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Effect of seed priming on physiological and agronomic traits of sunflower genotypes under different irrigations

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Abstract Seed priming with nutrients improves germination of seed, establishment of seedling as well as growth of crop and oil content. Irrigation is one of the most significant aspects to facilitate necessary for accurate crop growth, constant improvement and superior yield and oil content of sunflower. Water deficit affects growth of plant and oil content. The field experiments were carried out at Students' Experimental Farm, Sindh Agriculture University, Tandojam for two years throughout autumn 2017 and 2018. Treatments for priming had significantly influenced on germination of seeds (m^{-2}), rate of crop growth (g m^{-2} day^{-1})**,** stem girth (cm), achene $head^{-1}$, (1000-achenes wt., g), achene yields (t ha^{-1}) and % of oil content. The influence of irrigation frequencies was found considerable in all traits. Interaction was initiated also significant in all parameters, except seed germination (m^{-2}). Priming of seed with 0.2% $ZnSO_4$ showed higher (6.3 m^{-2}) germination, crop growth rate (1.8 g m^{-2} day^{-1})**,** stem girth (7.1cm), achene $head^{-1}$ (833), (1000-achenes wt., (66.5 g), achene yields (2.01 t ha^{-1}) and oil content (38.1%) than the control. Irrigation frequency five also influenced on all parameter which produced maximum output more than other irrigations. Thus, it is concluded that use of 0.2% $ZnSO_4$ priming along with five irrigations gave maximum physiological and agronomic traits. Sunflower variety HO-1 may be preferred for better oil performance under agro-climate of Tandojam, Sindh, Pakistan.

Keywords: Sunflower, Germination, Seedling growth, Seed priming

Introduction

Sunflower is an essential worldwide crop for oilseed and a member of compositae family, suitable for agro-climatic conditions and cropping system of Pakistan (Hassan and Kaleem, 2014). Sunflowers have become one of the most essential world's annual crops grown for edible oil purpose (Wills and Burke,

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2006). North America is the origin of sunflower crop. Its inflorescence looks sun-like structure due to this artist inspired from sunflower crop (Badouin *et al.*, 2017). Its seed contain 35-55% oil. In Russia first half of 19^{th} century sunflower was enlarged as a most important oil crop (Mangin *et al*., 2017). It is fourth largest source of vegetable oil after rapeseed and palm all over the world. It is 2^{nd} after cotton seed in Pakistan (Siddiqui and Oad, 2015). Sunflower has revealed that there is great prospective of growing under different agro-ecological zones in all kinds of soil, climatic situation like rain fed and irrigated. Area under cultivation on country base throughout 2018-19 was 1,600,000 hectares and their output was 620,000 million tons (FAO, 2018). The edible oil has been reported as most important commodities of daily use (Amjad, 2014). The edible oil import bill for 2018-19 was Rs 192.203 billion (GOP, 2019). Pakistan is largest country in the world about importing edible oil and it ranks 3^{rd} (Soomro *et al*., 2015). The existing position of sunflower is one of the necessary crops for oil in Pakistan due to its high production (Sheidaie *et al*., 2013). Sunflower contains low cholesterol; due to this reason stands all over the world as good source of edible oil. Sunflower seeds are also rich in protein23%as well as high oil contents about 40-50% (Grompone, 2005).The dried stems of crop make an excellent fuel for domestic purpose. Fiber of the stem used to papermaking, yellow dye is obtained from its flower and its seeds also utilized for black dye (Tengong *et al*., 2010).

Water is one of the most significant aspects necessary for proper development, balanced maturity and superior yield for most of the crops (Hussain *et al*., 2004). It is fact that fresh water becoming costlier as well as scarcer in crop production increase water use efficiency due to the drought conditions (Khatri *et al*.,2001).The availability of water is strongly regulated productivity of sunflower (Kazemeini *et al*., 2009). It is need of the hour to increase efficiency of irrigation and implement management techniques and available technologies (Khan, 2005). Water management strategies and their practices need to be considered to produce more crops with less water requirement. The analysis has confirmed that neglecting irrigation frequencies during the periods of vegetative outcome might be yield reduce considerably and appropriate irrigation management can lead to enhanced efficiency of water use. (Bakht *et al*., 2010) disclosed that maximum seed yield of sunflower was obtained from five irrigations as compared through other irrigation frequencies. Among the hybrids, SF-187 produced more yields as compared to hybrid Parsun-1. Head diameter of sunflower was improved with increased number of irrigations (Flagella *et al*., 2002). Therefore, knowledge about the frequencies of irrigation is essential for the capable utilization of water.

Objectives of the study were evaluated the effect of seed priming on growth and yield of sunflower, assessed the performance of sunflower in response to varying irrigation levels and determined the genotypic variation of sunflower.

Materials and methods

The field study was undertaken at student's experimental Farm of Sindh Agriculture University, Tandojam, during autumn 2017 and repeated for precision of results 2018. The experimental design was Split plot design arrangements with replicated three times. The actual size of each plot was 5 m x 6 m (30 m^2). The treatments arranged in experiment as seed priming sources four: no seed priming(control), priming of seeds with canal water, priming of seed through 1.0% urea and priming of seeds by 0.2% zinc sulphate, irrigation frequencies; two, three, four and five irrigations and sunflower genotypes two; HO-1, and Hysun-33.

Land preparation

Irrigation was applied to the field as a pre-soaking. The soil once sun dried for the level of proper moisture, prepared the seedbed by three times cultivating the soil through a tractor-mounted cultivator. The sowing was done by means of single coulter hand drill. After 15 days of sowing to maintain proper plant distance, thinning was done manually. The NPK fertilizer applications were done with dosage of 100-50-50 kg ha^{-1}. (SSP) phosphorus and (K2SO4) potash fertilizer was practiced at the time of land preparation whereas, (urea) nitrogen in three equivalent split dosages was applied i.e. first dose applied at first irrigation, second at flowering time and third split at grain filling stage. Inter culturing was done to make soil porous for strong plant roots. Weeds of crop were controlled by hoeing manually twice time. The whipping of drums manually were protected flowers from attack of parrots. Data regarding the mentioned soil properties have been summarized in Table I while annual precipitation and temperature data are given in Table II. Data on agronomic observations like seed germination (m^2) after 10 days sowing by counting the emerged seedlings, crop growth rate (g m^{-2} d^{-1}) was recorded from tagged five plants at peak vegetative growth by using formula: $(W2 - W1) \div (T2 - T1)$, stem girth (cm) was considered from three part of plant top, middle and bottom of the stem at harvesting time through measuring tape and average was calculated, achenes $head^{-1}$five discs were selected randomly, the seed were taken out from disc manually, counted and their average was calculated, (1000-achene wt., g) 1000 achene weight data was measured from each plot by thousand achenes counting and weight with electronic balance, achene yield (t ha^{-1}) calculating data was converted into (t ha^{-1}) with following formula, yields $plot^{-1}$ (tones) × (10000 m^2) ÷ plot area (m^2) and oil content (%) by adopting proper method was extracted through Soxhlete apparatus by using 10 g seed from each treatment. The equipment was available at Oilseeds Research Institute, Agriculture Research Centre, Tandojam. According to the formula oil content % was calculated: Oils weight (g) ÷ Weight of seed sample (g) × 100. The data was brought to investigation of variance test using the Statistix version software 8.1 (2006). The consequently least significance test LSD was applied 0.05 at alpha for comparing differences of treatments.

Physico-chemical properties of soil

The experimental soil pre-sowing and post-harvesting of sunflower was brought to analysis for different properties (Table 1). The study of the soil was suggested that soil texture be sandy clay loam. The various samples for physical and chemical properties were analyzed with following procedures (Rayan *et al*., 2001). Soil texture was measured by Bouyoucos hydrometer method. Soil pH and Electrical conductivity (EC) was measured in 1:2 soil water extract using pH and EC meters, correspondingly. Organic matter content was followed by Walkley Black method. Total N was calculated. However, soil was extracted for determining extractable P and K using (AB-DTPA) Ammonium bicarbonate di-ethylene tri amine penta acetic acid. The pH, EC (dSm^{-1}), organic matter%, available phosphorous (P_2O_5) (mg kg^{-1}), extractable potassium (K_2O) (mg kg^{-1}) and total nitrogen (%) were concluded by standard procedures and methods. The values of each chemical analysis of soil are presented in Table 1.

Table 1. Physico-chemical properties of experimental soil for the year 2017 and 2018

Parameters	Before sowing	After harvesting
Soil texture analysis		
Sand%	20.6	-
Silt%	43.2	-
Clay%	37.7	-
Textural class	Silty clay loam	
Soil chemical analysis		
Soil Ph	8.70	8.40
Organic matter (%)	0.50	0.42
EC (dSm^{-1})	2.38	1.52
Available P (mg kg^{-1})	1.35	0.91
Extractable K (mg kg^{-1})	219	172
Total N %	0.03	0.03

Meteorological data

The meteorological data during experimental seasons of both years (2017 and 2018) were obtained from Meteorological Station, Tandojam. The information of meteorological data on basis of August, September, October and November monthsregarding foraverage temperature (℃), Rainfall (mm) and humidity (%) are presented in Table 2.

Table 2. Meteorological data of Tandojam for autumn 2017 and 2018

Month	Week	2017				2018			
		Temperature (°C)		(%) of Relative Humidity	Rainfall in (m.m)	Temperature (°C)		Relative Humidity (%)	Rainfall in (m.m)
		Min.	Max.			Min.	Max.		
August	I	25.14	35.85	67.57	0.0	24.21	36.21	61.14	**0.0**
	Ii	24.81	35.93	65.0	0.0	24.43	35.12	68.37	**0.0**
	Iii	24.62	37.56	63.0	0.38	24.06	36.31	66.62	**0.09**
	Iv	24.68	36.18	68.5	2.32	23.0	36.31	63.5	**0.0**
September	I	24.21	34.78	68.57	0.0	22.42	36.57	62.14	**0.0**
	Ii	23.14	35.64	70.42	0.0	22.78	35.21	63.71	**0.0**
	Iii	23.18	38.31	63.62	0.0	21.68	37.0	59.75	**0.0**
	Iv	21.93	36.56	61.75	0.0	22.81	38.43	57.5	**0.0**
October	I	21.14	37.57	57.85	0.0	20.25	39.92	59.42	**0.0**
	Ii	19.35	39.56	52.0	0.0	17.75	36.43	49.5	**0.0**
	Iii	19.31	39.0	48.87	0.0	17.5	35.93	45.75	**0.0**
	Iv	18.25	37.25	55.0	0.0	16.75	37.81	48.87	**0.0**
November	I	16.35	35.28	50.85	0.0	14.42	33.14	46.0	**0.0**
	Ii	13.5	33.21	55.42	0.0	15.07	32.64	59.71	**0.0**
	Iii	10.37	26.93	50.25	0.0	15.5	31.18	59.0	**0.0**
	Iv	**10.43**	**30.18**	**47.62**	**0.0**	**14.75**	**29.87**	**60.75**	**0.0**

Results

Seed germination (m^{-2})

Germination of seed is the prerequisite for obtaining optimum number of seedlings which ultimately produces greater seed yield. The analysis of variance showed that germination of seed (m^{-2}) of sunflower was considerably ($P \leq 0.05$) influenced on priming of seeds whereas, non-substantially ($P \geq 0.05$) on irrigations, varieties, irrigations × varieties, irrigations × seeds priming, varieties × seeds priming and irrigations × varieties × seeds priming. The results indicated that priming of seed by 0.2% $ZnSO_4$ gave markedly ($P \leq 0.05$) maximum (6.3 m^{-2}) germination of seed followed by seeds priming with 1.0% urea (6.0 m^{-2}) whereas, minimum in no priming (control) seed germination 5.3 m^{-2} (Table 3).

Table 3. Seed germination (m^{-2}) of sunflower genotypes under the influence of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	Three irrigations	Four irrigations	Five irrigations	
HO-1	No priming	5.3	5.3	5.3	5.3	5.3
	Seed priming: canal water	5.7	5.7	5.7	5.7	5.7
	Seed priming: 1.0% Urea	6.0	6.0	6.0	6.0	6.0
	Seed priming: 0.2% $ZnSO_4$	6.3	6.3	6.3	6.3	6.3
	Mean	**5.8**	**5.8**	**5.8**	**5.8**	**5.8**
Hysun-33	No priming	5.3	5.3	5.3	5.3	5.3
	Seed priming: canal water	5.7	5.7	5.7	5.7	5.7
	Seed priming: 1.0% Urea	6.0	6.0	6.0	6.0	6.0
	Seed priming: 0.2% $ZnSO_4$	6.3	6.3	6.3	6.3	6.3
	Mean	**5.8**	**5.8**	**5.8**	**5.8**	**5.8**
Averages	No priming	5.3	5.3	5.3	5.3	5.3 d
	Seed priming: canal water	5.7	5.7	5.7	5.7	5.7 c
	Seed priming: 1.0% Urea	6.0	6.0	6.0	6.0	6.0 b
	Seed priming: 0.2% $ZnSO_4$	6.3	6.3	6.3	6.3	6.3 a
	Mean	**5.8**	**5.8**	**5.8**	**5.8**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.4547	-
Varieties (V)	0.1113	-
Priming (P)	0.0000	0.2807
I x V	0.9852	-
I x P	1.0000	-
V x P	0.9892	-
I x V x P	1.0000	-

Table 4. Crop growth rate (g m^{-2} day^{-1}) of sunflower genotypes under the influence of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	Three irrigations	Four irrigations	Five irrigations	
HO-1	No priming	1.1	1.1	1.1	1.5	**1.2**
	Seed priming: canal water	1.0	1.6	2.1	2.2	**1.7**
	Seed priming: 1.0% Urea	1.0	1.9	2.2	2.5	**1.9**
	Seed priming: 0.2% $ZnSO_4$	1.4	2.0	2.5	2.6	**2.1**
	Mean	**1.1**	**1.7**	**2.0**	**2.2**	**1.7 a**
Hysun-33	No priming	0.8	0.6	0.7	1.4	**0.9**
	Seed priming: canal water	0.9	1.3	1.2	1.7	**1.3**
	Seed priming: 1.0% Urea	1.1	1.2	1.8	1.8	**1.4**
	Seed priming: 0.2% $ZnSO_4$	1.2	1.0	1.6	1.9	**1.4**
	Mean	**1.0**	**1.0**	**1.3**	**1.7**	**1.3 b**
Averages	No priming	0.9 h	0.9 h	1.0 h	1.4 e-g	**1.2 c**
	Seed priming: canal water	1.0 gh	1.5 d-f	1.7 b-e	1.9 a-d	**1.5 b**
	Seed priming: 1.0% Urea	1.0 f-h	1.5 c-f	2.0 a-c	2.1 a	**1.7 ab**
	Seed priming: 0.2% $ZnSO_4$	1.3 e-h	1.5 c-e	2.0 ab	2.2 a	**1.8 a**
	Mean	**1.1 c**	**1.3 b**	**1.7 a**	**1.9 a**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.0499	0.2485
Varieties (V)	0.0029	0.1757
Priming (P)	0.0000	0.2485
I x V	0.3660	-
I x P	0.0397	0.4971
V x P	0.1597	-
I x V x P	0.5225	-

Crop growth rate (g m^{-2} day^{-1})

The statistical analysis illustrated that crop growth rate of sunflower was appreciably ($P \leq 0.05$) impacted by irrigation, varieties, seeds priming and irrigation × priming whereas, not-markedly ($P \geq 0.05$) by irrigations × varieties,

varieties ×priming and irrigations × varieties × priming. The data (Table 4) indicated that priming of seeds through 0.2% $ZnSO_4$ conferred maximum crops growth rate (1.8 gm^{-2} day^{-1}) followed by priming of seed with 1.0% urea (1.7 gm^{-2} day^{-1}) while minimum crop growth rate (1.2 g m^{-2} day^{-1}) was documented in No priming. In case of irrigation, highest (1.9 gm^{-2} day^{-1}) crop growth rate was recorded under the five irrigations followed by four irrigations 1.7g m^{-2} day^{-1}. In addition, data indicated that least crop growth rate (1.1 g m^{-2} day^{-1}) was noted under two irrigations. In varieties, HO-1 was found superior in crop growth rate (1.7g m^{-2} day^{-1}) as compared toward Hysun-33 which produced crop growth rate1.3g m^{-2} day^{-1}. In interaction of irrigation × priming the results showed that highest 2.2 g m^{-2} day^{-1}crop growth rate was recorded on five irrigations × priming of seeds with 0.2% $ZnSO_4$ followed by2.1 g m^{-2} day^{-1} crop growth rate on same irrigation × priming of seed with 1.0% Urea. Whereas, minimum 0.9 g m^{-2} day^{-1} was noted on two irrigations × with interaction of No priming.

Stem girth (cm)

The statistically analysis of data illustrated that girth of stem for sunflower plants affected considerably ($P \leq 0.05$) on irrigations, varieties, priming of seed, irrigations × varieties, varieties × seeds priming while, non-substantially ($P \geq 0.05$) on irrigations × seeds priming and irrigations × varieties × seeds priming. The outcomes (Table 5) proved that priming of seed by 0.2% $ZnSO_4$ produced substantially ($P \leq 0.05$) highest (7.1 cm) stem girth followed by seed primed through 1.0% urea (6.8 cm), whereas, lowest (6.1 cm) in no priming. In case of irrigation, highest (7.3cm) stem girth was recorded on five irrigations followed by four irrigations which resulted (7.1 cm) stem girth while lowest (5.4 cm) stem girth was recorded on second irrigation. In case of varieties, the HO-1 variety was superior with 6.8 cm stem girth in comparison with 6.5 cm of Hysun-33. In interaction of varieties × irrigation, the data illustrated that interaction of variety HO-1 × irrigation frequencies five produced maximum (7.6 cm) stem girth followed by the interaction of HO-1 × irrigation frequencies four with 7.4 cm stem girth whereas, lowest stem girth (5.5 cm) was noted in the interaction of Hysun-33 × irrigation frequencies two. In case of interaction of varieties × priming results proved that HO-1 variety produced maximum stem girth (7.3cm) on interaction of priming of seeds with 0.2% $ZnSO_4$ fallowed by (7.1cm) with priming of seed with 1.0% urea while minimum stem girth (6.1cm) was obtained on Hysun-33 interaction of no priming (control).

Table 5. Stem girth (cm) of sunflower genotypes under the influences of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	**Three irrigations**	**Four irrigations**	**Five irrigations**	
HO-1	No priming	5.0	6.0	6.3	6.8	**6.0 e**
	Seed priming: canal water	5.2	6.3	7.6	7.5	**6.6 cd**
	Seed priming: 1.0% Urea	5.5	7.1	7.9	8.0	**7.1 ab**
	Seed priming: 0.2% $ZnSO_4$	5.6	7.5	8.0	8.1	**7.3 a**
	Mean	**5.3 d**	**6.7 bc**	**7.4 a**	**7.6 a**	**6.8 a**
Hysun-33	No priming	5.3 d	6.2	6.5	6.5	**6.1 e**
	Seed priming: canal water	5.4	6.5	6.7	6.7	**6.3 de**
	Seed priming: 1.0% Urea	5.6	6.8	6.7	7.1	**6.5 cd**
	Seed priming: 0.2% $ZnSO_4$	5.8	6.9	7.1	7.7	**6.9 bc**
	Mean	**5.5 d**	**6.6 c**	**6.7 bc**	**7.0 b**	**6.5 b**
Averages	No priming	5.1	6.1	6.4	6.7	**6.1 c**
	Seed priming: canal water	5.3	6.4	7.1	7.1	**6.5 b**
	Seed priming: 1.0% Urea	5.6	7.0	7.3	7.5	**6.8 a**
	Seed priming: 0.2% $ZnSO_4$	5.7	7.2	7.5	7.9	**7.1 a**
	Mean	**5.4 c**	**6.7 b**	**7.1 a**	**7.3 a**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.0001	0.2462
Varieties (V)	0.0149	0.1741
Priming (P)	0.0000	0.2462
I x V	0.0450	0.3482
I x P	0.5103	--
V x P	0.0332	0.3482
I x V x P	0.4091	-

Achenes head^{-1}

The achene head^{-1} represents for yield of crop. Higher achene head^{-1} helps for obtaining targeted yield. The study of data illustrated to achenes head^{-1} of sunflower had notably ($P \leq 0.05$) influenced on irrigations, varieties, priming of seeds and irrigations × priming while, non-substantially ($P \geq 0.05$) on irrigations × varieties, varieties × priming along with irrigations × varieties × seeds priming. The results (Table 6) demonstrated that, priming of seed through 0.2% $ZnSO_4$ effected ($P \leq 0.05$) considerably greatest (833) achenes head^{-1} followed by (809) achenes head^{-1}seed priming with 1.0% Urea while least (684) achenes head^{-1} were observed in No priming. In irrigation frequencies highest (914) achenes head^{-1} were documented on five irrigations followed by (908) achenes head^{-1} were recorded on four irrigations though, lowest (583) achenes head^{-1} were noted on two irrigations. Among varieties, HO-1 proved better by producing 797 achenes head^{-1} in contrast to Hysun-33 which gave 754 seeds head^{-1}. As far as irrigation × seeds priming is concerned, highest result achenes head^{-1}(1008) was noticed on irrigation five × priming of seeds with 0.2% $ZnSO_4$ followed by(1002)result was noted on the interface irrigation four × priming of seeds with 0.2% $ZnSO_4$. Whereas, lowest (563) achenesheads^{-1} was documented in the interaction of two irrigations × no priming.

Thousand-achenes weight (g)

Thousand achene weight is counter as indicator to attain most favorable weight of seeds. The statistical analysis of results illustrated that sunflower1000-achene weight was appreciably ($P \leq 0.05$) impacted on irrigations, varieties, priming of seeds and irrigations × priming whereas, not-markedly ($P \geq 0.05$) on irrigations × varieties, varieties × priming and irrigations × varieties × priming. The data (Table 7) showed that seeds primed with 0.2% $ZnSO_4$ conferred maximum (66.5 g) 1000-achene weight followed by (64.3 g) achene weight was registered on priming of seeds with 1.0% Urea while, minimum (51.8 g) achene weight was documented on No priming. In irrigation frequencies highest achene weight (70.6 g) was recorded on irrigations five followed by (69.1 g) achene weight was recorded on the four irrigations While, the least (48.6 g) achene weight was noted on two irrigations. Variety, HO-1 was found highest in achene weight (62.9 g) as compared to Hysun-33 which produced 59.2 g achene weight. In interaction of irrigation × priming the results showed that maximum result was documented on five irrigation × priming of seeds by 0.2% $ZnSO_4$ followed by 76.3 g achene weight was recorded on four irrigations × priming of seed with 0.2% $ZnSO_4$, both were not significant with each other Whereas, minimum 45.5 g achene weight was noted on two irrigations × with interaction of No priming affected on 1000- achene weight of sunflower.

Table 6. Achenes head^{-1} of sunflower genotypes under the influences of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	Three irrigations	Four irrigations	Five irrigations	
HO-1	No priming	575	704	764	777	705
	Seed priming: canal water	583	711	938	941	793
	Seed priming: 1.0% Urea	592	731	1015	1023	840
	Seed priming: 0.2% $ZnSO_4$	608	741	1023	1028	850
	Mean	**589**	**722**	**935**	**942**	**797 a**
Hysun-33	No priming	551	658	718	725	663
	Seed priming: canal water	568	666	899	902	759
	Seed priming: 1.0% Urea	581	677	924	929	778
	Seed priming: 0.2% $ZnSO_4$	609	686	980	988	816
	Mean	**577**	**672**	**880**	**886**	**754 b**
Averages	No priming	563 e	681 cd	741 c	751 c	684 c
	Seed priming: canal water	575 e	688 c	918 b	922 b	776 b
	Seed priming: 1.0% Urea	587 e	704 c	970 ab	976 ab	809 ab
	Seed priming: 0.2% $ZnSO_4$	608de	714 c	1002 a	1008 a	833 a
	Mean	**583 c**	**697 b**	**908 a**	**914 a**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.0000	39.157
Varieties (V)	0.0024	27.688
Priming (P)	0.0000	39.157
I x V	0.3945	-
I x P	0.0006	78.313
V x P	0.8807	-
I x V x P	0.9999	-

Table 7. 1000-achene weight (g) of sunflower genotypes under the influence of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	**Three irrigations**	**Four irrigations**	**Five irrigations**	
HO-1	No priming	46.0	50.3	55.0	60.0	**52.8**
	Seed priming: canal water	49.0	56.3	74.3	76.0	**63.9**
	Seed priming: 1.0% Urea	51.0	60.7	75.0	77.7	**66.1**
	Seed priming: 0.2% $ZnSO_4$	53.0	63.3	78.7	80.0	**68.8**
	Mean	**49.8**	**57.7**	**70.8**	**73.4**	**62.9 a**
Hysun-33	No priming	45.0	49.3	51.7	56.7	**50.7**
	Seed priming: canal water	46.7	56.7	68.3	70.0	**60.4**
	Seed priming: 1.0% Urea	48.7	58.3	70.0	71.0	**62.0**
	Seed priming: 0.2% $ZnSO_4$	49.3	60.0	71.7	73.3	**63.6**
	Mean	**47.4**	**56.1**	**65.4**	**67.8**	**59.2 b**
Averages	No priming	45.5 h	49.8 fg	53.3 ef	58.3 cd	**51.8 c**
	Seed priming: canal water	47.8 gh	56.5 de	72.3 b	73.0 ab	**62.4 bc**
	Seed priming: 1.0% Urea	49.8 f	59.5 cd	73.5 ab	74.3 ab	**64.3 b**
	Seed priming: 0.2% $ZnSO_4$	51.2 fg	61.7 c	76.3 ab	76.7 a	**66.5 a**
	Mean	**48.6 c**	**56.9 b**	**69.1 a**	**70.6 a**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.0000	1.9763
Varieties (V)	0.0035	1.3974
Priming (P)	0.0000	1.9763
I x V	0.3438	-
I x P	0.0000	3.9525
V x P	0.4043	-
I x V x P	0.9987	-

Achene yield (t ha^{-1})

The analysis of variance showed that achene yield of sunflower had considerable ($P \leq 0.05$) effect on irrigations, varieties, seeds priming, irrigations × seeds priming, varieties × seeds priming, irrigations × varieties and irrigations × varieties × seeds priming. The Table 8 reveled that seed priming results showed that greatest (2.01 t ha^{-1}) achene yield was documented on priming of seed with 0.2% $ZnSO_4$ followed by (1.97 t ha^{-1}) observed on seed priming 1.0% urea Whereas, lowest (1.76 t ha^{-1}) achene yield was noticed on no priming. As regards irrigation frequencies, five irrigations gave maximum achene yield (2.35 t ha^{-1}), followed by (2.33) t ha^{-1}documented on four irrigations both are non-significant with each other. However, least achene yield (1.47 t ha^{-1}) was registered on two irrigations. In case of varieties, highest achene yield (1.95 t ha^{-1}) was noted in (HO-1) variety followed by Hysun-33with 1.89 t ha^{-1} achene yield. With regards to irrigation ×seeds priming, highest achene yield(2.46 t ha^{-1}) was documented in interaction of irrigation frequencies five × 0.2% $ZnSO_4$ followed by (2.46t ha^{-1}) on interactive effects of irrigations four ×0.2% $ZnSO_4$both results are non-significant with each other whereas, lowest (1.45 t ha^{-1}) was observed in the interactive outcomes of two irrigations × No priming. In case of varieties × seed priming the maximum (2.03 t ha^{-1}) achene yield was recorded on HO-1variety with interaction of 0.2% $ZnSO_4$ fallowed by (1.99 t ha^{-1}) achene yield on same variety with interaction of seed priming with 1.0% urea. The lowest (1.70 t ha^{-1}) achene yield was observed on variety Hysun-33 ×interaction of seed priming with No priming. In case of irrigation × varieties greatest achene yield (2.29 t ha^{-1})was reported in interaction of irrigations five with (HO-1) variety followed by (2,44 t ha^{-1}) noted on same variety with four irrigations while, lowest amount achene yield (1.44 t ha^{-1}) was registered on two irrigations with (Hysun-33). As for as irrigations × varieties × priming of seeds greatest achene yield (2.48 t ha^{-1}) was recorded on four irrigations with interaction of priming of seed with 0.2% $ZnSO_4$ along with (HO-1) variety followed by (2.47 t ha^{-1}) on priming of seeds with 1.0% urea on same variety whereas, least achene yield (1.40 t ha^{-1}) was obtained from interactive effect of two irrigations on (Hysun-33) along with no priming.

Table 8. Achene yield (t ha^{-1}) of sunflower genotypes under the influence of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	Three irrigations	Four irrigations	Five irrigations	
HO-1	No priming	1.50jkl	1.53ij	2.40 b-e	1.80 f	**1.81 e**
	Seed priming: canal water	1.46 j-n	1.53ij	2.43a-d	2.44 a-d	**1.97bc**
	Seed priming: 1.0% Urea	1.50jkl	1.53ij	2.45	2.47 ab	**1.99 b**
	Seed priming: 0.2% $ZnSO_4$	1.53ijk	1.66 g	2.48 a	2.46abc	**2.03 a**
	Mean	**1.50 e**	**1.56 d**	**2.44 a**	**2.29 b**	**1.95 a**
Hysun-33	No priming	1.40 n	1.42mn	1. 46 k-n	2.36 e	**1.70 f**
	Seed priming: canal water	1.43lmn	1.47 j-m	2.38 de	2.40cde	**1.92 d**
	Seed priming: 1.0% Urea	1.46 k-n	1.48 j-m	2.41 a-e	2.43 a-d	**1.95**
	Seed priming: 0.2% $ZnSO_4$	1.50jk	1.57 hi	2.45 a-d	2.46abc	**1.99 b**
	Mean	**1.44 f**	**1.48 e**	**2.22 c**	**2.41 a**	**1.89 b**
Averages	No priming	1,45 h	1.47 gh	2.02 e	2.08 d	**1.76 c**
	Seed priming: canal water	1.45 h	1.50 g	2.41 c	2.42 d	**1.94 b**
	Seed priming: 1.0% Urea	1.48gh	1.51 g	2.43 abc	2.45 abc	**1.97 b**
	Seed priming: 0.2% $ZnSO_4$	1.51g	1.62 f	2.46 a	2.46 ab	**2.01 a**
	Mean	**1.47 c**	**1.52b**	**2.33 a**	**2.35 a**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.0000	0.0119
Varieties (V)	0.0000	0.0590
Priming (P)	0.0000	0.0119
I x V	0.0000	0.0168
I x P	0.0000	0.0238
V x P	0.0212	0.0168
I x V x P	0.0000	0.0336

Oil content (%)

Oil content is an essential remarkable tool to indicate quality of oil crop. The value of sunflower crop depends upon its oil content percentage. The analysis of variance illustrated that oil content% of sunflower was appreciably ($P \leq 0.05$) influenced on irrigations, varieties, priming of seeds, irrigations × varieties, irrigations × seeds priming, varieties × seed priming and irrigation ×varieties × seeds priming. While (Table 9) showed that in priming highest (38.1 %) oil content in priming of seed through 0.2% $ZnSO_4$ followed by (37.5%)oil content was registered on seed priming with1.0% Urea. Nevertheless, No priming noted (33.2%) smallest amount of oil content. Among irrigation frequencies greatest (40.1%)oil content was recorded on irrigations five followed by (39.8%) oil content on four irrigations while, lowest (31.4 %) on two irrigations. Variety, HO-1 produced higher (36.7%) oil content whereas, Hysun-33 which content (35.8%) low oil content. In case of irrigation × varieties maximum (40.9%) oil content recorded on five irrigations with variety HO-1 followed by (40.2%) oil content was registered on the four irrigation and HO-1 variety Whereas, Hysun-33was observed least (31.3%) oil content on two irrigations. As regards irrigation × seed priming highest (43.1%) oil content was recorded on five irrigation with interaction priming of seeds with 0.2% $ZnSO_4$ followed by (42.3%) oil content registered on interaction of four irrigation with seed priming 0.2% $ZnSO_4$whereas, minimum (30.4%) oil content was observed on two irrigation with interaction of No priming. Among the interaction of variety × priming, the data illustrated that greatest (38.3%) oil content was observed in the interaction priming of seed with 0.2% $ZnSO_4$× (HO-1) variety followed by (37.7%) oil content with interaction of seed priming 1.0% urea of same cultivar. Nonetheless, lowest oil content (33.2%) was noticed in the interactive effect of No priming × cultivar Hysun-33. In case of interaction of irrigation × variety × seed priming the results indicated that the maximum (43.1%) oil content on five irrigations with interaction of priming of seeds through 0.2% $ZnSO_4$ on variety (HO-1) followed by (42.5%) was registered on five irrigations with interaction of priming of seed with 0.2% $ZnSO_4$ on (HO-1) variety however, lowest (30.4%) oil content was observed on two irrigation with interaction of No priming with Hysun-33 genotype.

Table 9. Oil content (%) of sunflower genotypes under the influence of seed priming and irrigation frequencies

Sub-plot (Varieties)	Sub-sub plot (Sources of seed priming)	Main-plot (Frequencies of irrigation)				Mean
		Two irrigations	Three irrigations	Four irrigations	Five irrigations	
HO-1	No priming	30.9 mn	33.2 jk	36.0 d	36.4 d	**34.1 d**
	Seed priming: canal water	31.1 mn	33.5 h-k	40.6 b	41.4 b	**36.7 b**
	Seed priming: 1.0% Urea	31.6 lm	35.0 c	41.7 b	42.5 ab	**37.7 ab**
	Seed priming: 0.2% $ZnSO_4$	32.4 kl	35.3 c	42.3 b	43.1 a	**38.3 a**
	Mean	**31.5 c**	**34.3 b**	**40.2 a**	**40.9 a**	**36.7 a**
Hysun-33	No priming	30.4 n	32.5 kl	34.7 gi	35.2 fg	**33.2 e**
	Seed priming: canal water	30.9 mn	33.4 i-k	38.2 c	38.4 c	**35.2 c**
	Seed priming: 1.0% Urea	31.8 lm	34.1 h-j	41.0 b	41.4 b	**37.1 ab**
	Seed priming: 0.2% $ZnSO_4$	32.0 lm	34.6 gh	40.7 b	42.5 ab	**37.5 a**
	Mean	**31.3 c**	**33.7 b**	**38.7 a**	**39.4 a**	**35.8 b**
Averages	No priming	30.6 m	32.9 ij	35.3 gh	35.8 fg	**33.2 d**
	Seed priming: canal water	31.0 lm	33.5 i	39.7 cd	39.9 cd	**36.0 c**
	Seed priming: 1.0% Urea	31.7 kl	34.6 h	41.7 bc	42.0 b	**37.5 b**
	Seed priming: 0.2% $ZnSO_4$	32.2 jk	35.0 f	42.3 ab	42.8 a	**38.1 a**
	Mean	**31.4 c**	**34.0 b**	**39.8 a**	**40.1 a**	**-**

Variables	P-value	$LSD_{0.05}$
Irrigation (I)	0.0000	0.3900
Varieties (V)	0.0488	0.2758
Priming (P)	0.0000	0.3900
I x V	0.0000	0.5515
I x P	0.0000	0.7800
V x P	0.0142	0.5515
I x V x P	0.0000	1.1031

Discussion

Seed priming is a technique in which seeds are soaked in nutrient solution instead of pure water. It is an approach to increase seed nutrient content along with the priming effect to improve seed quality for better germination and seedling establishment (Harris *et al*., 2007). Nutri-seed priming is a technique in which seeds are soaked in nutrient solution instead of pure water. The nutri-primed seeds reserve mobilization, activation, re-synthesis of some enzymes start their activities (Hussain *et al*., 2006). Priming techniques are in advance and importance in agriculture with the increase in environmental stresses. This technique has become a common seed treatment that can increase percentage and uniformity of germination or seedling emergence, mainly under unfavorable environmental conditions (Farhoudi *et al*., 2007). Priming could increase germination traits, accelerate germination, improve seedling establishment and enhance plant growth (Pirasteh-Anosheh *et al*., 2011). Seed priming with urea increase germination percentage, vigour index and root length (Arif *et al*., 2008). Urea priming increased radical and shoot length of sunflower. The increased effect of urea seed priming on seedling growth was more due to seed nutrition. The sunflower vegetative growth, seed yield and oil content enhanced when seed priming with urea (Kouchebagh *et al*., 2014). This practice has realistic importance and could be recommended to farmers to achieve higher germination, uniform emergence, improved growth, flowering and yield characteristics of sunflower.The present study shows that sunflower traits evaluated were significantly ($P<0.05$) affected by varying seed priming. The sunflower crop given0.2% Zinc sulphate resulted in maximum values for all the examined traits (6.3 m^{-2}) seed germination, 1.7 g m^{-2} day^{-1} crop growth rate, 7.1cm stem girth, 833 achenes $head^{-1}$, 66.5 1000-achene weight, 2.01t achene yield and38.1% oil content followed an adverse trend for all the growth and yield traits and achene yields were declined considerably as compared to seed priming with 1.0% Urea. The enhancement in studied traits under zinc priming may be because Zn is an activator for several enzymes including carbonic anhydrase, alcohol dehyrogenase and RNA polymerase. It is involved in the synthesis of Auxin or indole acetic acid (IAA) (Rashid and Memon, 2001). These results are in agreement with those of Moeinzadeh *et al*. (2010) who reported that seed priming caused improvement in seed germination, seed vigour and growth of sunflower plants. Another study of (Toklu, 2015) supported that $ZnSO_4$ increased rate of germination and their percentage. Furthermore, the results of (Sharma and Parmar, 2017) reported that the green peas yield was highest due to priming with 1% $ZnSO_4$. The findings are corroborated with the results of Pirasteh-Anosheh *et al*. (2011) who suggested that seed priming caused improvement in gm^{-2} day^{-1}seed priming exhibited boost in seeds number $head^{-1}$ of sunflower plants.

Water use efficiency is one of the most important ways to increase crop production. It is need of the hour to adopt management techniques and technologies available for increasing irrigation efficiency. Irrigation frequency refers to the number of days between irrigation during periods. Irrigation frequency is one of the most important factors in pressurized irrigation scheduling. When the same quantity of water is applied under different irrigation frequencies crop yields may be different (Abdelraouf and Abuarab, 2012). Productivity of sunflower is strongly regulated by the availability of water (Kazemeini *et al.*, 2009). In order to produce more crops with less water, water management strategies and practices need to be considered with different irrigation (Khan, 2005). Irrigation frequency increased sunflower growth and yield. Due to the variations in soil moisture and wetting pattern, yields of crop may be different when the diverse quantity of irrigation water is applied. High irrigation frequency might be supply desirable conditions for water movement in soil and for uptake by roots (Segal *et al*., 2000). The results of the study positively indicated that five and four irrigations frequencies both are non significant with each other. The results of study suggested that four irrigations produced significantly optimal growth and seed yield as compared to five, three and two irrigations. The findings of this study are in agreement with Alahdadi *et al*. (2011) who recommended an irrigation interval of 10 to 15 days is most favorable for reasonable sunflower production. Ghani *et al*. (2000) reported positive impact of different levels of irrigation on seeds number $head^{-1}$ of sunflower. Our results are also corroborated by (Khaliq and Cheema, 2015) who revealed influence of irrigation application caused significant difference in seeds $heads^{-1}$. Kalroo *et al*. (2013) conferred that using of irrigation frequencies significantly affected on 1000- achene weight of sunflower. (Darwesh *et al*. (2016) revealed that irrigation scheduling was significantly affected on 100-achene weight. Achene yield of sunflower were increased with number of irrigation (Flagella *et al*., 2002). The results are further supported by (Fazel and Lack, 2011) who reported that irrigation frequencies caused substantial influence on achene yield. The results with similar trend have also been revealed by (Khan, 2005) were affected significantly by different irrigation frequencies caused significant difference on oil percentage. The results are also in accordance with Yasin *et al*. (2013) who reported that irrigation frequencies significantly affected sunflower oil content. The results were significantly different among the genotypes. However, the highest yield was observed in HO-1. Response of Sunflower genotypes to different Irrigation frequencies authenticated in all parameters more prominently for seed yield in HO-1, as reflected by the lower Hysun-33. Results showed that there was a high, positive and significant yield difference among genotypes. This consolidates the results of Karam *et al*. (2007) who reported that the increase in seed weight, increase most vegetative organs of sunflower with increasing irrigation supply. It was concluded that Sunflower genotype Gimsun-94 has higher production potential (Flagella *et al.*, 2002). The results of sunflower genotype SF-187 which produced maximum crop growth rate and more yield kg ha^{-1} than the genotype Parsun (Bakht *et al.*, 2010). The results eventually indicated maximum seed yield was obtained from sunflower genotypes Gimsun-94 than Gimsun-256 (Ghani *et al.,* 2000).

It is concluded that the priming of seed, frequencies of irrigation and their interactions caused almost substantial ($P \leq 0.05$) effects on all the traits of growth particularly seed yield and oil content of sunflower genotypes. However, increased seed and oil yield was obtained with0.2% $ZnSO_4$seed priming at four irrigations from genotype HO-1.

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