Effect of planting date and mulching on growth, yield and quality parameters of garlic *(Allium sativum* L.)

THESIS

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Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

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By

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2020

CERTIFICATE – I

This is certify that the thesis entitled **Effect of planting date and mulching on growth, yield and quality parameters of garlic *(Allium sativum* L.)** submitted in partial fulfillment for the requirements of **MASTER OF SCIENCE in Agriculture, Horticulture-Vegetable Science** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. Govind Patel** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions, J.N.K.V.V., Jabalpur (M.P.).

All the assistance and help received during the course of the investigation has been acknowledged by him.

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I, Govind Patel S/o Shri Pyarelal Patel, certify the work embodied in thesis entitled "**Effect of planting date and mulching on growth, yield and quality parameters of garlic *(Allium sativum* L.)"** is my own first hand bonafide work carried out by me under the the guidance of **Dr.B.R. Pandey**, Professor, Department of Horticulture, College of Agriculture, Jabalpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2019 -2020.

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Place: Jabalpur **(Govind Patel)**

Date……

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LIST OF SYMBOLS

ABBREVIATION		Stand for
@	:	At the rate
ANOVA	:	Analysis of variance
Cm	:	Centimeter
CD	:	Critical difference
F value	:	Fisher's value
D.F.	:	Degree of freedom
DAP	:	Day after planting
et al	:	And co-worker
M	:	Meter
Fig.	:	Figure
G	:	Gram
ha	:	Hectare
kg	:	Kilogram
Max.	:	Maximum
Min.	:	Minimum
M.S.S	:	Mean Sum of Square
i.e.	:	That is
Mt	:	Million tonnes
%	:	Percentage
Viz.	:	That is
°C	:	Degree Celsius
Q	:	Quintal
S.E.(m) ±	:	Standard Error of mean

INTRODUCTION

Garlic (*Allium sativum* L.) belongs to family Alliaceae and is a most important bulbous annual spice after onion crop. It is native of Central Asia and is having a chromosome number 2n=16. It produces hermaphrodite flowers. Garlic produces small bulbs having group of cloves covered with thin skin which is economic part of the crop. It is commonly used as a spice and also in the medicinal purposes because it contains antibacterial substance allicin which is a effective drug against amoebic dysentery. Its medicinal value is also well recognized to cure hypertension, worm, germ, bacterial and fungal diseases, diabetes, cancer, ulcer and rheumatism (Kilgori *et al*., 2007).

The therapeutic value of garlic has attracted the attention of one and all since vedic era and every Indian home can prescribe garlic based effective treatment for many common ailments because of its medicinal properties. It is rich in protein, phosphorus, potash, calcium, magnesium and carbohydrates. Ascorbic acid content is very high in green garlic (Pandey, 1997).

A colour less, odour less water-soluble amino acids allin contain by uninjured bulb on crushing the garlic cloves, the enzyme allinase breaks down allin to allcin of which the principal ingredient is the odoriferous diallyl-disulphide is reported to be major flavouring component in garlic. Supplementation with garlic extract inhibited vascular calcification in human patients with high blood cholesterol (Durake *et al*., 2004). Garlic contains different essential minerals, vitamins and many other substances used for health of human beings.

Garlic is an important commercial crop grown throughout India. It is exported every year to other countries and has become a source of earning foreign exchange. In India, garlic occupies an area of 317.0 thousand ha with total annual production of about 1611.0 thousand tonnes (NHB, 2019). The important states growing garlic are Rajasthan, Madhya Pradesh, Uttar Pradesh and Gujarat. These states account for about more than 80% of the area and production in the country. Among different states of India,

Rajasthan is the leading state accounting for 112.89 thousand ha area and 582.0 thousand tonnes of production contributing 36.20% production of India (Horticulture Statistics, 2019).

In Madhya Pradesh, garlic is cultivated in 92.50 thousand ha area with production of 405.00 thousand tonnes and contributes 29.28 and 25.15% to the total area and production of the country respectively (Horticulture Statistics, 2019). Its cultivation is mainly confined to Ratlam, Ujjain, Mandsaur, Neemuch and Indore districts of Madhya Pradesh. It is consumed by almost all the people who take onion.

The time of sowing is an important factor in the cultivation of garlic. The crop yield was largely reported to dependent on planting time (Rahim *et al*.,1984 and Hari Om and Srivastava, 1977). Planting of garlic too early or too late is reported to result in poor growth and yield (Sonkamble *et al*., 1999). Planting of garlic crop between November to December was found to be ideal time for obtaining higher yield (Rahim *et al.,* 1984)

Mulching is a cropping practice that entails placing organic or inorganic or synthetic materials on soil close to plants to provide a more favorable environment for growth and development. Organic or inorganic mulches can be used for weed control. Mulch controls weeds by smothering seedlings, prevent day light which helps faster germination reduce water loss and prevents disease from taking hold on the soil surface (Amoroso *et al*., 2009). Mulch reduces water loss resulting in more conservation of soil moisture. Mulches serve as protective covering, reduce moisture loss from the soil by preventing evaporation from the sunshine and desiccating winds, regulate soil temperature cooler in summer and warmer in winter. The temperature regulating effect encourages the root growth. It was observed that different mulching materials highly influenced the plant height and bulb diameter as well as yield of garlic (Iroc *et al*.,1991).

Plastic mulch gave satisfactory weed control without any application of herbicides (Mahajan *et al.,* 2007). White polythene mulch or organic mulch are a reasonable expense but conserve soil moisture (Mukherjee *et al*., 2004). Polythene mulch also increases soil temperature and moisture

especially in early spring. These synthetic mulches reduce weed problems and certain insect pests and also stimulate higher crop yields by more efficient utilization of soil moisture and nutrients (Rhu *et al.,*1990 and Kashi *et al.,* 2004). Mulching with plant residues and synthetic materials is a well-established technique for increasing the profitability of many vegetable crops (Duranti and Cuocolo, 1989 and Gimenez *et al.,* 2002). Investigation show that mulching by transparent polyethylene improve the growth of garlic (Kwon *et al*., 2011). Many reaserch is available in the literature pertaining to sowing dates compled with mulch in garlic.

Therefore, keeping the above facts in view, the present investigation entitled "**Effect of planting date and mulching on growth, yield and quality parameters of garlic (*Allium sativum* L.)"** was conducted with the following objectives:

1. To study the effect of planting dates on growth, yield and quality parameters of garlic
2. To study the effect of mulching on growth, yield and quality parameters of garlic
3. To determine the interaction effect of planting dates and mulching on growth, yield and quality parameters of garlic.

REVIEW OF LITERATURE

This chapter of brief is a review of work done on evaluation of various crops in general and garlic in particular with respect to planting dates and mulching materials.

Plant growth and development of any crop depends mainly on climatic conditions prevailing in particular area. It is well documented that photoperiod, sunshine hours, temperature, rainfall and other climatic factors affect growth and development of plants, depending upon the plant species and varieties.

The relevant literature on the effect of planting dates and mulching in relation to growth, yield and quality characteristics has been reviewed under the following heading:

2.1 Effect of planting date

2.2 Effect of mulching

2.3 Effect of planting date and mulching

2.1 Effect of planting date

In order for getting higher yield with quality, time of planting is one of most important factors. The climatic factors like temperature, humidity and rainfall play a major role in successful production of crop. The relevant literature on the effect of planting date in relation to growth, yield quality of garlic has been reviewed as follows:

Hari Om and Srivastva (1974) observed maximum number of leaves per plant when planted on 6 September compared to planting of 20 September and 3, 17 October and 4 November. 6 September to October 3 as optimum than other sowing dates for getting higher bulb yield in garlic.

Bhathal and Thakur (1986) observed different planting dates with three different cultivars (56-4, G-11 and G-15) and recorded highest mean yield (133.1 q/ha) from October 15 planting which declined to 100.6 q/ha when planted on 16 November.

Lee *et al.* (1989) reported that the garlic cultivar Daeseo and Namdo when planted on 10, 20, and 30 September produced higher number of leaves per plant when compared to 10 and 20 October plantings.

Kargirwar and Kulwal (1991) reported that planting on 20 September resulted in significantly more growth and highest yield (99.21 q/ha) followed by planting on 10 October (82.08 q/ha) and 1 September (78.69 q/ha). Yield reduction was quite high from planting on 30 October and thereafter.

Orlowski and Rekowska (1993) observed that the optimum planting dates were 20 September and 5 October in garlic crop which was recorded higher number of leaves per plant when compared to 5 November.

Mishra *et al.* (1997) studied the effect of different dates of planting on growth and yield of garlic (*Allium sativum* L.) under high altitude conditions of southern Orissa. Planting of garlic cloves between 21 October and 1 November resulted a greater number of cloves per bulb, higher bulb weight and higher total bulb yield. Delay in planting resulted in an early harvest and low total bulb yield.

Humayun-Khan *et al.* (1997) conducted on experiment on garlic cultivars were planted on 3 different dates 22 September, 7 and 22 October. For all cultivars, the yields were highest for the early planting followed by the 2 and 3 planting dates.

Mishra *et al.* (1997) experiment results exhibited the garlic planted on 1 October had produced the maximum cloves per bulb.

Mohamed Ali and El-Sayed (1999) studied the response of two garlic varieties (*Allium sativum* L.) to different planting dates and revealed that the early planting on 22 October gave the highest bulb yields of large bulbs averaged over the two seasons 8452, 6717, 5963 and 5202 kg/ha for the 22 October, 7 November, 22 November and 7 December respectively.

Sonkamble *et al.* (1999) studied the effect of different dates of planting on growth and yield of garlic and revealed that planting on 20 October recorded significantly maximum plant height, number of leaves per plant and stem girth. Planting of garlic crop on 20 October produced

significantly highest 63.44 q/ha. The lowest yield of 40.93 q/ha was recorded with the sowing on 1 September.

Muhammad *et al.* (2001) observed that the yield in garlic were maximum with planting date of 1 November followed by planting date of 15 December.

Mohanty (2001) noticed that, the planting done on 16 November gave significantly the maximum leaves per plant in onion as compared to rest of the planting dates.

Panda and Mohanty (2002) studied the response of onion to time of planting and revealed that planting on 16 November registered the tallest plant (50.52 cm) and maximum leaves per plant (14.85) when compared to other dates of plantings.

Sawant *et al*. (2002) found that, the maximum total soluble solid was recorded with the onion crop planted on 19 September.

Gupta *et al.* (2003) registered that the garlic crop planted on 20 September had produced the cloves with the maximum TSS as compared to other dates of planting.

Bhuiya *et al.* (2003 A) studied the effect of the growth and yield of garlic and revealed that highest plant height (52.63 cm) was recorded from November 9 plantations. The lowest plant height (46.69 cm) was recorded from December 23 planting, while the maximum number of leaves was counted from November 25 (8.97). In garlic early planting of October 25 gave maximum yield of bulb (3.92 t/ha) when compared to late plantings.

Gupta *et al.* (2003) reported that planting of garlic (cv. Yamuna safed-3) on 5 October and 20 September resulted in the highest bulb diameter (3.26, 3.23 cm), bulb size index (8.76 and 8.68 cm^2), clove diameter (0.97 and 0.98), clove size index (1.86 and 1.84), weight of 20 bulbs (269.17 and 268.39 g), gross yield (166.20 and 166.15 q/ha), and marketable yield (154.17 and 151.85 q/ha).

Rahman *et al*. (2004) shown that the 7 November planting of garlic had produced the maximum leaves plant as compared to rest of the planting dates.

Shahidur *et al*. (2004) recorded that the highest yield (2.67 t/ha) was obtained from November 7 planting while the lowest yield (0.92 t/ha) was from December 22 planting.

Sawarkar and Nandekar (2004) reported that the garlic crop planted earlier (5 September) fetched the highest net profit per hectare and BC ratio. Whereas, minimum net profit per hectare and B: C was registered in late planted crop (30 October) under Chhindwara (M.P.) conditions.

Chattopadhyay *et al*. (2006) recorded that the plant height, plant girth, number of leaves, recorded to be maximum in early date of sowing i.e. on November 15 when compared to late sowings of December 1 and December 15 except the crop growth rate which was more in late planting of December 15. The yield recorded maximum in garlic with early planting date of November 15 (5.40 t/ha) decreased in late planting dates.

Gautam *et al.* (2007) studied the effect of plant density, planting date and irrigation time on the growth and yield of garlic (*Allium sativum* L). The results revealed that garlic planted in the 1 fortnight of November gave the highest yield. The highest plant density produced higher yield but poor quality, while low plant density produced high quality cloves and bulbs. The frequency of irrigation did not exhibit a clear trend due to irregular rain during the cropping season.

Singh *et al*. (2010) studied that the bulb yield of garlic was significantly influenced by the different dates of planting. Crop planted on 1 November recorded maximum bulb yield (88.75 q/ha), when compared to other dates of planting. Minimum bulb yield (64.21 q/ha) was recorded in 15 December planted crop. Maximum yield in early planting could be attributed to better growth of plants and large sized bulb and also the enhanced crop growth rate which might have resulted in efficient metabolism, there by increased the sink capacity. Higher metabolism, greater photosynthetic mobilization and better source sink relationship helped to produce higher

yield. Bulb volume, bulb diameter and bulb weight also might have influenced the bulb yield.

2.2 Effect of mulching

Mulching is one of the simplest and most beneficial practices. Mulch is simply a protective layer of a material that is spread on top of soil. Mulches can either be organic- such as grass clippings, straw, bark chips and similar material or inorganic such as stones, brick chips and plastic. Both organic and inorganic mulches have numerous benefits. Mulch protects the soil from erosion, reduces compactions from impact of heavy rains, conserve moisture, reducing the need for frequent watering, maintain a more even soil temperature and prevents weed growth. The relevant literature on the effect of mulching in relation to growth yield and quality characteristics of garlic has been reviewed as follows.

Manrique and Mayer (1984) observed that plastic mulches raised soil temperature during the winter giving significantly higher yield. In summer, plastic mulches increased day soil temperature to above 30°C giving an unfavorable environment for plant growth and tuber formation in potato. But favorable soil temperature in both winter and summer was maintained by straw mulch.

Kwon *et al.* (1988) reported that natural mulches like sugarcane tresses and paddy straw had significant effect on yield attributing characters as compared to control but the sugarcane tresses had effect more prominent than paddy straw mulch.

Duranti and Cuocolo (1989) reported that mulching with plant residues and synthetic materials is a well-established technique for increasing the profitability of many horticultural crops.

Sumi *et al.* (1986) stated that mulching gave a maximum yield of garlic (10.30 t/ha) with an average bulb size of 31.22 g while the lowest was 6.06 t/ha with an average bulb size of 19.01 g respectively for the unmulched control.

Suh *et al*. (1991) conducted an experiment and stated that polythene film mulches in onion crops found that the mean soil water content was 2.1-

2.8% higher in the mulched plots than the control. They also stated that soil moisture conservation was an important aspect for crop-growth and yield.

Iroc *et al*. (1991) reported that different mulching materials influenced the average height and the average bulb diameter of garlic seedlings. Garlic mulched with rice husk produced the biggest bulb diameter while the other treatments resulted in reduced bulb diameters.

Alam *et al*. (1993) reported that Mulching with straw reduced the maximum soil temperature.

Adetunji (1994) conducted a trial to optimize water use and soil condition during dry season in semi-arid region, onion was mulched with polythene film and reported that mulching significantly enhanced vegetative growth.

Gajri *et al.* (1994) studied that mulching has been conserved moisture by protecting the plant from excess transpiration and direct evaporation from soil thus reducing the irrigation requirements.

Teasdale and Abdul-Baki (1995) reported that straw mulch allowed better air-circulation, which resulted in better overall performance of tomato.

Baten *et al*. (1995) conducted experiment and reported that plants treated with any kind of mulches under study significantly increased plant height, number of leaves per plant, length of leaf, length of pseudo stem, number of roots per plant, bulb and neck diameter over the control.

Hossain (1996) carried out an experiment and observed that Plant height, number of leaves, pseudostem and bulb diameter, bulb weight and bulb yield were found significantly higher for mulched plants.

Rekowaka (1997) stated that plastic film mulching has been proved to be effective in garlic production. Plastic film mulch has a positive effect on yield and quality of garlic and adding that the highest marketable yield was obtained compared with unmulched control. Plastic mulch also produced the largest and heaviest bulb.

Uddin (1997) studied that straw has been proved to be the best mulch for garlic compared to transparent plastic, black plastic and cabbage

residues as it yielded the largest bulbs and the highest number of cloves/bulbs.

Abdallah (1998) conduced an experiment on onion seedbed solarization in field naturally infested with weeds. Seedbed plots were covered early with 50 micrometer thick transparent polythene mulch for 6 weeks. Seedbed solarization gave the lowest number and weight of weeds and significantly increased the production of healthy onion seedlings per unit area compared to the control.

Abu-Awad (1999) described that with mulch treatments, evapotranspiration was significantly reduced, while transpiration was significantly increased compared with open soil surface treatments. In covered soil surface treatments, onion yields were significantly higher than in open surface treatments.

Bhuiyan (1999) reported that different mulches had marked influence on the yield contributing characters of garlic.

Hassan (1999) reported that water organic mulch gave the tallest plant highest and numbers of leaves per plant at 75 DAP. The author also added that fresh weight of bulbs and bulbs diameter were increased.

Umar *et al*. (2000) reported that mulching is a cropping practice that entails placing organic or inorganic or synthetic materials on soil close to plants to provide a more favorable environment for growth and development. Organic or inorganic mulches can be used for weed control. Mulch controls weeds by smothering seedlings, prevent day light which helps foster germination from reaching weed seeds and prevents airborne seeds from taking hold on the soil surface.

Bhuiya *et al.* (2003 B) conducted an experiment to study the effect of mulch and irrigation on growth and yield of garlic. There were seven types of mulch and irrigation treatments viz. Straw, water hyacinth, black polyethylene, transparent polyethylene, 10 days interval irrigation, 20 days interval irrigation and control (no mulch and no irrigation) were used as the experimental treatments. Water hyacinth mulching yielded (4.27 t ha-1) best

which was statistically identical with straw mulch (3.97 t ha-1). The lowest yield was obtained from white polyethylene mulch and control.

Kashi *et al*. (2004) reported that polythene mulch also increases soil temperature and moisture especially in early spring. These synthetic mulches reduce weed problems and certain insect pests and also stimulate higher crop yields by more efficient utilization of soil nutrients.

Mukherjee *et al. (*2004) calculated that black and white polythene mulch or organic mulch are a reasonable expense and conserve soil moisture.

Jamil *et al*. (2005) observed the effects of different type of mulches (plastic, straw and sawdust, excluding, control) and their duration (one month and whole season) on the growth and yield of garlic were observed in a field experiment. Straw and plastic mulch increased the bulb yield and yield components, irrespective of their duration. Straw mulch is recommended for the garlic production based on better overall performance than the others and also for being cheaper and organic in nature.

Singh *et al.* (2005) noticed that the plots mulched with paddy straw or sugarcane tresses showed slightly higher temperature (0.9-1.7°C) as compared to control.

Karaye and Yakubu (2006) indicated that the number of leaves/plants, weed growth and cured bulb yield responded significantly to mulching and they based on their results for optimum bulb yield in garlic proposed the using of 9 t/ha mulch.

Rahman *et al*. (2006) reported that treatments with mulches in rice straw, water hyacinth and wastage of rice straw, significantly increased the tomato yield over control (no mulch).

Khurshid *et al.* (2006) mulching increased the soil porosity and reduced soil compaction.

Hossain *et al*. (2007) reported that mulching helps in significant increase in N, P and K uptake over unmulched. Therefore, a better understanding of the uses of mulching in garlic production is very important

in order to develop management strategies, which optimize moisture and increasing returns to the producers by increasing garlic yield and quality.

Gebrehaweria (2007) studied that the mulch regulates soil temperature control weeds and diseases and reduce loss of nutrients.

Mahajan *et al*. (2007) studied that plastic mulch gave satisfactory weed control without any application of herbicides.

Rekowska and Skupien (2007) observed that the mulch serves as protective covering, reduce moisture loss from the soil by preventing evaporation from the sunshine and desiccating winds, regulate soil temperature cooler in summer and warmer in winter. The temperature regulating effect encourages the root growth and weight. It was observed that different mulching materials highly influenced the plant height and bulb diameter (Iroc *et al*. 1991) as well as yield of garlic.

Glab and Kulig (2008) reported that straw mulch unlike other mulches was able to increase the infiltration rate of rain or irrigation water.

Anisuzzaman *et al.* (2009) conducted an experiment to investigate the effect of mulches on soil nutrients and microclimate status, growth and bulb yield of onion. Application of different mulches improved soil microclimates, increased plant growth and bulb yield over control. Among the mulches, black polythene mulch showed superiority in growth and yield contributing characters compared to other mulches, resulting the highest bulb yield.

Anzalone *et al*. (2010) observed that paper, biodegradable plastic and rice straw are potential substitutes for polyethylene and herbicides.

Singh (2011) reported that the crop management practices like mulching with crop residues and plastic mulches help in conserving soil moisture.

Kwon *et al*. (2011) investigated the effects of mulching by transparent polyethylene and net polyethylene on the growth of garlic plant height and leaf number of garlic were highest at transparent polyethylene treatment and this treatment also promoted the number of cloves.

Karim *et al.* (2011) conducted an experiment and reported that rice straw mulch produced higher bulb yield (11.12 t/ha) than that (8.72 t/ha) of the control treatment.

Mahdieh *et al*. (2012) conducted an experiment using three kinds of mulches (Transparent and black PE and rice straw) and found that plastic mulch increased minimum temperature of soil, accelerated plant height, early growth, early yield, and bring satisfactory weed control without any application of herbicides. Results also showed that garlic total yield, bulb ash percent, TSS, vitamin C and flavonoids content were affected by mulching. Although mulching could improve some quality indices in garlic but no effect on forcing was observed. Due to two 10 years experiment and interaction between year and mulches the usage of rice straw in rainy and cool season and plastic mulch in low rain fall and warm season recommended increasing garlic quality.

Wolde (2014) reported that many of these effects were attributed to the capacity of the mulch to conserve soil moisture.

Kabir *et al.* (2016) conducted an experiment to study the effect of mulches on the growth and yield of garlic. The experiment consisted of four mulches (control, rice straw, water hyacinth and Curcuma amada leaf). The results revealed that different mulches had remarkable contributions on the growth and yield of garlic. The highest values of growth parameters as well as bulb yield were obtained from rice straw mulch.

2.3 Effect of planting date and mulching

Chung (1987) reported that growth rate is always accelerated under polyethylene mulch. Maximum bulbs survival percentage (71.83) was observed in plastic mulch used for the whole season followed by straw (65.59%) mulch, whereas it was minimum (50%) in control plots. These results are coinciding with the findings of Shing *et al*. (1988) who reported that garlic plants under polyethylene film survived better than control. The diameter of bulbs was maximum (4.71 cm) in plastic mulch followed by straw mulch (4.69 cm) while it was minimum in control and sawdust mulch i.e., 4.18 and 4.33 cm, respectively. This revealed that plants were more efficient

when top soil temperature and moisture was higher under plastic and straw mulches. Although the straw and plastic mulches both gave maximum yield of garlic crop as compared to straw dust but straw mulch overall performed better than others. It is also cheaper and organic in nature. Therefore, straw mulch is recommended for better garlic production.

Tuli and Yesilsoy (1997) plant attained maximum height under mulches, particularly in plastic mulch, which might be due to the increased soil temperature.

Diaz-Perez *et al.* (2003) conferred that different coloured plastic mulches including black polythene mulch and tomato cultivars affected the time between transplanting and appearance of first symptoms of tomato spotted wilt virus (TSWV). For all tomato cultivars, vegetative top fresh weight, total fruit yield and fruit number increased linearly with the time of the plants remained free from TSWV symptoms. Marketable fruit yield also increased the time from transplanting to the first appearance of TSWV symptoms increased. Mulches were found beneficial as it decreased TSWV incidence.

Rashidi and Gholami (2011) studied interaction effect of plastic mulch and tillage method on yield and quality of tomato. Results indicated that mulch levels and tillage methods significantly increased yield and quality. The maximum number of plants per hectare, maximum number of fruits per plant and total yield were observed in black polythene mulch plot. On the whole for reaching the highest yield and enhanced quality of tomato integrated use of black polythene mulch and tillage can be recommended.

MATERIALS AND METHODS

This chapter comprises the detail about the materials used and the methods adopted during the course of investigation entitled "**Effect of planting date and mulching on growth, yield and quality parameters of garlic (*Allium sativum* L.)"** are as follows.

3.1 Experimental site

The experiment was conducted at the Vegetable Research Farm, Maharajpur, Department of Horticulture, College of Agriculture Jabalpur (M.P.) during *rabi* season 2019-2020.

3.1.1 Soil

The soil of the experimental field was medium black with good drainage, uniform texture and medium NPK status.

3.1.2 Climate and weather conditions

Jabalpur is situated in Kymore Plateau and satpura hills agroclimatic Region of Madhya Pradesh at 23°91" N latitudes and 79°58" E longitude and at the altitude of 411.78 meter above the mean sea level. It has hot, dry summer and cold winter with occasional showers. The average annual precipitation is nearly 1350 mm, distributed mainly between the mid-June and first week of October, with occasional rains during winter. In general, the maximum temperature reaches up to 46ºC in April-May and minimum below 5˚C in the month of December-January. The mean relative humidity reaches up to 78% during winter (November-February) with occasional frost.

3.1.3 Weather during the crop season

Seasonal variation prevailing during the growth period plays an important role in the growth and development of the crop. The weekly meteorological data recorded during the crop season at meteorological observatory. The data related to weekly maximum and minimum temperature (ºC), relative humidity, sunshine hours, (morning and evening) and rainfall (mm). During entire crop growing period of experiment recorded at meteorological observatory Krishi Nagar, J.N.K.V.V., Jabalpur, (M.P.) has been presented in table 3.1

Table: 3.1 Weekly meteorological information during entire crop season of the year 2019-20 at Jabalpur.

Month	Standard Week	Temp (oC)		RH	RH	Total rainfall (mm)	No. of rainy days	Pan evapor-ration (mm)	Sun-shine hours
		Max.	Min.	Mor	Eve				
October	41	30.1	21	90	66	14.3	2	3	7.2
	42	30.3	18	91	56	0	0	3.3	8.4
	43	29.2	18.7	93	63	2.2	0	2.3	5.6
	44	27.1	19.1	92	60	1	0	1.8	0.9
	45	30.3	17.7	92	52	0	0	2.3	5.3
November,	46	29.6	14	92	52	0	0	2.3	6.5
	47	28.7	10.3	92	41	0	0	2.3	8.7
	48	28.2	10.5	91	48	0	0	2	6.8
	49	29.1	11.3	94	49	0	0	1.9	6.4
December	50	25.8	8.4	90	46	0	0	2	6.8
	51	24.8	12.1	95	70	12.4	2	1.4	3.6
	52	21	6.3	89	55	0	0	1.4	5.3
	1	22.1	6.7	87	50	0	0	1.8	5.9
January	2	20.3	10.3	91	62	17.9	2	1.4	3.5
	3	22	8	89	48	15.8	1	2	7.7
	4	23.8	11.2	89	51	0.4	0	1.8	5.9
	5	24.1	9.1	84	44	0	0	1.9	7.8
February	6	24.2	8.3	88	41	0	0	2.7	7.3
	7	22.2	7.9	85	40	8.7	1	2.3	6.6
	8	26.8	7.5	90	32	0	0	2.7	9.8
	9	28.8	14.1	86	49	0	0	3.1	6.4
March	10	29.2	12.7	87	34	1.8	0	2.7	8.3
	11	28.5	13.1	84	45	0.8	0	3.1	7.4
	12	29.9	14.7	81	35	0.5	0	3.4	7.6
	13	31.6	16.9	69	40	36.4	1	3.2	7.2
April	14	34.5	20.4	61	33	0.9	0	3.4	7.5
	15	36.8	20.3	45	22	0	0	4	7.3
	16	38.9	21.6	37	21	0	0	4.6	9.4
	17	38.7	24.5	45	23	0	0	4.4	7.7
	18	37.9	23	51	28	0	0	4.1	7.5
May	19	39.3	24	50	26	0	0	4.7	10

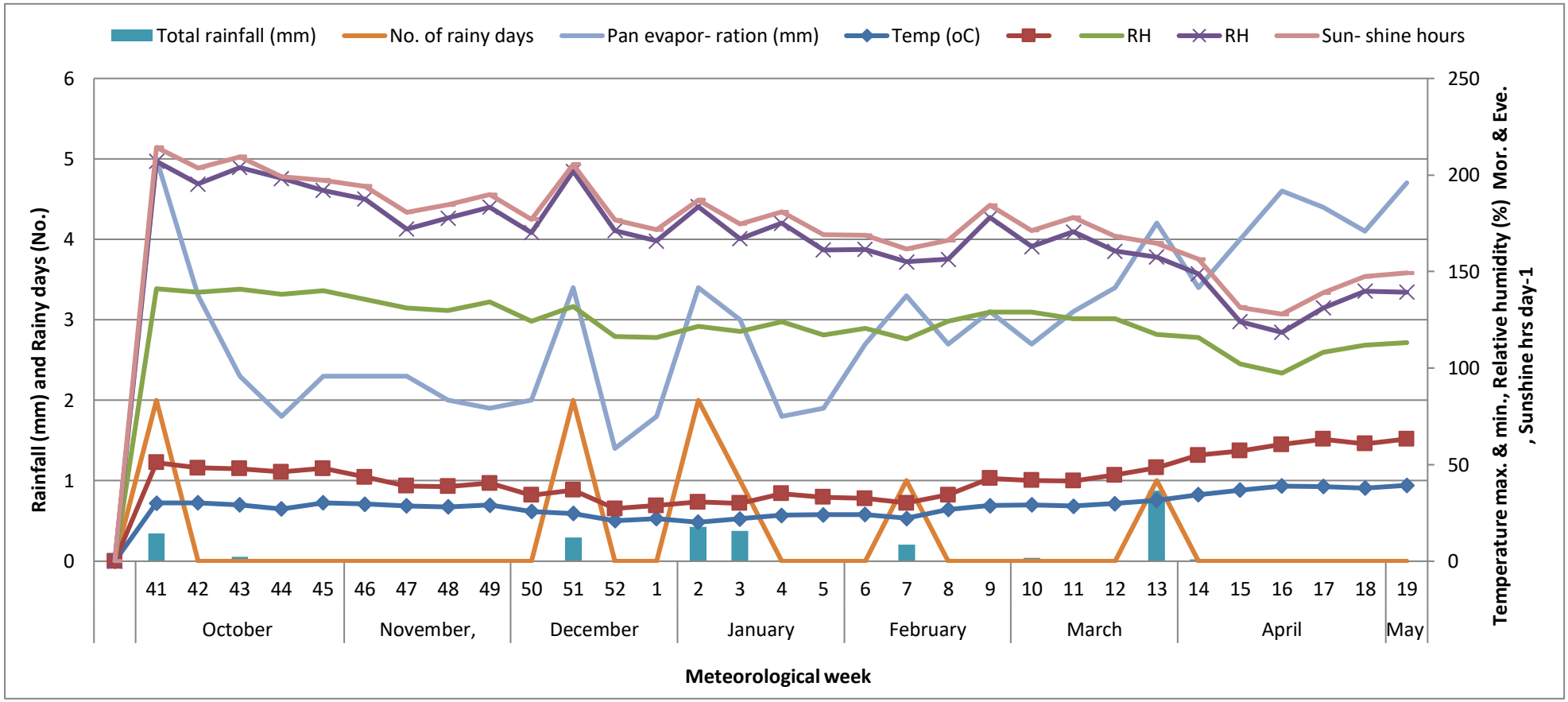

Fig. 3 Meteorological parameters during crop season (October to May, 2019-2020)

Table: 3.2 Soil characteristics of the experimental site

S. NO.	Soil component	Analytical value
1	Organic carbon (%)	0.98
2	Available nitrogen (kg/ha)	259
3	Available phosphorus (kg/ha)	26.3
4	Available potash (kg/ha)	319
5	Soil Ph	7.60
6	Electrical counductivity (ds/m)	0.20

3.2 Experimental details

The Experiment was laid out in Factorial Randomized Block Design with three replications and each replication consisted of nine treatments.

Table: 3.3 Details of experiment are given below

1.	Location	Vegetable Research Complex, Department of Horticulture, JNKVV, Jabalpur (M.P.)
2.	Crop	Garlic (*Allium sativum L*.)
3	Season	*Rabi (2020*)
4	Experimental Design	factorial randomized block design
5.	Number of replications	03
6.	Number of treatments	09
7.	Number of plots	27
8.	Spacing	15 cm x 10 cm
9.	Distance between replication	1 m
10.	Plot size	2 ×1.95 m
11	Gross experiment area	180.55 m^2
12	Net experiment area	105.3 m^2
13.	Number of plants per plot	260
14.	Distance between plot	0.5 m
15.	Seed rate	500-600 kg /ha
16.	Variety	G- 50

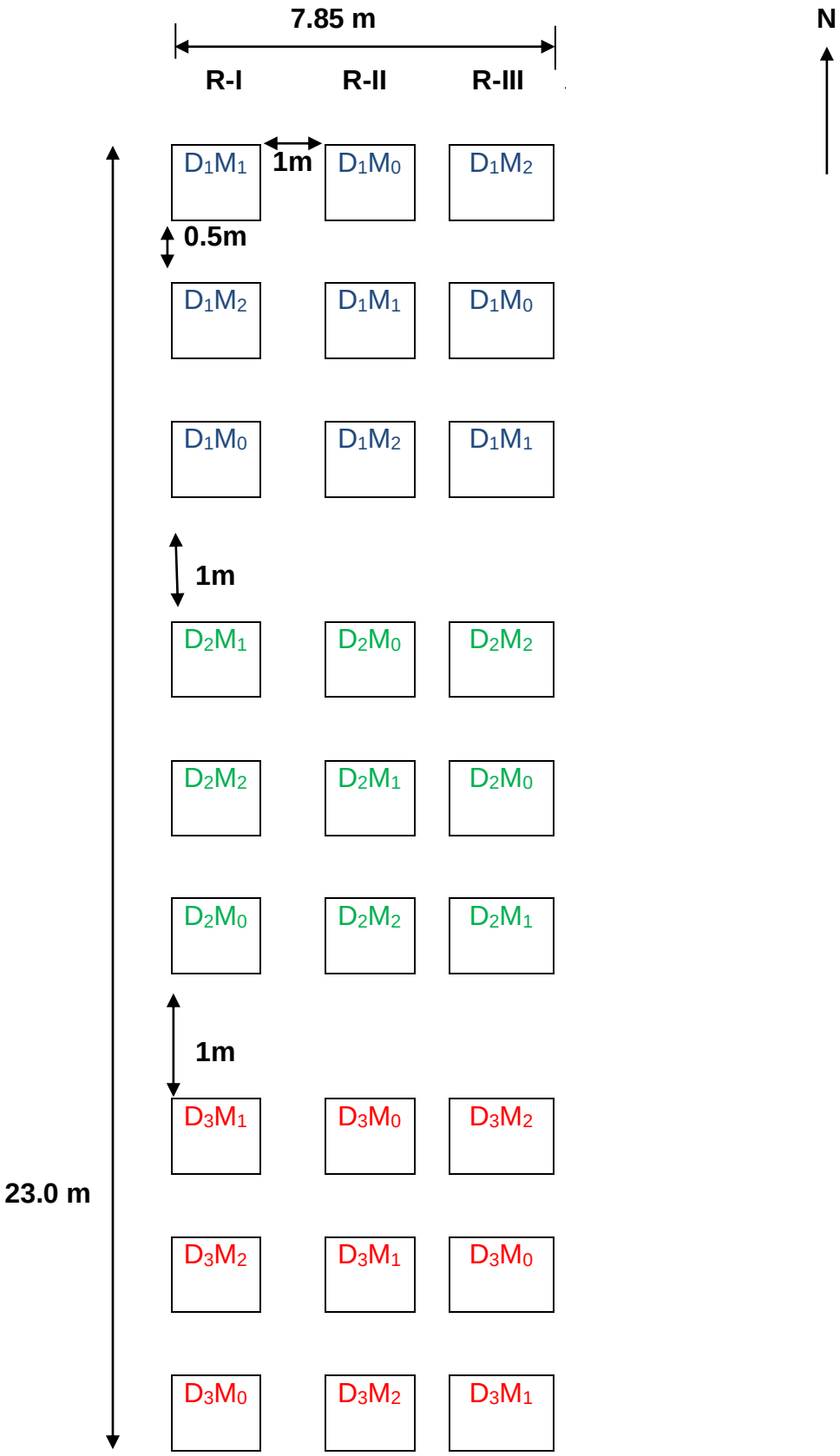

Fig. 3.2 LAYOUT OF FIELD

3.3 Details of Treatment:

The standard cultural practices to raise the crop will be adopted as per the recommendations of package of practices for vegetable crops.

(a) Treatment (main)– Date of sowing (15-day interval)

D_1 - 15 November

D_2 - 1 December

D_3 - 16 December

(b) Treatment - Mulching material

M_0 - No mulch

M_1 - Paddy straw

M_2 - Plastic mulch

The experimental material comprised date of sowing with different mulch the treatment combinations were as follow:

T_1	$D_1 M_1$	15 November + Paddy straw
T_2	D_1M_2	15 November + Plastic mulch
T_3	D_1M_0	15 November + No mulch
T_4	D_2M_1	1 December + Paddy straw
T_5	D_2M_2	1 December + Plastic mulch
T_6	D_2M_0	1 December + No mulch
T_7	D_3M_1	16 December + Paddy straw
T_8	D_3M_2	16 December + Plastic mulch
T_9	D_3M_0	16 December + No mulch

3.4 Cultural Operations:

3.4.1 Field preparation:

The field preparation was made by two ploughing with disc harrow and pulverized than after leveling properly was made by use of heavy wooden planker by tractor. Each plot was prepared according to the layout plan.

3.4.2 Application of manure, fertilizers and treatments:

A basal dose of 100 kg N 50 kg P_2O_5 and 50 kg K_2O per ha along with 20 t FYM per ha was applied. The fertilizer, applied through SSP, urea and murate of potash. Nitrogen was incorporated in three split, 1/3 part of planting time and remaining dose of 2/3 nitrogen as per treatment was applied in two equal split at 30 days and 45 days after planting with irrigation.

3.4.3 Variety:

The variety used in these experiments was G-50, which is good in demand mainly due to yield and good keeping quality. G-50 variety is suitable for Bundelkhand region.

3.4.4 Seed rate:

The seed rate was 500-600 kg/ha. After sowing cloves were covered with thin layer of soil for its proper germination.

3.4.5 Mulching:

Transparent plastic mulch sheets of bed size with small circular holes as per the spacing were spread. Paddy straw mulch (6 cm width) was also one of the mulch materials used and then these mulch materials were spread properly on the beds as per the layout of the experiment.

3.4.6 Planting:

Pre-planting seed treatment was done with Thairam @ 3.0 g per kg seed to control fungal infection. The sowing was done in rows at 15 x10 cm, cloves of healthy bulbs 8-10 mm in diameter were dibbled 5 - 7.5 cm deep

keeping their growing ends upward, on 15 November, 1 December and 16 December during year 2019. A week after planting gap filling was done.

3.4.7 Irrigation:

The first irrigation was given immediately after planting to ensure proper germination. Subsequent irrigation was given at 15-day interval up to month of January and the interval was reduced to 10 days from the month of February.

3.4.8 Weeding and plant protection:

Three hand weeding were done to check the weed in control plots at 20,40,70 days after sowing. The crop was sprayed with Trizophos (1.5 ml/li. water) twice to keep the crop free from pests during growth period.

3.4.9 Harvesting:

Harvesting was done manually by hand digger when the top turn yellowish or brown colour and shown signs of drying up and bend over (neck fall stage). The harvested bulb with tops were weighed and subjected to other observations.

3.5 Observations recorded:

Observations were recorded on the morphological, yield attribute and chemical properties of bulb of garlic.

3.5.1 Sampling technique:

Five plants were randomly selected from each plot and tagged for recording observations on various characters.

3.5.2 Morphological parameters

A. Plant height (cm):

Five plant were randomly selected and tagged in each plot. The plant height was measured from ground level to the tip of the longest leaf at 30,60 and 90 DAP . The meter scale was used to measure the height. The average was worked out and expressed as plant height in cm. Finally, treatment mean was computed by average over the treatments.

B. Number of leaves per plant:

The leaves from five selected plant from each plot were counted at 30,60 and 90 DAP. The average was computed and expressed as number of leaves per plant.

C. Length of leaves (cm):

The leaves from five randomly selected plants from each plot were length was measured at 30,60 and 90 DAP. The average was computed and expressed as length of leaves per plant.

D. Leaf width (cm):

It was measured by taking five leaves from each of five randomly taken plants then average.

E. Length of pseudostem (cm)

Length of pseudostem of selected and tagged plants was measured from the ground level to first emerged green leaf.

F. Diameter of pseudostem (cm)

Diameter of pseudostem of tagged plants was measured with the help Vernier callipers in centimeter, it was measured at 30,60 and 90 DAP.

3.5.3 Yield parameters:

With respect to yield and its components and bulb properties sample were taken at harvest to record the following characteristics : -

A. Fresh weight of bulb (g):

Five plants were randomly selected from each plot and weighted to determine the average weight.

B. Number of cloves per bulb:

The average number of cloves per bulb was calculated on the basis of total number of cloves obtained from bulbs chosen at random.

C. Average weight of 10 cloves (g):

The average weight of cloves determined by taken 10 cloves of a bulb and note weight of that cloves.

D. Yield per plot (kg):

he bulb of each plot was dug separately and then weighed.

E. Total yield (q/ha):

After harvest of the crop the bulbs were thoroughly cured for 15 days and per plot and per ha quintal yield were calculated. Plot yields were recorded and same was converted into quintals per hectare.

3.5.4 Quality parameters:

A. TSS (ºBrix):

TSS content of the garlic bulb measured by using hand refract meter.

3.6 Economics:

The economics of treatment is the most important consideration for making any recommendation to the farmer for its adoption. Economic analysis was done with a view to find out the cost and benefit ratio for different treatment under the study.

3.6.1 Cost of cultivation

The prices of the inputs cost like land preparation, planting material fertilizers and manures and plant protection was recorded against each treatment and the labour cost prevailed at the time of their uses was taken into consideration. The cost of cultivation was calculated and expressed in rupees per ha.

3.6.2 Gross income

The gross income was worked out based on the prevailing market price (rupees per kg) for the bulb yield and expressed in rupees per ha.

3.6.3 Net income

The net income per hectare was calculated by subtracting the cost of cultivation from the gross income and expressed in rupees per ha.

3.6.4 Benefit - Cost ratio

The benefit cost ratio was worked out by using the following.

$$\text{Benefit: Cost ratio (B:C)} = \frac{\text{Net returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

3.7 Statistical analysis:

All the data obtained with regard to the growth yield and yield attributing were analyzed statistical using the analysis of variance of fisher (1958) and Fisher and Yates, 1963. The data have been presented in the form of summery tables with mean values of the characters and the CD at 5% level of probability. The significant differences between different treatments were judge by using critical differences (C.D.) which was calculated as follow:

The table 3.4 For analysis of variance (ANOVA) will be calculated as follows

Source of variations	Degree of freedom	Sum of squares	Mean sum of squares	F. Cal.	F.tab. 5%
Replications	(r-1)	S_r	$S_{r/}(r-1)$	M_r/M_e	
Treatments	(t-1)	S_t	$S_{t/}(t-1)$	M_t/M_e	
Planting dates	(a-1)	S_a	$S_{a/}(a-1)$	M_a/M_e	
Mulching material	(b-1)	$S_{\mathbf{b}}$	$S_{\mathbf{b/}}(b-1)$	M_b/M_e	
Planting dates× Mulching material interaction	(a-1) (b-1)	S_{ab}	$S_{ab/}(a-1)$ (b-1)	M_{ab}/M_e	
Error	(t-1) (r-1)	S_{tr}	$S_{tr/}(t-1)$ (r-1)	M_{tr}/M_e	
Total	(tr-1) S(tr-1)	$S_{(tr-1)}$			

Where,

r = Number of replications

t = Number of treatments

a = Planting dates

b = Mulching materials

standard error of mean SE (m) and critical difference (CD) for comparing the means of any two treatments were calculated as below:

$$SE\ (m) = \pm\ (Me/r)\ ½$$

$$SE\ (d) = \pm\ (2Me/r)\ ½$$

Critical Difference (CD) = SE (d) × t (5%) value at error degrees of freedom.

The calculated ‘F’ values were compared with the tabulated ‘F’ values at 5 % level of significance. If the calculated ‘F’ value was higher than the tabulated, it was considered to be significant.

RESULTS

The present experiment was carried out to explore the possibilities of the "**Effect of planting date and mulching on growth, yield and quality parameters of garlic (*Allium sativum* L.)"**.

Data were statistically analyzed as per factorial randomized block design and the "ANOVA" table are given in Appendix I. The findings of different characters as influenced by various treatments are presented in foregoing pages.

Growth parameters

Plant height

The data presented in Table: 4.1 and Figure: 3 revealed that planting date and mulching and their interaction had showed significant effect on plant height at all the stages of crop growth viz., 30, 60 and 90 DAP.

Maximum plant height was noted (31.26, 43.09, 63.09 cm) under date of planting 15 November (D_1) at 30,60 and 90 DAP respectively, and it was found significantly superior over other date of planting, the minimum plant height of (20.86, 40.13 60.49 cm) were noted under date of planting 16 December (D_3) at 30,60 and 90 DAP respectively.

Plastic mulch (M_2) recorded maximum plant height of 28.04, 44.73 and 64.73 cm at 30,60 and 90 DAP respectively which was significantly superior over other mulches. The minimum plant height of 24.38, 48.46 and 58.50 cm was recorded at 30,60 and 90 DAP with no mulch (M_0).

Interaction was found to be significant of planting date with mulch where, maximum plant height (34.48, 47.76, 67.76 cm) was noted under interaction of 15 November where, garlic was shown with plastic mulch treatment. Whereas, the minimum plant height (22.38, 40.99, 60.99 cm) was at 30,60 and 90 DAP respectively.

Table 4.1 Plant height as affected by planting date and mulching

Planting date	**30 DAP**	**60 DAP**	**90 DAP**
D_1 (15 November)	31.26	43.09	63.09
D_2 (1 December)	26.42	42.90	62.90
D_3 (16 December)	20.99	40.13	60.17
SE(m)±	0.22	0.38	0.54
C.D. at 5% level	0.68	1.17	1.64
Mulching			
M_1 (Paddy straw)	26.25	42.93	62.93
M_2 (Plastic mulch)	28.04	44.73	64.73
M_0 (no mulch)	24.38	38.46	58.50
SE(m)±	0.22	0.39	0.54
C.D. at 5% level	0.68	1.18	1.63
Interaction			
D_1M_1	30.77	44.58	64.58
D_1M_2	34.48	47.76	67.76
D_1M_0	28.54	36.93	56.93
D_2M_1	26.84	42.78	62.79
D_2M_2	27.27	45.44	65.44
D_2M_0	25.15	40.47	60.48
D_3M_1	21.15	41.42	61.42
D_3M_2	22.38	40.99	60.99
D_3M_0	19.45	37.99	58.10
S E(m)±	0.39	0.68	0.93
CD at 5%	1.18	2.04	2.83

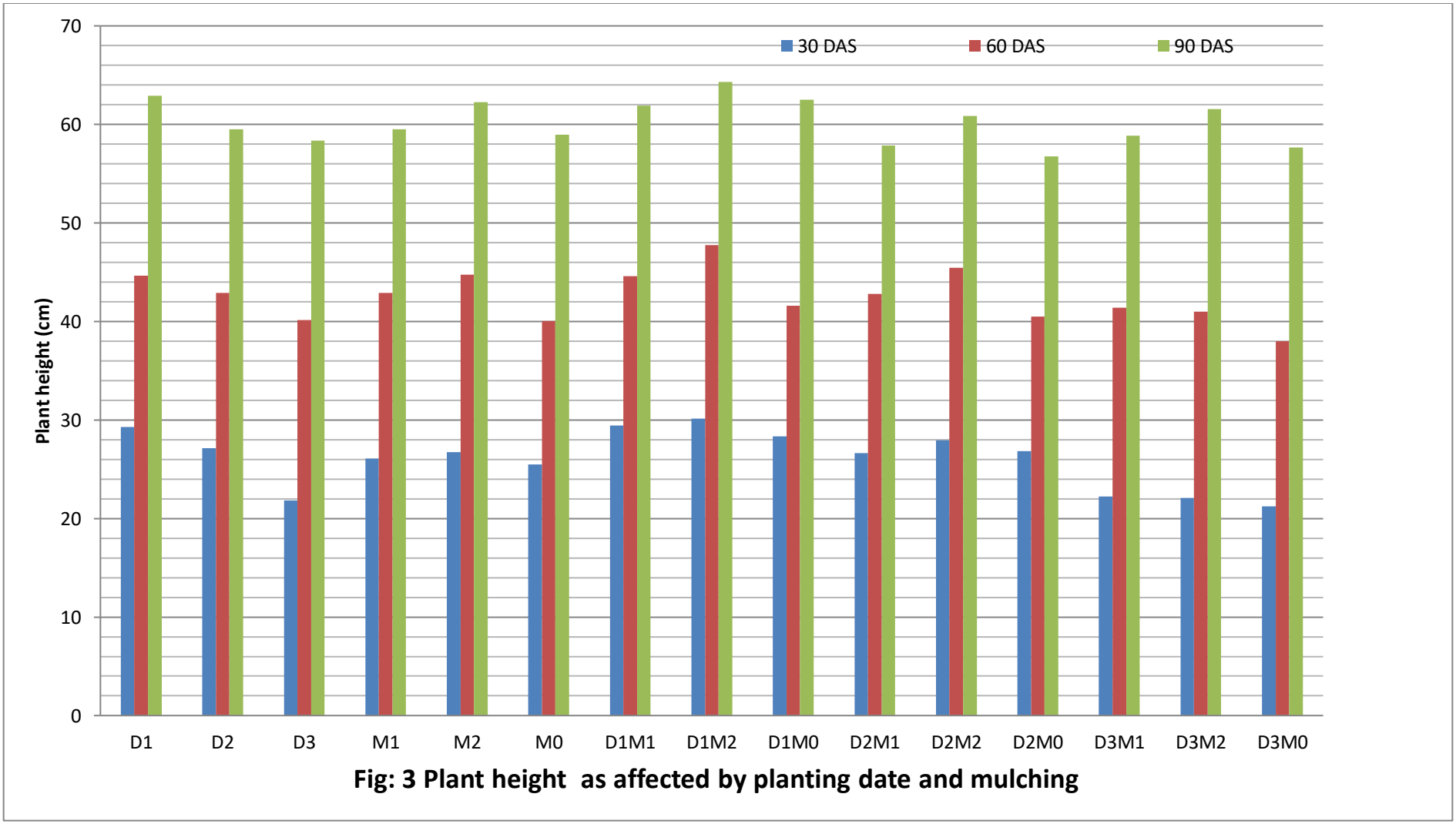

Fig: 3 Plant height as affected by planting date and mulching

Number of leaves per plant

Number of leaves per plant were recorded maximum (4.2, 7.2 , 8.9) under date of planting 15 November (D_1) at 30, 60 and 90 DAP respectively which was significantly superior over other date of planting.

Table:4.2 Number of leaves per plant as affected by planting date and mulching

Planting date	**30 DAP**	**60 DAP**	**90 DAP**
D_1 (15 November)	4.27	7.27	8.90
D_2 (1 December)	4.19	7.21	8.53
D_3 (16 December)	3.64	6.98	8.70
SE(m)±	0.04	0.08	0.04
C.D. at 5% level	0.12	NA	0.14
Mulching			
M_1 (Paddy straw)	3.70	6.84	8.03
M_2 (Plastic mulch)	4.65	7.75	9.72
M_0 (no mulch)	3.64	6.76	8.37
SE(m)±	0.04	0.07	0.05
C.D. at 5% level	0.12	0.21	0.13
Interaction			
D_1M_1	2.97	5.97	8.01
D_1M_2	5.16	8.19	9.50
D_1M_0	4.26	7.54	9.00
D_2M_1	4.09	7.18	8.00
D_2M_2	4.77	7.67	9.50
D_2M_0	3.71	6.80	8.10
D_3M_1	4.22	7.57	8.90
D_3M_2	4.02	7.41	9.08
D_3M_0	2.80	5.52	7.24
S E(m)±	0.07	0.12	0.08
CD at 5%	0.20	0.38	0.25

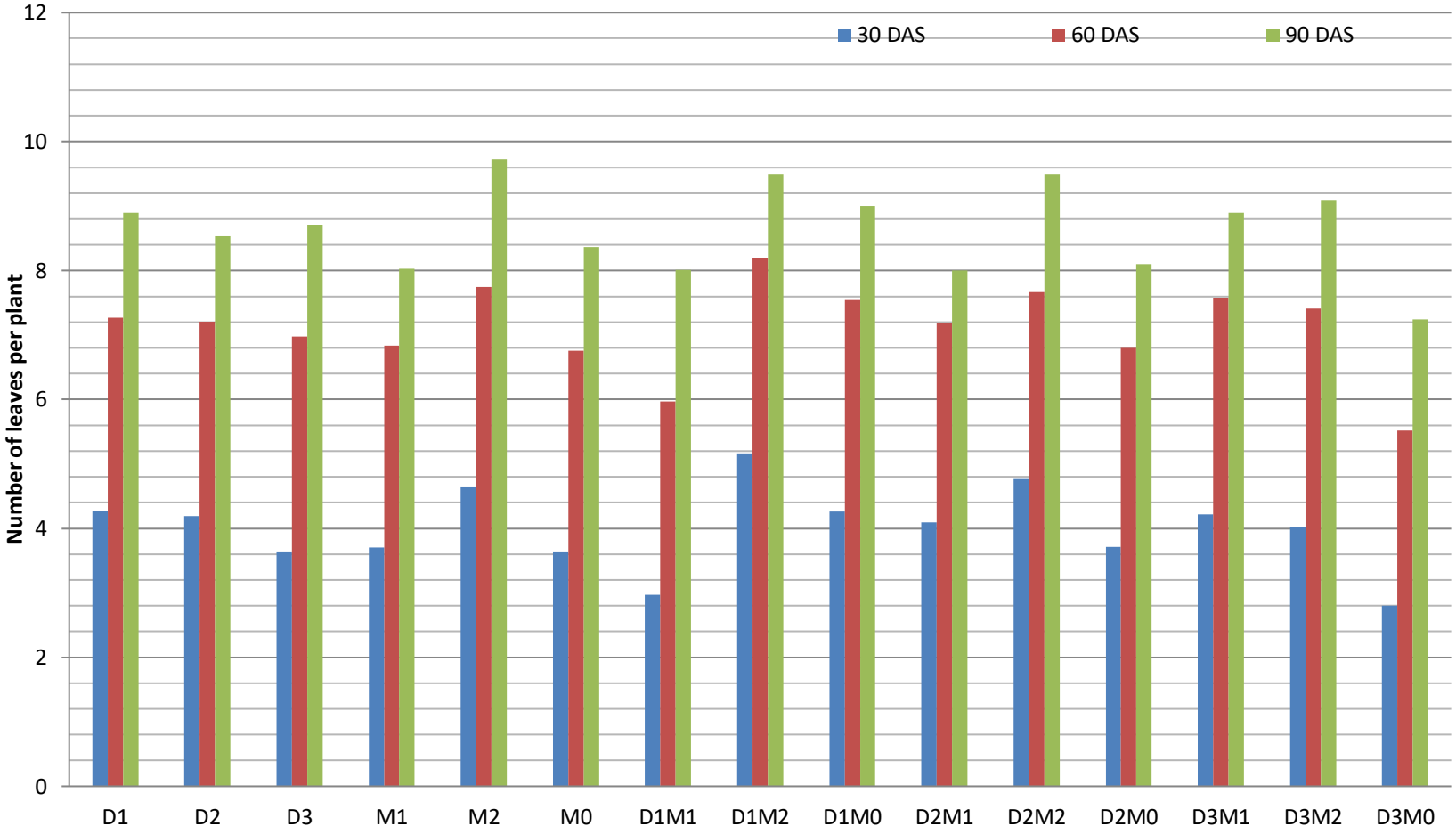

Fig: 4 Number of leaves per plant as affected by planting date and mulching

Minimum number of leaves (3.6, 6.9, 8.7) were recorded under 16 December planting (D_3) at 30, 60 and 90 DAP respectively.

Plastic mulch recorded maximum number of leaves (4.6, 7.7, 9.7) which was significantly superior over other mulching at 30,60 and 90 DAP respectively. Minimum number of leaves (3.6, 6.7 , 8.3) observed in no mulch at 30, 60 and 90 DAP respectively.

The interaction of planting date and mulching had showed significant influenced on number of leaves per plant at 30,60 and 90 DAP. Date of planting 15 November along plastic mulch (D_1M_2) recorded maximum number of leaves (4.6, 7.7 , 9.7) minimum number of leaves (2.8, 5.5 , 7.2) was recorded under 16 December planting without no mulch (D_3M_0).

Length of leaves

The data presented in table: 4.3 and figure: 5 revealed that maximum length of leaves (23.89, 35.52, 47.77 cm) at 30, 60 and 90 DAP respectively were observed under date of planting 15 November which was significantly superior over other date of planting date. Minimum length of leaves (21.78, 31.11, 42.93 cm) were noted under planting date of 16 December (D_3) at 30, 60 and 90 DAP respectively.

Plastic mulch (M_2) recorded maximum length of leaves (23.94, 34.98 46.85 cm) at 30,60 and 90 DAP respectively which was found to be significantly superior over other mulches. Minimum length of leaves (21.81, 32.14,43.49 cm) were observed under no mulch (M_0) at 30 ,60 and 90 DAP respectively.

The interaction effect of planting date and mulching showed significant effect on length of leaves at all the stages. Planting date of 15 November and plastic mulch recorded maximum length of leaves (23.9, 34.98, 46.85 cm) at 30, 60 and 90 DAP respectively which was followed by $D_2M_2 > D_2M_1 > D_1M_1 > D_1M_0 > D_3M_1 > D_3M_0 > D_2M_0$ at 30,60 and 90 DAP. Minimum length of leaves was recorded under planting date of 16 December and no mulch (D_3M_0) treatment at 30,60 and 90 DAP respectively. The treatment (D_1M_2) was found superiorly over rest of the treatments.

Table: 4.3 Length of leaves as affected by planting date and mulching

Planting date	30 DAP	60 DAP	90 DAP
D_1 (15 November)	23.89	35.52	47.77
D_2 (1 December)	22.71	34.54	44.37
D_3 (16 December)	21.78	31.11	42.93
SE(m)±	0.17	0.34	0.37
C.D. at 5% level	0.52	1.02	1.10
Mulching			
M_1 (Paddy straw)	22.63	34.05	44.56
M_2 (Plastic mulch)	23.94	34.98	46.85
M_0 (no mulch)	21.81	32.14	43.49
SE(m)±	0.17	0.34	0.37
C.D. at 5% level	0.52	1.02	1.10
Interaction			
D_1M_1	22.87	35.84	47.71
D_1M_2	26.37	37.00	48.78
D_1M_0	22.45	33.74	46.29
D_2M_1	22.95	34.58	44.39
D_2M_2	23.54	36.00	45.93
D_2M_0	21.66	33.06	42.81
D_3M_1	22.09	31.73	41.59
D_3M_2	21.94	31.96	45.87
D_3M_0	21.33	29.63	41.36
S E(m)±	0.30	0.59	0.63
CD at 5%	0.90	NS	NS

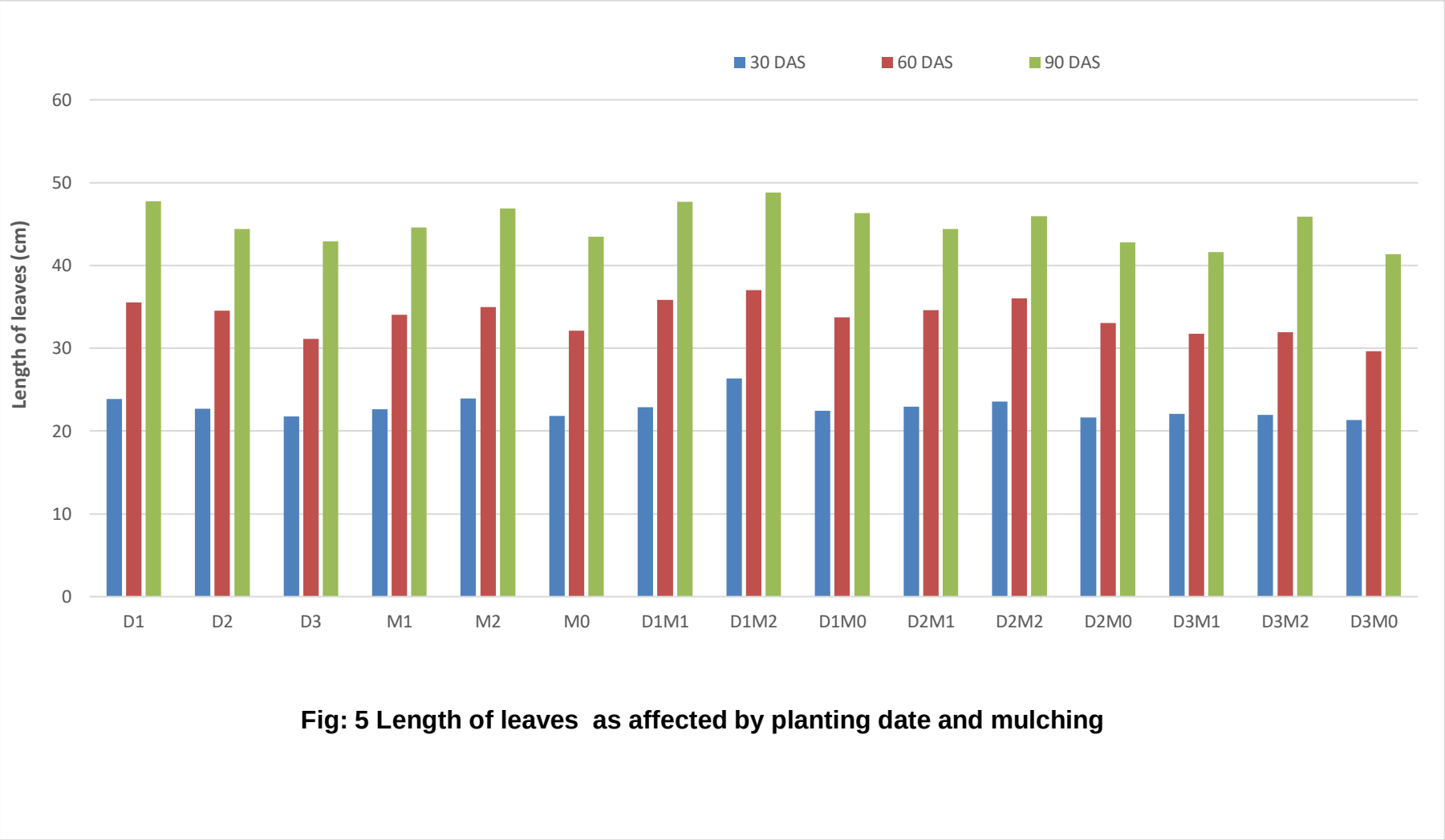

Fig: 5 Length of leaves as affected by planting date and mulching

Width of Leaf

Planting date and mulching table: 4.4 and figure: 6 significantly affected the width of leaves. Maximum width of (0.80,1.47 , 1.89 cm) at 30, 60 and 90 DAP respectively were noted under planting date (D_1) which was found significantly superior over other date of planting and minimum width of leaves (0.68,1.30 1.70 cm) were noted planting date 16 December at 30,60 and 90 DAP respectively.

Plastic mulch (M_2) recorded maximum width of leaves (0.76,1.42 ,) 1.85 cm) at 30, 60 and 90 DAP respectively and minimum width of leaves (0.73,1.38,1.74 cm) were noted under no mulch (M_0) at 30, 60 and 90 DAS respectively.

The interaction of planting date and mulching had showed significant effect on width of leaves of (0.81, 1.49 , 1.76 cm) was noted under planting date of 15 November and plastic mulch (D_1M_2) at 30, 60 and 90 DAP which was followed by D_1M_2 > D_1M_1 > D_1M_0 > D_2M_2 > D_2M_1 > D_2M_0 > D_3M_1. Minimum width of leaves was recorded under D_3M_0 treatment (0.67, 1.28 1.69 cm) at 30,60 and 90 DAP.

Table: 4.4 Width of leaf as affected by planting date and mulching

Planting date	**30 DAP**	**60 DAP**	**90 DAP**
D_1 (15 November)	0.80	1.47	1.89
D_2 (1 December)	0.75	1.39	1.79
D_3 (16 December)	0.68	1.30	1.70
SE(m)±	0.006	0.011	0.014
C.D. at 5% level	0.018	0.034	0.041
Mulching			
M_1 (Paddy straw)	0.74	1.36	1.80
M_2 (Plastic mulch)	0.76	1.42	1.85
M_0 (no mulch)	0.73	1.38	1.74
SE(m)±	0.006	0.011	0.014
C.D. at 5% level	0.018	0.034	0.041
Interaction			
D_1M_1	0.80	1.43	1.89
D_1M_2	0.81	1.49	1.76
D_1M_0	0.79	1.50	1.72
D_2M_1	0.76	1.37	1.77
D_2M_2	0.77	1.46	1.81
D_2M_0	0.74	1.36	1.74
D_3M_1	0.69	1.29	1.72
D_3M_2	0.71	1.32	1.70
D_3M_0	0.67	1.28	1.69
S E(m)±	0.010	0.019	0.024
CD at 5%	0.018	0.059	0.072

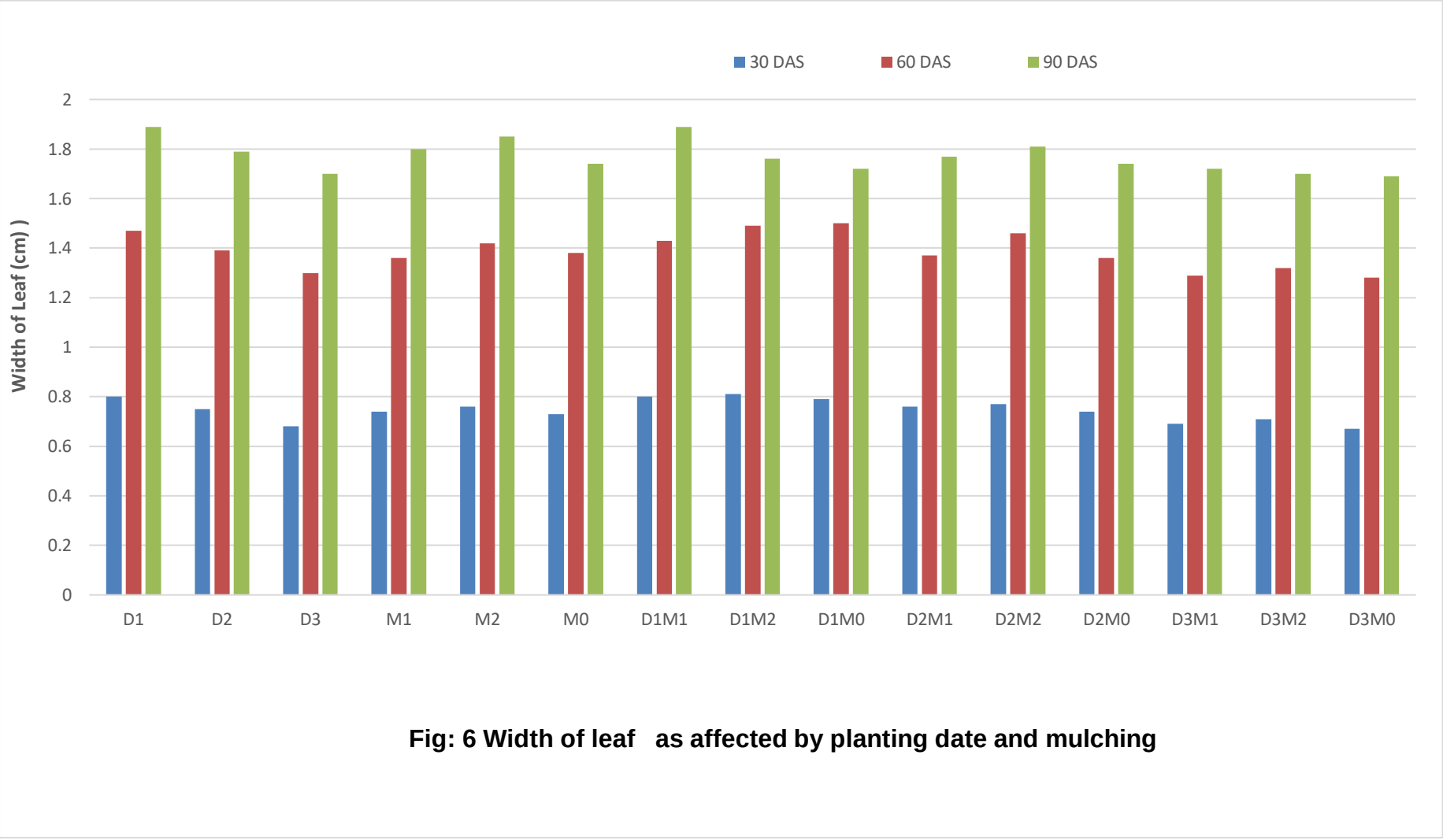

Fig: 6 Width of leaf as affected by planting date and mulching

Length of pseudostem

Planting date and mulching table: 4.5 and figure: 7 significantly affected the pseudostem length (cm). Maximum length of pseudo stem (2.13, 3.31, 4.25 cm) at 30, 60 and 90 DAP respectively were noted under planting date (D_1) which was found significantly superior over other date of planting and minimum length of pseudostem (1.98, 3.01,4.06 cm) were noted planting date (D_3) at 30, 60 and 90 DAP respectively.

Plastic mulch (M_2) recorded maximum length of pseudostem (2.14, 3.28 4.36 cm) at 30,60 and 90 DAP respectively and minimum length of pseudostem (1.98, 3.15 4.21 cm) were noted under no mulch (M_0) at 30, 60 and 90 DAP respectively.

The interaction of planting date and mulching had showed significant effect on pseudostem length of (2.24, 3.30, 4.53 cm) was noted under planting date of 15 November and plastic mulch (D_1M_2) at 30,60 and 90 DAP which was followed by D_1M_2 > D_1M_1> D_1M_0> D_2M_2> D_2M_1> D_2M_0>D_3M_1. Minimum length of pseudostem was recorded under D_3M_0 treatment (1.95, 2.85, 3.89 cm) at 30,60 and 90 DAP.

Table: 4.5 Length of pseudostem as affected by planting date and mulching

Planting date	**30 DAS**	**60 DAS**	**90 DAS**
D_1 (15 November)	2.13	3.31	4.25
D_2 (1 December)	2.10	3.22	4.45
D_3 (16 December)	1.98	3.01	4.06
SE(m)±	0.02	0.02	0.02
C.D. at 5% level	0.08	0.07	0.06
Mulching			
M_1 (Paddy straw)	2.08	3.11	4.18
M_2 (Plastic mulch)	2.14	3.28	4.36
M_0 (no mulch)	1.98	3.15	4.21
SE(m)±	0.02	0.02	0.02
C.D. at 5% level	0.07	0.08	0.06
Interaction			
D_1M_1	2.18	3.41	3.87
D_1M_2	2.24	3.30	4.53
D_1M_0	1.99	3.23	4.35
D_2M_1	2.11	2.87	4.52
D_2M_2	2.19	3.46	4.40
D_2M_0	2.01	3.35	4.42
D_3M_1	1.98	3.09	4.15
D_3M_2	2.01	3.08	4.16
D_3M_0	1.95	2.85	3.89
S E(m)±	0.04	0.04	0.02
CD at 5%	NS	0.12	0.06

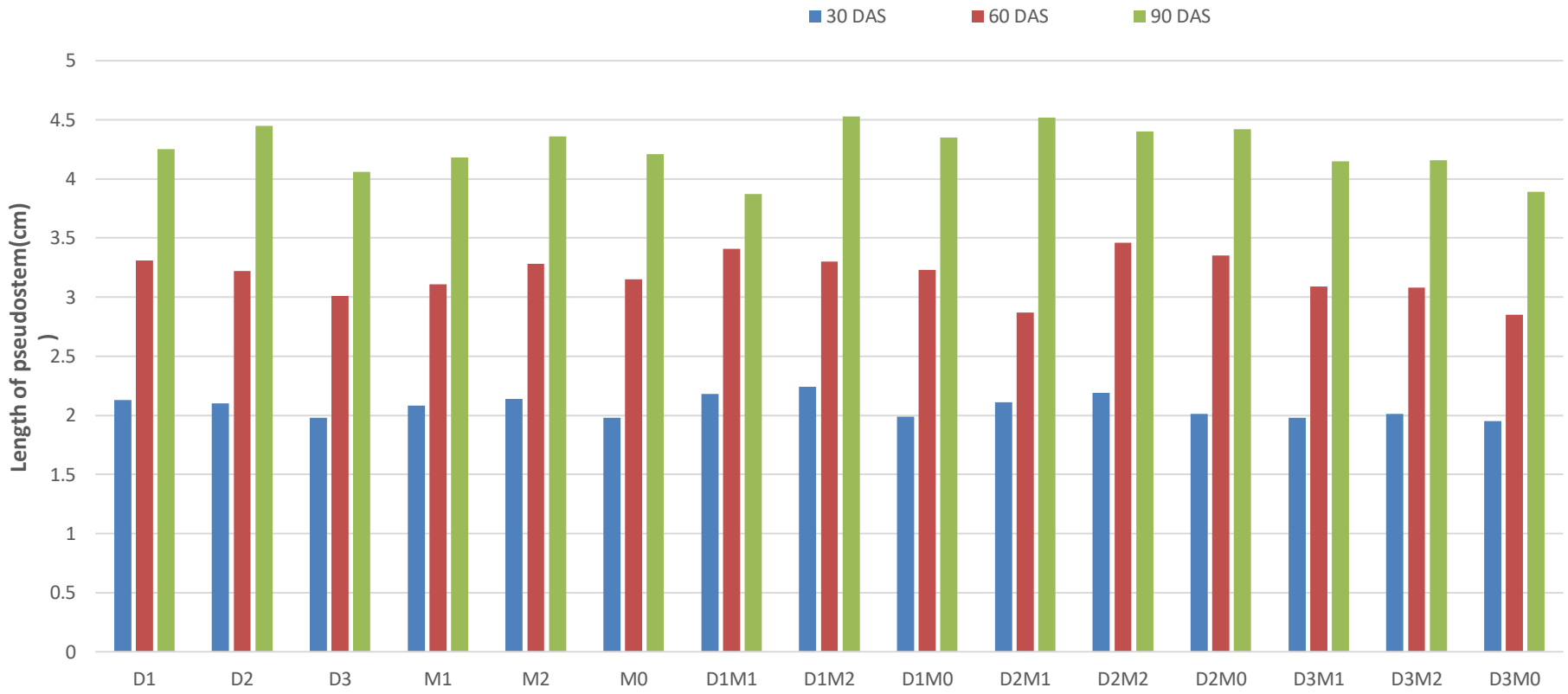

Fig:7 Length of pseudostem as affected by planting date and mulching

Diameter of pseudostem

Planting date and mulching table: 4.6 and figure: 8 significantly affected the diameter of pseudosstem (cm). Maximum diameter of pseudostem (0.51, 0.60, 0.82 cm) at 30, 60 and 90 DAP respectively were noted under planting date (D_1) which was found significantly superior over other date of planting and minimum diameter of pseudostem (0.44, 0.56, 0.74 cm) were noted planting date (D_3) at 30, 60 and 90 DAP respectively.

Plastic mulch (M_2) recorded maximum diameter of pseudostem (0.50, 0.62 , 0.78 cm) at 30, 60 and 90 DAP respectively and minimum diameter of pseudostem (0.46, 0.57 , 0.75 cm) were noted under no mulch (M_0) at 30, 60 and 90 DAP and respectively.

The interaction of planting date and mulching had showed significant effect on diameter of pseudostem of (0.58, 0.66 , 0.80 cm) was noted under planting date of 15 November along with plastic mulch (D_1M_2) at 30, 60 and 90 DAP which was followed by D_1M_2 > D_1M_1> D_1M_0> D_2M_2> D_2M_1> D_2M_0>D_3M_1. Minimum diameter of pseudostem was recorded under D_3M_0 treatment (0.40, 0.52 , 0.73 cm) at 30,60 and 90 DAP.

Table:4.6 Diameter of pseudostem as affected by planting date and mulching

Planting date	**30 DAS**	**60 DAS**	**90 DAS**
D_1 (15 November)	0.51	0.60	0.82
D_2 (1 December)	0.50	0.60	0.79
D_3 (16 December)	0.44	0.56	0.74
SE(m)±	0.004	0.006	0.008
C.D. at 5% level	0.012	0.019	0.011
Mulching			
M_1 (Paddy straw)	0.48	0.56	0.79
M_2 (Plastic mulch)	0.50	0.62	0.78
M_0 (no mulch)	0.46	0.57	0.75
SE(m)±	0.004	0.006	0.008
C.D. at 5% level	0.012	0.019	0.023
Interaction			
D_1M_1	0.45	0.54	0.81
D_1M_2	0.58	0.66	0.8
D_1M_0	0.47	0.60	0.78
D_2M_1	0.35	0.58	0.83
D_2M_2	0.51	0.63	0.80
D_2M_0	0.49	0.59	0.76
D_3M_1	0.50	0.58	0.74
D_3M_2	0.43	0.59	0.75
D_3M_0	0.40	0.52	0.73
S E(m)±	0.007	0.011	0.008
CD at 5%	0.022	0.033	0.023

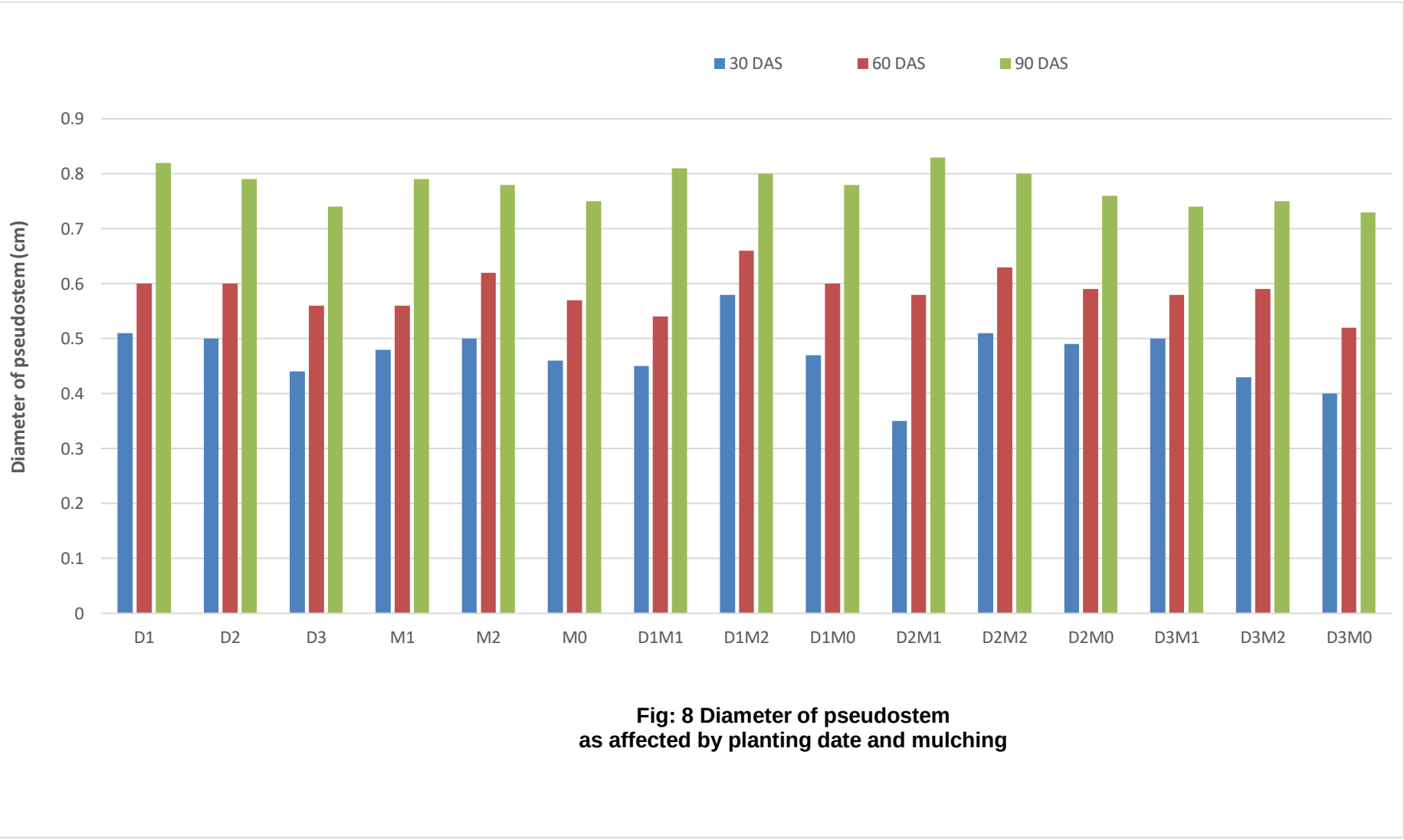

Fig: 8 Diameter of pseudostem as affected by planting date and mulching

Yield parameters

Fresh weight of bulb

Table: 4.7 Fresh weight of bulb as affected by planting date and mulching

Mulch / Date	Paddy straw	Plastic mulch	No mulch	Mean date
15 November	26.71	29.40	24.13	26.00
1 December	19.72	24.15	19.13	21.24
16 December	14.10	15.26	13.71	14.00
Mean mulch	20.17	22.93	18.99	
Factors	CDat 5%	SE(d)±	SE(m)±	
Planting date	0.696	0.325	0.230	
Mulch	0.696	0.325	0.230	
Planting date × mulch	1.205	0.563	0.398	

Maximum bulb weight (26.0 g) was noted under date of planting 15 November (D_1) which was followed by the treatment (D_2) 21.24 g whereas, lowest fresh weight of bulb (14.0 g) was noted under 16 December (D_3) planting date.

Plastic mulch (M_2) exhibited maximum bulb weight (22.93 g) followed by paddy straw (M_2) 20.17 g and minimum fresh weight of bulb (18.99 g) was noted under no mulch (M_0).

There was significant difference in fresh weight of bulb due to the interaction of planting date and mulching. The heaviest bulb (29.40 g) was recorded in treatment (D_1M_2) which was followed by D_1M_1 >D_2M_2 >D_1M_0> D_2M_1 >D_1M_0 >D_3M_2 >D_3M_1 and lowest bulb weight (13.71 g) was recorded in D_3M_0 treatment.

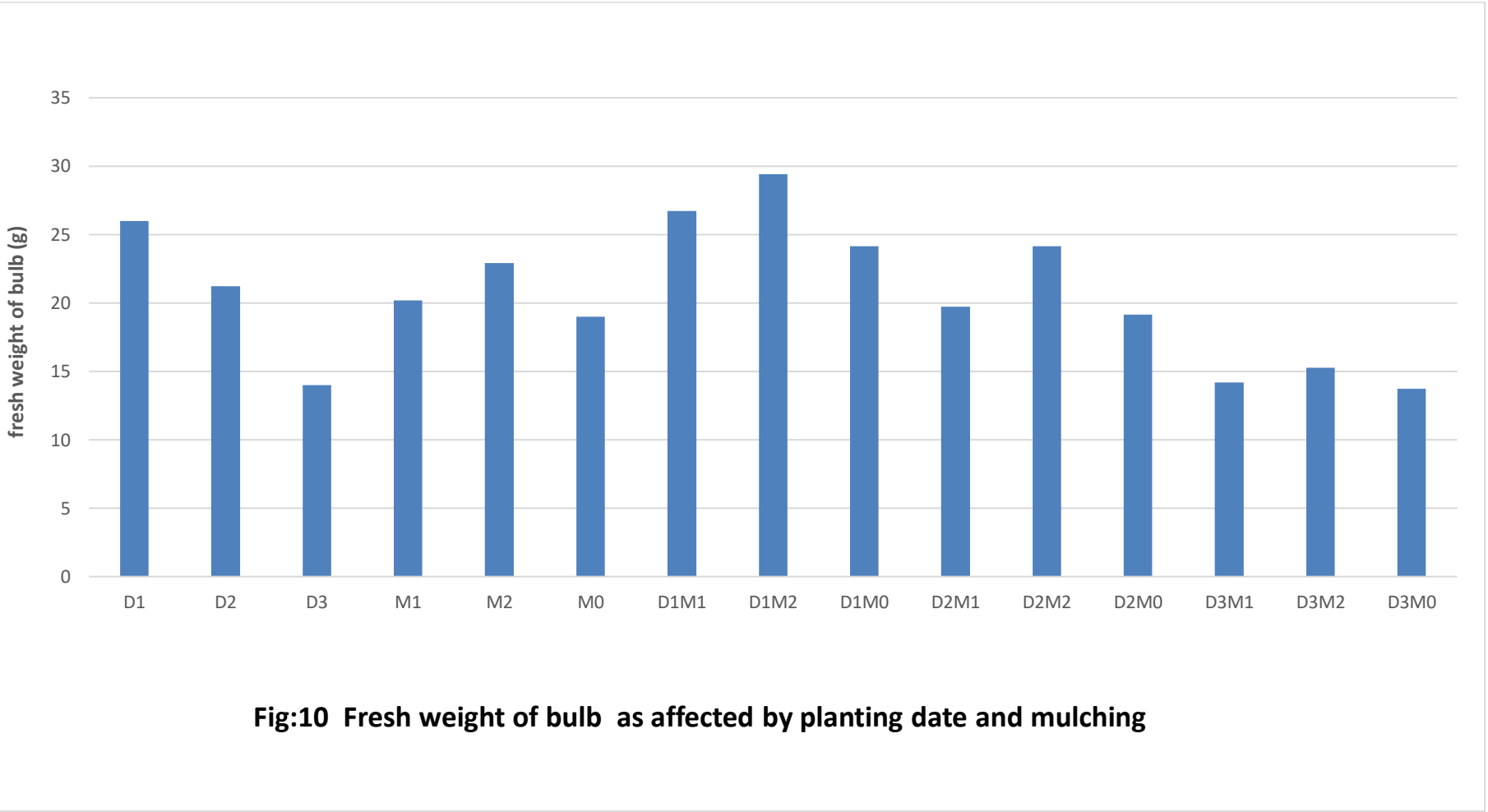

Fig:10 Fresh weight of bulb as affected by planting date and mulching

Number of cloves per bulb

The maximum number of cloves per bulb (18.42) were recorded with planting date of (D_1) (20.49) which was followed by (D_2) (17.22) whereas, minimum number of cloves (15.13) were noted under planting date of ($D_{3)}$.

Plastic mulch (M_2) recorded maximum number of cloves (18.66) as compared to paddy straw (M_1) (18.24) whereas minimum number of cloves (16.10) were noted under no mulch (M_0).

The interaction of planting date and mulches had not showed any significant effect on number of cloves per bulb**.** However maximum number of cloves was recorded under treatment (21.67) ($D_1M_{2)}$.

Table: 4.8 Number of cloves per bulb as affected by planting date and mulching

Mulch / Date	Paddy straw	Plastic mulch	No mulch	Mean date
15 November	20.67	21.67	18.88	20.49
1 December	18.11	18.41	15.59	17.22
16 December	16.21	16.04	13.83	15.13
Mean mulch	18.24	18.66	16.10	
Factors	CD at 5%	SE(d)±	SE(m)±	
Planting date	0.67	0.31	0.22	
Mulch	0.66	0.31	0.22	
Planting date ×mulch	NS	0.54	0.39	

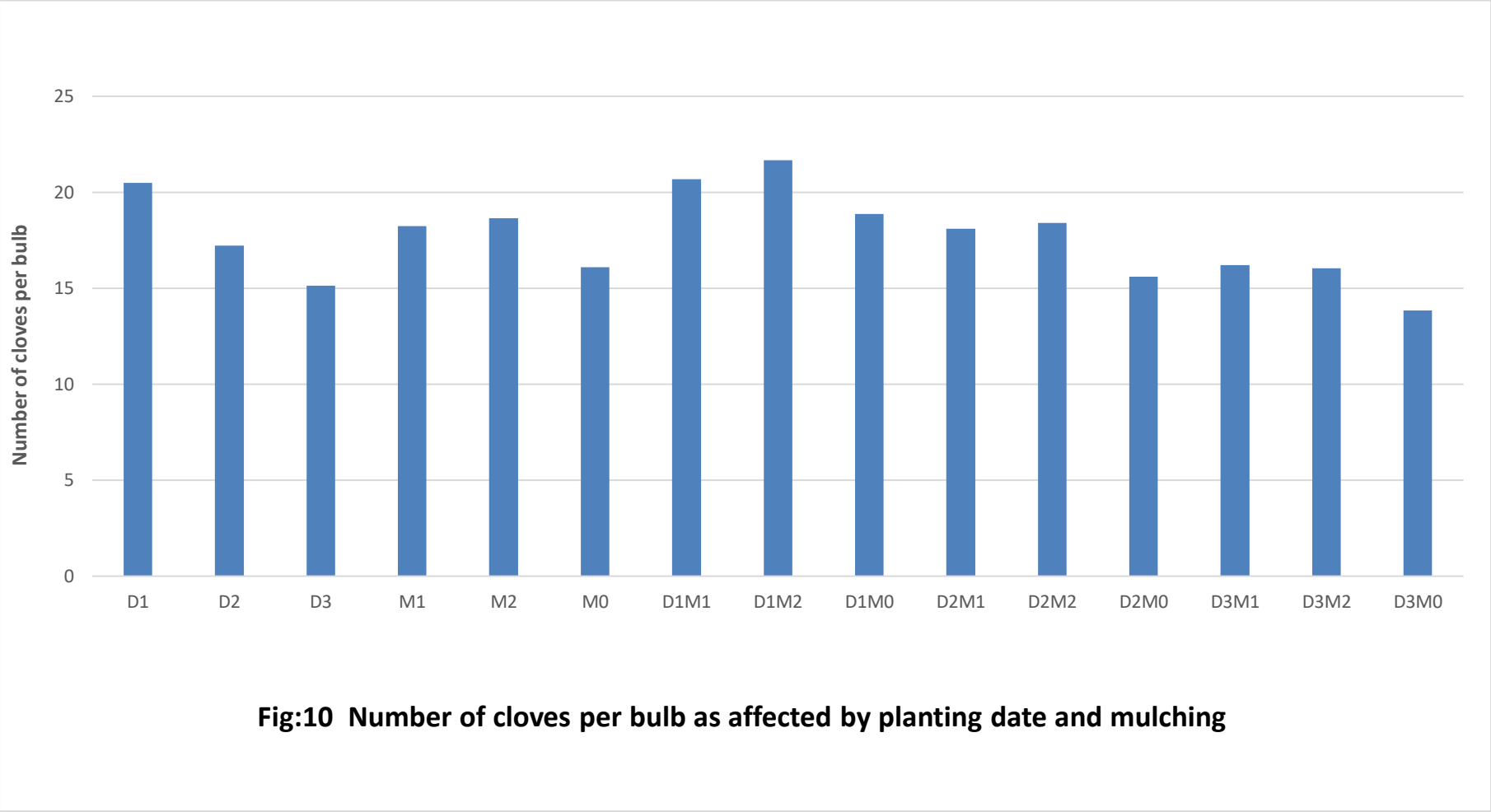

Fig:10 Number of cloves per bulb as affected by planting date and mulching

Average weight of 10 cloves

Data on weight of 10 cloves were recorded and presented in table: 4.9 and figure 11 revealed that weight of cloves was significantly influenced by the planting date and mulching.

Maximum weight (6.4 g) were found under planting date of 15 November (D_1) which was followed by 1 December (D_2) (5.5 g) while minimum weight (4.6 g) was recorded with the planting date of 16 December (D_3).

Plastic mulching (M_2) recorded maximum weight of cloves (6.2 g) followed by M_1, (5.7 g) whereas, minimum weight (4.5 g) was recorded with M_0.

There was significant difference in weight of cloves due to the interaction of planting date and mulching. Maximum weight of cloves (7.17 g) was recorded in treatment D_1M_2, which was followed by D_1M_1 >D_2M_2 >D_2M_1 > D_1M_0 >D_3M_2 >D_3M_1 >D_2M_0 and minimum weight was recorded (3.3 g) was recorded in treatment D_3M_0 where planting date 16 December with no mulch.

Table: 4.9 Average weight of 10 cloves as affected by planting date and mulching

Mulch / Date	Paddy straw	Plastic mulch	No mulch	Mean date
15 November	6.54	7.17	5.48	6.40
1 December	5.60	6.10	4.70	5.50
16 December	5.10	5.40	3.30	4.60
Mean mulch	5.70	6.20	4.50	
Factors	CD at 5%	SE(d)±	SE(m)±	
Planting date	0.20	0.10	0.06	
Mulch	0.19	0.09	0.06	
Planting date × mulch	0.31	0.15	0.10	

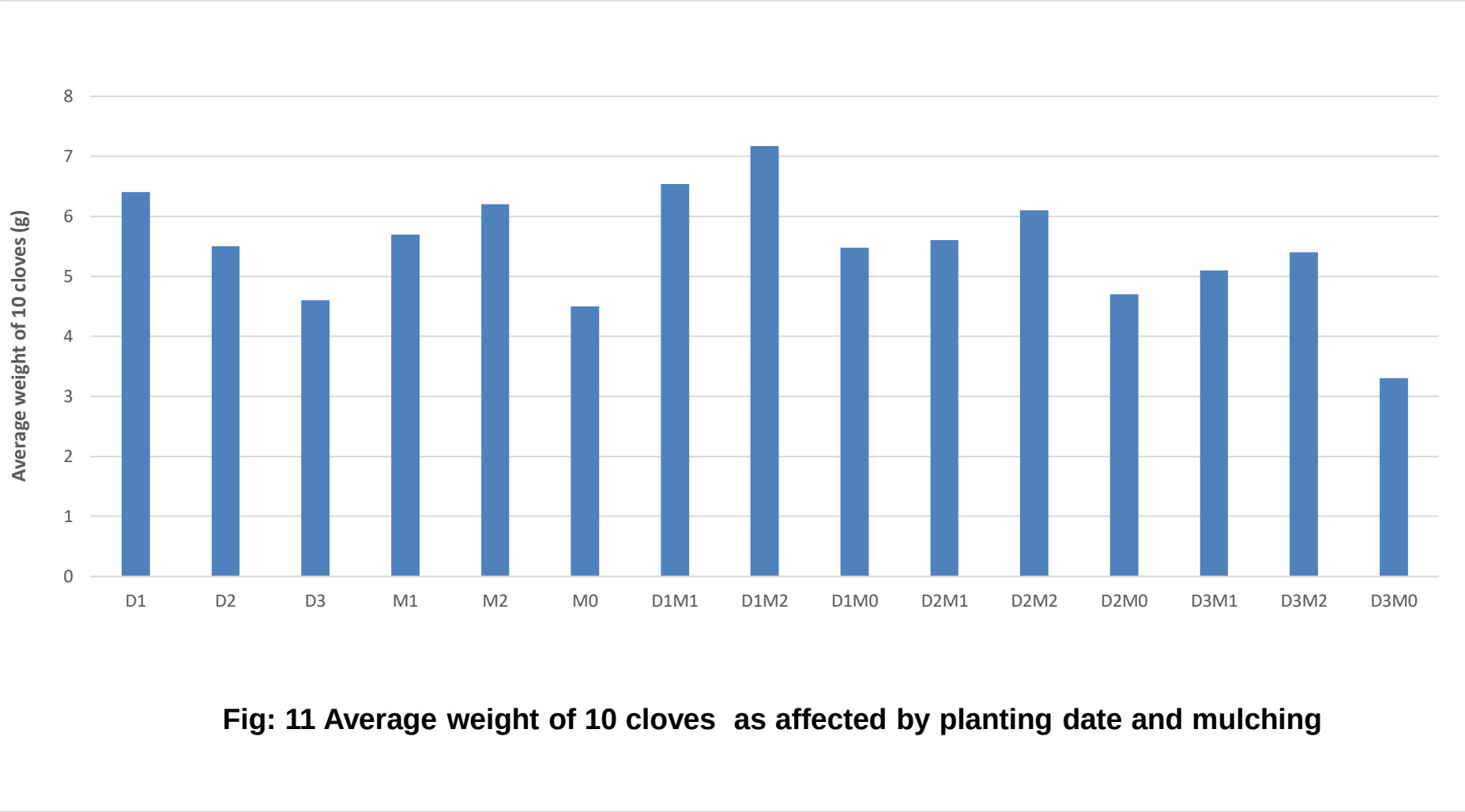

Fig: 11 Average weight of 10 cloves as affected by planting date and mulching

Yield per plot

The data presented in table: 4.10 and figure: 12 showed significant effect of planting date and mulching on yield per plot. The maximum yield per plot (3.57 kg) was recorded with the planting date 15 November (D_1) whereas minimum bulb yield per plot (2.99 kg) was recorded with planting date 16 December (D_3).

Plastic mulch (M_2) recorded maximum yield per plot (3.11 kg) and minimum yield per plot (2.87 kg) was recorded under no mulch (M_0).

Significant difference was observed in bulb yield per plot due to the interaction of planting date and mulching. The treatment D_1M_2 was found quite effective and recorded maximum bulb yield per plot (4.08 kg) which was followed by D_2M_1 >D_1M_0 >D_2M_0 >D_1M_1 >D_2M_2 >D_3M_1 >D_2M_2 whereas, minimum per plot bulb yield was recorded under treatment D_3M_0 (2.87 kg).

Table: 4.10 Yield per plot as affected by planting date and mulching

Mulch / Date	Paddy straw	Plastic mulch	No mulch	Mean date
15 November	3.19	4.08	3.44	3.57
1 December	3.50	3.11	3.25	3.13
16 December	3.00	2.95	2.87	2.99
Mean mulch	3.23	3.38	3.25	
Factors	CD at 5%	SE(d)±	SE(m)±	
Planting date	0.13	0.07	0.05	
Mulch	0.14	0.07	0.05	
Planting date × mulch	0.23	0.11	0.08	

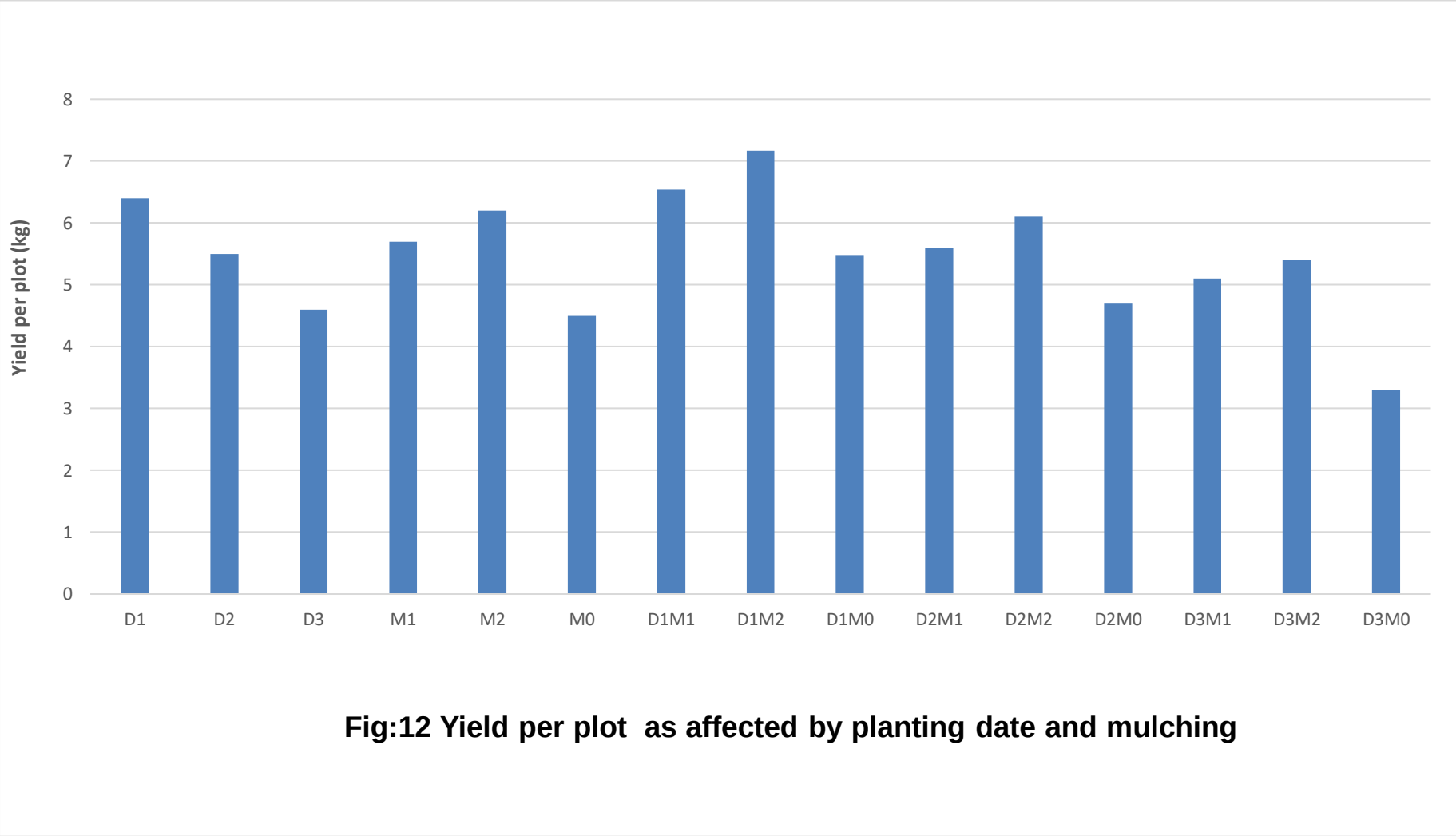

Fig:12 Yield per plot as affected by planting date and mulching

Total bulb yield

The data presented in table 4.11 had showed significant difference in total yield per hectare are under planting date and mulching.

Maximum yield (74.81 q/ha) was noted under planting date 15 November (D_1). which was followed by D_2, (68.79 q/ha) while lowest yield (64.50 q/ha) was noted under (D_3) 16 December.

Table: 4.11 Total Bulb yield as affected by planting date and mulching

Mulch / Date	Paddy straw	Plastic mulch	No mulch	Mean date
15November	70.26	89.55	62.64	74.81
1 December	65.57	80.81	60.54	68.79
16 December	62.90	75.76	55.83	64.50
Mean mulch	66.24	82.04	59.33	
Factors	CD at 5%	SE(d)±	SE(m)±	
Planting date	1.669	0.781	0.552	
mulch	1.665	0.781	0.552	
Planting date×mulch	2.891	1.352	0.956	

Bulb yield was recorded maximum (82.04 q/ha) in M_2 where plastic mulch was used, it was followed by M_2 (66.24 q/ha) whereas, minimum total yield per hectare (59.33 q/ha) was noted under no mulch (M_0).

The interaction effect of planting date and mulching had exerted significant effect on total yield per hectare. Planting date 15 November along with plastic mulch (D_1M_2) recorded maximum yield (89.55 q/ha) which was followed by D_2M_2 >D_3M_2 >D_1M_1 >D_2M_1 >D_3M_1 >D_1M_0 >D_2M_0 and minimum yield per hectare (55.83 q/ha) was noted under planting date of 16 December and no mulch (D_3M_0).

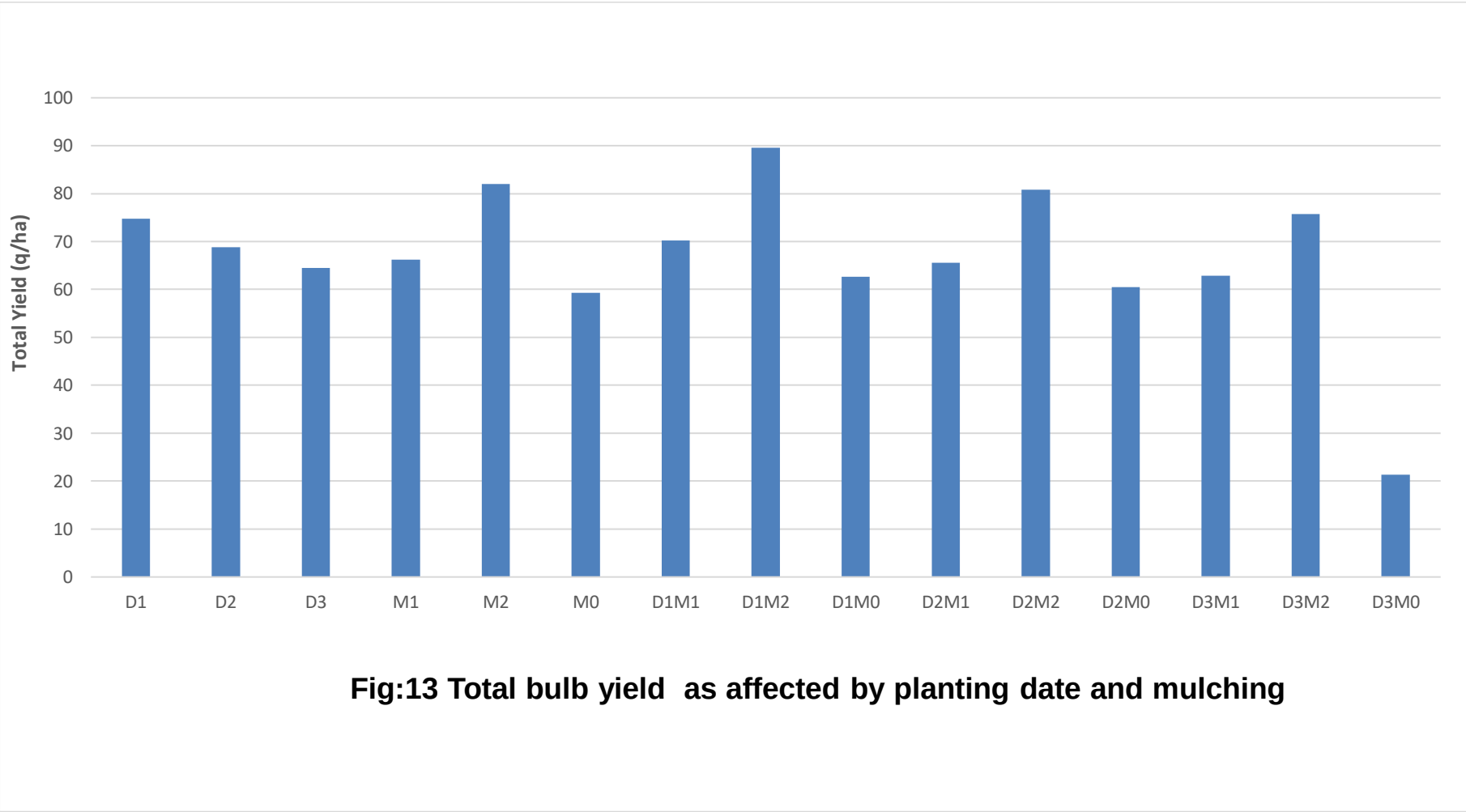

Fig:13 Total bulb yield as affected by planting date and mulching

Quality parameters

Total soluble solids

The effect of planting date and mulching treatment on TSS (ºBrix) had showed significant effect. The data presented in table 4.12 and graphically depicted in fig. 14

Table: 4.12 Effect of planting date and mulching on Total soluble solids (ºBrix)

Mulch / Date	Paddy straw	Plastic mulch	No mulch	Mean date
15 November	38.68	39.06	37.86	38.54
1 December	38.06	38.54	37.36	37.99
16 December	37.61	38.12	36.88	37.54
Mean mulch	38.12	38.57	37.37	
Factors	CD at 5%	SE(d)±	SE(m)±	
Planting date	0.716	0.335	0.237	
Mulch	0.716	0.335	0.237	
Planting date × mulch	NS	0.580	0.410	

The data presented in table 16 showed that the maximum TSS(38.54 ºBrix) was recorded with the date of planting 15 November (D_1) which was found significantly superior over rest of the treatments, whereas minimum TSS (37.54 **º**Brix) was recorded with the planting date of 16 December.

The effects of mulching on TSS (**º**Brix) was observed maximum (38.57 **º**Brix) which was found significantly superior over rest of the mulches and minimum TSS (37.37 ºBrix) was noted under no mulch (M_0).

The interaction of planting date and mulching had not showed any significantly effect on TSS (**º**Brix). However, Maximum TSS (39.06 ºBrix) was recorded in treatment (D_1M_2) which was found superior over rest treatments and minimum TSS (36.37 **º**Brix) was recorded under 16 December with no mulch (D_3M_0) treatment.

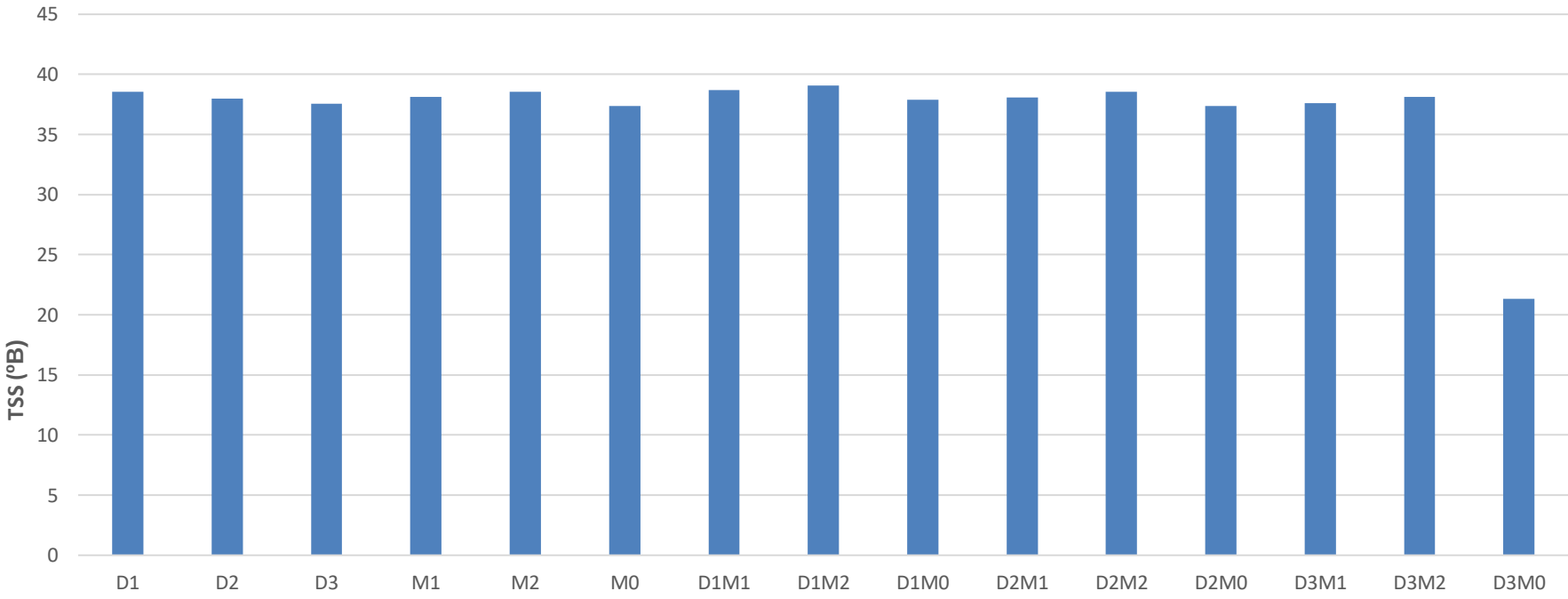

Fig:14 Total soluble solids as affected by planting date and mulching

Table :4.13 Economics of different treatments

Tr. No.	Treatments	Cost of cultivation (Rs/ha)	Gross monetary return (Rs/ha)	Net monetary return (Rs/ha)	B:C Ratio
Factors					
D_1	15 November	131100	259525	128425	1.97
D_2	1 December	131100	240765	109665	1.83
D_3	16 December	131100	226905	95805	1.73
M_1	Paddy straw	101100	231840	130740	2.29
M_2	Plastic mulch	101100	287140	186040	2.84
M_0	No mulch	131100	208215	77115	1.58
Treatments					
T_1	**15 November + Paddy straw**	117600	252910	135310	2.10
T_2	**15 November + Plastic mulch**	136800	313425	135425	2.29
T_3	**15 November + No mulch**	131100	219240	112940	1.67
T_4	**1 December + Paddy straw**	117600	229495	111895	1.95
T_5	**1 December +Plastic mulch**	136800	282835	146035	2.06
T_6	**1 December + No mulch**	131100	210000	78900	1.60
T_7	**16 December + Paddy straw**	117600	220150	102550	1.87
T_8	**16 December + Plastic mulch**	136800	265195	128395	1.93
T_9	**16 December + No mulch**	131100	195405	64305	1.49

Cost of cultivation

The cost of cultivation of garlic per hectare varied under different treatments. Economics of treatments are presented in table 4.13. The minimum cost of cultivation was incurred in T_1,T_4,T_7 and it was increased in rest of the treatments with the Paddy straw mulch and plastic mulch respectively.

Gross monetary return

Gross monetary return (GMR) varied due to different treatments. It was minimum Rs. 195405 in crop receiving 16 December + no mulch (T_9).

It was maximum under 15 November + plastic mulch Rs. 313425 (T_2) followed by 16 December + plastic mulch Rs. 265195 (T_8).

Net monetary return

The net monetary return (NMR) also varied due to different treatments. Among the different treatments 1 December + no mulch (T_6) fetched the lowest Rs.78900 NMR whereas, the maximum NMR was found 15 November + plastic mulch (T_2) amounting to Rs.135425 followed by (T_1) Rs.135310.

Benefit cost ratio

It is the ratio of profit (GMR) over each rupee of investment (cost) and also expressed as profitability. Among the different treatments the lowest profit (1.49) per rupee of investment was obtained due to treatment T_9 minimum. The highest profit of (2.29) rupees per rupee of investment was obtained with T_2 followed by T_1 (2.10), T_5 (2.06) and T_8 (1.93).

Common expenditure

Includes expenditure of operations performed equally in all the treatments.

Total expenditure

It includes cost of the treatments. Rate of treatments were paddy straw mulch 16500 Rs/ha and plastic mulch 35700 Rs/ha.

Gross monetary return (GMR)

garlic were sold @ Rs 3500/q

GMR = Yield (q/ha) x 35

DISCUSSION

5.1 Growth parameter

The morphological growth observation recorded periodically have exhibited interesting variations due to different treatments. The plant height (cm) follows particular trend under successive growth stage i.e. from 30 days to 90 days stage. The number of leaves per plant, width of leaf and length of leaves also followed the same pattern as plant height.

The plant height in general was enhanced up to 60 DAP, thereafter, it was very slow in last stage. In general, leaf formation increased remarkably up to 90 DAP and become more than double in number, and then a decline in leaf count was noticed beyond 100 days stage, which may be on account of leaf senescence. The expression of growth characters is generally controlled and affected by environmental factors i.e. temperature, humidity and nutrient status of the soil and their effective utilization by plants.

The significant effect of planting date along with mulching was obtained in case of plant height(cm), number of leaves per plant, length of leaves(cm) width of leaf (cm), length of pseudostem (cm) and diameter of pseudostm (cm) at every stage.

Planting date of 15 November and plastic mulch encouraged the plant foliage and boosted plant growth parameters at every growth stage. Date of planting 15 November along with plastic mulch being at par with planting date of 1December along with paddy straw mulch in general resulted in significantly tallest plants height, leaves per plant, longest and widest leaf consequently.

This might be due to the fact that, an early planted garlic crop might have produced more photosynthetically active area, which ultimately resulted its efficiency to utilize more solar radiation and which might have increased the dry matter production. The results of the present investigation are in line with the findings of Stahlschmidt *et al*. (1997), Sonkamble *et a*l. (2000) and Rahman *et al*. (2004) in garlic crop.

The response to date of sowing in terms of overall improvement in growth parameters is further supported by the fact that the climate of the experimental region favours the crop growth. The rise in temperature during the growth period of late planting garlic increases the rate of respiration which resulting in more utilization of carbohydrates and other products of photosynthesis. Due to this, the lesser quantity of assimilates is available for translocation from source to sink during the bulbing period by the finding of Das *et al*. (1985).

Considerably differences in the growth characters and productivity parameters were observed due to variation in mulching.

The result reported in previous chapter have clearly indicated that performance of garlic crop inconsiderably affected by mulching when plant height (cm), number of leaves per plant, length of leaves(cm), width of leaf (cm), length of pseudostem (cm) and diameter of pseudostem (cm), were at their maximum.

The magnitude of superiority of plastic mulch over its paddy straw mulch in respect of these growth-parameters under reference was significant. In case of plant height in plastic mulch recorded significantly tallest plant as compared to paddy straw mulch, these finding conformity by Amil *et al*. (2005) evaluated, the effects of different type of mulches (plastic, straw and sawdust, excluding control) on the growth and yield of garlic were observed in a field experiment. Straw and plastic mulches increased the bulb yield and yield components and the same result also reported by Vavrina and Roka (2000) compared production of short-day onion plastic mulch versus bare ground. The results showed that plastic mulch provided yield enhancement from increased weight and bulb size.

5.2 Yield parameters

The factors, which are directly responsible for ultimate bulb production viz., fresh weight of bulb (g), number of cloves per bulb, average weight of 10 cloves (g), yield per plot (kg), total bulb yield (q/ha), were significantly affected by different treatments. The number cloves per bulb,

and cloves weight per bulb are also responsible for the yield of bulb per hectare.

Planting date 15 November + plastic mulch (T_2) was found significantly superior over other treatments and gave maximum yield 89.55 q/ ha followed by 1 December + paddy straw mulch (T_1) 80.55 q/ha. The similar result was found by Sultana *et al*. (1997) and Islam *et al.* (1998). Earliest planting gave the highest bulb weight which might be due to plant received cool temperature for longer period which possibly increased the vegetative growth and yield of bulb. Bhatal and Thakur (1986) also reported higher bulb yield of garlic under 15 October planting situation. Similar results have been reported by Das *et al.* (1985) and Singh and Phogat (1989). Delay in planting laid to early bulbing, early harvest and considerably fewer cloves per bulb with less bulb weight, there by resulting in lower total yield.

5.3 Economics

The maximum benefit cost ratio (2.29) was obtained by the treatment of 15 November planting date and plastic mulch. The lowest benefit cost ratio (1.49) was found with the treatment of 16 December planting date along with no mulch. These differences appear due to the respective yield levels and cost of production under different treatments.

5.4 Total Soluble Solid (ºBrix)

The maximum TSS 39.06 ºBrix was obtained by the treatment (D_1M_2). The minimum TSS 36.88 ºBrix (T_9) was recorded by the treatment (D_3M_0). These differences may be appeared due to the planting date and mulching. The similar finding by Gupta *et al*. (2003) registered that the garlic crop planted on 20 September had produced the cloves with the maximum TSS (ºBrix) as compared to other dates of planting.

SUMMARY, CONCLUSIONS & SUGGESTIONS FOR FURTHER WORK

6.1 SUMMARY

The present investigation "**Effect of planting date and mulching on growth, yield and quality parameters of garlic (*Allium sativum* L.)"** was taken up during *Rabi* season 2019-20 at the Vegetable Research Farm, Maharajpur, Department of Vegetable Science, JNKVV, Jabalpur (M.P). The nine treatment viz., D_1M_1-15 November + paddy straw, D_1M_2- 15 November + plastic mulch, D_1M_0- 15 November + no mulch, D_2M_1- 1 December + paddy straw, D_2M_2-1 December + plastic mulch, D_2M_0- 1 December + no mulch, D_3M_1-16 December + paddy straw, D_3M_2-16 December + plastic mulch, D_3M_0-16 December + no mulch were tested in factorial randomized block design with three replications the salient findings of the research work are summarized as below:

Growth parameters

In growth parameters the plant height (cm), number of leaves per plant, length of leaves (cm), width of leaf (cm), length of pseudostem (cm) and diameter of pseudostem (cm) were recorded significantly affected. Maximum plant height, number of leaves per plant, length of leaves, width of leaf, length of pseudostem and diameter of pseudostem was recorded maximum 15 November + plastic mulch (T_9) treatment.

Yield parameters

Various yield parameters were significantly affected by planting date and mulching.15 November + plastic mulch (T_2) was recorded Maximum yield 89.55 q/ha whereas, minimum yield 55.83 q/ha were observed under 16 December + no mulch (T_9).

Quality parameters

1. The combination of 15 November + plastic mulch (T_2) Significantly increased the total soluble solids of garlic.

Net return

A minimum net monetary return of Rs. 64305 per hectare was obtained when planting date 16 December along with no mulch was used and that net monetary return reached to its maximum amounting Rs. 135425 per hectare in plots where planting date 15 November along with plastic mulch (T_2) were used.

6.2 Conclusion

1. It is concluded that planting date 15 November would be beneficial to obtained higher values of yield as well as growth and quality parameters of garlic.

2. Plastic mulch found to be superior as it attain superior value of growth ,yield and quality attributing characteristics of garlic crop.

3. Sowing of garlic along with plastic mulch was found to be more productive.

6.3 Suggestion for further work

Based on the experience of present investigation, the following further studies are proposed

1. Since the conclusions are drawn on the basis of the results of one-year experimentation, the study may be repeated for at least 1-2 years more for confirmation of the findings.
2. The treatments need to be tested for other garlic varieties.

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APPENDICES- I

Growth parameter

Plant height 30 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**0.319**			
Factor (D)	**2**	**263.352**	**131.676**	**330.922**	**3.4**
Factor (M)	**2**	**7.088**	**3.544**	**8.907**	**3.4**
Factor(D)× (M)	**4**	**2.664**	**0.666**	**1.674**	**2.1**
Error	**16**	**6.367**	**0.398**		
Total	**26**	**279.791**			

Plant height 60 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**6.482**			
Factor (D)	**2**	**93.263**	**46.631**	**76.126**	**3.4**
Factor (m)	**2**	**101.292**	**50.646**	**82.679**	**3.4**
Factor(D)× (M)	**4**	**13.335**	**3.323**	**5.482**	**2.8**
Error	**16**	**9.801**	**0.613**		
Total	**26**	**224.173**			

Plant height 90 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**2.616**			
Factor (D)	**2**	**99.367**	**49.68**	**20.283**	**3.4**
Factor (M)	**2**	**55.194**	**27.597**	**11.266**	**3.4**
Factor(D)× (M)	**4**	**5.588**	**1.397**	**0.570**	**2.8**
Error	**16**	**39.193**	**2.450**		
Total	**26**	**201.504**			

Number of leaves per plant 30 D.AP

Source of Variations	Df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.213**			
Factor (D)	**2**	**1.001**	**0.501**	**36.455**	**3.4**
Factor (M)	**2**	**5.731**	**2.866**	**208.666**	**3.4**
Factor(D)× (M)	**4**	**7.193**	**1.798**	**130.947**	**2.8**
Error	**16**	**0.220**	**0.014**		
Total	**26**	**14.159**			

Number of leaves per plant 60 DAP

Source of Variations	df	S. S	M.S	F. Cal	F Tab 5%
Replication	2	**0.013**			
Factor (D)	**2**	**0.280**	**0.140**	**3.062**	**3.4**
Factor (M)	**2**	**5.455**	**2.727**	**59.701**	**3.4**
Factor(D)× (M)	**4**	**9.665**	**2.414**	**52.837**	**2.8**
Error	**16**	**0.731**	**0.046**		
Total	**26**	**16.134**			

Number of leaves per plant 90 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.03**			
Factor (D)	**2**	**0.611**	**0.305**	**17.198**	**3.4**
Factor (M)	**2**	**14.484**	**7.242**	**406.939**	**3.4**
Factor(D)× (M)	**4**	**8.838**	**2.097**	**117.815**	**2.8**
Error	**16**	**0.285**	**0.018**		
Total	**26**	**23.770**			

Length of leaves (cm) at 30 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**2.855**			
Factor (D)	**2**	**20.081**	**10.41**	**37.79**	**3.4**
Factor (M)	**2**	**20.841**	**10.420**	**39.219**	**3.4**
Factor(D)× (M)	**4**	**13.448**	**3.372**	**12.690**	**2.8**
Error	**16**	**4.291**	**0.276**		
Total	**26**	**61.515**			

Length of leaves (cm) at 60 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**0.154**			
Factor (D)	**2**	**96.882**	**48.441**	**47.021**	**3.4**
Factor (M)	**2**	**37.729**	**187.864**	**18.311**	**3.4**
Factor(D)× (M)	**4**	**1.430**	**0.397**	**0.347**	**2.8**
Error	**16**	**16.486**	**1.030**		
Total	**26**	**152.678**			

Length of leaves (cm) at 90 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**0.964**			
Factor (D)	**2**	**102.219**	**91.109**	**42.803**	**3.4**
Factor (M)	**2**	**53.327**	**26.163**	**22.303**	**3.4**
Factor(D)× (M)	**4**	**9.261**	**2.315**	**1.939**	**2.8**
Error	**16**	**19.305**	**1.194**		
Total	**26**	**184.874**			

Width of leaf (cm) at 30 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**0.01**			
Factor (D)	**2**	**0.556**	**0.028**	**88.528**	**3.4**
Factor (M)	**2**	**0.004**	**0.002**	**6.357**	**3.4**
Factor(D)× (M)	**4**	**0.0000**	**0.000**	**0.027**	**2.8**
Error	**16**	**0.005**	**0.000**		
Total	**26**	**0.067**			

Width of leaf (cm) at 60 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**0.006**			
Factor (D)	**2**	**0.139**	**0.069**	**61.840**	**3.4**
Factor (M)	**2**	**0.014**	**0.0027**	**6.173**	**3.4**
Factor(D)× (M)	**4**	**0.014**	**0.004**	**3.198**	**2.8**
Error	**16**	**0.018**	**0.001**		
Total	**26**	**0.191**			

Width of leaf (cm) at 90 DAP

Source of Variations	**df**	**S.S**	**M.S**	**F. Cal**	**F Tab 5%**
Replication	2	**0.226**			
Factor (D)	**2**	**0.730**	**0.365**	**3.353**	**3.4**
Factor (M)	**2**	**0.428**	**0.214**	**1.966**	**3.4**
Factor(D)× (M)	**4**	**0.277**	**0.069**	**0.635**	**2.8**
Error	**16**	**1.742**	**0.109**		
Total	**26**	**3.403**			

Length of pseudostem (cm)at 30 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.006**			
Factor (D)	**2**	**0.121**	**0.0161**	**12.017**	**3.4**
Factor (M)	**2**	**0.126**	**0.063**	**12.827**	**3.4**
Factor(D)× (M)	**4**	**0.0131**	**0.008**	**1.562**	**2.8**
Error	**16**	**0.079**	**0.005**		
Total	**26**	**0.364**			

Length of pseudostem (cm)at 60 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.001**			
Factor (D)	**2**	**0.429**	**0.214**	**40.472**	**3.4**
Factor (M)	**2**	**0.130**	**0.065**	**12.291**	**3.4**
Factor(D)× (M)	**4**	**0.643**	**0.161**	**30.362**	**2.8**
Error	**16**	**0.085**	**0.005**		
Total	**26**	**1.288**			

Length of pseudostem (cm)at 90 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.033**			
Factor (D)	**2**	**0.669**	**0.335**	**79.909**	**3.4**
Factor (M)	**2**	**0.154**	**0.077**	**18.383**	**3.4**
Factor(D)× (M)	**4**	**0.669**	**0.174**	**41.530**	**2.8**
Error	**16**	**0.067**	**0.004**		
Total	**26**	**1.619**			

Diameter of pseudostem (cm)at 30 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.001**			
Factor (D)	**2**	**0.026**	**0.013**	**86.192**	**3.4**
Factor (M)	**2**	**0.008**	**0.0004**	**26.120**	**3.4**
Factor(D)× (M)	**4**	**0.033**	**0.008**	**53.879**	**2.8**
Error	**16**	**0.002**	**0.000**		
Total	**26**	**0.071**			

Diameter of pseudo stem (cm)at 60 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.000**			
Factor (D)	**2**	**0.008**	**0.004**	**11.300**	**3.4**
Factor (M)	**2**	**0.021**	**0.010**	**28.793**	**3.4**
Factor(D)× (M)	**4**	**0.016**	**0.004**	**10.911**	**2.8**
Error	**16**	**0.006**	**0.000**		
Total	**26**	**0.050**			

Diameter of pseudostem (cm)at 90 DAP

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.000**			
Factor (D)	**2**	**0.030**	**0.015**	**28.400**	**3.4**
Factor (M)	**2**	**0.015**	**0.007**	**13.881**	**3.4**
Factor(D)× (M)	**4**	**0.009**	**0.002**	**4.031**	**2.8**
Error	**16**	**0.009**	**0.001**		
Total	**26**	**0.062**			

Fresh weight of bulb(g)

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.038**			
Factor (D)	**2**	**692.014**	**340.007**	**726.546**	**3.4**
Factor (M)	**2**	**73.730**	**36.865**	**77.409**	**3.4**
Factor(D)× (M)	**4**	**16.858**	**4.215**	**8.850**	**2.8**
Error	**16**	**7.620**	**0.476**		
Total	**26**	**790.259**			

Number of cloves per bulb

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.502**			
Factor (D)	**2**	**131.050**	**65.525**	**150.720**	**3.4**
Factor (M)	**2**	**32.454**	**16.227**	**37.325**	**3.4**
Factor(D)× (M)	**4**	**0.758**	**0.190**	**0.436**	**2.8**
Error	**16**	**6.956**	**0.435**		
Total	**26**	**171.721**			

Average weight of 10 cloves

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.002**			
Factor (D)	**2**	**13.576**	**6.788**	**209.194**	**3.4**
Factor (M)	**2**	**13.895**	**6.947**	**214.108**	**3.4**
Factor(D)× (M)	**4**	**0.753**	**0.188**	**5.802**	**2.8**
Error	**16**	**0.519**	**0.032**		
Total	**26**	**28.745**			

Yield per plot (kg)

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.042**			
Factor (D)	**2**	**1.619**	**0.809**	**46.295**	**3.4**
Factor (M)	**2**	**0.323**	**0.616**	**9.227**	**3.4**
Factor(D)× (M)	**4**	**1.184**	**0.296**	**16.934**	**2.8**
Error	**16**	**0.0280**	**0.017**		
Total	**26**	**3.448**			

Total bulb yield (q/ha)

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**9.342**			
Factor (D)	**2**	**393.510**	**196.755**	**71.773**	**3.4**
Factor (M)	**2**	**2411.631**	**1205.815**	**439.863**	**3.4**
Factor(D)× (M)	**4**	**52.200**	**13.050**	**4.760**	**2.8**
Error	**16**	**43.862**	**2.741**		
Total	**26**	**2910.544**			

TSS (º Brix)

Source of Variations	df	S.S	M.S	F. Cal	F Tab 5%
Replication	2	**0.351**			
Factor (D)	**2**	**7.412**	**3.706**	**3.380**	**3.4**
Factor (M)	**2**	**7.002**	**3.501**	**3.194**	**3.4**
Factor(D)× (M)	**4**	**0.133**	**0.033**	**0.030**	**2.8**
Error	**16**	**17.541**	**1.096**		
Total	**26**	**32.440**			

APPENDIX -II

Economics

General cost of cultivation (fixed cost) for all the treatment (Rs ha^{-1})

S.N.	Input	Unit	Rate (Rs unit^{-1})	Quantity used	Total
A	**Preparatory tillage**				
1.	Ploughing of land	Ploughing	1500	1	1500
2.	Planking	planking	1100	1	1100
3.	Preparation of plots	mandays	300	6	2000
B	**Sowing and fertilizer Application**				
1.	Seed	Quintal	6400	5	32000
2.	Labour Sowing and fertilizer Application	mandays	300	40	12000
C	**Plant protection**	-		-	5300
D	**Interculture operation**	-			
1.	Weeding and hoeing	mandays	300	100	30000
2.	Irrigation	mandays	400	18	7200
E	**Harvesting**	mandays	300	90	27000
F	**Transportation**	-			10000
G	**Miscellaneous**	-			3000
	Total	-			131100

CURRICULUM VITAE

The author of this thesis **Mr. Govind Patel** S/O Shri Pyarelal Patel was born 5 march 1996 at Damoh (M.P). He passed the high school examination in the year of 2011 with 80.60 percent marks from the School of Excellence Patharia, Damoh (M.P.) In the year of 2013 acquiring 90. percent in 12 class from the school of Excellence Damoh (M.P.)

He join the Jawahar Lal Nehru Krishi Vishwa Vidhyalaya, College of Agriculture Jabalpur (M.P.) in the year 2014 and successfully complete the degree of B.Sc. (Agri.) during the year June, 2018 with first division (7.35 out of 10.0 point scale)

After completion graduation, he was selected for M.Sc. (Agri.) Horticulture degree programme in the Jawahar Lal Nehru Agriculture University Jabalpur, in the 2018 for specialization in vegetable science . He successfully completed all the cource requirements for master‘s degree with first division securing an OGPA of 7.60 out of 10 point scale.

For the fulfillment of the master degree programme he was allotted a research problem **“Effect of Planting date and mulching on growth, yield and quality parameters of Garlic *(Allium sativum* L.)”.** This is duly completed by him and presented in the form of thesis.