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Effect of Organic, Inorganic and Liquid Biofertilizer on Growth and Yield of Barley (*Hordeum vulgare* L.)

Khushvinder Singh Gadhwal*[1], K. C. Nagar[2], Ramawtar[3], R. K. Sharma[4], L.L. Panwar [5], Mayank Goyal[6]

[1]Research Scholar, Department of Agronomy, College of Agriculture Bhilwara, MPUAT, Udaipur (Rajasthan)- India
[2]Professor, Department of Agronomy, College of Agriculture Bhilwara, MPUAT, Udaipur (Rajasthan)- India
[3] Assistant Professor, Department of Agronomy, College of Agriculture Bhilwara, MPUAT, Udaipur (Rajasthan)- India
[4] Professor, Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan)- India
[5] Professor, Department of Genetic and Plant Breeding, College of Agriculture Bhilwara, MPUAT, Udaipur (Rajasthan)- India
[6] Senior Research Fellow at DFRS Bhilwara
*Corresponding Author
Corresponding author Email ID: Khushvindergadhwal1717@gmail.com

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Abstract— *A field experiment was conducted during rabi, 2025 at the Dryland Farming Research Station, Arjia, Bhilwara, to study the effect of integrated nutrient management on growth characters of barley (*Hordeum vulgare *L.). The experiment was laid out in a factorial randomize block design with four fertility levels (% RDF) viz., 100 (inorganic), 100 (vermicompost), 75 (inorganic) + 25 (vermicompost), 50 (inorganic) + 50 (vermicompost) and four liquid bio-fertilizers viz., control, Azotobacter, PSB and Azotobacter + PSB, replicated three times. The experimental results showed that application of 75 (inorganic) + 25 (vermicompost) recorded significantly higher values of growth characters viz., plant height (97.78 cm) and dry matter accumulation (26.24 g plant^{-1}) at harvest in barley which was superior to lower fertility levels and was at par with 100 (inorganic). Among the liquid bio-fertilizers, application of Azotobacter + PSB recorded significantly higher values of plant height (96.16cm) and dry matter accumulation (26.78 g plant^{-1}) at harvest which was found superior over control and PSB but statistically at par with Azotobacter. The results indicated that application of 75 (inorganic) + 25 (vermicompost) in combination with Azotobacter + PSB had a positive effect on the growth of barley.*

Keywords— ***barley, fertility levels, bio-fertilizers, growth parameters***

I. INTRODUCTION

Barley (*Hordeum vulgare* L.) is among the earliest domesticated plant species in human history. An annual, fast-growing, cool-season cereal, it was originally selected from wild grasses. Often referred to as "the poor man's crop," barley thrives with minimal inputs and shows remarkable resilience to harsh conditions such as drought, salinity, and alkalinity (FAO 2002). Barley's main industrial use is in making malt for the brewing industry. Because it does not contain gluten, barley is also easier to digest than wheat, which adds to its nutritional value. Every 100 g of barley provides 10.6 g protein, 2.1 g fat, 64.0 g carbohydrate, along with essential minerals and vitamins, including calcium, iron, vitamin B_1, B_2, and folate (Vaughan *et al*., 2006). Globally, barley occupies an area of 46.25 m ha giving 145.74 million tonnes of grain yield with an average of 3151.2 kg ha^{-1} (FAO, 2024). In India, nearly 1.65 m tonnes of barley is produced in 0.55 m ha area with average productivity of 2998 kg ha^{-1}. Among barley growing states, Rajasthan holds the top slot in producer state of India having more than 52.0 percent area and more than 62.0 percent production followed by Uttar Pradesh, Haryana and Madhya Pradesh. In Rajasthan, barley is cultivated in 0.28 m ha area with annual production of 1.02

m tonnes with productivity of 3603 kg ha^{-1} (Anonymous, 2023-24). 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) In Bhilwara, total sown area under barley was 26,486 hectare and production came out 80.691 thousand tonnes with productivity of 3,047 kg ha^{-1} (DES, 2024).

Adequate mineral fertilization is considered to be one of the most important prerequisites in this respect. Despite the application of recommended quantities/doses of major nutrients, the increase in yield is not encouraging. Nitrogen is a key determinant of chlorophyll formation and plays a vital role in overall crop growth and yield. Its deficiency is one of the major yield-limiting factors in barley production. Insufficient nitrogen application adversely affects vegetative growth and grain yield, whereas increasing nitrogen levels generally enhances crop productivity and boosts protein content in barley seeds. Adequate phosphorus availability improves seed plumpness, malting quality, and protein content in barley grains, in addition to enhancing the fodder value of the crop (Narolia, 2009).

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). *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). Integrated Nutrient Management (INM), which combines organic and inorganic nutrient sources, offers a promising approach to maintain soil fertility, enhance crop productivity, and ensure environmental sustainability.

II. MATERIAL AND METHODS

A field experiment was conducted at Field no.10, Instructional Farm, Dryland Farming Research Station, MPUAT, Bhilwara during *ra*bi, 2025. The experimental soil was clay-loam in texture, slightly alkaline in reaction (pH 7.8), medium level of organic carbon and low level of available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in a factorial randomized block design with three replications, comprising four fertility levels (% RDF) *viz*., 100 (inorganic), 100 (vermicompost), 75 (inorganic) +25 (vermicompost), 50 (inorganic) + 50 (vermicompost) and four liquid bio-fertilizers *viz*., control, *Azotobacter*, PSB and *Azotobacter* + PSB, replicated three times. The test crop was barley variety RD 2899, sown at a spacing of 22.5 cm × 10 cm^2 with a seed rate of 100 kg ha^{-1}. The crop was managed through thinning, pre-emergence clodinafop propargyl + metsulfuron and hand weeding at critical stages. Observations were recorded on plant height and dry matter accumulation using standard procedures and the data were analyzed by ANOVA as per factorial randomized block design (Panse and Sukhantme, 1985).

III. RESULTS AND DISCUSSION

3.1 Plant Growth Attribute

During *rabi,* 2025, fertility levels had a significant effect on the Application of fertility levels and liquid biofertilizers significantly influenced plant height and dry matter accumulation at harvest. Among the fertility treatments, 75% inorganic fertilizer + 25% vermicompost recorded the maximum plant height (97.78 cm) and dry matter accumulation (26.24 g $plant^{-1}$), which remained statistically at par with 100% inorganic fertilizer (96.43 cm and 25.97 g $plant^{-1}$, respectively), but proved significantly superior to 100% vermicompost (82.74 cm and 22.83 g $plant^{-1}$) and 50% inorganic fertilizer + 50% vermicompost (84.90 cm and 23.60 g $plant^{-1}$, respectively). Likewise, among the liquid biofertilizer treatments, seed inoculation with Azotobacter + PSB recorded the highest plant height (96.16 cm) and dry matter accumulation (26.78 g $plant^{-1}$), which was significantly superior to the control (84.57 cm and 22.70 g $plant^{-1}$, respectively) and PSB alone (88.91 cm and 23.41 g $plant^{-1}$, respectively), but remained statistically at par with Azotobacter inoculation (92.21 cm and 25.76 g $plant^{-1}$, respectively).

The significant improvement in plant height and dry matter accumulation under the integrated application of fertility levels and liquid biofertilizers may be attributed to the complementary effects of inorganic fertilizers, vermicompost and beneficial microorganisms. The combined use of inorganic fertilizers and vermicompost ensured balanced and sustained nutrient availability, improved soil physical properties and enhanced microbial activity, while Azotobacter and PSB increased nitrogen fixation and phosphorus solubilization, resulting in greater nutrient uptake, higher photosynthetic efficiency and increased biomass production. These favourable conditions

promoted enhanced plant height and dry matter accumulation. Similar findings were reported by Limanpure et al. (2017), who observed improved growth and productivity of barley with optimum fertilizer application. Comparable results were also reported by Kumar et al. (2018), Singh et al. (2019) and Meena et al. (2020), who concluded that integrated nutrient management involving inorganic fertilizers, organic manures and biofertilizers significantly improved plant growth and dry matter accumulation in barley. Similar results were also recorded in barley crop by Sunag *et al*., 2021.

3.2 yield

Application of different fertility levels and liquid biofertilizers exerted a significant influence on grain yield, straw yield and biological yield of barley, whereas among the fertility levels, application of 75% inorganic fertilizer + 25% vermicompost recorded the highest grain yield (4307 kg ha^{-1}), straw yield (5450 kg ha^{-1}) and biological yield (9757 kg ha^{-1}). These values were statistically at par with 100% inorganic fertilizer (4268, 5404 and 9672 kg ha^{-1}, respectively), but were significantly superior to 100% vermicompost (3636, 4831 and 8467 kg ha^{-1}, respectively) and 50% inorganic fertilizer + 50% vermicompost (3747, 4956 and 8703 kg ha^{-1}, respectively). Similarly, among the liquid biofertilizer treatments, seed inoculation with Azotobacter + PSB recorded the highest grain yield (4286 kg ha^{-1}), straw yield (5412 kg ha^{-1}) and biological yield (9698 kg ha^{-1}), which were significantly superior to the control (3640, 5009 and 8649 kg ha^{-1}, respectively) and PSB inoculation alone (3912, 4996 and 8908 kg ha^{-1}, respectively), while remaining statistically at par with Azotobacter inoculation (4119, 5223 and 9342 kg ha^{-1}, respectively). The significant improvement in grain yield, straw yield and biological yield under different fertility levels and liquid biofertilizer treatments may be attributed to the balanced and continuous supply of nutrients throughout the crop growth period. The integrated use of 75% inorganic fertilizer + 25% vermicompost ensured adequate availability of essential nutrients, while vermicompost improved soil physical properties, water-holding capacity and microbial activity, thereby enhancing nutrient use efficiency. Similarly, seed inoculation with Azotobacter + PSB promoted biological nitrogen fixation and phosphorus solubilization, resulting in improved root growth, nutrient uptake and photosynthetic activity. The cumulative effect of these factors enhanced vegetative growth, dry matter accumulation and yield attributes, which ultimately resulted in higher grain, straw and biological yields. Similar findings were reported by Limanpure *et al*. (2017), who observed significant improvement in barley productivity with optimum fertilizer application. Comparable results were also reported by Kumar *et al.* (2018), Singh *et al*. (2019) and Meena *et al*. (2020), who concluded that integrated nutrient management along with biofertilizer inoculation significantly increased grain and biological yields of barley through improved nutrient availability and efficient partitioning of photosynthates towards the economic sink.

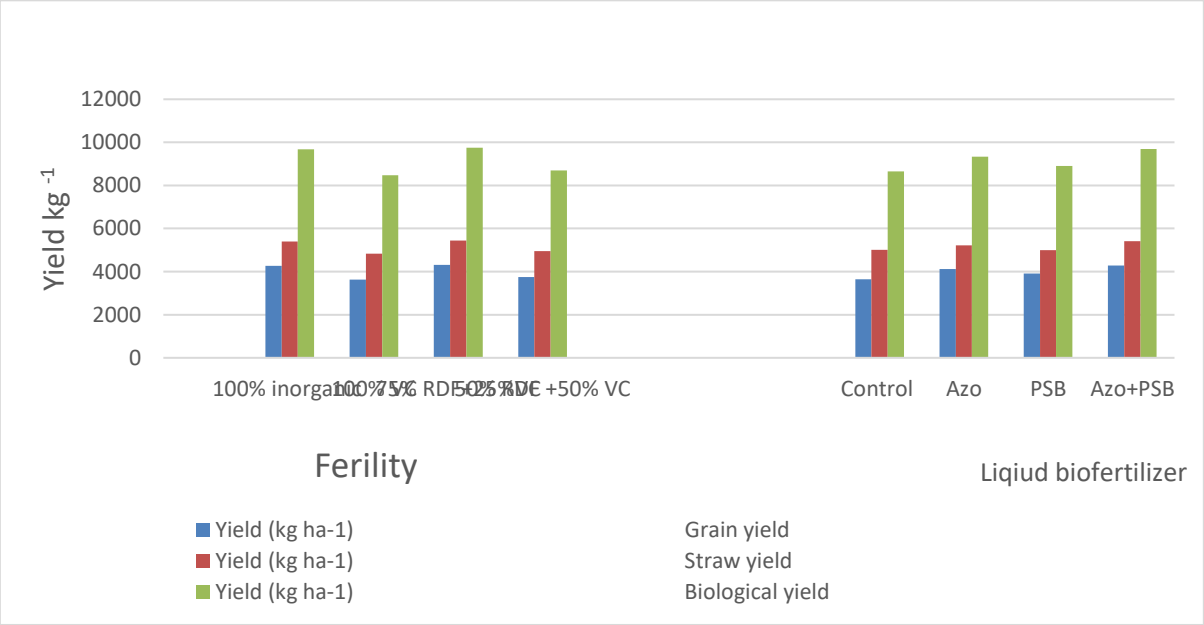
IV. CONCLUSION

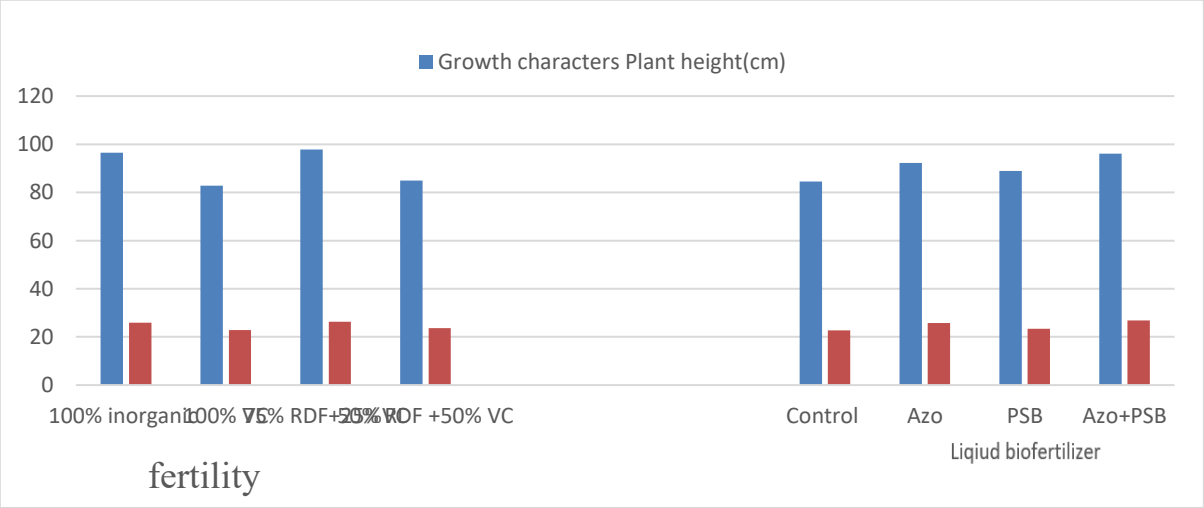
Based on findings, it is proposed that application of 75 (inorganic) +25 (vermicompost) recorded the best growth performance in black gram with the highest plant height and dry matter accumulation. Among the bio-fertilizers, *Azotobacter* + PSB performed best and was better than *Azotobacter*, PSB and control. Overall, the combined use of 75 (inorganic) +25 (vermicompost) and *Azotobacter* + PSB was most effective for improving growth of barley.

Table: - Effect of INM on plant growth and yield

Treatments	**Yield (kg ha^{-1})**			**Growth characters**	
	Grain yield	Straw yield	Biological yield	Plant height(cm)	DMA (g $plant^{-1}$)
Fertility (%RDF)					
100 (Inorganic)	4268	5404	9672	96.43	25.97
100 (Vermicompost)	3636	4831	8467	82.74	22.83
75 (Inorganic) + 25 (VC)	4307	5450	9757	97.78	26.24
50 (Inorganic) +50 (VC)	3747	4956	8703	84.90	23.60
S.Em.±	88	110	152	2.03	0.49
C.D. at 5%	254	316	438	5.86	1.40
Liquid biofertilizers					

Control	3640	5009	8649	84.57	22.70
Azotobacter	4119	5223	9342	92.21	25.76
PSB	3912	4996	8908	88.91	23.41
Azotobacter+ PSB	4286	5412	9698	96.16	26.78
S.Em.±	88	110	152	2.03	0.49
C.D. at 5%	254	316	438	5.86	1.40
C.V. (%)	7.63	7.36	5.74	7.76	6.82





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