Effects of Different Nutrient Management Methods on Growth and Yield of Barley (*Hordeum vulgare* L.)

ABSTRACT

A field experiment was conducted during the *Rabi* season of the year 2022-2023 at the KVK Farm, Mahendergarh of CCS Haryana Agricultural University, Hisar during *Rabi* season 2022-23 with the objective to study the effect of different nutrient management practices on growth and yield of barley. The experiment containing eleven treatments viz. Control, 100% RDF (60 kg N + 30 kg P_2O_5 + 15 kg K_2O ha^{-1}, 100% RDF) + Azotobacter + PSB, 50% RDF + Azotobacter + PSB, 50% RDF + 50% RDN through Vermicompost, 50% RDF + 50% RDN through Vermicompost+ Azotobacter + PSB, 75% RDF + Azotobacter + PSB, 75% RDF + 25% RDN through Vermicompost, 75% RDF + 25% RDN through Vermicompost + Azotobacter + PSB, 100% RDN through vermicompost and 100% RDN through vermicompost + Azotobacter + PSB. All the growth and yield parameters increased significantly with75% R.D.F + 25% N through Vermicompost. The growth characters like plant height (cm) and number of tillers/mrl were significantly higher under 75% R.D.F + 25% N through Vermicompost + Azotobacter + PSB as compared to other nutrient combinations. The yield components like spike length (cm), number of grains $spike^{-1}$, grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) were significantly higher under 75% R.D.F + 25% N through Vermicompost+ Azotobacter + PSB. Harvest index and 1000-grain weight (g) were not influenced significantly due to different nutrient combinations The nitrogen and protein content in grain were obtained higher with 75% R.D.F + 25% N through Vermicompost + Azotobacter + PSB which was significantly higher than rest of treatments. Thus, it can be concluded that a dose of 75% R.D.F + 25% N through Vermicompost+ Azotobacter + PSB may be most suitable nutrient combination for achieving higher growth and yield of barley.

Keywords: Growth, Yield, Vermicompost, Biofertilizers

INTRODUCTION

"Barley (*Hordeumvulgare*L.), also known as 'groats', with chromosome number 2n=14, is an edible annual grass in the family Poaceae, which is grown as a cereal grain crop. It is reported to have originated from western Asia or Ethiopia. It is the fourth largest grain crop produced globally after wheat, rice and corn. It is highly adaptable functional cereal crop that is produced in climates ranging from subarctic to subtropical. Barley is generally grown in areas with limited irrigation facilities and are affected with salt problems, as it can tolerate moisture and salt stress to a great extent" (Yadav *et al.*, 2003). "Only 10% of barley is used as human food, while the remaining is used for brewing malt beverages, including beer and whiskey. However, the majority of the harvested barley is fed to animals. In India, barley is planted from October through November during the Rabi season, and it is harvested from March through April. It is grown on an area of 6.84 lakh hectares with production of 1.99 million metric tonnes" (Anonymous, 2021). "The major states for barley production are Rajasthan, Uttar Pradesh and Madhya Pradesh. It is also cultivated for malting and brewing purposes in Haryana, Western U.P., Punjab and Rajasthan with relatively better management to get good grain quality" (Gautam*et al.,* 2021).

"Rajasthan ranks first in barley production (935.75 thousand tonnes), followed by Uttar Pradesh (488.11 thousand tonnes) and Madhya Pradesh (47.98 thousand tonnes). Rajasthan had the maximum area under barley (269.75 thousand hectares) and contributed a share of 43 per cent to the total area and 54 per cent to the total production. The average crop productivity of barley was highest in Punjab (3777 kg ha^{-1}) followed by Rajasthan (3469 kg ha^{-1}), Haryana (3343 kg ha^{-1}), and Uttar Pradesh (3109 kg ha^{-1})" (Indiastat, 2020-21). "Barley in Haryana is grown mainly in the South-Western zone with an area of 9.26 thousand hectares with production 30.96 thousand tones and average productivity 3343 kg ha^{-1}" (Indiastat, 2016-17).

"To increase yield and quality parameters, integrated nutrient management (INM) is flexible approach to minimize the use of chemical fertilizers and at the same time, maximize their use efficiency and farmers' profit. INM refers to maintenance of soil fertility and plant nutrient supply to an ideal level for sustaining the desired crop productivity through the use of all possible sources of plant nutrients in an integrated manner. It involves a combination of fertilizers, organic manures and bio-fertilizers not only to sustain crop production, preserve soil health and biodiversity, but also helps in minimizing the cost of chemical fertilizers and improving crop performance and soil fertility by improving fertilizer use efficiency. The advantage of merging organic and inorganic sources of nutrients in INM has been proved superior to the use of each component separately" (Shukla *et al*., 2014). "Also, integrated nutrient management significantly improves phenological and growth parameters, yield components and yield of barley" (Dinka *et al*., 2018).

"Vermicomposting is a method of converting organic wastes into usable substrates. In this process, the digestive tracts of certain earthworm species (e.g., *Eiseniafetida*) are used to convert organic materials (usually wastes) into a stable, humus-like material known as vermicompost or worm castings. Vermicompost is a rich source of major and minor plant nutrients. On an average, it contains 3% N, 1% P_2O_5 and 1.5% K_2O. It serves as an excellent base for many beneficial free living and symbiotic microbes which improve the availability of nutrients to the plants" (Das and Avasthe,2018). "Biofertilizers can be defined as biological products containing living microorganisms that, when applied to seed, plant surfaces, or soil, promote growth by several mechanisms such as increasing the supply of nutrients, increasing root biomass or root area and increasing nutrient uptake capacity of the plant" (Vessey, 2003). "Biofertilizers such as *Azotobacter*, an abiotic and free-living soil microbe, naturally fix atmospheric nitrogen in the rhizosphere, while the phosphate solubilizing bacteria (PSB) play an important role in converting insoluble P (chemically fixed and applied) into soluble form resulting in higher crop yields" (Gull *et al.,* 2004). "Therefore, adoption of integrated plant nutrient supply (IPNS) and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in agriculture. The combined use of organic and inorganic sources of plant nutrient, therefore, not only pushes the production and quality of field crops, but also a help in maintaining the permanent fertility status of the soil" (Sharma *et al.*, 2001).

The purpose of integrated nutrient management (INM) is to optimize nutrient use efficiency in agriculture by combining various sources of nutrients, such as chemical fertilizers, organic manures, biofertilizers, and crop residues. INM aims to ensure sustainable soil fertility, increase crop productivity, minimize environmental pollution, and enhance farm profitability. By integrating different nutrient sources, INM also promotes balanced nutrient supply to crops, reducing the risk of nutrient deficiencies or excesses.

MATERIALS AND METHODS

The present investigation entitled "Effect on growth and yield of barley (*Hordeum vulgare* L.) under different nutrient management practices" was conducted at the KVK Farm, Mahendergarh of CCS Haryana Agricultural University, Hisar during Rabi season 2022-23. The site is located at 27° 47° North latitude and 76°51 East longitude. It is situated at an average height of 262 m (859 feet) above sea level.The climate of Mahendergarh is tropical, semiarid and hot. It is mostly dry with very hot summer and cold winter except during the monsoon when moist air from the ocean penetrates in to the district.The soil was loam sandy texture, having pH 8.0(Richards 1954), organic carbon (0.28) (Jackson 1973), low levels of readily available nitrogen (141 kg ha^{-1})(Subbiah and Asija, 1956), medium levels of phosphorus (18 kg ha^{-1}) (Olsen et al., 1954) and medium levels of potash (169 kg ha^{-1}) (Richards 1954) as per the limits.The experiment was conducted in Randomized Block Design having three replications with the eleven treatments viz., (T_1) Control, (T_2) 100% RDF, (T_3) 100% RDF + Azotobacter + PSB, (T_4) 50% RDF + Azotobacter+ PSB, (T_5) 50% RDF + 50% RDN through Vermicompost, (T_6) 50% RDF + 50% RDN through Vermicompost+ *Azotobacter* + PSB, (T_7) 75% RDF + *Azotobacter* + PSB, (T_8) 75% RDF + 25% RDN through Vermicompost, (T_9) 75% RDF + 25% RDN through Vermicompost + *Azotobacter* + PSB, (T_{10}) 100% RDN through vermicompost and (T_{11}) 100% RDN through vermicompost + *Azotobacter* + PSB. The treatments were allocated to different plots at random in all the three replications using the random table. For this experiment observations were recorded on the growth parameter *viz.*,Plant population/mrl, plant height (cm) and number of tillers/mrland yield attributes *i.e* Spike length (cm), Number of grains $spike^{-1}$, 1000-grain weight (g); Grain yield (t ha^{-1}), Straw yield (t ha^{-1}) and Harvest index (%).Barley variety 'BH 396' was sown on 4 November 2022 and the crop was harvested on 22 March 2023. All other operations were performed as per the recommendations for the crop.The data recorded in the study were analysed using RBD with two factor for ANOVA as per the procedures described by Gomez and Gomez

(1984) and differences among treatments were compared at P ≤ 0.05 level of significance using the OPSTAT.

RESULTS AND DISCUSSION

Growth attributes

The significant increases in growth attributes observed with the use of INM such as 75% RDF + 25% RDN through vermicompost + biofertilizers (Azotobacter and PSB) over control and other treatments. This might be because appropriate environmental conditions and the application of NPK help to increase the availability of nitrogen, phosphorous, and potassium to the developing plant. The increase in plant height due to seed inoculation with Azotobacter and PSB may be due to secretion of various growth hormones by microorganisms.“Maximum plant height was recorded under 75% R.D.F + 25% N through vermicompost at 30 DAS (24.40 cm), 60 DAS (40.37 cm), 90 DAS (58.32 cm) and at maturity (77.57 cm) which was mainly due to more availability of nitrogen and other essential nutrients due to higher mineralization rate of vermicompost compared to FYM”.[19] Similar results were also observed by Kakraliya*et al.* (2017).Maximum numbers of tillers were recorded under 75% R.D.F + 25% N through Vermicompost+ Azotobacter + PSB at 60 and 90 days after sowing and at maturity (37.47, 121.94, 122.70 and 93.31) respectively(Table 1).Reduction in number of tillers after 90 days of sowing may be due to mortality of shoots. Similar results have been reported by Suna*get al.* (2021).

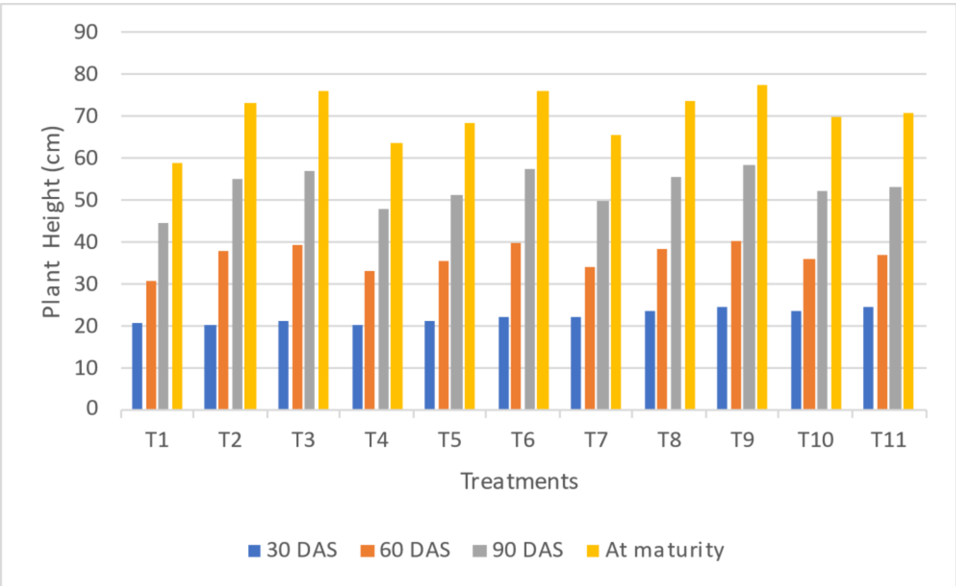

Figure 1: Effect of integrated nutrient management on plant height (cm) of barley

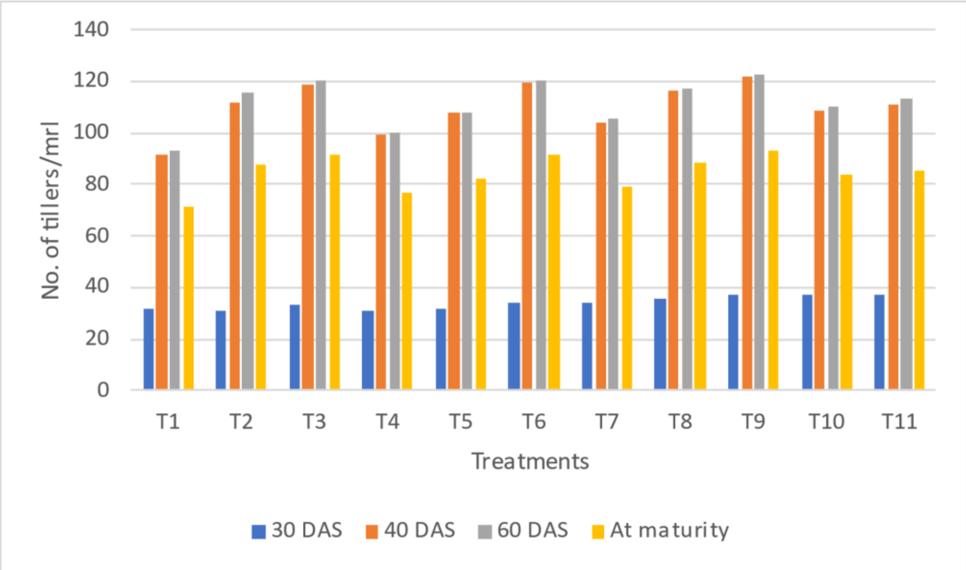

Figure 2: Effect of integrated nutrient management on number of tillers/mrl of barley

Table1. Effect of different nutrient management practices on plant height (cm) and on number of tillers/mrl of barley

Treatments	Plant height (cm)				Number of tillers/mrl			
	30 DAS	60 DAS	90 DAS	At maturity	30 DAS	60 DAS	90 DAS	At maturity
T_1:Control	20.67	30.64	44.40	58.65	31.53	91.82	93.24	71.04
T_2: 100% RDF (60 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 15 kg K_2O ha^{-1})	20.33	37.94	54.98	73.13	30.77	111.54	115.46	87.44
T_3: 100% RDF + *Azotobacter* + PSB	21.35	39.34	57.03	75.85	33.14	119.13	120.26	91.49
T_4: 50% RDF + *Azotobacter* + PSB	20.33	33.02	47.81	63.59	31.01	99.59	100.40	76.50
T_5: 50% RDF + 50% RDN through Vermicompost	21.35	35.41	51.31	68.27	31.86	107.76	108.26	82.46
T_6: 50% RDF + 50% RDN through Vermicompost + *Azotobacter* + PSB	22.30	39.58	57.22	76.10	34.22	119.37	120.00	91.63
T_7: 75% RDF + *Azotobacter* + PSB	22.37	34.06	49.60	65.39	34.25	104.17	105.37	79.37
T_8: 75% RDF + 25% RDN through Vermicompost	23.38	38.30	55.51	73.83	35.46	116.57	117.26	88.71
T_9: 75% RDF + 25% RDN	24.40	40.37	58.32	77.57	37.47	121.94	122.70	93.31

through Vermicompost + *Azotobacter* + PSB								
T_{10}: 100% RDN through vermicompost	23.38	36.16	52.32	69.58	37.10	109.09	110.36	83.71
T_{11}: 100% RDN through vermicompost+ *Azotobacter* + PSB	24.50	36.78	53.30	70.59	37.59	111.26	113.05	85.29
SEm±	1.218	0.54	0.77	1.04	1.71	0.97	1.66	1.12
C.D. at 5%	NS	1.61	2.28	3.09	NS	2.89	4.94	3.33

Yield attributes and yield

"The number of grains spike^{-1} was affected by various treatments. The maximum number of grains spike^{-1} was recorded under 75% R.D.F and 25% N through Vermicompost + Azotobacter + PSB (56.58) in comparison to other treatments. The number of grains spike-1 determined primarily by the amount of nutrient observed and secondary by the amount of carbohydrate produced at the time of spikelets differentiation. Maximum length of spike was recorded with 75% R.D.F and 25% N through Vermicompost + Azotobacter + PSB (8.82)was significantly superior over rest of the treatment. The lowest value of yield attributing characters was obtained under T_1 treatment as the plants were subjected to utilize the least amount of available nitrogen which resulted into reduced translocation of photosynthates from source to sink".[19]The results are in line with those of Devi *et al.* (2011). The yield was recorded significantly higher under 75% R.D.F + 25% N through vermicompost + Azotobacter + PSB(3.22 t/ha)which was statistically at par with 50% RDF + 50% RDN through Vermicompost+ *Azotobacter* + PSB(3.18 t/ha) and 100% RDF + *Azotobacter* + PSB(3.14 t/ha)(Table 2). This might be due to adequate nitrogen availability which contributed to increased dry matter accumulation. Better vegetative growth coupled with high yield attributes resulted into higher grain yield due to higher availability of macro, micronutrients and plant growth promoters present in the vermicompost. Reduced nutrient supply as in case of rest of the treatment, recorded lower yield due to both poor growth and yield attributes. The results are in conformity with Singh *et al.* (2018) and Dhakal *et al.* (2016). Maximum straw yield was recorded under 75% R.D.F and 25% N through Vermicompost + Azotobacter + PSB(3.85 t/ha). This may be probably due to higher density of tiller and increased rate of dry matter production per unit area as a result of better performance of vegetative growth caused due to efficient assimilation and absorption of nutrients from the soil during entire period of growth.From the present investigation it has been concluded that treatment with integration of 75% RDF + 25% RDN through vermicompost + *Azotobacter*+ PSB (T_9) performed best in case of plant height, number of tillers per meter row length, spike length, number of grains per spike, grain yield, straw yield and biological yield and the minimum success was obtained in control. While the data obtained was found non-significant with plant population per meter row length, test weight and harvest index. Treatment with integration of 100% RDF + *Azotobacter*+ PSB has more P and K in soil after harvest.

Table 2. Effect of different nutrient management practices on yield attributes, yield and harvest index of barley

Treatments	**Spike length (cm)**	**No. of grains/spike**	**Test weight (g)**	**Grain yield (t/ha)**	**Biological yield (t/ha)**	**Straw yield (t/ha)**	**Harvest index (%)**
T_1:Control	6.73	42.62	38.03	2.46	5.40	2.94	45.57
T_2: 100% RDF (60 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 15 kg K_2O ha^{-1})	8.25	52.78	39.81	2.99	6.59	3.59	45.45
T_3: 100% RDF + *Azotobacter* + PSB	8.60	55.14	40.25	3.14	6.93	3.78	45.35
T_4: 50% RDF + *Azotobacter* + PSB	7.17	45.23	38.55	2.62	5.77	3.14	45.48
T_5: 50% RDF + 50% RDN through Vermicompost	7.70	49.68	39.77	2.82	6.23	3.40	45.38
T_6: 50% RDF + 50% RDN through Vermicompost + *Azotobacter* + PSB	8.66	55.72	40.07	3.18	6.99	3.81	45.45
T_7: 75% RDF + *Azotobacter* + PSB	7.44	46.98	39.81	2.72	5.99	3.27	45.40
T_8: 75% RDF + 25% RDN through Vermicompost	8.32	53.29	41.94	3.04	6.70	3.65	45.45
T_9: 75% RDF + 25% RDN through Vermicompost + *Azotobacter* + PSB	8.82	56.58	42.49	3.22	7.10	3.85	45.40
T_{10}: 100% RDN through vermicompost	7.85	50.60	39.07	2.87	6.29	3.42	45.60

T_{11}: 100% RDN through vermicompost+ *Azotobactor* + PSB	7.99	50.88	39.71	2.91	6.41	3.50	45.47
SEm±	0.12	0.95	1.04	39.7	92.2	53.03	0.08
C.D. at 5%	0.37	2.83	NS	118	274	158	NS

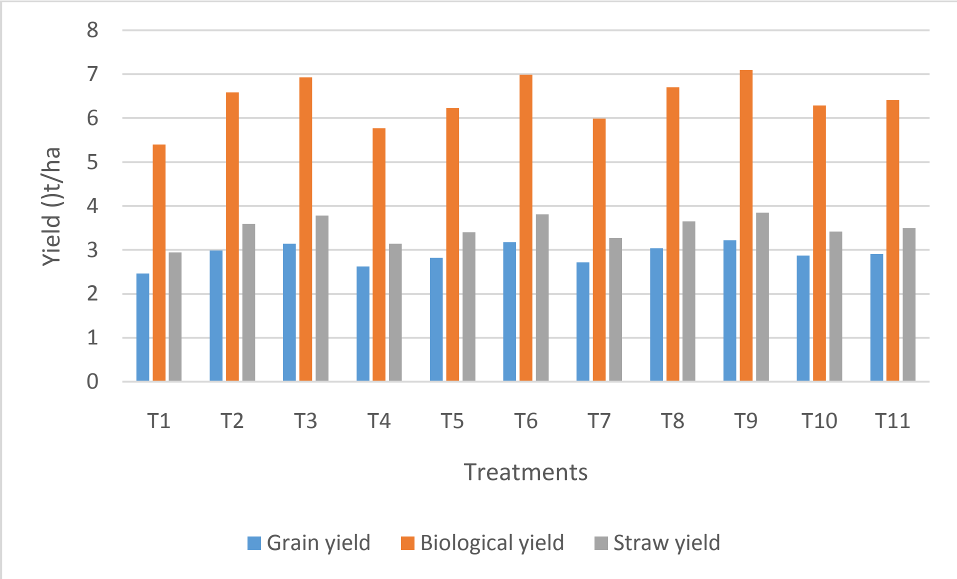

Figure 3: Effect of integrated nutrient management practices on yield and harvest index of barley

CONCLUSION

The results of this study indicated that integrated nutrient management significantly improved growth and yield of barley. Based on one year study, it can be concluded that plant height and number of tillers were highest in treatment T_9 followed by treatment T_6 and T_3. Among various combinations of chemical fertilizer, vermicompost, *Azotobactor*and PSB highest spike length (cm), number of grains spike-1, grain yield (kg ha^{-1}) and straw yield was recorded in treatment T_9 followed by treatment T_6 and T_3. Overall, it can be concluded on the bases of conducted experiment that integrated nutrient management can significantly enhance the yield of barley by optimizing nutrient availability, increasing nutrient use efficiency and promoting crop resilience, all while ensuring the sustainability of agricultural production systems.

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