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Kamini Thakur
M.Sc. Research Scholar, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Mohd Shah Alam
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Jay Nath Patel
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Ravinder
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Yograj
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Corresponding Author:
Kamini Thakur
M.Sc. Research Scholar, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Influence of combined and solo application of organic manure, mulching and chemical fertilizer on growth and yield of barley crop under mid hill region of Himachal Pradesh

Kamini Thakur, Mohd Shah Alam, Jay Nath Patel, Ravinder and Yograj

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Abstract
A field experiment was conducted at the Research Farm of School of Agriculture, Abhilashi University, Mandi (H.P.) during the Rabi season of 2022–23 to study the effects of organic manure, mulching, and chemical fertilizer on the growth and yield of barley crop in the mid-hill region of Himachal Pradesh. The experiment used a randomized block design (RBD) with seven treatments: T_1= recommended dose of fertilizer (RDF), $T_2 = T_1$ + FYM 5 t ha^{-1}, $T_3 = T_1$ + FYM 5 t ha^{-1} + mulch, $T_4 = T_3 + ZnSO_4$ spray @ 0.5%, $T_5 = T_4$ + 2 $ZnSO_4$ sprays at flag leaf and post anthesis stages, T_6= 50% RDF + 50% N Vermicompost, and T_7 = Absolute control. The results showed that the application of T_5 (T_4+ 2 spray of $ZnSO_4$ at flag leaf and post anthesis) led to the maximum plant height, number of tillers, and dry matter accumulation of barley. Similarly, the maximum number of effective tillers and spike length were recorded with the application of T_5, while the minimum growth parameters were observed in the absolute control. Various treatments had no significant effect on grains per spikes and on test weight. The grain yield, straw yield, and biological yield of barley were recorded maximum with the application of T_5, while the harvest index did not significantly influence due to different nutrient management practices.

Keywords: Barley, $ZnSO_4$, RDF (Recommended dose of fertilizer), FYM (Farm yard manure), mulching

Introduction
After wheat, rice, and maize, barley (*Hordeum vulgare* L.) ranks among the four most important grains in the world. Most people refer to it as "Jau." Barley outperforms wheat in terms of certain mineral and fiber values. Because it is a strong source of protein and includes water soluble fiber (Bet gluons) and an oil compound (tocotrienol), which have been shown to effectively control blood cholesterol, this crop is in high demand in the industrial sector. Grown in a variety of climates, from the high altitudes of the Himalayas to the Middle East's desert, barley is an annual grain crop. It's used for making alcoholic and non-alcoholic beverages, as well as bread, porridge, soup, and roasted grains.
In terms of both total area and barley crop production, India is ranked seventh in the globe. In India, 540 hectares are planted to the barley crop, which yields 1,400 tons of grain and 25.1 q ha^{-1} of productivity (Anonymous, 2018). One of the most significant states in India for barley cultivation is Uttar Pradesh. A cool-season annual grain crop with rapid growth, barley can be used as a cover crop to increase soil fertility and as fodder. In the 2021–2022 crop years, barley output reached a volume of approximately 145.9 million metric tons worldwide. This is a decrease from approximately 160.9 million metric tons in 2020–2021 and from 0.54 million hectares with an average national productivity of 2930 kg/ha in India in 2021–2022.
An integrated nutrient management system (INMS) may play a vital role in sustaining both the soil health and crop production on long-term basis. The INMS primarily relates to combined application of different sources of plant nutrients (organic and inorganic) for sustainable crop production without degrading the natural resource base, the soil and that too, on long term basis.

The increased organic and inorganic fertilizer application rates have obvious effect in increasing vegetative growth of crop pants. Integrated nutrient management (INM) has been suggested for the replenishment of nutrients which removed by the crop from the soil, maintenance of humus level in the soil, i.e. physical texture of the soil, avoidance of weeds, pests and diseases and control of soil acidity and toxicity. The role of soil biota in these principles of INM cannot be undermined, since soil microbes contribute in a big way to the soil organic matter dynamics, nutrient use. Integration of inorganic and organic sources of nutrients was found to give higher productivity and more monetary returns. Therefore, use of balance fertilization is essential in integrated manner to sustain the crop production and soil fertility. The production potential of barley can be increased with the application of manures in combination with chemical fertilizers.

Farm yard Manure is prepared basically using cow dung, cow urine, waste straw and other dairy wastes. It is highly useful and some of its properties are as follows. FYM is rich in nutrients. A small portion of N is directly available to the plants while a larger portion is made available as and when the FYM decomposes. Organic fertilizers can be used for crop production as a substitute for chemical fertilizers. Application of farmyard manure to improve the organic carbon and there by the total nitrogen content of the soil. The beneficial effects of farmyard manure alone or in combination with fertilizers have also been observed by Kumar *et al.* (2000) [13]. Application of 5 t ha^{-1} FYM in combination with different rates of inorganic Nitrogen and Phosphorus significantly increased NP uptake by grain, straw. Mulching is a common practice to cover soil surface and it not only conserves moisture but also moderates temperature besides effectively controlling the weeds. It creates congenial conditions for the growth and ameliorates various environmental stresses. Mulching involves covering the soil surface to conserve moisture, control weeds, and increase the populations of beneficial microflora thereby augmenting the crop yield. Crop residue mulches are also effective in conserving moisture, increasing yield and reducing erosion. It also increases the soil-water storage in the root zone.

Materials and Methods

Study area

The experimental farm is situated at 30^0 32’ N latitude and $74^0$53’ E longitudes, with an elevation of 1391 m above mean sea level. The soil of the experimental field was slightly acidic in reaction, medium in organic carbon, low in available nitrogen and medium in organic carbon, low in available nitrogen and medium in available phosphorus and potassium. The pH of the experimental soil was slightly acidic in reaction with an electrical conductivity of dSm^{-1}, medium in organic carbon, low in available nitrogen, medium in available phosphorus, potassium.

Table 1: Initial soil parameters of the experimental soil

Sr. No.	Parameters	Values obtained	Methods of analysis Reference
1	pH (1:2.5, soil: water suspension)	5.54	Potentiometric (Page *et al.* 1982) [21]
2	EC (dS m^{-1})	0.29	EC meter (Page *et al.*, 1982) [21]
3	Organic carbon (%)	0.43%	Rapid titration method (Walkley and Black 1934) [22]
4	Available N	263.09	Alkaline permanganate method (Subbiah and Asija 1956) [23]
5	Available P	23.59	Olsen’s method of extraction with 0.5N $NaHCO_3$ at pH 8.5 (Olsen *et al.* 1954) [24]
6	Available K	278.11	Ammonium acetate extraction method (Jackson, 1973) [25]

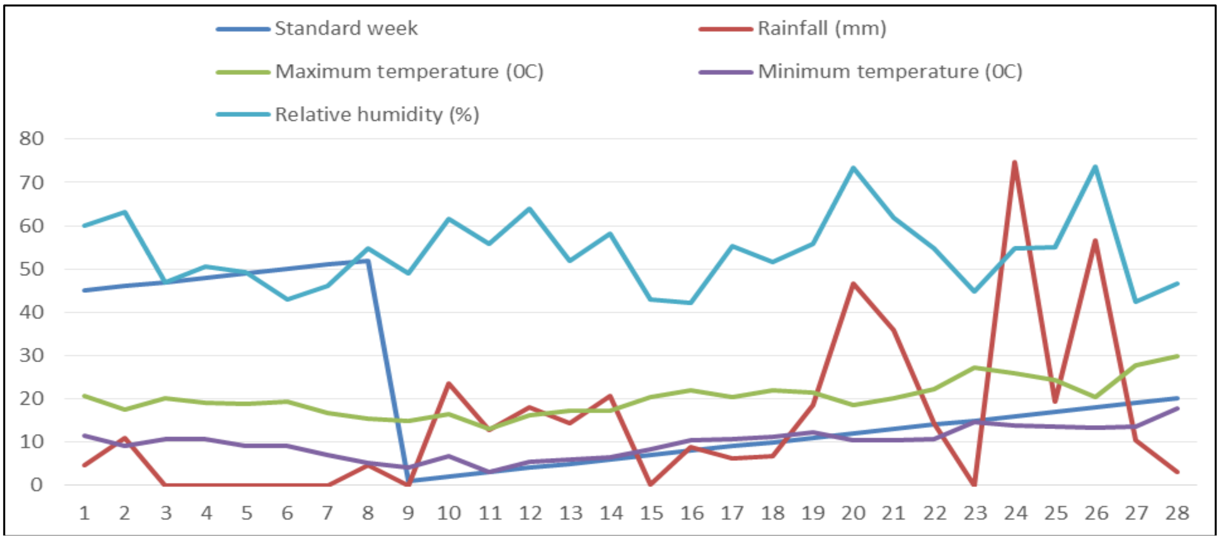

Fig 1: Mean weekly whether data experiment

Treatments and experimental design

The experiment was laid out in a randomized block design (RBD) with seven treatments and three replications. The treatments, *viz*., T_1= RDF (recommended dose of fertilizer), T_2= T_1 + FYM 5 t ha^{-1}, T_3= T_1 + FYM 5 t ha^{-1} + mulch, T_4= T_3 + spray of $ZnSO_4$ @ 0.5%, T_5 = T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis), T_6= 50% RDF + 50% N Vermicompost, T_7 = Absolute control. The gross plot size was 3.0 m × 2.5 m= 7.5 m^2 and the net plot size was 2.0 m × 1.5 m= 3.0 m^2. All nutrients were applied according to the treatments in experiment. Recommended dose of 40:20:20 kg ha^{-1} (N, P_2O_5 and K_2O) were applied through Urea, DAP and MOP. At the time of the most recent ploughings, FYM and vermicompost were applied in the field. Full dose of phosphorous and potassium and half dose of nitrogen were applied at the time of sowing. The remaining nitrogen was applied as a top dressing in two equal splits: 25% at 40 DAS and 25% a half dose of phosphorus, and potash were applied as the basal dose. Similar to RDF, half of the nitrogen delivered to each 75% RDF plot was used as basal, while the remaining nitrogen was top dressed. Foliar spray of $ZnSO_4$ @ 0.5% was given was applied at two stage i.e., at flage leaf stage and second at post anthesis stage. Seed rate was used as 100 kg ha^{-1}. Seed was shown by line method. All of the plots were sown on November 10, 2022. Considering that the crop was raised for grain. Once the crop reached physical maturity, the barley was harvested.

Data collection

Observations include growth parameter like plant height (cm), no. of tillers (m^{-2}) and dry matter accumulation (g m^{-2}) at periodic interval of 30 days, yield attributes via. no. of effective tillers(m^{-2}), spike length (cm), no. of spikes (m^{-2}), grains per $spike^{-1}$ and test weight(g) and yields *i.e.*, grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) of barley crop.

Results and Discussion

Plant height (cm)

The information concerning to plant height of barley as affected by different nutrient treatments were recorded at 30, 60, 90 DAS and at harvest are presented in Table 2 and graphically shown in Table 2.

The data displayed in Table 2 and Fig. 2 indicated that the plant grew at a relatively sluggish pace in the first 60 days following seeding and after that, the plant's height increased rapidly until maturity, or the grand growth period. Plant height rose gradually up to the harvest stage, while after 90 DAS the increase was comparatively higher. Plant height was significantly impacted by different applications of organic manure, mulching, and chemical fertilizers at every stage of crop growth, with the exception of 30 DAS. The highest plant height measured under treatment T_7 was considerably higher than that of the other treatments and comparable to T_4 (T_3 + $ZnSO_4$ @0.5%) at all stages of crop growth, with the exception of 30 DAS. The minimum height of the plants was noted under treatment T_7 (Absolute control 68.83 cm) during the investigation. The lack of mulch covering the field and the application of fertilizer and manure were the primary causes of the decline in plant height. The growth of barley crops, including plant height, can be linked to the optimal application of both organic and inorganic fertilizers, mulch made from rice residue, and slow mineralization of nutrients. Additionally, the enhanced moisture-holding capacity of the soil owing to FYM may also play a role in this growth. The plot where mulch was applied ensured higher plant height than the other treatments when compared to other plots. Pareta *et al.* (2009) [26], Kumar *et al.* (2000) [13] and Kumawat *et al.* (2015) [14] all reported findings that were similar. The RDF produced taller plants mainly due to of better utilization of nitrogen and other nutrients that were responsible for plant height growth and development as supported by Gupta *et al.* (2010) [27].

Table 2: Effect of organic manure, mulching and chemical fertilizers on plant height of Barley

Sr. No	Treatment	30 DAS (cm)	60 DAS (cm)	90 DAS (cm)	At Harvest (cm)
T_1	RDF (recommended dose of fertilizer)	18.75	49.21	85.15	91.33
T_2	T_1 + FYM 5 t ha^{-1}	20.52	51.30	86.88	92.60
T_3	T_1 + FYM 5 t ha^{-1} + mulch	22.65	53.69	87.88	94.62
T_4	T_3 + spray of $ZnSO_4$ @ 0.5%	25.50	58.23	96.08	99.85
T_5	T_4 + 2 spray of $ZnSO_4$ at flag leaf and post anthesis stage	26.82	60.10	98.34	101.58
T_6	50% RDF + 50% N Vermicompost	16.79	45.80	83.47	90.54
T_7	Absolute control	16.30	41.32	68.43	68.83
	CD at 5%	N/S	5.28	9.93	7.24
	Sem±	2.57	1.69	3.19	2.32

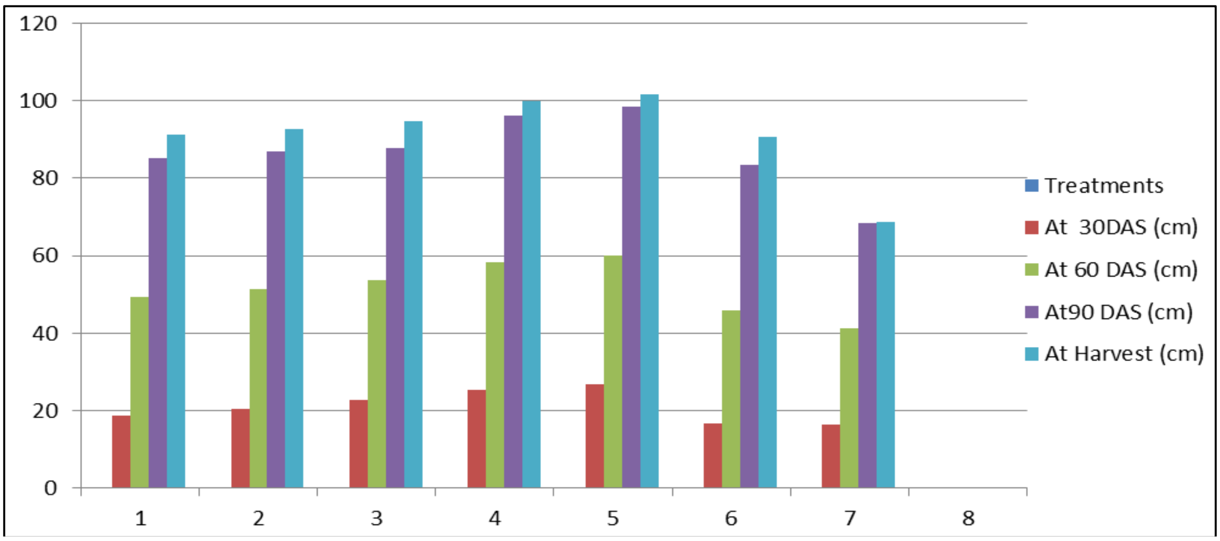

Fig 2: Effect of organic manure, mulching and chemical fertilizers on plant height on Barley

No. of tillers (m^{-2})

Table 3 presents the data on the number of tillers (m^{-2}) that was recorded at several phases of crop growth, including 30, 60, 90 DAS, and harvest. The data is visually depicted in Fig. 3. Tiller development generally occurred extremely quickly between 30 and 90 DAS; the highest number of tillers was observed at 90 DAS, and after that, crop aging led to a progressive decrease in the number of tillers. Additives had a substantial impact on the quantity of tillers at every stage of the crop, with the exception of 30 DAS. During the experiment, T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)] produced the largest number of tillers m-2, outperforming all other treatments by a wide margin and matching T_4 (T_3 + spray of $ZnSO_4$ @ 0.5%). Throughout the trial, T_7 (Absolute control) had the fewest tillers.

The inability to apply manure and fertilizer, as well as to cover the field with mulch, was the primary factor contributing to the decrease in the number of tillers. Conversely, the best possible application of mulch made from rice residue and organic and inorganic fertilizer boosted the growth of the barley crop, including the number of tillers. The temperature variations between the mulching treatments and the moisture level of the soil could be the cause of this. Compared to control, straw mulch preserved greater soil moisture. In addition to greatly improving plant water usage efficiency and reducing the need for tillers, soil mulching improved the amount of stored moisture available in the soil profile. This growth might have been explained by the nutrients' slow mineralization and availability, as well as the soil's enhanced ability to retain moisture as a result of FYM. Pareta *et al*. (2009) [26], Kumar *et al*. (2000) [13], and Al Amin *et al*. (2017) [1] all reported findings that were comparable.

Table 3: Effect of organic manure, mulching and chemical fertilizer on no. of tillers (m^{-2}) of barley

S. No.	Treatment	30 DAS (m^{-2})	60 DAS (m^{-2})	90 DAS (m^{-2})	At harvest (m^{-2})
T_1	RDF (recommended dose of fertilizer)	133.31	285.72	269.59	263.16
T_2	T_1 + FYM 5 t ha^{-1}	139.03	322.01	312.04	301.16
T_3	T_1 + FYM 5 t ha^{-1} + mulch	141.78	350.21	333.32	321.09
T_4	T_3 + spray of $ZnSO_4$ @ 0.5%	152.98	410.00	412.76	397.06
T_5	T_4 + 2 spray of $ZnSO_4$ at flag leaf and post anthesis stage	155.53	431.58	433.64	416.61
T_6	50% RDF + 50% N Vermicompost	121.11	229.45	213.15	201.13
T_7	Absolute control	81.26	172.97	160.78	153.72
CD at 5%		13.24	32.25	31.64	40
S.Em±		4.25	10.35	10.15	12.83

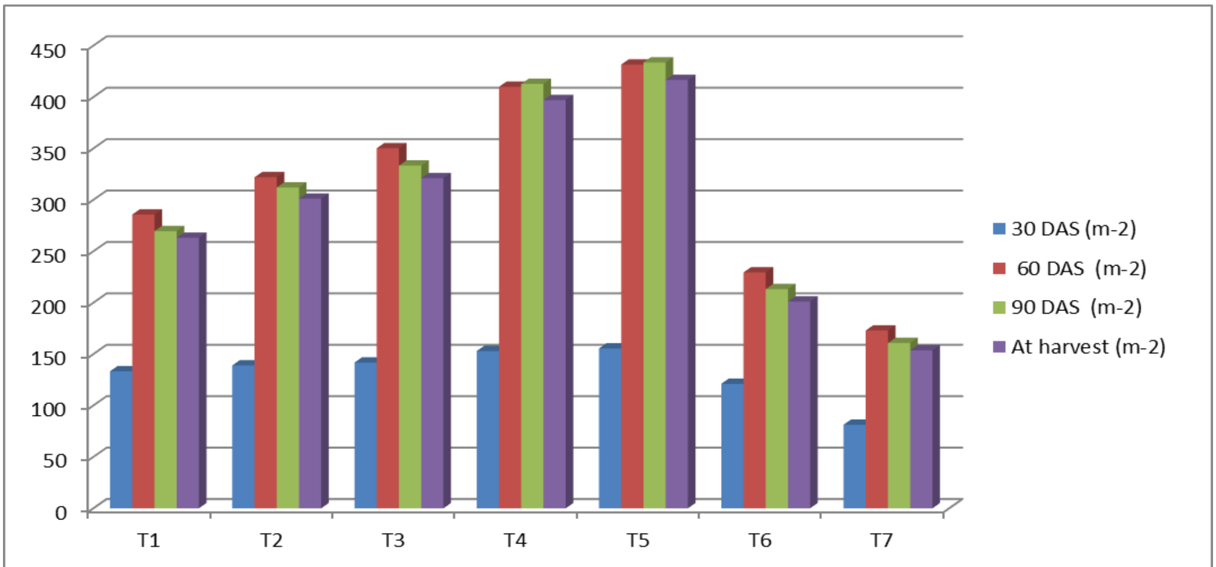

Fig 3: Effect of organic manure, mulching and chemical fertilizers on number of tillers (m^{-2}) of Barley

Dry matter accumulation (g m^2)

The data pertaining to dry matter accumulation at successive stages of crop growth were summarized in Table 4 and depicted in Fig.4. Among the various treatments, dry matter accumulation influenced significantly at all stages of crop growth except 30DAS. The dry matter production was very slow in the initial stage, up to 30 days after that was found faster up to maturity of the crop. The dry matter increased with increase in the age and maximum dry matter accumulation recorded under T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)] which was at par with T_4 (T_3 + spray of $ZnSO_4$ @ 0.54%) and significantly superior to the rest treatments at 60, 90 DAS and at harvest stages but it was found non-significant at 30 DAS. Mulching might have reduced the fluctuation of soil temperature and increased the soil moisture and resulted in more rapid crop growth and produced more dry matter accumulation. Application of organic and inorganic fertilizer resulted in increase in leaf area resulted in better interception and utilization of radiant energy which led to higher photosynthesis and ultimately more dry matter accumulation. Similar results were reported AlAmin *et al*. 2017 [1] and Randhawa *et al*. 2020 [15].

Table 4: Effect of organic manure, mulching and chemical fertilizers on dry matter accumulation of Barley

Sr. No.	Treatment	30 DAS (g m^{-2})	60DAS (gm^{-2})	90 DAS (gm^{-2})	At harvest (gm^{-2})
T_1	RDF (recommended dose of fertilizer)	85.59	375.61	645.28	753.99
T_2	T_1 + FYM 5 t ha^{-1}	86.29	389.17	646.18	775.79
T_3	T_1 + FYM 5 t ha^{-1} + mulch	87.31	390.74	650.39	779.92
T_4	T_3 + spray of $ZnSO_4$ @ 0.5%	89.41	418.91	698.73	813.35
T_5	T_4 + 2 spray of $ZnSO_4$ at flag leaf and post anthesis stage	91.86	430.81	720.31	850.98
T_6	50% RDF + 50% N Vermicompost	84.39	370.53	630.35	740.59
T_7	Absolute control	61.98	309.38	586.39	693.00
S.Em±		6.92	12.37	19.71	22.18
CD (P=0.05)		N/A	38.54	61.41	69.11

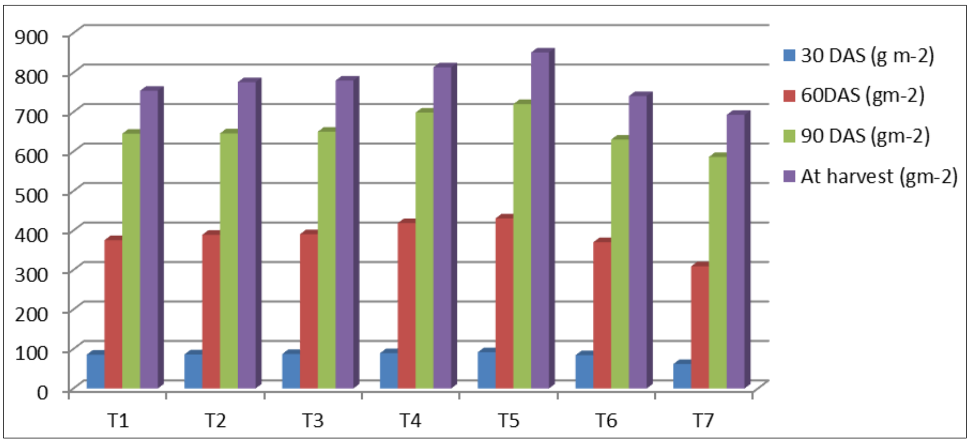

Fig 4: Effect of organic manure, mulching and chemical fertilizers on dry matter accumulation (gm^{-2}) of Barley

Yield attributes

Number of effective tillers (m^2)

Data regarding to no. of spike (m^2) have been presented in Table 4.4 and depicted in fig. 4.4, indicated that the effect of organic manure, mulching and chemical fertilizer on number of effective tillers (m^2) was found significant. The maximum number of effective tillers (m^2) recorded under treatment T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)] which was at par with treatment T_4 (T_3 + spray of $ZnSO_4$ @ 0.54%) while significantly higher than rest of treatments. The lowest number of effective tiller was found under treatment T_7 (Absolute control) during the investigation. Number of effective tillers m^{-2} was found significant by mulching treatments. The highest number of effective tillers m^{-2} was obtained from mulch @ 5 t/ha which was significantly higher than control and it was statistically at par with straw mulch @ 10 t/ha. Lowest number of effective tillers m^{-2} was found in control.

Length of spikes (cm)

Data regarding to length of spikes (cm) were presented in table 4.4 and illustrated in figure 4.4. Data revealed that 2 spray of $ZnSO_4$ at flag leaf and post anthesis, mulching and RDF of fertilizer had significant effect on length of spike. The maximum spike length (8.36 cm) was noted in treatment T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)] which was at par with T_4 [T_3 + spray of $ZnSO_4$ @ 0.54% (7.98)] while significantly higher than rest of treatments. However, the least spike length was observed under treatment T_7 during the experimentation.

Number of grains spike^{-1}

Data presented in Table 4.4 and depicted in fig.4.4 revealed that the different treatments had no significant effect on number of grains spike^{-1}. However, the maximum no. of grains spike^{-1} (39.62) was noted in treatment T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)]. And, the least no. of grains spike^{-1} was observed under treatment T_7 [Absolute control (27.59)] during the experimentation.

Test weight

Data presented in Table 4.4 and depicted in fig.4.4 revealed that the different treatments had no significant effect on test weight. Nevertheless, during the experiment, treatment T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)] recorded the highest test weights (40.32 g) and treatment T_7 [Absolute control (36.11 g)] recorded the lowest test weights.

Table 5: Effect of organic manure, mulching and chemical fertilizers on yield attribures of barley

Sr. No.	Treatment	No of effective tillers (m^{-2})	Spikes length (cm)	No. of grain per spike	Test weight (g)
T_1	RDF (recommended dose of fertilizer)	266.58	6.91	32.52	37.25
T_2	T_1 + FYM 5 t ha^{-1}	310.26	7.19	34.84	38.16
T_3	T_1 + FYM 5 t ha^{-1} + mulch	336.16	7.44	35.90	38.06
T_4	T_3 + spray of $ZnSO_4$ @ 0.54%	401.49	7.98	37.62	39.58
T_5	T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)	425.12	8.36	39.62	40.32
T_6	50% RDF + 50% N Vermicompost	237.39	6.47	31.69	36.43
T_7	Absolute control	154.92	5.32	27.59	36.11
S.Em±		12.03	0.21	2.90	2.16
CD (P=0.05)		25.81	0.66	NS	NS

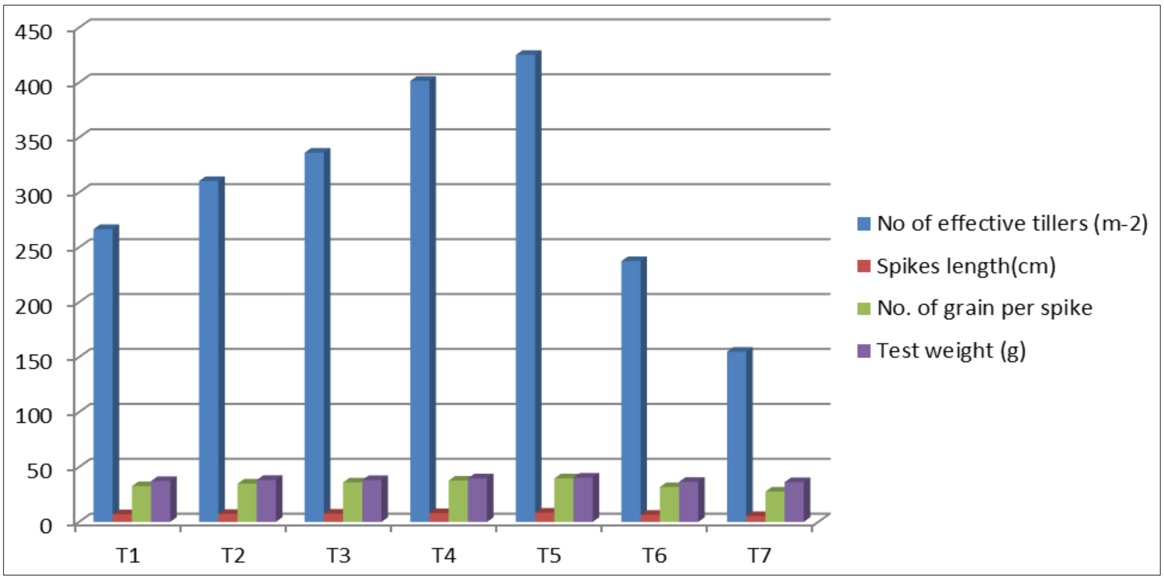

Fig 5: Effect of organic manure, mulching and chemical fertilizers on yield attribures of barley

Grain yield (q ha^{-1})

Data pertaining to grain yield presented in Table 4.5 and graphically depicted in fig, 4.5, revealed that grain yield of barley was significantly affected by various nutrient and mulching treatments. The maximum grain yield (45.74 q ha^{-1}) was obtained under treatment T_5 [T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)] which was at par T_4 [T_3 + spray of $ZnSO_4$ @ 0.5% (44.28 q ha^{-1})] while significantly higher than other treatments. The lowest grain yield was recorded under treatment T_7 (21.43 q ha^{-1}) where no nutrient management and mulching was done. Rest of the treatments follows a pattern of $T_3>T_2>T_1>T_6$ (Higher to lower) during the investigation.

Application of FYM @ 5 t ha^{-1} along with chemical fertilizer and mulching had shown significant higher grain yield than the rest of the treatment. This is quite obvious due to addition of NPK through farmyard manure. Organic manure (farmyard manure) influences favourably plant growth and yield is thus increased as a direct or indirect consequence. Ground cover through mulch reduces soil water evaporation and ensures that a high proportion of the soil water is used as transpiration. Which ultimately improved the plant growth and results in higher grain yield. Similar result was found by Banik, P., & Sharma, R. C. (2008) [4].

Straw yield (q ha^{-1})

The perusal of data presented in table 4.5, illustrated in fig. 4.5, recorded that the maximum straw yield under 2 spray of $ZnSO_4$ at flag leaf and post anthesis stages with other additives i.e., RDF of chemical fertilizer, FYM @ 5 t ha^{-1} and rice residue mulching (65.72 q ha^{-1}) which was at par with T_4 [T_3 + spray of $ZnSO_4$ @ 0.54% (62.25 q ha^{-1})] while significantly higher than rest of other nutrient additives. However, the minimum straw yield was found under treatment T_7 (Absolute control, 31.64 q ha^{-1}) during the investigation. The straw yield increase due to the application of 100% RDF, FYM 5 t ha^{-1} and residue mulch was in the range of 52.63, 56.18, 57.36, and 62.25, respectively, over treatments $T_3>T_2>T_1>T_6$ (during the investigation). The increased supply of N, P, and K and their higher uptake by plants may have stimulated the rate of various physiological processes in the plant, leading to increased growth and yield parameters, and ultimately increased grain and straw yield of the plant. Alternatively, the increased grain and straw yields with the application of chemical fertilizers may be due to a better nutritional environment in low nitrogen and phosphorus soil, as evidenced by their uptake in the plant. Moreover, mulching might have been crucial in transforming unavailable soil moisture into accessible forms, which would have enhanced nutrient intake and raised output. The increase in production may possibly be attributable to improved soil nutrient uptake, which may have contributed to increased dry matter buildup and the number of tillers plant-1, resulting in increased grain and straw yield of barley. Similar result was found by Karol, A., Sharma, P. K., Raj, A., Rawat, A., & Shaji, A. (2023) [12].

Biological yield (q ha^{-1})

The application of RDF (recommended dose of fertilizer)+ FYM 5 t ha^{-1} + mulch + 2 spray of $ZnSO_4$ (flag leaf and post anthesis) (T_5) gave significantly highest biological yield of barley (111.46 q ha^{-1}) over RDF (recommended dose of fertilizer) (T_1), T_1 + FYM 5 t ha^{-1} (T_2), T_1 + FYM 5 t ha^{-1} + mulch (T_3) and 50% RDF+ 50% N through vermicompost (T_6) but remained at par with application of T_4 [T_3 + spray of $ZnSO_4$ @ 0.54%(106.53 q ha^{-1})] as shown in table 4.5 and illustrate in fig 4.5. Nutrient additives along with mulch had significantly influenced the biomass yield of barley crop. This might be due to adequate availability of all plant nutrients which contributed to increase dry matter accumulation. Productivity of biomass yield of a crop is collectively determined by vigour of the vegetative growth, development as well as yield attributes. Better vegetative growth coupled with high yield attributes resulted into higher biomass yield. The minimum biomass yield recorded under treatment T_7 lowest yield might be due to both poor growth and yield attributes. Biological yield improved significantly due to various additives along with RDF over RDF applied alone. Similar results were found by Kumar and Singh, 2018 [11].

Harvest index (%)

The data presenting to harvest index was presented in table 4.5 and fig 4.5. The data clearly indicated that harvest index did not influenced significantly by various treatments during the investigation. However, the highest harvest index was recorded under treatment T_4 and the lowest harvest index was recorded under treatment T_2.When zinc was applied typically to barley plant during their reproductive growth stage, their grain and straw yields improved noticeably. Different nutrient strategies had no discernible impact on the harvest index.

Table 6: Effect of organic manure, mulching and chemical fertilizers on grain yield, straw yield, biological yield and harvest index of Barley

Sr. No	Treatment	Grain yield (qha^{-1})	Straw yield (qha^{-1})	Biological yield (qha^{-1})	Harvest index (%)
T_1	RDF (recommended dose of fertilizer)	36.28	52.63	88.91	40.83
T_2	T_1 + FYM 5 t ha^{-1}	37.44	56.18	93.62	39.95
T_3	T_1 + FYM 5 t ha^{-1} + mulch	39.82	57.36	97.18	40.94
T_4	T_3 + spray of $ZnSO_4$ @ 0.5%	44.28	62.25	106.53	41.59
T_5	T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis)	45.74	65.72	111.46	41.02
T_6	50% RDF + 50% N Vermicompost	33.35	48.63	81.98	40.65
T_7	Absolute control	21.43	31.64	53.07	40.37
CD (P=0.05)		4.47	5.69	5.52	NS
S.Em±		2.80	2.65	2.57	0.79

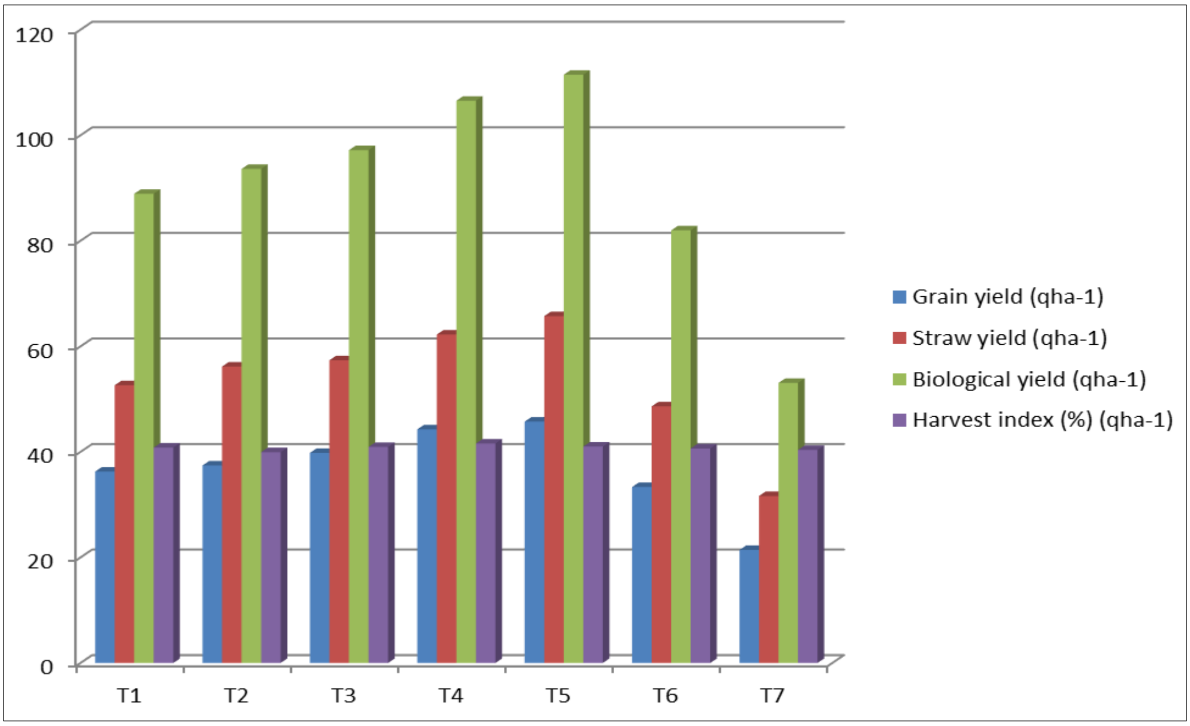

Fig 6: Effect of organic manure, mulching and chemical fertilizers on grain yield, straw yield, biological yield and harvest index of Barley

Conclusion

Based on the findings of an experiment carried out during the Rabi season of 2022-23, it can be said that: Treatment T_5= T_4 + 2 spray of $ZnSO_4$ at flag leaf and post anthesis stages promote growth parameters and gave maximum yield than the rest of the treatment. The higher yield of barley could be achieved by adopting organic manure, mulching and chemical fertilizers treatment as T_5- T_4 + 2 spray of $ZnSO_4$ (flag leaf and post anthesis). The higher net return of (Rs. 64018 ha^{-1}) was obtained under T_5 – RDF+ FYM5 t ha^{-1} + mulch+ 2 spray of $ZnSO_4$ @ 0.5% (flag leaf and post anthesis) and net returns per rupees invested (1.61) was recorded under treatment T_1. (RDF (recommended dose of fertilizer).

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