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STUDIES ON WATER UPTAKE, GERMINATION AND SEEDLING GROWTH OF WHEAT GENOTYPES UNDER PEG-6000 INDUCED WATER STRESS

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Eight wheat genotypes were tested for caryopses water uptake, germination and seedling growth under PEG-6000 induced water stress (0.0, -0.50, -0.75, and -1.100 MPa). Caryopses were surface sterilized and planted on moistened filter paper with the respective solutions in 9 cm petri-dishes and in glass jars over nylon net. After planting, petri-dishes or glass bowls were placed in a growth chamber maintained at 30/25°C day/night temperature and 16hr photoperiod. Water uptake reached a peak value within 24-30 hr in all genotypes under all water stress conditions. Water imbibition, germination percentage and seedling growth decreased with concomitent reduction in water potential of the medium. The genotypes, Chakwal-86, DS-4, Barani-83 and C-228 performed comparatively better than DS-17, Pavon, LU-26S and Sarsabz under our experimental conditions.

Key words. Water uptake, Germination, Wheat genotypes, Induced water stress.

Introduction

Caryopsis germination is the first critical phase most affected by drought. For achieving good crop stand and economical yield, it is imperative to have good germination and seedling growth. Three stages are identified during germination: (i) imbibition of water, (ii) induction of enzymatic activities and (iii) initiation of meristematic growth leading to protrusion of radical through the seed coat [1]. This sequence of events is initially governed by water uptake from the external substate available to caryopses, i.e. the soil solution.

Keeping in view the importance of caryopsis germination and seedling growth for a satisfactory crop stand, experiments were conducted using eight wheat genotypes stressed to decreasing water potentials.

Materials and Methods

Imbibition. Wheat genotypes *(Triticum aestivum L.)* Barani-83, Chakwal-86, DS-4, DS-17, C-228 Pavon, Sarsabz and Lu-26S were tested for water uptake, germination and seedling growth. Polyethylene glycol '6000' (PEG-6000) 0.0, 19.6, 22.0 and 28.9 g was dissolved separately in 100 in 10 ml of distilled water to obtain solutions of 0.00, -0.50, -0.75 and -1.00 MPa water potential, respectively. Five lots of 10 caryopses were weighed and surface sterilized by 10% sodium hypochlorite for five minutes, then washed three times with distilled water. After washing, each lot (10 caryopses) was placed on nylon netted stands, in glass jars containing PEG solution of different water potentials at 30$\pm$2°C. The caryopses, from each treatment, were removed after 3, 6, 9, 12, 18, 24, 30, 36, 42 and 48 hr, washed with distilled water, blotted dry and weighed. Caryopses were then oven dried (80°C) for 24 hr and weighed again. The water uptake (as the percentage of dry weight) by each lot of caryopses was calculated as follows:

$$\text{Water uptake} = \frac{W - W_1}{W_1} \times 100$$

where

W = weight at different water potentials

W_1 = oven dry weight

Germination. For germination studies, caryopses were placed on moistened filter papers in petri-dishes with solutions of various water potentials. After planting, the petri-dishes were covered and placed in growth chambers maintained at 30/25°C day/night temperature in complete darkness. The filter papers were moistened at regular intervals with the respective solutions.

Germinated caryopses, in each treatment, were counted every day at 10 a.m. for 10 days. Caryopses having 2-5 mm radical, at the time of observation, were considered germinated. At the end of the experiment, percentage germination was computed.

Seedling growth. To determine the effects of water stress on shoot and root lengths, 25 caryopses were planted in glass bowls over nylon netted stands. These glass Jars, containing solution of various water potentials, were kept in a growth chamber maintained at 30/25°C day/night temperature and a photoperiod of 16 hr (41.69 μ mol m^2S^{-1}). Shoot and root lengths were measured on the 14th day when the experiment was terminated. All the above experiments were replicated 3 times and repeated twice. Data were subjected to ANOVA to get proper indices of significance.

Results and Discussion

Water imbibition by germinating seeds decreased, as the external water potential was progressively lowered (Fig. 1). The peak water inhibition was recorded at 24 hr in Barani-83, Chakwal-86 and DS-4 and at 30 hr in the others. Genotype C-228 had the best imbibition response i.e. least affected by external water stress. Chakwal-86, Barani 83 and DS-4 were the next best genotypes, with LU-26S and Sarsabz slightly more affected by stress. Pavon and DS-17 were the genotypes whose imbibition declined most dramatically with increasing water stress.

In control (0.0 MPa), 98-100% germination was achieved by 4th day in all genotypes (Fig. 2). It is further noted that the germination percentage, in all the genotypes, was reduced with the decrease in external water potential. Although the genotypes Chakwal-86, C-228, Barani-83 and DS-4 recorded 95-98% germination at -0.50 MPa but the time taken to reach this percentage was 1.5 times than that of the control. Fig. 2 showed that the genotypes appear to be clearly segregated into 2 groups. Group 1 comprising the cultivars C-228, Chakwal-86, Barani-83 and DS-4 showed consistently greater germination at all water stresses (apart from 0 MPa) than the other 4 genotypes.

There was progressive retardation of shoot and root lengths of all the genotypes with the decrease in water potential of the media (Fig. 3 a,b). However, the reduction in shoot

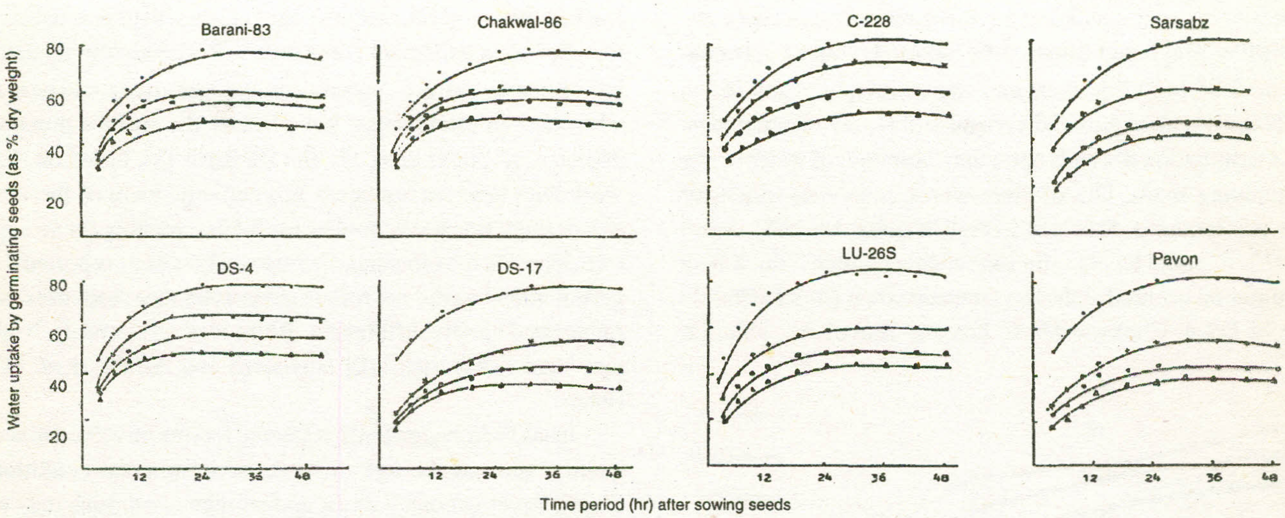

Fig. 1. Water uptake by germinating seeds grown under different water stress treatments. (•------• 0.00 MPa., x------x - 0.50 MPa., O-----O - 0.75 MPa., Δ-----Δ - 1.00 MPa .)

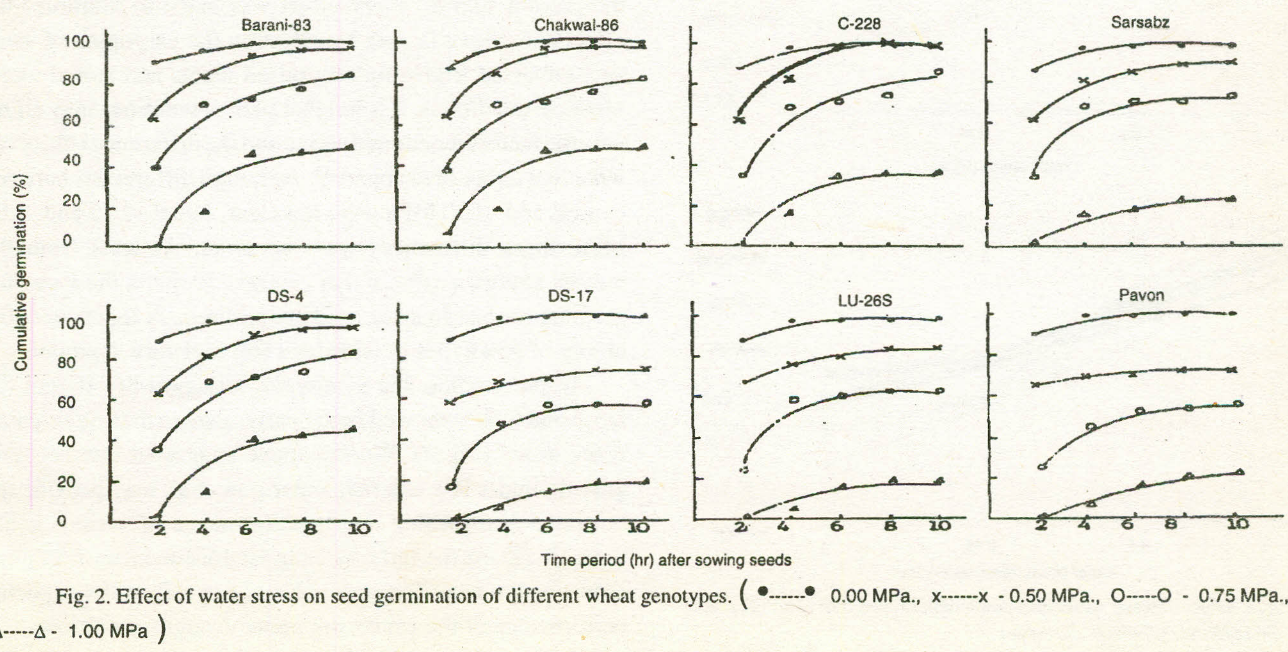

Fig. 2. Effect of water stress on seed germination of different wheat genotypes. (•------• 0.00 MPa., x------x - 0.50 MPa., O-----O - 0.75 MPa., Δ-----Δ - 1.00 MPa)

and root length was found non-significant at -0.50 MPa in all the genotypes, except Pavon and DS-17. Higher water stress (-0.75, -1.00 MPa) caused significant reduction in shoot and root lengths in all the genotypes. Fig. 3 (a,b) showed increased sensitivities of cultivars Lu-26S, Sarsabz, Pavon and DS-4 to water stress with regards to seedling growth.

Under drought, germination and early seedling growth are considered critical for a favourable crop stand. Therefore, establishment of seedlings play an important role in the capability of a crop to withstand water shortages and yet give an economic yield [2]. Percentage germination decreases with lowering of external water potential. Ashraf *et al.* [3] working with sorghum found reduction in percentage germination even at - 0.10 MPa in the case of sensitive genotypes. However, in a tolerant genotype, a similar reduction occured at - 0.50 MPa. Singh and Singh [5,6] reported reduced germination at -1.00 MPa for wheat and rice genotypes tested. Khan and Naqvi [4] also observed varietal differences in mungbean.

Germination depends upon the imbibition of water by the germinating seeds. Out of eight wheat genotypes tested for their performance, four genotypes, Sarsabz, Lu-26S, Pavon and DS-17 could be classified as sensitive where reduction in germination occured at the lowest water stress (-0.50 MPa). In case of DS-4, Chakwal-86, C-228 and Barani-83, a similar reduction occured at the moderate water stress (-0.75 MPa) (Fig.2). Many workers have observed a progressive fall in water imbibition with lowering of external water potential. The peak of water imbibition, by germinating seeds was between 36-42 hr in different genotypes of rice [6] and between 24-30 hr in different wheat genotypes [5], 24-30 hr in sorghum [3] and 24 hr in mungbean [4]. The peak of water imbibition, in the present study, was also between 24-30 hr (Fig. 1). This peak occurs at the same time irrespective of external water potentials in the cultivars used. Therefore, its significance on the germination and survival of seedlings seems to be doubtful as a strategy.

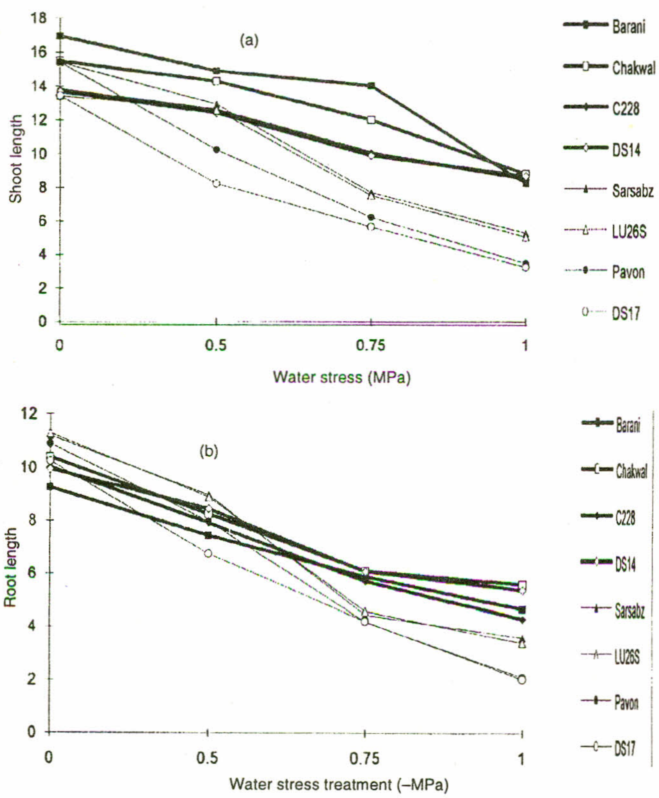

Fig. 3. Effect of water stress on shoot length (a) and root length (b) of 14 days old seedlings of wheat genotypes.

The decrease in total water content, observed by the above quoted workers, may be of more significance. The role of rate and percentage germination, in the subsequent performance of the plant, has generated controversy. Theoretically it should have a positive effect. A seed germinating early would be at an advantage in establishing itself before the surface moisture depletes. Williams *et al.* [7] and Richards [8], based on their work with brassica and corn respectively, were of the view that germination tests could be useful in screening for drought tolerance. On the other hand, some workers have reported that germination test did not reflect stress tolerance responses, but rather seed quality differences, Blum *et al.* [9] (wheat), Boustama and Schapaugh [10] (soybean) and Ashraf *et al.* [11] (wheat).

It has been suggested that several factors, involved in seed quality, such as the age of seed, environmental conditions during development, harvest and storage conditions may affect the germination [10]. As a result, the genotypes may respond differently resulting in erroneous conclusion (s). In the present studies, every effort was made to minimize the effects of above factors by selecting the caryopses of same age, collected from similarly raised plants and stored under identical conditions. It is felt that such precautions may eliminate the factors mentioned above and the differences observed were real rather than apparent. Although differences between control and -0.50 MPa were not clear, but at -0.75 and -1.00 MPa, these differences were apparent. At least from the present study the pattern that emerges supports the view that germination test could be used as a preliminary indicator of the ability of genotypes to withstand soil moisture depletion.

In our studies, the genotypes, Chakwal-86, Barani-83, DS-4 and C-228 showed better early growth than other genotypes tested (Fig 3). Workers have suggested that seedling growth, under low external water potential, may provide the information regarding exact performance of various genotypes [9-12]. As the early seedling establishment ensures good crop stand, the seedling growth test can reflect the expected performance of the genotypes under drought conditions.

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