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How Seed Size and Water Stress Effect the Seed Germination and Seedling Growth in Wheat Varieties?

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ABSTRACT

Water stress has adverse impacts on crop growth, yield and quality parameters thus, considered among serious constraints to agriculture production. Under depleting natural resources, environmental fluctuation and increased risk of epidemic outbreak, the task of sufficient wheat production has become a serious problem. In this study, effect of seed size and water stress was analyzed in three wheat varieties (PBW-154, UP-2338, and UP-2425). Three seed size classes (large, medium, small) of each wheat variety were kept under four water stress levels. It was observed that the shoot length and root length were highly sensitive to water stress and showed minimum growth at highest water stress level. The comparison of varieties, seed size classes and water stress levels showed that in terms of seedling growth variety UP-2338 was more resistant to water stress as compared to other varieties, whereas in terms of germination variety PBW-154 was more resistant. Variety UP-2425 showed maximum reduction in seed germination with increasing water stress (33.3% at -15 bar stress level). Among seed size, large sized seeds showed highest seed germination (91.9%) followed by medium (89.7%) and small (82.8%) sized seeds.

Key words: *Triticum aestivum*, Water stress, Seed size, Seed germination, Seedling growth.

INTRODUCTION

In India, Wheat (*Triticum* spp.) is the second most important winter cereal after rice that contributes substantially to the National food security by providing more than 50% of the calories to the people who mainly depend on it[1]. Drought adversely affects plant growth and development, seed germination[2, 3, 4], seedling growth[5], enzyme activity[6], DNA, RNA, protein synthesis[7] and mitosis[8]. Fresh and dry mass production of crop was reduced due to adverse effect of water stress[9]. Drought imposes one of the commonest and most significant constraints to agricultural production, seriously affecting crop growth, gene expression, distribution, yield and quality [10-12]. Plant may be affected by drought at any time of life, but certain stage such as germination and seedling growth are critical[13]. In most of the developing countries, wheat is mainly grown in rainfed lands without supplementary irrigation. About 37% of land area in these countries consists of semiarid environments in which available moisture constitutes a primary constraint to wheat production[14]. Indian wheat breeding programme is facing the challenge of stagnating productivity and second generation problems of rice-wheat cropping system, increasing heat in north-eastern plain along with other associated problems, declining profit due to increase in cost of production and fear of epidemic out break due to increased genetic uniformity at the farmers field[15].

Seed size is an important parameter, which influences the germination, growth and biomass of the nursery seedlings and that trend leads to the future crop. Sowing of the mixed seed of a species may result in non uniform density of seedlings, which may lead to heterogeneity in the vigour and size of the seedlings[16-18]. The seed size often controls the germination and initial seedling growth in many tree species[19]. Different size of seeds having different levels of starch and other food storage may be one

factor which influences the expression of germination and growth of the plants[20]. Germination may be dependent on the ability of seed to utilize reserves more efficiently[21], by mobilization of seed reserves for germination traits[22]. Seed grading based upon their size and weight is a common practice to regulate the germination and subsequent seedling growth. Therefore, in the present study, an attempt has been made with the objective to determine the effect of seed size and water stress on seed germination and early seedling growth in three Indian varieties (PBW-154, UP-2338 and UP-2425) of wheat (*Triticum aestivum* L.).

MATERIALS AND METHODS

The present study has been carried out in the laboratory of Department of Botany, DSB Campus, Kumaun University, Nainital in the year 2014. The seeds of three locally and extensively used varieties of wheat named PBW-154, UP-2338 and UP-2425 were collected from the G.B. Pant University of Agriculture & Technology, Pantnagar. On the basis of diameter, the seeds were categorized into three size classes *viz.* small (0.2 - 0.25 cm), medium (0.26 – 0.30 cm) and large size class (0.31 – 0.38 cm).

Water stress experiment

Three levels of external water stress (-5, -10 and -15 bars) were produced by mannitol solution, according to the formula given by Helmericls and Pfeifer[23].

$$Water\ stress = \frac{1}{-25} \times \frac{Molality}{\Psi P}$$

Where ψP=Osmotic Potential of mannitol solution (water stress)

In addition, distilled water is used to maintain control. Healthy and uniform seeds of all varieties were surface sterilized and washed with distilled water. The seeds were placed in sterile petri dishes (9 cm diameter) lined with two sterile Whatman No. 1 filter papers in 5 ml of distilled water or the respective mannitol solutions. There were 10 seeds per petri dish and three replicate in each treatment of each size class. Germination test were conducted under condition of 12 h light/dark cycle with 14^{0}C minimum and 24^{0}C maximum temperature. Number of germinated seeds was recorded daily after sowing of seeds up to 15 days. A seed was considered germinated when visible protrusion of plumule was observed. After 15 days seedlings were harvested. Root and shoot length, fresh and dry weights were recorded for each variety, size class and treatment.

After final count, germination percentage (GP) and germination rate (GR) were calculated by the following formulae[24].

GP= (Number of total germinated seeds)/(Total number of seeds tested ×100)

$$GR = \frac{Number\ of\ germinated\ seeds}{Day\ of\ first\ count} + \ldots\ldots\ldots$$

$$\ldots\ldots\ldots\ldots + \frac{Number\ of\ germinated\ seeds}{Day\ of\ final\ count}$$

Effects of seed size and treatments on seedling growth were analyzed by Fisher's analysis of variance (ANOVA). Differences between mean values for treatments were tested by Tukey's LSD test. All statistical analyses were performed using the SPSS 16 package.

RESULTS

Effect on shoot and root length

Among all the three varieties the maximum shoot length (SL) was measured in controlled condition of medium sized seeds of UP-2425 (11.43 cm) and UP-2338 (11.16 cm). In all the varieties, the shoot and root length (RL) gradually decreased towards higher water stress levels so that the maximum SL was recorded in the controlled condition for all varieties along with all size classes (Figure 1). The maximum (7.79 cm) RL was measured in the large seed size class of PBW-154 variety in -5 bar stress level.

Effect on shoot and root dry weight

Among all the varieties, the large sized seeds of UP-2338 variety had the highest shoot dry weight (SDW = 0.104 g) at controlled condition and the lowest dry weight was recorded for small size

class of variety UP-2425 in -15 bar water stress level. Root dry weight (RDW) was highest (0.068 g) for medium size class of UP-2425 variety in controlled condition. Variety PBW-154 had the maximum RDW (0.066 g) in large seed size class at -5 bar water stress level whereas UP-2338 variety had the maximum RDW (0.066 g) in controlled condition (Figure 2).

Effect on seedling growth

The maximum effect of water stress was recorded on small seed size class of all the three varieties. The large sized seeds had the highest seedling growth in two varieties PBW-154 (16.3 cm) and UP-2338 (16.6 cm) whereas in variety UP-2425 it was 19.1 cm (Figure 3). The seedling growth gradually decreased towards higher water stress level.

Effect on germination rate

The germination rate was maximum (13.08) in large seed size class of variety PBW-154 at -10 bar water stress level. The minimum (2.5) germination rate was obtained in the small sized seeds of variety UP-2425 at -15 bar water stress level (Figure 4).

Effect on germination percentage (GP)

The minimum germination percentage (33.3 %) was observed in small seed size class of variety UP-2425 at -15 bar water stress level. The

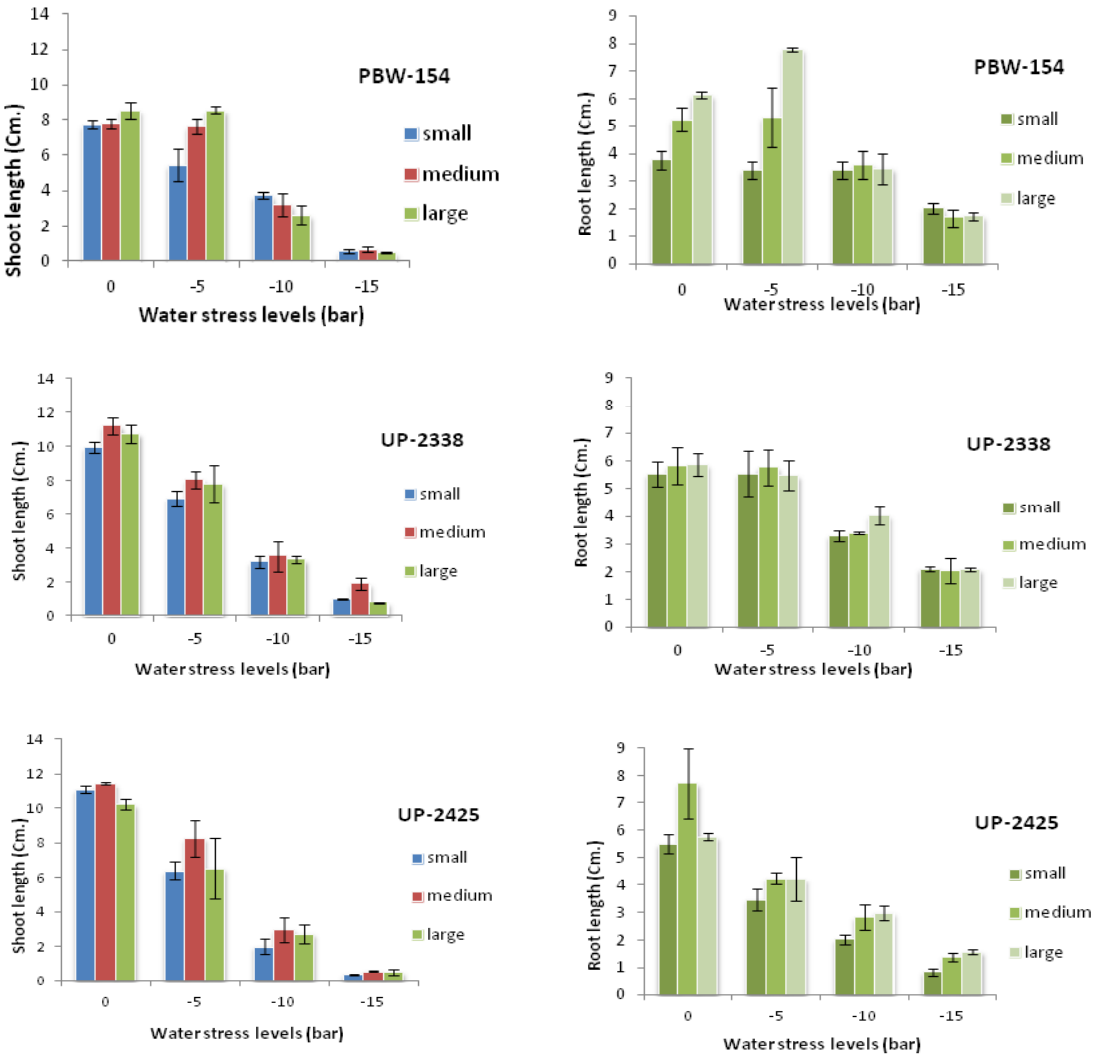

Fig. 1: Effect of seed size and water stress on shoot and root length of three wheat varieties

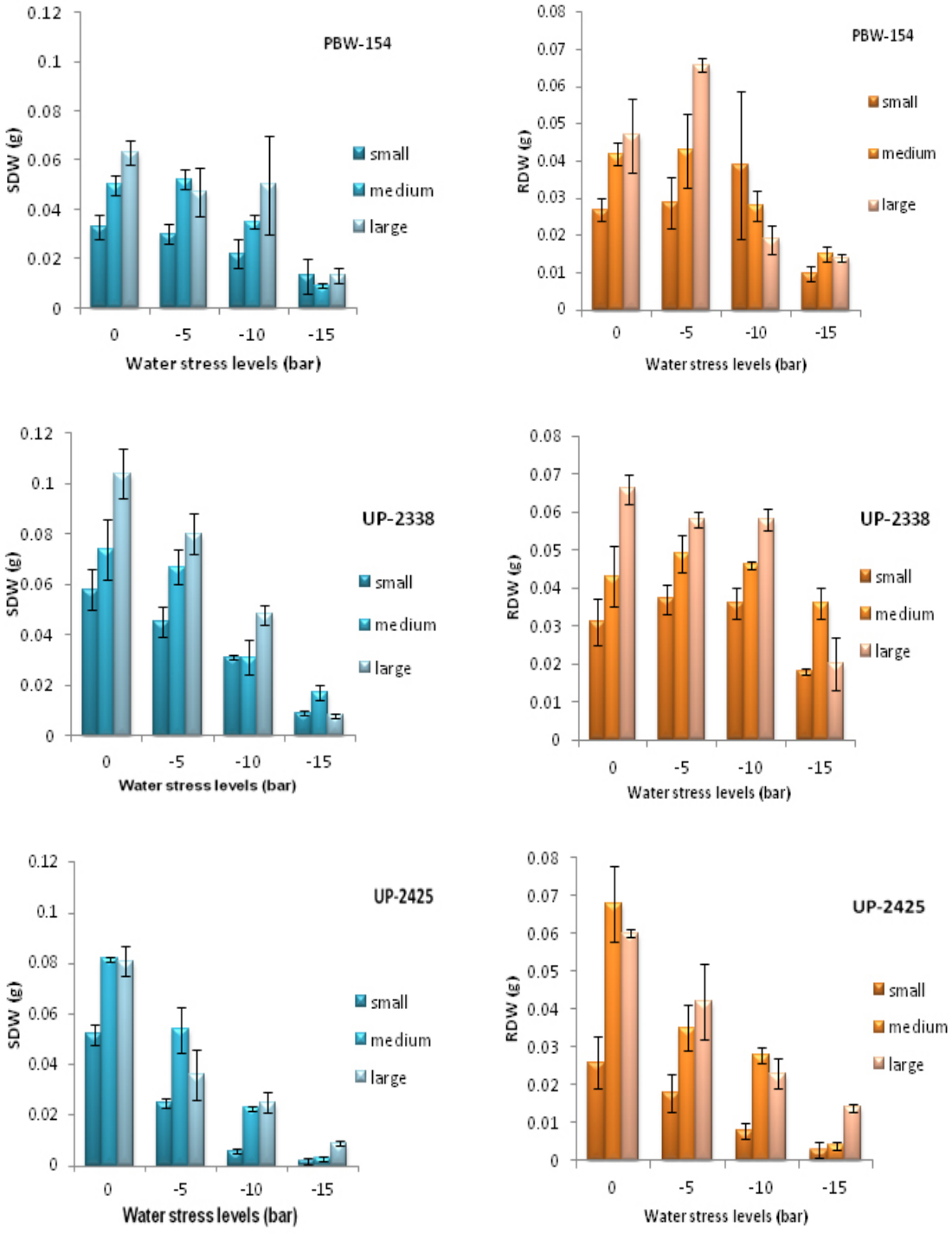

Fig. 2: Effect of seed size and water stress on shoot dry weight (SDW), root dry weight (RDW) of three wheat varieties

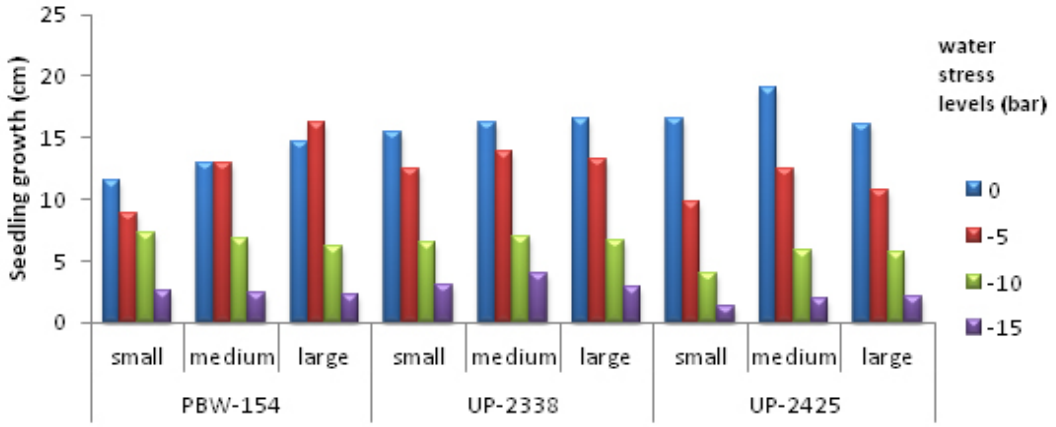

Fig. 3: The effect of seed size and water stress on seedling growth of three wheat varieties

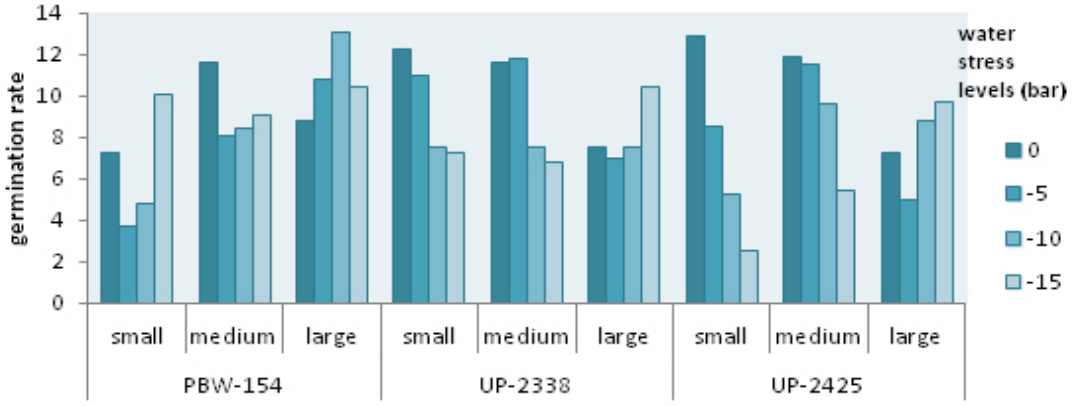

Fig. 4: The effect of seed size and water stress on germination rate of three wheat varieties

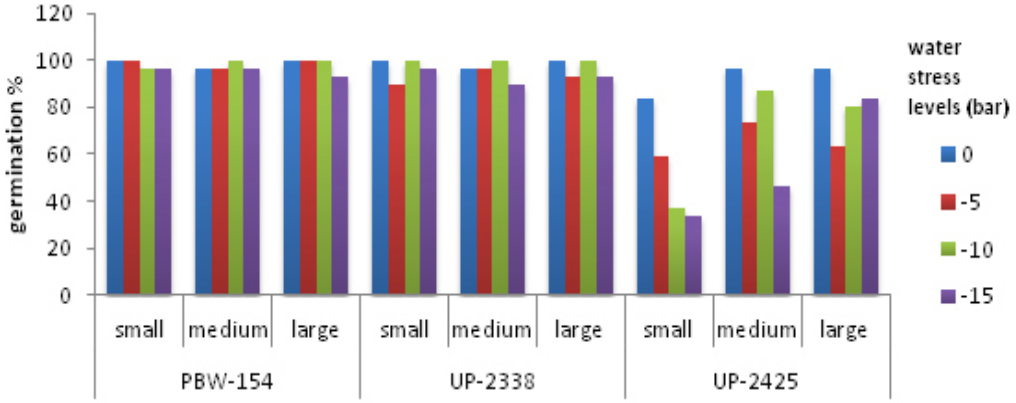

Fig. 5: The effect of seed size and water stress on germination percentage (%) of three wheat varieties

GP for variety PBW-154 ranged from 93.3-100 % and for variety UP-2338 it ranged between 90 and 100 % (Figure 5).

Effects on initiation and completion of germination

The early initiation of germination was recorded in small sized seeds of variety PBW-154 and UP-2338, whereas it was delayed in variety UP-2425. Time taken to initiate and complete the germination processes varied in different seed size classes of all the three wheat varieties. The emergence time was 4-5 days for all three varieties at controlled condition but with an increase in water stress levels there was a regular delay in emergence in variety UP-2425. UP-2338 variety showed better performance in initiation and completion of emergence rather than the rest two varieties.

DISCUSSION

Effect of water stress

The results of present study indicated that the SL and RL were highly sensitive to the water stress as they showed minimum growth at highest water stress level. Water stress had significantly

Table 1: Variance analysis (ANOVA) for the traits investigated for the three varieties in response to water stress

Parameters	Df	Mean of square			
		SL	RL	SDW	RDW
Variety	2	27.72^{ns}	11.63^{ns}	0.003*	0.002^{ns}
Size	2	12.81^{ns}	24.35*	0.005*	0.008*
Treatment	3	1338.3*	263.7*	0.016*	0.007*

Df, SL, RL, SDW, RDW, ns and * respectively, are Degree of freedom, shoot length, root length, shoot dry weight, root dry weight, not significant and significant at 0.05 level of probability

Table 2. Means (± SE) comparison of effects of variety, seed size and water stress on various growth parameters of wheat

	Traits				
	SL (cm)	RL (cm)	SDW (g)	RDW (g)	GP (%)
Variety					
PBW-154	4.75±0.99	3.96±0.93	0.03±0.004	0.03±0.004	98.06±0.64
UP-2338	5.89±0.96	4.25±0.46	0.05±0.008	0.04±0.004	96.39±1.7
UP-2425	5.25±0.99	3.55±0.98	0.03±0.008	0.03±0.006	70.04±6.2
Size (cm)					
Small	4.86±0.55	3.41±0.44	0.03±0.007	0.02±0.009	82.8±7.2
Medium	5.80±0.96	4.08±0.56	0.04±0.007	0.04±0.004	89.7±4.4
Large	5.23±0.96	4.26±0.56	0.05±0.008	0.04±0.006	91.9±9.2
Treatment (bar)					
0	9.84±0.40	5.70±0.34	0.06±0.007	0.05±0.005	96.7±1.8
-5	7.29±0.34	5.03±0.45	0.05±0.005	0.04±0.004	89.8±5.4
-10	3.04±0.17	3.2±0.18	0.03±0.004	0.03±0.004	89.1±6.8
-15	0.76±0.15	1.72±0.13	0.009±0.001	0.01±0.009	81.1±7.9

SL, RL, SDW, RDW and GP respectively, are shoot length in centimeter, root length in centimeter, shoot dry weight in gram, root dry weight in gram and germination percentage

affected (P< 0.05) to SL, RL, SDW and RDW (Table 1). Water stress has been found to limit growth in several tree seedlings such as *Virola surinamensis*[25], *Antidesma cuspidatum*, *Hopea grithii*, *Vatica maingayi*[26], *Acacia nilotica, Mundulea*[27], and *Grevillea robusta*[28]. In all the seed size classes of all the 3 varieties, maximum length of shoot occurred in controlled conditions.

Under controlled condition PBW-154 and UP-2338 (100%) had the highest and UP-2425 (83.3%) had the lowest germination percent. The 100% germination percentage was recorded in two wheat varieties (PBW-154 and UP-2338) at different water stress levels in different seed size classes, whereas a delay in initiation and completion of seed germination was occurred. Water stress had the highest impact on variety UP-2425 as its germination percent was 33.3% at -15 bar stress level. Hegarty[29] indicated that water stress at germination stage can result in delayed and reduced germination or may prevent germination completely.

Effect of seed size

ANOVA showed that the effect of seed size was significant on RL, SDW and RDW whereas on the SL it was insignificant (Table 1). The germination rate was maximum (12.25 and 12.87) for small seed size class of varieties PBW-154 and UP-2338, respectively whereas it was maximum (13.08) in large seed size class of variety UP-2425. Large sized seeds recorded highest seed germination (91.9%) followed by medium (89.7%) and small (82.8%) sized seeds. Higher and quicker germination in large sized seeds may be due to the presence of higher amount of carbohydrates and other nutrients than in medium and small sized seeds. Seedling height, root and shoot length and dry weights were also higher for large seeds than those of medium and small seeds (Table 2). Gunaga *et al.*[30] also reported that large seeds germinate quicker and would take lesser duration when compared to that of smaller ones. The highest effect of seed size was observed in GP of variety UP-2425 as it was highly sensitive to water stress. The germination rate of small sized seeds was highest among other seed sizes, probably because of less need for water absorption compared to large seed size. Large seeds need more water absorption than small seeds and because of this, it takes more time to germinate and finally resulted in decline in germination rate[31]. The SDW and RDW were least in small seed size class among all the varieties. Ghorbani *et al.*[32] reported that seed size had significant effect on seedling dry weight. They also observed that the small seed size showed higher germination rate as compared to large seed size which was in agreement with our results. Effect of seed size (less than 1.95, 1.95-2.35 and more than 2.35 mm) on germination characteristics of six oat (*Avena sativa* L.) cultivars under water stress condition showed that germination was increased with increasing seed size[33].

Towards higher water stress levels all the growth parameters decreased significantly as indicated by best performance at controlled condition. On the basis of overall performance it can be suggested that PBW-154 (98.06%) variety had best germination characteristics and was less affected by water stress during establishment.

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