is derived as the total cost of cultivation. The highest cost of cultivation was found in (D_2 x V_2), (Rs. 108200) and (Rs. 107170) of in first and second year, respectively.

Gross income

Among all the treatments studied, D_8 x V_1 gave the highest gross income in the first year (Rs. 2095923) and in second-year (Rs. 1428639.56) at the Lucknow condition, respectively. The minimum gross income for the first year (Rs. 385425) and the second year (Rs. 349992.67) occurred at D_8 x V_1

Net income:

The highest net income of first-year (Rs. 1988882.66) and second-year (Rs. 1322598.74) was obtained in treatment (D_2 x V_2) respectively, whereas the minimum net income in the first year (Rs. 278384.18) and second-year (Rs. 243951.853) obtained in (D_8 x V_1).

Benefit: Cost ratio

The maximum benefit: cost ratio for the first year (18.58) has been obtained with the (D_2 x V_2), while the minimum benefit: cost ratio (2.60) was calculated under D_8x V_1 which was also found in second year. Pooled data revealed that treatment D_2 x V_2 grave the maximum benefit: cost ratio (15.53) for *kharif* onion production.

Table 4.20: Economic assessment for *kharif* onion production.

S.N.	Treatment combinations (D×V)	Benefit : Cost ratio		
		2018-19	2019-20	Pooled
T_1	$D_1 \times V_1$- 30th August	16.55	11.31	13.93
T_2	$D_1 \times V_2$- 30th August	17.57	11.78	14.68
T_3	$D_2 \times V_1$-10th September	18.11	12.32	15.22
T_4	$D_2 \times V_2$-10th September	18.58	12.47	15.53
T_5	$D_3 \times V_1$-20th September	3.39	3.16	3.28
T_6	$D_3 \times V_2$-20th September	3.47	3.41	3.44
T_7	$D_4 \times V_1$-30th September	3.64	3.46	3.55
T_8	$D_4 \times V_2$-30th September	3.96	3.70	3.83
T_9	$D_5 \times V_1$-10th October	3.24	2.90	3.07
T_{10}	$D_5 \times V_2$-10th October	3.10	3.00	3.05
T_{11}	$D_6 \times V_1$-20th October	3.29	3.18	3.24
T_{12}	$D_6 \times V_2$-20th October	3.12	2.80	2.96
T_{13}	$D_7 \times V_1$-30th October	2.84	2.61	2.73
T_{14}	$D_7 \times V_2$-30th October	2.70	2.39	2.55
T_{15}	$D_8 \times V_1$-10th November	2.60	2.30	2.45
T_{16}	$D_8 \times V_2$-10th November	3.08	2.79	2.94

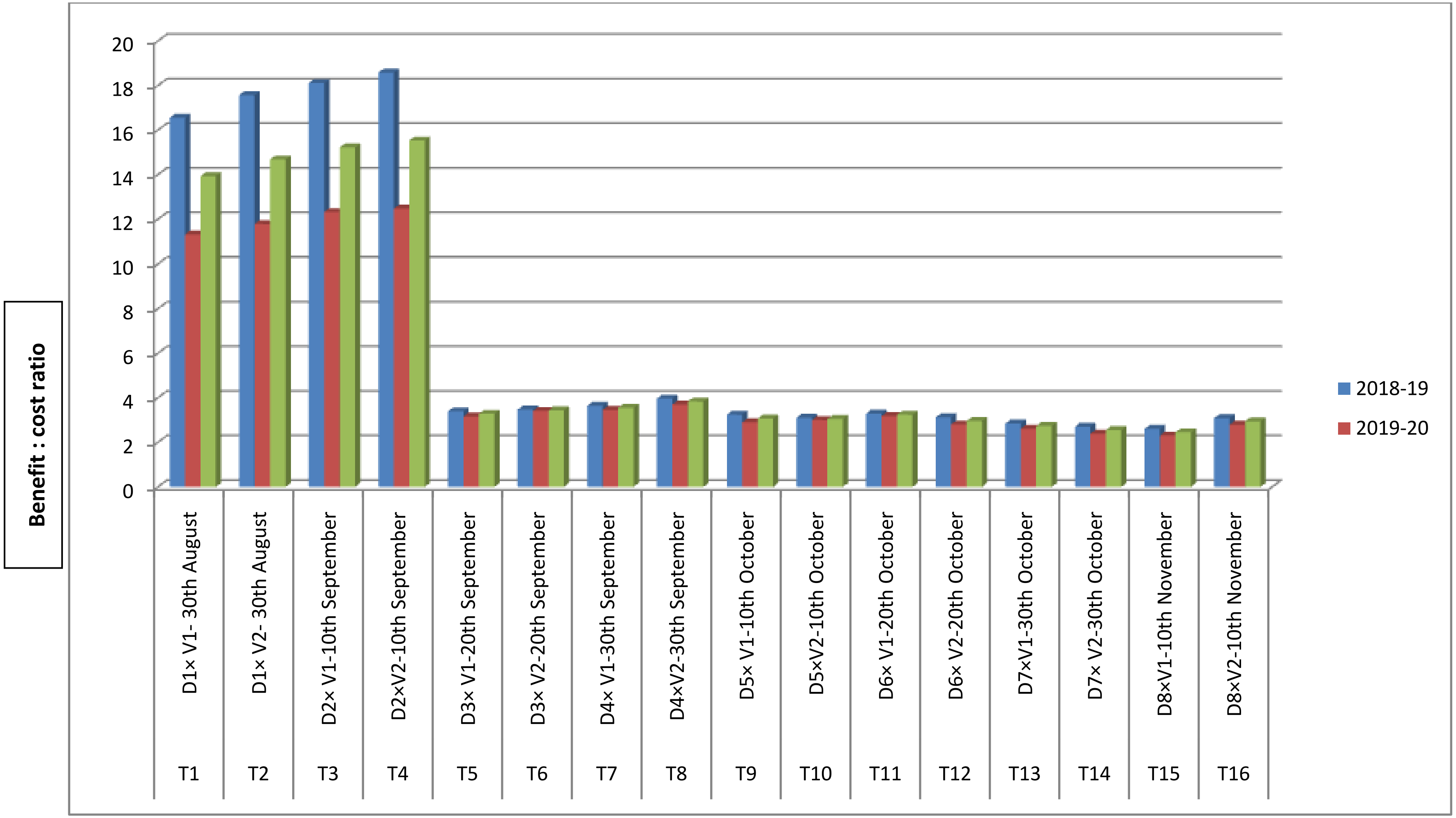


Fig 4.36 Effect of dates of transplanting and varieties on Benefit : cost ratio of *Kharif* onion

4.2 DISCUSSION

The present investigation entitled "**Performance of onion (*Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting**" was planned for the execution of present experiment during *kharif* season 2018-19 and 2019-20.

The observations on vegetative growth characters, yield and quality behaviour offer information of paramount importance to research workers as well as commercial growers of vegetables. The experimental findings presented in previous chapter are discussed here in with probable causes citing supporting evidences on the subject which are available in review of related literature.

4.2.1. Effect of varieties and dates of transplanting on vegetative growth of onion.

4.2.1.1. Plant height

The experimental findings advocated that plant height was influenced with the different dates of transplanting and onion cultivars on the basis of pooled values (at 120 DAT) of two years of data (2018-19 and 2019-20), the maximum plant height (66.93 cm) was found when it was transplanted on 30thSeptember (D_4) followed by 20th October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the highest plant height (65.80 cm & 65.36 cm, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (64.98 cm & 64.69 cm in first and second year, respectively). The interaction effect of date of transplanting and cultivars on the plant height was also noted as statistically significant. The maximum plant height (68.78 cm and 67.98 cm in 1st and 2nd year trials, respectively) was observed with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red) and the minimum plant height (61.20 cm and 60.08 cm in 2018-19 and 2019-20, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). It was clear that late transplanted plants had a greater maximum plant height than early transplanted plants and it might be due to the fact that congenial weather (Table 3.1) at later dates of transplanting was better for its growth. Because optimum temperature is important for photosynthesis and related physiological activities in plants which has a positive correlation with its growth and development. Similar findings were also reported by Singh *et al*. (2011), Santra *et al.* (2017), Nayee *et al.* (2010), Khodadadi (2012) and Sharma and Jarial (2017) who also worked in onion. However, Mohanta and Mandal (2014) cited a non-significant effect of interaction between dates of transplanting and varieties in plant height.

4.2.1.2. Number of leaves per plant

Pooled values of two years of data (2018-19 and 2019-20) also showed that the maximum number of leaves(14.99) was found in D_4 transplanting (30^{th} September) followed by 20^{th} October transplanting (D_6) and L-883 (V_2) showed the highest number of leaves (14.44 & 14.16, in 2018-19 and 2019-20, respectively) compared Agrifound Dark Red (V_1) (13.90 & 13.99in two years, respectively). Interaction effect showed that maximum number of leaves (15.91 in 1^{st} and15.64 in 2^{nd} year trials, respectively) was observed with D_4 xV_2 (30^{th} September transplanting x L-883 variety), followed by D_6 xV_1 (20^{th} October x Agrifound Dark Red) and the minimum number of leaves (12.14 and 12.43 in two years, respectively) was observed with D_1 x V_1 (30^{th} August x Agrifound Dark Red). It was also seen that maximum number of leaves per plant was counted from 30^{th} September transplanting at all the growth stages (30 to 120 DAT) which was found statistically *at par* with 1^{st} September planting date at 30 and 90 DAP. Whereas, the minimum number of leaves per plant was noted on 1^{st}, August planting (30, 60 and 90 DAP), which was noted statistically *at par* with 15^{th} August planting (30 and 60 DAP) in pooled analysis of two years data. Similar significant effect of different planting dates on number of leaves per plant was also recorded by Sharma *et al.* (2009), Kushal *et al*. (2016), Dewangan and Sahu (2014b) and Jatav (2014).

4.2.1.3 Length of leaves.

It was evident that the maximum length of leaves (47.60 cm) (at 120 DAT) was recorded on onions transplanted on 30^{th} September (D_4) followed by 20^{th} October transplanting (D_6). Cultivar L-883 (V_2) showed the higher leaf length (46.70 cm & 45.69 cm, in 2018-19 and 2019-20, respectively) over Agrifound Dark Red (V_1) (45.62 cm & 45.20 cm in two years, respectively). The interaction effect also had statistically significant effect on the length of leaves. The maximum length of leaves (49.58 cm and 48.89 cm in 1^{st} and 2^{nd} year trials, respectively) was observed with D_4 xV_2 (30^{th} September transplanting x L-883 variety), followed by D_6 x V_1 (20th October x Agrifound Dark Red), and the minimum length of leaves (43.26 cm and

41.68 cm in two years, respectively) was observed with D_1 x V_1 (30^{th}August x Agrifound Dark Red). The results are also in the line of findings noted by Nayee *et al*. (2009), Mohanty (2001) and Khurana *et al*. (2003) in onion. The heavy rainfall during early transplanting might be responsible for poor results in early transplanting where as optimum weather condition during September onwards transplanting had better growth in terms of leaf length as well as leaf number.

4.2.1.4 Neck thickness

At 120 DAT, Maximum neck thickness (23.19 mm) was found when onion was transplanted on September 30^{th} (D_4) followed by 20^{th} October (D_6). Among the two cultivars, L-883 (V_2) showed the neck thickness (22.97 mm &22.48 mm, in 2018-19 and 2019-20, respectively) compared to Agrifound Dark Red (V_1) (22.47 mm &21.98 mm in two years, respectively). The interaction effect of both the date of transplanting and cultivars was noted as having a statistically significant effect on the neck thickness. The maximum neck thickness (24.11 mm and 23.87 mm in 1^{st} and 2^{nd} year trials, respectively) was observed with D_4 xV_2 (30^{th} September transplanting x L-883 variety), followed by D_6 x V_1 (20^{th} October x Agrifound Dark Red) and minimum neck thickness (20.50 mm and 20.76 mm in two years, respectively) was observed with D_1 x V_1 (30^{th} August x Agrifound Dark Red). Whereas, the minimum neck diameter was noted on 30^{th} August planting at 30, 60 and 90 DAP in pooled analysis of two years data though it was statistically *at par* with 30^{th} August transplanting at 60 DAP. Improved plant growth with mid to delayed transplanting probably contributed to more photo synthesis causing thicker neck in onion (Nayee *et al.,* 2010, Mohantaand Mandal, 2014, Dewangan and Sahu, 2014 and Tripathy *et al*., 2014).

4.2.2 Effect of different dates of transplanting yield attributing traits in onion cultivars:

4.2.2.1. Effect of different dates of transplanting on days to harvesting of bulb in *kharif* onion

The experimental finding revealed that days to harvesting of bulb influenced with the different dates of transplanting and onion cultivars on the basis of pooled values of two years of data (2018-19 and 2019-20), the maximum days to harvesting of bulb (138.00 days from transplanting) was found when onion seedlings were transplanted on September 30th (D_4) followed by 20th October transplanting (D_6). Cultivar L-883 (V_2) showed late harvesting (higher days to harvest) (133.04 days & 132.67 days in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (131.67 & 131.54 days in two years, respectively). The interaction effect of date of transplanting and cultivars also showed the maximum days of harvesting of bulb (145 and 142 days in 1st and 2nd year, respectively) with D_7 xV_2 (30th November transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red), while, the minimum days to harvesting (122 days and 123 days in two years, respectively) was observed with D_1xV_1 (30thAugust x Agrifound Dark Red). These results are in close conformity with the work of Rajalingam and Haripriya (2000), Sharma and Jarial (2017) and Ketema *et al*. (2013). Early transplanting might fasten the rate of growth and development in better way due to presence of higher temperature and humidity. Whereas, mid to late transplanted onions entered the maturity stages during early and mid winter when temperature was low and thus, growth and development was also might be slow and resulted delay in harvesting.

4.2.2.2 Effect of different dates of transplanting on fresh weight of bulb in onion cultivars without curing

There was a significant effect on fresh weight of bulb as influenced by different dates of transplanting of onion cultivars transplanting on 30th September (D_4) showed the maximum fresh weight of bulb (116.26 g) followed by 20th October transplanting (D_6). Among the cultivars, L-883 (V_2) showed the highest fresh weight (103.11g &101.26 g in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (99.66 g & 97.92 g in two years, respectively). In terms of interaction effect the maximum fresh weight of bulb (123.77 g and 121.40g in 1st and 2nd year of experiment, respectively) was observed with D_4 xV_2 (30th September transplanting x L-883) followed by D_6 xV_1 (20th October x Agrifound Dark Red). The minimum fresh weight (74.33g and73.87g in two years, respectively) was observed with D_1xV_1 (30th August x Agrifound Dark Red). The findings of Das *et al*. (2015), Bosekeng and Coetzer (2013) and Ketema *et al.* (2013) also corroborated with the present study and it might be due to more uptake of moisture and higher vegetative growth which enhanced photosynthetic activity resulting better food reserve.

4.2.2.3 Effect of different dates of transplanting and varieties on average weight of bulb in *kharif* onion after short curing

Similar to the fresh weight, dry weight of onion bulbs after short curing was also influenced with the different dates of transplanting and cultivars. Maximum average weight of short cured bulb (77.27 g) was found when it was transplanted on September 30th (D_4) followed by 20th October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the dry weight of bulb after curing (71.67 g & 70.17 g, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (70.11 g & 69.22 g in two years, respectively). In the interaction effect maximum dry weight of bulb after curing (80.36g and 77.39g in 1st and 2nd year, respectively) was observed with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 x V_1 (20th October x Agrifound Dark Red) while, the minimum dry weight of bulb after curing (60.17g and 59.91g in two years, respectively) was observed with D_1V_1 (30th August x Agrifound Dark Red). The results were also supported with the observed data as reported by Walle *et al*. (2018), Rugi *et al*. (2018) and Ketema *et al.* (2018).

4.2.2.4 Effect of different dates of transplanting on bulb yield per plot (kg) in onion cultivars (*kharif*)

The maximum yield per plot (10.02 kg) was estimated when onion was transplanted on September 30th (D_4) followed by 20th October (D_6). Among the cultivars, L-883 (V_2) showed the yield per plot (9.29 kg & 9.16 kg, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (9.11 kg & 8.97 kg in two years, respectively). There was also a significant interaction effect of date of transplanting and cultivars on the yield per plot. The maximum yield per plot (10.45 kg and 10.19 kg in 1st and 2nd year trials, respectively) was observed with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red) and the minimum yield per plot (7.82kg and 7.79 kg in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). The similar findings were also noted by Sharma *et al*. (2003) and Mahadeen (2009) and Prasad *et al*. (2017) in onion.

4.2.2.5 Effect of different dates of transplanting and varieties on yield per hectare in *kharif* onion

Subsequently, the yield per hectare was calculated and it was seen from the pooled values of two years of data (2018-19 and 2019-20) that the maximum yield (382.68 q/ha) was found when it was transplanted on September 30th (D_4) followed by 20th October (D_6). Among the two cultivars, L-883 (V_2) showed the yield per (357.84 q/ha & 351.98 q/ha, in 2018-19 and 2019-20, respectively) compared to Agrifound Dark Red (V_1) (350.21 q/ha & 344.96 q/ha respectively in two years). The interaction effect of both the date of transplanting and cultivars was also noted a statistically significant effect on the yield per hectare. The maximum yield per hectare (395.87 q/ha and 391.95 q/ha in 1st and 2nd year trials, respectively) was observed with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red) and the minimum yield per hectare (300.87 q/ha and 299.57 q/ha in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). These results are in close conformity with the findings of Mohanta and Mandal (2014), Das *et al*. (2015), Sharma and Jarial (2017), Vidhya and Anburani (2004) and Ghosh *et al*. (2004). The increase in bulb yield might be due to increase in plant growth in terms of plant height, leaf number, leaf length which caused increase in photosynthesis having more surface area for higher synthesis of chlorophyll. It was also seen that the bulb yield decreased due to too early and too late transplanting which might be due to less favourable weather condition for both the varieties.

4.2.3 Effect of date of transplanting and varieties on morphological characters of *kharif* onion bulb

4.2.3.1 Effect of different dates of transplanting on dry matter content in onion bulbs

Dry matter content is one of the most important quality characters which determines the proper growth and development of crop. In the present study, pooled values of two years of data (2018-19 and 2019-20) showed that the maximum dry matter content (15.22 %)on D_4 *i.e.* transplanting on 30th September followed by 20th October transplanting (D_6). The cultivar L-883 (V_2) reported the maximum dry matter content of 13.10 % & 12.79 %, in 2018-19 and 2019-20, respectively compared to the variety

Agrifound Dark Red (V_1) (12.60 % & 11.99 % in two years, respectively). The interaction effect of date of transplanting and cultivars had statistically significant effect on the dry matter content and recorded maximum dry matter (17.45 % & 16.45 % in 1st and 2nd year, respectively) with D_4 xV_2 (30th September transplanting x L-883 variety) followed by D_6 x V_1 (20th October x Agrifound Dark Red) and the minimum dry matter content (9.96 % & 9.80 % in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). The similar findings were also noted by Wal and Corgan (1999), Mallangouda *et al.* (1995), Gupta *et al.* (1999) and Devi and Limi (2005). Better vegetative growth in D_4 and V_2might produce more food materials and thus plants under that treatment reserved more food materials in onion bulb causing more dry matter content.

4.2.3.2 Effect of different dates of transplanting on volume of bulb in onion cultivars

On the basis of pooled values of two years of data (2018-19 and 2019-20), the maximum volume of bulb (75.82 ml) was found when it was transplanted on September 30th (D_4) followed by 20th October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the volume of bulb (72.08 ml & 68.19 ml, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (70.29 ml&65.88ml in two years, respectively). The interaction effect of both the date of transplanting and cultivars noted a statistically significant effect on the volume of bulb. In the interaction of treatments, maximum volume of bulb (85.00 ml&80.31ml in 1st and 2nd year, respectively) was measured with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red) and the minimum volume of bulb (61.33 ml&57.17 ml in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). The similar findings were also noted by Rajalingam and Haripriya (2000), Soni *et al*. (2016), Ahmed *et al*. (2020) Khan *et al.* (2020).

4.2.3.3 Effect of different dates of transplanting on specific gravity of onion bulbs of *kharif* onion

Specific gravity signifies the relative ration of weight and volume. On the basis of pooled values of two years of data (2018-19 and 2019-20), the maximum specific gravity (1.17 g/cc) was found when onion was transplanted on September 30th (D_4) followed by 20th October transplanting (D_6) and L-883 (V_2) showed the maximum specific gravity (1.13 g/cc & 1.12 g/cc, in 2018-19 and 2019-20, respectively). It was also observed that D_4 xV_2 (30th September transplanting x L-883 variety) caused maximum specific gravity (1.23 g/cc & 1.20 g/cc in 1st and 2nd year trials, respectively) followed by D_6 x V_1 (20th October x Agrifound Dark Red). The similar findings were also noted by Ballabh *et al.* (2013) while working on onion. Better vegetative growth in D_4 accelerated photosynthesis and translocation of photosynthetic materials in to storage organ (bulb), resulting an increase in bulb dry matter content, average weight and thus increase specific gravity.

4.2.3.4 Effect of different dates of transplanting on length of bulb in onion cultivars

As mentioned earlier, length of bulb was also influenced with the different dates of transplanting on length of bulb (cm)of onion cultivars, maximum length of bulb (63.91 cm) was found on September 30th (D_4) followed by 20th October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the length of bulb (59.81 mm & 58.50 mm, in 2018-19 and 2019-20, respectively). There was also a significant interaction effect of date of transplanting and cultivars on bulb length. The maximum length of bulb (66.53 mm and 65.53 mm in 1st and 2nd year, respectively) was observed with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red), and the minimum length of bulb **(**48.46 mm and 47.79 mm in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). These results are in close conformity with the findings of Singh (2005), Rajalingam and Haripriya (2000) and Prasad *et al.* (2017) in onion.

4.2.3.5 Effect of different dates of transplanting on polar diameter of onion bulb of *kharif* onion

On the basis of pooled values of two years of data, it was clear that the maximum polar diameter (53.98 mm) was found on September 30th (D_4) transplanting followed by 20th October transplanting (D_6). L-883 (V_2) showed the polar diameter (48.43 mm & 47.37 mm, in 2018-19 and 2019-20, respectively) compared to the variety

Agrifound Dark Red (V_1) (46.84 mm & 45.94 mm in two years, respectively). The experiment also revealed that maximum polar diameter (58.68 mm and 55.47 mm in 1^{st} and 2^{nd} year, respectively) was observed with D_4 x V_2 (30^{th} September transplanting x L-883 variety), followed by D_6 x V_1 (20^{th} October x Agrifound Dark Red), and the minimum (41.33 mm and 41.49 mm in two years, respectively) was recorded with D_1 x V_1 (30^{th} August x Agrifound Dark Red). These results are in close conformity with the findings of Kushal *et al*. (2016), Sharma *et al*. (2009), Umamaheswarappa *et al*. (2015). It might be due to more uptakes of moisture and higher vegetative growth which resulting better food reserve and more bulb diameter.

4.2.3.6 Effect of different dates of transplanting on equatorial diameter in onion cultivars

The maximum equatorial diameter (69.06 mm) was found when it was transplanted on September 30^{th} (D_4) followed by 20^{th} October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the more equatorial diameter (69.06 mm & 63.75 mm, respectively) compared to Agrifound Dark Red (V_1) (63.22 mm & 62.51 mm in two years, respectively). Considering the interaction of date of transplanting and cultivars maximum equatorial diameter (74.50 mm and 73.43 mm in 1^{st} and 2^{nd} year trials, respectively) was noted with D_4 x V_2 (30^{th} September transplanting x L-883 variety), followed by D_6 x V_1 (20^{th} October x Agrifound Dark Red), and the minimum (51.31 mm and 50.71 mm in two years, respectively) was observed with D_1 x V_1 (30^{th} August x Agrifound Dark Red). The results are in accordance with the report by Tripathi (2006), Mohanta and Mandal (2014), Dhotre *et al*. (2010).It was also seen that the equatorial diameter decreased due to too early and too late transplanting which might be due to less favourable weather condition for both the varieties.

4.2.3.7 Effect of different dates of transplanting on number of fresh scales per bulb in *kharif* onion

Maximum number of scales per bulb was recorded with the different dates of transplanting on onion cultivars on the basis of pooled values; the maximum number of scales per bulb (11.75) was counted when onion seedlings were transplanted on September 30^{th} (D_4) followed by 20^{th} October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the number of scales per bulb (10.00 & 9.12, in 2018-19 and 2019-20, respectively) as compared to variety Agrifound Dark Red (V_1) (9.46 & 8.54 in two years, respectively). The interaction effect of both the date of transplanting and cultivars also had a statistically significant effect on the number of scales per bulb. The maximum number of scales per bulb (13.00 and 12.33 in 1^{st} and 2^{nd} year trials, respectively) was observed with $D_4 x V_2$ (30^{th}September transplanting x L-883 variety), followed by D_6 x V_1 (20^{th} October x Agrifound Dark Red) and the minimum number of scales per bulb (6.33 and 5.33 in two years, respectively) was observed with D_1 x V_1 (30^{th} August x Agrifound Dark Red). These results are also in close conformity with the finding of Hygrotech (2010) and Ballabh *et al.* (2013) in onion. The heavy rainfall during early transplanting might be responsible for poor results in early transplanting where as optimum weather condition during 30^{th} September onwards transplanting had better growth in terms of number of scales of onion bulb.

4.2.4 Effect of different dates of transplanting and cultivars on chemical quality traits in onion bulbs

4.2.4.1 Effect of different dates of transplanting on total soluble solids in bulb of onion cultivars

The perusal of data of two years study significantly revealed that transplanting on 20^{th} September (D3) had TSS content in onion bulb followed by 30^{th} October transplanting (D_7). Among the two cultivars, TSS was higher in L-883 (V_2) (11.25 ^{0}Brix & 10.84 ^{0}Brix in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (11.41 & 11.41 ^{0}Brix in two years, respectively). The interaction effect of combined treatment having various dates of transplanting and cultivars had significant impact on TSS content. The laboratory analysis recorded that maximum TSS was found with D_3 xV_2 (20^{th} September transplanting x L-883 variety), followed by D_7 x V_1 (30^{th} October x Agrifound Dark Red), and the minimum TSS (8.86 & 8.76 ^{0}Brix in two years, respectively) was observed in the bulb with D_1 x V_1 (30^{th} August x Agrifound Dark Red). These results are in close conformity with the findings of (Crowther *et al*. 2005) Mahanthesh *et al.* (2009b), Patil *et al.* (2012) and Tripathy *et al.* (2014).

4.2.4.2 Effect of different dates of transplanting and varieties on total sugars in onion bulbs.

As reported in the preceding chapter, total sugars varied with the different dates of transplanting. On the basis of pooled values of two years of data (2018-19 and 2019-20), the maximum total sugars (10.17 %) estimated from the bulb of onion which were transplanting September 20th (D_3) followed by 30th October transplanting (D_7).Cultivar, L-883 (V_2) showed the total sugars (9.72 % & 9.69 %, in 2018-19 and 2019-20, respectively) content in bulb compared to Agrifound Dark Red (V_1) (9.14 % & 9.10 % in two years, respectively). Considering the interaction effect maximum total sugars (11.10 % and 11.04 %) in 1st and 2nd year respectively) was observed with D_3 xV_2 (20th September transplanting x L-883 variety), followed by D_7 xV_1 (30th October x Agrifound Dark Red), and the minimum total sugars (8.03 % and 7.95 % in two years, respectively) was recorded with D_1 x V_1 (30th August x Agrifound Dark Red). These results are in close conformity with the findings of Dewangan and Sahu (2014) Navaldey *et al*. (2016) Ashok *et al.* (2013) Deshpande *et al*. (2013) and Steen and Benkeblia (2014) while working on onion. High total sugars content in D3 (September 20th) transplanting might be done to accumulation of more dry matter in bulb which was attributed due to maximum vegetative growth with enhanced photosynthesis as discussed earlier. This might be also being the region for higher TSS content.

4.2.4.3 Effect of different dates of transplanting on reducing sugar in onion cultivars

In the similar way reducing sugar was also recording as higher (5.58%) when onion cultivars were transplanting during 20th September followed by 30th October transplanting (D_7). Among the two cultivars, L-883 (V_2) showed higher reducing sugar (5.47 % & 5.44 %, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (5.09 % & 5.07 % in two years, respectively). The interaction effect of date of transplanting and cultivars was noted as statistically significant effect on the reducing sugar .The maximum reducing sugar (5.45 % and 5.43 %) in 1st and 2nd year respectively) was observed with D_3 x V_2 (20th September transplanting x L-883 variety), followed by D_7 xV_1 (30th October x Agrifound Dark Red), and the minimum reducing sugar (4.43 % and 4.40 % in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). Earlier finding of Steen and Benkeblia (2014),Kandoliya *et al.* (2015), Prajapati *et al.* (2016) Behera *et al.* (2017) also are in conformity of present result.

4.2.4.4 Effect of different dates of transplanting on non-reducing sugar in onion cultivars

Similarly, the maximum non-reducing sugar (4.59 %) was found when it was transplanted on September 20th (D_3) followed by 30th October transplanting (D_7). Among the two cultivars, L-883 (V_2) showed the total sugars (4.27 % & 4.25 %, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (4.05 % & 4.03 % in two years, respectively). In the interaction of combined treatments, the maximum non-reducing sugar (4.92 % and 4.87 %) in 1st and 2nd year trials, respectively) was observed with D_3 xV_2 (20th September transplanting x L-883 variety), followed by D_7 xV_1 (30th October x Agrifound Dark Red), and the minimum non-reducing sugar (3.59 % and 3.55% in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). The similar findings were also noted by Deshpande *et al.* (2013), Ashok *et al.* (2013) Navaldey *et al.* (2016) in onion.

4.2.4.5 Effect of different dates of transplanting and cultivars on ascorbic acid content in onion bulbs.

As reported in the findings ascorbic acid (vitamin C) content was also significantly influenced by early or late transplanting for *kharif* onion production. It was seen that the maximum ascorbic acid (10.16 mg/100g) was recorded on 20th September for transplanting (D_3) followed by 30th October transplanting (D_7). Among the two cultivars, L-883 (V_2) showed better response in respect of ascorbic acid 9.28 mg/100g & 9.27 mg/100g, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (9.25 & 9.18 mg/100g in two years, respectively). The interaction effect of date of transplanting and cultivars was also had a significant effect on ascorbic acid. The maximum ascorbic acid (10.47 and10.32 mg/100g) in 1st and 2nd year trials, respectively) was observed with D_3 xV_2 (20th September transplanting x L-883 variety), followed by D_7 x V_1 (30th October x Agrifound Dark Red), and the minimum ascorbic acid (8.29mg/100g and 8.17 mg/100g in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). These results are in close conformity with the findings of Leja *et al.* (2008) and Prasad *et al.* (2017). It was clear from the observed data that the acidity increased in early date of transplanting. It might be due to fact that plants transplanted during early dates might have less vegetative growth due to heavy rain fall or having less favourable weather which caused imbalance in photosynthesis reservation and translocation. Then the situation might increase acidity in onion bulbs.

4.2.4.6 Effect of different dates of transplanting on acidity titratable in onion bulbs.

Titratable acidity is an important quality parameter and in the pre the maximum acidity (0.52%) was found when it was transplant on August 30th (D_1) followed by 10th September transplanting (D_2). Among the two cultivars, L-883 (V_2) showed the acidity (0.42 % & 0.40 %, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (0.44 % & 0.41 in two years, respectively). The interaction effect of date of transplanting and cultivars observed a the maximum acidity (0.54%and 0.53 %) in 1st and 2nd year trials, respectively) with D_1 xV_1 (30th August transplanting x L-883 variety), followed by D_2 x V_1 (10th September x Agrifound Dark Red), and the minimum acidity (0.28 % and 0.25 % in two years, respectively) was observed with $D_{3\ x}$ V_2 (30th September x Agrifound Dark Red). These results are in close conformity with the findings of (Khan *et al.* (2020)

4.2.4.7. Effect of different dates of transplanting on and cultivars sulphur content in onion bulbs.

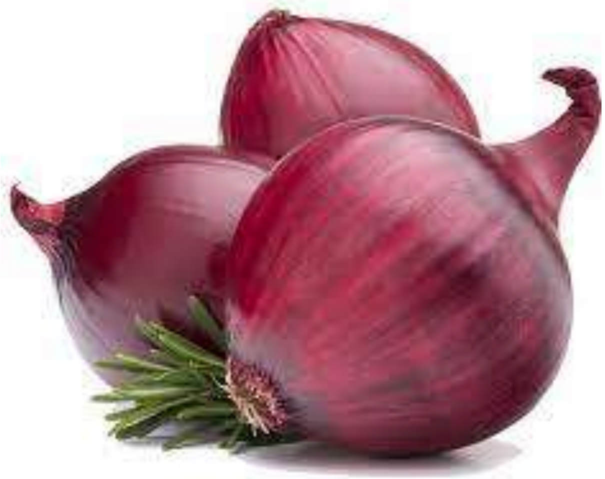
On the basis of pooled values of two years of data (2018-19 and 2019-20), the maximum sulphur content was determined in plants transplanting on September 30th (D_4) followed by 20th October transplanting (D_6). Among the two cultivars, L-883 (V_2) showed the sulphur (0.39 % & 0.27 %, in 2018-19 and 2019-20, respectively) compared to the variety Agrifound Dark Red (V_1) (0.29 % & 0.20 % in two years, respectively).There was also significance effect due to combined effect of date of transplanting and cultivars. The maximum sulphur (0.29 % and 0.51%) in 1st and 2nd year, respectively) was observed with D_6 xV_2 (10th October transplanting x L-883 variety), followed by D_3 x V_1 (20th September x Agrifound Dark Red), and the minimum sulphur content (0.31 % and 0.16 % in two years, respectively) was observed with D_1 x V_1 (30th August x Agrifound Dark Red). The similar findings were also noted by **Mukesh Kumar. (2015)**

4.2.5 Benefit cost ratio:

4.2.5 Effect of different dates of transplanting and varieties on economic feasibility of *kharif* onion production.

The economic study revealed that different dates of transplanting had significant effect on gross return and net return for *kharif* onion production. It was also varied with varieties. The results showed that maximum gross and net return was obtained from variety V_2 (L- 883) when transplanted on 10th September (D_2) followed by V_1 (Agrifound Dark Red) transplanted on same day (D_2). The higher net return caused are marketable increase in Benefit: cost ratio of (18.58) and (12.47) followed by (18.11) and (12.32) as compared to late transplanting. The highest B:C ratio obtained in early transplanting also boosted up early harvesting when there was huge price for onion due to unavailability on onion in market. The high demand caused high return as well as high B:C ratio. However, at later stage of harvesting the market price was lower than early harvesting time and resulted less return and lower B: C ratio as compared to other treatments. It was also observed that in the second year of trial the market price was not so high all over the country and therefore the net return and B: C ratio was comparatively lower than first year trial. Overall performance of kharif onion suggested that more return might be granted for off season production as was also stated several scientist similar results were reported by Nandal and Singh (2002), Kalhapure and Shete (2013) and Patel *et al.* (2011), in this field like onion.

Chapter-V



SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled "**Performance of onion *(Allium cepa* L.) cultivars as *kharif* crop under different dates of transplanting"** was carried out at Horticulture Research Farm of the Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow during 2018-19 and 2019-20. The result was discussed in light of literature available and research work reported by earlier workers on onion and related. The experimental finding are now summarized and presented below:

Vegetative growth and attributes:

Effect of different dates of transplanting and varieties on vegetative growth of *kharif* onion.

1. The maximum plant height (66.93 cm) was observed during both the years with D_4 xV_2 (30th September transplanting x L-883 variety) followed by D_6 xV_1 (20th October x Agrifound Dark Red) and the minimum plant height (62.22 cm) was recorded in D_1 x V_1 (30th August x Agrifound Dark Red)).

2. The number of leaves per plant (14.99) was observed maximum with treatment D_4 xV_2 (30th September transplanting x L-883 variety), followed by in D_6 xV_1 (20th October x Agrifound Dark Red),

3. Leaf length was also found maximum in V_2 (L-883) when (47.60), transplanted on 30th September (D_4) followed by (47.16) D_6 xV_1 (20th October x Agrifound Dark Red), whereas the minimum leaf length (43.34) and was recorded in D_1 x V_1 (30th August x Agrifound Dark Red)).

4. Similarly, maximum neck thickness (23.19 mm) was observed during both the years under treatment D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 x V_1 (20th October x Agrifound Dark Red) (23.03 mm).

Yield parameters as influenced by different dates of transplanting and varieties.

1.Transplanting on D_4 xV_2 (30th September transplanting), of variety V_2 (L-883) showed delay in harvesting 30th August transplanting caused early harvesting by taking minimum days to harvest.

2. The maximum fresh weight of bulb (116.26 g) was observed with during both the years of treatment D_4 x V_2 (30th September transplanting x L-883 variety), followed by D_6 x V_1 (20th October x Agrifound Dark Red) while minimum value of fresh weight of bulb (79.16 g) was recorded D_1 x V_1 (30th August x Agrifound Dark Red)).

3. Maximum average weight of bulb after short curing (77.27 g) during both the years was obtained in the treatment D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 x V_1 (20th October x Agrifound Dark Red)),while minimum average weight of bulb after curing (61.49 g) was recorded D_1 x V_1 (30th August x Agrifound Dark Red)).

4. Treatment D_4 xV_2 (30th September transplanting x L-883 variety) caused maximum bulb yield followed by D_6 xV_1 (20th October x Agrifound Dark Red)), (9.46 kg) while the minimum bulb yield per plot (7.99 kg) was recorded with the D_1 x V_1 (30th August x Agrifound Dark Red)).

Similar trend was also observed in case of yield per ha also. The mature harvested onion bulb exhibited higher bulb size in respect of length of bulb, volume of bulb when transplanted on 30th September (D_4) and variety V_2 had better bulb size over V_1. The bulb diameter was also significantly influenced by dates of transplanting and variety. It was observed that both polar and equatorial diameter was recorded maximum under treatment D_4 x V_2 (30th September transplanting x L- 883 variety).

Effect of dates of transplanting and varieties on morphological characteristics of bulb.

1. The maximum dry matter content of bulb (15.22%) was recorded with treatment (D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 x V_1 (20th

October x Agrifound Dark Red)), while the minimum dry matter content of bulb (10.08 %) was recorded with D_1 x V_1 (30th August x Agrifound Dark Red).

2. The maximum specific gravity (1.17 g/cc) was recorded with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 x V_1 (20th October x Agrifound Dark Red), in both year while, the minimum specific gravity (1.08 g/cc) was recorded with the D_1 xV_1 (30th August x Agrifound Dark Red).

3. Maximum number of fresh scales (11.75), per bulb was recorded with D_4 xV_2 (30th September transplanting x L-883 variety), followed by D_6 xV_1 (20th October x Agrifound Dark Red). The minimum number of scales (6.17) was recorded with theD_1 x V_1 i.e. 30th August x Agrifound Dark Red.

Quality attributes of onion bulbs.

1. A significant increase in TSS in bulb was found with 20th September transplanting of (V_2) followed by D_7 xV_1 (30th October x Agrifound Dark Red). The minimum total soluble solids (9.24 ^{0}Brix)) was recorded with the D_1 x V_1 (30th August x Agrifound Dark Red).
2. The maximum total sugars (10.17 %) was recorded during both the year with D_3 xV_2 (20th September transplanting x L-883 variety), followed by (9.99 %) D_7 x V_1 30th October x Agrifound Dark Red),) while the minimum total sugar (8.81%) was recorded with the (D_1 x V_1 30th August x Agrifound Dark Red).
3. Similarly, reducing sugar and non- reducing sugar content in bulb was also analysis and found maximum with 20th September transplanting (D_3) in variety L-883 (V_2). D_7 x V_1 also had high sugar (reducing and non- reducing) close to D_3 x V_2. Also show the maximum reducing sugar (5.66 %) was recorded during both the year followed by D_7 x V_1 (30th October x Agrifound Dark Red),

Highest acidity was found in early transplanting i. e. D_1 x V_1 (30th August x Agrifound Dark Red), followed by D_2 x V_1 (10th September x Agrifound Dark Red), while the minimum acidity percentage (0.35 %) was recorded with the D_4 x V_1 (30th September x Agrifound Dark Red).

4. The maximum sulphur content was recorded during both the year with D_6 x V_2 (10^{th} October transplanting x L-883 variety), (0.39 %), followed by D_3 x V_1, (20^{th} September transplanting x Agrifound Dark Red), (0.32%) while the and maximum sulphur content was observed.
5. Regarding economic assessment of *kharif* onion production, maximum B:C ratio was recorded during both the year with D_2 xV_2 (20^{th} September transplanting x L-883 variety), followed by D_2 xV_1 (10^{th} September transplanting + Agrifound Dark Red), while lower B: C ratio was recorded with the D_8 x V_1 (10^{th} November transplanting + Agrifound Dark Red).

Conclusion

In the present investigation, it was noticed that maximum values for vegetative growth and yield contributing traits like plant height, number of leaves/plant, leaf length, neck thickness, average bulb weight, bulb yield, as well as bulb physical quality parameters like length of bulb, polar diameter, equatorial diameter, volume of bulb, dry matter content, number of scale were observed when Variety L 883, were transplanted on 30^{th} September (D_4 x V_2). However, chemical quality parameters namely total soluble solids, total sugars, reducing sugar, non -reducing sugar, ascorbic acid, acidity were found to be superior in Variety L 883 when transplanted on 20^{th} September (D_3 x V_2).While, maximum sulphur content was estimated when variety L- 883 was transplanted on 20^{th} October (D_6 x V_2). It was also clear that all the varieties (V_1 , V_2) produced higher yield when transplanted on 30^{th} September(D_4) which exhibited maximum income and high B: C ratio. Therefore, it can be concluded that cultivar L-883 transplanting on 30^{th} September (D_4 x V_2) can be suggested for off-season onion production in the subtropical agro-climatic region of Central Uttar Pradesh for better bulb growth, yield and getting more profit for growers.

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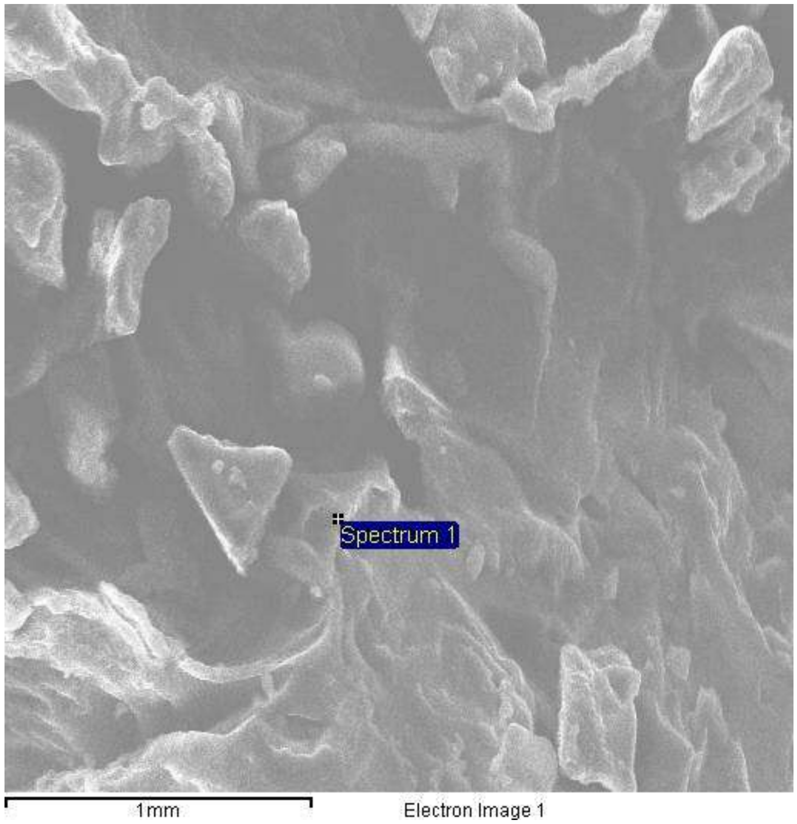
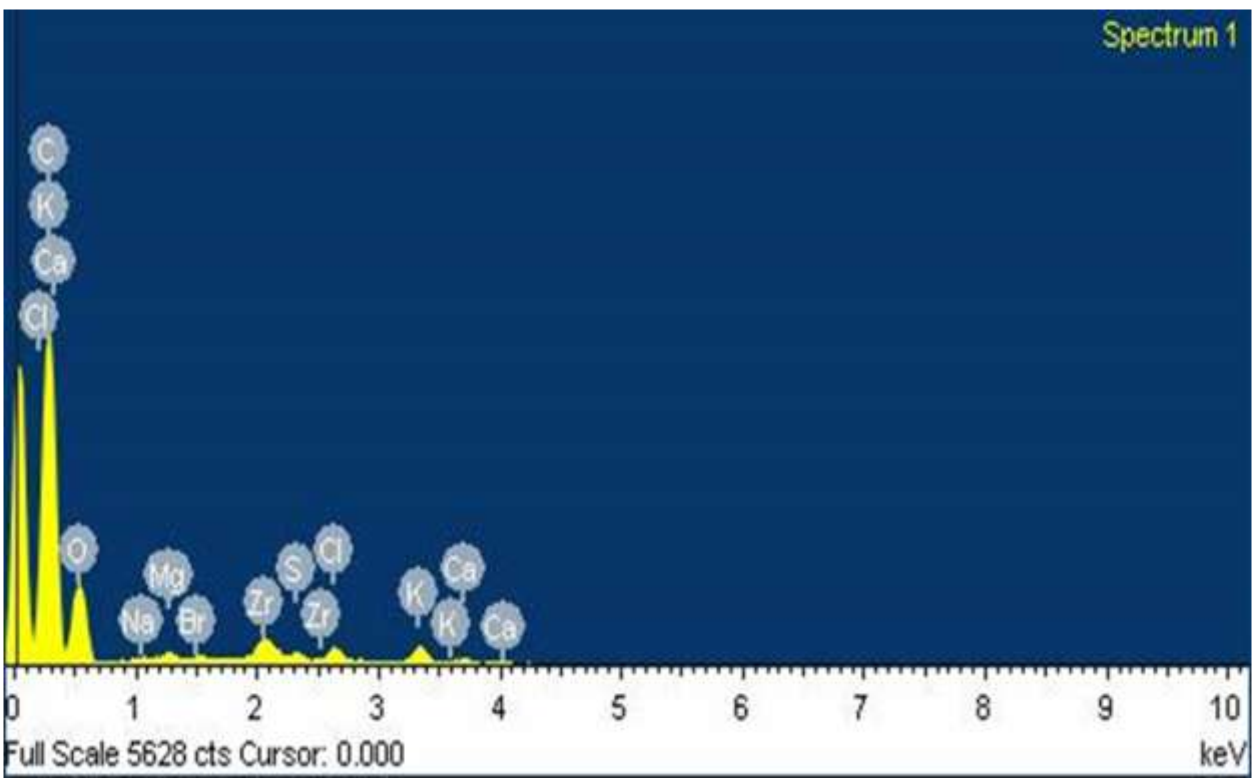
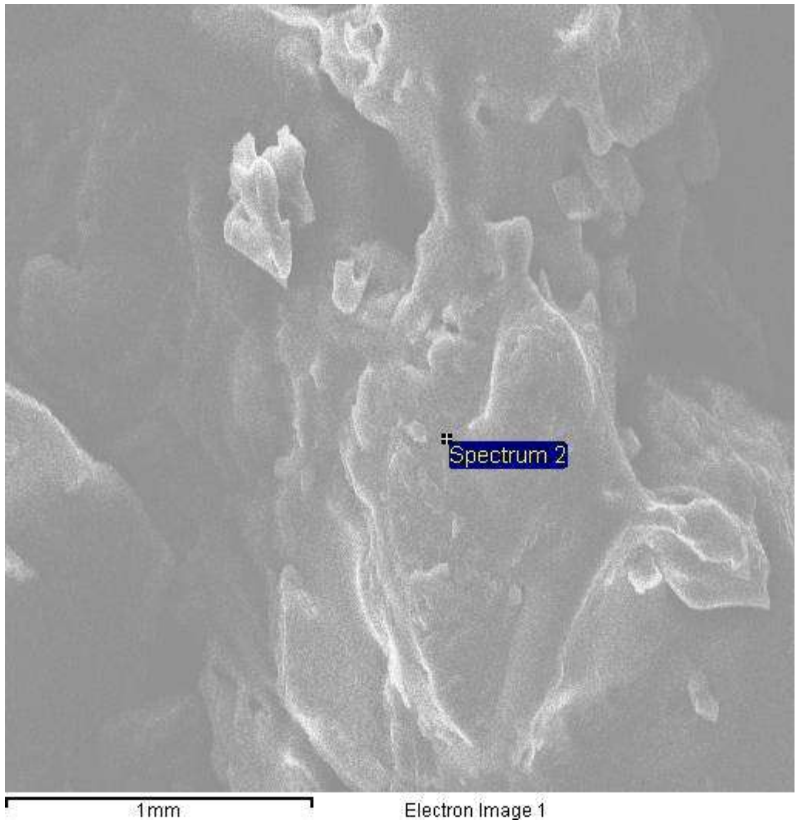
APPENDICES

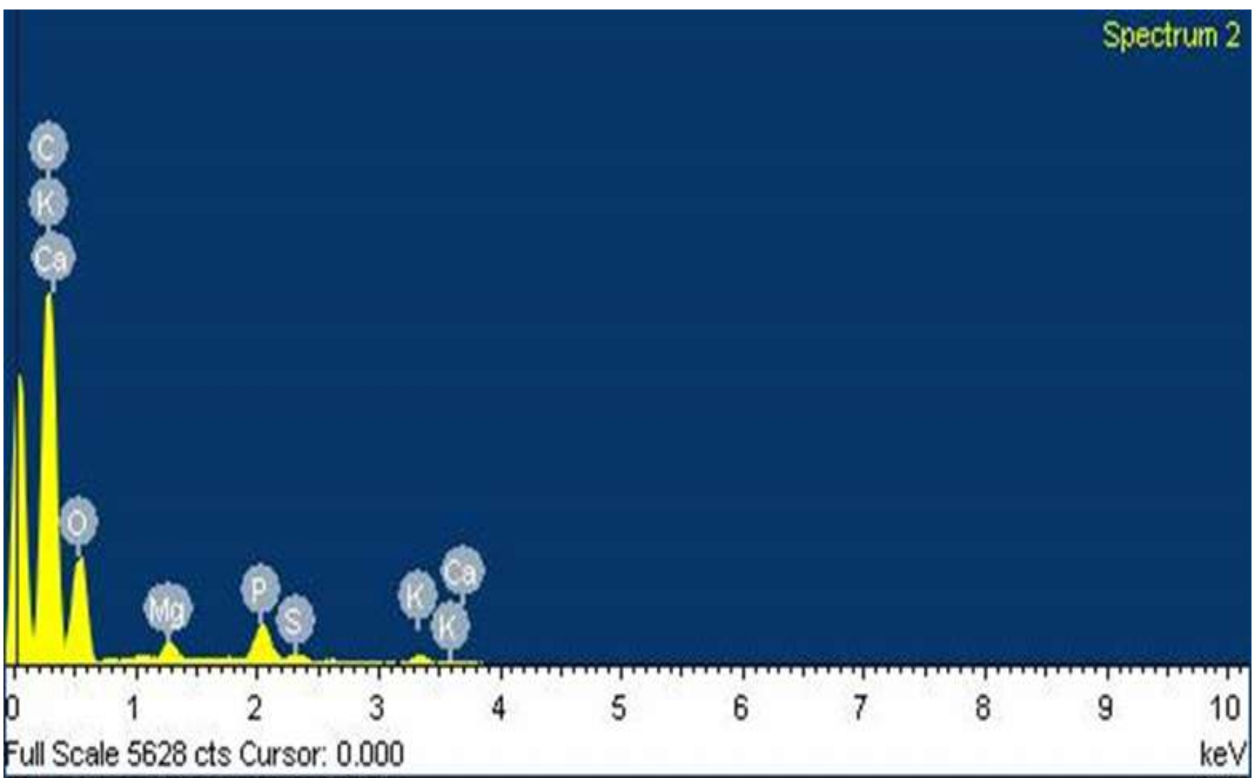




SEM analysis for T_1 (D_1V_1)

SEM analysis for T_2 (D_1V_2)





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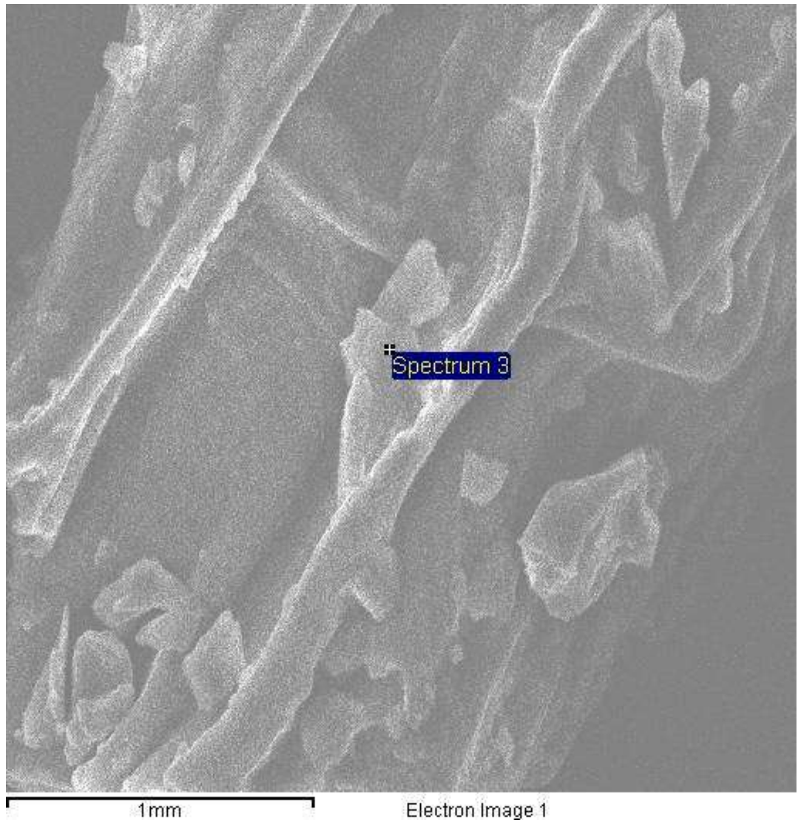
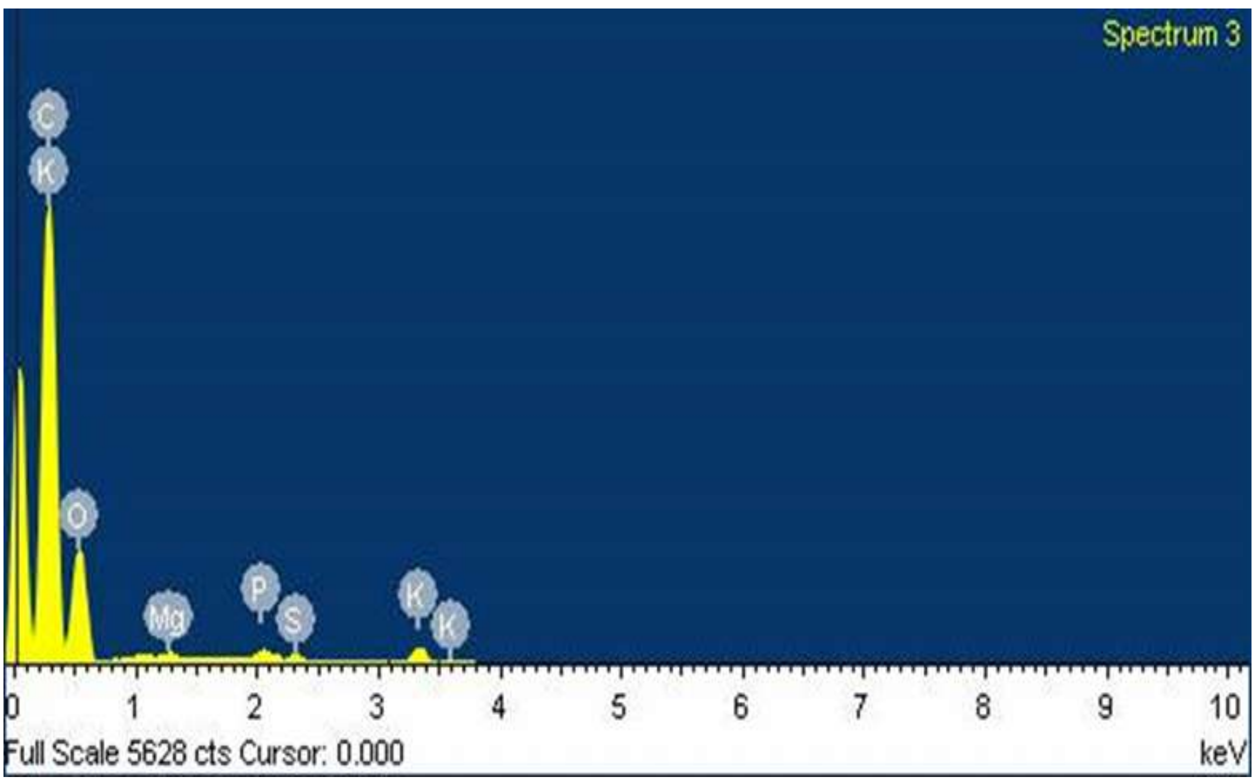
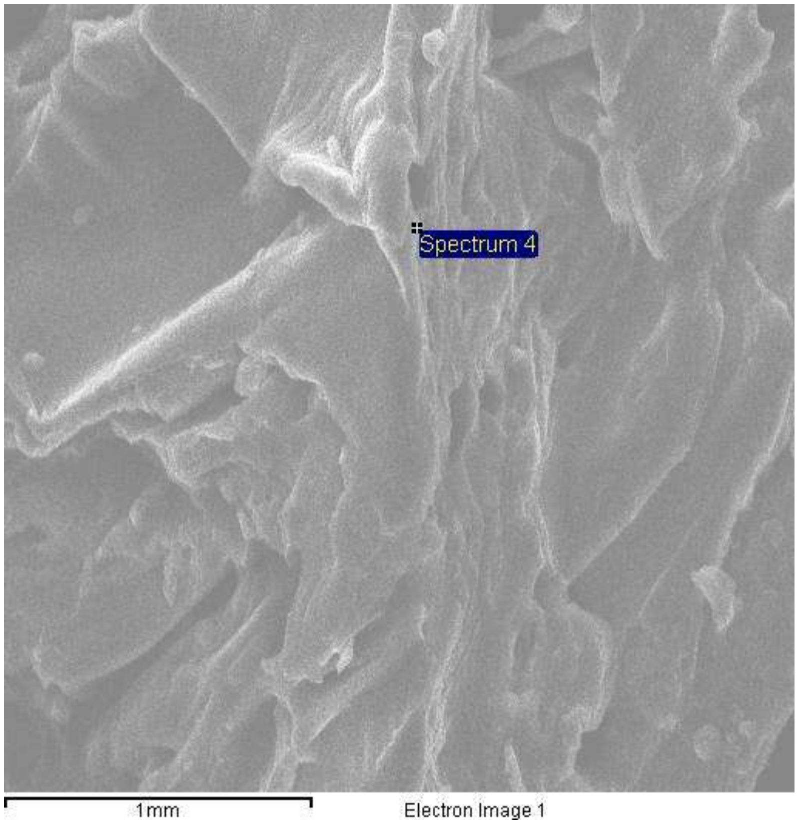
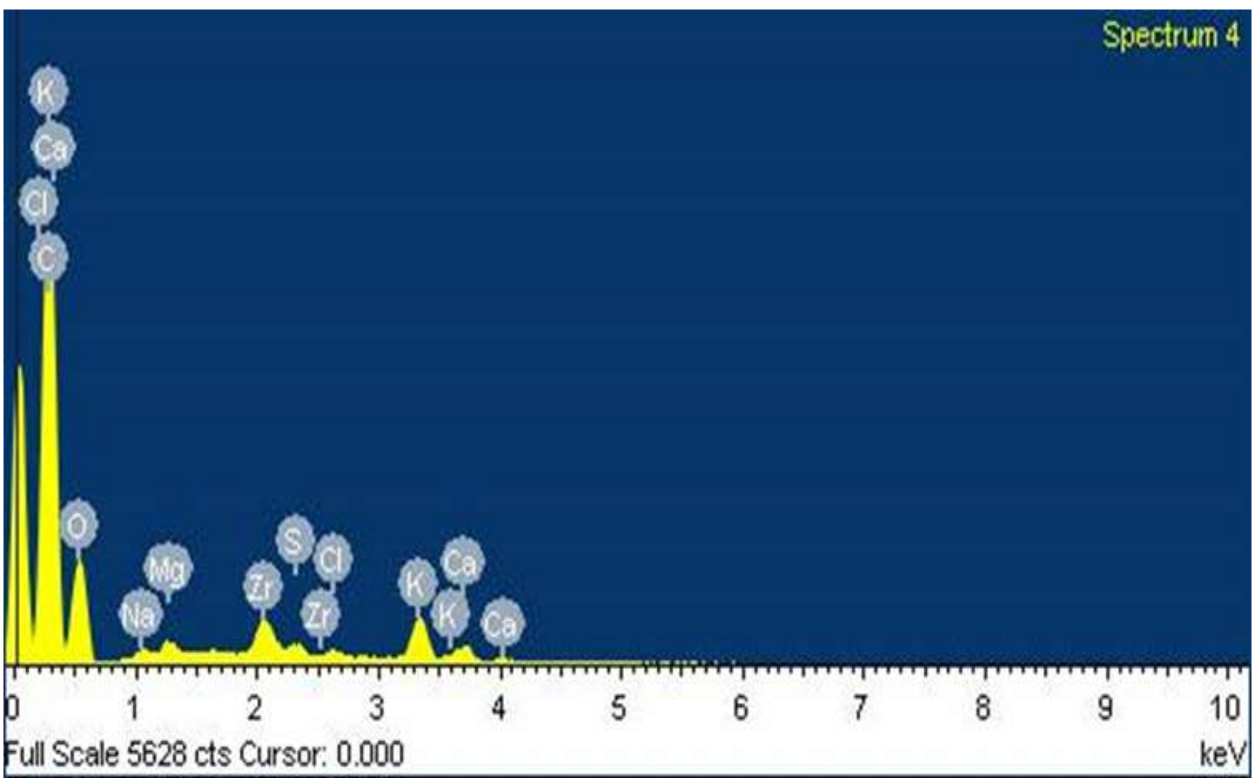




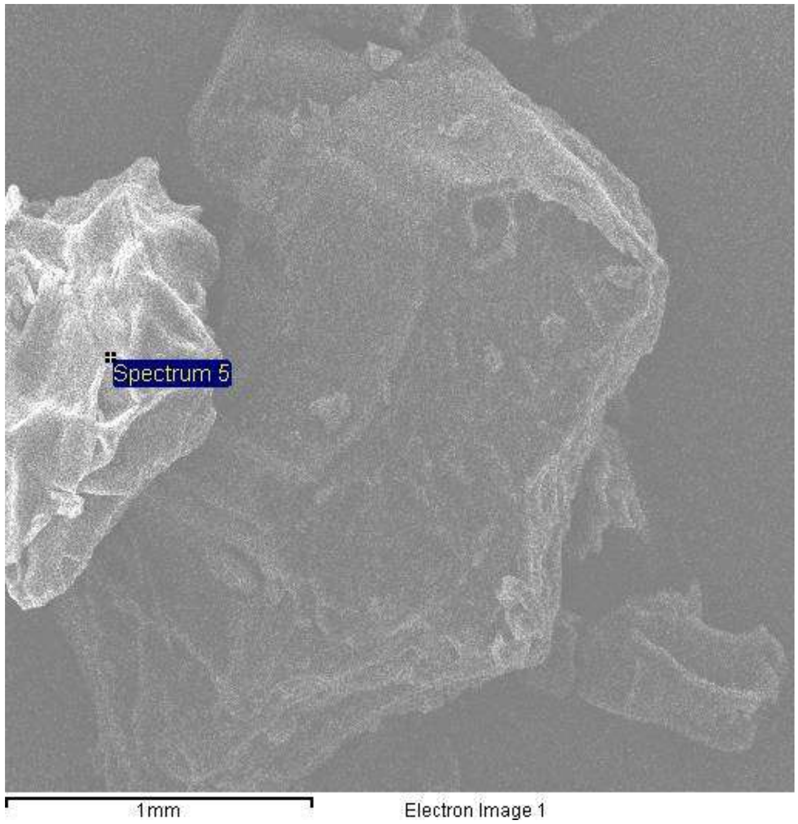
SEM analysis for T_3 (D_2V_1)

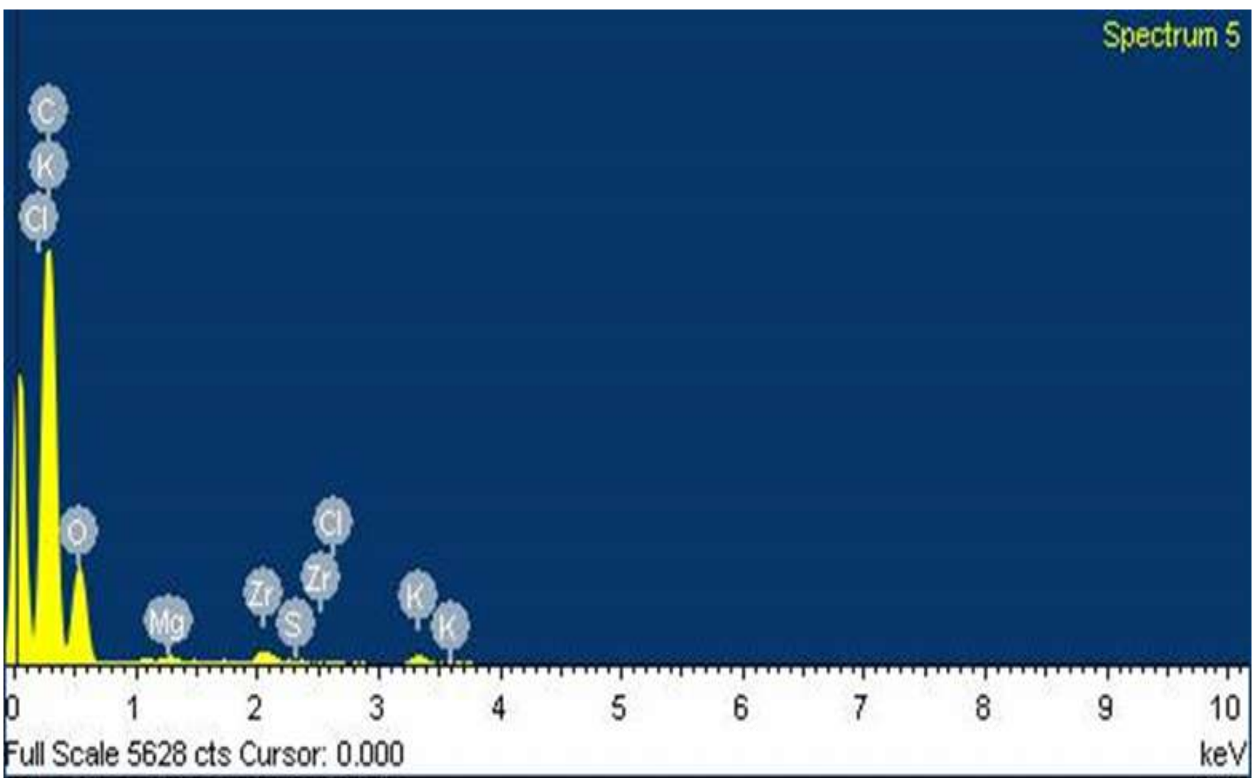
SEM analysis for T_4 (D_2V_2)



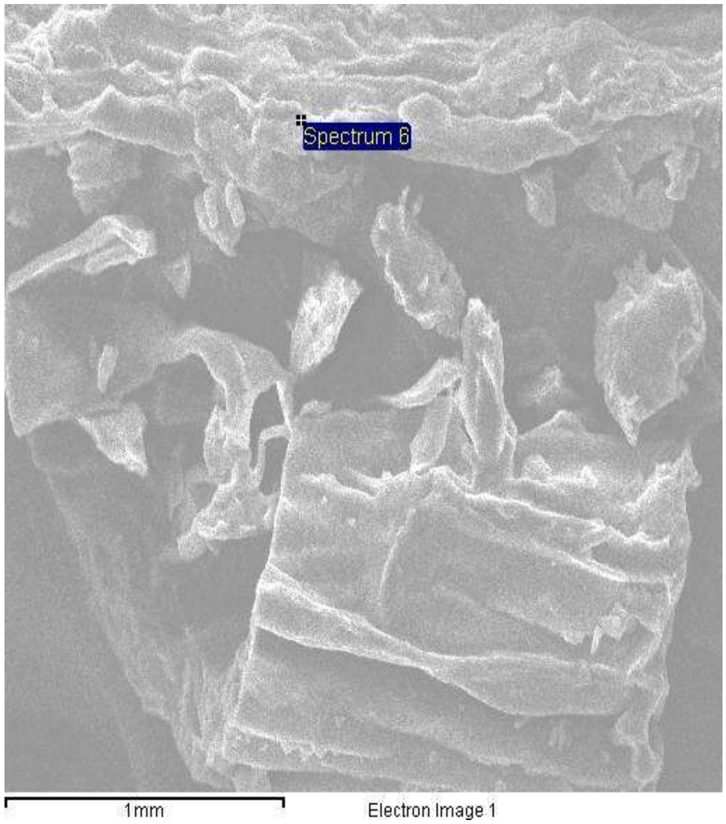


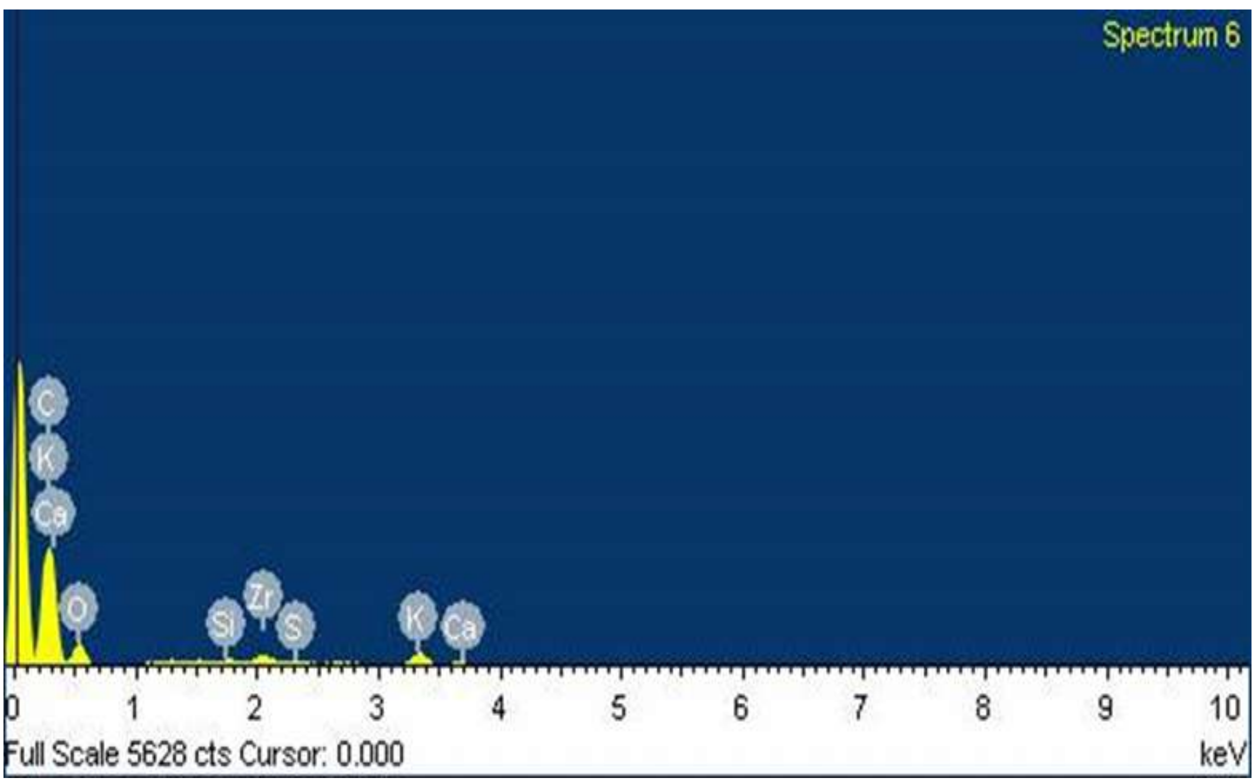
SEM analysis for T_4 (D_2V_2)





SEM analysis for T_5 (D_3V_1)





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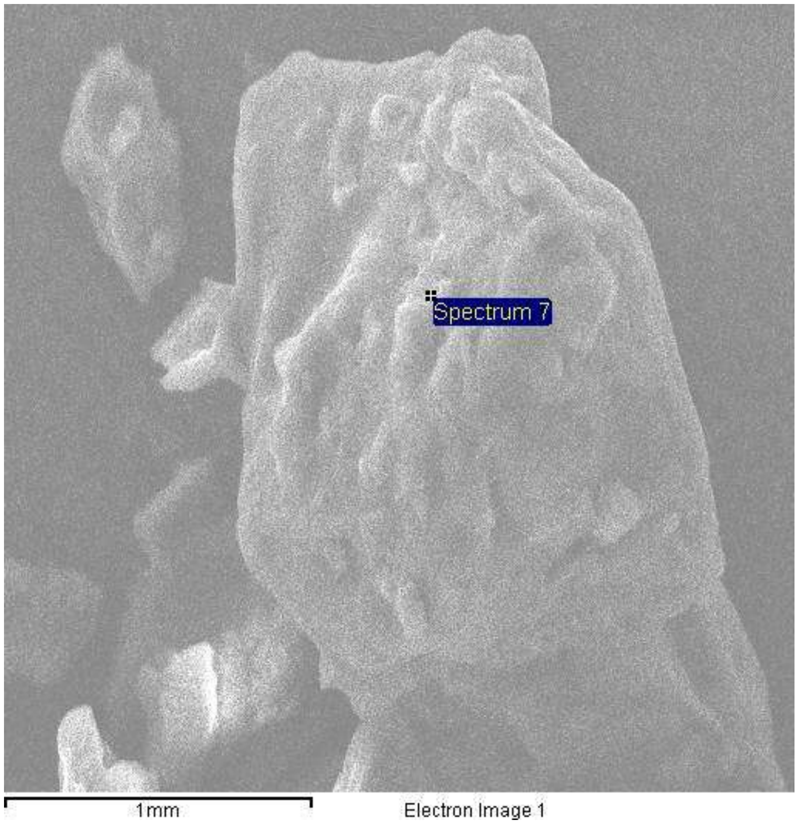
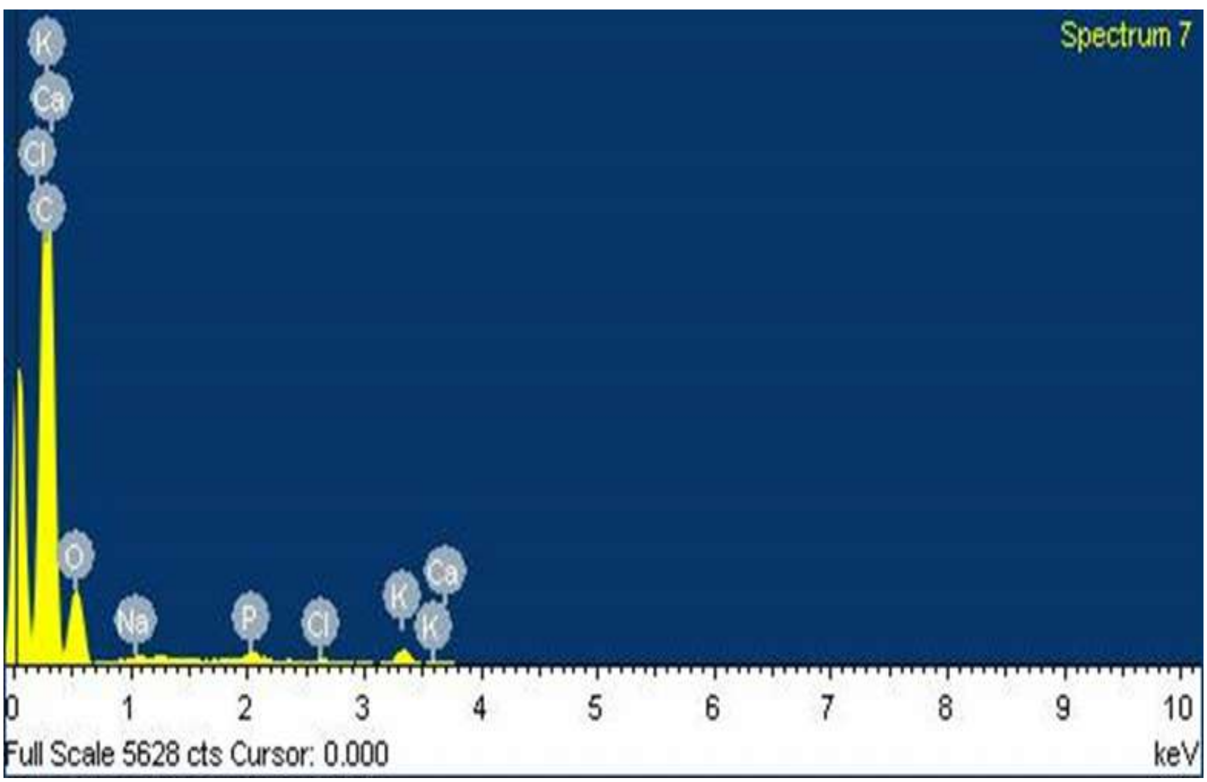
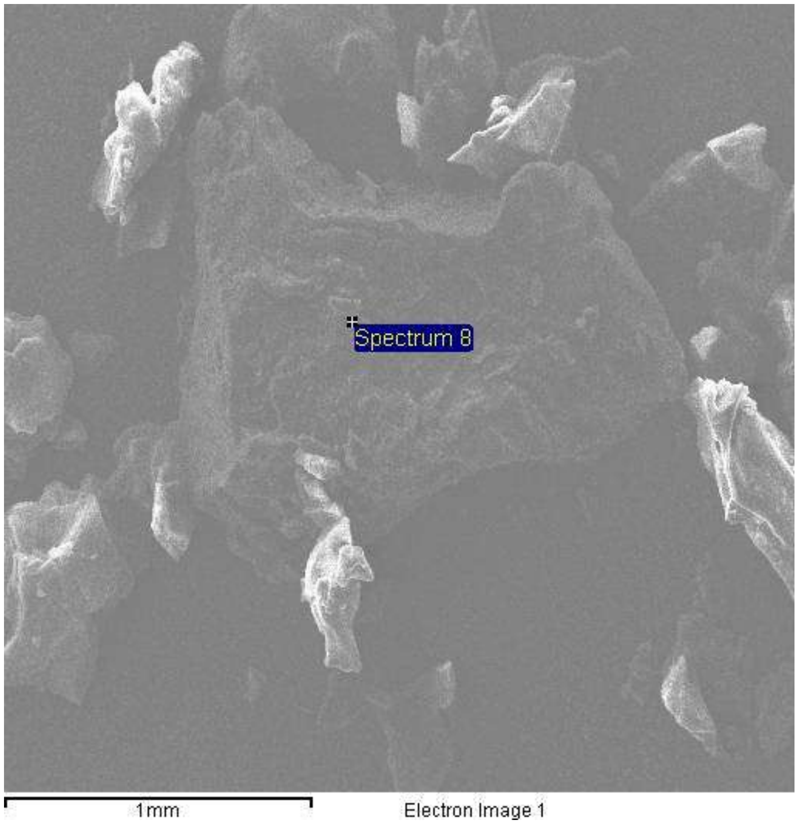
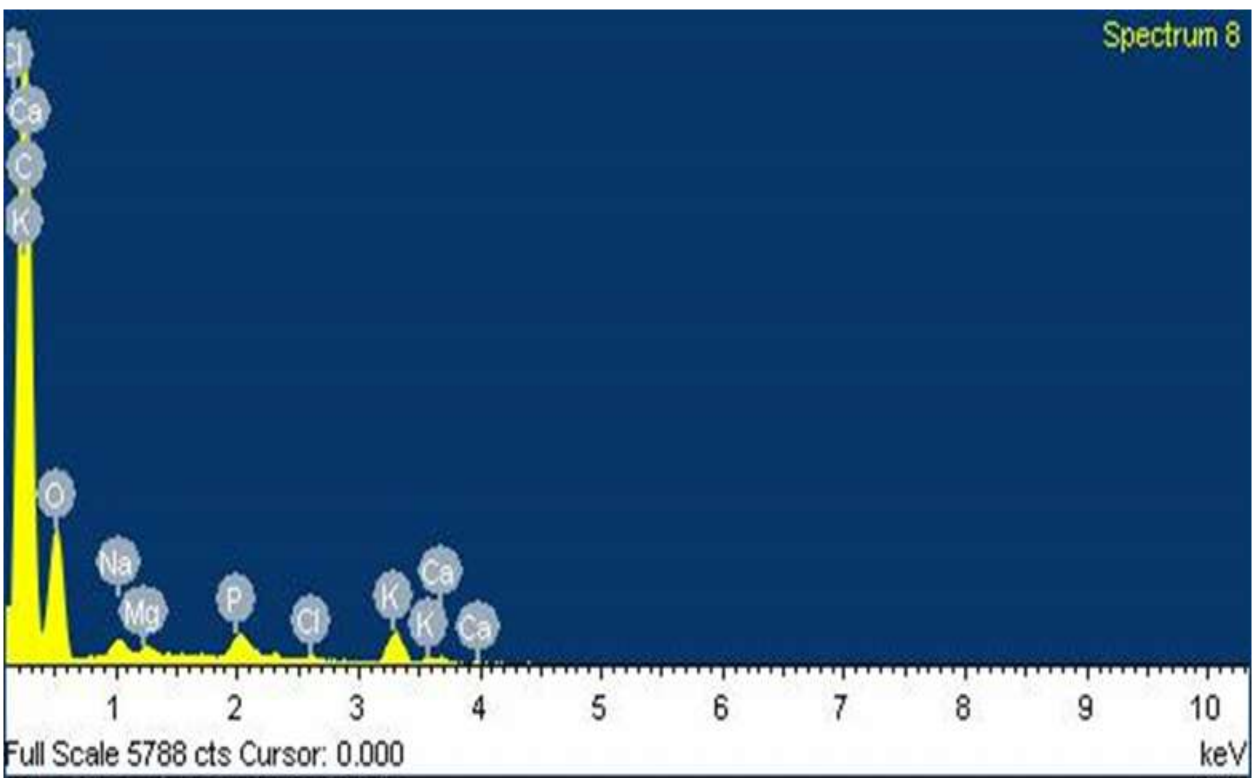


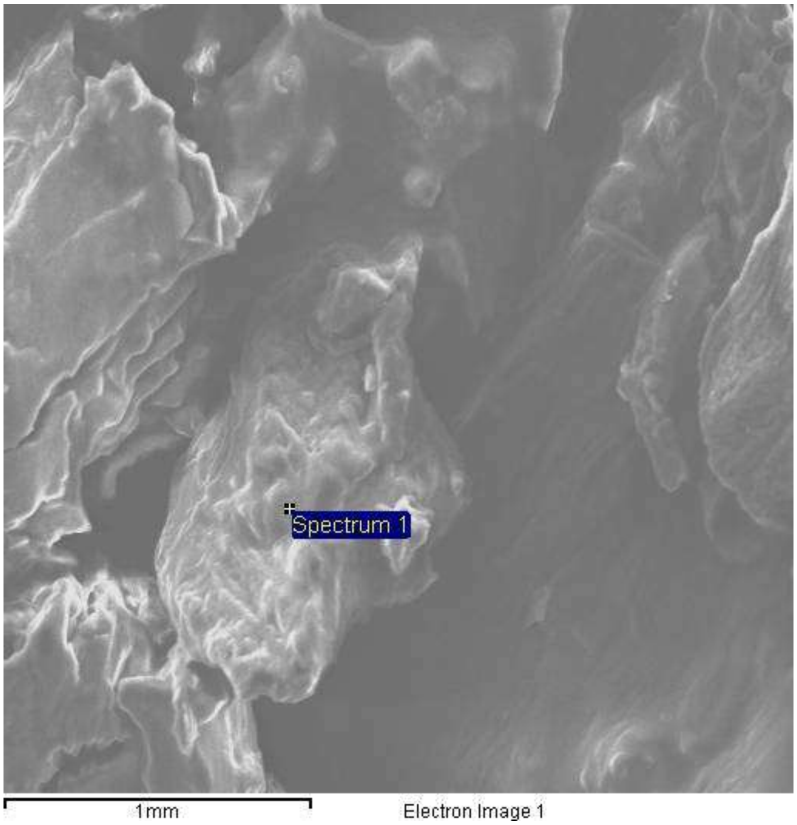


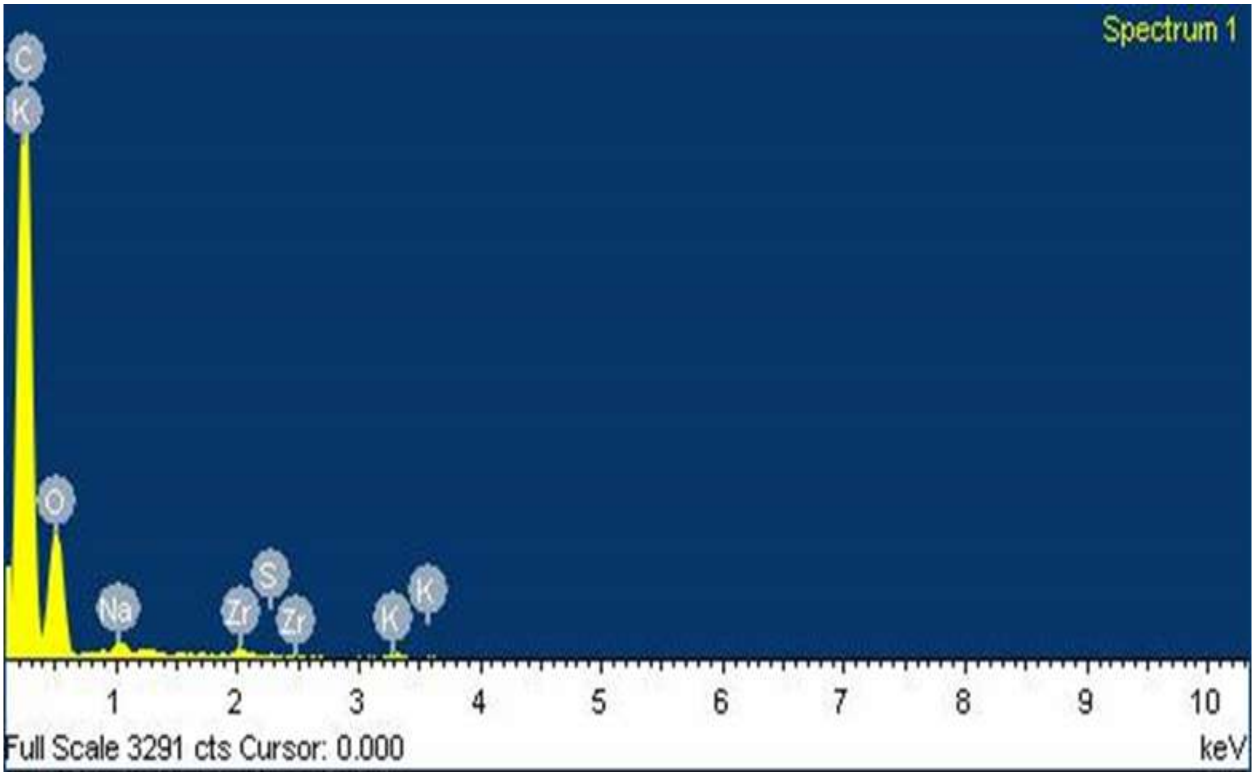
SEM analysis for T_7 (D_4V_1)



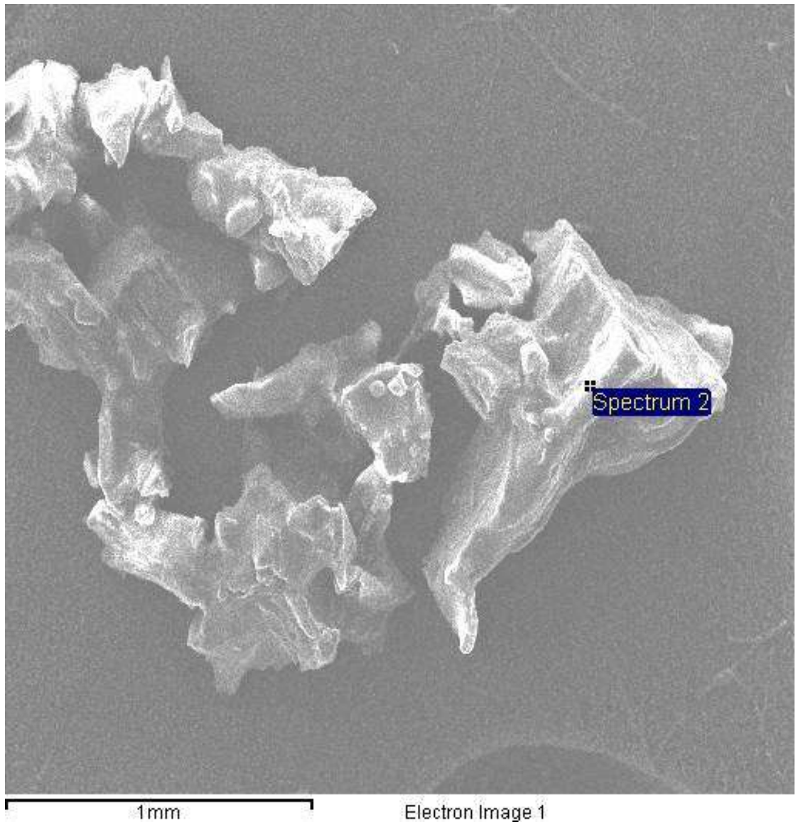


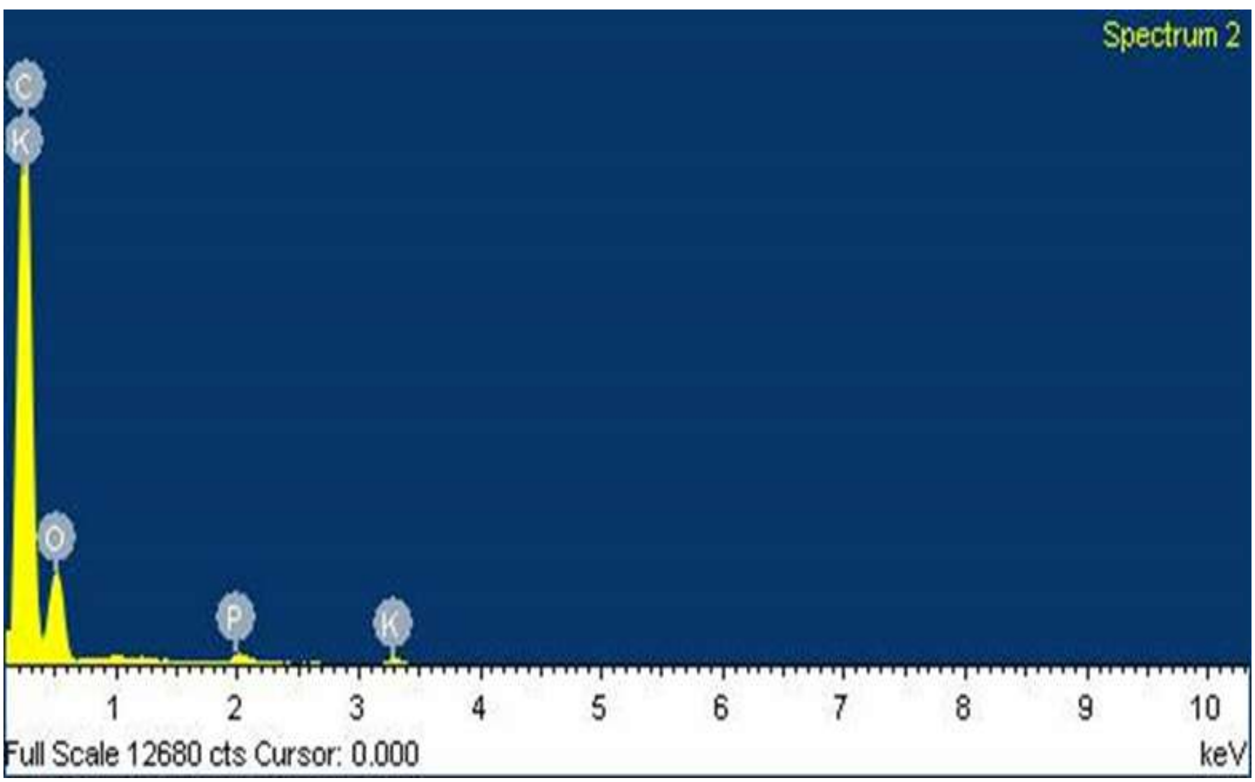
SEM analysis for T_8 (D_4V_2)



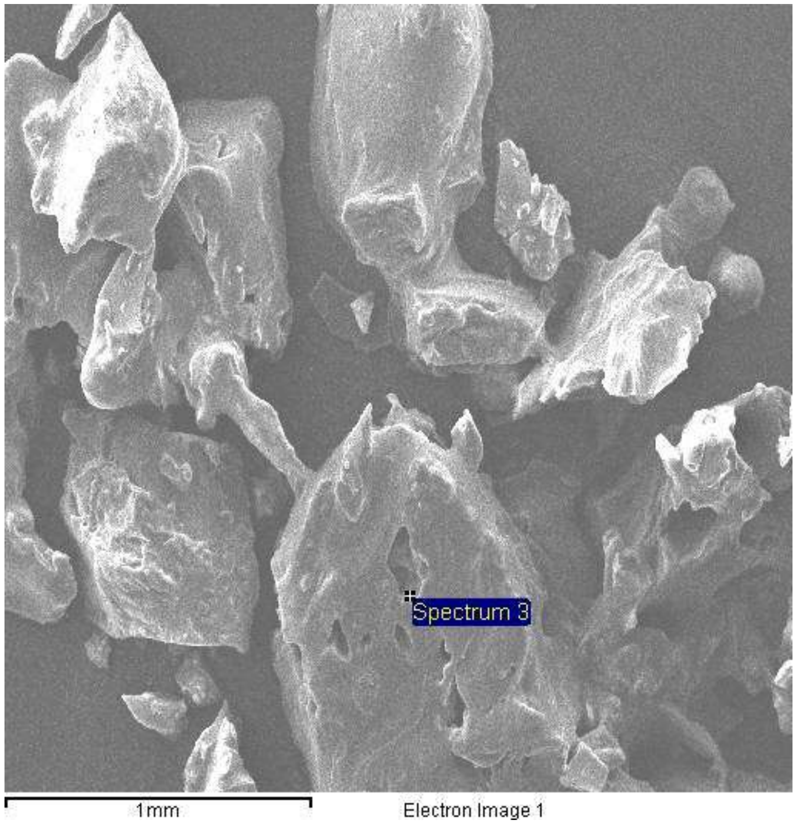


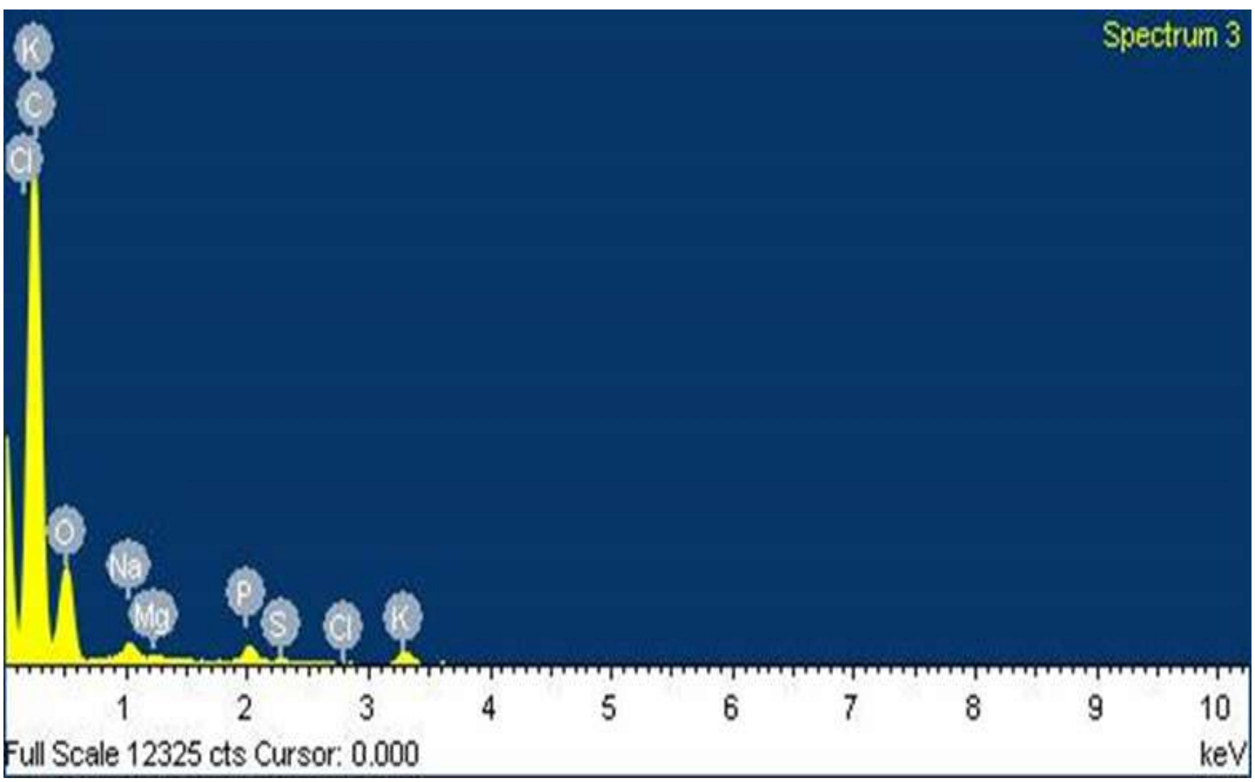
SEM analysis for T_9 (D_5V_1)



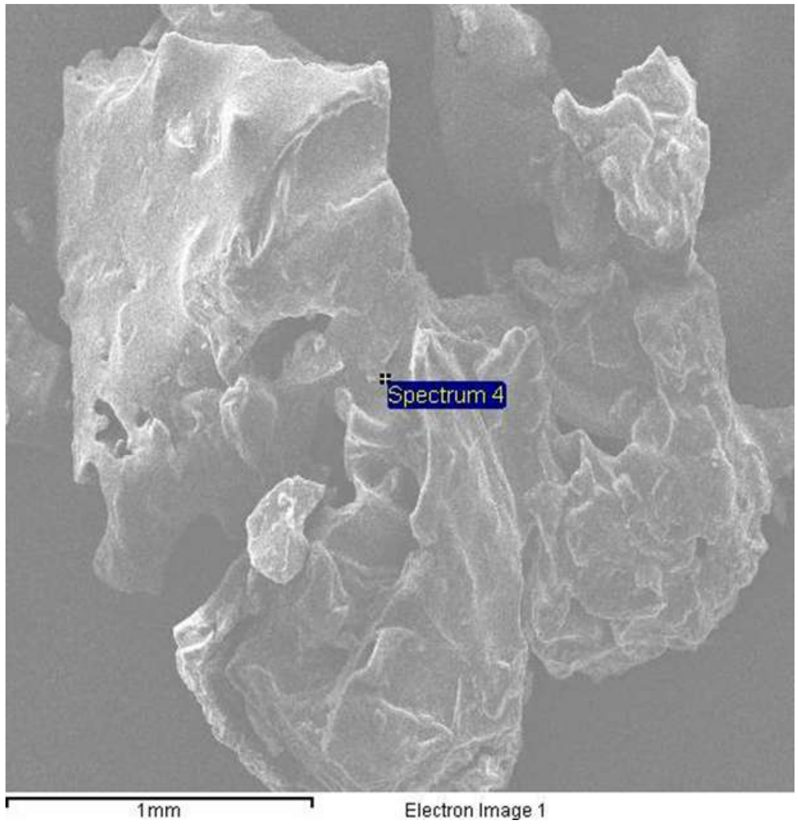


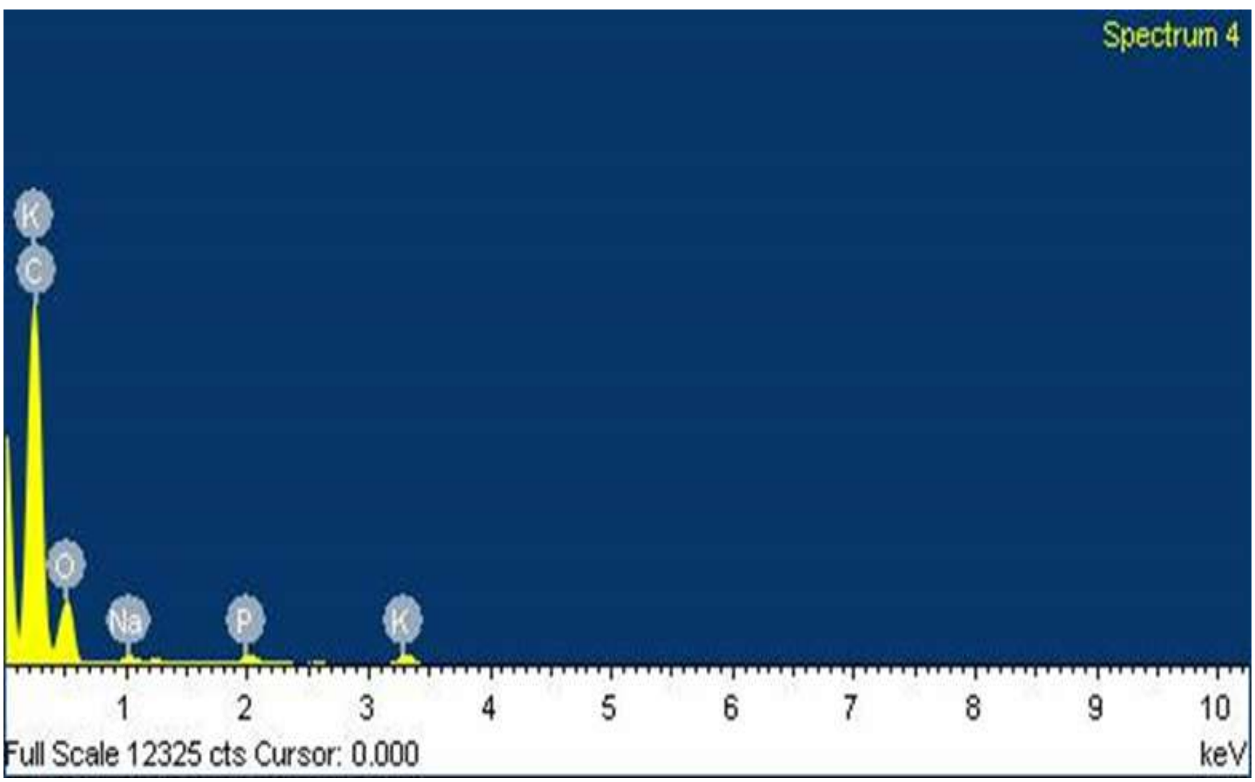
SEM analysis for T_{10} (D_5V_2)



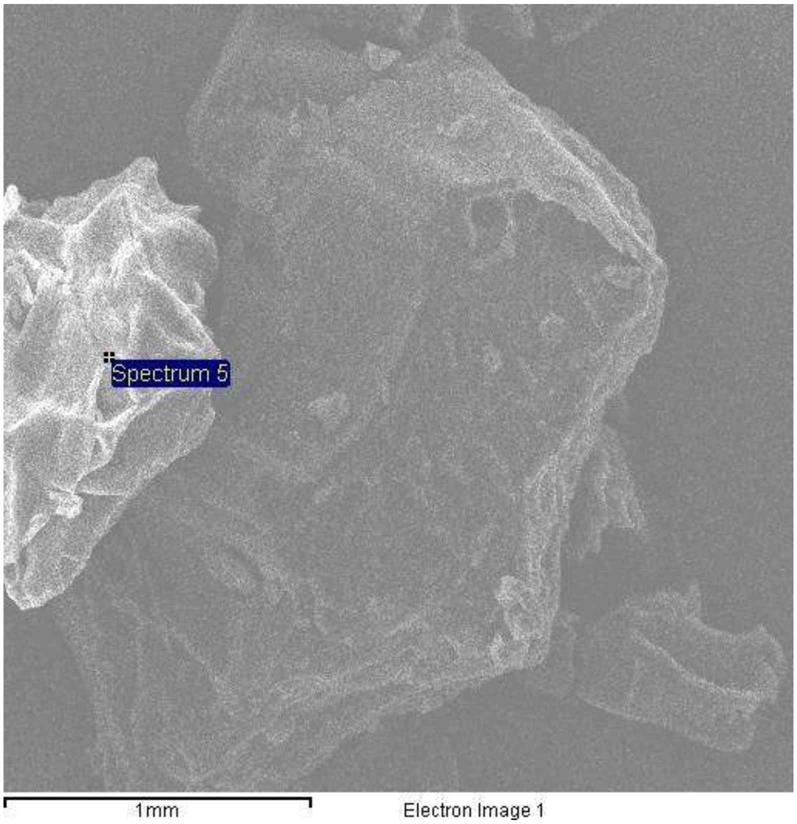


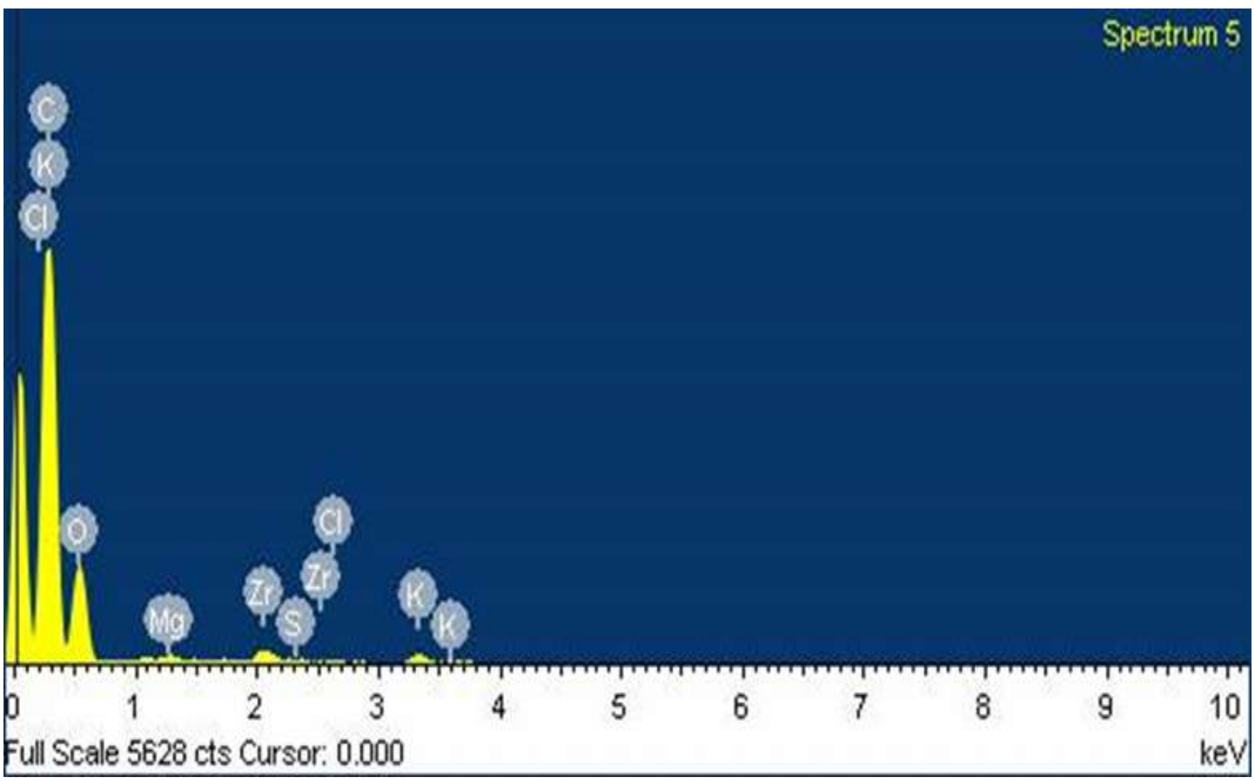
SEM analysis for T_{11} (D_6V_1)



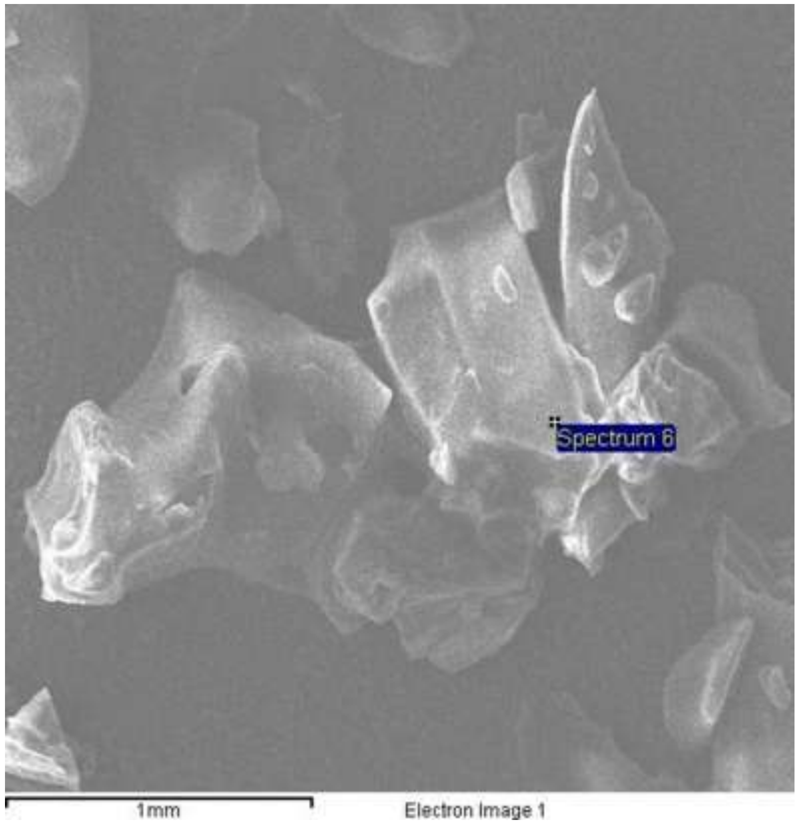


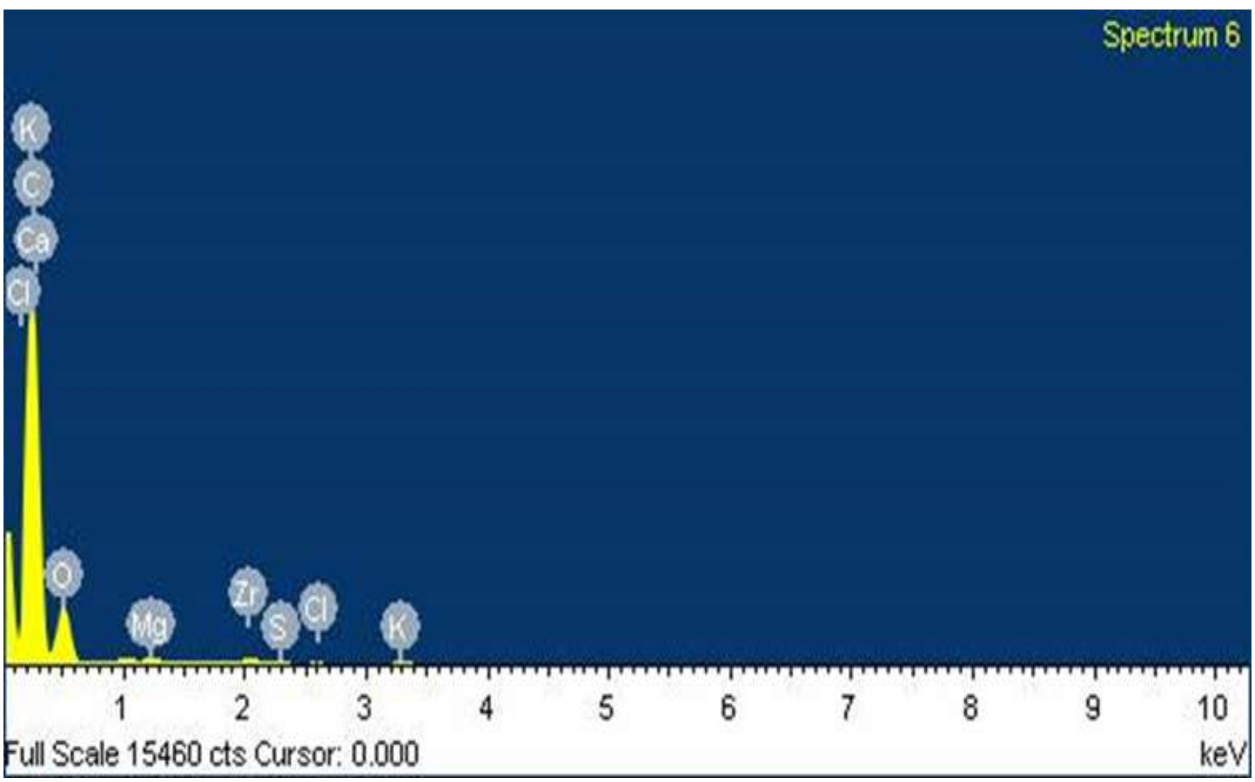
SEM analysis for T_{12} (D_6V_2)



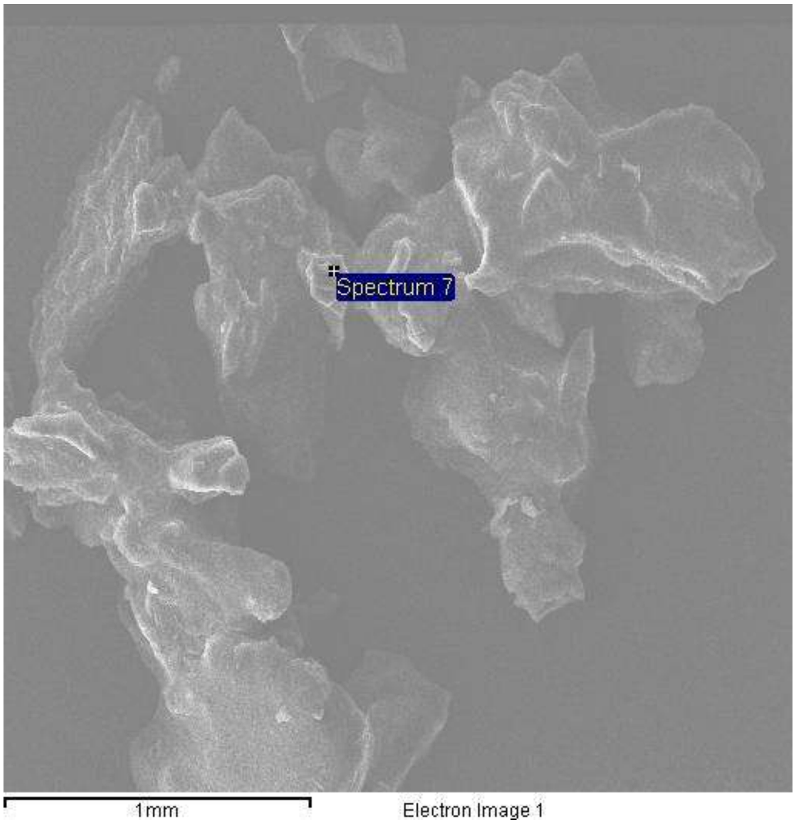


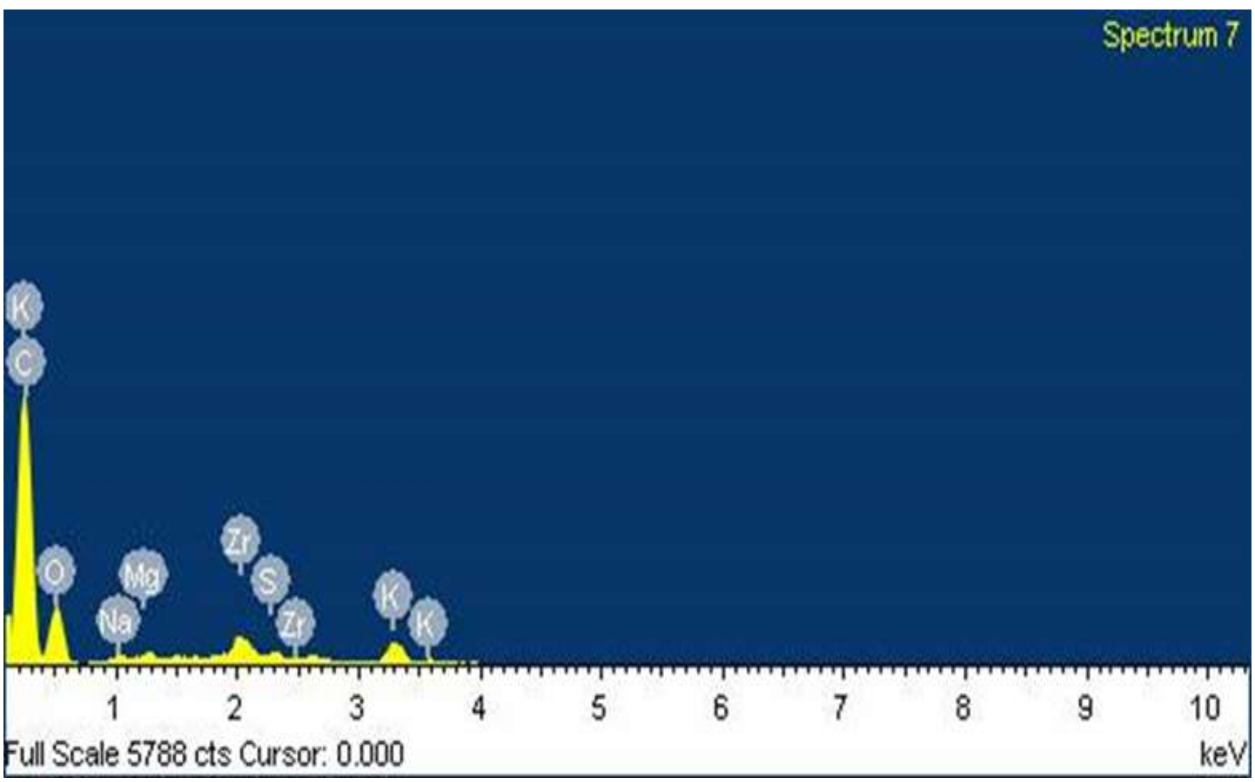
SEM analysis for T_{13} (D_7V_1)



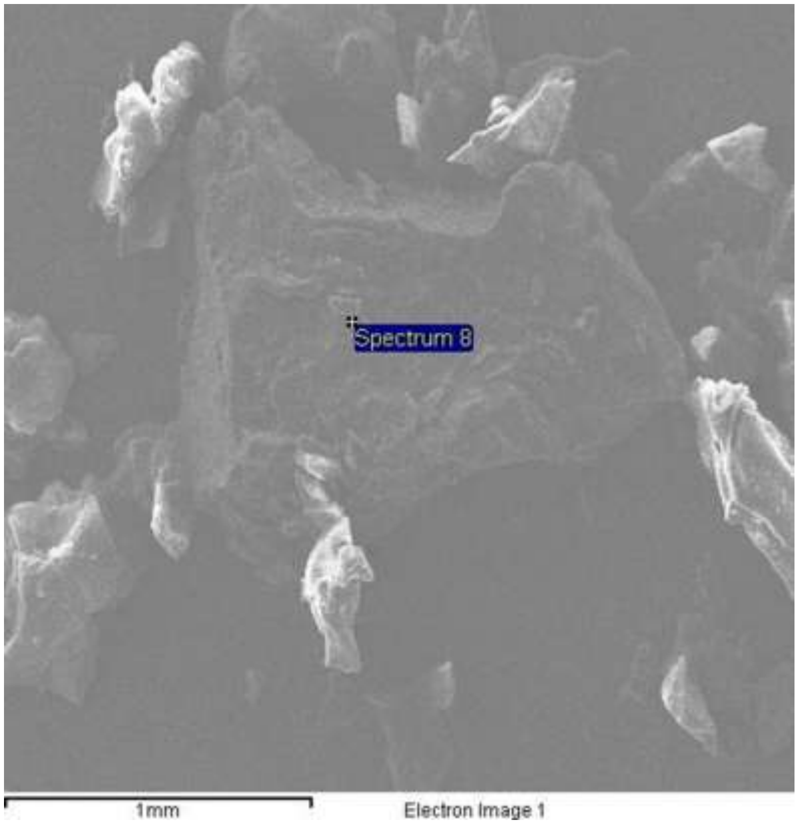


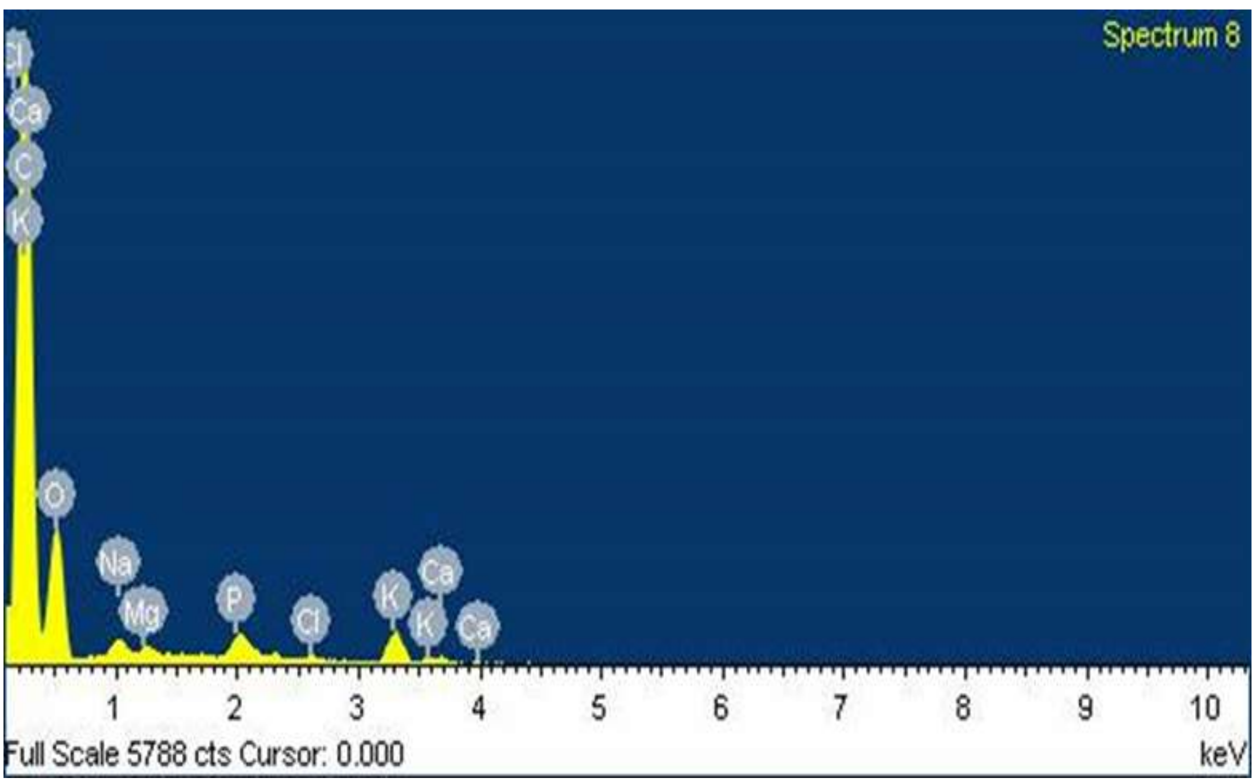
SEM analysis for T_{13} (D_7V_2)





SEM analysis for T_{14} (D_8V_1)





SEM analysis for T_{15} (D_8V_2)

Economic of different treatments of different date of transplanting *kharif* onion (2018-19):

S.N.	Treatment combinations (D×V)	Common cost (₹ /ha)	Treatment cost (₹/ha)	Total cost of cultivation (Rs. /ha.)	Bulb yield (q. /ha.)	Grass return Rs. /ha.	Net return (Rs. /ha.)	B: C Ratio
T_1	D_1xV_1- 30th August	99280	9010	108290	300.87	1878632	1771591.46	16.55
T_2	$V_2x\ D_1$- 30th August	99280	9010	108290	318.42	1988214	1881173.66	17.57
T_3	D_2xV_1-10th September	99280	8920	108200	327.65	2045847	1938805.78	18.11
T_4	D_2xV_2-10th September	99280	8920	108200	335.67	2095923	1988882.66	18.58
T_5	D_3xV_1-20th September	99280	8810	108090	351.01	470353	363312.58	3.39
T_6	D_3xV_2-20th September	99280	8810	108090	357.07	478474	371432.98	3.47
T_7	D_4xV_1-30th September	99280	8769	108049	370.71	496751	389710.58	3.64
T_8	$V_2x\ D_4$-30th September	99280	8769	108049	395.87	530466	423424.98	3.96
T_9	D_5xV_1-10th October	99280	8960	108240	374.42	453423	346381.80	3.24
T_{10}	$V_2x\ D_5$-10th October	99280	8960	108240	362.31	438757	331716.59	3.10
T_{11}	D_6xV_1-20th October	99280	8695	107975	379.5	459575	352533.68	3.29
T_{12}	V_2xD_6-20th October	99280	8695	107975	364.18	441022	333981.16	3.12
T_{13}	D_7xV_1-30th October	99280	8850	108130	360.02	411143	304102.02	2.84
T_{14}	D_7xV_2-30th October	99280	8850	108130	347.21	396514	289473.00	2.70
T_{15}	$V_1x\ D_8$-10th November	99280	9025	108305	337.5	385425	278384.18	2.60
T_{16}	D_8xV_2-10th November	99280	9025	108305	381.97	436210	329168.92	3.08

Economic of different treatments of different date of transplanting *kharif* onion (2019-20):

S.N.	Treatment combinations (D×V)	Common cost (₹/ha)	Treatment cost (₹/ha)	Total cost of cultivation (Rs. /ha.)	Bulb yield (q. /ha.)	Grass return Rs. /ha.	Net return (Rs. /ha.)	B: C Ratio
T_1	D_1xV_1- 30th August	98280	8995	107275	299.57	1305540.59	1199499.77	11.31
T_2	$V_2x\ D_1$- 30th August	98280	8995	107275	311.07	1355657.59	1249616.77	11.78
T_3	$D_2x\ V_1$-10th September	98280	8890	107170	324.15	1412631.17	1306590.35	12.32
T_4	$D_2x\ V_2$-10th September	98280	8890	107170	327.82	1428639.56	1322598.74	12.47
T_5	$D_3x\ V_1$-20th September	98280	8775	107055	347.15	441223.413	335182.593	3.16
T_6	D_3xV_2-20th September	98280	8775	107055	367.97	467694.107	361653.287	3.41
T_7	$D_4x\ V_1$-30th September	98280	8940	107220	372.2	473061.963	367021.143	3.46
T_8	$V_2x\ D_4$-30th September	98280	8940	107220	391.95	498168.45	392127.63	3.70
T_9	D_5 x V_1-10th October	98280	8685	106965	351.97	413568.667	307527.847	2.90
T_{10}	$V_2x\ D_5$-10th October	98280	8685	106965	360.67	423787.25	317746.43	3.00
T_{11}	D_6 x V_1-20th October	98280	9040	107320	377.35	443382.333	337341.513	3.18
T_{12}	V_2xD_6-20th October	98280	9040	107320	342.55	402492.333	296451.513	2.80
T_{13}	D_7xV_1-30th October	98280	8860	107140	359	382690.447	276649.627	2.61
T_{14}	D_7 x V_2-30th October	98280	8860	107140	336.85	359078.547	253037.727	2.39
T_{15}	$V_1x\ D_8$-10th November	98280	8930	107210	328.32	349992.673	243951.853	2.30
T_{16}	D_8 x V_2-10th November	98280	8930	107210	376.97	401850.02	295809.2	2.79

S.No.	Particular	Quantity	Rate (Rs.)	Total(Rs.)
A	**Fix cost**			
1.	**Field preparation**			
a.	Pre – ploughing irrigation	1 no.	2000irrigation^{-1}	2000
b.	Labour for irrigation	2 no.	175 labour^{-1}	350
c.	Ploughing by disc plough	2 no.	3000 ha^{-1}	6000
d.	Ploughing by cultivator	2 no.	2500 ha^{-1}	5000
e.	Planking	2 no.	1000 ha^{-1}	2000
2.	**Raising of nursery**			
	Nursery area	500 sq. meter		
	Labour for nursery bed Preparation	10 no.	175 labour^{-1}	1750
	Seed	200g/400Rs, 12 kg/ha	24000	24000
	Labour for sowing of seed	6 no.	175labour^{-1}	1050
	Polythene cast	600sq. meter ,15 Rs/ meter	9000	9000
	Polythene is used to protect nursery beds.	10 no.	175 labour^{-1}	1750
c.	**Manure and fertilizer**			
	FYM	10q	60q^{-1}	600
	Urea	1kg	5.40 Rs/kg^{-1}	
	Phosphorus	1kg	8 Rs/kg^{-1}	
	Potash	30kg	30 Rs/kg^{-1}	930
d.	Mulching		300	300
e.	Labour for mulching	2no.	175 labour^{-1}	350
f.	Labour for open of mulch	2no.	175 labour^{-1}	350
g.	Irrigation	2no.	175 labour^{-1}	350
3.	**Layout and transplanting**			
a.	Labour for layout	30no.	175 labour^{-1}	5250
b.	Labour for transplanting	40no.	175 labour^{-1}	7000
4.	**Cultural practices**			
a.	Labour for one hoeing	40no.	175 labour^{-1}	7000
b.	Labour for two weeding	40no.	175 labour^{-1}	7000
c.	Irrigation by tube well	100 hrs.	70 hr^{-1}	7000
d.	Labour for irrigation	10no.	175 labour^{-1}	1750
5.	**Plant protection**			
	Pest and disease are observed	5000		
6.	**Harvesting**			
a.	Labour for Digging up onion bulb	20 no.	175 labour^{-1}	3500
7.	**Transport charges**	-	-	-
8.	**UP keep charges**	-	-	-
9.	**Miscellaneous**	-	-	-
	Total cost of cultivation			99280.00

Cost of cultivation

S.No.	Particular	Quantity	Rate (Rs.)	Total(Rs.)
B.	**cost (Including interest and managial risk)**			
1.	**Nutrients**			
a.	NPK(Recommended)	Nitrogen=100kg Phosphorus=50kg Potash=80kg	Urea = 217.40kg (5.4/kg) SSP = 312.50 (8/kg) MOP = 133.33kg (30/kg)	1260.92 2500.00 3999.9
	Total			7760.82

S.No.	Particular	Quantity	Rate (Rs.)	Total(Rs.)
A	**Fix cost**			
1.	**Field preparation**			
a.	Pre – ploughing irrigation	1 no.	2000irrigation^{-1}	2000
b.	Labour for irrigation	2 no.	175 labour^{-1}	350
c.	Ploughing by disc plough	2 no.	3000 ha^{-1}	6000
d.	Ploughing by cultivator	2 no.	2500 ha^{-1}	5000
e.	Planking	2 no.	1000 ha^{-1}	2000
2.	**Raising of nursery**			
	Nursery area	500 sq meter		
	Labour for nursery bed Preparation	10 no.	175 labour^{-1}	1750
	Seed	200g/400Rs, 12 kg/ha	24000	24000
	Labour for sowing of seed	6 no.	175labour^{-1}	1050
	Polythene cast	600sq meter ,15 Rs/ meter	9000	9000
	Polythene is used to protect nursery beds.	10 no.	175 labour^{-1}	1750
c.	**Manure and fertilizer**			
	FYM	10q	60q^{-1}	600
	Urea	1kg	5.40 Rs/kg^{-1}	
	Phosphorus	1kg	8 Rs/kg^{-1}	
	Potash	30kg	30 Rs/kg^{-1}	930
d.	Mulching		300	300
e.	Labour for mulching	2no.	175 labour^{-1}	350
f.	Labour for open of mulch	2no.	175 labour^{-1}	350
g.	Irrigation	2no.	175 labour^{-1}	350
3.	**Layout and transplanting**			
a.	Labour for layout	30no.	175 labour^{-1}	5250
b.	Labour for transplanting	40no.	175 labour^{-1}	7000
4.	**Cultural practices**			
a.	Labour for one hoeing	40no.	175 labour^{-1}	7000
b.	Labour for two weeding	40no.	175 labour^{-1}	7000
c.	Irrigation by tube well	100 hrs.	70 hr^{-1}	7000
d.	Labour for irrigation	10no.	175 labour^{-1}	1750
5.	**Plant protection**			
	Pest and disease are observed	4000		
6.	**Harvesting**			
a.	Labour for Digging up onion bulb	20 no.	175 labour^{-1}	3500
7.	**Transport charges**	-	-	-
8.	**UP keep charges**	-	-	-
9.	**Miscellaneous**	-	-	-
	Total cost of cultivation			98280.00

Cost of cultivation

S.No.	Particular	Quantity	Rate (Rs.)	Total(Rs.)
B.	**cost (Including interest and managial risk)**			
1.	**Nutrients**			
a.	NPK(Recommended)	Nitrogen=100kg Phosphorus=50kg Potash=80kg	Urea = 217.40kg (5.4/kg) SSP = 312.50 (8/kg) MOP = 133.33kg (30/kg)	1260.92 2500.00 3999.9
	Total			7760.82