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

Abstract

A field experiment was conducted during *Rabi*seasonof 2022-2023at Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.). The present experiment having 13 treatmentcombinations replicated thrice in randomized block design.Barley variety HUV-113was grown with recommended agronomic practices. On the basis of the results emanated from present investigation, it could be concluded that application of T_{11} [100 % N & P + *PSB* + *Azotobacter* + 100 % K]significantly recorded maximum growth parameters of barley such asplant 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}) andstraw yield (62.71 q ha^{-1}),with application of treatment T_{11} [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 T_1 [Control]

Keywords:Azotobacter, Barley, Growth Parameters, PSB, andYield

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 Utter 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. One such mechanism that is used to meet the agricultural need is "Biofertilizer"**(MeCarty*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 **(Venkatashwarlu, 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**), lowin 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 16.36kg 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
T_4	50 % N & P + 100 % K
T_5	100 % N & P + PSB + 100 % K
T_6	75 % N & P + PSB + 100 % K
T_7	50 % N & P + PSB+ 100 % K
T_8	100 % N & P + Azotobacter + 100 % K
T_9	75 % N & P + Azotobacter + 100 % K
T_{10}	50 % N & P + Azotobacter + 100 % K
T_{11}	100 % N & P + PSB + Azotobacter + 100 % K
T_{12}	75 % N & P + PSB + Azotobacter + 100 % K
T_{13}	50 % N & P + PSB + Azotobacter + 100 % K

2.5Fertilizer 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, Potassium and Sulphur 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})

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 driedon 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 tillersare 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 T_{11} [100 % N & P + PSB + Azotobacter + 100 % K]followed by treatment T_{12} [75 % N & P + PSB + Azotobacter + 100 % K] with the value 39.75, 90.37 cm and 85.64 respectivelywhile 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 T_1 (Control). 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 spikeletand test weight (g) are presented in tableno. 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 T_{11} [100 % N & P + PSB + Azotobacter + 100 % K]followed by treatment T_{12} [75 % N & P + PSB + Azotobacter + 100 % K] with the value 72.69, 49.85, 253.43 and 45.26 g respectivelywhile 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 T_1 (Control). 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**

3.3Productivity 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 T_1 [Control]. The treatment combination T_{11} [100 % N & P + PSB + Azotobacter + 100 % K] gave the maximum grain yield (40.19 q ha^{-1}) followed by the treatment T_{12} [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 T_1 [Control]. The treatment combination T_{11} [100 % N & P + PSB + Azotobacter + 100 % K] gave the maximum straw yield (62.71 q ha^{-1}) followed by the treatment T_{12} [75 % N & P + PSB + Azotobacter + 100 % K] with the value 60.32 q ha^{-1}.These findings are further supported by the findings of **Nega *et al.* (2015), Dhiman and Dubey (2017), Prasad *et al.*, (2019)andJatinderpal, (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
T_{11}	40.19	62.71
T_{12}	39.42	60.32
T_{13}	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 T_{11} [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

Abebe, B., &Manchore, M. (2016). Effect of the rate of N-fertilizer application on growth & yield of wheat (*Triticum aestivum L*.) at Chencha, southern Ethiopia. *International Journal of Plant, Animal & Environmental Sciences,* **6**(3), 2231-4490.

Chen, Y.P., Rekha, P.D., Arunshen, A.B., Lai, W.A. and Young, C.C. (2006). Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities. *Applied Soil and Ecology* **34**(1): 33-41.

Choudhary, J., Jat, U., Jat, M.L. and Mohsin, M. (2018). Impact of integrated nutrient management in enhancing productivity of barley (*Hordeum vulgare* L.) in Southern Rajasthan. *International Journal of Chemical Studies* **6**(5): 2363- 2365.

Dhiman, S., & Dubey, Y.P. (2017). Effect of biofertilizers and inorganic fertilizers on yield attributes, yield and quality of *Triticum aestivum*and *Zea mays* in an acid Alfisol. *International Journal of Current Microbiology and Applied Sciences*, **6**(7), 2594-2603.

Game. B.C., Ilhe, B.M., Pawar, V.S. and Khandagale, P.P. (2020). Effect of *Azotobacter,* phosphate solubilizing bacteria and potash mobilizing bacteria inoculants on productivity of wheat (*Triticum aestivum*L.). *International Journal of Current Microbiology and Applied Sciences* **9**(03): 2800-2807.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John wiley& sons.

Gull, M., Hafeez, F.Y., Saleem, M. and Malik, K.A. (2004). Phosphorus uptake and growth promotion of chickpea by co-inoculation of mineral phosphate solubilizing bacteria and a mixed rhizobial culture. *Australian Journal of Experimental Agriculture* **44**(6): 623-628.

Hanway, J.J; and Heidel, H. (1952). Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. *Iowa Agriculture* **54**: 1-31.

IIWBR. (2020-21). Progress Report, All India Coordinated Wheat and Barley Improvement Project. ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana **6**: pp-1.1.

Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd, New Delhi.

Jat, M. L. (2021). Integrated nutrient management in barley (*Hordeum vulgare* L.). Ph.D. Thesis, Department of Agronomy, MPUAT, Udaipur.

Jatinderpal, S.M. (2021). Effect of nitrogen levels and bio-fertilizers on growth and productivity of malt barley (*Hordeum vulgare* L.). M.Sc. (Ag) Thesis, Department of Agronomy, PAU, Ludhiana, Punjab.

Kumawat, H. (2021). Effect of fertility levels and liquid biofertilizers on productivity of wheat (*Triticum aestivum*L.). M.Sc. Thesis, Department of Agronomy, MPUAT, Udaipur.

Malghani, Abdul Latif, Malik, Asmat Ullah, Sattar, A., Hussain, fiaz, Abbas, G. and Hussain, J. (2010). Response of growth and yield of wheat to NPK fertilizer. *Science international* (Lahore), **24** (2):185-189.

MeCarty, S.C., Chauhan, D.S., MeCarty, A.D., Tripathi, K.M., Selvan, T. and Dubey, S.K. (2017). Effect of *Azotobacter* and phosphobacteria on yield of wheat (*Triticum aestivum*). *Vegetos***30**(2): 13-16.

Neelam, S.B., Khippal, A., Mukesh and Satpal. (2018). Effect of different nitrogen levels and biofertilizers on yield and economics of feed barley. *Wheat and Barley Research* **10**(3): 214-218.

Nega, Y., Abraha, A., & Samuel, G. (2015). Interaction effects of inorganic N-fertilizer & seed rates on yield & quality traits of malt barley varieties in the highland of Tigray, north Ethiopia. *Journal of Natural Sciences Research,* **5**(13), 157-164.

Olsen, S.R, Cole, C.V., Watanable, F. S. and Dean, L. A. (1954). Estimation of available phosphorous in soil by extraction with sodium bicarbonate. *USDA, Cric*. **930**:19- 23

Prasad, J., Thomas, T., Bharosre, R. and Mir, Z.A. (2019). Effect of organic and inorganic source of nutrient on growth and yield of barley (*Hordeum vulgare* L). *Journals of Pharmacognosy and Phytochemistry* **8**(21): 521-523.

Schelling, K., Born, K., Weissteiner, C. and Kühbauch, W. (2003). Relationships between yield and quality parameters of malting barley (*Hordeum vulgare* L.) and phenological and meteorological data. *Journal of Agronomy and Crop Science* **189:** 113-122.

Singh, A., Singh, K.B., Singh, S. and Gandhi, N. (2019). Effect of different organic, inorganic and bio-fertilizer on the yield and yield components of wheat. *Journal of Pharmacognosy and Phytochemistry* **4**: 4-6.

Soleimanzadeh, H. and Gooshchi, F. (2013). Effect of *Azotobacter* and nitrogen chemical fertilizer on yield and yield component wheat (*Triticum aestivum*). *World Applied Science Journal* **21**(8): 1180-2013.

Subbiah, B.V. and Asija, C.L. (1956). A rapid procedure for the estimation of available N in Soil. *Curr. Sci.* **25**:259-260.

Utoor, H., Al-Shamma, Ayyad, W. and Al-Shahwany. (2014). Effect of mineral and bio-fertilizer application on growth and yield of wheat (*Triticum aestivum*L.). *Iraqi Journal of Science* **55**(4): 1484-1495.

Venkatashwarlu, B. (2008). Role of bio-fertilizers inorganic farming: Organic farming in rain fed agriculture. Central Research Institute for Dry Land Agriculture, Hyderabad. pp. 85-95.

Walkley, A. and Black, C. S.A. (1934). Old piper, S.S. soil and plant analysis. Soil Sci. 37:29-38.