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EFFECTS OF DIFFERENT MULCHING MATERIALS, MANURES AND BIO-FERTILIZERS ON GROWTH AND YIELD PARAMETERS OF GARLIC *(ALLIUM SATIVUM L.)* VAR. AGRIFOUND PARVATI IN GARHWAL REGION OF UTTARAKHAND, INDIA

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ABSTRACT

In this study, the effects of different type of mulches viz., Green fern foliage, Mixed forest litter (Alnus nepalensis leaves and Rhododendron leaves), Dry walnut litter and without mulching (control), Manures viz., Goat manure and FYM, and bio-fertilizers namely *Trichoderma asperellium*, and *Pseudomonas fluorescence* on the growth and yield characters of garlic were observed in a field experiment. Mixed forest litter, FYM and *Pseudomonas fluorescence* and Mixed forest litter, FYM and *Trichoderma asperellium* increased the bulb yield and yield components, irrespective of their duration. The treatment Mixed forest litter, FYM and *Pseudomonas fluorescence* performed better than other treatment in respect of fresh weight of bulb, dry weight of bulb, fresh weight of individual clove, dry weight of individual clove, width of bulb, width of individual cloves and numbers of cloves per bulb. Mixed forest litter, FYM and *Pseudomonas fluorescence* is recommended for the garlic production based on better performance than the others and also for being cheaper and abundant in the nature.

Keywords: *Allium Sativum L,* Mulching, Manures, Bio-fertilizers, Yield

INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family Alliaceae is one of the most important spice crops. It is originated from the progenitor *Allium longicuspis* and its center of origin is Central Asia (Mc. Collum 1976). It is a bulbous herbaceous spice and second most important bulb crop after onion. It is widely grown in tropical and temperate regions. It is an important and widely cultivated crop for food as well as medicinal purposes because of its thrombotic, lipid-lowering cardiovascular and anti cancer effects (Agarwal, 1996). Garlic is a rich source of carbohydrates (29%), proteins (6.30%), minerals (0.30%), and essential oils (0.1-0.4%) and a fair source of fat, vitamin C and sulphur (Memane *et al.,* 2008). Garlic is grown in many countries at a wide range of altitudes; China, India, the Republic of Korea and Egypt are the major producers of garlic.

In India, the area under garlic is 281 thousand hectares in 2015-16 with annual production of 1617 thousand metric tonnes (NHB, 2017). Garlic is cultivated mainly in Madhya Pradesh, Gujarat, Orissa, Maharashtra and Uttar Pradesh. Madhya Pradesh is the leading state in garlic production contributing 81.17 thousand hectare area with 424.50 thousand metric tonnes production in 2015-16, followed by Rajasthan, Gujarat and Uttar Pradesh (NHB, 2017).

Mulching is beneficial and important it helps to suppress weed growth, prevent soil erosion, retain moisture in the soil and also it helps to improve the soil's fertility.

The main advantage of organic mulches is nutrient supply In 1963 Tukey and Schoff reported increased amounts of available soil P and K under organic mulches. They suggested that the release of nutrients from decomposing mulches rapidly and slowly decomposing might have positive effect on the soil. The slow release of nitrogen from decomposing organic mulch is better synchronized with plant uptake than sources of inorganic nitrogen (Cherr *et al.,* 2006). Mulches are important for weed control (Bilalis *et al.,* 2002). Mulch can have positive or negative effects on crops apart from its impacts on weeds. Mulching improves plant growth, yield and yield quality reported by (Sharma and Sharma, 2003).

MATERIALS AND METHODS

The present study was carried out on Agrifound Parvati cultivar of Garlic at Village Bhanaj, District Rudraprayag Uttarkhand, during the period from November, 2018 to June, 2019. The present study area located between 30°25'N latitude and 79°08'E longitude and 2000 M above mean sea level. The experimental site had mostly cold condition and maximum and minimum temperature was recorded during June 2019 30.0°C and January 2019 1°C respectively. The soil at experimental plot was clay loam. The experiment was conducted using Factorial Complete Randomized Block Design with three replications of each treatment combination and total treatments are sixteen. The area occupied by a single plot was 2.00 x 1.2m and the whole experiment consist 48 such plots. Flat types of bed were made a spacing of 10x30cm. The main objective of the study was to identify optimum

plant growth and yield by using different mulching practices, manures and bio-fertilizers. M_1: Green fern foliage were used @ 9.5 kg/bed at 3 inch thickness, M_2: Mixed forest litter were used @ 4.5 kg/bed at 3 inch thickness, M_3: Dry walnut litter were used @ 4 kg/bed at 3 inch thickness and M_0: No mulching (control), C_1: Goat manure 3.6 kg/bed, C_2: FYM 3.6 kg/bed, B_1: *Trichoderma asperellium* 72g/bed, B_2: *Pseudomonas fluorescence* 72g/bed. In each bed 3.6kg manure and 72 gm bio-fertilizers were added. 25 days before application Bio-fertilizer was cultured with FYM and Goat manure and kept under shade and covered with paddy straw. The experimental field was thoroughly prepared by deep ploughing and surface was leveled. All the unwanted weeds and stones were removed from the plots. After land prepared, manures and Bio-fertilizers were applied according to recommendation for the garlic at the rate 15 t/ha, spread uniformly in the bed. At planting time, cloves were separated from the bulb, Small size of cloves, diseased, and damages clove were separated. Cloves with the same size were used for planting. Total 3840 cloves were used under the experiment. The cloves were planted at 3 to 4 cm depth of soil. The cloves were planted with the help of pointed stick for making holes to required depth in the soil. Mulching with green fern foliage, walnut litter and forest litter was done immediately after planting the cloves on field. Irrigation was done after three days of planting. Data were collected from 10 randomly selected plants at interval of 60, 90 and 120 days after planting till the final harvest. The observation were under taken on Germination percentage, Plant height (cm) at 60, 90 and 120 DAS, Number of leaves at 60, 90 and 120 DAS, Length of leaf (cm) at 60, 90 and 120 DAS, Width of leaf (cm) 60, 90 and 120 DAS, Fresh weight of bulb (g), Dry weight of bulb(g), Length of bulb(cm), width of bulb(cm), fresh weight of cloves (g), dry weight of cloves (g) length of cloves (cm) width of cloves (cm) number of cloves and bulb yield per plot (kg) and yield (t/ha) were estimated at the time of final harvest. The final harvest was done on 12th of June 2019 after the attainment of maturity, showing the sign of drying out most of the leaves and softening of neck of the bulb.

RESULTS AND DISCUSSION

Growth parameters

Germination (%)- It is clear from the data in (table-1) that different mulches had significant effect on germination percentage after 15 days after sowing. The treatment $M_0C_2B_2$ shows highest (97.83) germination percentage while the lowest germination percentage showed by $M_3C_2B_2$ (90.30). Similar result was also recorded in rice straw mulch (95.17%) by Kabir *et al.,* (2016).

Plant height- The plant height at 60, 90 and 120 DAS was significantly influenced by the application of different mulches, manures and bio-fertilizers. Significantly maximum plant height at 60, 90 and 120 DAS was observed 21.06cm 29.74cm and 43.37cm with treatment $M_2C_2B_1$ respectively and minimum plant height at 60, 90 and 120 DAS was 13.79 cm, 20.08 cm and 34.20cm with treatment $M_3C_2B_2$, respectively. The increasing plant height at 60, 90 and 120 DAS may be due to production of promoting substances that might have caused cell elongation and multiplication by enhancing availability of nutrients in the soil. Similar results were also reported by Gautam *et al.,* (2014).

Number of leaves- The numbers of leaves was also significantly influenced by the different treatments. Significantly maximum number of leaves at 60, 90 and 120 DAS was observed in the treatments $M_2C_2B_1$ i.e. 4.30, 5.07 and 5.87 respectively and the minimum number of leaves at 60, 90 and 120 DAS was 2.97, 3.63 and 4.61 when we apply $M_3C_2B_2$ treatments. The maximum number of leaves was also found in the treatment possibly due to the greater plant height and favorable moisture condition of the soil. The results showed a similarity to the work done by Seifu *et al.,* (2017) in Grass mulch (5.46)**.**

Length of leaf- Data in table -1 showed that length of leaf was significantly influenced by the application of treatments at different stages *i.e.,* 60, 90 and 120 DAS, significantly the maximum length of leaf per plant *i.e.,* 18.17 cm, 26.64cm and 39.80cm, respectively was observed in treatment $M_2C_2B_1$ However, the minimum length of leaf at 60, 90 and 120 DAS was observed 12.99cm, 19.63cm and 30.33cm in treatment $M_3C_2B_2$ respectively. Similar results were reported by Seifu *et al.,* (2017) in Black polyethylene mulch.

Width of leaf- The maximum width of leaf at 60, 90 and 120 DAS was 1.13cm, 1.25cm and 1.49cm in treatment $M_0C_2B_1$ respectively, while the minimum width of leaf was 0.94cm at 60 DAS, 1.06cm at 90 DAS and 1.22cm at 120 DAS in the treatment $M_0C_2B_2$.

Number of roots per plant- Number of roots per plant was counted after careful uprooting of the plants on 240 DAS. Different mulch treatments under study showed highly significant variation in number of roots per plant. The application of $M_3C_1B_1$ produce the highest (69.63) number of roots per plant and the lowest number (43.50) of roots per plant was found in $M_1C_1B_2$. The production of higher number of roots may be because of the availability of better growing conditions under such treatments. These results are coincide with the findings of Shahidul *et al.,* (2003) in black polyethylene.

Length of roots- Statistically non-significant effect of mulches and their duration was observed on length of roots. Plant grown with the treatments $M_3C_1B_1$ had maximum (6.01cm) length of roots, while those grown under control *i.e.,* $M_0C_2B_1$ had minimum (4.05 cm) length of roots.

Fresh weight of roots-The variation in fresh weight of roots of individual plant recorded at the final harvested significantly different among various mulch treatments. The highest fresh weight of roots was found in $M_3C_1B_1$ i.e., 0.56 g and lowest (0.24g) fresh weight of

Taple-1. Effects of different mulching materials, manures and bio-fertilizers on growth and yield parameters of Garlic (*Allium sativum* L.) var. Agrifound Parvati

Treatments	Germination (%)	Growth parameters															
		Plant height (cm)			Number of leaves per plant			Length of leaf (cm)			Width of leaf (cm)			Number of Roots	Length of roots (cm)	Fresh Weight of root (g)	Dry Weight of root (g)
		60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS				
M1C1B1	92.02	18.34	27.28	40.87	3.47	4.27	5.10	15.65	21.61	36.10	1.10	1.24	1.44	58.17	5.77	0.41	0.16
M1C1B2	96.11	17.69	26.62	38.75	3.27	4.07	4.83	14.57	23.33	36.54	1.05	1.24	1.36	43.50	5.59	0.30	0.13
M1C2B1	94.04	16.46	24.92	38.30	3.50	4.10	4.97	16.35	21.52	34.98	0.99	1.15	1.30	68.33	5.91	0.46	0.20
M1C2B2	97.05	17.49	25.60	38.64	3.70	4.40	5.10	14.07	20.63	32.31	1.06	1.25	1.40	54.23	5.83	0.34	0.14
M2C1B1	91.22	16.76	25.47	38.41	3.17	3.83	4.70	13.22	22.41	33.72	1.00	1.20	1.32	56.80	4.77	0.39	0.17
M2C1B2	96.63	17.98	26.90	40.68	3.27	3.83	4.67	16.16	24.37	37.27	1.07	1.22	1.42	57.47	4.41	0.37	0.10
M2C2B1	94.73	21.06	29.75	43.37	4.30	5.07	5.87	18.17	26.64	39.80	1.11	1.24	1.45	50.27	4.70	0.33	0.15
M2C2B2	97.73	19.69	27.91	41.29	4.13	4.77	5.53	18.11	22.08	31.85	1.01	1.13	1.35	47.03	4.34	0.42	0.19
M3C1B1	94.43	15.88	24.70	37.45	3.60	4.33	5.50	14.77	23.63	38.68	1.04	1.18	1.43	69.63	6.01	0.56	0.21
M3C1B2	95.18	15.50	22.92	36.42	3.10	3.80	4.80	15.80	25.15	34.62	1.03	1.23	1.41	65.70	5.70	0.32	0.12
M3C2B1	93.87	15.61	22.58	36.09	3.57	4.20	5.17	13.03	21.74	33.75	0.96	1.10	1.29	51.37	4.86	0.28	0.09
M3C2B2	90.30	13.79	20.08	34.20	2.97	3.63	4.61	12.99	19.63	30.33	0.98	1.07	1.31	45.30	4.25	0.24	0.07
M0C1B1	92.52	16.61	25.27	38.33	3.50	4.00	4.00	14.95	19.71	36.33	0.97	1.13	1.44	61.33	4.74	0.45	0.18
M0C1B2	95.35	15.07	22.41	35.08	3.23	4.03	4.87	14.61	21.45	37.25	1.08	1.23	1.38	65.33	4.77	0.44	0.15
M0C2B1	97.52	17.64	25.69	38.66	3.77	4.43	5.23	14.60	21.71	34.35	1.13	1.25	1.49	57.17	4.05	0.35	0.10
M0C2B2	97.83	15.86	24.32	37.11	3.53	4.37	5.20	15.88	20.39	31.87	0.94	1.06	1.22	63.10	5.09	0.30	0.11
C.D.(at 5%)	0.529	1.394	1.186	0.951	0.175	0.136	0.138	1.292	1.258	1.723	0.053	0.104	0.143	1.590	N/S	0.033	0.034
SE(m)±	0.183	0.483	0.410	0.329	0.060	0.047	0.048	0.447	0.436	0.596	0.018	0.036	0.050	0.550	0.306	0.011	0.012

roots was found in $M_3C_2B_2$. Similar result was also recorded in rice straw mulch by Kabir *et al.,* (2016).

Dry weight of roots-The maximum 0.21g dry weight of roots was found in treatment $M_3C_1B_1$ and the minimum 0.07g dry weight of roots was found in treatment $M_3C_2B_2$. Similar result was also recorded in rice straw mulch by Kabir *et al.,* (2016).

Fresh weight of bulb-The variation in fresh weight of individual bulb recorded at the final harvest was significantly different among various mulch treatments (table-2) the highest (24.67g) fresh weight of bulb was found in plants grown in the treatment $M_2C_2B_2$ the lowest (15.83g) was obtained in the treatment $M_3C_2B_2$ the increase in average bulb weight with the combined treatments was mainly due to increased in bulb in diameter. This might be due to efficient translocation of photosynthates to bulbs thereby increasing bulb size and hence increase in dry matter accumulation of bulbs. These results showed a similarity to the work done by A.C Mishra (2016) in Agrifound Parvati.

Dry weight of bulb-The maximum dry weight of bulb was recorded 9.59g in the treatment $M_2C_2B_2$ while the minimum dry weight of bulb 5.69g was found in the treatment $M_3C_2B_2$. These results are coincide with the findings of Kabir *et al.,* (2016) in rice straw mulch.

Length of bulb-The length of bulb significantly differed among the treatments (table 2). The longest bulb (4.32cm) was found in $M_2C_2B_1$ and the shortest bulb (3.25cm) was found in $M_3C_2B_2$. These results show similarity with Jamil *et al.,* 2005 in plastic and straw mulch.

Width of bulb-Different mulches showed significant variation in bulb width (table-2). The highest (4.42cm) width of bulb was recorded in the treatment $M_2C_2B_2$) while lowest (3.35cm) width of bulb recorded in $M_3C_2B_2$ the width of bulb was directly influenced by size and length of

Taple-2. Effects of different mulching materials, manures and bio-fertilizers on growth and yield parameters of Garlic (*Allium sativum* L.) var. Agrifound Parvati

Treatments	Yield Parameters										
	Fresh Weight of bulb (g)	Dry Weight of bulb (g)	Length of bulb (cm)	Width of bulb (cm)	Fresh Weight of cloves (g)	Dry Weight of cloves (g)	Length of clove (cm)	Width of clove (cm)	Number of cloves per bulb	Yield of bulb (kg/plot)	Yield of bulb (q/ha)
M1C1B1	22.30	8.31	3.61	3.64	1.23	0.57	2.27	1.13	19.07	1.08	45.14
M1C1B2	20.93	7.86	3.43	3.51	1.22	0.61	2.18	1.11	18.63	1.16	48.19
M1C2B1	21.90	7.94	3.37	4.34	1.10	0.56	2.12	1.27	19.80	1.16	48.47
M1C2B2	22.33	8.50	3.49	4.20	0.94	0.53	2.23	1.21	18.93	1.24	51.94
M2C1B1	23.40	8.72	3.38	4.24	1.28	0.64	2.13	1.22	18.13	1.15	47.77
M2C1B2	20.10	7.77	3.66	3.68	1.15	0.57	2.32	1.16	18.67	1.14	47.63
M2C2B1	23.73	9.35	4.32	3.65	1.17	0.58	2.44	1.14	18.87	1.32	54.86
M2C2B2	24.67	9.59	3.57	4.42	1.37	0.77	2.24	1.28	20.10	1.57	65.27
M3C1B1	24.20	9.42	4.13	3.45	1.02	0.55	2.40	1.12	18.73	1.13	47.08
M3C1B2	18.89	7.39	3.45	3.71	1.20	0.54	2.20	1.17	16.47	1.13	47.22
M3C2B1	19.40	7.46	3.72	3.50	1.14	0.59	2.39	1.10	17.67	1.27	52.91
M3C2B2	15.83	5.69	3.25	3.35	0.82	0.40	1.83	1.05	14.43	0.93	38.89
M0C1B1	18.83	6.43	3.33	3.37	0.88	0.44	2.09	1.09	17.07	0.95	39.44
M0C1B2	23.33	8.70	3.67	3.72	0.95	0.50	2.33	1.19	19.73	1.28	53.47
M0C2B1	19.43	7.54	3.64	3.74	0.93	0.46	2.29	1.20	19.70	0.98	40.97
M0C2B2	18.73	6.37	3.31	3.67	0.90	0.47	2.06	1.15	18.20	0.96	39.86
C.D. (at5%)	2.092	0.466	0.350	0.404	0.065	0.098	0.167	0.063	1.043	0.030	1.251
SE(m)± (q/ha)	0.724	0.161	0.121	0.140	0.023	0.034	0.058	0.022	0.361	0.010	0.433

clove. Better size of cloves is responsible for improved diameter of bulb. These results show similarity with Jamil *et al.,* (2005) in plastic and straw mulch.

Fresh weight of cloves- Mulching treatments greatly influenced fresh weight of cloves (table-2) the treatment $M_2C_2B_2$ showed maximum and treatment $M_3C_2B_2$ showed minimum fresh weight of cloves *i.e.*, 1.37 g and 0.82 g respectively.

Dry weight of cloves- The maximum and minimum dry weight of cloves was also found same as in the fresh weight of cloves. The maximum dry weight of cloves was 0.77g in the treatment $M_2C_2B_2$ while the minimum was 0.40g in control i.e., $M_3C_2B_2$

Length of clove- The data of length of clove revealed that plants grown in the treatment $M_2C_2B_1$ showed maximum (2.44cm) length of clove. However, the length of plants which were grown with the treatment $M_3C_2B_2$ showed minimum (1.83cm) length of cloves. The length of cloves was directly influenced by the enhanced vegetative growth of plants better growth might have accumulated more carbohydrates, resulting in to increased diameter of bulb which is the storage organ.

Width of clove- Significantly maximum width of clove (1.28cm) was recorded under the treatment $M_2C_2B_2$ and the minimum width of clove (1.05cm) was found in the treatment $M_3C_2B_2$

Number of cloves per bulb- The variation in the number of cloves per bulb due to the application of different mulching treatments was highly significant (table-2) the treatment produce the highest (20.10) numbers of cloves per bulb. The lowest (14.43) numbers of cloves was found in the treatment $M_3C_2B_2$. The formation of maximum number of cloves might be due to gradual and steady release of nutrient during the growth period as well as proper nutrition to the crop. These results are coincide with the findings of Kabir *et al.,* (2016) in water hyacinth mulch.

Yield of bulb (kg/plot)-There was highly significant variation in garlic yield per plot due to the effects of different mulches, manures and bio-fertilizers (table-2). The treatment $M_2C_2B_2$ (gave the maximum (1.57kg) yield followed 1.32kg

by $M_2C_2B_1$ and 1.28kg with $M_0C_1B_2$ The lowest yield was recorded in the treatment $M_3C_2B_2$ (0.93kg) which was followed by the treatment $M_0C_1B_1$ i.e., (0.95kg and 0.96kg with treatment which might be a reason of yield increment. On the other hand organic manures are capable of supplying adequate macro and micro plant nutrients which play major role in quality improvement.

Yield of bulb (q/ha)-Maximum yield quintal per hectare (table-2) with a value of 1.57kg and 65.27q respectively was found in treatment $M_2C_2B_2$ the minimum yield quintal per hectare 0.93kg and per hectare 38.89q was recorded in treatment $M_3C_2B_2$ The present studies are in congruent with Memane *et al.,* (2008) who reported that increased vegetative and bulb growth observed in large sized clove due to more reserve food materials might had helped in increasing the overall yield of garlic. Moreover in support of above findings Castellanous *et al.,* (2004**)** reported that extra large sized seed cloves do not yield more than the large sized cloves due to less number of cloves in the former i.e. extra large clove weight.

CONCLUSIONS

Garlic is one of the important bulb crops grown and used as a spice or a medicinal purpose throughout India. It is rich in protein, calcium, sulfur, vitamins, sugar and many other substances that contribute nutritional value to the human diet and many medicinal properties etc.

The results of our study on various mulches materials shows that the mixed forest litter (Alnus nepalensis leaves and Rhododendron leaves)+FYM@15t/h+*Pseudomonas fluorescence @2%* could be used for increasing the quality of garlic production and recommended for the garlic production based on better performance than the others treatments. It is also for being cheaper and abundant in the nature itself, Therefore, if cultivation of high yielding varieties of garlic (Agrifound Parvati) and underground vegetables will be promoted on large scale may be beneficial and this crop are less perishable and has better economical value for the sustainable livelihood enhancement for the local community and also less harm by the wild animals.

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