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Unlocking Yield Potential: Influence of Varieties and Fertilizer Levels on Malt Barley in Medium Black Soils

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Abstract

Malt barley (*Hordeum vulgare* L.) growth and yield performance were examined in relation to various cultivars and fertiliser concentrations. Three malt barley varieties (DWR-UR-52, RD 2035 and PMVM 10/2 R) and four fertilizer levels (GRDF 100:75:50 kg NPK ha⁻¹, GRDF 80:60:40 kg NPK ha⁻¹, GRDF 60:45:30 kg NPK ha⁻¹ and GRDF 100:75:50 kg NPK ha⁻¹) were studied in *rabi* season of 2024-25. The trial was conducted in a split-plot design and replicated thrice across two locations: Manjari and Nagpur R&D farms of the Vasantdada Sugar Institute. The results of this study indicated that maximum emergence (153.56 plants m⁻²), dry matter production (374.95 g m⁻²) at 60 DAS, grain weight per ear (1.33 g) and highest grain yield (31.82 q ha⁻¹) were recorded in RD-2035 barley variety. While plant height, ear length and grain yield was maximum with 100:75:50 kg N: P₂O₅: K₂O ha⁻¹ fertilizer level. Based on field performance it proved that, exploring the maximum potential of malt barley under the agro-climatic conditions of the study area, integrated approach can be recommended for achieving higher productivity and economic returns in malt barley cultivation.

Keywords: Varieties, fertilizer levels, malt barley, agronomic performance, yield potential

Introduction

In terms of global production and acreage, barley (*Hordeum vulgare* L.) ranks fourth in importance among cereal crops, behind maize, wheat, and rice. Because it can be cultivated in a wider range of environmental conditions than any other cereal crop, this particular *rabi* season crop is commonly referred to as the most cosmopolitan of the cereal crops. Because of its many qualities, including greater flexibility and hardiness, it is also regarded as one of the ancient crops that humans domesticated.

Barley serves various purposes and is a significant cereal crop for the brewing industry. It is primarily utilised as animal fodder and is malted for use in alcoholic beverages, particularly beers. Additionally, it serves as a flavouring agent, vinegar, sweeteners, and malt flours, among other applications. Barley is a robust cereal crop recognised for its adaptability to marginal soils and environmental conditions. The global focus on food and environmental sustainability has led to an increased demand for cereals, especially hardy and drought-tolerant varieties like barley (Tuppad *et al.*, 2023) ^[14].

Yield and yield attributes are influenced by polygenic inheritance and environmental factors, resulting in variations in performance (Dia *et al.*, 2016) ^[2]. Addressing the high yielding varieties is prior importance for the development of production technology. Adequate mineral fertilization is also important intervention for higher yield. Amongst nutrients, nitrogen plays an important role in synthesis of chlorophyll, amino acids and other organic compounds of physiological significance for plant system (Havlin *et al.*, 2003) ^[4]. Next to nitrogen, phosphorus is of paramount importance for energy transfer in living cells by mean of high energy phosphate bonds of ATP. Thus, it plays pivotal role in formation and translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. Likewise, potassium act as a chemical traffic policeman, root booster, stalk strengthen, food formic, sugar and starch transport, protein builder, breathing regulator, water stretcher and as a disease retarder thus improve grain quality (Brady *et al.*, 2003) ^[1].

Material and Methods

The field experiment was initiated at Vasantdada Sugar Institute's Manjari and Nagpur farms in two separate sites during the 2024-25 rabi season. Three malt barley types (DWR-UR-52, RD 2035, and PMVM 10/2 R) were used as the main factor in a split plot design, and four fertiliser rates (GRDF 100:75:50 kg NPK ha⁻¹, GRDF 80:60:40 kg NPK ha⁻¹, GRDF 60:45:30 kg NPK ha⁻¹, and GRDF 100:75:50 kg NPK ha⁻¹) were used as subfactors and replicated thrice. The full dose of P₂O₅ and K₂O were applied at the time of sowing, while N was applied in two splits: 50% at sowing and 50% at 30 DAS. As needed, the recommended agronomic techniques and plant protection strategies were implemented. The information on growth performance, yield and the factors that contribute to it was documented during the entire growing season.

Result and Discussion

Emergence count (per m²)

The results indicated that there was a significant difference ($p < 0.05$) in crop emergence amongst the studied malt barley varieties; however, there was no significant variation in fertiliser levels or their interaction (Table 1). The highest plant emergence (153.56 per m²) was noted from variety RD-2035, which was closely followed by PMVR 10/2R (130.99 per m²). This indicates that plant emergence is primarily governed by varietal potential rather than fertilizer application during the initial establishment phase.

Tillering ratio at harvest

The analysis result of variance reveals that tillering ratio at harvest had significant ($p < 0.05$) variation among fertilizer levels, but hadn't significance due to varieties and interaction effect on both factors (Table 1).

Statically significant variation was observed on tillering ratio among the tested fertilizer levels in the study area. The highest tillering ratio (3.50) was recorded with the fertilizer level 100:75:50 kg N: P₂O₅: K₂O ha⁻¹, which was statistically at par with 80:60:40 kg N: P₂O₅: K₂O ha⁻¹ fertilizer level with 3.31 tillering ratio, while the remaining two fertilizer levels produced comparatively less tillers. This indicates that tillering response was positively influenced by nutrient availability. More tillers were produced from the main stem and tiller mortality was decreased as a result of higher nitrogen levels. These findings support those reported by Kumar *et al.* (1999)^[7].

Leaf chlorophyll content at 60 DAS

The analysis of variance shows that leaf chlorophyll content at 60 DAS was significant ($p < 0.05$) due to fertilizer levels, while varieties and interaction effect was not significant difference on leaf chlorophyll content (Table 1). The maximum SPAD value (44.87) was observed with 100:75:50 kg N: P₂O₅: K₂O ha⁻¹ fertilizer level followed by (42.72) 80:60:40 N: P₂O₅:K₂O ha⁻¹ fertilizer level. The increasing trend in chlorophyll content with fertilizer levels results enhanced nutrient uptake, leading to improved photosynthetic activity.

Plant Height

Plant height was recorded at 30, 60 DAS, and at harvest. The analysis revealed a significant difference ($p < 0.05$) in plant height among the tested malt barley varieties only at 30 DAS, whereas fertilizer levels showed significant effects

at all growth intervals. However, the interaction between varieties and fertilizer rates was not significant (Table 2).

At 30 DAS, the highest plant height (43.28 cm) was observed in variety RD-2035, which was statistically at par with PMVR 10/2R (42.96 cm). The lowest height (36.37 cm) was recorded in variety DWR-UR-52 (Table 2). The variation in plant height among varieties may be attributed to genetic differences and their interaction with environmental conditions, which appeared more favorable for RD-2035.

Across all growth stages (30, 60 DAS, and harvest), the highest plant height (45.03 cm, 74.87 cm, and 86.29 cm, respectively) was recorded with fertilizer level F₄ (100:75:50 kg N:P₂O₅:K₂O ha⁻¹), followed by F₃ (42.00 cm, 71.00 cm, and 82.96 cm, respectively) at 80:60:40 kg N:P₂O₅:K₂O ha⁻¹. Similar results were reported by Moreno *et al.* (2003)^[10], who observed maximum plant height and dry matter accumulation in barley with 120 kg N ha⁻¹ compared to lower nitrogen doses.

Plant dry matter (g m⁻²)

The analysis result of variance reveals that plant dry matter (g m⁻²) had significant ($p < 0.05$) variation among varieties at 60 DAS and fertilizer levels at 30 and 60 DAS (Table 2). The variety RD-2035 produce notably higher dry matter (374.95 g m⁻²), followed by PMVR 10/2R (320.44 g m⁻²) at 60 DAS. The dry matter increased significantly with fertilizer levels. The plant dry matter was higher in F₄ fertilizer level (100:75:50 kg N: P₂O₅: K₂O ha⁻¹) (119.61 & 403.44 g m⁻²) however this was not significant at harvest.

The interaction effect of both factors presented in (Table 2.1) showed significant variation in dry matter production at 30 DAS. Among the various treatment combinations, the maximum dry matter production (127.80 g m⁻²) was obtained in RD-2035 with 100:75:50 N-P₂O₅-K₂O kg ha⁻¹ fertilizer level, which was statistically comparable with PMVR 10/2R (124.21 g m⁻²) with 100:75:50 N-P₂O₅-K₂O kg ha⁻¹ fertilizer level.

Yield Attributes

The analysis result of variance shows that ear length, grains per ear and grain weight per ear had significant ($p < 0.05$) variation among varieties. While ear length and test weight had significant influence on fertilizer levels. But interaction effect hadn't any significance response due to both factors.

The highest ear length (7.33 cm) was obtained from barley variety PMVR 10/2R, which was statistically on par with RD-2035 (7.13 cm). While RD-2035 recorded higher grains per ear (23.42) & grains weight per ear (1.33 g). The longest ears (7.72 cm) and test weight (47.67 g) was observed with 100:75:50 kg N: P₂O₅: K₂O ha⁻¹ fertilizer level. These results are in conformity with those of Moreno *et al.* (2003) and Liben *et al.* (2011)^[10, 9] who got best results with maximum dose of nitrogen. Tuppad *et al.*, 2023^[14] stated that the yield characteristics were significantly impacted by higher nitrogen levels, which peaked at 120 kg N ha⁻¹ but were comparable to 80 kg N ha⁻¹. Higher dose of nitrogen significantly increased grain weight. Patel and Upadhyay (1993)^[11].

Grain Yield (q ha⁻¹)

The analysis of variance revealed that fertilizer levels had a significant effect ($p < 0.05$) on grain yield, whereas the effects of variety and the interaction between variety and

fertilizer level were found to be non-significant (Table 4). The highest grain yield (32.41 q ha^{-1}) was recorded with the application of $100:75:50 \text{ kg N:P}_2\text{O}_5:\text{K}_2\text{O ha}^{-1}$, indicating that a higher nutrient supply positively influenced yield performance. However, straw yield and harvest index did not exhibit any statistically significant differences across treatments. These findings are in alignment with previous studies. Singh *et al.* (2016) [13] reported that the RD 2035 variety outperformed RD 2552, recording 5.6% higher green fodder yield, 12.4% more grains per earhead, 10.0% higher grain yield, and 9.4% greater grain equivalent yield. Similarly, Sharma (2009) [12] documented that the maximum seed yield (46.20 q ha^{-1}) was obtained from the RD 2035 variety, further supporting its superior performance. Regarding fertilizer response, noted that the application of 100 kg N ha^{-1} , being at par with 80 kg N ha^{-1} , significantly outperformed 60 kg N ha^{-1} in terms of both grain and straw yield. They also found that higher phosphorus levels,

particularly $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, resulted in increased grain yield compared to lower levels also demonstrated that the highest fertilizer dose ($120\text{N}:75\text{P}:45\text{K kg ha}^{-1}$) significantly improved spikelet number, spike dry weight, grain number, grain dry weight, spike relative growth rate, and grain relative growth rate, emphasizing the importance of adequate nutrient supply in enhancing yield components.

Conclusion

Based on the present findings, the barley variety RD 2035 demonstrated superior performance across most agronomic traits, indicating its potential as a high-yielding and adaptable cultivar. Similarly, the use of $100:75:50 \text{ kg N:P}_2\text{O}_5:\text{K}_2\text{O ha}^{-1}$ as the most effective fertilizer regime, significantly enhancing growth and yield parameters. Therefore, it can be concluded that the combination of RD 2035 variety with $100:75:50 \text{ kg N:P}_2\text{O}_5:\text{K}_2\text{O ha}^{-1}$ fertilizer level is optimal for achieving higher productivity.

Table 1: Crop emergence, tillering ratio and leaf chlorophyll at 60 DAS of malt barley as influenced by varieties and fertilizer levels (Pooled).

Treatment	Emergence count (per m^2)	Tillering ratio	Leaf chlorophyll at 60 DAS (SPAD values)
Factor A: Varieties			
V ₁ : DWR-UR-52	113.33	3.27	42.13
V ₂ : RD 2035	166.52	3.27	41.37
V ₃ : PMVR 10/2R	146.88	3.12	41.68
Sem $\pm$	3.73	0.08	0.20
C.D. @ 5%	14.63	NS	NS
Factor B: Fertilizer levels			
F ₁ - GRDF 40:30:20 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	138.00	2.98	38.60
F ₂ - GRDF 60:45:30 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	153.47	3.16	40.79
F ₃ - GRDF 80:60:40 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	137.67	3.33	42.74
F ₄ - GRDF 100:75:50 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	139.83	3.40	44.77
Sem $\pm$	5.87	0.02	0.34
C.D. @ 5%	NS	0.07	1.00
Interaction V$\times$F			
Sem $\pm$	10.16	0.04	0.58
C.D. @ 5%	NS	NS	NS

Table 2: Plant height at 30, 60 DAS and at harvest of malt barley as affected by varieties and fertilizer levels (Pooled)

Treatment	Plant Height (cm)			Plant Dry Matter (g m^2)		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
Factor A: Varieties						
V ₁ : DWR-UR-52	36.37	68.07	77.63	86.88	251.83	468.56
V ₂ : RD -2035	43.28	70.08	81.43	108.40	374.95	556.99
V ₃ : PMVR 10/2R	42.96	71.05	84.95	89.20	320.44	531.33
Sem $\pm$	3.05	1.37	1.85	2.00	38.59	14.46
C.D. @ 5%	4.16	NS	NS	NS	24.92	NS
Factor B: Fertilizer levels						
F ₁ - GRDF 40:30:20 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	36.56	64.81	76.57	73.32	244.79	402.80
F ₂ - GRDF 60:45:30 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	39.88	68.26	79.53	86.63	288.44	493.68
F ₃ - GRDF 80:60:40 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	42.00	71.00	82.96	99.74	326.28	554.21
F ₄ - GRDF 100:75:50 N-P ₂ O ₅ -K ₂ O Kg ha^{-1}	45.03	74.87	86.29	119.61	403.44	625.13
Sem $\pm$	0.38	0.63	0.84	4.72	14.00	33.16
C.D. @ 5%	1.08	1.82	3.77	21.23	63.03	NS
Interaction V$\times$F						
Sem $\pm$	0.65	1.10	1.68	2.29	26.91	19.79
C.D. @ 5%	NS	NS	NS	6.57	NS	NS

Table 3: Interaction effect of malt barley varieties and fertilizer levels on plant dry Matter at 30 DAS

Treatment	F ₁	F ₂	F ₃	F ₄
V ₁	60.37	80.31	100.01	106.81
V ₂	93.35	104.25	108.20	127.80
V ₃	66.23	75.34	91.02	124.21

Sem±	2.29
C.D. @ 5%	6.57

Table 4: The effects of varieties and fertilizer levels on yield attributes of malt barley (Pooled)

Treatments	Ear length (cm)	Grains per ear	Grain weight per ear (g)	Test Weight (g)
Factor A: Varieties				
V ₁ : DWR-UR-52	6.40	13.68	0.55	45.81
V ₂ : RD -2035	7.13	23.42	1.33	45.30
V ₃ : PMVR 10/2R	7.33	13.51	0.88	47.12
Sem±	0.24	3.46	0.31	0.42
C.D. @ 5%	0.52	3.95	0.13	NS
Factor B: Fertilizer levels				
F ₁ - GRDF 40:30:20 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	6.17	12.63	0.56	44.46
F ₂ - GRDF 60:45:30 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	6.74	13.91	0.71	45.97
F ₃ - GRDF 80:60:40 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	7.17	17.22	0.89	46.20
F ₄ - GRDF 100:75:50 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	7.72	23.72	1.53	47.67
Sem±	0.10	1.79	0.19	0.26
C.D. @ 5%	0.28	NS	NS	0.75
Interaction V×F				
Sem±	0.17	1.20	0.11	0.45
C.D. @ 5%	NS	NS	NS	NS

Table 5: The effects of varieties and fertilizer levels on yield and harvest index of malt barley (Pooled)

Treatments	Yield (q ha ⁻¹)		Harvest Index
	Grain	Straw	
Factor A: Varieties			
V ₁ : DWR-UR-52	22.01	90.52	19.04
V ₂ : RD -2035	31.82	89.52	25.90
V ₃ : PMVR 10/2R	25.86	94.66	21.08
Sem±	1.14	4.28	1.07
C.D. @ 5%	NS	NS	NS
Factor B: Fertilizer levels			
F ₁ - GRDF 40:30:20 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	21.33	79.86	20.79
F ₂ - GRDF 60:45:30 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	24.76	88.19	21.48
F ₃ - GRDF 80:60:40 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	27.77	94.98	22.22
F ₄ - GRDF 100:75:50 N-P ₂ O ₅ -K ₂ O Kg ha ⁻¹	32.41	103.23	23.53
Sem±	0.54	4.06	1.33
C.D. @ 5%	1.56	NS	NS
Interaction V×F			
Sem±	0.94	3.22	1.71
C.D. @ 5%	NS	NS	NS

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