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Influence of seed hardening on growth and yield of chickpea *var.* GG-2 (*Cicer arietinum* L.)

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Abstract
The present investigation was carried out to study the effect of seed hardening on growth and yield of chickpea. The chickpea *var.* GG-2 was imposed with various seed hardening treatments *i.e.*, $CaCl_2$ @ 2%, 1000 ppm Cycocel, 20 ppm Succinic Acid, 10 ppm GA_3, 100 ppm GA_3, 100 ppm Kinetin, 10 ppm $MnCl_2$, 100 ppm $MnCl_2$, 150 ppm KNO_3, 150 ppm KCl, Water soaked and Absolute Control. The above treated seeds along with control were evaluated for their morpho-physiological and yield attributing parameters under field conditions. The study revealed that seeds hardened with $CaCl_2$ @ 2% recorded maximum height, leaf area, LAI, CGR, dry matter production, yield per ha and harvest index. The treatments $CaCl_2$ 2% followed by Cycocel 1000 ppm were found to be superior for most morpho-physiological parameters as compared to other treatments and control on the basis of field studies.

Keywords: Chickpea**,** seed hardening**,** $CaCl_2$, cycocel, GA_3, KCl, KNO_3, growth parameters

Introduction
Chickpea is most important pulse crop of India in terms of both area and production. Chickpea is also called as chana, gram or bengal gram. The varieties of chickpea are separated on the basis of seed size, colour and taste and belong broadly to two types namely Kabuli and Desi. Chickpea is an herbaceous annual temperate crop and highly self-pollinated. The protein in chickpea is highly digestible (70-90 per cent). It contains 21 per cent protein and 38-59 per cent carbohydrates. It is an excellent animal feed and fodder has good nutritional value. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Since it has deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile.

The average yield of chickpea in India is very low, which might be due to the cultivation on residual soil moisture in cool dry season. It is generally grown on conserved soil moisture. As a consequence, plant experience progressively increasing degree of terminal moisture stress. Thus, soil moisture stress assumes a major limiting factor determining the growth and yield of chickpea in peninsular India. Such situation particularly affects the pod formation, which is critical for determining the yield potential (Verma and Pramilakumari, 1978) [21]. Added to this, some of the important physiological constrains in productivity are intensive flower dropping. It is a drought resistant crop and suitable for dry land farming. Chickpea is a medium duration, low input requiring crop that matures in 95 to 110 days, photo and thermo-insensitive in nature.

Efforts made to maximize yield, is largely hampered by adverse effect of abiotic stress such as salinity and drought. These effects cause a huge loss due to low yield and failure of the crop to establish in some cases. Pre-sowing hardening seed treatment is an easy, low cost and low risk technique and also an alternative approach recently used to overcome the effect of abiotic stresses in agricultural production. It is found to be efficient in improving seed emergence and growth of crops (Sankar Ganesh *et al.*, 2013) [18]. It was reported clearly that the hardening treatment enhance seeds vigour by protecting structure of the plasma membrane against injury during stress (Bewley and Black, 1982 [2]; JunMin *et al*., 2000) [9]. It is a well established fact that, pre-soaking seeds with optimal concentration of phytohormones enhance their germination, growth and yield of some crop species under condition of environmental stress by increasing nutrient reserves through increased physiological activities and root proliferation (Bozeuk, 1981) [3].

Considering the constraints in the production potential of chickpea it is worthwhile to study the influence of different seed hardening treatments on the production potential of chickpea. It is also of utmost importance to understand the physiological basis of yield variation due to seed hardening of various growth regulators and chemicals.

Materials & Methods

A Field experiment was conducted at Agronomy Farm, Anand Agricultural University, Anand during *Rabi* 2013 to study the influence of various seed hardening chemicals on morpho-physiological, yield and yield components in Chickpea (GG-2). The experiment was laid out in randomized block design with three replications. The seeds of chickpea *var.* GG- 2 were imposed with the following seed treatments.

T1: $CaCl_2$ @ 2%, T2: 1000 ppm Cycocel, T3: 20 ppm Succinic Acid, T4: 10 ppm GA_3, T5: 100 ppm GA_3, T6: 100 ppm Kinetin, T7: 10 ppm $MnCl_2$, T8: 100 ppm $MnCl_2$, T9: 150 ppm KNO_3, T10: 150 ppm KCl, T11: Water soaked and T12: Absolute Control.

A day before sowing, under laboratory conditions, seeds of gram variety GG-2 were soaked for three hours separately in respective solutions. Later seeds were dried under shade for eighteen hours and sown on next day.

Five plants from each plot were selected randomly and tagged for the purpose of recording morpho- physiological and yield parameters. Plant height was recorded by measuring the height of plant from ground level to the tip of main branch using a meter scale and the mean value was expressed in centimeter. Randomly selected five plant samples were separated into leaf, stem and reproductive parts and dried in oven at 80°C until constant weight was obtained. Total dry matter was calculated by adding dry weight of different plant parts and expressed as grams per plant at different intervals of crop growth period. Leaf area/plant was taken with the help of Leaf area meter (Model- 3100). The leaf area index was calculated by dividing the leaf area per plant by land area occupied by the plant (Sestak *et al*., (1971) [19]. Crop growth rate is the increase in dry matter accumulation of any plant part or whole plants per unit time per area. It is expressed in g/m^2/day. It is first studied by Watson in (1952) [22]. The five tagged plants were uprooted at maturity and processed for seed yield from which the average was calculated and expressed as seed yield per plant (g). The plants harvested from net plot were threshed, clean, sun dried for five days and then grain weight per plot was recorded separately for each treatment. This was further converted on hectare basis. Harvest index is the ratio of economic yield to the biological yield. It was calculated by using following formula suggested by Donald and Hamblin (1976) [5]. The data were statistically analyzed using ANOVA.

Results & Discussion

Morpho-physiological parameters

The data on morpho-physiological parameters of chickpea revealed significantly higher plant height (73.70 cm) in seed hardening with 2% $CaCl_2$, where as lower plant height recorded in absolute control (60.16 cm) at harvesting stage. This clearly indicates mode of action differs for the chemicals studied. Seed hardening with 2% $CaCl_2$ increased the plant height this may be due to redistribution of nutrient reserves leading to cell enlargement and increase in normal cell division. These findings were in accordance with the work of Karivartharaju and Ramakrishnan (1985) [11].

Among the treatments, seed hardening with 2% $CaCl_2$ (T1) recorded significantly the highest leaf area 502.03 cm^2 as compared to control. This might be due to increase in cell division, cell enlargement as well as induce more extensive and denser network of veins and ribs and there by increased foliar leaf area. These results are conformity with the findings of Ginzo *et al.* (1977) [6] in chick pea and Prakash *et al.* (2013) [17] in rice. Increase in TDM, leaf dry matter, stem dry matter and redistribution of dry matter in reproductive parts is noticed with seed hardening with 2% $CaCl_2$ and other chemicals as compare to control. Increase in leaf dry weight might be due to metabolic changes like high level of synthesis reaction even during drought; leaves of hardened plants have more starch, higher rate of photosynthesis because of increase in the bound water and higher organic phosphorous and nucleoproteins. The treatment of calcium chloride leads to redistribution of nutrient reserves which results in the greater internodal length and thereby increases the stem dry weight. These results are conformity with finding of Misra and Dwivedi (1980) [15] and Singh *et al*. (1991) [20] in wheat. Seed hardening with 2% $CaCl_2$ significantly increased total dry matter production. The increase in TDM towards maturity may be due to higher rate of CO_2 fixation and RuBP carboxylase activity during crop growth. The association of TDM with grain yield was more significant at all the stages of crop growth. Similar results were also recorded by Arjunan and Srinivasan (1989) [1] in groundnut. These results are conformity with the finding of Ginzo *et al.* (1977)[6] in chick pea, Karivartharaju and Ramakrishnan (1985)[11] in red gram. Thus, TDM and its partition and leaf area were important parameters to boosting the source sink relationship, which is evident from the improvement in the yield and yield parameters.

Maximum leaf area index (1.673) was recorded in seed hardening with 2% $CaCl_2$ and lowest with absolute control (1.307) as compared to other treatments. Seed hardening with 2% $CaCl_2$ recorded significantly higher LAI followed by (T2) – cycocel as compared to other treatments. Similar results were also recorded by Maitra *et al.*, (1998) [12] in finger millet and Govindan and Thirumurugan (2000) [7] in green gram. Crop growth rate (CGR) is a useful growth parameter for estimating production efficiency of crop stand by Watson (1952) [22]. In the present study seed hardening treatments significantly increased CGR over control. The treatment T1 – $CaCl_2$ 2% recorded significantly the highest crop growth rate 8.141 g/m^2/day as compared to control.

Yield parameters

The treatment, of pre-sowing seed hardening with 2% $CaCl_2$ (21.50 q/ha) recorded highest seed yield followed by Cycocel 1000 ppm (16.54 q/ha) and significantly lowest seed yield (11.74 q/ha) was noticed in control. The seed hardening with T1 -2% $CaCl_2$ recorded significantly higher values for harvest index (33.37 %) followed by Cycocel 1000 ppm (31.26 %) as compared to the control (19.82%) and the increased yield was due to higher harvest index. The data clearly indicated that seed hardening treatments are very effective in increasing yield and yield attributes as compared to control. The increase in seed yield with respect to seed hardening treatments was probably due to maximum water absorbing capacity of seeds, more intense photosynthetic activity as well as more tissue hydration and thereby, enabling the plant to resist soil moisture stress more efficiently recorded by Henckel (1964) [8]. This is in conformity with the findings of Mehrotra *et al*., (1970) [14] in okra, Kadam *et al*. (2008) [10] in black gram, Manjunath and Dhanoji (2011) [13] in chick pea, Prakash *et al.* (2013) [17] in rice, Patil *et al.* (2014) [16] in cotton and Chavan *et al*. (2014) [4] in soybean.

Table 1: Influence of seed hardening chemicals on Morpho-physiological parameters in Chickpea variety GG-2

Treatments	Morpho-Physiological parameters							Yield attributing characters		
	Plant height (cm)	Leaf area (cm^2)	Leaf dry weight (g plant $^{-1}$)	Stem dry weight (g plant $^{-1}$)	Total dry matter (g plant^{-1})	Leaf Area Index	Crop Growth Rate (g m^{-2} days^{-1})	Seed yield (g plant^{-1})	Seed yield (q ha^{-1})	Harvest index (%)
T1 - $CaCl_2$ 2%	**73.70**	**502.03**	**3.327**	**6.159**	**21.306**	**1.673**	**8.141**	**6.31**	**21.50**	**33.37**
T2 - Cycocel 1000 ppm	72.20	458.71	3.189	5.788	19.666	1.529	7.244	5.21	16.54	31.26
T3 -Succinic Acid 20 ppm	68.23	403.77	2.671	4.188	18.383	1.345	4.508	4.08	10.85	25.04
T4 - GA_3 10 ppm	65.43	410.52	3.105	4.200	20.486	1.368	4.841	3.61	14.70	29.59
T5 - GA_3 100 ppm	63.10	446.47	3.121	5.118	17.450	1.488	7.066	3.56	12.83	28.59
T6 - Kinetin 100 ppm	63.16	406.37	2.896	4.041	18.333	1.354	5.786	3.46	14.77	22.49
T7 - $MnCl_2$ 10 ppm	65.26	446.11	2.893	4.895	17.243	1.487	6.536	3.87	16.54	28.43
T8 - $MnCl_2$ 100 ppm	62.10	435.62	3.115	5.607	18.253	1.452	6.580	5.19	16.28	22.56
T9 - KNO_3 150 ppm	65.40	456.16	2.857	4.187	19.350	1.520	6.911	3.54	15.45	26.69
T10- KCl 150 ppm	60.40	435.52	2.685	4.677	16.883	1.451	6.486	3.33	12.92	24.71
T11- Water Soaked Control	60.20	403.40	2.691	3.455	16.246	1.344	6.783	3.20	11.87	20.78
T12- Absolute Control	60.16	392.30	2.570	3.303	15.383	1.307	4.380	2.98	11.74	19.82
S. Em. +/-	0.645	1.412	0.108	0.369	0.069	0.004	0.061	0.020	0.603	2.083
CD at 5% C	1.567	3.428	0.262	0.897	0.167	0.011	0.149	0.050	1.466	5.059
CV %	1.72	0.27	11.22	13.11	1.44	4.75	3.95	3.56	5.07	5.52

Conclusion

On the basis of above finding it can be concluded that pre sowing seed hardening with 2% $CaCl_2$ and cycocel 1000 ppm played an effective role in improving morpho-physiological and yield attributing characters in chickpea. Significant increase in plant height, dry matter in leaf, stem and total dry matter content was due to treatments as compare to control. Improvement of seed quality by seed hardening with 2% $CaCl_2$ and cycocel 1000 ppm is a simple and easy approach to enhance the seed performance and agricultural productivity especially in the dry land and marginal lands of resource poor farmers.

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