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A study of seed germination and early seeding growth of wheat genotypes affected by different seed pyridoxine-priming duration

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ABSTRACT

The objective of this study was to evaluate the effects of seed pyridoxine-priming duration on germination and early seeding growth characteristics of two wheat genotypes included inbred lines of PBW-154 and PBW-343. The experiments were carried out in completely randomized design (CRD) with five seed priming treatments in three replications. The seed priming treatments included three pyridoxine-priming duration treatments consist of 6, 12 and 24 h were compare with the unsoaked seed control and a hydro-priming with distilled water for 12 h. The pyridoxine concentration of 200 mg 1^{-1} prepared in distilled water was used as pyridoxine-priming media. Seed pyridoxine-priming treatments improved seed germination and early seeding growth traits included germination percentage, coleoptiles and radical length, seeding dry matter accumulation, mean germination time (MGT), germination index (GI), vigor index (VI), and time to 50% germination (T_{50}) of both genotypes. Seed pyridoxine-priming duration of 12 h produced maximum value for most of the germination and early seedling growth characteristics of wheat inbred lines of PBW-154 and PBW-343. These results have practical implications in the pre-sowing seed treatment with pyroxene solution could enhance the seed germination and early seedling growth characteristics of wheat plant.

Key Words: pyridoxine; seed priming; wheat; inbred lines.

INTRODUCTION

Wheat is an important cereal in many developed and developing countries of the world. It is widely used for animal feed and industrial raw material in the developed countries where as the developing countries use it in general for feed. As regards to area and production wheat ranks third in world production following wheat and rice. World wheat production must increase by approximately 1.5% annually to meet the growing demand for food that will result from population growth and economic development [25]. Rapid and uniform field emergence is an important factor to achieve high yield with respect to both quantity and quality in annual corps [23,34]. Seed priming has been found a double technology to enhance rapid and uniform emergence, and to achieve high vigor and better yields in field corps [13,11]. Many studies have been carried out on the effect of seed priming on germination and growth rate of corps. Subedi and Ma [34] reported that seed soaked with 2.5% KCl for 16 h reduced both coleoptile and radicle length of wheat. Chiu et al., [8] observed enhanced germination in sweet wheat when primed using polyethylene glycol. Misra and Dwibedi [20] found that seed soaking in 2.5% potassium chloride (KCl) for 12 h before sowing increased wheat yield by 15%. Furthermore, Paul and Choudhury [24] observed that seed soaking with 0.5 to 1% solution of KClor potassium sulfate (K_2SO_4) significantly increased plant height, yield attributes, and grain yield in wheat. Earlier studies showed that the success of seed priming is affected by the complex interaction of factors including priming agent, plant species, priming duration, temperature, seed vigor and dehydration, and also storage conditions of the primed seed [23]. It has been established that pyridoxine (Vitamin B_6) enhances the growth of root system [26,27,7] which helps in better seedling establishment, and higher nutrient and water uptake [28,2]. The work with regard to seed soaking treatment with pyridoxine has been proved promising in mustard [15], lentil and mung [29] and wheat [17]. Khan et al. [16] reported that application of 0.02% pyridoxine for both mustard and wheat gave maximum value for growth and yield parameters. Pre-sowing seed treatment of mung been cultivar of K-851 in pyridoxine solution significantly enhanced leaf nitrogen, phosphor and potassium concentrations at different growth stages, and seed protein concentration at harvest [2]. In our knowledge, responses to seed pyridoxine-priming treatment on seed germination and early seedling growth of wheat have not been investigated to date. Hence, the specific objective of this study was to evaluate the effect of different seed pyridoxine-priming duration on seed germination and early seedling growth of wheat genotypes.

MATERIALS AND METHODS

The experiment were laid out in completely randomized design (CRD) with two wheat genotypes included inbred lines of PBW-154 and PBW-343 and five seed priming treatment in three replications. The seed priming treatments included three pyridoxine-priming duration treatments consist of 6, 12 and 24 h were compare with the unsoaked seed control and a hydro-priming with distilled water for 12 h. The pyridoxine concentration of 200 mg 1^{-1} prepared in distilled water was used as pyridoxine-priming media. Approximately 500 g of seed of genotypes were placed in individual nylon net bags and immersed in priming agent at 20 ºC. After soaking seeds were redried to original weight with forced air under shade. Thirty seeds from each of the treatments were placed on 90 mm φ Petri dishes on Whatman No. 2 filter paper moistened with 15 ml distilled water. Seeds were kept in germinator at 25 ºC in darkness. Germination was counted in 24 h intervals and continued until fixed state. A seed was considered as germinated when radicle had emerged more than 2 mm. final germination percentage, seedling length, coleoptiles and radicle length and also seedling dry weight were recorded at 11^{th} day of planting on filter paper. The vigor index (VI) was calculated as the product of seedling length by germination percentage. Germination percentage, mean germination time (MGT) [9] germination index (GI) [32] and time to 50% germination (T_{50}) [6] were calculated using the following equations:

$$Germination\ percentage = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ planted\ seeds} \times 100$$

$$MGT = \frac{\sum Dn}{\sum n}$$

Where, n is the number of seeds were germinated on day D, and D is the number of days counted from the beginning of the germination.

$$GI = \frac{\sum T_i N_i}{S}$$

Where, T_i is the number of days after planting, N_i is the number of seeds germinated on day I, and S is the total number of planted seeds.

$$T_{50} = t_i + \frac{(\frac{N}{2} - n_i)(t_i - t_j)}{n_i - n_j}$$

Where, N is the final number of germination, n_i and n_j cumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < \frac{N}{2} < n_j$.

Data for various indices were subjected to analysis of variance using SAS/STAT software version 8 [30]. Duncan's multiple range test (DMRT) [10] at the 0.01 level of probability was used to evaluate the difference among treatment means.

RESULTS AND DISCUSSION

Table 1 indicates the effect of different seed priming treatments on various seed germination and early seedling growth characteristics of PBW-154 wheat genotype. Pyridoxine-priming duration was significantly affected germination and early seedling growth traits of PBW-154. The maximum level of germination percentage was observed at Pyridoxine-priming of 24 h which significantly improved germination percentage as compared Pyridoxine-priming duration of 6 and 12, and also control and hydro-priming treatments. The coleoptile length was positively responded to Pyridoxine-priming duration treatments of 6, 12 and 24 h ($p<0.01$). The highest amount of coleoptile length was observed in Pyridoxine-priming duration of 24 h, which significantly improved coleoptile length with an increase of 112.34% and 38.35% as compare with control and hydro-priming treatment, respectively.

The Pyridoxine-priming of 12 h produced the maximum amount of radicle length with an increase of 52.16% and 35.54% as compared unsoaked control and hydro-priming treatments, respectively. However, variation in the set of accessions was not possible to discern at Pyridoxine-priming of 12 and 24 h for both aforementioned traits included coleoptile and radicle length ($p<0.01$). The seedling dry weight was also positively correlated to Pyridoxine-priming duration. Pyridoxine-priming duration of 6, 12 and 24 h promoted seedling dry weight with an increase of 15.00%, 55.00% and 57.50% respectively. However, difference in the set of accessions was not possible to discern at pyridoxine-priming duration of 6 h, control and hydro-priming treatments. The mean germination time inversely correlated to the pyridoxine-priming duration. Hence, the minimum level of MGT was observed at pyridoxine-priming of 24 h with no significant difference with pyridoxine-priming duration of 12 h and hydro-priming treatments. A significant positive response of both germination index and vigor index to pyridoxine-priming duration treatments relative to the both control and hydro-priming treatments was observed in all levels ($p<0.01$). Pyridoxine-priming duration of 12 h produced the maximum level of germination index and vigor index with an increase of 35.42% and 24.49% in germination index, and with an increase of 91.58%, 38.51% in vigor index, as compared unsoaked control and hydro-priming treatment, respectively. The time to 50% germination (T_{50}) negatively influenced by pyridoxine-priming treatments. Pyridoxine-priming duration of 12 h produced the minimum level of T_{50} with a reduction of 29.67% and 13.99% as compare with control and hydro-priming treatments, respectively.

Table 2 demonstrates the seed germination and early seedling growth traits of PBW-343 wheat genotype as influenced by different seed pyridoxine-priming duration treatments. Seed germination and early seedling growth of PBW-343 genotype was significantly affected by varying levels of seed pyridoxine-priming duration. A positive reaction of germination percentage to pyridoxine-priming duration treatments was observed in all levels. Hence, the maximum level of germination percentage was observed at pyridoxine-priming duration of 24 h which significantly improved germination percentage as compared pyridoxine-priming duration of 6 and 12, and also control and hydro-priming treatments. According to coleoptile and radicle length, the highest amount was observed in pyridoxine-priming duration of 12 h, which significantly improved coleoptile length with an increase of 187.19% and 44.82% and promoted radicle length with an increase of 64.50% and 20.37% as compare with control and hydro-priming treatment, respectively. The seedling dry weight was positively affected due to pyridoxine-priming duration treatments. Pyridoxine-priming duration of 6, 12 and 24 h promoted seedling dry weight with an increase of 30.95%, 57.14% and 16.66% respectively. However, variation in the set of accessions was not possible to discern at pyridoxine-priming duration of 6 and 24 h, along with hydro-priming treatment.

Time to 50% germination (T_{50}) negatively influenced by pyridoxine-priming treatments. Pyridoxine-priming duration of 24 h produced the minimum level of T_{50} with a reduction of 43.34% and 33.34% as compare with control and hydro-priming treatment, respectively. However, variation in the set of accessions was not possible to discern at pyridoxine-priming duration of 12 h and 24 h ($p<0.01$).

The mean germination time (MGT) inversely correlated to the pyridoxine-priming duration. Hence, the minimum level of MGT observed at pyridoxine-priming duration of 24 h with no significant different with pyridoxine-priming duration of 6 and 12 h, and hydro-priming treatments. Pyridoxine-priming duration of 12 h produced the maximum level of both germination index and vigor index with an increase of 47.14% and 26.94% in germination index, and with an increase of 82.47%, 22.81% in vigor index, as compared unsoaked control and hydro-priming treatment, respectively

Table 1: Overall mean values for the effect of seed priming treatments on various characteristics of germination and early seedling growth of PBW-154 wheat genotype.

Treatments	Germination (%)	Coleoptile length (mm)	Radicle length (mm)	Seedling dry weight (g)	‡MGT (day)	§GI	¶VI	#T_{50} (day)
Control	†85.97^{b}	27.26^{c}	89.75^{c}	0.40^{b}	3.03^{a}	15.29^{c}	60.94^{c}	2.36^{a}
Hydro-priming 12 h	86.01^{b}	36.49^{b}	104.12^{bc}	0.47^{b}	2.22^{bc}	17.72^{c}	98.12^{b}	1.98^{b}
Pyridoxine-priming 6 h	85.76^{b}	31.71^{bc}	114.57^{b}	0.46^{b}	2.58^{b}	17.79^{bc}	103.24^{b}	1.91^{b}
Pyridoxine-priming 12 h	86.33^{b}	46.40^{a}	141.13^{a}	0.60^{a}	2.06^{c}	22.06^{a}	135.91^{a}	1.66^{b}
Pyridoxine-priming 24 h	90.01^{b}	46.65^{a}	132.83^{a}	0.63^{a}	2.00^{c}	19.60^{b}	135.43^{a}	1.68^{b}

† Within a column, means followed by the same letter are not significantly different at the 0.01 level of probability by Duncan's multiple range test
‡ MGT, mean germination time
§ GI, germination index
¶ VI, vigor index
 # T_{50}, time to 50% germination

Table 2: Overall mean values for the effect of seed priming treatments on various characteristics of germination and early seedling growth of PBW-343 wheat genotype.

Treatments	Germination (%)	Coleoptile length (mm)	Radicle length (mm)	Seedling dry weight (g)	‡MGT (day)	§GI	¶VI	#T_{50} (day)
Control	†70.08^{c}	5.31^{d}	92.46^{c}	0.42^{c}	3.33^{a}	18.22^{b}	74.05^{c}	1.80^{a}
Hydro-priming 12 h	81.74^{bc}	11.53^{bc}	133.35^{b}	0.58^{b}	2.77^{b}	21.47^{b}	113.02^{b}	1.53^{b}
Pyridoxine-priming 6 h	80.21^{bc}	9.38^{c}	136.36^{ab}	0.55^{b}	2.73^{b}	21.55^{b}	115.81^{b}	1.41^{b}
Pyridoxine-priming 12 h	81.83^{b}	15.25^{a}	152.10^{a}	0.66^{a}	2.34^{b}	26.81^{a}	135.12^{a}	1.09^{c}
Pyridoxine-priming 24 h	85.31^{a}	12.26^{b}	145.98^{ab}	0.59^{b}	2.20^{b}	21.66^{b}	133.92^{a}	1.02^{c}

† Within a column, means followed by the same letter are not significantly different at the 0.01 level of probability by Duncan's multiple range test
‡ MGT, mean germination time
§ GI, germination index
¶ VI, vigor index
 # T_{50}, time to 50% germination

CONCLUSION

It has been established that pyridoxine is required for root development [7] which can positively influence the early seedling growth. Ansari and Khan [1] reported that seed soaking application of graded aqueous pyridoxine solutions increased the dry matter accumulation of mung bean. The findings of Samiullah and Khan [28] showed pyridoxine requirement for optimum performance of mustard cultivars of PK-8203 and Varuna were 0.05% and 0.0125% respectively. Seed pyridoxine-priming duration of 12 h produced maximum value for most of the germination and early seedling growth characteristics of wheat inbred lines of PBW-154 and PBW-343. In conclusion, these results have practical implications in that pre-sowing seed treatment with pyridoxine solution could enhance the seed germination and early seedling growth characteristics of crops. Seed pyridoxine-priming is a simple economical way to improve the seedling establishment of wheat plant.

Seed priming is an important factor influenced germination and early seedling growth of annual crops. The effects of seed priming on crops are dependent on the complex interaction of factors such as priming substance, plant genotype, and priming duration. Germination and seedling establishment are influential stages which affected both quality and quantity of crop yields [23].

We have investigated that how seed pyridoxine-priming duration influenced seed germination and early seedling growth characteristics of two wheat genotypes. Seed pyridoxine-priming treatments improved seed germination and early seedling growth traits of both genotypes.

The increment in seed germination and early seedling growth due to seed priming treatment is also in conformity with the findings of other researchers [21,4,18]. Basra *et al.* [3] found that priming of wheat seed using polyethylene glycol or potassium salts (K_2HPO_4 or KNO_3) resulted in accelerated seed germination. A significant enhancement in seed germination and seedling growth characteristics of wheat was achieved through the hydro-priming of seeds for 24 h [22]. The three early phases in seed germination are (i) imbibition, (ii) lag phase and (iii) protrusion of the radicle through the testa [33].

Generally, priming affects the lag phase and causes early DNA replication [5] increased RNA and protein synthesis [12] and greater ATP availability [19]. Furthermore, pyridoxine is a cofactor for many enzymatic reactions, especially those involved in amino acid metabolism [31].

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