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Influence of Fertilization and Mulching Techniques on Yield, Weed Management and Economics of Elephant Garlic (*Allium ampeloprasum* L.)

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ABSTRACT

The experiment comprised four doses of organic and inorganic fertilizers and four different types of mulches viz. no mulch, rice straw mulch, Saccharum spp. mulch, black polyethylene mulch laid out on factorial randomized complete block design replicated thrice. The major challenge in the study was the efficient management of weeds through eco-friendly technologies involving mulches. The studies revealed that high yields in elephant garlic can be achieved by fertilizing it with N:P:K @120:60:60 kg/ha + FYM @ 24 t/ha and mulching it with rice straw. The study pointed out the effectiveness of locally available rice straw as a potential mulch for improving the micro-climate of elephant garlic and thereby enhancing its important horticultural traits. The highest benefit-cost ratio of 1:4.0 was however obtained in treatment having N:P:K @120:60:60 Kg/ha, FYM @24 t/ha in combination with rice straw mulch which resulted in a high net income of ₹ 1139007 with a gross income of ₹ 1423575 at cultivation cost of ₹ 284568. The study will be helpful in checking of weed menace in closed spaced crop of Alliums spp. and will help in increasing the farm income of the growers.

Keywords: *Allium ampeloprasum* L., Economics, Fertilization, Growth, Mulching, Weed management, Yield

INTRODUCTION

The allium genus under the Alliaceae family has as low as 260 and as high as 979 species [1] which differ in maturity, color, taste, and pharmaceutical properties throughout the world. Among all species, elephant garlic or great-headed garlic (*Allium ampeloprasum* L.) is an important species. It is a tetraploid species of alliums and very similar to diploid garlic (*Allium sativum* L.). It is not a true garlic but a variant of the species to which the garden leek belongs. It has a tall, solid, flowering stalk with sterile bluish flowers and broad, flat leaves much like those of the leek but forms a bulb consisting of very large, garlic-like cloves. The cloves are comparatively bigger, 4-6 in number and less pungent. The bulb weighs 2-3 times more than garlic and flavors much similar to garlic. There are also much smaller cloves with a hard shell that occur on the outside of the bulb ranging between 10-20 in number, weighing 1-2g each. These hard cloves (ver. Ghainthia thom) are cubical and have a shelf life of 3-4 years. Owing to the presence of many sulphur-containing bio-active constituents which include dimethyl disulphide, methyl propenyl disulphide, dimethyl trisulphides, and other cysteine sulphoxides [2] and other medicinal properties of external cloves, it is sold at premium prices [3]. These are often ignored but if they are planted, they will produce a non-flowering plant that has a solid bulb in the first year, essentially a single large clove. This clove will break up into many separate cloves in the following years.

The role of mulching in the growth and production of plants is well recognized. Mulching has been suggested to conserve soil moisture [4,5,6] decrease soil temperature, and decrease runoff and soil erosion [7]. Mulches help check weed growth and improve soil structure and fertility by trapping nutrient-rich and wind-borne dust [8]. Similarly, organic (FYM) and inorganic fertilizers (N, P, K) are essential for the proper growth and development of all crops. Standardization of proper dosages and proper weed management in long-duration crops like elephant garlic will help maximize its yield and improve the socio-economic status of the farmers. Owing to the lack of quality planting material, the standardized package of practices, and the economics of growing this crop. Keeping the importance of this crop under consideration, the following research experiment was conducted to address some issues to harness the full potential of this crop.

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Kashmir of Agricultural Sciences & Technology of Jammu, Faculty of Agriculture, Division of Vegetable Science, Jammu (J&K) during the *Rabi* season 2019-2020. The experimental site is geographically located at 32^0 40′ N latitude and 74^0 82′ E longitude with an altitude of 293 meters above mean sea level. Chatha, Jammu falls under the subtropical plain zone of the Jammu region and is bestowed with hot and dry early summers followed by hot and humid monsoon season and cold winters.

The total annual rainfall received by the crop was 422.6 mm, out of which approx. 50 percent of rainfall was received from the 44th

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week to the 2nd week of the growing season while the remaining 50 percent was received in other weeks as a result of Western disturbances. The highest mean weekly temperature was recorded at 41.8° C in the 21st standard week and the lowest mean weekly temperature of 4.7° C was recorded in the 6th standard week. Maximum RH (95 %) was recorded in the 51st standard week whereas minimum RH was recorded in the 21st standard week of the year respectively (Fig 1.)

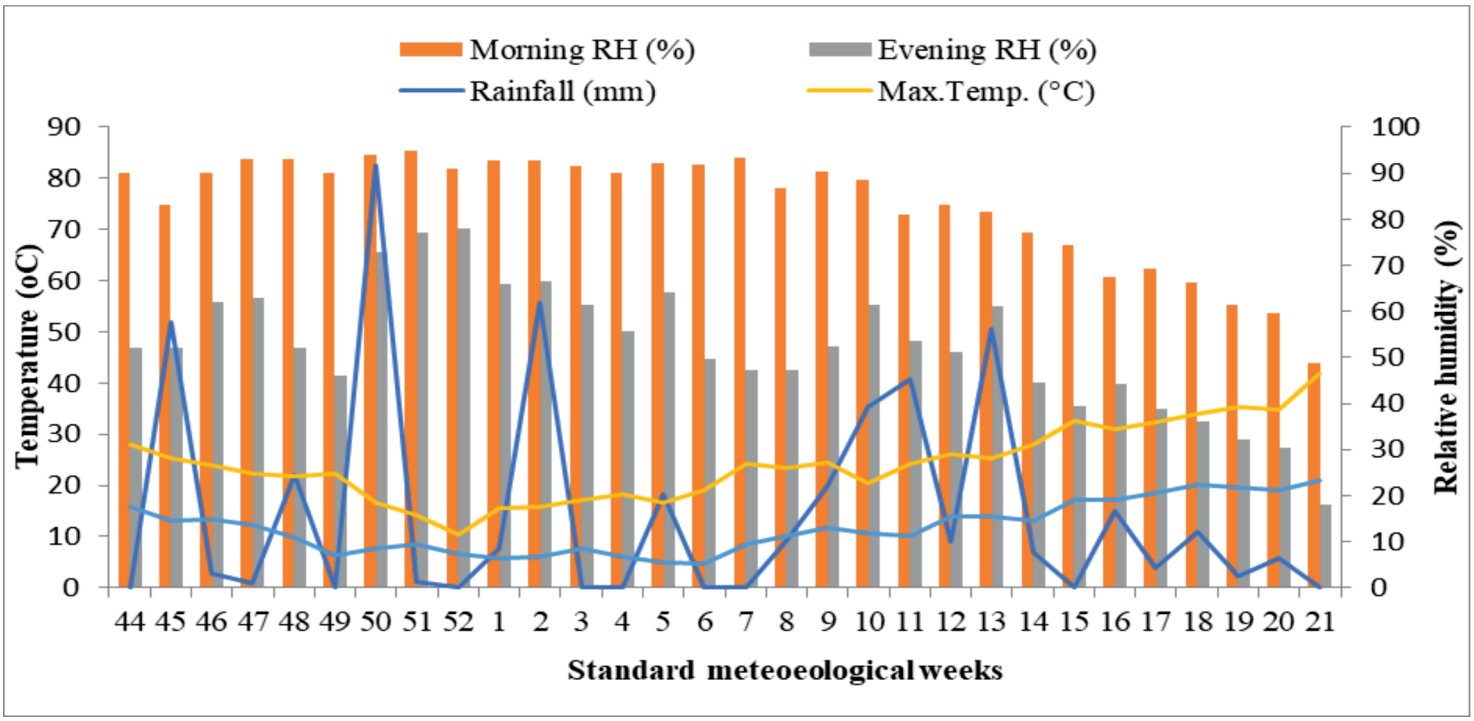

Fig.1. Meteorological data of the location

EXPERIMENTAL MATERIALS, TREATMENTS AND EXPERIMENTAL DESIGN

The experiment was laid out in RBD (Factorial) fashion and replicated thrice. The experiment comprised four levels of fertilizers namely recommended dose of fertilizer of garlic (RDF) (100:50:50 Kg/ha N:P: K and 20 T/ha FYM), 20 % less than RDF of garlic (80:40:40 Kg/ha N:P: K and 16 T/ha FYM), 20% more than RDF of garlic (120:60:60 Kg/ha N:P: K and 24 t/ha FYM) and 40% more than RDF of garlic (140:70:70 Kg/ha N:P: K and 28 t/ha FYM) and four mulching treatments namely M_0-No mulch, M_1- Rice straw mulch, M_2- Saccharum spp. mulch and M_3- Black Polyethylene mulch. All the fertilizer doses were calculated based on the standardized dose of garlic recommended in the Package of Practices for Vegetable Crops (2020) Directorate of Extension, SKUAST-Jammu. The genotype of elephant garlic used in the study is an advanced selection (SJEG-18-01), developed by the Division of Vegetable Science and Floriculture, SKUAST-Jammu with a high yield potential of 100-150q/ha. The genotype was sown in October 2019 by dibbling method at a spacing of 15 cm × 15 cm at the seed rate of 15-20q/ha. The cloves with growing ends upwards were planted manually about 3-6 cm deep, depending on the diameter of the clove, using a hand hoe. They were later covered with loose soil and established. Harvesting was done when 50% of the plants showed yellowness in the pseudo stem i.e., after 7 months. Harvesting continues for 22 days i.e., 6-28th May 2020, depending on the maturity of the crop under different treatments.

RESULTS AND DISCUSSION

Bulb yield

The effect of fertilization had a significant effect on the bulb yield of elephant garlic. Maximum bulb weight (87.49g), bulb yield per plot (7.87 kg), and maximum bulb yield (118.11q/ha) was recorded in plots fertilized with T_3. This might be due to increased morphological characteristics like leaf width, leaf area index, and plant height which enable the plants to increase the overall growth of the crop, and rational allocation of produced organic food to both leaf and bulb growth which led to an increase in bulb yields. From the results, it is clear that growth, yield, and yield attributes of garlic bulbs increase significantly with the increase in the rates of N, P, and S.

A significant effect of mulching was recorded on the bulb yield of elephant garlic. The highest bulb weight (83.76g), bulb yield per plot (7.53kg) and per hectare (113.07q) were found in treatment with rice straw mulch (M_1). The reason for higher yields might be due to the efficient use of available soil moisture, inhibition of weed growth, protection of surface soil erosion, reduction in nutrient losses from the soil and more importantly the decomposition of rice straw used as mulch, etc. might have played a conducive role in enhancing yield contributing character [9]. Results of [10] clearly indicated that black polyethylene results showed superiority in yield and its contributing characters as compared to other mulches like rice straw mulch, water hyacinth, sawdust and white polyethylene mulch resulting in highest bulb yield of onion. Findings of [11] suggested increase in the yield to the tune of 140 % in some genotypes of garlic in the mulched soil as compared to the one without mulch directly supports the present finding.

The interaction effect of mulching and fertilization revealed significant results in the total bulb yield of elephant garlic. Maximum bulb weight (100.16 g), bulb yield per plot (9.01kg), and maximum bulb yield (135.22q/ha) were recorded in treatment combination of N:P: K @120:60:60 Kg/ha, FYM @24 t/ha along with rice straw mulch (T_2M_1). This might have been attributed to the synergistic role played by the sufficient amount of nutrients under a conducive plant environment. [12] reported that the concentration of nitrogen and phosphorus and

nutrient uptake was significantly higher in mulched plots over un mulched plots in tomatoes. This is consistent with the findings of [13] who observed increased yield components of onion at 100:80:50:30 of N:P:K: S. The results of [14] confirmed the insignificant effect of either mulch types or compost dose on the shallot bulbs' number or weight.

Number, weight, and yield of external cloves per bulb

Fertilization at higher doses had a significant effect on the number and yield of external cloves. However, it was significantly higher in T_3. At much higher rates, a significant reduction in all the yield-attributing parameters of external cloves was recorded. This clearly showed that elephant garlic being long duration and hardy crop than garlic (more than 2 months) requires only 20% more fertilization than garlic concerning N, P, K, and FYM for proper growth and development. As reported by [15] that mixed forest litter (*Alnus nepalensis* leaves and Rhododendron leaves)+FYM@15t/ha+*Pseudomonas fluorescence @ 2%* resulted in significantly maximum number of cloves in garlic than other treatments.

Mulching and their interaction effect with fertilization revealed non-significant results in terms of the number and yield of external cloves.

Days to harvest

All the fertilization doses except treatment with the highest dose T_4 recorded significant effects on minimum days to harvest in elephant garlic but were at par with each other. However, a maximum number of days (203.75) were taken by the treatment fertilized with T_4, thereby showing a delay in maturity by 7.0 days. Delay in days to harvest at height levels of fertilizers and FYM could be attributed to delayed senescence of the canopy of the crop and extended physiological activity in the continuity of photosynthesis. These results are in agreement with the finding of [16] who reported the effect of nitrogen on days to maturity for onion.

The effect of mulching on days to harvest in elephant garlic did not differ significantly. However, minimum days (133.08 days) were recorded in treatment having Saccharum spp. mulch (M_2).

The interaction effect between mulching and fertilization revealed significant results. Minimum days to harvest were recorded in treatment combination of N:P: K @80:40:40 kg/ha, FYM @16 t/ha along with black polyethylene mulch (T_1M_3). This might be attributed to the fact that in the same treatment bulb yield was statistically lower than other treatment combinations which supports its early harvest. Early harvest in less fertile soils has been reported by a lot of workers. Soil productivity is the ability of the soil to support crop production. Good, natural, or improved soil with adequate essential nutrients support heavy yields of the crops at much higher duration and vice-versa. Delay in harvest in the treatments with heavy yields in onion in Poland has been reported [17].

Weed density (plants/m^2)

Weeds density means the number of weed per unit area and in the case of mulching the number of weeds were recorded as statistically low, more than 300% in the case of black polyethylene (M_3) and 268% in the case of Saccharum spp. mulch (M_2) and 227.8 % in the case of rice straw mulch (M_1) as compared to control (no mulch) (M_0) in elephant garlic. Minimum weed density (42.58 plants/m^2) was recorded in black polyethylene mulch followed by saccharum spp. and rice straw mulch. This might be because black polyethylene mulch absorbs most of the solar energy and passes little or no energy through it for other flora to grow as envisaged by [18]. Similar results were obtained by [19] who reported a reduction in weed density in garlic by paddy straw mulching at 10 t/ha.

The effect of fertilization on weed density in elephant garlic revealed significant results as minimum weed density (72.41 plants/m^2) was recorded in treatment having the lowest dose of fertilizers (T_1) and vice-versa. This might be due to high crop-weed competition for nutrients in comparatively less fertilized treatments leading to low weed density. The findings of [20] indicated that increasing the levels of N and k fertilizers had a significant effect on dry weight and total weeds (g/m^2) in onions in Giza, Egypt.

Weed index (%)

The weed index is defined as the percent reduction in the seed yield under a particular treatment due to the presence of weeds in comparison to the seed yield obtained in a weed-free plot. The weed index is inversely proportional to yield, maximum weed index indicates minimum yield and vice versa. In the present study, significant results were observed for weed index under fertilization treatments. A minimum weed index (13.21%) was found in treatment comprising of N:P: K @120:60:60 Kg/ha, FYM @24 t/ha (T_3) as compared to a maximum (36.78 %) in treatment having N:P: K @80:40:40 kg/ha, FYM @16 t/ha (T_1). The yield data revealed the maximum yield in the same treatment which led to a reduction in weed index percentage. Similarly, the maximum weed index was recorded by [21].

The effect of mulching on weed index in elephant garlic revealed significant results as a minimum weed index (16.83 %) was recorded in treatment with rice straw mulch (M_1). The probable reason might be poor weed competition and suppression of weeds by mulches resulting in higher yields [22].

The interaction effect between mulching and fertilization revealed significant results as minimum weed index was found in treatment combination of N:P: K @120:60:60 Kg/ha, FYM @24 t/ha along with rice straw mulch (T_3M_1). Controversy results were however studied by [23] who reported non-significant results of mulching on weed index.

Economic parameters

An economic evaluation of the experiment presented in Table 2 showed the highest gross income of ₹ 1423575 with a net income of ₹ 1139007 and a Benefit-Cost ratio of 4.00 was recorded in treatment combination of N:P: K @120:60:60 Kg/ha, FYM @24 t/ha along with rice straw much.

The economics of any crop depends on the benefit-cost ratio of the produce. In the present experiment, maximum bulb yield was obtained in treatment having N:P: K @120:60:60 Kg/ha, FYM @24 t/ha with rice straw mulch which resulted in a high benefit-cost ratio of 1:4.0. This is clearly due to a high net income of ₹ 1139007 with a gross income of ₹ 1423575 at cultivation cost of ₹ 284568 recorded in this treatment. [24] The reported highest net return (196647 Tk/ha) and highest BCR of 2.90 from zero tillage with rice straw mulching under Bangladesh conditions corroborate the present study. Similar results were obtained by several workers [19] in garlic.

CONCLUSION

Among all the treatment combinations, application of 20 % more than RDF of garlic (NPK @120:60:60 kg/ha + FYM@24 t/ha) along with rice straw mulch (T_3M_1) resulted in maximum

yield (135.22 q/ha) and yield related parameters with minimum weed index of 1.0% and highest BCR of 1:4.0. Rice straw being cheaper and organic not only suppresses weeds but also aids in overall growth and development of the crop.

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Table 1: Effect of mulching, fertilization and their interaction on yield, external cloves and weed parameters of elephant garlic.

Treatment	Bulb weight (g)	Bulb yield per plot (kg)	Total bulb yield (q/ha)	Number of external cloves/bulb	Yield of external cloves (kg/ha)	Days to harvest	Weed density (plants/m²)	Weed index (%)	BCR
T_1	63.37	5.70	85.56	5.45	804.37	196.75	72.41	36.78	-
T_2	77.42	6.96	104.51	6.75	979.87	198.50	75.58	22.69	-
T_3	87.49	7.87	118.11	6.98	1010.25	199.08	80.91	13.21	-
T_4	83.80	7.54	113.14	6.53	949.50	203.75	87.58	16.46	-
C.D. (5%) (T)	**6.70**	**0.59**	**9.12**	**0.66**	**90.28**	**4.16**	**3.97**	**6.92**	
M_0	76.98	6.90	103.92	6.01	879.75	200.25	173.75	26.54	-
M_1	83.76	7.53	113.07	6.74	977.62	201.41	53.00	16.83	-
M_2	79.70	7.19	107.96	6.35	925.87	133.08	47.16	20.45	-
M_3	81.56	6.42	96.36	6.16	960.75	197.33	42.58	25.46	-
C.D. (5%) (M)	**6.70**	**0.59**	**9.12**	**NS**	**NS**	**4.16**	**3.97**	**6.92**	
T_1M_0	67.19	6.05	90.70	5.00	742.50	200.25	160.66	32.96	2.56
T_1M_1	64.77	5.82	87.44	5.33	787.50	201.41	47.66	35.12	2.32
T_1M_2	68.09	613	91.93	5.83	855.00	133.08	41.66	31.98	2.76
T_1M_3	53.45	4.18	72.16	5.66	832.50	197.33	39.66	47.06	1.92
T_2M_0	73.88	6.65	99.74	6.06	886.50	NS	172.00	25.95	3.10
T_2M_1	83.15	7.48	112.25	6.80	985.50	197.33	50.33	17.43	3.30
T_2M_2	73.85	6.64	99.69	7.00	1012.50	200.33	43.33	26.60	3.30
T_2M_3	78.79	7.09	106.37	7.16	1035.00	197.33	36.66	20.80	3.11
T_3M_0	78.85	7.09	106.45	6.66	967.50	188.00	179.33	28.72	3.24
T_3M_1	100.16	9.01	135.22	8.33	1192.50	199.66	55.00	1.00	4.00
T_3M_2	99.24	8.93	133.98	5.93	868.50	197.33	45.66	2.00	3.81
T_3M_3	71.70	6.45	96.80	7.00	1012.50	197.33	43.66	21.10	2.71
T_4M_0	81.01	7.82	108.81	6.33	922.50	202.00	183.00	18.55	3.41
T_4M_1	86.95	7.82	117.38	6.50	945.50	204.33	59.00	13.18	3.14
T_4M_2	78.70	7.83	106.24	6.66	967.50	202.00	58.00	21.21	3.15
T_4M_3	81.56	7.34	110.11	6.33	963.00	206.66	50.33	12.91	2.89
C.D. (5%) (T×M)	**13.40**	**1.18**	**18.24**	**NS**	**NS**	**8.33**	**NS**	**13.84**	**-**

NOTE: T_1: N:P:K @80:40:40 kg/ha, FYM @16 t/ha (20 % less than RDF of garlic), T_2: N:P:K @100:50:50 kg/ha, FYM @ 20 t/ha (RDF of garlic), T_3: N:P:K @120:60:60 Kg/ha, FYM @24 t/ha (20% more than RDF of garlic), T_4: N:P:K @ 140: 70:70 Kg/ha, FYM @28 t/ha (40% more than RDF of garlic), M_0: No Mulch, M_1: Rice straw mulch, M_2: Saccharum spp. mulch, M_3: Black polyethylene mulch

Table 2: Economics analysis of treatment combinations

S. No.	Treatments	Cost of cultivation (₹/ha)	Bulb yield Q/ha	Gross return (bulb yield) ₹/ha	Yield of external cloves Kg/ha	Gross returns (Ext. cloves) ₹/ha	Total gross returns (4+6) ₹/ha	Net returns (7-2) ₹/ha	BCR (8/2)
	1	2	3	4	5	6	7	8	9
1	T_2M_0	261904	90.71	634945.5	742.50	297000	931945.5	670041.5	2.56
2	T_2M_1	279404	87.45	612120	787.50	315000	927120	647716.0	2.32

3	T_2M_2	261904	91.93	643500.9	855.00	342000	985500.9	723596.9	2.76
4	T_2M_3	286904	72.16	505101.9	832.50	333000	838101.9	551197.9	1.92
5	T_1M_0	256727	99.75	698229	886.50	354600	1052829	796102.0	3.10
6	T_1M_1	274227	112.25	785773.8	985.50	394200	1179974	905746.8	3.30
7	T_1M_2	256727	99.70	697873.1	1012.50	405000	1102873	846146.1	3.30
8	T_1M_3	281727	106.37	744608.3	1035.00	414000	1158608	876881.3	3.11
9	T_3M_0	267068	106.46	745195.5	967.50	387000	1132196	865127.5	3.24
10	**T_3M_1**	**284568**	**135.23**	**946575**	**1192.50**	**477000**	**1423575**	**1139007**	**4.00**
11	T_3M_2	267068	133.98	937840.1	868.50	347400	1285240	1018172	3.81
12	T_3M_3	292068	96.80	677615.4	1012.50	405000	1082615	790547.4	2.71
13	T_4M_0	272326	118.82	831726	922.50	369000	1200726	928400.0	3.41
14	T_4M_1	289826	117.38	821678.1	945.00	378000	1199678	909852.1	3.14
15	T_4M_2	272326	106.25	743715	967.50	387000	1130715	858389.0	3.15
16	T_4M_3	297326	110.12	770805	963.00	385200	1156005	858679.0	2.89

NOTE: Sale rate of garlic bulbs = ₹7000/ Q
Sale rate of external cloves = ₹400/ kg

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