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Comparative Physiological Basis of Variability in Germination, Seedling Vigour and Vegetative Vigour in Wheat and Barley

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Abstract: *Wheat and barley are two important cereal crops with similar phenological stages but varing in terms of growth and developmental behavior. A comparative study on the physiological basis of variability in germination, seedling and vegetative vigour was made in wheat and barley in terms of germination rate, seedling growth, vegetative growth and its relation to cell wall properties (ferulic acid content), assimilate partitioning to roots, root distribution in soil profile. The study showed that the wheat genotype (H2824) showed a faster germination rate, due to its ability to maintain lower critical water potential of seed, higher β amylase activity, shorter duration of the II^{nd} phage in triphasic imbibition curve than the barley genotype (RD2668). However, the seedling and vegetative vigour was higher in barley as compared to wheat. At 15-21 DAS in field, the seedling vigour of barley was greater as compared to wheat similarly, the vegetative vigour was greater in barley than wheat in relation to higher dry matter production, leaf area, specific leaf area, no of nodal roots, root dry wt., root length. The higher specific leaf area was negatively associated with cell wall ferulic acid, which helps in cell wall lignifications, thus limiting cell expansion. Root distribution study was done by trench profile wall method (1 m depth), showed a higher percentage of total root distribution in the upper soil horizon (0 -30 cm) in barley as compared to wheat. Thus the present the study have shown physiologically that wheat genotype showed faster germination rate than barley genotype but the seedling and vegetative vigour is higher in barley as compared to wheat.*

1. INTRODUCTION

Wheat and barley are two important cool season cereal crops with similar growth seasons and phenological stages [1]. However in terms of the overall development there are differences on wheat and barley. It has been reported that barley exhibits earlier germination, emergence and vigour as compared to wheat [2,3]. However, the physiological basis of these differences has not been studied. The present study was therefore conducted to understand the physiological and biochemical aspects and comparisons among wheat and barley in terms of early vigour and crop growth.

2. MATERIAL AND METHODS

Wheat genotype *T. aestivum* (HD 2824) and *Hordeum vulgare* (RD2668 and RD2552) were investigated. Plants were grown in earthen pots each of diameter 29 cm and height 29 cm, on 16^{th} November, 2011 with standard management practices. From these plants the dry matter and plant growth were measured at 21 days interval upto 105 days. Root distribution pattern was studied in field by trench profile wall method as per [4]. Also, wheat and barley were evaluated for the germination rate and critical water potential of seeds as per as per the standard methods described in [5] and [6]. Estimation of β-amylase activity in seeds was done as per the method given by [7] using Dinitrosalicylic acid reagent. The leaf ferulic acid content was determined by the molar extinction coefficient of 18200 as per [8].

3. RESULTS AND DISCUSSION

In the present study *T. aestivum* (HD2824) and *Hordeum vulgare* (RD2668 and RD2552) were investigated in terms of early vigour and crop growth. The wheat genotype HD2824 showed higher seed germination rate compared to the barely genotype RD2668. This difference in seed germination can occur due to variability in seed imbibition pattern [9], critical water potential or base water potential [10, 11] and enzymes for seed reserve mobilization e.g. amylases [12]. These characteristics related to faster germination are shown in Table 1. The analysis of triphasic seed imbibitions pattern in many studies indicates that the hydration level during second phase and the duration of second phase can be related to rate of seed germination. The shorter duration of second phase makes the seed to attain faster germination rates. Further, the germination rates of the wheat and barley were estimated using osmotic potentials created with Polyethylene Glycol (PEG-6000) ranging from 0, -0.3, -0.6, -0.9 and -1.2 MPa. The minimum water potential for seed germination of wheat has been reported to be -2.20 MPa [13]. In the present studies the wheat genotype showed a water potential level of -2.55 MPa compared to barley of -2.1 MPa. The lower basal water potential requirement can be reached earlier and therefore the HD2824 showed earlier germination and a higher seed germination rate as compared to others. The base water potential has important application in terms of hydro time modeling of seed germination [6]. Comparison of the fastest (HD2824) and slowest germinating (RD2552) genotypes on the basis of the initial activity of β-amylase upto 3 days after imbibitions indicated a consistently higher β-amylase activity in HD2824 as compared to RD2552. The β-amylase activity has also been reported as an index for germination potential in rice [12] and thus it helps in initiating the germination and supporting early seedling growth.

The Crop physiological parameters of pot grown plants at 21 DAS are presented in Table 1. It was observed that the mean seedling height, dry matter, leaf area, specific leaf area, no. of nodal roots and root length was higher in barley than wheat genotypes. The results of field grown plants also showed that in barley there was a comparatively faster emergence (Fig. 1) and development in terms of number of tillers which was associated with number of leaves and number of nodal roots. Besides this, the dry matter production of above ground parts, roots and total dry matter showed a higher increase in barley as compared to wheat. Barley exhibits earlier germination, emergence and vigour as compared to wheat [2,3]. Seedlings of barley emerged first in a crop and maintained a competitive advantage over their neighbours throughout the growing season [14].

The Crop physiological parameters of pot grown plants at 105 DAS are presented in Table 1. It was observed that the mean dry matter, leaf area, specific leaf area, no. nodal roots, root dry wt. and maximum tiller nos. was higher in barley than wheat genotypes. This higher growth potential can be associated with cell wall properties e.g. ferulic acid. It has been observed that ferulic acid and other cell wall phenolics are associated with the lignin synthesis. Lignin synthesis leads to the increase in the cell carbon content as compared to the other organic compounds except lipids) as mentioned by [15]. Therefore, such leaves having higher ferulic acid will have lower specific leaf area. In the present study the ferulic acid content was measured in wheat and barley leaves. It was observed that ferulic acid content of leaves at seedling stage was negatively associated with the SLA.

The belowground growth in wheat and barley was studied in terms of root distribution by trench profile wall method (1m depth). A higher % of total root distribution was observed in the upper soil horizon (0-30cm and 0-60 cm) in barley as compared to the wheat genotypes (Fig. 2). Comparative study showed that in 0-30 cm zone 35.8% and 77.5% of total roots were present in wheat and barley respectively. Whereas in the deeper zone below 60 cm 19.8% and 4.2% of total roots were present in wheat and barley respectively.

Fig. 1. Barley and wheat seedlings at 15 Days after sowing.

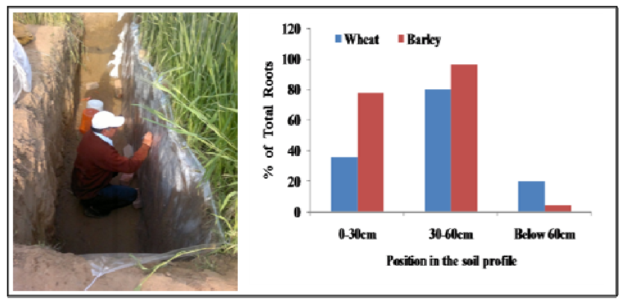

Fig. 2: Root distribution of wheat and barley in the soil profile by trench profile wall method.

Table 1: A comparison of growth parameters in wheat and barley.

Characteristics	**Wheat**	**Barley**	**Level in barley over wheat (%)**
Earliness in Germination			
Critical water potential of seeds	-2.55 MPa	-2.15 MPa	-15.6
Duration of IInd phase during triphasic water uptake	10-28 hrs	10-35 hrs	-20
β-amylase activity upto 3 days after imbibition (µmol maltose /g seed FW/min)	1122.41	516.147	-50
Seedling growth 21 DAS (per plant)			
Seedling height (cm)	19.16	23.66	23.5
Dry matter (g)	0.054	0.150	177.8
Leaf area (cm2)	8.15	27.88	242.1
Specific leaf area (cm2 g-1)	203.12	263.83	29.9
No. nodal roots	0.50	3.33	566.0
Root Length (cm)	21.33	40.00	87.5
Vegetative growth 105 DAS (per plant)			
Dry matter (g)	32.40	71.23	119.8
Leaf area (cm2)	736.98	1449.44	96.7
Specific leaf area(cm2 g-1)	115.71	203.12	75.5

No. nodal roots	31.39	57.00	81.6
Root dry wt. (g)	4.93	5.82	18.1
Maximum tiller nos.	13.4	53.1	296.3
Leaf ferulic acid content (% dry wt.)	0.945	0.899	-4.9
% Root distribution in upper profile (0-30) cm	35.8% of total roots	77.5% of total roots	-
% Root distribution in 0-60 cm	80.2% of total roots	95.8% of total roots	-
% Root distribution below 60 cm	19.83 of total roots	4.23 of total roots	-

4. CONCLUSIONS

Comparative analysis of growth in wheat and barley showed that there was a higher germination rate in wheat genotype (HD2824) due to its ability to maintain lower critical water potential of seed, higher β amylase activity and shorter duration of the II^{nd} phage in triphasic imbibition curve than the barley genotypes. However, barley has a higher dry matter production potential in terms of seedling and vegetative vigour as compared to wheat. It was associated with higher production rate of leaves, shoots, number of nodal roots, total roots. A higher CGR in barley was therefore maintained in comparison to wheat. The cell wall ferulic acid also explained the higher SLA and growth of barley as compared to wheat. Due to faster growth and tillering in barley it had a higher nodal root production as well as a higher % of roots in the upper soil zone than wheat. This competitive ability of barley has implications in adaptation and crop improvement.

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