Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Seed Priming with Sorghum Water Extracts and Calcium Chloride Improves the Stand Establishment and Seedling Growth of Sunflower and Maize

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ARTICLE INFO
Received: Apr 02, 2018
Accepted: Dec 14, 2018,

Keywords
Germination
Maize
Seed priming
Sorghum water extract
Sunflower

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ABSTRACT
This study investigated the potential of seed priming through sorghum water extract for improving the seedlings establishment and early seedling growth of sunflower and maize. The experiments consisted of following treatments viz., (i) control, (ii) hydropriming, (iii) seed priming with 1% sorghum water extract (SWE), (iv) seed priming with 1.5% SWE, (v) seed priming with 2% SWE, (vi) seed priming with 2.5% SWE (vii) seed priming with 3% SWE and (viii) seed priming with 1% (w/v) calcium chloride. Results revealed that various priming treatments on seed significantly affected the number of leaves per plant, plant height, root length, shoot length, root dry weight and shoot dry weight of sunflower and maize. Seed priming with 1-1.5% SWE and calcium chloride was beneficial for improvement in root/shoot dry weight in maize. In sunflower, root dry weight was the highest when seeds were primed with 2.5% SWE while seed priming with other concentrations of SWE were equally beneficial for improvement in shoot dry weight of sunflower. In crux, seed priming with calcium chloride and SWE (1 to 3%) should be opted to improve the seedling growth of maize and sunflower. The choice of seed priming osmotica can be made based on source of osmotica easily available at farmer field.

INTRODUCTION

Maize (*Zea mays* L.) is one of the highest yielding cereal crops in the world and possesses a special importance among cereals in Pakistan. In world, it is the 3rd most significant cereal after wheat and rice (Anonymous, 2000). In Pakistan, it is grown on area of 1.23 million hectares with a production of 5.70 million tonnes (Anonymous, 2018). Beside its use as grain, the seeds of maize are also used to feed the animals and poultry birds after processing (Hossain and Shahjahan, 2007).

However, the average yield of maize in Pakistan is low. There are various biotic and abiotic factors that supposed to be responsible for low maize yield in Pakistan. These factors include poor stand establishment, weeds, pests, drought, heat and chilling stresses and diseases (Maqbool et al., 2016; Daryanto et al., 2016; Khan et al., 2015; Kamara et al. 2003). Among these constraints, the poor stand establishment is a serious issue which hinders the productivity of maize. Thus, due to increasing population, there is a dire need to find the ways to combat these production constraints in maize crop.

Like maize, sunflower is an important oilseed crop which is grown in various cropping systems in Pakistan. In 2018, it was grown on an area of 0.203 million acres and its production was 0.104 million tonnes. The total oil production from sunflower was 0.041 million tonnes (Anonymous, 2018). However, the average yield of sunflower is low in Pakistan. There are several factors which affect the performance of sunflower in Pakistan. Among these, poor stand establishment, weed and insect pressure are the principle reasons for low yield of sunflower (Kandel; 2016; Sedghi, 2008; Chivasa, 1998).

In this scenario, seed priming with various osmotica might be a workable option to improve the stand establishment and productivity of maize and sunflower (Nawaz et. al. 2013; Bajehbaj, 2010). In priming, seed metabolism is initiated by control hydration of seeds but radical protrusion is not allowed. It has been reported in previous studies that stand establishment and productivity of field crops can be enhanced by priming under diverse soil and environmental conditions (Nawaz et al., 2016; Pirasteh-Anosheh et al., 2011; Bailly et al., 2000). Indeed, quick seed germination and seedling growth rate protect the plants from other competitors like unwanted plant and ensures vigorous plant growth (Du and Tuong, 2002). Priming further leads towards improvement of the emergence and stand establishment (McDonald, 2000) which ultimately improves the yields of crops.

Among the various seed priming osmotica used for seed germination, the use of plant extracts has appeared as a new tool to enhance the seed germination under diverse environmental conditions. Studies has witnessed that little dose spray of SWE has promotory effect on plant germination and growth (Bajwa and Farooq, 2017). Different allelochemicals have been identified in sorghum plant like p-coumaric acid, benzoic acid, ferulic acid, chlorogenic acid, p-hydroxybenzoic acid, vanillic acid, gallic acid, m-coumaric acid, caffeic acid and sorgoleone (Guenzi and McCalla 1966; Cheema, 1988; Nimbal et al., 1996). In a previous study, maize yield was increased when 3% water extract of sorghum, moringa and brassica were foliage applied (Farooq et al., 2013). In another study, foliar application of 2% moringa, sunflower, brassica, and rice water extract enhanced the grain yield of wheat (Cheema et al., 2012).

Thus, present experiment was carried out to evaluate the effect of seed priming with various concentrations of SWE on emergence and seedling growth of maize and sunflower crop.

MATERIALS AND METHODS

Both the pot trials were conducted at Agronomy Department, Bahauddin Zakariya University Multan, Pakistan. The experiments were consisted of following treatments viz. (i) control, ii) hydropriming, (iii) priming with 1% SWE, (iv) priming with 1.5% SWE, (v) priming with 2% SWE, (vi) priming with 2.5% SWE, (vii) priming with 3% (SWE) and (viii) priming with calcium chloride (1%). For preparing the SWE, the mature sorghum crop was harvested and kept for drying for a period of two weeks under shade. Then it was chopped, and one kilogram of sorghum chopped material was dipped in 10 L of water. After 24 hours, the water extract was filtered through a thin cloth. This water extract was boiled at a high temperature until its volume was reduced by 20 times. This was regarded as 100% pure the SWE. Further dilutions were made as per treatments from this SWE. Then the seeds of maize and sunflower were primed with each respective concentration of SWE for 14 and 8 hours respectively. Continuous aeration was provided by an aquarium pump. In case of hydropriming, the seeds were soaked in tap water for 14 and 8 hours for maize and sunflower respectively. In calcium chloride priming, maize and sunflower seeds were soaked in solutions with osmotic potential –1.25 MPa (22.2 g/L $CaCl_2$) for similar time periods. Each of the treatments has four replications. In this experiment, we used the S-272 variety of the sunflower and Hyson-11 variety of maize. Each experiment was laid out following Completely Randomized Design and replicated 4 times. Both sunflower and maize crop were sown in 4 kg soil filled pots on March 13, 2017. Initially, seven seeds of both crops were sown in each of the pot which **was** later thinned to 6 and 5 plants after uniform emergence for maize and sunflower respectively. The seedling growth was supplemented by half strength Hoagland nutrient solution (Epstein and Bloom, 2005) two times during whole course of growth period. After 3 weeks of sowing, the seedlings were harvested. The data on final germination count, plant height, shoot length, number of leaves per plant, root length, shoot and root dry weight and number of roots plant^{-1} was recorded following the standard procedures in maize and sunflower. The collected data on all parameters was analyzed statistically by using Fisher analysis of variance technique and the treatment means were equated using the least significant difference test at 5% probability level (Steel et al. 1997).

RESULTS

Experiment I (Maize)

This study showed that various priming techniques of seed significantly affected the number of leaves per plant, plant height, root length, shoot length, number of roots per plant, shoot and root dry weight; results being non-significant for final germination count (Table 1). At first sampling date, the highest numbers of leaves per plant were noted when seeds were primed with calcium chloride and that was statistically similar with the hydro-primed seeds and seed priming with 1-1.5% SWE. At second sampling date, the highest numbers of leaves per plant were recorded with 3% SWE seed priming (Table 1).

At first sampling date, the highest plant height was noted when priming of seed was done with 1% SWE which was statistically similar with when seeds were hydro-primed or were primed with calcium chloride and 1.5-3% SWE. At second sampling date, the highest plant height was recorded in hydro-primed seeds followed by seed priming with calcium chloride (Table 1). The maximum root length was noted where seeds were primed with 2% SWE which was statistically similar with when seeds were hydro-primed or were primed with calcium chloride and 1.5%-3% SWE (Table 1). The highest shoot length was noted in hydro-primed seeds followed by seed priming with calcium chloride (Table 1). The highest numbers of roots per plant were noted in hydro-primed seeds followed by seed priming with 1% SWE (Table 1). Root dry weight was the highest with 1.5% SWE seed priming and that was statistically similar with hydropriming, or seed priming with calcium chloride and 1% SWE (Table 1). Shoot dry weight was the highest with calcium chloride seed priming (Table 1).

Experiment II (Sunflower)

This study showed that various priming techniques of seed significantly affected the number of leaves per plant, plant height, root length, shoot length, root dry weight and shoot dry weight; results being non-significant for final germination count (Table 2). At both sampling date, the highest plant height was noted when seeds were primed 1.5% SWE and that was statistically similar with seed priming with 2% SWE for both sampling dates and with 1% SWE for second sampling date (Table 2).

At first sampling date, seed priming with either concentration of SWE was equally useful for improvement in number of leaves per plant except seed priming with 1% SWE. At second sampling date, the highest numbers of leaves per plant were recorded with seed priming with 2.5% SWE (Table 2).

The highest root length was noted when seeds were primed with 1.5% SWE which was statistically similar with hydro-primed seeds (Table 2). Priming with either concentration of SWE and calcium chloride was equally beneficial for improvement in shoot length (Table 2). Root dry weight was the highest when seeds were primed with 2.5% SWE (Table 2). Seed priming with either concentration of SWE was equally beneficial for improvement in shoot dry weight (Table 2).

DISCUSSION

From the above experiments, it is concluded that the SWE (1-3%) and calcium chloride were the best osomotics for improvement in seedling growth of maize and sunflower. It has been earlier reported that seed priming improves the stand establishment and productivity of field crops under diverse soil and environmental conditions (Nawaz et al., 2016; Pirasteh - Anosheh et al., 2011; Bailly et al., 2000). Indeed, rapid seed germination and seedling growth rate protect the plants from other competitors like weeds and ensures vigorous plant growth (Du and Tuong, 2002).

Table 1: Influence of seed priming on germination and seedling growth of maize

Treatments	Germination	Number of leaves		Plant height (cm)		Root length (cm)	Shoot length (cm)	Number of roots per plant	Root dry weight (g/plant)	Shoot dry weight (g/plant)
		6-DAS	**21-DAS**	**6-DAS**	**21-DAS**					
Control	6.00	1.67^{bc}	5.81^{c}	6.59^{cd}	36.86^{d}	38.50^{d}	39.00^{b}	11.14^{d}	1.92^{d}	2.39^{c}
Hydropriming	5.75	1.95^{a}	6.11^{b}	8.42^{a}	39.75^{a}	44.12^{ab}	41.81^{a}	11.24^{d}	2.94^{ab}	2.68^{b}
SWE (1%)	6.00	1.95^{a}	6.00^{b}	8.85^{a}	38.24^{bc}	40.65^{cd}	40.12^{b}	14.17^{ab}	2.96^{ab}	2.16^{d}
SWE (1.5%)	6.00	1.86^{ab}	6.00^{b}	8.27^{ab}	37.39^{cd}	45.72^{ab}	38.88^{b}	13.14^{bc}	3.06^{a}	2.70^{b}
SWE (2%)	6.00	1.65^{bc}	6.04^{b}	6.22^{d}	35.05^{e}	46.71^{a}	36.61^{c}	11.10^{d}	2.60^{bc}	2.31^{cd}
SWE (2.5%)	6.00	1.49^{c}	6.10^{b}	7.29^{bc}	34.90^{e}	43.46^{bc}	36.51^{c}	12.46^{c}	2.30^{cd}	2.24^{cd}
SWE (3%)	6.00	1.75^{ab}	6.43^{a}	8.52^{a}	37.01^{cd}	44.11^{ab}	39.10^{b}	11.30^{d}	2.48^{c}	2.23^{cd}
$CaCl_2$ (1%)	6.00	1.97^{a}	6.04^{b}	8.41^{a}	39.44^{ab}	45.69^{ab}	40.38^{ab}	14.50^{a}	3.03^{ab}	3.11^{a}
LSD ($P \leq 0.05$)	NS	0.24	0.15	0.98	1.24	2.87	1.51	1.09	0.43	0.20

Means with same case letter did not differ significantly at $P \leq 0.05$; NS= non-significant; DAS= Days after sowing

Table 2: Influence of seed priming on germination and seedling growth of sunflower

Treatments	Germination count	Plant height (cm)		No of leaves		Shoot length (cm)	Root length (cm)	Shoot dry weight (g/plant)	Root dry weight (g/plant)
		6-DAS	**21-DAS**	**6-DAS**	**21-DAS**				
Control	5.00	11.06^{d}	14.07^{d}	5.68^{c}	6.05^{e}	15.20^{c}	13.17^{e}	0.42^{d}	12.3^{d}
Hydropriming	4.75	12.16^{bcd}	15.00^{cd}	5.76^{abc}	6.45^{cd}	17.00^{bc}	19.12^{ab}	1.12^{bc}	16.8^{c}
SWE (1%)	4.25	13.05^{a-d}	16.79^{ab}	5.73^{bc}	6.64^{bc}	19.67^{a}	17.22^{bcd}	1.37^{ab}	18.9^{b}
SWE (1.5%)	5.00	14.69^{a}	17.01^{a}	5.85^{ab}	6.92^{b}	18.85^{ab}	20.08^{a}	1.38^{ab}	16.7^{c}
SWE (2%)	5.00	13.92^{ab}	16.60^{ab}	5.87^{ab}	6.59^{bc}	19.41^{a}	18.52^{abc}	1.59^{a}	16.7^{c}
SWE (2.5%)	5.00	12.79^{a-d}	15.93^{abc}	5.91^{a}	7.52^{a}	19.05^{ab}	15.86^{cd}	1.63^{a}	21.5^{a}
SWE (3%)	4.75	13.33^{abc}	15.76^{abc}	5.89^{ab}	6.61^{bc}	18.96^{ab}	15.57^{de}	1.41^{a}	19.1^{b}
$CaCl_2$	5.00	11.62^{cd}	15.36^{bcd}	5.64^{c}	6.10^{de}	19.20^{ab}	15.09^{de}	0.93^{c}	17.1^{c}
LSD ($P \leq 0.05$)	NS	2.17	1.49	0.17	0.29	2.26	2.66	0.28	1.58

Means with same case letter did not differ significantly at $P \leq 0.05$; NS= non-significant; DAS= Days after sowing

Indeed, priming leads towards improvement of the seed germination and seedling establishment (McDonald, 2000) which ultimately improves the yields of crops.
Among the various seed priming osmotica used for seed germination, the use of crop water extracts has emerged as a new tool to improve the seed germination under diverse environmental conditions. Studies has reported that low dose spray of SWE has promotory effect on plant germination and growth (Cheema *et. al*., 2012; Anwar et al., 2003) and the same results were observed in this study that seed priming with SWE at lower concentration (1-3%) improved the seedling growth of maize and sunflower.
Sorghum being the maximum studied allelopathic crop regarding its usage as water extract and its allelochemicals have significant role in crop production (Alsaadwi and Dayan, 2009; Weston and Duke, 2003). Sorghum possess several allelochemicals like 2,5-dimethoxysorgoleone, 5-ethoxysorgoleone, sorgoleone (Czarnota et al. 2003), phenolics (Lehle and Putnam, 1983; Einhellig et al., 1993) such as p-hydroxybenzoic acid, p-hydroxybenzaldehyde, p-coumaric acid, vanillic acid, ferulic acid (Séne et al., 2001) ranging from 1.1 to 2.2% in different plant parts. All these allelochemicals have growth promotive potential when used in lower concentrations. In a previous study, maize yield was increased when 3% water extract of sorghum, moringa and brassica were foliage applied (Farooq et al., 2013). While in some other study, foliar application of 2% moringa, sunflower, brassica, and rice water extract enhanced the grain yield of wheat (Cheema *et. al*., 2012).
In conclusion, it is well proved that allelopathic plant extracts can be exploited for seedling development of different crops that ultimately is a pre-requisite for the good crop yield. Seed priming with calcium chloride and SWE at lower concentrations must be opted to improve the seedling growth of maize and sunflower. Nonetheless, the present results of the pot trial need to be confirmed under field environments.

Authors' contributions

All the authors have equally contributed in the conducting this trial and manuscript preparation.

Acknowledgements

The first author acknowledges the financial support from the Directorate of Research and External Linkages, Bahauddin Zakariya University, Multan, Pakistan.

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