Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 214-220
Received: 22-01-2019
Accepted: 25-02-2019

Rajesh Kumar Singhal
Seed Priming Laboratory, Department of Plant Physiology, Institute of Agricultural Sciences (IAS), Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India

Vivek Kumar
Seed Priming Laboratory, Department of Plant Physiology, Institute of Agricultural Sciences (IAS), Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India

Bandana Bose
Seed Priming Laboratory, Department of Plant Physiology, Institute of Agricultural Sciences (IAS), Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India

Correspondence
Rajesh Kumar Singhal
Seed Priming Laboratory, Department of Plant Physiology, Institute of Agricultural Sciences (IAS), Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India

Improving the yield and yield attributes in wheat crop using seed priming under drought stress

Rajesh Kumar Singhal, Vivek Kumar and Bandana Bose

Abstract

An experiment was conducted in the Seed priming Laboratory, Department of Plant Physiology and poly-house of Dept. of Genetics and Plant Breeding, Institute of Agricultural Sciences, for two consecutive years to analyse the responses of two wheat varieties namely HUW-468 and HUW-510 under control and drought stress conditions using hydro, Mg $(NO_3)_2$, $ZnSO_4$ and combination of Mg $(NO_3)_2$ and $ZnSO_4$ primed seeds. On the basis of various parameters regarding yield and yield attributes of wheat crop. Parameters related to yield and yield attributes, viz., number of the spike length, spike number plant^{-1}, spike weight, spikelet number spike^{-1}, seed number spike^{-1}, number of productive tillers plant^{-1}, biological yield plant^{-1}, grain yield plant^{-1} (g) and test weight (g) were found to be higher in combined primed seed set, and $Mg(NO_3)_2$, followed by $ZnSO_4$ treated sets in respect to others in drought and control conditions and used verities of wheat. Therefore, from the data of yield and yield attributes parameters, it can be assumed that seed priming improves the seed yield by improving earlier reproductive growth and more allocation of assimilates toward the developing grains. Through these parameters it can be concluded that seed priming improves the yield of important agriculture crops by improving yield and yield attributes.

Keywords: Attributes, wheat crop, seed priming

Introduction

Wheat is a major staple food crop of the world and the second most important crop after rice. Wheat is grown over a large latitudinal range of areas such as from tropical to temperate and irrigated to rain-fed climatic conditions. Two third of the world population directly depends upon wheat or wheat products for their daily calorific intakes. Food security has become a global challenge and it is projected that world food supply need to increase about 70% in the next four decades. Considering the limitations of expanding cultivated areas, a remarkable rise in the wheat crop productivity will be needed to achieve this milestone (Reynolds *et al*., 2011) [20]. Worldwide wheat production in the year 2017-18 was 771.72 million tons and it occupies approximately 17% of the total cultivated land in the world. Whereas, in India wheat production was 98.50 million tons and occupies 30.60 Mha area (Annual report, 2016-17) [2] (www.agricoop.nic.in).Drought is one of the most frequent environmental stresses, responsible for ample changes in growth and development of all agriculture crop including wheat. Drought continues to be a decisive challenge to agricultural researchers and plant breeders. It is assumed that by the year 2025, around 1.8 billion people will face absolute water shortage and 65% of the world's population lives under water-regimes environments. Drought stress influence the plant performance from germination to maturity stage. At the seed germination and seedling stage, it is a major determinant of wheat production in many parts of the world. In particular, seed vigour index and shoot length are the most sensitive to drought stress, followed by root and coleoptile length (Dhanda *et al*., 2004) [8]. Early season drought severely reduce the seed germination and establishment of seedling principally due to diminished water uptake, energy supply, and impaired enzyme activities (Okcu *et al*., 2005) [18]. Drought stress at germination stage influence the activity of key germinating enzymes such as α- amylase, protease, and lipase and reduce the capacity of seedling to healthy germination (Bose *et al*., 2018) [3]. The main consequences of drought in crop plants are the reduced rate of cell division and expansion, leaf size, stem elongation and root proliferation, and disturbed the stomatal oscillations, which may alters the status of plant water and flow of nutrients with diminishing crop productivity and water use efficiency (WUE) (Farooq *et al*., 2009) [13]. Drought stress delayed the flowering at pre-anthesis stage and increase the sterility of pollen grais, which may affect the setting of grains. During flowering drought stress escalation the rate of ear abortion owing to a decline in the assimilate supply to developing ears (Yadav *et al*., 2004) [27].

Effect of drought stress on heading stage are non-significant in wheat crop, but its duration (time taken to pollination to maturity) was reduced and weight of dry matter also reduced at maturity (Wardlaw and Willenbrink, 2000) [25]. Grain filling in wheat crop is depends upon the current photosynthesis and redistribution of assimilates from reserve pools in the vegetative tissues (Farooq *et al.*, 2011) [12]. Therefore, scarcities of water during the early grain development phase reduces the grain size by diminishing the rate and duration of grain filling (Saini and Westgate, 1999) [22]. Terminal drought in wheat crop shortened the life cycle and duration of grain filling. The grain-filling rate, under drought decreases due to reduced photosynthesis rate, acceleration of leaf senescence, and limitations of sink activities (Madani *et al*., 2010; Wei *et al*., 2010) [15]. Terminal drought has more influence on grain number rather than the grain size, which may be largely accounts for the decline in wheat yields (Dolferus *et al*., 2011) [9]. Meiosis and anthesis processes are extremely susceptible to drought, and their failure directly diminished grain number, thus causing substantial reduction in grain yield potential (Cattivelli *et al*., 2008) [4]. This analysis reveals the effect of seed priming treatment on yield and yield attribute of wheat varieties under control and drought stress.

Material and Methods

The present piece of work entitled "Drought stress responses of wheat varieties (*Triticum aestivum* L.*)* using Mg $(NO_3)_2$ and $ZnSO_4$ primed seeds" was undertaken during the calendar years 2015 to 2017. Details of the materials and methods used in this investigation have been described as follows.

Yield and Yield attributes: Following parameters were taken into consideration for this part of the study:

Number of productive tiller plant^{-1}: Tillers having spikes were counted as productive tiller, while the tillers having no spike were counted as unproductive tillers.

Spike length (cm): Length of spike were measured in cm by the help of scale.

Spike number plant^{-1}: Spike number was counted in each plant.

Spike weight plant^{-1}: Weight of spikes plant-1 were measured by the help of electronic weighing balance ((Sartorius BT-224S) in gm.

Grain number plant^{-1}: Grain number of each pant were counted manually.

Grain weight plant^{-1} (g): Grain weight of each plant were measured by the use of electronic weighing balance ((Sartorius BT-224S).

Test weight plant^{-1} (g): Weight of 100 seeds were calculated by the use of electronic weighing balance ((Sartorius BT-224S).

Biological yield, Grain yield and straw yield (g plant^{-1})

The mature crop was harvested from the pot and weight was recorded after sun drying. After threshing, grain yield was recorded. The difference of the total weight and grain yield gave the straw yield of the crop per pot.

Harvest index (%): HI of wheat crop calculated by the ratio of grain yield to biological yield in percentage.

Result

Yield and yield attributes

Number of productive tiller plant^{-1}: Number of productive tiller plant^{-1} are important yield attributes indicates the spike wearing ability of plants. A high number of productive tiller plant^{-1} represents the higher yield potential. Table 1 represent the data of number of productive tiller plant^{-1} in 2016-17 and 2017-18 under water stress and control condition of two wheat varieties HUW-468 (V_1) and HUW-510 (V_2) respectively. Highest number of productive tiller plant^{-1} was noted in case of treatment W_0T_5 in control and W_1T_5 in water stress condition in both the varieties and both the experimentation period, which was followed by treatment W_0T_3 and W_1T_3. While the lowest number of productive tiller plant^{-1} were noted in case of W_0T_1 and W_1T_1 respectively. Statistical analysis of number of productive tiller plant^{-1} represent the significant differences in case of non-stress and control conditions. Whereas, the other factors and factor interactions were non-significant in all the observed cases.

Table 1: Responses of two wheat varieties HUW-468 and HUW-510 on number of productive tiller plant^{-1}under control and water stress conditions, using non-primed and primed seeds.

		2016			2017		
Water Stress (W)	Treatments	Number of productive tiller plant^{-1}			Number of productive tiller plant^{-1}		
		V_1	V_2	Mean	V_1	V_2	Mean
W_0	T_1	2.33	2.67	2.50	2.67	2.67	2.67
	T_2	2.67	2.67	2.67	3.00	3.00	3.00
	T_3	2.67	3.00	2.83	3.00	2.67	2.83
	T_4	3.00	2.67	2.83	2.67	2.67	2.67
	T_5	3.33	3.33	3.33	3.33	3.33	3.33
W_1	T_1	2.00	2.33	2.17	2.33	2.33	2.33
	T_2	2.33	2.33	2.33	2.67	2.67	2.67
	T_3	2.33	2.67	2.50	2.67	2.33	2.50
	T_4	2.67	2.33	2.50	2.33	2.33	2.33
	T_5	2.67	2.67	2.67	3.00	2.67	2.83
Mean table	**2016**	**2017**	**Table of CD and ±SEm**	**2016**		**2017**	
V_1	2.60	2.77		**CD**	**±SEm**	**CD**	**±SEm**
V_2	2.67	2.67	Factor(V)	N/A	0.10	N/A	0.10
W_0	2.83	2.90	Factor(W)	0.28	0.10	0.29	0.10
W_1	2.43	2.53	Intraction (V × W)	0.39	0.14	N/A	0.15
T_1	2.33	2.50	Factor(T)	N/A	0.15	N/A	0.16
T_2	2.50	2.83	Intraction V× T	N/A	0.22	N/A	0.23
T_3	2.67	2.67	Intraction W × T	N/A	0.22	N/A	0.23
T_4	2.67	2.50	Intraction V × W × T	N/A	0.31	N/A	0.33
T_5	3.00	3.08					

CD@5% Varieties: V_1: HUW-468, V_2: HUW-510, W_0: Control W_1: Imposed drought

T_1: Non primed; T_2: Hydro primed; T_3: Mg $(NO_3)_2$ primed; T_4: ZnSO4 primed; T_5 : Mg(NO_3) and ZnSO4 primed

Spike length (cm)

Table 2 represents the data of spike length (cm) in primed and non primed wheat seeds under control and imposed drought condition during 2016-17 and 2017-18. Data depicted that under control condition highest spike length was observed in combination salt of Mg $(NO_3)_2$ and $ZnSO_4$ primed sets in V_1 and $ZnSO_4$ primed sets in V_2 respectively. While under drought stress highest spike length was observed in $ZnSO_4$ primed sets in V_1 and combined primed sets of V_2. Lowest spike length was observed in non-primed treatment in both the varieties under control and water stress conditions. Similar trends were observed during the 2017-18. Statistical analysis of spike length revealed that the all studied factor and interactions were significant except interaction V x W and W x T during 2017-18.

Spike number plant^{-1}

Table 2 represent the data of spike number plant^{-1} in primed and non primed wheat varieties under control and imposed drought condition in both the years 2016-17 and 2017-18. Data depicted that under control condition highest spike number plant^{-1} was observed in combined Mg $(NO_3)_2$ and $ZnSO_4$ primed sets in both the varieties. Similar trend were followed in case of imposed water stress conditions. Lowest spike number plant^{-1} was observed in non-primed primed set in both the varieties under control and water stress condition. Same trend were observed during the year 2017-18. Statistical analysis of spike number plant^{-1} revealed that factors W showed the significant differences during both the studied years and interaction V x W are significant during 2017-18. Otherwise, all the studied factors and interactions were showed non-significant differences.

Table 2: Responses of two wheat varieties HUW-468 and HUW-510 on spike length (cm) and spike number plant^{-1} under control and water stress conditions, using non-primed and primed seeds.

		2016						2017					
Water stress	Treatments	Spike length (cm) (SL)			Spike number plant^{-1} (SN)			Spike length (cm)			Spike number plant^{-1} (SN)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V1	V2	Mean
W_0	T_1	9.37	9.53	9.45	2.33	2.67	2.50	9.23	9.77	9.50	2.67	2.67	2.67
	T_2	9.57	10.00	9.78	2.67	2.67	2.67	9.40	10.33	9.87	3.00	3.00	3.00
	T_3	9.40	9.53	9.47	2.67	3.00	2.83	9.53	9.70	9.62	3.00	2.67	2.83
	T_4	8.87	10.00	9.43	3.00	2.67	2.83	9.07	10.23	9.65	2.67	2.67	2.67
	T_5	10.60	9.93	10.27	3.33	3.33	3.33	10.40	10.10	10.25	3.33	3.33	3.33
W_1	T_1	7.10	8.07	7.58	2.00	2.33	2.17	7.30	8.13	7.72	2.33	2.33	2.33
	T_2	7.67	7.80	7.73	2.33	2.33	2.33	7.60	8.20	7.90	2.67	2.67	2.67
	T_3	7.47	7.30	7.38	2.33	2.67	2.50	7.57	7.47	7.52	2.67	2.33	2.50
	T_4	7.63	7.97	7.80	2.67	2.33	2.50	7.73	8.00	7.87	2.33	2.33	2.33
	T_5	7.20	8.70	7.95	2.67	2.67	2.67	7.37	8.50	7.93	3.00	2.67	2.83
Mean table	**2016**		**2017**		**Table of CD and ±SEm**	**2016**				**2017**			
	SL (cm)	**SN/plant**	**SL (cm)**	**SN/plant**	**Particulates**	**SL (cm)**		**SN/plant**		**SL (cm)**		**SN/plant**	
V_1	8.49	2.60	8.52	2.77		CD	±SEm	CD	±SEm	CD	±SEm	CD	±SEm
V_2	8.88	2.67	9.04	2.67	Factor (V)	0.140	0.05	N/A	0.10	0.14	0.047	N/A	0.10
W_0	9.68	2.83	9.78	2.90	Factor (W)	0.140	0.05	0.28	0.10	0.14	0.047	0.29	0.10
W_1	7.69	2.43	7.79	2.53	V × W	0.20	0.07	0.39	0.14	N/A	0.067	N/A	0.15
T_1	8.52	2.33	8.61	2.50	Factor (T)	0.22	0.08	N/A	0.15	0.21	0.075	N/A	0.16
T_2	8.76	2.50	8.88	2.83	V× T	0.31	0.11	N/A	0.22	0.30	0.106	N/A	0.23
T_3	8.43	2.67	8.57	2.67	W × T	0.31	0.11	N/A	0.22	N/A	0.106	N/A	0.23
T_4	8.62	2.67	8.76	2.50	V × W × T	0.44	0.15	N/A	0.31	0.42	0.149	N/A	0.33
T_5	9.11	3.00	9.1	3.08									

CD at 5% Varieties: V_1: HUW-468 V_2: HUW-510 W_0: Control W_1: Imposed drought

T_1: Non primed; T_2: Hydro primed; T_3: $Mg(NO_3)_2$ primed; T_4 : ZnSO4 primed; T_5 : $Mg(NO_3)$ and ZnSO4 primed

Spike weight (g)

Table 3 represent the data of spike weight (g) in primed and non primed wheat varieties under control and imposed drought conditions. Data depicted that under control condition highest spike weight was observed Mg $(NO_3)_2$ primed set in V_1 and combination of Mg $(NO_3)_2$ and $ZnSO_4$ primed set in V_2. Similar trend were followed in case of imposed water stress condition. Lowest spike weight were observed in non primed set in both the varieties under control and water stress condition during 2016-17. During 2017-18 highest spike weight (g) was observed in case of Mg $(NO_3)_2$ primed sets in both the varieties, while under drought highest values recorded in Mg $(NO_3)_2$ primed seed in V_1 and combined Mg $(NO_3)_2$ and $ZnSO_4$ primed set in V_2. Statistical analysis of spike weight (g) revealed the significant difference in all the studied factors and interactions except interaction V x W x T at all studied stages.

Spikelet number / spike

Table 3 represent the data of spikelet number / spike in primed and non primed sets of wheat varieties under control and imposed drought conditions. Data depicted that under control condition highest spikelet number / spike was observed in combined Mg $(NO_3)_2$ and $ZnSO_4$ primed seed in V_1 and $ZnSO_4$ primed seed in V_2. Under drought condition during 2016-17 combination of salts treatment gave best results, whereas in the year 2017-18 in V_1 $ZnSO_4$ primed set and combined primed set in V_2 gave best performances. Lowest spike number plant^{-1} was observed in non primed treatment in both the varieties under control and water stress condition. Statistical analysis of spikelet number / spike revealed that significant differences in all the studied factors and interactions except interaction V x W x T in 2016-17 and W x T in 2016-17.

Table 3: Responses of two wheat varieties HUW-468 and HUW-510 on spike weight (g) and spikelet number spike^{-1} under control and water stress conditions, using non-primed and primed seeds.

		2016-17						2017-18					
Water stress	Treatments	Spike weight (g) (SW)			Spikelet number/spike (SN)			Spike weight (gm)			Spikelet number/spike		
		V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
W_0	T_1	1.45	1.92	1.68	15.00	21.00	18.00	1.45	1.91	1.68	15.00	23.00	19.00
	T_2	1.55	2.28	1.92	21.00	25.00	23.00	1.63	2.09	1.86	19.00	23.00	21.00
	T_3	2.35	2.45	2.40	21.00	25.00	23.00	2.14	2.48	2.31	21.00	25.00	23.00
	T_4	1.64	2.31	1.98	21.00	27.00	24.00	1.46	2.08	1.77	21.00	27.00	24.00
	T_5	1.79	2.46	2.13	23.00	27.00	25.00	1.77	2.18	1.97	23.00	27.00	25.00
W_1	T_1	1.27	1.64	1.46	13.00	17.00	15.00	1.39	1.57	1.48	13.00	17.00	15.00
	T_2	1.38	1.73	1.56	15.00	17.00	16.00	1.41	1.72	1.57	15.00	17.00	16.00
	T_3	1.83	1.81	1.82	15.00	17.00	16.00	1.69	1.75	1.72	15.00	17.00	16.00
	T_4	1.52	2.19	1.85	17.00	17.00	17.00	1.30	1.95	1.63	19.00	17.00	18.00
	T_5	1.61	2.27	1.94	19.00	19.00	19.00	1.40	2.01	1.70	19.00	19.00	19.00
Mean table	2016-17		2017-18		Table of CD and SEm	2016-17				2017-18			
	SW (g)	SN/spike	SW (g)	SN/spike	Particulates	SW (g)		SN/spike		SW (g)		SN/spike	
V_1	1.69	18.029	1.56	18.02		CD	±SEm	CD	±SEm	CD	±SEm	CD	±SEm
V_2	1.64	21.27	2.03	21.03	Factor (V)	0.05	0.02	0.56	0.20	0.06	0.02	0.50	0.18
W_0	2.11	22.383	1.89	22.30	Factor (W)	0.05	0.02	0.56	0.20	0.06	0.02	0.50	0.18
W_1	2.02	16.572	1.70	16.67	V × W	0.08	0.03	0.79	0.28	N/A	0.03	N/S	0.25
T_1	1.73	16.358	1.51	16.56	Factor(T)	0.09	0.03	0.89	0.31	0.10	0.03	0.79	0.28
T_2	1.57	19.15	1.58	19.08	V× T	0.12	0.04	1.25	0.44	0.14	0.05	1.12	0.39
T_3	1.74	19.725	2.03	19.32	W × T	0.12	0.04	1.25	0.44	0.14	0.05	N/A	0.39
T_4	2.11	20.672	2.05	21.17	V × W × T	N/A	0.06	N/A	0.62	N/A	0.07	1.59	0.56
T_5	1.91	21.483	1.82	21.30									

CD at 5% Varieties: V_1: HUW-468, V_2: HUW-510 W_0: Control W_1: Imposed drought
T_1: Non primed; T_2: Hydro primed; T_3: Mg $(NO_3)_2$ primed ; T_4 : ZnSO4 primed; T_5 : Mg(NO_3) and ZnSO4 primed

Seed number spike^{-1}

Seed number is the important trait indicates the yield potential of crop. Table 4 represent the data of seed number spike^{-1} in primed and non primed sets of wheat varieties under control and imposed drought condition. Data depicted that under control condition highest seed number spike^{-1} was observed in combined treatment of Mg $(NO_3)_2$ and $ZnSO_4$ primed set in both conditions i.e. control and drought conditions in both the varieties. Whereas, the lowest seed number spike^{-1} was observed in non primed treatment in both the varieties under control and water stress condition. Statistical analysis of seed number spike^{-1} revealed that significant differences in all the studied factors. Although, interactions V x T and V x W x T showed the non-significant difference during both the studied period. Interaction W x T showed significant difference during 2016-17 but non-significant differences during 2017-18.

Test weight (g)

Test weight is the important trait indicates the yield potential of crop. Table 4 represents the data of test weight (g) in primed and non primed wheat seeds under control and imposed drought condition. Data depicted that under control condition highest test weight (g) was observed in combination of Mg $(NO_3)_2$ and $ZnSO_4$ primed set in control conditions in both the varieties. Under drought condition combined treatment showed the best performance in V_1, whereas in V_2 Mg $(NO_3)_2$ primed set showed best results. The lowest test weight (g) was observed in non primed treatment in both the varieties under control and water stress condition. During 2017-18 under control condition highest test weight in V_1 was observed in combination of Mg and Zn salts treatment and Mg $(NO_3)_2$ primed in V_2 variety respectively. Under drought situations best result was observed in case of Mg $(NO_3)_2$ primed sets in both the varieties. Statistical analysis of test weight (g) showed the significant differences among the all the studied factors in both the years. Whereas, the non-significant differences among factors interactions were observed during 2016-17.

Table 4: Responses of two wheat varieties HUW-468 and HUW-510 on seeds number spike^{-1} and test weight (g) under control and water stress conditions, using non-primed and primed seeds.

		2016-17						2017-18					
Water stress	Treatments	Seeds number spike^{-1}			Test weight (g)			Seeds number spike^{-1}			Test weight (g)		
		V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
W0	T_1	31.33	39.33	35.33	32.80	47.80	40.30	33.00	40.00	36.50	32.53	47.17	39.85
	T_2	35.00	44.67	39.83	34.30	48.33	41.32	37.00	42.33	39.67	33.90	47.57	40.73
	T_3	38.00	46.67	42.33	35.13	53.37	44.25	39.00	44.00	41.50	34.87	48.90	41.88
	T_4	36.33	45.33	40.83	34.17	48.50	41.33	37.67	41.67	39.67	34.27	44.03	39.15
	T_5	38.67	47.33	43.00	37.60	49.87	43.73	39.33	46.00	42.67	37.80	44.67	41.23
W1	T_1	29.00	34.73	31.87	24.50	40.17	32.33	30.00	31.67	30.83	25.07	37.50	31.28
	T_2	31.00	35.67	33.33	29.27	42.60	35.93	33.00	36.67	34.83	30.70	37.83	34.27
	T_3	34.00	36.00	35.00	32.17	45.17	38.67	33.67	38.00	35.83	32.17	38.60	35.38
	T_4	31.00	35.67	33.33	30.20	41.83	36.02	32.00	36.33	34.17	27.67	37.47	32.57
	T_5	34.67	37.00	35.83	32.50	44.53	38.52	34.67	38.00	36.33	30.87	36.70	33.78
Mean table	2016-17		2017-18		Table of CD and ±SEm	2016-17				2017-18			
	Seeds number spike^{-1}	Test weight (g)	Seeds number spike^{-1}	Test weight (g)	Particulates	Seeds number spike^{-1}		Test weight (g)		Seeds number spike^{-1}		Test weight (g)	

V_1	33.90	32.26	34.93	31.98		CD	±SEm	CD	±SEm	CD	±SEm	CD	±SEm
V_2	40.24	46.22	39.47	42.04	Factor(V)	0.60	0.21	0.92	0.32	0.78	0.27	0.50	0.18
W_0	40.27	42.19	40.00	40.57	Factor(W)	0.60	0.21	0.92	0.32	0.78	0.27	0.50	0.18
W_1	33.87	36.29	34.40	33.46	V × W	0.85	0.30	N/A	0.45	1.11	0.39	0.71	0.25
T_1	33.60	36.32	33.67	35.57	Factor(T)	0.95	0.33	1.45	0.51	1.24	0.43	0.79	0.28
T_2	36.58	38.63	37.25	37.50	V× T	N/A	0.47	N/A	0.72	N/A	0.61	1.12	0.39
T_3	38.67	41.46	38.67	38.63	W ×T	1.35	0.47	N/A	0.72	N/A	0.61	1.12	0.39
T_4	37.08	38.68	36.92	35.86	V ×W × T	N/A	0.67	N/A	1.02	N/A	0.87	1.59	0.56
T_5	39.42	41.13	39.50	37.51									

CD at 5% Varieties: V_1: HUW-468 V_2: HUW-510 W_0: Control W_1: Imposed drought

T_1: Non primed; T_2: Hydro primed; T_3: $Mg(NO_3)_2$ primed; T_4: ZnSO4 primed; T_5: $Mg(NO_3)$ and ZnSO4 primed

Biological yield plant^{-1} (g)

Table 5 represent the data of biological yield plant^{-1} (g) in primed and non primed sets in wheat varieties under control and imposed drought condition. Data depicted that under control condition biological yield plant^{-1} (g) was observed in combination of salts Mg $(NO_3)_2$ and $ZnSO_4$ primed set in control conditions in V_1 and Mg $(NO_3)_2$ primed set in V_2 varieties respectively. Under drought condition Mg $(NO_3)_2$ primed set showed the best performance in both the varieties. The lowest test weight (g) were observed in non primed treatments in both the varieties under control and water stress condition. Same trend were observed during the studied period of 2017-18. Statistical analysis of biological yield plant^{-1} (g) showed the significant differences among the all the studied factors and factor interactions except V x W during 2016-17 and W x T during 2017-18.

Seed yield plant^{-1} (g)

Table 5 represent the data of seed yield plant^{-1} (g) in primed and non primed set in wheat varieties under control and imposed drought condition. Data depicted that under control and stress condition higher seed yield plant^{-1} (g) were observed in case of combination of Mg $(NO_3)_2$ and $ZnSO_4$ primed wheat sets in both the varieties followed by Mg $(NO_3)_2$ primed set. During the studied period of 2017-18 in control condition best results was observed in case of combined salt treatment in V_1 and Mg $(NO_3)_2$ primed set in V_2 respectively. During stress condition best result was performed by Mg $(NO_3)_2$ primed set in V_1 and combined salt primed set in V_2 respectively. Statistical analysis of seed yield plant^{-1} (g) showed the significant differences among the all the studied factors, while the factor interactions showed non-significant differences except V x W X T during 2017-18.

Table 5: Responses of two wheat varieties HUW-468 and HUW-510 on biological yield plant^{-1} (g) and seeds yield plant^{-1} (g) under control and water stress conditions, using non-primed and primed seeds.

Water stress	Treatments (T)	2016-17						2017-18					
		Biological Yield/ plant (g) (BY)			Seeds yield/plant (g) (SY)			Biological Yield (g)			Seeds yield/plant (g)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
W_0	T_1	3.28	4.83	4.06	1.24	1.61	1.42	3.25	4.72	3.99	1.20	1.61	1.41
	T_2	3.43	4.88	4.16	1.34	1.65	1.50	3.39	4.76	4.07	1.21	1.64	1.43
	T_3	3.69	4.97	4.33	1.55	1.89	1.72	3.62	4.89	4.25	1.54	1.80	1.67
	T_4	3.50	4.30	3.90	1.45	1.68	1.56	3.55	4.58	4.06	1.46	1.64	1.55
	T_5	3.76	4.44	4.10	1.64	1.80	1.72	3.76	4.61	4.19	1.62	1.73	1.68
W_1	T_1	2.45	4.02	3.23	1.09	1.34	1.21	2.51	3.91	3.21	1.06	1.35	1.21
	T_2	2.99	4.05	3.52	1.11	1.44	1.28	3.07	3.96	3.51	1.14	1.38	1.26
	T_3	3.22	4.24	3.73	1.28	1.68	1.48	3.20	4.03	3.62	1.30	1.58	1.44
	T_4	3.08	4.09	3.59	1.26	1.59	1.43	3.06	3.93	3.49	1.24	1.55	1.40
	T_5	3.22	4.10	3.66	1.30	1.72	1.51	3.17	4.00	3.58	1.27	1.74	1.51
Mean table	2016		2017		Table of CD and ±SEm	2016				2017			
	BY/plant (g)	SY/plant (g)	BY/ plant (g)	SY/plant (g)	Particulates	BY/ plant (g)		SY/plant (g)		BY/ plant (g)		SY/plant (g)	
V_1	3.26	1.32	3.26	1.31		CD	±SEm	CD	±SEm	CD	±SEm	CD	±SEm
V_2	4.39	1.64	4.34	1.60	Factor(V)	0.07	0.02	0.04	0.01	0.05	0.02	0.04	0.01
W_0	4.11	1.58	4.11	1.55	Factor(W)	0.07	0.02	0.04	0.01	0.05	0.02	0.04	0.01
W_1	3.55	1.38	3.48	1.36	V ×W	N/A	0.03	N/A	0.02	0.07	0.03	N/A	0.02
T_1	3.65	1.32	3.60	1.31	Factor(T)	0.10	0.04	0.06	0.02	0.08	0.03	0.07	0.02
T_2	3.84	1.39	3.79	1.34	V× T	0.15	0.05	N/A	0.03	0.12	0.04	N/A	0.03
T_3	4.03	1.60	3.94	1.55	W × T	0.15	0.05	N/A	0.03	N/A	0.04	N/A	0.03
T_4	3.74	1.49	3.78	1.47	V × W ×T	0.21	0.07	N/A	0.04	0.16	0.06	0.13	0.05
T_5	3.88	1.61	3.89	1.59									

CD@5% Varieties: V_1: HUW-468 V_2: HUW-510 W_0: Control W_1: Imposed drought

T_1: Non primed; T_2: Hydro primed; T_3: $Mg(NO_3)_2$ primed ; T_4 : ZnSO4 primed; T_5 : $Mg(NO_3)$ and ZnSO4 primed

Harvest index (%)

The data as regards to harvest index (%) of primed and non primed wheat varieties under control and imposed drought condition were presented in table 6. Data depicted that under control condition combined salt primed set showed best results and lowest was observed in case of non priming set. Under drought situation highest HI (%) showed by non-primed seed and lowest by hydropriming in V_1. While in V_2 combined treatment of salt primed set gave best result and lowest by non-primed set. Same trend was followed in the experimentation period 2017-18. Statistical analysis of harvest index (%) showed the significant differences among the all the studied factors except factor W during 2016-17. Factor interactions V x W and W x T showed the non-significant differences. Interaction V x T showed the significant difference during 2016-17 but non-significant during 2017-18. Interaction V x W X T showed the significant differences during 2017-18.

Table 6: Responses of two wheat varieties HUW-468 and HUW-510 on harvest (%) under control and water stress conditions, using non-primed and primed seeds.

		2016-17			2017-18		
		Harvest index (%)			Harvest index (%)		
Water Stress (W)	Treatments	Varieties (V)			Varieties (V)		
		V_1	V_2	Mean	V_1	V_2	Mean
W_0	T_1	37.90	33.25	35.58	36.86	34.10	35.48
	T_2	39.21	33.88	36.55	35.93	34.41	35.17
	T_3	41.91	37.95	39.93	42.69	36.75	39.72
	T_4	41.37	39.09	40.23	41.22	35.83	38.53
	T_5	43.56	40.55	42.05	42.99	37.60	40.30
W_1	T_1	44.37	33.38	38.88	42.34	34.57	38.46
	T_2	37.17	35.67	36.42	37.36	34.80	36.08
	T_3	39.72	39.62	39.67	40.64	39.14	39.89
	T_4	41.08	38.87	39.98	40.67	39.47	40.07
	T_5	40.27	41.94	41.10	40.22	43.45	41.83
Mean table	**2016**	**2017**	**Table of CD and ± SEm**	**2016**		**2017**	
V_1	40.66	40.09		CD	±SEm	CD	±SEm
V_2	37.42	37.01	Factor(V)	1.3	0.44	1.29	0.452
W_0	38.87	37.84	Factor(W)	N/A	0.44	1.29	0.452
W_1	39.21	39.27	Intraction V ×W	N/A	0.63	N/A	0.639
T_1	37.23	36.97	Factor(T)	2.01	0.70	2.04	0.714
T_2	36.48	35.62	Intraction V× T	2.84	0.99	N/A	1.01
T_3	39.80	39.81	Intraction W × T	N/A	0.99	N/A	1.01
T_4	40.10	39.30	Intraction V × W × T	4.02	1.41	4.08	1.429
T_5	41.58	41.07					

CD at 5% Varieties: V_1: HUW-468 V_2: HUW-510 W_0: Control W_1: Imposed drought
T_1: Non primed; T_2: Hydro primed; T_3: Mg $(NO_3)_2$ primed; T_4: ZnSO4 primed; T_5: Mg(NO_3) and ZnSO4 primed.

Discussion

Reproductive stage is the most critical stage of the plant growth and development, it ensures the final economical yield to the consumers. Moreover, it is also very sensitive to various kind of stresses and causes a huge penalty in final yield of many crops such as mustard, fenugreek, wheat, and rice (Denčić *et al*., 2000; Sodani *et al*., 2017; Chauhan *et al*., 2017b) [7, 23, 6]. Drought can reduce or completely inhibit the process of flowering, pollination, grain filling, and grain development phase. It affects the biomass partitioning towards the grain during grain filling stage, resulting in the bareness of field crops. It also alters the endosperm cell, amyloplast cell during grain development stage and affects the sink strength in agriculturally important crops (Saini, and Westgate, 1999) [21]. One of report suggested that the number of grain per spike, test weight and final yield are more sensitive to drought stress than the plant height and number of spikelets per spike in wheat crop (Denčić *et al*., 2000) [7]. Filling of biomass in grains contributed by the current photosynthesis and redistribution of assimilates from reserve pools in vegetative tissues in wheat crop (Farooq *et al*., 2011) [12]. Therefore, scarcities of water during early grain development stage reduces the potential grain size by reducing the rate and duration of grain filling (Saini and Westgate, 1999) [21]. Terminal drought in wheat shortens the life cycle and duration of grain filling. Likewise, the grain-filling rate decreased due to decline in current photosynthesis rate, acceleration of leaf senescence and sink limitations (Madani *et al*., 2010; Wei *et al*., 2010) [15]. Further, terminal drought has more influence on grain number rather than grain size, which largely accounts for the decline in wheat yield under drought conditions (Dolferus *et al*., 2011) [10]. Meiosis and anthesis are also extremely susceptible to drought, and their failure directly influence the grain number, and causes for substantial reduction in grain yield (Cattivelli *et al*., 2008) [5]. Effect of drought on grain yield and yield attributes are discussed in followed manners.

Drought stress notably reduced the plant height, spike length, spikelets per spike, grain per spike and test weight in 25 wheat varieties (Mirbahar *et al*., 2009) [16]. Furthermore, beside the changes in yield and yield component, it also affects the quality of grains. Quality parameters such as grain size, grain weight, grain colour, amylose, gluten and micronutrient content are also affected during drought stress (Ozturk and Aydin, 2004) [19]. In the presented work the effect of induced water stress was clearly observed in case of several yield and yield attributes such as the number of the spike length, spike number plant^{-1}, spike weight, spikelet number spike^{-1}, seed number spike^{-1}, number of productive tillers plant^{-1}, biological yield plant^{-1}, grain yield plant^{-1} (g) and test weight (g) (table- 38-43).

Data showed that during stress condition all the yield and yield attributing parameters were declined in comparison to non-stress control condition for both the varieties (table 38-43 and fig. 25-28 (a &b). From the data of number of the spike length, spike number plant^{-1}, spike weight, spikelet number spike^{-1}, seed number spike^{-1}, number of productive tillers plant^{-1}, biological yield plant^{-1}, grain yield plant^{-1} (g) and test weight (g), it was clear that the drought stress reduce the all yield attributes in studied treatments. Also, from the data it was interpreted that non-priming seed set showed the lower values as compared to primed sets. In the primed sets combination of salt priming sets gave the best performance in both control and drought conditions, which was followed by Mg and Zn primed sets. All these parameter related with the yield and quality of particular crop. Seed priming improved the germination, physiological, biochemical and molecular traits of wheat crop under moisture stress condition. All these traits lead to improvements in final economical yield as of showed by Farooq *et al*. (2006) [11]; Nawaz *et al*. (2015) [17]. Many studies reported on seed priming in enhancing yield of many crops including wheat. On farm seed priming trial in Pakistan by using zinc sulphate ($ZnSO_4$) in wheat crop increase grain yield by 14 %, while the Zn content in grain was 12 % higher (Harris *et al*., 2008) [14]. Likewise, Aboutalebian *et al*. (2012) [1] reported that on farm seed priming with zinc sulphate and urea improve the yield and yield component of three wheat cultivars (Sardari, Azar 2 and Sardari 39). Paul and Choudhury (1991) reported that seed priming with potassium salt improve growth and yield under rain-fed conditions. Several other studies on wheat crop by using different chemical compound suggested that seed priming significantly improves the wheat crop yield under moisture stress condition. Recent study suggested that priming seed remember the memory of earlier drought and transfer to next generation which provide the tolerance to next generations (Tabassum *et al*., 2017) [24]. Therefore, from the data of yield and yield attributes parameters, it can be assumed that seed priming improves the seed yield by improving earlier reproductive growth and more allocation of assimilates toward the developing grains.

References

1. Aboutalebian MA, Ekbatani GZ, Sepehri A. Effects of on-farm seed priming with zinc sulfate and urea solutions on emergence properties, yield and yield components of three rainfed wheat cultivars. Annals of Biological Research. 2012; 3(10):4790-4796.
2. Annual Report. www.agricoop.nic.in. Agriculture and farmer welfare ministry. Government of India. New Delhi, 2016-17.
3. Bose B, Kumar M, Singhal RK, Mondal S. Impact of Seed Priming on the Modulation of physico-chemical and molecular processes during germination, growth, and development of crops. In Advances in Seed Priming. Springer, Singapore, 2018, 23-40.
4. Cattivelli L, Rizza F, Badeckc F-W, Mazzucotelli E, Mastrangelo AM, Franciaa E *et al*. Drought tolerance improvement in crop plants: An integrated view from breeding to genomics. Field Crops Res. 2008; 105:1-14.
5. Cattivelli L, Rizza F, Badeckc F-W, Mazzucotelli E, Mastrangelo AM, Franciaa E *et al*. Drought tolerance improvement in crop plants: An integrated view from breeding to genomics. Field Crops Res. 2008; 105:1-14.
6. Chauhan J, Singhal RK, Kakralya BL, Kumar S, Sodani R. Evaluation of yield and yield attributes of fenugreek (*Trigonella foenum* graecum) genotypes under drought conditions. Int. J Pure App. Biosci. 2017; 5(3):477-484.
7. Denčić S, Kastori R, Kobiljski B, Duggan B. Evaluation of grain yield and its components in wheat cultivars and landraces under near optimal and drought conditions. Euphytica. 2000; 113(1):43-52.
8. Dhanda SS, Sethi GS, Behl RK. Indices of drought tolerance in wheat genotypes at early stages of plant growth. J Agron. Crop Sci. 2004; 190:6-12.
9. Dolferus R, Ji X, Richard RA. Abiotic stress and control of grain number in cereals. Plant Sci. 2011; 181:331-34.
10. Dolferus R, Ji X, Richard RA. Abiotic stress and control of grain number in cereals. Plant Sci. 2011; 181:331-34.
11. Farooq M, Basra SMA, Afzal I, Khaliq A. Optimization of hydropriming techniques for rice seed invigoration. Seed Science and Technology. 2006; 34(2):507-512.
12. Farooq M, Bramley H, Palta JA, Siddique KH. Heat stress in wheat during reproductive and grain-filling phases. Critical Reviews in Plant Sciences. 2011; 30(6):491-507.
13. Farooq M, Wahid A, Kobayashi N, Fujita D, Basra SMA. Plant drought stress: effects, mechanisms and management. In Sustainable agriculture. Springer, Dordrecht, 2009, 153-188.
14. Harris D, Rashid A, Miraj G, Arif M, Yunas M. 'On-farm'seed priming with zinc in chickpea and wheat in Pakistan. Plant and soil. 2008; 306(1-2):3-10.
15. Madani A, Rad AS, Pazoki A, Nourmohammadi G, Zarghami R. Wheat (*Triticum aestivum* L.) grain filling and dry matter partitioning responses to source:sink modifications under postanthesis water and nitrogen deficiency. Acta Sci. Agron. 2010; (32):145-151.
16. Mirbahar AA, Markhand GS, Mahar AR, Abro SA, Kanhar NA. Effect of water stress on yield and yield components of wheat (*Triticum aestivum* L.) varieties. Pak. J Bot. 2009; 41(3):1303-1310.
17. Nawaz F, Ashraf MY, Ahmad R, Waraich EA, Shabbir RN, Bukhari MA. Supplemental selenium improves wheat grain yield and quality through alterations in biochemical processes under normal and water deficit conditions. Food chemistry. 2015; 175:350-357.
18. Okçu Gamze, Mehmet DK, Mehmet A. Effects of salt and drought stresses on germination and seedling growth of pea (*Pisum sativum* L.). Turk J Agric For. 2005; 29(4):237-242.
19. Ozturk A, Aydin F. Effect of water stress at various growth stages on some quality characteristics of winter wheat. Journal of Agronomy and Crop Science. 2004; 190(2):93-99.
20. Reynolds M, Bonnett D, Chapman SC, Furbank RT, Manès Y, Mather DE *et al*. Raising yield potential of wheat. I. Overview of a consortium approach and breeding strategies. Journal of Experimental Botany. 2011; 62(2):439-452.
21. Saini HS, Westgate ME. Reproductive development in grain crops during drought. In Advances in agronomy. Academic Press. 1999; 68:59-96.
22. Saini HS, Westgate ME. Reproductive development in grain crops during drought. In Advances in agronomy. Academic Press. 1999; 68:59-96.
23. Sodani R, Seema RKS, Gupta S, Gupta N, Chauhan KS, Chauhan J. Performance of Yield and Yield Attributes of Ten Indian Mustard (*Brassica juncea* L.) Genotypes under Drought Stress. Int. J Pure App. Biosci. 2017; 5(3):467-476.
24. Tabassum T, Farooq M, Ahmad R, Zohaib A, Wahid A. Seed priming and trans-generational drought memory improves tolerance against salt stress in bread wheat. Plant Physiology and Biochemistry. 2017; 118:362-369.
25. Wardlaw IF, Willenbrink J. Mobilization of fructan reserves and changes in enzyme activities in wheat stems correlate with water stress during kernel filling. New Phytologist. 2000; 148(3):413-422.
26. Wei TM, Chang XP, Min DH, Jing RL. Analysis of genetic diversity and trapping elite alleles for plant height in drought-tolerant wheat cultivars. Acta Agron. Sin. 2010; (36):895-904.
27. Yadav RS, Hash CT, Bidinger FR, Devos KM, Howarth CJ. Genomic regions associated with grain yield and aspects of post-flowering drought tolerance in pearl millet across stress environments and tester background. Euphytica. 2004; 136(3):265-277.