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ON FARM SEED PRIMING TO IMPROVE CROP ESTABLISHMENT, SEED YIELD AND QUALITY OF SAFFLOWER

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ABSTRACT

On farm seed priming is practiced by farmers involving soaking the seeds in water or chemicals which helps in reducing the risk of crop failure under variable soil moisture conditions. Experiment conducted over three years' (2012-13 to 2014-15) has shown 9.6 per cent increase in seed yield in 2% $CaCl_2$ soaked seeds attributed to optimum plant population (101.33) per plot, earliness in days to 50% flowering (46.33days), more plant height (89.33 cm), capsule weight (48.12g), seed yield (18.04 g) per plant and 100 seed weight (6.33 g) at harvest and numerically less number of branches (13.19) per plant as compared to the unsoaked seeds (85.45, 51.78 days,78.64 cm, 44.27 g, 15.45 g 5.63 g and 13.59, respectively). Soaking in 2% $CaCl_2$ for 12 hours resulted in seed yield of 9.81 quintals per hectare over un-soaked (8.95 q/ha) treatment. Further, seeds harvested from 2.0 % $CaCl_2$ seed priming showed relatively more seed germination (92.00 %), root length (12.93 cm), shoot length (8.77cm), seedling dry weight (0.174 g) and seedling vigor index (2064) as against unprimed seeds. Thus, the study shows importance of on farm seed priming in increasing seed yield and seed quality traits in safflower.

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INTRODUCTION

Safflower (*Carthamus tinctorius* L.), is an annual oilseed crop, mainly grown in the semi-arid region in post rainy season as an intercrop with bengal gram, sorghum, linseed and as a sole crop in the black soils under receding soil moisture conditions. Seed germination, seedling emergence and crop establishment are the important aspects of safflower cultivation and are related to early growth and resistance to seasonal stresses influencing final yield of the crop (Musa *et al.,* 1999). Early and uniform seedling emergence and enhanced canopy are considered as essential contributors for determining final yield of the sunflower crop (Khan *et al.,* 2003) and finger millet (Kumar *et al*., 2002). Poor field emergence and crop establishment are the major constraints of safflower crop cultivation under rainfed conditions. The constraints to good crop establishment may be the improper land preparation, untimely sowing, use of low quality seeds, poor sowing techniques, inadequate soil moisture conditions, etc. Seed priming is a pre-sowing treatment that enhances rapid and uniform field emergence, better crop stand, more vigorous plants, enhanced drought tolerance, early flowering and higher grain yield, apart from reduced risk of crop failure under variable soil moisture conditions. Seed priming induces a range of biochemical and physiological changes in the seed that are required to start the germination process (Asgedom and Becker, 2001; Jamadar and Chandrashekar, 2015). Thus, primed seeds can rapidly imbibe and revive the seed metabolism (breaking of dormancy, imbibitions, enzyme activation) resulting in improved crop stand and establishment which reportedly increases drought tolerance and improve nutrient uptake and crop yield (Harris *et al.,* 2000; Ajouri *et. al.,* 2004). Similarly, on farm seed priming is a treatment practiced by farmers that involves soaking the seeds in water or chemicals, surface drying and sowing on the same day which improves germination and field performance by reducing the time of germination and allowing the seedlings to establish quickly by escaping the receding soil moisture conditions under rainfed conditions in many field crops. Therefore, there is necessity to study the effect of various on farm seed priming practices in increasing the seed yield and seed quality traits. In this regard, the present study aims at understanding the response of on farm seed priming treatments with water and chemicals on early seedling emergence, crop establishment, seed yield and seed quality attributes of safflower.

MATERIALS AND METHODS

A field experiment was carried out for three years' (2012-13 to 2014-15) in the Randomized Block design with three replications in the black soil at Regional Agricultural Research Station, Vijayapur (RARS, latitude 16° 49'; Longitude 75° 43'; Altitude 593.6 m above mean sea level) with an average rainfall of 594 mm. In order to determine the effects of on farm seed priming in safflower, popular cultivar A-1 was considered. There were nine treatments *viz.*, T_1 : Seeds without water soaking (unprimed), T_2 : Seeds soaked in water for 12 hours, T_3 : Seeds soaked in 1% $CaCl_2$ for 12 hours, T_4 : Seeds soaked in 2% $CaCl_2$, T_5 : Seeds soaked in 1% KH_2PO_4, T_6 : Seeds soaked in 2% KH_2PO_4, T_7 : Seeds soaked in 1% KCL, T_8 : Seeds

soaked in 2% KCL and T_9 : Seeds soaked in 2% cow urine for 12 hours. Primed seeds were dried back to primary moisture. A sub sample of safflower seed lot was also kept as control (unprimed). The procedure of seed priming was followed as given by Ajouri *et al.,* 2004.

The crop was sown during first fortnight of October with a spacing of 60 cm between rows and 30 cm between plants within a row. The recommended dose of FYM and fertilizer was applied as per the package of practices *i.e.,* 40:40:20 NPK kg/ha. The various observations recorded were plant population per plot at 45 days after sowing, earliness in days to 50 % flowering, plant height (cm), number of branches per plant, capsule weight (g), seed yield per plant (g), seed yield (q/ha) and hundred seed weight (g) at harvest. Five plants in each replication were selected at random for recording of observations at 45 days after sowing and at harvest.

The seed quality parameters *viz.,* seed germination (%), root length (cm), shoot length (cm), seedling dry weight (g) and seedling vigor index were recorded in each of the treatments as per the procedure given by ISTA, 2012.

RESULTS AND DISCUSSION

The three years' field data revealed significant and positive effect of on farm seed priming treatment with water; 1.0 and 2.0 % $CaCl_2$; 1.0 and 2.0 % KH_2PO_4; 1.0 and 2.0 % KCl; 2.0 % cow urine for 12 hours and unprimed (without water soaking) control on crop stand and growth parameters. The overall plant population per plot at 45 days after sowing (DAS) has increased significantly in all the on farm seed priming treatments over unprimed control (without water soaking) seeds (Table 1). The priming of safflower seeds with 2.0 % $CaCl_2$ for 12 hours recorded significantly maximum (101.33; 100.33; 101.33) plant population per plot as against unprimed control seeds (85.67; 86.33; 84.33) in the three years' field trials which accounts for 18.3, 16.2 and 20.2 per cent increase in different years and it was statistically on par with the rest of the priming treatments. Likewise, the mean data pooled over three years' recorded significantly maximum (101.00) plant population per plot in the 2.0 % $CaCl_2$ seed priming as against unprimed control seeds (85.45), which accounts for an average of 18.3 % over the unprimed seeds. The similar increase in plant population per plot due to seed priming was also confirmed by Bastia *et al.,* (1999), Jolli *et al.,* (2012) and Chavan *et al.,* (2014) who reported that the primed seeds would germinate more rapidly and establish more quickly in the field than the unprimed control seeds, when sowing was done in post rainy season which would normally experience the receding soil moisture during the cropping period.

Similarly, 2.0 % $CaCl_2$ seed priming for 12 hours also resulted in significantly maximum plant height (87.83, 89.33 and 89.50 cm) at harvest which was at par with other priming treatments as against unprimed seeds (78.77, 79.33 and 77.83 cm)

Table 1: Effect of pre sowing seed treatments on plant population/plot at 45 days after sowing (DAS) and number of branches per plant at harvest in safflower

S. No.	Treatments	Plant population/plot at 45 DAS				Number of branches per plant at harvest			
		2012-13	2013-14	2014-15	Pooled mean	2012-13	2013-14	2014-15	Pooled mean
T_1	Seeds without water soaking	85.67	86.33	84.33	85.45	13.60	13.53	13.53	13.59
T_2	Seeds soaking with water for 12hrs	101.00	98.00	99.00	99.33	12.90	12.50	12.90	12.77
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	101.00	99.00	98.00	99.34	13.00	12.97	12.77	12.91
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	101.33	100.33	101.33	101.00	13.43	13.13	13.00	13.19
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	100.00	99.00	98.67	99.22	13.00	12.90	13.14	12.93
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	100.67	99.00	99.00	99.56	12.57	12.80	12.93	12.77
T_7	Seeds soaking with 1% KCl for 12hrs	100.00	98.00	99.00	99.00	12.83	12.80	12.93	12.86
T_8	Seeds soaking with 2% KCl for 12hrs	101.00	99.00	98.33	99.44	12.93	13.07	12.69	12.99
T_9	Seeds soaking with 2% Cow urine for 12hrs	99.67	99.00	99.00	99.22	12.93	12.90	12.90	12.91
	S.Em.±	3.02	2.67	2.87	2.90	0.52	0.55	0.57	0.60
	C.D. @ 5%	9.05	8.01	8.48	8.70	NS	NS	NS	NS

Table 2: Effect of pre sowing seed treatments on plant height at harvest (cm) and days to 50% flowering in safflower

S. No.	Treatments	Plant height (cm)at harvest				Days to 50% flowering			
		2012-13	2013-14	2014-15	Pooled mean	2012-13	2013-14	2014-15	Pooled mean
T_1	Seeds without water soaking	78.77	79.33	77.83	78.64	54.33	52.33	52.00	51.78
T_2	Seeds soaking with water for 12hrs	82.83	83.50	84.83	83.72	47.67	47.65	46.33	47.22
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	82.17	84.33	83.50	83.33	47.33	47.67	47.00	47.33
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	87.83	89.33	89.50	89.33	46.67	46.64	45.67	46.33
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	87.50	88.67	87.17	87.55	47.66	47.68	47.65	47.67
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	86.50	88.62	87.38	87.50	48.00	47.67	48.67	48.11
T_7	Seeds soaking with 1% KCl for 12hrs	87.17	87.83	88.17	87.72	47.67	48.00	47.67	47.66
T_8	Seeds soaking with 2% KCl for 12hrs	85.83	85.65	87.69	86.83	47.67	47.33	47.33	47.44
T_9	Seeds soaking with 2% Cow urine for 12hrs	87.17	87.67	86.83	87.22	47.65	47.67	48.00	47.78
	S.Em.±	1.32	1.11	1.50	1.46	1.28	0.98	1.10	0.93
	C.D. @ 5%	3.96	3.33	4.51	4.37	3.84	2.94	3.31	2.78

Table 3: Effect of pre sowing seed treatments on Capsule wt. (g)/plant and seed yield/plant in safflower.

S. No.	Treatments	Capsule weight (g)/plant				Seed yield(g)/plant			
		2012-13	2013-14	2014-15	Pooled mean	2012-13	2013-14	2014-15	Pooled mean
T_1	Seeds without water soaking	43.94	44.23	44.63	44.27	15.53	15.29	15.53	15.45
T_2	Seeds soaking with water for 12hrs	46.08	47.52	47.50	47.03	17.93	17.88	17.78	17.87
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	47.33	47.38	47.49	47.40	17.80	17.68	17.85	17.78
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	48.27	48.07	48.03	48.12	17.97	18.03	18.11	18.04
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	47.27	47.47	47.72	47.49	17.86	17.72	17.87	17.82
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	47.36	47.30	47.53	47.39	17.92	18.66	17.80	17.79
T_7	Seeds soaking with 1% KCl for 12hrs	47.77	47.75	47.23	47.59	17.87	17.78	17.63	17.76
T_8	Seeds soaking with 2% KCl for 12hrs	47.52	47.43	47.57	47.51	17.85	17.76	17.53	17.71
T_9	Seeds soaking with 2% Cow urine for 12hrs	47.40	47.43	47.34	47.39	17.73	17.70	17.63	17.69
	S.Em. ±	0.67	0.63	0.62	0.68	0.39	0.53	0.38	0.46
	C.D. @ 5%	2.01	1.90	1.87	2.03	1.17	1.59	1.13	1.38

Table 4: Effect of pre sowing seed treatments on seed yield (q/ha) in safflower

S. No.	Treatments	Seed yield (q) per ha			
		2012-13	2013-14	2014-15	Pooled mean
T_1	Seeds without water soaking	8.95	8.86	8.85	8.95
T_2	Seeds soaking with water for 12hrs	9.68	9.56	9.65	9.62
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	9.45	9.64	9.62	9.57
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	9.89	9.73	9.61	9.81
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	9.85	9.67	9.58	9.70
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	9.84	9.66	9.34	9.62
T_7	Seeds soaking with 1% KCl for 12hrs	9.75	9.58	9.63	9.66
T_8	Seeds soaking with 2% KCl for 12hrs	9.64	9.63	9.43	9.57
T_9	Seeds soaking with 2% Cow urine for 12hrs	9.71	9.80	9.70	9.74
	S.Em. ±	0.12	0.16	0.16	0.12
	C.D. @ 5%	0.36	0.49	0.47	0.36

Table 5: Effect of pre sowing seed treatments on 100 seed weight and seed germination (%) in safflower

S. No.	Treatments	100 seed weight (g)				Seed Germination (%)			
		2012-13	2013-14	2014-15	Pooled mean	2012-13	2013-14	2014-15	pooled mean
T_1	Seeds without water soaking	5.64	5.60	5.63	5.63	91.67	92.33	93.33	93.00
T_2	Seeds soaking with water for 12hrs	6.17	6.13	6.16	6.15	92.67	92.67	93.00	92.78
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	6.19	6.18	6.20	6.19	92.67	94.67	95.00	93.89
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	6.33	6.36	6.30	6.33	91.00	92.67	92.33	92.00
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	6.15	6.27	6.16	6.19	92.67	92.33	92.00	92.22
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	6.15	6.18	6.09	6.14	92.33	92.00	92.67	92.33
T_7	Seeds soaking with 1% KCl for 12hrs	6.17	6.09	6.18	6.15	92.00	92.00	91.00	91.67
T_8	Seeds soaking with 2% KCl for 12hrs	6.23	6.11	6.17	6.18	92.33	93.00	92.33	92.55
T_9	Seeds soaking with 2% Cow for urine 12hrs	6.15	6.19	6.17	6.17	93.67	91.67	92.000	92.44
	S.Em. ±	0.07	0.12	0.14	0.12	0.65	0.58	0.65	0.51
	C.D. @ 5%	0.20	0.35	0.41	0.35	NS	NS	NS	NS

(Table2). The similar significant increase in plant height at harvest was also noticed in the $CaCl_2$ primed seeds (89.33 cm) as against unprimed seeds (78.64 cm) in the pooled analysis also. The significant increase in plant height in the 2.0 % $CaCl_2$ primed seeds may be attributed to its faster seedling emergence and crop establishment leading to more vigorous plants as compared to those raised from control seeds. Our results are in accordance with Harris *et al.,* (2000) and Chavan *et al.,* (2014) who noticed the increased seedling emergence and establishment, higher plant height and enhanced drought tolerance in the rice and soybean crops, respectively raised by the primed seeds unlike those raised from the unprimed seeds. However, the 3 years data as well as pooled analysis revealed that number of branches per plant at harvest was statistically non-significant due to on farm seed priming treatments (Table 1). It was numerically (13.60, 13.53 13.53 and 13.59) superior in the crop raised from the control seeds without water soaking and it may be related to the less plant population and more space availability per plot resulting in more horizontal growth of the safflower plants, whereas, it was less (12.90, 12.50, 12.90 and 12.77) in the water soaked seeds and other priming treatments which may be due to its higher plant population per plot and less space availability affecting the horizontal growth of the plants.

On farm seed priming has shown pronounced effect on days to 50 per cent flowering as against the control unprimed seeds during the three years' field trials as well as pooled analysis

Table 6: Effect of pre sowing seed treatments on seed quality in safflower

S. No.	Treatments	Root length(cm)				Shoot length (cm)			
		2012-13	2013-14	2014-15	Pooled mean	2012-13	2013-14	2014-15	Pooled mean
T_1	Seeds without water soaking	12.47	12.28	12.47	12.45	8.43	8.57	8.60	8.53
T_2	Seeds soaking with water for 12hrs	12.73	12.43	12.77	12.66	8.50	8.57	8.53	8.53
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	12.67	12.70	12.70	12.69	8.73	8.53	8.60	8.62
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	13.13	12.73	12.93	12.93	8.77	8.83	8.70	8.77
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	12.80	12.60	12.90	12.77	8.70	8.57	8.77	8.68
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	12.87	12.83	12.80	12.84	8.60	8.63	8.40	8.55
T_7	Seeds soaking with 1% KCl for 12hrs	12.70	12.83	12.80	12.78	8.57	8.37	8.40	8.44
T_8	Seeds soaking with 2% KCl for 12hrs	12.80	12.90	12.87	12.86	8.40	8.37	8.43	8.40
T_9	Seeds soaking with 2% Cow urine for 12hrs	12.93	12.70	12.77	12.80	8.47	8.33	8.43	8.41
S.Em.±		0.23	0.24	0.17	0.16	0.14	0.18	0.13	0.14
C.D. @ 5%		NS	NS	NS	NS	NS	NS	NS	NS

Table 7: Effect of pre sowing seed treatments on seed quality in safflower.

S. No.	Treatments	Seedling dry weight(g)				Seedling vigour index			
		2012-13	2013-14	2014-15	Pooled mean	2012-13	2013-14	2014-15	Pooled mean
T_1	Seeds without water soaking	0.156	0.151	0.159	0.155	1940	1953	2033	1976
T_2	Seeds soaking with water for 12hrs	0.168	0.166	0.165	0.166	1992	1967	2021	1993
T_3	Seeds soaking with 1%$CaCl_2$ for 12hrs	0.164	0.168	0.165	0.166	1984	1996	2014	1998
T_4	Seeds soaking with 2%$CaCl_2$ for 12hrs	0.175	0.174	0.172	0.174	2103	2049	2040	2064
T_5	Seeds soaking with 1% KH_2PO_4 for 12hrs	0.167	0.174	0.172	0.171	2031	1966	2009	2002
T_6	Seeds soaking with 2% KH_2PO_4 for 12hrs	0.172	0.171	0.172	0.171	2025	1993	1961	1994
T_7	Seeds soaking with 1% KCl for 12hrs	0.172	0.173	0.170	0.172	1977	1985	1946	1969
T_8	Seeds soaking with 2% KCl for 12hrs	0.168	0.172	0.174	0.172	1966	1992	1954	1972
T_9	Seeds soaking with 2% Cow urine for 12hrs	0.172	0.171	0.172	0.171	2005	1928	1942	1958
	S.Em.±	0.006	0.008	0.004	0.006	0.09	0.04	0.04	0.03
	C.D. @ 5%	NS	NS	NS	NS	NS	NS	NS	NS

(Table 2). The crop raised with the 2.0 % $CaCl_2$ primed seeds exhibited significant earliness (46.67, 46.64 and 45.67 days) in days to 50 per cent flowering over un primed but was statistically on par with water, KH_2PO_4, KCl and cow urine primed seeds. The crop raised from the unprimed seeds took more number of days (54.33, 52.33 and 52.00) for 50 per cent flowering in the respective field trials. The pooled data also revealed that less (46.33) number of days to 50 per cent flowering was recorded in the 2.0 % $CaCl_2$ primed seeds compared to unsoaked seeds (51.78 days). This study pointed out the significant effect of seed priming with 2.0 % $CaCl_2$ for 12 hours in inducing the earliness in terms of days to 50 per cent flowering which was attributed to faster seedling emergence, taller and vigorous plants compared to the unprimed seeds. Likewise, significant earliness in days to 50 per cent flowering was also observed in safflower by Bastia *et al.,* (1999) and Jolli *et al.,* (2012) who noticed the faster seedling emergence and establishment and more vigorous plants in the primed seeds over unprimed seeds sown during the post rainy season. Harris *et al.*, (2000) and Chivassa *et al., (*2000) also noted the significantly faster emergence, taller and heavier seedlings and more leaves per plant (at 14 DAS) from the maize seeds primed for longer than 8 hours compared to the non-primed treatment.

The results of the three years' field trials and pooled analysis revealed significant and positive effect of on farm seed priming treatments on seed yield and its attributes (Table 3). Seed yield of safflower crop has increased substantially due to the on farm seed priming treatments as a result of increase in capsule weight and seed yield per plant over those raised from control seeds (without water soaking). The crop raised from the seeds primed with 2.0 % $CaCl_2$ for 12 hours recorded significantly highest capsule weight (48.27, 48.07 and 48.03 g) per plant, seed yield per plant (17.97, 18.03 and 18.11 g) and seed yield per hectare (9.89, 9.73 and 9.61 q) (Table 4) compared to the unprimed seeds (43.94, 44.23 and 44.63 g capsule weight; 15.53, 15.29 and 15.53 g seed yield per plant; 8.95, 8.86 and 8.85 q seed yield per hectare, respectively) and it was statistically on par with other priming treatments. Similar trend was also seen in the pooled analysis over three years' under 2.0 % $CaCl_2$ seed priming (48.12 g, 18.04 g and 9.81 q/ha, respectively) over control seeds (44.27 g, 15.45 g and 8.95 q/ha, respectively) for plant height, seed yield per plant and seed yield per ha. Earlier, Jolli *et al.,* (2012) in sesame, Ghosh *et al.,* (1986) in mustard, Khan *et al.,* (2003) in sunflower and Jamadar and Chandrashekar (2015) in castor have also noticed the significant increase in seed yield per hectare due to $CaCl_2$ seed priming treatment. Likewise, significantly higher seed yield due to hydro-priming was reported in chickpea (Musa *et al.,* 1999), sunflower (Kathiresan and Gnanamurthy, 1985), maize (Kulkarni and Eshanna, 1988) and in peanut (Vasudevan *et al.,* 2012). Whereas, Kibit and Harker (1991) concluded that seed hydro-priming could not show significant effect on wheat, barley and oats crops sown in the moist soils, but it only increased the seed yield under limited water availability.

The crop raised from the 2.0 % $CaCl_2$ primed seeds recorded 10.5, 9.8, 8.6 and 9.6 per cent increase in seed yield per

hectare over the unprimed seeds in the three years' data and pooled analysis over three years' respectively. Thus, these results have shown the pronounced effect of $CaCl_2$ seed priming on seed yield per hectare. The significant increase in seed yield noticed in the crop raised from 2% $CaCl_2$ primed seeds was attributed to the increased plant population (101.33) and earliness in flowering (46.33 days) resulting in the higher capsule weight (48.12 g) and seed yield (18.04 g/per plant) as against the crop raised from unprimed seeds (85.45, 51.78 days, 44.27 g, 15.45 g, respectively). Significantly higher seed yield observed in the treatment primed with $CaCl_2$, other chemicals and water may be attributed to effective removal of growth-retarding elements present in the seeds due to their pre-soaking in the priming treatments (Vasudevan *et al.,* 2012, Musa *et al*., 1999) and also due to optimum duration of seed soaking in $CaCl_2$, KNO_3, KH_2PO_4, KCl and water for 12 hours (Chavan *et al.,* 2014 and Jolli *et al.,* 2012). All these factors have favorably promoted the seedling emergence, crop establishment and growth parameters of the plants raised from the $CaCl_2$, other chemicals and water primed seeds by utilizing the light, soil moisture and nutrients efficiently and thus increased their number of branches and capsules per plant and capsule weight per plant compared to those raised from the unprimed seeds.

The results of the three years' individual data and pooled analysis revealed non-significant effect of on farm seed priming treatments on seed quality parameters like germination percentage, root length, shoot length, seedling dry weight and seedling vigor index except 100 seed weight (Table 5). The seeds harvested from 2.0 % $CaCl_2$ seed priming treatment showed significantly highest 100 seed weight (6.33, 6.36, 6.30, 6.33g over three years) and relatively more seed germination (91.00, 92.67, 92.33, 92.00 % over three years), root length (13.13, 12.73, 12.93, 12.93 cm over three years), shoot length (8.77, 8.83, 8.70, 8.77cm over three years), seedling dry weight (0.175, 0.174, 0.172, 0.174 g over three years) and seedling vigor index (2103, 2049, 2040, 2064 over three years) as against unprimed (without water) control seeds for 100 seed weight (5.64, 5.60, 5.63, 5.63 g), seed germination (91.67, 92.33, 93.33, 93.00 %), root length (12.47, 12.28, 12.47, 12.45 cm); shoot length (8.43, 8.57, 8.60, 8.53 cm); seedling dry weight (0.156, 0.151, 0.159, 0.155 g); and for seedling vigour index (1940, 1953, 2033, 1976, respectively). These results indicated that consistently better seed quality traits noticed in the $CaCl_2$ primed seeds may be attributed to its higher capsule weight and seed yield per plant as against those obtained from unprimed seeds. These results are in conformity with those of Bastia *et al.,* (1999), Harris *et al.,* (2000) and Jolli *et al.,* (2012).

The overall study of three year field trials concluded that safflower crop showed significant and positive effect of on farm seed priming with $CaCl_2$, KNO_3, KH_2PO_4, KCl, cow urine and water for 12 hours and shade drying on crop stand, growth, flowering, seed yield and quality parameters as against unprimed (without water) control seeds. Among the different on farm seed priming treatments, the 2.0 per cent $CaCl_2$ seed priming for 12 hours and shade drying was found more effective treatment as it registered about 9.6 per cent increase in seed yield per hectare (9.81 q/ha) due to its higher plant population per plot, earliness in flowering, higher capsule weight, 100 seed weight and seed yield per plant and seed quality parameters as against the crop raised from unprimed (without water) seeds (8.95 q/ha). Thus, on farm seed priming in safflower showed its potential to increase both in terms of seed yield and seed quality parameters.

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