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Effect of nutrient management on growth, yield attribute and yield of barley crop (*Hordeum vulgare* L.) in barley-fodder sorghum cropping sequence

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Abstract

A field experiment was conducted at Agricultural Research farm of R. B. S. College Bichpuri, Agra to study the effect of nutrient management on growth, yield attribute and yield of barley crop in barley-fodder sorghum crop sequence during 2021-22 and 2022-23.The experiment was laid out in randomized block design with three replications. The treatments were comprised of T_1 Control, T_2 N60, T_3 N120, T_4 N60 P30, T_5 N120 P60, T_6 N60 P30 K30, T_7 N120 P60 K60, T_8 N60 P30 K30 Zn5, T_9 N120 P60 K60 Zn5, T_{10} N60 P30 K30 S20, T_{11} N120 P60 K60 S20 and T_{12} N60 P30 K30 VC5. Results revealed that the aapplication of @ (T_9) 120kg N + 60kg P_2O_5 + 60kg K_2O + 5kg Zn ha^{-1} recorded significantly higher the number of tillers $meter^{-1}$, plant height, ear length, grain ear^{-1}, test weight, grain yield, straw yield and biological yield over control. Similarly, the increase in the number of tillers $meter^{-1}$, plant height, ear length, grain ear^{-1}, test weight, grain yield, straw yield and biological yield of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management over control.

Keywords: INM, yield attribute, yield, barley crop

Introduction

Barley (*Hordeum vulgare* L.) is the world´s fourth most important cereal crop after wheat, rice and maize and the most dependable crop in alkali soils and areas where frost or drought occurs. The major use of barley grain is in brewing industries for manufacturing malt which is used to make beer, industrial alcohol, whisky, malt syrups, brandy, malted milk, vinegar and yeast. In India, barley is mainly grown in the northern plains and concentrates in the states of Rajasthan, Haryana, Punjab and western UP. The average productivity of barley in the state is far behind in the attainable yield of 40-50 q/ha, due to water and nutritional stresses. Among the various constraints of its lower productivity in arid and semiarid region is erratic nature of climate, poor quality of irrigation water, inadequate fertilization, poor soil physical conditions, nutrient imbalances and deficiencies of some macro and micro nutrients. Besides these, coarse texture of the soil, poor organic matter content, low water receptivity, excessive permeability and sharp increase in soil strength upon drying are also important factors associated with low production. Nitrogen, being an essential constituent of protein nucleic acid and chlorophyll, plays a major role in photosynthesis and chlorophyll. There is a wide gap between production and consumption of N fertilizer and greater emphasis necessarily has to be laid on supplementation and use of chemical fertilizers with renewable and cheaper sources of nutrients *viz*., bio fertilizers and organics. The P input in Indian agriculture comes from fertilizers, organic manures and to a very small extent from crop residues. It is an indispensable constituent of nucleic acid, ADP and ATP. It has beneficial effects on root development, growth and also hastens maturity as well as improves quality of crop produce. The availability and form of P in the soil depends upon the native and/or added sources of phosphate fertilizer and organic matter content from external sources. The deficiency of sulphur and zinc are the most wide spread micro nutrient disorder in light textured soil and application of Zn along with NPK fertilizer increases the yield dramatically in most crops. Deficiency symptoms of sulphur in barley and sorghum crop are frequent and reduced the yield of both the crops. The integration of chemical fertilizers with organic manures has been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production. A judicious combination of organic and inorganic fertilizers can maintain long-term fertility and sustain higher productivity of crops. Integrated nutrient management approaches involving FYM and mineral sources of nutrients need to be standardized.

Materials and Methods

A field experiments were conducted at the Agriculture Research farm of R.B.S. College Bichpuri, Agra (located in semi arid or gray steppe arid region of South-Western Uttar Pradesh. the intersect of 27.2 ^{0}N attitude and 77.9 ^{0}E longitude), during two consecutive rabi seasons of 2021-22 and 2022-23 on sandy loam soil. The soil had EC 0.18 dSm^{-1}, pH 8.20, organic carbon 4.6 g kg^{-1}, available N 198.4, P 14.6, K 214.3, S 15.7 kg ha^{-1} and zinc 0.58 mg kg^{-1}. The experiment was laid out in randomized block design with three replications. The treatments were comprised of T_1 Control, T_2 N60 (60 kg N ha^{-1}), T_3 N120 (120 kg N ha^{-1}), T_4 N60 P30 (60kg N + 30kg P_2O_5 ha^{-1}), T_5 N120 P60 (120 kg N + 60 kg P_2O_5 ha^{-1}), T_6 N60 P30 K30 (60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1}), T_7 N120 P60 K60 (120kg N+60kg P_2O_5+60kg K_2O ha^{-1}), T_8 N60 P30 K30 Zn5 (60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1}), T_9 N120 P60 K60 Zn5 (120kg N+60kg P_2O_5+60kg K_2O +5kgZn ha^{-1}), T_{10} N60 P30 K30 S20 (60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}), T_{11} N120 P60 K60 S20 (120kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1}) and T_{12} N60 P30 K30 VC5 (60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1}). The half of N and full amount of P, K , Zn and S as per treatments were applied at time of sowing and remaining N was top dressed at two stages in equal amount. The source N, P_2O_5 K_2O, Zn and S were applied as urea, single super phosphate, muriate of potash and zinc sulphate respectively. Vermicompost (1.07 %N, 0.86% P 1.79 %K) were applied before 15 days of sowing. The barley crop (BH-393) was sown in the third week of November during both the years using @ 100 kg seed ha^{-1}. The crop was harvested at physiological maturity and grain and straw yields were recorded. The observations on growth and yield attributes were recorded at harvest.

Results and discussion

Number of tillers:

The number of tillers meter^{-1} row length of barley crop increased significantly with each nutrient management treatment as compared to control. Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O +5kg Zn ha^{-1} recorded significantly higher the number of tillers meter^{-1} row length of barley crop (72.3, 70.3, 71.3) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (69.3, 68.7, 69.0), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (67.7, 65.7, 66.7), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (64.0, 63.3, 63.7), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (62.7, 62.0, 62.3), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (61.7, 60.7, 61.2), (T_3) 120 kg N ha^{-1} (59.7, 58.7, 59.2), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (57.0, 56.3, 56.7), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (56.7, 55.3, 56.0), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (55.0, 54.0, 54.5), (T_2) 60 kg N ha^{-1} (53.7, 53.3, 53.5), and (T_1) control (50.3, 50.7, 50.5) at both the years and pooled analysis. Similarly, the increase in number of tillers meter^{-1} row length of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 5.9, 7.9, 10.9, 12.2, 17.2, 21.1, 23.4, 26.1, 32.0, 36.6 and 41.3 % respectively during the pooled data of the two years respectively (Table 1). Jat et al. (2023), application of 125% RDF in conjunction with FYM 5 t/ha had significant effect on effective tillers (45.36), which was at par with 100% RDF + FYM 5 t/ha. Prasad et al. (2019).

Plant height

Among the nutrient management treatments, application of (T_9) @ 120kg N+60kg P_2O_5+60kg K_2O +5kg Zn ha^{-1} recorded significantly higher plant

Table 1: Effect of nutrient management treatments on no. of tillers and plant height of barley crop in barley-fodder sorghum cropping sequence

Treatments	No. of tillers (M^{-1})			Plant height (cm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T1	50.3	50.7	50.5	61.6	60.0	60.8
T2	53.7	53.3	53.5	66.1	65.7	65.9
T3	59.7	58.7	59.2	78.0	78.5	78.3
T4	56.7	55.3	56.0	70.3	72.4	71.3
T5	61.7	60.7	61.2	81.9	83.0	82.5
T6	55.0	54.0	54.5	68.1	69.2	68.7
T7	62.7	62.0	62.3	84.9	86.1	85.5
T8	57.0	56.3	56.7	73.8	75.1	74.4
T9	72.3	70.3	71.3	96.2	97.3	96.8
T10	64.0	63.3	63.7	87.2	89.1	88.2
T11	69.3	68.7	69.0	92.1	94.1	93.1
T12	67.7	65.7	66.7	89.0	92.0	90.5
SEm±	1.18	1.34	0.92	1.56	1.39	1.09
CD @ 5%	2.44	2.78	1.90	3.23	2.89	2.27

height of barley crop (96.2, 97.3 and 96.8 cm) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (92.1,94.1 and 93.1 cm), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t Vermicompost ha^{-1} (89.0, 92.0 and 90.5 cm), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (87.2, 89.1 and 88.2 cm), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (84.9, 86.1 and 85.5 cm), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (81.9, 83.0 and 82.5 cm), (T_3) 120 kg N ha^{-1} (78.0, 78.5 and 78.3 cm), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (73.8, 75.1 and 74.4 cm), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (70.3, 72.4 and 71.3 cm), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (68.1, 69.2 and 68.7 cm), (T_2) 60 kg N ha^{-1} (66.1, 65.7 and 65.9 cm), and (T_1) control (61.6, 60.0 and 60.8 cm) at both the years and pooled analysis. Similarly, the increase in plant height of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 8.39, 12.91, 17.30, 22.40, 28.70, 35.64, 40.63, 45.01, 48.82, 53.13 and 59.16 % respectively during the pooled data of the two years (Table 1). These results are in agreement with the opinion of Singh 2017), the maximum values of plant height were recorded at 75% NPK+5t FYM ha^{-1} + biofertilizer and minimum in control. Munna et al. (2019) and Prasad et al. (2019), the best treatment for maximum growth parameters was noted in treatments applied with combination of both high concentration of NPK and FYM.

Ear Length

Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O +5kg Zn ha^{-1} recorded significantly increased the ear length of barley crop (9.37, 9.87, 9.62 cm) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (9.13, 9.63, 9.38 cm), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (8.92, 9.42, 9.17 cm), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (8.78, 9.28, 9.03 cm), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (8.64, 9.04, 8.84 cm), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (8.50, 8.89, 8.69 cm), (T_3) 120 kg N ha^{-1} (8.38, 8.71, 8.55 cm), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (8.24, 8.51, 8.38 cm), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (8.00, 8.29, 8.15 cm), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (7.74, 8.00, 7.87 cm), (T_2) 60 kg N ha^{-1} (7.41, 7.67, 7.54 cm), and (T_1) control (6.78, 6.96, 6.87 cm) at both the years and pooled analysis. Similarly, the increase in ear length of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 9.7, 14.5, 18.6, 21.9, 24.4, 26.5, 28.7, 31.4, 33.5, 36.6 and 40.0 % respectively during the pooled data of the two years respectively (table-2).Our findings are in agreement with those of Ravali et al. (2020) the growth parameters (plant height, number of tillers per meter row length, dry matter accumulation) increased significantly with every addition of 15 kg N/ha up to 60 kg N/ha at all the periodical stages of crop without any exception.

Grain ear^{-1}

Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O + 5kg Zn ha^{-1} recorded significantly higher grain ear^{-1} of barley crop (54.67, 57.67, 56.17) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (52.67, 56.33, 54.50), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (50.67, 54.00, 52.33), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (49.00, 52.33, 50.67), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (47.00, 50.33, 48.67), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (45.33, 48.00, 46.67), (T_3) 120 kg N ha^{-1} (43.67, 46.33, 45.00), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (42.33, 44.67, 43.50), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (41.00, 42.33, 41.67), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (39.33, 40.67, 40.00), (T_2) 60 kg N ha^{-1} (37.33, 38.67, 38.00), and (T_1) control (35.33, 36.00, 35.67) at both the years and pooled analysis. Similarly, the increase in grain ear^{-1} of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 6.5, 12.1, 16.8, 22.0, 26.2, 30.8, 36.4, 42.1, 46.7, 52.8 and 57.5 % respectively during the pooled data of the two years respectively (Table 2). An earlier study conducted by Jat et al. (2023) reported that, application of 125% RDF in conjunction with FYM 5 t/ha had significant effect on yield attributes, viz. effective tillers (45.36), ear length (9.37 cm), ear weight (3.22g), grains/ear (54.49), grain weight/ear (2.70 g), straw weight/ear (0.52 g), filled spikelet/ear (54.47), least number of unfilled spikelet/ear (3.24) and test weight (49.92 g), and grain (5.20 t/ha), straw (7.79 t/ha) and biological yield (12.99 t/ha) which was at par with 100% RDF + FYM 5 t/ha.

Test weight

Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O +5kg Zn ha^{-1} observed significantly higher test weight (gm) of barley crop (52.74, 54.02, 53.38 gm) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O+20kg S ha^{-1} (51.30, 52.53, 51.92 gm), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (48.93, 49.97, 49.45 gm), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (47.32, 48.39, 47.85

Table 2: Effect of nutrient management treatments on ear length, grain ear^{-1} and test weight of barley crop in barley-fodder sorghum cropping sequence

Treatments	Ear Length (cm)			Grain Ear^{-1}			Test weight (gm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T1	6.78	6.96	6.87	35.33	36.00	35.67	36.37	36.81	36.59
T2	7.41	7.67	7.54	37.33	38.67	38.00	38.82	39.27	39.05
T3	8.38	8.71	8.55	43.67	46.33	45.00	42.38	43.50	42.94
T4	8.00	8.29	8.15	41.00	42.33	41.67	40.15	41.17	40.66
T5	8.50	8.89	8.69	45.33	48.00	46.67	43.45	44.96	44.21
T6	7.74	8.00	7.87	39.33	40.67	40.00	39.52	40.17	39.84
T7	8.64	9.04	8.84	47.00	50.33	48.67	45.33	46.50	45.92
T8	8.24	8.51	8.38	42.33	44.67	43.50	41.27	42.41	41.84
T9	9.37	9.87	9.62	54.67	57.67	56.17	52.74	54.02	53.38
T10	8.78	9.28	9.03	49.00	52.33	50.67	47.32	48.39	47.85
T11	9.13	9.63	9.38	52.67	56.33	54.50	51.30	52.53	51.92
T12	8.92	9.42	9.17	50.67	54.00	52.33	48.93	49.97	49.45
SEm±	0.09	0.085	0.07	1.33	1.45	0.82	0.97	1.65	1.12
CD @ 5%	0.19	0.177	0.15	2.75	3.00	1.69	2.01	3.42	2.33

gm), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (45.33, 46.50, 45.92 gm), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (43.45, 44.96, 44.21 gm), (T_3) 120 kg N ha^{-1} (42.38, 43.50, 42.94 gm), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (41.27, 42.41, 41.84 gm), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (40.15, 41.17, 40.66 gm), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (39.52, 40.17, 39.84 gm), (T_2) 60 kg N ha^{-1} (38.82, 39.27, 39.05 gm), and (T_1) control (36.37, 36.81, 36.59 gm) at both the years and pooled analysis. Similarly, the increase in test weight (gm) of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 6.70, 8.88, 11.10, 14.34, 17.34, 20.81, 25.48, 30.77, 35.14, 41.87 and 45.87 % respectively during the pooled data of the two years respectively (table 2). Reddy et al. (2021) Thus, Integrated Nutrient Management, which uses both organic and inorganic fertilizers, results in higher barley growth, development, production, and yield characteristics.

Grain yield

The grain yield of barley crop increased significantly with each level of nutrient management treatment as compared to control. Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O + 5kg Zn ha^{-1} observed significantly higher grain yield of barley crop (47.10, 48.57, 47.83 qha^{-1}) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (45.37, 45.30, 45.33 qha^{-1}), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (43.03, 44.07, 43.55 qha^{-1}), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (40.77, 41.60, 41.18 qha^{-1}), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (39.30, 39.00, 39.15 qha^{-1}), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (37.47, 36.80, 37.13 qha^{-1}), (T_3) 120 kg N ha^{-1} (36.02, 34.33, 35.18 qha^{-1}), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (34.23, 32.47, 33.35 qha^{-1}), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (32.23, 30.50, 31.37 qha^{-1}), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (29.90, 28.87, 29.38 qha^{-1}), (T_2) 60 kg N ha^{-1} (28.13, 27.50, 27.82 qha^{-1}), and (T_1) control (25.83, 24.99, 25.41 qha^{-1}) at both the years and pooled analysis. Similarly, the increase in grain yield of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 9.47, 15.64, 23.44, 31.25, 38.43, 46.14, 54.07, 62.08, 71.39, 78.41 and 88.25 % respectively during the pooled data of the two years respectively (Table 3). According to Randhawa et al. (2020), application of 100% NPK through inorganic fertilizers (IF) increased the ear length (7.92 cm), number of grains/ear (28.3), grain yield (44.6 q/ha) and straw yield (64.6 q/ha) and at par with 75% NPK through IF + 25% N through FYM. For a sustainable agriculture practice, up to 25% inorganic fertilizers can be substituted by FYM with less yield compensation. Sharma et al. (2007) reported that the application of 187.5 kg N/ha + FYM (10 t/ha) and 150 kg N/ha + FYM (10 t/ha) + Azotobacter recorded significantly higher grain and straw yield. Munna et al. (2016) reported that the faba bean responded significantly upto 90 kg P_2O_5 ha^{-1} and increased the grain and straw yield by 13.4 and 15.7 percent, respectively, over control.

Straw yield

Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O +5kg Zn ha^{-1} observed significantly higher straw yield of barley crop (74.40, 80.38, 77.39 q ha^{-1}) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (72.48, 76.46, 74.47 q ha^{-1}), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (69.63, 74.59, 72.11 q ha^{-1}), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (67.25, 71.10, 69.18 q ha^{-1}), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (65.48, 67.88, 66.68 q ha^{-1}), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (63.06, 65.03, 64.05 q ha^{-1}), (T_3) 120 kg N ha^{-1} (61.24, 62.01, 61.62 q ha^{-1}), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (58.51, 59.30, 58.91 q ha^{-1}), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (55.83, 56.21, 56.02 q ha^{-1}), (T_6) 60kg N+ 30kg P_2O_5 + 30kg K_2O ha^{-1} (53.45, 53.95, 53.70 q ha^{-1}), (T_2) 60 kg N ha^{-1} (50.95, 2.14, 51.54 q ha^{-1}), and (T_1) control (47.52, 47.93, 47.73 q ha^{-1}) at both the years and pooled analysis. Similarly, the increase in straw yield of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) level of nutrient management treatments over control were 8.00, 12.52, 17.37, 23.43, 29.12, 34.20, 39.72, 44.95, 51.09, 56.04 and 62.15 % respectively during the pooled data of the two years respectively (Table 3). Kumar, and Jat (2021) reported that the succeeding

Table 3: Effect of nutrient management treatments on grain yield, straw yield and biological yield of barley crop in barley-fodder sorghum cropping sequence

Treatments	Grain yield qha^{-1}			Straw yield qha^{-1}			Biological yield qha^{-1}		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T1	25.8	25.0	25.4	47.5	47.9	47.7	73.4	72.9	73.1
T2	28.1	27.5	27.8	50.9	52.1	51.5	79.1	79.6	79.4
T3	36.0	34.3	35.2	61.2	62.0	61.6	97.3	96.3	96.8
T4	32.2	30.5	31.4	55.8	56.2	56.0	88.1	86.7	87.4
T5	37.5	36.8	37.1	63.1	65.0	64.0	100.5	101.8	101.2
T6	29.9	28.9	29.4	53.5	53.9	53.7	83.4	82.8	83.1
T7	39.3	39.0	39.2	65.5	67.9	66.7	104.8	106.9	105.8
T8	34.2	32.5	33.4	58.5	59.3	58.9	92.7	91.8	92.3
T9	47.1	48.6	47.8	74.4	80.4	77.4	121.5	128.9	125.2
T10	40.8	41.6	41.2	67.3	71.1	69.2	108.0	112.7	110.4
T11	45.4	45.3	45.3	72.5	76.5	74.5	117.8	121.8	119.8
T12	43.0	44.1	43.6	69.6	74.6	72.1	112.7	118.7	115.7
SEm±	1.42	1.48	1.06	2.47	2.15	1.63	3.07	1.89	1.94
CD @ 5%	2.95	3.07	2.19	5.12	4.46	3.37	6.36	3.92	4.02

crop barley crop produced the highest grain yield (61.5 q/ha) and straw yield (82.2 q ha^{-1}) of barley under 75% RDF+ 5 T (FYM)/ha + Biomix i.e. under 75% RDF+ 5 t FYM/ha + Biomix treatment which was 19.41% more over RDF.

Biological yield

Among the nutrient management treatments, application of @ (T_9) 120kg N+60kg P_2O_5+60kg K_2O +5kg Zn ha^{-1} observed significantly higher biological yield of barley crop (121.5, 128.9, 125.2 q ha^{-1}) followed by (T_{11}) 120 kg N+60kg P_2O_5+60kg K_2O +20kg S ha^{-1} (117.8, 121.8, 119.8 q ha^{-1}), (T_{12}) 60kg N+ 30kg P_2O_5+30kg K_2O+5 t vermicompost ha^{-1} (112.7, 118.7, 115.7 q ha^{-1}), (T_{10}) 60kg N+30kg P_2O_5+30kg K_2O +20Kg S ha^{-1}, (108.0, 112.7, 110.4 q ha^{-1}), (T_7) 120kg N+60kg P_2O_5+60kg K_2O ha^{-1}, (104.8, 106.9, 105.8 q ha^{-1}), (T_5) 120 kg N + 60 kg P_2O_5 ha^{-1} (100.5, 101.8, 101.2 q ha^{-1}), (T_3) 120 kg N ha^{-1} (97.3, 96.3, 96.8 q ha^{-1}), (T_8) 60kg N+30kg P_2O_5+30kg K_2O +5kg Zn ha^{-1} (92.7, 91.8, 92.3 q ha^{-1}), (T_4) 60kg N + 30kg P_2O_5 ha^{-1} (88.1, 86.7, 87.4 q ha^{-1}), (T_6) 60kg N+ 30kg P_2O_5 +30kg K_2O ha^{-1} (83.4, 82.8, 83.1 q ha^{-1}), (T_2) 60 kg N ha^{-1} (79.1, 79.6, 79.4 q ha^{-1}), and (T_1) control (73.4, 72.9, 73.1 q ha^{-1}) at both the years and pooled analysis. Similarly, the increase in biological yield of barley crop with: (T_2) > (T_6) > (T_4) > (T_8)> (T_3)> (T_5) > (T_7)> (T_{10})> (T_{12})> (T_{11})> (T_9) levels of nutrient management treatments over control were 8.5, 13.6, 19.5, 26.1, 32.4, 38.3, 44.7, 50.9, 58.1, 63.8 and 71.2 % respectively during the pooled data of the two years respectively (table 3). Our findings are in agreement with those of Kumar et al. (2020) among various nitrogen management practices treatments T10 recorded significantly higher growth parameters viz. [plant height (cm), number of tillers / m.r.l. and dry matter accumulation/plant (g/plant)] of barley. Treatment T8 (75 % RDN + Biomix+ Vermicompost @ 5t ha^{-1}) was at par with treatment T9 (RDN) and T10 (RDN + Biomix + Vermicompost @ 5t ha^{-1}) in terms of growth of barley. Karol et al. (2023) the application of 100% RDF + vermicompost 2.5 t ha^{-1} + Azotobacter (T3), the maximum plant height at 60 DAS and 90 DAS, total number of tillers at 60 DAS and 90 DAS, effective number of tillers, ear length, number of grains ear^{-1}, grain yield, straw yield, biological yield of barley were obtained.

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