

Substitution of Nitrogen and Phosphorous by Bio-Inoculants and their Effect on Growth Parameters, Yield Attributes and Yield of Barley

Abstract

A field experiment was conducted during *Rabi* season of 2022-2023 at Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.). The present experiment having 13 treatment combinations replicated thrice in randomized block design. Barley variety HUV-113 was grown with recommended agronomic practices. On the basis of the results emanated from present investigation, it could be concluded that application of T₁₁ [100 % N & P + *PSB* + *Azotobacter* + 100 % K] significantly recorded maximum growth parameters of barley such as plant population plot⁻¹ (41.56 m⁻²), plant height (91.78 cm), and number of tillers (87.74) and maximum yield attributing characters such as no. of spike (73.38 m⁻²), spike weight plant⁻¹ (51.20), number of spikelet (256.19) and test weight (45.76 g). Similarly highest grain yield (40.19 q ha⁻¹) and straw yield (62.71 q ha⁻¹), with application of treatment T₁₁ [100 % N & P + *PSB* + *Azotobacter* + 100 % K] in comparison to all the treatments. While minimum value of all the growth parameters, yield components and yield were associated with the treatment T₁ [Control]

Keywords: *Azotobacter*, Barley, Growth Parameters, *PSB*, and Yield

1. Introduction

“Barley (*Hordeum vulgare* L.) is the world’s 4th most essential cereal crop after wheat, rice and maize with a share of about 7% of the global cereals production and 15% of coarse grains consumption. Barley is grown throughout the temperate, tropical and subtropical regions of the world and can be successfully grown in adverse climatic conditions of drought, salinity and alkalinity due to its wider adaptability” (Neelam *et al.*, 2018).

“In India, barley is mainly grown in the northern plains and concentrated in the states of Uttar Pradesh, Haryana and Rajasthan. In India, barley was cultivated on 610.5 thousand ha area with 1600 thousand t of production at an average productivity of 26 q ha⁻¹. In India, Rajasthan is the largest state having more than 52 % in production and 46 % area followed by Uttar Pradesh.

In Rajasthan, barley was cultivated on 312.7 thousand ha area with 1059.3 thousand t of production at an average productivity of 33.88 q ha⁻¹ (IIWBR, 2020-21).

“One important factor influencing malting barley production is the supply of N because of its effects on yield on the one hand and grain protein content and malting quality, on the other. Excess soil N may raise the protein content of the kernel, which is undesirable trait for malting. Barley grains with high protein content are more difficult to malt, yield low amounts of extracts and can cause difficulties in brewing” (Schelling *et al.*, 2003).

Phosphorus nutrition plays key role in plant metabolism. Being involve in various biochemical processes, it ensures transfer and storage of energy as ADP and ATP, permits conversion and transmission of genetic characters as it is a constituent of DNA and RNA. Potassium plays an important role in the maintenance of cellular organism by regulating cell membrane and keeping the protoplasm in a proper degree of hydration. It activates the enzyme in protein and carbohydrate metabolism and translocation of carbohydrates and imparts resistance to plants against fungal and bacterial diseases.

“Due to climate change, increased population pressure and detrimental environmental impacts on agriculture fields and continuous use of chemicals leads to decrease in organic carbon, reduction in microbial flora of soil, increasing acidity and alkalinity and hardening of soil are constantly facing many detrimental effects which finally lead to scarcity of food production. To overcome the situation, new mechanism must be developed to meet the increased food demands with sustainable food production that has the potentiality to provide adequate food nutrition without hampering the fields”. (McCarty *et al.*, 2017) One such mechanism that is used to meet the agricultural need is “Biofertilizer” (McCarty *et al.*, 2017).

“Biofertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen both in association with plant roots and without it, solubilize insoluble soil phosphates and produces plant growth substances in the soil and solubilize inorganic potassium from insoluble compounds and make it available for plant uptake. They are in fact being promoted to harvest the naturally available biological system of nutrient mobilization” (Venkateshwarlu, 2008).

“*Azotobacter* are abiotic, free living soil microbes which play an important role in the nitrogen cycle in nature and binding atmospheric nitrogen which is inaccessible to plants. Inoculation with *Azotobacter* has been found to reduce the requirement of chemical fertilizer up

to 50 per cent” (Soleimanzadeh and Gooshchi, 2013). “Phosphorus solubilizing bacteria (PSB) plays an important role in converting insoluble phosphate and applied phosphorus into available form resulting in higher crop yields” (Gull *et al.*, 2004). “Among the whole microbial population in soil, PSB constitute 1 to 50 per cent in P solubilization potential” (Chen *et al.*, 2006).

2. Materials and Methods

2.1 Experimental Site

The experiment was carried out at Rajaula Agriculture farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) which lies in the semi- arid and sub-tropical region of Madhya Pradesh between 25.148° North latitude and 80.855°East longitude. The altitude of town is about 190-210 meter above mean sea level.

2.2 Edaphic Condition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.24 (1:2.5 soil: water suspension method given by Jackson, 1973), low in organic carbon percentage in soil is 0.32per cent (Walkley and Black’s rapid titration method given by Walkley and Black, 1934), low in available nitrogen 98.94 kg ha⁻¹ (Alkaline permanganate method given by Subbiah and Asija, 1956), medium in available phosphorus as sodium bicarbonate-extractable P was 16.36 kg ha⁻¹ (Olsen’s calorimetrically method, Olsen *et al.*, 1954), high in available potassium was 264.91 kg ha⁻¹ (Flame photometer method given by Hanwey and Heidel, 1952),

2.4 Experimental Details

The experiment was laid out in randomized block design and replicated thrice comprising with 13 treatment combinations.

Table no.-1: Treatment details

Treatment	Treatment Combination
T ₁	Control
T ₂	100 % N & P + K (RDF)
T ₃	75 % N & P + 100 % K

T₄	50 % N & P + 100 % K
T₅	100 % N & P + PSB + 100 % K
T₆	75 % N & P + PSB + 100 % K
T₇	50 % N & P + PSB+ 100 % K
T₈	100 % N & P + Azotobacter + 100 % K
T₉	75 % N & P + Azotobacter + 100 % K
T₁₀	50 % N & P + Azotobacter + 100 % K
T₁₁	100 % N & P + PSB + Azotobacter + 100 % K
T₁₂	75 % N & P + PSB + Azotobacter + 100 % K
T₁₃	50 % N & P + PSB + Azotobacter + 100 % K

2.5 Fertilizer and manure application

FYM and vermicompost were applied as basal dose as per treatment. “After the layout of experimental plot, the fertilizers were weighed and applied in the plots and thoroughly mixed with soil. As per the experimental recommended doses of Nitrogen, Phosphorus and Potassium were applied to all the plots. Recommended dose of Nitrogen, Phosphorus and Potassium were applied through Urea, DAP and MOP (80:50:50 kg ha⁻¹)” [27]

2.6 Biofertilizers

The seeds were treated with biofertilizers *Azotobacter*, PSB, using 10 kg seed / 200 g of biofertilizers through standard procedure before sowing as per treatment. The seeds were thoroughly mixed with biofertilizers in such a way that all the seeds were uniformly coated with a layer of biofertilizers and then allowed to dry in shade before sowing of crop.

2.7 Seed and sowing: Malt barley variety “HUV-113” was used as test crop. The seeds were sown in furrow opened at the depth of about 4-5 cm using seed rate of 100 kg ha⁻¹ keeping inter row spacing of 22.5 cm.. The crop was sown 08th November during the 2022, respectively.

2.8 Harvesting: The crop was harvested from the individual plot when plants were fully dried on 26th March, 2023. First border plants were harvested and removed from each plot. Then plants from net area were harvested and bundled separately and tagged. The tagged bundles were kept on threshing floor for sun drying.

2.9 Statistical Analysis: “The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant (“F” test), critical differences were worked out at five per cent probability level. The data obtained during the study were analyzed statistically” using the methods advocated by **Gomez and Gomez (1984)**.

3. Result and Discussion

3.1. Growth Parameters

Data pertaining to growth parameters mainly plant population plot⁻¹, plant height (cm), and number of tillers are presented in table no. 2 clearly revealed that application of inorganic fertilizers and biofertilizers increased these attributes significantly over control. Maximum plant population plot⁻¹ (41.56 m⁻²), plant height (91.78 cm), and number of tillers (87.74) were recorded under the treatment T₁₁ [100 % N & P + PSB + Azotobacter + 100 % K] followed by treatment T₁₂ [75 % N & P + PSB + Azotobacter + 100 % K] with the value 39.75, 90.37 cm and 85.64 respectively while the minimum plant population plot⁻¹ (29.26 m⁻²), plant height (79.53 cm), and number of tillers (73.42) were recorded under the treatment T₁ (Control). Increase in plant height might be due to adequate NPK supply through inorganic sources to growing plants. Nitrogen is a vital component of amino acids, proteins, and chlorophyll, all of which are essential for plant growth. Phosphorus is crucial for energy transfer within the plant and is a key component of DNA, RNA, and ATP. It promotes root development, which is critical for nutrient uptake and water absorption. Potassium plays a role in various physiological processes, including photosynthesis, water uptake, and enzyme activation. The increase in plant height and number of tillers due to seed inoculation with *Azotobacter* and *PSB* may be due to secretion of various growth hormones by microorganisms. These findings are further supported by **Utoor et al., (2014), Abebe and Manchore (2016), Singh et al., (2019) and Game et al. (2020)**

Table no.-2: Effect of different treatment combinations on growth parameters of barley

Treatment	Plant population plot ⁻¹	Plant height (cm)	No. of tillers
T ₁	29.26	79.53	73.42
T ₂	32.10	82.69	76.98
T ₃	31.59	81.75	75.27
T ₄	31.24	80.48	74.63
T ₅	36.47	86.40	81.75
T ₆	35.08	84.59	79.42
T ₇	34.49	82.32	77.21
T ₈	36.98	87.69	82.34
T ₉	35.49	85.78	80.40
T ₁₀	34.78	83.71	78.39
T ₁₁	41.56	91.78	87.74
T ₁₂	39.75	90.37	85.64
T ₁₃	38.42	89.47	84.29
S.E.m±	0.34	1.18	5.18
C.D. (P= 0.05)	NS	3.55	15.55

3.2. Yield Components

Data pertaining to yield attributing parameters mainly no. of spike (m⁻²), spike weight plant⁻¹, number of spikelet and test weight (g) are presented in table no. 3. clearly revealed that application of inorganic fertilizers and biofertilizers increased these attributes significantly over control except test weight (g). Maximum no. of spike (73.38 m⁻²), spike weight plant⁻¹ (51.20),

number of spikelet (256.19) and test weight (45.76 g) were recorded under the treatment T₁₁ [100 % N & P + PSB + Azotobacter + 100 % K] followed by treatment T₁₂ [75 % N & P + PSB + Azotobacter + 100 % K] with the value 72.69, 49.85, 253.43 and 45.26 g respectively while the minimum no. of spike (64.25 m⁻²), spike weight plant⁻¹ (36.52), number of spikelet (198.25) and test weight (43.61 g) was recorded under the treatment T₁ (Control). All the yield attributes increases significantly due to chemical fertilizers provide readily plant nutrients to crop. The reason for increased yield attributes of barley might be due to release of growth hormones by various biofertilizers. These findings are further supported by **Malghani et al. (2010)**, **Choudhary et al., (2018)**, **Kumawat (2021)** and **Jat, (2021)**

Table no.-3: Effect of different treatment combinations on yield attributes of barley

Treatment	No. of spike (m ⁻²)	Spike Weight Plant ⁻¹ (g)	No. of spikelet	Test weight (g)
T ₁	64.25	36.52	198.25	43.61
T ₂	66.97	39.54	208.34	43.97
T ₃	66.48	38.59	205.49	43.85
T ₄	65.36	37.27	202.27	43.72
T ₅	69.71	46.74	240.61	44.67
T ₆	68.35	43.58	224.71	44.34
T ₇	67.52	40.41	211.39	44.15
T ₈	70.13	47.31	243.43	44.79
T ₉	68.92	45.21	231.70	44.53
T ₁₀	67.96	42.39	219.75	44.26
T ₁₁	73.38	51.20	256.19	45.76
T ₁₂	72.69	49.85	253.43	45.26
T ₁₃	71.35	48.32	248.49	45.05
S.E.m±	0.52	0.48	7.28	0.42
C.D. (P= 0.05)	1.57	1.45	21.85	NS

3.3 Productivity Parameters

The data of grain yield and straw yield presented in table 4. The results revealed that the grain yield of barley varied in between 28.53 to 40.19 q ha⁻¹ and all the treatments were significantly superior to T₁ [Control]. The treatment combination T₁₁ [100 % N & P + PSB + Azotobacter + 100 % K] gave the maximum grain yield (40.19 q ha⁻¹) followed by the treatment T₁₂ [75 % N & P + PSB + Azotobacter + 100 % K] with the value 39.42 q ha⁻¹. Straw yield of barley varied in between 42.50 to 62.71 q ha⁻¹ and all the treatments were significantly superior to T₁ [Control]. The treatment combination T₁₁ [100 % N & P + PSB + Azotobacter + 100 % K] gave the maximum straw yield (62.71 q ha⁻¹) followed by the treatment T₁₂ [75 % N & P + PSB + Azotobacter + 100 % K] with the value 60.32 q ha⁻¹. It might also due to use of chemical fertilizers not only increase the rate of photosynthesis but also increase the translocation of source to sink which resulted in higher grain yield. Inoculation of barley with different combination of biofertilizers has synergic and additive effects on yield as they increase the fertilizer use efficiency as well as soil fertility by promoting soil microbial activities, narrow down C: N ratio, decline in bulk density and increase in water holding capacity at low moisture levels. These findings are further supported by the findings of **Nega *et al.* (2015), Dhiman and Dubey (2017), Prasad *et al.*, (2019) and Jatinderpal, (2021).**

Table no.-4: Effect of different treatment combinations on yields of barley

Treatment	Grain yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)
T ₁	28.53	42.50
T ₂	31.45	45.32
T ₃	30.15	44.39
T ₄	29.32	43.25
T ₅	35.79	53.47
T ₆	33.45	50.39
T ₇	32.42	47.39
T ₈	37.27	55.67
T ₉	34.58	51.75
T ₁₀	32.79	49.52

T₁₁	40.19	62.71
T₁₂	39.42	60.32
T₁₃	38.16	58.37
S.E.m±	1.21	1.69
C.D. (P= 0.05)	3.64	5.08

5. Conclusion

The experimental results indicated that superiority in regard to growth parameters, yield components and productivity parameters viz, grain yield (q ha⁻¹), straw yield (q ha⁻¹), with the use of treatment combination T₁₁ [100 % N & P + PSB + Azotobacter + 100 % K] gave in soil ensure highest growth parameters, yield components and productivity, of barley crop as comparison to all the treatments.

6. References

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