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Effect of Liquid Biofertilizers on N, P and K uptake by Grain and Straw of Malt Barley (*Hordeum vulgare* L.) under different Fertility Levels

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ABSTRACT: It has been observed that application of lower rates of fertilizer affects production and quality of grain below acceptable levels because they reduce nutrient transfer from vegetative components to grain. Therefore, an appropriate dose of nutrients should be made available to crop plants. For resolving this issue a field trial was carried out during *rabi* 2020-21 and 2021-22 at Agronomy farm, MPUAT, Udaipur with the aim to assess the response of malt barley to fertilizer's dose and biofertilizers. The experiment used a randomised block design (Factorial) with 15 treatment combinations consisting of three fertility levels *i.e.* application of 50 kg N + 25 kg P_2O_5 +15 kg K_2O ha^{-1}, 60 kg N + 30 kg P_2O_5 +20 kg K_2O ha^{-1} and 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} with five liquid biofertilizers *i.e.* control, *Azotobacter*, PSB, KMB and *Azotobacter* + PSB + KMB. The results discovered that, malt barley crop fertilized with 70 kg N +40 kg P_2O_5 + 25 kg K_2O ha^{-1} along with seed inoculation with *Azotobacter* + PSB + KMB accumulated maximum quantum of nutrients in grain, straw and thereby total.

Keywords: Malt barley, nitrogen, phosphorus, grain, straw, biofertilizers and fertility levels.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is the world's fourth most important cereal crop after wheat, rice, and maize, accounting for around 7% of worldwide cereal production and 15% of coarse grain consumption. Due to its wider flexibility, barley is planted throughout the world's temperate, tropical, and subtropical regions and can be successfully grown in severe climatic circumstances such as drought, salt and alkalinity (Neelam *et al.,* 2018). Barley grain is also recognised for its smothering and cooling impact on the body, as well as its vitamin B complex content. Apart from these traditional applications, it is a key industrial crop used as a raw material in the beer, whisky and brewing industries. Barley grain has 10.6 g protein, 2.1 g fat, 64.0 g carbohydrate, 50.0 mg calcium, 6.0 mg iron, 31.0 mg vitamin B1, 0.1 mg vitamin B2, and 50.0 g folate per 100 g (Vaughan *et al.,* 2006). Being a cereal crop, it requires significant amounts of main nutrients, particularly nitrogen, phosphorus, and potassium, to maximise output. The optimal rate of these nutrients for the crop under specific growing conditions must be determined. Climate change, increased population pressure, and negative environmental impacts on agriculture fields, as well as the continued use of chemicals, result in a decrease in organic carbon, a reduction in soil microbial flora, increased acidity and alkalinity, and soil hardening, all of which have a negative impact on food production (Schelling *et al.,* 2003). To address the dilemma, a new system must be established to satisfy the rising food demand with sustainable food production that has the capacity to offer appropriate food nutrition while minimising the impact on the fields. One such mechanism that is used to meet the agricultural need is "Biofertilizer". Biofertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen both with and without plant roots, solubilizing insoluble soil phosphates and producing plant growth chemicals in the soil and releasing inorganic potassium from insoluble compounds for plant uptake. *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 upto 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). Potassium mobilizing biofertilizer (KMB) is a biofertilizer based on selective strain of potassium mobilizing beneficial bacteria of *Frateuria* spp. The micro *Frateuria* spp is a beneficial bacteria capable of mobilizing available potash near the roots of plants.

Therefore, keeping in view of above facts the present study has been undertaken.

MATERIAL AND METHODS

A field experiment was carried out during two consecutive *rabi* seasons of the year 2020-21 and 2021-22.The experiment was set up at field number C_7, Agronomy Farm, Udaipur which is located at 24°35′N latitudes, 73°42′E longitude at an altitude of 581.35 m above mean sea level. The region is located in Rajasthan's NARP agro-climatic zone IV (Sub-Humid Southern Plains and Aravali Hills).The experiment's treatment included a mixture of three fertility levels and five liquid biofertilizers. In a factorial randomised block design, these fifteen treatment combinations were duplicated four times. Urea, DAP and MOP were used as nitrogen, phosphorus, and potassium sources. The seeds were treated with liquid biofertilizers *Azotobacter,* PSB, KMB (Potassium mobilizing bacteria) and *Azotobacter* + PSB + KMB using 5 ml kg^{-1} seed through conventional process 2-3 hours before sowing as per the treatment 2-3 hours before sowing. As a test crop, the malt barley variety "DWRB-137" was employed. The seeds were planted in a furrow opened at a depth of around 4-5 cm with a seed rate of 100 kg ha^{-1} and a row spacing of 20 cm. At harvest, grain and straw samples were gathered from each plot and dried in an oven at 65 °C until they reached a constant weight. These samples were ground in a laboratory mill, sieved through a 40 mm mesh sieve, and utilized to calculate the N, P, and K concentrations. Uptake of N, P and K by grain and straw was estimated by using following formula.

$$\text{Nutrient uptake (grain/straw) (kg ha}^{-1}) = \frac{\text{Nutrient content ingrain/straw (\%)} \times \text{Grain/straw yield (kg ha}^{-1})}{100}$$

RESULT AND DISCUSSION

Nitrogen uptake

Fertility levels. During both years, the maximum nitrogen uptake by grain, straw and total was estimated under the influence of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}which was much greater than the remaining fertility levels (Table 2, 2a & 2b).

According to pooled analysis, applying 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} increased nitrogen uptake by grain, straw and total to the extent of (22.38, 41.06), (29.60, 70.87) and (23.92, 46.90) per cent compared to applying 60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} and 50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}, respectively.

Liquid biofertilizers. Results reveal that inoculating malt barley seed with liquid biofertilizers, both alone and in combination, significantly influenced nitrogen uptake by grain, straw and total during both years of research and in pooled analysis. When compared to the least mean nitrogen uptake by grain, straw and total under control, single inoculation with *Azotobacter*, PSB, KMB and *Azotobacter*+ PSB + KMB significantly enrichedit by (25.71, 21.32, 19.61 and 40.53), (40.57, 36.57, 34.51 and 60.89), and (28.72, 24.39, 23.77 and 44.65) percent, respectively. Among liquid biofertilizers, seed inoculation with *Azotobacter* + PSB + KMB accumulated the maximum quantum of nitrogen by grain, straw and total, which was considerably higher than single inoculation with *Azotobacter*, PSB, and KMB during both years. Co-inoculation of *Azotobacter* + PSB + KMB enhanced nitrogen uptake by grain by (11.78, 15.83, 17.48), (14.45, 17.8, 19.61) and (12.37, 16.28, 16.86) percent over solo inoculation of *Azotobacter,* PSB and KMB, respectively.

Interaction effect of fertility levels and liquid biofertilizers on nitrogen uptake by grain. According to the data (Table 2a), the interaction impact of fertility levels and liquid biofertilizers caused significant variance in nitrogen uptake by grain during both years of inquiry and in pooled analysis. Regardless of liquid biofertilizers, malt barley crop fertilised with 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} had significantly better nitrogen uptake by grain than the other fertility levels. At all fertility levels, co-inoculation of malt barley seed with *Azotobacter* + PSB + KMB significantly enhanced nitrogen uptake by grain compared to solo inoculation with *Azotobacter,* PSB and KMB. The crop collected the most nitrogen in grain when 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} + liquid biofertilizer *Azotobacter* + PSB + KMB were applied together, which was considerably higher than the rest of the treatment combinations during both years of trial and on a pooled basis.

Interaction effect of fertility levels and liquid biofertilizers on total nitrogen uptake. The data (Table 2b) show that the interaction impact of fertility levels and liquid biofertilizers had a substantial influence on total nitrogen uptake by crop during both research years and in pooled analysis. Regardless of liquid biofertilizers, an application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} gathered much more total nitrogen by crop than the other fertility levels. At all fertility levels, co-inoculation of malt barley seed with *Azotobacter* + PSB + KMB gathered considerably more total nitrogen than single inoculation of *Azotobacter*, PSB and KMB. During two years of investigation and pooled analysis, the highest quantum of total nitrogen was estimated under the combined application of 70 kg N+40 kg P_2O_5 + 25 kg K_2O ha^{-1} along with inoculation with liquid biofertilizer consisting of *Azotobacter*+ PSB + KMB, which was significantly higher than the rest of the treatment combinations.

Table 1: Effect of fertility levels and biofertilizers on nitrogen, phosphorus and potassium content of malt barley.

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
	Pooled					
Fertility levels						
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	1.628	0.210	0.363	0.133	0.435	1.129
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	1.731	0.244	0.383	0.145	0.453	1.179
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	1.865	0.296	0.405	0.156	0.478	1.251
S.Em.±	0.011	0.002	0.002	0.001	0.002	0.007
C.D. (P=0.05)	0.031	0.006	0.005	0.003	0.006	0.018
Liquid biofertilizers						
Control	1.582	0.217	0.352	0.127	0.422	1.091
Azotobacter	1.766	0.256	0.388	0.147	0.460	1.200
PSB	1.763	0.254	0.390	0.148	0.456	1.189
KMB	1.758	0.252	0.386	0.146	0.462	1.208
Azotobacter + PSB + KMB	1.837	0.271	0.403	0.156	0.477	1.244
S.Em.±	0.014	0.003	0.003	0.001	0.003	0.01
C.D. (P=0.05)	0.040	0.008	0.007	0.004	0.008	0.02

Table 2: Effect of fertility levels and biofertilizers on nitrogen uptake (kg ha^{-1}) of malt barley.

Treatments	Grain	Straw	Total
	Pooled	Pooled	Pooled
Fertility levels			
50 kg N + 25 kg P_2O_5 +15 kg K_2O ha^{-1}	60.46	15.04	75.67
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	69.69	19.83	89.70
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	85.29	25.70	111.16
S.Em.±	1.08	0.32	1.07
C.D. (P=0.05)	3.05	0.90	3.01
Liquid biofertilizers			
Control	59.14	15.01	74.15
Azotobacter	74.35	21.10	95.45
PSB	71.75	20.50	92.24
KMB	70.74	20.19	91.78
Azotobacter + PSB + KMB	83.11	24.15	107.26
S.Em.±	1.40	0.41	1.38
C.D. (P=0.05)	3.94	1.17	3.88

Table 2a: Interaction effect of fertility levels and biofertilizers on nitrogen uptake (kg ha^{-1}) by grain of malt barley.

Fertility levels	Liquid biofertilizers				
	Pooled				
	Control	*Azotobacter*	PSB	KMB	*Azotobacter* + PSB + KMB
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	49.67	63.83	61.94	60.90	65.96
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	60.37	71.37	70.98	70.70	75.06
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	67.39	87.85	82.32	80.61	108.31
S.Em.±	2.42				
C.D. (P=0.05)	6.82				

Table 2b: Interaction effect of fertility levels and biofertilizers on total nitrogen uptake (kg ha^{-1}) by malt barley.

Fertility levels	Liquid biofertilizers				
	Control	*Azotobacter*	PSB	KMB	*Azotobacter* + PSB + KMB
	Pooled				
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	60.38	78.88	77.68	77.39	84.03
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	75.39	92.41	91.19	91.08	98.42
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	86.69	115.06	108.26	106.45	139.33
S.Em.±	2.39				
C.D. (P=0.05)	6.73				

Phosphorus uptake

Fertility levels. During both years, the malt barley crop fertilised with 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} collected the most phosphorus in grain, straw and total which was substantially higher than applications of 60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} and 50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1} (Table 3, 3a & 3b).

According to pooled readings, a substantial increment in phosphorus uptake by grain, straw and total with the fertilization of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} was (19.94, 37.38), (15.46, 42.90) and (18.00, 39.60) per cent over fertilization of 60 kg N +30 kg P_2O_5 + 20 kg K_2O ha^{-1} and 50 kg N +25 kg P_2O_5 + 15 kg K_2O ha^{-1}, respectively.

Liquid biofertilizers. Data show that inoculating malt barley seed with liquid biofertilizers alone or in combination significantly influenced phosphorus uptake by grain, straw and total over both years of inquiry and in pooled analysis. Thus when compared to mean phosphorus accumulated by grain, straw and total, under control, single inoculation of *Azotobacter,* PSB, KMB and conjoint inoculation of *Azotobacter* + PSB + KMB significantly increased phosphorus uptake by grain, straw and total to the tune of (23.84, 20.50, 17.76 and 38.26), (37.84, 36.81, 33.02 and 58.94) and (29.46, 26.99, 24.71 and 46.50) per cent, respectively. Among liquid biofertilizers, co-inoculation with *Azotobacter* + PSB + KMB gathered the most phosphorus by grain, straw and total during both years, which was considerably higher than inoculation with *Azotobacter,* PSB and KMB alone. The significant improvement in phosphorus uptake by grain, straw and total due to co inoculation with *Azotobacter* + PSB + KMB was (11.64, 14.74, 17.40), (15.30, 16.17, 19.48) and (13.16, 15.35, 17.47) per cent over single inoculation of *Azotobacter,* PSB and KMB, respectively, in pooled analysis.

Interaction effect of fertility levels and liquid biofertilizers on phosphorus uptake by grain. Results (Table 3a) reveal that the interaction effect of fertility levels and liquid biofertilizers had a substantial impact on grain phosphorus uptake during both years of research and in pooled analysis. Regardless of the liquid biofertilizers used, the crop accumulated the greatest amount of phosphorus by grain under the application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}, which was much greater than the other fertility levels. At all fertility levels, seed inoculation with liquid biofertilizer containing a combination of *Azotobacter* + PSB + KMB gathered the maximum quantum of phosphorus by grain, which was significantly higher than single inoculation with *Azotobacter,* PSB and KMB.

Table 3: Effect of fertility levels and biofertilizers on phosphorus uptake (kg ha^{-1}) of malt barley.

Treatments	Grain	Straw	Total
	Pooled	Pooled	Pooled
Fertility levels			
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	13.48	9.51	23.03
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	15.44	11.77	27.25
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	18.52	13.59	32.15
S.Em.$\pm$	0.24	0.16	0.31
C.D. (P=0.05)	0.69	0.46	0.86
Liquid biofertilizers			
Control	13.17	8.72	21.89
Azotobacter	16.31	12.02	28.34
PSB	15.87	11.93	27.80
KMB	15.51	11.60	27.30
Azotobacter + PSB + KMB	18.21	13.86	32.07
S.Em.$\pm$	0.32	0.21	0.40
C.D. (P=0.05)	0.89	0.59	1.11

Table 3a: Interaction effect of fertility levels and biofertilizers on phosphorus uptake (kg ha^{-1}) by grain of malt barley.

Fertility levels	Liquid biofertilizers				
	Control	*Azotobacter*	PSB	KMB	*Azotobacter* + PSB + KMB
	Pooled				
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	11.37	14.04	13.91	13.46	14.62
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	13.45	15.88	15.77	15.57	16.54
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	14.68	19.02	17.95	17.51	23.46
S.Em.$\pm$	0.55				
C.D. (P=0.05)	1.53				

Table 3b: Interaction effect of fertility levels and biofertilizers on total phosphorus uptake (kg ha^{-1}) of malt barley.

Fertility levels	Liquid biofertilizers				
	Control	*Azotobacter*	PSB	KMB	*Azotobacter* + PSB + KMB
	Pooled				
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	18.00	23.68	23.94	23.53	26.01
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	22.35	28.31	27.79	27.50	30.29
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	25.30	33.02	31.67	30.87	39.90
S.Em.$\pm$	0.69				
C.D. (P=0.05)	1.93				

The combined application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} + conjoint inoculation with liquid biofertilizer *Azotobacter* + PSB + KMB resulted in considerably higher phosphorus uptake by grain than the other treatment combinations over both years of experiment and on a pooled basis.

Interaction effect of fertility levels and liquid biofertilizers on total phosphorus uptake. According to the findings (Table 3b), the interaction impact of fertility levels and liquid biofertilizers caused considerable variance in total phosphorus uptake during both years of inquiry and in pooled analysis. Regardless of liquid biofertilizers, the application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} resulted in the largest quantum of total phosphorus, which was significantly greater than the rest of the fertility levels. At all fertility levels, combined inoculation of *Azotobacter* + PSB + KMB resulted in greater total phosphorus uptake than single inoculation of *Azotobactor*, PSB and KMB. The maximum quantum of total phosphorus determined under the combined application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} + liquid biofertilizer *Azotobacter* + PSB + KMB was significantly greater than the rest of the treatment combinations over both years of study and pooled analysis.

Potassium uptake

Fertility levels. Throughout the years, the malt barley crop under the effect of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} had the highest potassium uptake by grain, straw and total which was significantly greater than the rest of the fertility levels (Table 4).

The significant increases in potassium uptake by grain, straw and total with the application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} were by (19.93, 35.14), (13.57, 34.40), and (14.58, 34.52) per cent over application of 60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} and 50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}, respectively.

Liquid biofertilizers. A study of the data reveals that inoculating malt barley seed with liquid biofertilizers alone or in combination with *Azotobacter* + PSB + KMB significantly altered potassium uptake by grain, straw and total during both years of study and in pooled analysis. The mean data show that inoculating malt barley seed with the liquid biofertilizers *Azotobacter*, PSB and KMB alone and in combination with *Azotobacter* + PSB + KMB significantly improved potassium uptake by grain, straw and total by (23.04, 17.88, 18.26, and 37.17), (31.10, 27.51, 28.51, and 46.93), and (29.73, 25.85, 26.75, and 45.25) per cent, respectively. Among liquid biofertilizers, co inoculation with *Azotobacter* + PSB + KMB produced the highest quantum of potassium by grain, straw and total which was considerably higher than inoculation with *Azotobacter*, PSB, and KMB over both years. Co-inoculation of *Azotobacter* + PSB + KMB enhanced potassium uptake by grain, straw and total by (11.48, 16.36 and 15.98), (12.07, 15.22 and 14.33) and (11.96, 15.41 and 14.59) per cent over solo inoculation of *Azotobacter*, PSB and KMB, respectively.

Interaction effect of fertility levels and liquid biofertilizers on potassium uptake by grain. The data (Table 4b) show that the interaction effect of fertility levels and liquid biofertilizers significantly affected potassium uptake by grain over both years of study and in pooled analysis. Regardless of liquid biofertilizers, an application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} accumulated the maximum quantum of potassium by grain, which was much higher than the remaining fertility levels. Although co-inoculation of malt barley seed with *Azotobacter* + PSB + KMB significantly enhanced potassium uptake in grain over solo inoculation of *Azotobactor*, PSB and KMB at all fertility levels. The combined application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} + liquid biofertilizer *Azotobacter* + PSB + KMB yielded the highest quantum of potassium by grain, which was significantly higher than the rest of the treatment combinations during both years of experimentation as well as on a pooled basis.

The significant improvement in nutritional status of seed and straw owing to application of 70 kg N+40 kg P_2O_5 + 25 kg K_2O ha^{-1} might be attributed primarily to enhanced availability of these nutrients in soil environment, as well as extraction and translocation towards plant system. Higher photosynthetic activity, as evidenced by higher dry matter production from the early stages of crop growth, helps metabolites to readily available from shoot to root. The importance of NPK fertilisation in increasing nutrient extraction conditions in plant systems was underlined. It is widely assumed that extracted nutrients are employed in plant systems to maintain critical concentrations that can be used for the formation of new structures. Thus maximum availability of nutrients with the fertilization of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} to malt barley crop seems to have maintained critical availability of nutrients at cellular level, fulfilled their requirements for profuse plant growth and their efficient translocation towards sink component (straw and grain). The findings are consistent with those of other researchers (Meena *et al.,* 2012; Prakash *et al.,* 2015; Jat *et al*., 2018).

It is well established fact that uptake of nutrients by the crop is primarily governed by total biomass production and secondarily on nutrient status at cellular levels. The concomitant improvement in both of these components reflected higher accumulation of nutrients with the application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}. The results confirm the finding of Rai *et al.* (2013); Shantveerayya *et al.* (2017); Parashar *et al*. (2020).

The beneficial effect of concurrent inoculation with liquid biofertilizer *Azotobacter* + PSB + KMB appears to be due to an increase in growth of above ground plant parts due to the secretion of growth promoting substances, which may have maintained an adequate supply of metabolites for enhancing root growth and functional activities, resulting in greater extraction of nutrients from soil and efficient translocation in the plant system. Second, enhanced specific activities of isocitric and malic dehydrogenase, the source of electron for nitrogen fixation, can be linked to a better nutritional environment, as well as the solubilization and mobilization of native and administered phosphorus and potassium (Thalooth *et al*., 2012).

The significant increase in uptake of N, P and K was mainly due to combined inoculation of seed with *Azotobacter* + PSB + KMB seems to be due to fact that uptake of nutrient is product of biomass accumulated by particular part and its nutrient content. Thus, positive impact of liquid biofertilizers on both these aspects ultimately led to higher accumulation of nutrients (Tarun *et al.*, 2010; Malik 2018).

Table 4: Effect of fertility levels and biofertilizers on potassium uptake (kg ha^{-1}) of malt barley.

Treatments	Grain	Straw	Total
	Pooled	**Pooled**	**Pooled**
Fertility levels			
50 kg N + 25 kg P_2O_5 +15 kg K_2O ha^{-1}	16.16	80.75	96.91
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	18.21	95.56	113.78
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	21.84	108.53	130.37
S.Em.$\pm$	0.25	1.43	1.44
C.D. (P=0.05)	0.71	4.01	4.06
Liquid biofertilizers			
Control	15.71	74.87	90.57
Azotobacter	19.33	98.16	117.50
PSB	18.52	95.47	113.99
KMB	18.58	96.22	114.80
Azotobacter + PSB + KMB	21.55	110.01	131.56
S.Em.$\pm$	0.33	1.84	1.86
C.D. (P=0.05)	0.92	5.17	5.24

Table 4a: Interaction effect of fertility levels and biofertilizers on potassium uptake by grain (kg ha^{-1}) of malt barley.

Fertility levels	Liquid biofertilizers				
	Control	***Azotobacter***	**PSB**	**KMB**	***Azotobacter* + PSB + KMB**
Pooled					
50 kg N + 25 kg P_2O_5 + 15 kg K_2O ha^{-1}	13.71	16.87	16.39	16.38	17.45
60 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}	16.03	18.86	18.38	18.22	19.57
70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1}	17.38	22.27	20.79	21.13	27.63
S.Em.$\pm$	0.57				
C.D. (P=0.05)	1.59				

CONCLUSIONS

Based on the results emanated, it is concluded that combine application of 70 kg N + 40 kg P_2O_5 + 25 kg K_2O ha^{-1} + seed inoculation with *Azotobacter* + PSB + KMB accumulated maximum quantum of nutrients in grain and straw of malt barley crop.

FUTURE SCOPE

The results of present investigation suggest future need to assess effect of integrated nutrient system in involving organic and inorganic fertilization on malt barley based cropping system rather than single crop to improve their efficiency and economic gains.

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REFERENCES

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.

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.

Jat, M. K., Purohit, H. S., Choudhary, S. K., Singh, B. and Dadarwa, R. S. (2018). Influence of INM on yield and nutrient uptake in sorghum-barley cropping sequence. *International Journal of Chemical Studies, 6*(3), 634-638.

Malik, P. (2018). Response of barley to fertilizer levels and different combinations of biofertilizers. Ph. D. Thesis, Department of Agronomy, CCSHAU, Hisar.

Meena, R., Singh, R. B. and Singh, Y. V. (2012). Effect of integrated nutrient management on barley (*Hordeum vulgare* L.) Under alluvial soil of Western Uttar Pradesh. *The Journal of Rural and Agricultural Research, 12*(1), 36-38.

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.

Parashar, A., Kumar, S., Gupta, S., Dogra, P. and Tyagi, B.S. (2020). Response of malt barley (*Hordeum vulgare* L.) varieties to nitrogen and sulphur application under Agro-climatic zone IIIa (semiarid eastern plain zone) of Rajasthan. *Journal of Cereal Research, 12*(1), 55-60.

Prakash, J., Siddiqui, M. Z., Dwivedi, A., Thaneshwar, B. P. and Singh, A. (2015). Effect of irrigation and fertility balance on performance and production economics of barley (*Hordeum vulgare* L.). *International Journal of Agriculture Sciences, 7*(13), 817-821.

Rai, K. N., Kumar, A., Pathak, R. K., Rai, T. N. and Pandey, P. (2013). Yield, nutrient uptake and quality of barley (*Hordeum vulgare*) with integrated use of farmyard manure and inorganic fertilizers. *Current Advances in Agricultural Sciences, 5*(1), 121-123.

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.

Shantveerayya, Mansur, C. P., Alagundagi, S. C. and Salakinkop, S. R. (2017). Nutrient dynamics and productivity of barley genotypes as influenced by INM and soil moisture conservation practices in rainfed condition of Southern India. *The Bioscan, 11*(4), 2495-2498.

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.

Tarun, M., Gulluce, M., Cakmakci, R., Oztas, T. and Sahin, F. (2010). The effect of PGPR strain on wheat yield and quality parameter. Proceeding of the 19th World Congress of Soil Science: Soil solution for a changing world, Brisbane, Australia. *Management and protection of receiving environment,* 209-212.

Thalooth, T., Bahr, A. and Tawfik, M. M. (2012). Productivity of some barley cultivars as affected by inoculation under water stress conditions. *Applied Botany, 51*, 10743-10749.

Vaughan, J. G., Judd, P. A. and Bellamy, D. (2006). The Oxford Book of Health Foods. Available online at http://books.google.co.in/books pp. 37.

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