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Hydroprimed sunflower achenes perform better than the salicylic acid primed achenes

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Salicylic acid (SA) and water (hydropriming; control) priming for enhancing germination and early seedling growth in hybrid sunflower were evaluated. Sunflower achenes were primed with 50, 100, 150 and 200 ppm solutions of SA, while controlled achenes were soaked in distilled water. After 24 hours of soaking achenes were air dried for 24 hours. Half the portion of achenes was repeated with the priming applications. Both SA and hydropriming did not affect the time to start emergence while the energy of emergence was decreased by freshly primed achenes with SA compared with hydropriming and it remained unaffected in case of dry primed achenes. The emergence index was decreased in fresh primed achenes with SA compared with hydropriming while it was enhanced in dry primed achenes with SA as compared with hydropriming. Final emergence percentage was not affected in case of dry primed achenes but it was decreased for the freshly primed achenes with SA at all concentrations compared with hydropriming. Mean emergence time was low in hydroprimed achenes compared with fresh primed achenes with SA, while it remained unaffected in case of dry primed achenes. Maximum root length was resulted in freshly achenes with SA at 150 ppm. Shoot length was increased in fresh primed achenes with SA and decreased in dry primed achenes. The dry weight of achenes was not affected by the use of salicylic acid for achenes. Fresh primed achenes performed better than dry primed achenes. It was found that fresh primed achenes performed better. During this study it was concluded that the hydroprimed achenes performed better compared with achene priming with SA at all concentrations.

Key words: achene invigoration, hydropriming, salicylic acid, sunflower

Introduction

Pakistan has chronic deficiency in edible oilseed production and is the third largest importer of edible oil in the world involving huge foreign exchange.

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Presently indigenous oilseed production is estimated 0.78 million tons which meets only 27% of domestic requirement, while the remaining 73% is met through imports (Govt. of Pakistan, 2008-2009). For the year 2008-2009 (July-March), Pakistan imported 1.29 million tons edible oil and spent nearly Rs.84.6 billion to meet its edible oil requirements and thus become the third largest importer of edible oil in the world (Govt. of Pakistan, 2008-2009). Nevertheless, the demand for the edible oil is increasing steadily over the time while production is stagnant. All this necessitates more concerted efforts to increase domestic oilseed production. Sunflower is one of the major oilseed crops of Pakistan grown over an area 1.12 million acres, an achene production of 0.75 million tons and oil production of 0.087 million tons, nevertheless it possesses uses other than an oilseed (Govt. of Pakistan, 2008-2009; Jabran *et al.,* 2008, 2010; Razzaq *et al.* 2010). The average yield of sunflower is low than the potential of the hybrids while sub-optimal population is one of the most important reasons for low sunflower yield in Pakistan. The optimum plant population directly depends upon germination percentage. Poor germination leads to sub optimum plant population. In recent years, a lot of work has been done on the seed priming to improve the germination rate, uniformity of the growth and reducing the germination time of many vegetables and some field crops including sunflower (Basra *et al.* 2003; Iqbal and Ashraf, 2005). The seed priming increases germination under less than optimum conditions such as salinity (Muhayaddin and Weibe, 1989). Furthermore the seed invigoration persists under less than optimum conditions such as salinity (Muhayaddin and Weibe, 1989), excessively high and low temperature. Seed invigoration treatments such as hydropriming, osmopriming, hardening, matripriming growth regulators have been successively employed in many parts of the world (Kang and Saltveit, 2002; Basra *et al.,* 2004).

Salicylic acid is an endogenous growth regulator of phenolic nature, which participates in regulation of physiological process in plants (Raskin, 1992). These include effect on ion uptake, membrane permeability etc. salicylic acid also induces an increase in the resistance of seedlings to osmotic stress (Basra *et al.,* 2004), and low or high temperature by activation of gluthathione reeducates (Kang and Saltveit, 2002). Seed treatment with salicylic acid improved the germination and early seedling growth in coarse and fine rice (Basra *et al.,* 2004). Hussain *et al.* (2010) found that foliar application of SA at flowering and budding stage enhanced the achene yield under water stress conditions compared with control i.e. no application of SA.

Some work on sunflower achene invigoration was done by Hussain et al. (2006) with priming agents such as NaCl but no comprehensive study has been conducted to evaluate the response of sunflower to achene priming with salicylic acid. Moreover, in priming after soaking for a prescribed duration, achenes are re-drying nearly to their original weight. But there is a need to test other aspects, either re-drying the achene after priming is vital or not. The present study was therefore planned to explore the feasibility of sunflower achene invigoration by priming with salicylic acid; with the objectives to evaluate salicylic acid as an achene priming agent, to check the response of fresh primed achene and dry primed achene and also evaluate the proper level of salicylic acid for priming sunflower achenes.

Materials and methods

Site design and plant materials

The experiment was carried out at Seed Physiology Laboratory, Department of Crop Physiology University of Agriculture Faisalabad, Pakistan. The experiment was laid out in completely randomized design (CRD) with three replications. Sunflower hybrid Hysun-33 was used as an experimental material. Achenes of sunflower hybrid Hysun-33 were obtained from Pioneer Seed Corporation Ltd. and initial achene moisture contents were 8.33%.

Achene treatments

Achene condition (S) for the experiment included freshly primed achenes and re-dried primed achenes. Achene priming treatments (T) included achene priming with salicylic acid at 50, 100, 150, 200 ppm for 24 hours while achenes soaked in distilled water (hydropriming) were taken as control.

Priming methodology

Salicylic acid solutions according to the concentrations to be used for different treatments were prepared. Achenes were divided in two portions for soaking in respective solutions. The ratio of achene weight to solution volume was 1:5 (g ml^{-1}) (Basra *et al.,* 2004). During soaking, aeration was provided to the achenes by air pumps. After 24 hours of soaking achenes were air dried for 24 hours. Half the portion of achenes was repeated with the priming application. Control (hydroprimed) and achenes primed with salicylic acid were sown in 5 kg plastic pots containing moist water washed sand and placed in a net-house for 15 days.

Vigor evaluation

Data on days to start emergence was recorded from the date of sowing until first achene emerged in each pot. To count final emergence percentage (FEP), the number of emerged achenes was recorded daily according to the seedlings evaluation Handbook of Association of Officials of Seed Analysts (1990) until a constant count was achieved and FEP was calculated as the ratio of total achenes emerged to total achene sown expressed in percentage.

Time taken to 50% emergence of seedlings (E50) was calculated according to the formulae of Coolbear *et al.* (1984) modified by Farooq *et al.* (2005) as follows:-

$$E_{50} = t_i + \frac{\left(\frac{N}{2} - n_i\right)(t_j - t_i)}{n_j - n_i}$$

Where N is the final number of germination and n_i, n_j cumulative number of achenes germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$.

Mean emergence time (MET) was calculated according to the equation of Ellis and Roberts, (1981) as follows:-

$$MET = \frac{\sum Dn}{\sum n}$$

Where n is the number of achenes, which were emerged on day D, and D is the number of days counted from the beginning of emergence.

Emergence index (EI) was calculated as described in the Association of Official Seed Analysts, (1983) as the following formulae:

$$\mathrm{EI} = \frac{\text{No. of emerged seedlings}}{\text{Days of first count}} + \frac{\text{No. of emerged seedlings}}{\text{Days of final count}}$$

Energy of emergence was recorded at 4^{th} day after planting. It is the percentage of emerged achenes at 4^{th} days after planting relative to the total number of achenes sown (Farooq *et al.,* 2005).

Radicle and plumule lengths and seedlings fresh and dry weights were recorded 15 days after sowing. Five plants from each pot were selected randomly and their root lengths and shoot lengths were measured with the help of measuring tape and then averaged. Five plants from each pot were selected randomly and their fresh weight was recorded and averaged. These plants were dried in an oven at 70 ± 5°C, till a constant weight. Weight was measured with the help of electrical balance and then averaged (Farooq *et al.,* 2007) to get seedling dry weight.

Statistical analysis

The data collected were tabulated and analyzed statistically by using Fisher's analysis of variance technique under completely randomized design. Significant means were compared by Duncan's New Multiple Range Test (DMRT) test at 0.05 probability level (Steel *et al.,* 1997).

Results

Time taken to start emergence was not significantly affected by achene priming treatments either in freshly or dried primed conditions (Table 1). Data regarding energy of emergence (EE; Table 1) depicted that it was significantly decreased by freshly primed achenes with salicylic acid (SA) compared with hydropriming (control) while dry primed achenes with salicylic acid had non-significant effect on EE. Freshly hydroprimed achenes had more EE compared with all other treatments (Table 1). Fresh primed achenes with 100 ppm SA resulted in minimum emergence index (EI) but it was statistically at par with all other priming treatments except hydropriming having maximum EI but it was also at par with fresh primed achenes with 50 and 150 ppm of SA (Table 1). Dry primed achenes with 50 ppm SA enhanced the EI but it was at par with all other dry primed achenes except hydropriming. Hydropriming gave minimum EI but it was also at par with all other treatments except achenes primed with 50 ppm SA (Table 1). Hydroprimed achenes resulted in highest final emergence percentage (FEP) compared with all other treatments, while dry primed achenes had non-significant effect on final emergence percentage (FEP) (Table 1).

Time taken for 50% emergence (E_{50}) and mean emergence time (MET) was significantly lower by hydroprimed achenes as compared to achenes primed with SA at all concentrations, while dry primed achenes had non-significant effect on E_{50} and MET (Table 1). Maximum E_{50} and MET was recorded by fresh primed achenes with 50 ppm SA against the minimum E_{50} and MET was obtained by hydropriming. The effect of fresh and dry primed achenes with distilled water and SA on root length was non significant. The effect of fresh primed and dry primed achenes with SA was significant regarding the shoot length (Table 2). In freshly primed achenes maximum shoot length was recorded when achenes were primed with 150 ppm of SA against the minimum shoot length recorded in achenes primed with 200 ppm SA but it was at par with hydropriming. In case of dry primed achenes, maximum shoot length was recorded in hydropriming followed by achenes primed with 50 ppm of SA where the minimum shoot length was recorded in achenes primed with 100 ppm of SA and it was at par with rest of treatments except hydropriming (Table 2). Furthermore, both fresh and dry primed achenes with SA at all concentrations and distilled water had non-significant effect on seedlings fresh and dry weight (Table 2).

Discussion

Achene priming with salicylic acid neither reduced the time to start emergence nor improved the energy of emergence in sunflower (Lee and Kim, 2000), nevertheless, some contradictory results were reported by Harris *et al.* (1999). Hydroprimed (control) achenes improved the energy of emergence which might be due to extended lag phase during hydration process (Hussain *et al.,* 2006). The emergence index which indicated the rate of emergence per day was increased by achene priming with salicylic acid in dry achenes (Rao and Sing, 1992).

Reduction in final emergence percentage compared with the hydropriming might be due to some toxic effects of salicylic acid (Strognov, 1964; Dell and Tritto, 1990). Although most of the priming agents have been found to increase the final emergence percentage (Lee *et al.,* 1998); hydroprimed achenes resulted in maximum FEP which might be due to the extended lag phase during hydration process. During lag phase genetic and structural repair might have taken place (Bray *et al.,* 1989) in osmoprimed leek seeds. Similarly, (Hussain *et al.,* 2006) also reported maximum FEP in sunflower hydroprimed achenes. Fresh primed achenes took more time to achieve 50% emergence compared with the dried primed achenes which conveys a clear message of dry primed seeds being better in accomplishing the germination process (Haris *et al.,* 1999; Lee and Kim, 2000). Furthermore, hydroprimed achenes resulted in low E_{50} compared with SA primed achenes either fresh or dry (Hussain *et al.,* 2006, 2008).

Achene priming with SA enhanced the mean emergence time compared with hydropriming instead of reducing it as has been reported by a number of researchers (Lee and Kim, 2000; Hussain *et al.,* 2006), the reason may be the toxic effects of some priming agent (Dell and Tritto, 1990). Achene priming with SA improved the root length and shoot length of the sunflower seedlings which are an indication of stronger vigor (Demir and Vande-venter, 1999; Pill and Necker, 2001; Basra *et al.,* 2004). Priming of the achenes proved helpful in attaining healthy seedlings with higher fresh achenes weight compared with the non-primed achenes (Badole *et al.,* 1992; Ashraf and Rauf, 2001).

Conclusion

Hydropriming increased in FEP and EE, while decresed in time taken to complete 50% emergence and MET. Achene priming with SA at all concentrations performed poor when compared with hydropriming except root length, which increased by achene priming with 150 ppm SA. Furthermore, freshly primed achenes performed better when compared with dry primed achenes.

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Table 1. Effect of pre-sowing achene treatments by salicylic acid on number of days to start germination, germination energy, germination index, final germination percentage, time for 50% germination and mean germination time

Treatments	Days to start emergence (days)			Energy of emergence [EE] (%)			Emergence index [EI]			Final emergence [FEP] (%)			Time for 50% emergence [E_{50}] (days)			Mean emergence time [MET] (days)		
	FPS	DPS	Mean	FPS	DPS	Mean	FPS	DPS	Mean	FPS	DPS	Mean	FPS	DPS	Mean	FPS	DPS	Mean
Hydropriming (control)	3.00^{NS}	3.00	3.00	93.0 a[1]	88.88	90.94 a	8.58 a	5.77 b	7.17	88.89 a	88.89	91.11	2.90 b	2.90	3.13 b	4.14 c	4.33	4.24 c
SA 50 ppm	4.33	3.00	3.67	35.53 b	97.78	66.65b	6.2 abc	8.51 a	7.36	62.22 b	97.78	80.00	7.27 a	3.54	5.41 a	12.40 a	4.16	8.28 a
SA 100 ppm	3.67	3.00	3.33	28.89 b	100.0	64.44b	5.66 c	7.30 ab	6.48	62.22 b	100.0	81.11	6.75 a	2.89	4.82 a	7.57 b	3.38	5.47 bc
SA 150 ppm	3.67	3.00	3.33	40.00 b	100.0	70.00 b	8.22 ab	8.19 ab	8.21	71.11 b	100.0	85.55	6.26 a	2.53	4.39 ab	8.03 b	4.17	6.10 b
SA 200 ppm	4.00	3.00	3.50	22.22 b	93.33	57.77 b	6.10 bc	8.14 ab	7.12	62.22 b	95.55	78.89	8.00 a	2.87	5.43 a	8.56 b	4.53	6.54 ab
Mean	3.73	3.00		43.93	96.00		6.95	7.58		70.22	96.44		6.24	3.04		8.139	4.115	

SA: Salicylic acid
NS: Non significant
FPM: Fresh primed seeds
DPM: Dry primed seeds
[1]Any two means not sharing a letter in common differ significantly at p<5.

Table 2. Effect of pre-sowing achene treatments by salicylic acid on root length, shoot length, fresh weight and dry weight of sunflower

Treatments	**Root length (cm)**			**Shoot length (cm)**			**Achenes Fresh weight (g)**			**Achenes Dry weight (g)**		
	FPS	**DPS**	**Mean**	**FPS**	**DPS**	**Mean**	**FPS**	**DPS**	**Mean**	**FPS**	**DPS**	**Mean**
Control (hydro-priming)	11.80	9.38	10.59b	19.03 cd	18.90 a	18.97 ab	7.183	5.290	6.237bc	0.443	0.127	0.435
SA 50ppm	11.93	13.70	12.82a	20.50 bc	17.53 ab	19.02 ab	7.683	7.440	7.562a	0.480	0.417	0.448
SA 100ppm	11.23	13.57	12.40ab	21.33 b	16.27 b	18.80 ab	7.263	6.267	6.765ab	0.493	0.367	0.430
SA 150ppm	13.23	13.49	13.36a	23.73 a	16.80 b	20.27 a	7.620	6.887	7.253a	0.463	0.413	0.438
SA 200ppm	10.27	12.67	11.47ab	18.30 d	16.77 b	17.53 b	6.193	5.437	5.815c	0.413	0.367	0.390
	11.69	12.60		20.58	17.25		7.189	6.264		0.459	0.398	

SA: Salicylic acid
NS: Non significant
FPM: Fresh primed seeds
DPM: Dry primed seeds
[1]Any two means not sharing a letter in common differ significantly at p<5.