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A study on "Variation in Phenological stages of Malt Barley (*Hordeumvulgare* L.) As influenced by Varying Fertility Levels and Liquid Biofertilizers under Semi-arid Region of Rajasthan, India

Research Article

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Abstract

A field experiment was conducted during 2020-21 and 2021-22 on clay loam soil having low in available nitrogen (278.36 to 279.42 kg ha^{-1}), medium in available phosphorus (18.73 to 20.39 kg ha^{-1}) and high in available potassium status (328.40 to 332.72 kg ha^{-1}) with slightly alkaline in reaction at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during the *rabi* season 2020-21 and 2021-22 with the objective to evaluate the response of malt barley to fertility levels and biofertilizers. The experiment was laid out in randomized block design (Factorial) with 15 treatment combinations comprised of three fertility levels *i.e.* application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1}, 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} with five liquid biofertilizers *i.e.* control, *Azotobacter*, PSB, KMB and *Azotobacter* + PSB + KMB. The experimental results revealed that malt barley crop took maximum days to attain heading, 50 % anthesis and physiological maturity when crop was fertilized with highest fertility levels *i.e.* 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} as compared to 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}. Among different liquid biofertilizers, Seed inoculation with *Azotobacter* + PSB + KMB recorded maximum days taken to heading, 50% anthesis and physiological maturity over single inoculation of *Azotobacter*, PSB and KMB. The study showed the result that combined application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} + liquid biofertilizers *Azotobacter* + PSB + KMB extended the growth duration of crop and helps to increase productivity of malt barley crop.

Keywords: Fertility levels; biofertilizers; Heading; Anthesis; Malt barley

Introduction

Barley (*Hordeumvulgare* 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 [1].

Barley is preferred cereal for malting because its glumes and hull are firmly cemented to the kernel and remain attached to the grain after threshing. The use of two-rowed barley for malting and brewing industry has picked up recently with increased consumption of beer and other malt-based products in many countries [2].

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The malt utilization pattern has also changed in confectionaries, 8 % for whiskies and the balance (around 60-62 %) for brewing [3,4]. 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 for malting. Barley grains with high protein content are more difficult to malt, yield low amounts of extracts and can cause difficulties in brewing.

Adequate mineral fertilization is considered to be one of the most important prerequisite in this respect. Nitrogen is the most important nutrient for plant growth and development. It is an integral part of chlorophyll, which is essential for photosynthesis. Phosphorus nutrition plays key role in plant metabolism. Being involved in various biochemical processes. 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.

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.

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. Phosphorus solubilizing bacteria (PSB) plays an important role in converting insoluble phosphate and applied phosphorus into available form resulting in higher crop yields [1]. 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 bacterium capable of mobilizing available potash near the roots of plants. Now it is indeed to promote the integrated use of biofertilizer with chemical fertilizer to minimize the dependence on inorganic fertilizer alone. Therefore keeping in view of above facts the present study"Response of Malt Barley (*Hordeumvulgare* L.) to Fertility levels and Biofertilizers" has been undertaken.

Material & Methods

The field experiment was conducted during *rabi* 2020-21 and 2021-22at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India. This region has typical sub-tropical climatic condition characterized by mild winters and moderate summers associated with high relative humidity during the months of June to September. The mean annual rainfall of the region is 637 mm, most of which is contributed by South West monsoon from June to September. The soil of experimental site was clay loam in texture, slightly alkaline in reaction, low in available nitrogen (278.36 to 279.42 kg ha^{-1}), medium in available phosphorus (18.73 to 20.39 kg ha^{-1}) and high in available potassium status (328.40 to 332.72 kg ha^{-1}). The experiment was laid out in randomized block design (Factorial) with 15 treatment combinations comprised of three fertility levels *i.e.* application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1}, 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} with five liquid biofertilizers *i.e.* control, *Azotobacter*, PSB, KMB and *Azotobacter* + PSB + KMB. The total quantities of phosphorus and potassium with half dose of nitrogen were drilled in furrows before sowing of seed. Remaining half dose of nitrogen was top dressed at the time of first irrigation. The seeds were treated with liquid biofertilizers using 5 ml kg^{-1} seed through standard procedure 2-3 hours before sowing as per treatment. Malt barley variety "DWRB-137" 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 20 cm. The crop was irrigated at critical growth stages *viz.*, tillering (30 DAS) and flowering (80 DAS) as per recommendation during both the year of experimentation to ensure good crop growth. The crop was harvested from the individual plot when plants were fully dried. 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 sundrying. In each plot observation was recorded by counting the number of days taken for boot leaf stage, 50 % heading, 50% anthesis and physiological maturity which were computed from date of sowing.

Results & Discussion

Days to boot leaf stage

Fertility levels: A perusal of data reveals that increasing fertility levels to malt barley crop failed to record significant influence on days to boot leaf stage during both the years of experimentation as well as in pooled analysis (Table 1).

Liquid biofertilizers: Irrespective of years as well as on pooled basis, malt barley seed inoculated with liquid biofertilizersdid not significantly influencedays taken to boot leaf stage.

Days to heading

Fertility levels: Data) reveals that fertility levels had significant effect on days to heading during both the year of study as well as in pooled analysis (Table 1). Application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} took maximum days to heading which was significantly later over application of 50 kg N+25 kg P_2O_5+15 kg K_2O ha^{-1} but at par with 60 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1} during both years.

On pooled basis, application of 50 kg N+25 kg P_2O_5+15 kg K_2O ha^{-1} took 67.51 days to heading which was significantly earlier by 2.8 and 4.7 days over application of 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}, respectively.

Liquid biofertilizers: Data reflects that inoculation of malt barley seed with liquid biofertilizers alone and in combination significantly influenced days to heading during both the years of investigation as well as in pooled analysis (Table 1). The crop took minimum days to heading under control which was significantly earlier than seed inoculation with *Azotobacter* alone and co inoculation of *Azotobacter* + PSB + KMB but at par with single inoculation of PSB and KMB during both years. On pooled basis, compared to control, inoculation

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Table 1: Effect of fertility levels and biofertilizers on days to boot leaf stage, heading stage, 50% anthesis and physiological maturitystage of malt barley.

Treatments	Days to boot leaf stage			Days to heading stage			Days to 50 % anthesis			Days to physiological maturity		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Fertility levels												
50 kg N+25 kg P_2O_5+15 kg K_2O ha^{-1}	53.00	54.45	53.73	67.00	68.01	67.51	74.15	75.22	74.69	114.36	115.57	114.97
60 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1}	54.60	55.50	55.05	69.70	70.81	70.26	76.85	78.07	77.46	116.06	117.27	116.67
70 kg N+40 kg P_2O_5+25 kg K_2O ha^{-1}	55.70	56.85	56.28	71.70	72.81	72.26	78.85	80.07	79.46	120.06	121.27	120.67
S.Em.±	1.25	1.27	0.89	1.26	1.28	0.90	1.28	1.30	0.91	1.31	1.34	0.94
C.D. (P=0.05)	NS	NS	NS	3.61	3.64	2.52	3.65	3.71	2.57	3.74	3.83	2.64
Liquid biofertilizers												
Control	51.75	53.42	52.58	65.58	66.53	66.06	72.53	73.50	73.02	112.54	113.75	113.15
Azotobacter	55.75	56.75	56.25	70.75	71.86	71.31	77.95	79.17	78.56	118.21	119.42	118.82
PSB	54.42	55.42	54.92	69.42	70.53	69.97	76.62	77.84	77.23	116.88	118.09	117.48
KMB	53.83	55.08	54.46	68.83	69.94	69.39	76.03	77.25	76.64	116.29	117.50	116.90
Azotobacter + PSB + KMB	56.42	57.33	56.88	72.75	73.86	73.31	79.95	81.17	80.56	120.21	121.42	120.82
S.Em.±	1.61	1.64	1.15	1.63	1.65	1.16	1.65	1.68	1.18	1.69	1.73	1.21
C.D. (P=0.05)	NS	NS	NS	4.66	4.70	3.26	4.72	4.79	3.31	4.83	4.95	3.41

with *Azotobacter*, PSB, KMB alone and conjoint inoculation of *Azotobacter* + PSB + KMB significantly enhanced days to heading by 5.25, 3.91, 3.33 and 7.25 days respectively.

Days to 50% anthesis

Fertility levels: It is evident from data that fertility levels had significant influence on days to 50% anthesis during both the years of experimentation as well as in pooled analysis (Table 1). Application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} took maximum days to 50 % anthesis which was significantly later over application of 50 kg N+25 kg P_2O_5+15 kg K_2O ha^{-1} but at par with 60 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1} during both years.

Pooled results show that application of 50 kg N+25 kg P_2O_5+15 kg K_2O ha^{-1} took 74.69 days to 50% anthesis which was significantly earlier by 2.7 and 4.8 days over application of 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}, respectively.

Liquid biofertilizers: It can be inferred from the data that inoculation of malt barley seed with liquid biofertilizers alone and in combination significantly influenced days to 50% anthesis during both the years of study as well as in pooled analysis (Table 1). The crop took minimum days to 50% anthesis under control which was significantly earlier than seed inoculation with *Azotobacter* alone and co inoculation with *Azotobacter* + PSB + KMB but at par with single inoculation of PSB and KMB during both years. On pooled basis, inoculation with *Azotobacter*, PSB, KMB alone and co inoculation of *Azotobacter* + PSB + KMB significantly enhanced days to 50% anthesisby 5.54, 4.21, 3.62 and 7.54 days over control, respectively.

Days to physiological maturity

Fertility levels: Fertility levels had significant influence on days to physiological maturity during both the years of investigation as well as in pooled analysis (Table 1). The malt barley crop fertilized with70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} took maximum days to maturity which was significantly later 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} during both years.

On the basis of pooled analysis, application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} took 120.67 days to physiological maturity which was significantly later by 4.0 and 5.7 days 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: Inoculation of malt barley seed with liquid biofertilizers alone and in combination significantly influenced days to physiological maturityduring both the years of investigation as well as in pooled analysis (Table 1). The crop took minimum days to physiological maturity under control which was significantly earlier than seed inoculation with *Azotobacter* alone and co inoculation with *Azotobacter* + PSB + KMB but at par with single inoculation of PSB and KMB during both years. On pooled basis, single inoculation of *Azotobacter*, PSB, KMB and co inoculation of *Azotobacter* + PSB + KMB significantly enhanced days to physiological maturity by 5.67, 4.33, 3.75 and 7.67 days over control, respectively.

The phenological studies showed that application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} increased days taken to heading, 50% anthesis and physiological maturity. The increased duration for each of the phenological stages (heading, 50 % anthesis, and physiological maturity) and overall crop growth period with increasing rate of fertility levels seems to be due to their pivotal role in improving nutrient status of the plant organs along with adequate supply of metabolites. These might have facilitated optimum growth of each plant parts and delayed their senescence. Nitrogen application increased the vegetative growth as it increases the photosynthetic activity and the leaves remain functional for a longer period which improved plant height and dry matter accumulation which ultimately delayed the ear heading in barley. The above findings are also in cognizance with the findings [5-10].

Conclusion

The combined application of 70 kg N+40 kg P_2O_5 +25 kg K_2O ha^{-1} along with seed inoculation with *Azotobacter* + PSB + KMB is proved to be beneficial for extending the growth duration of crop and which helps to increase the productivity of malt barley.

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