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Seed Priming in Chickpea (*Cicer arietinum* L.) – A Review

L.K. Sharma[1], G.U. Kulkarni[1], R.M. Javia[1], B.A. Monpara[1], V.B. Paradva[1] and S.P. Singh[2]
Pulses Research Station, Junagadh Agricultural University , Junagadh (Guj.)
CSAUAT-Agriculture Research Station, Kalai, Aligarh, Uttar Pradesh
**Email : lkatre@yahoo.com*

Abstract

Chickpea (*Cicer arietinum* L.) is an important third most widely cultivated legume crop after dry bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). The study on seed priming has been done in chickpea by the researchers or seed technologists. The number of researchers reported seed priming in chickpea (*Cicer arietinum* L.) and its effect on other parameters like plant morphological and seed quality parameters etc" Chickpea is a cool season legume crop and is grown in several countries worldwide as a protein source. Seed is the main edible part of the plant and is a rich source of protein, carbohydrates and minerals especially for the vegetarian population. India is the largest producer contributing to 65% of world's chickpea production. Seed deterioration is loss of seed quality, viability and vigour due to effect of adverse environmental factors. Deteriorative changes enhance when seed exposure to external challenges increases and decrease the ability of the seed to survive. One of the simple techniques which can improve seedling vigour and establishment and consequently crop performance in the field is seed priming. Seed priming appears to reverse the detrimental effects of seed deterioration. The effect of priming over artificial aged seeds in the laboratory condition, varieties, ageing and priming were significant for germination percentage, speed of germination, root length, shoot length, seedling fresh weight, seedling dry weight, vigour index-I and vigour index-II. The maximum improvement in the seed quality parameters could be attained by priming treatments. Seed priming improved chickpea performance under both optimal temperature conditions and chilling stress through better germination metabolism and the accumulation of trehalose, which protected from oxidative damage and helped to maintain carbon assimilation and seedling growth.

Introduction

Chickpea (*Cicer arietinum* (L.)) 2n=16, belongs to family leguminaceae. It is also known as Bengal gram. Gram is the most important rabi pulse crop grown in India. It is a cool season legume crop and is grown in several countries worldwide as a food source. Seed is the main edible part of the plant and is a rich source of protein (23.3-28.9%), carbohydrates (61.5%), fats (4.5%) and minerals (phosphorus, calcium, magnesium, iron, zinc). Seed priming is a physiological strategy that involves soaking of seeds in a solution of a specific priming agent followed by drying of seeds that initiates germination related process. This has been recognized as an important technology to obtain good germination, rapid development and improved yields in some field crops. The effectiveness of the priming with simple salt solution, perhaps, depends both on the osmotic potential and the chemical nature of the salt species used.

Seed priming with biocontrol agents or fungicides protect the seed from infection by seed borne and soil borne pathogens, enables the seed to germinate and establish as a healthy seedling (Chang and Kommedahl, 1968; Henis and Chet, 1975). Seed priming is a routine practice to increase emergence and establish better crop stand (Nene and Thapliyal, 1979; Ramos and Ribeiro, 1993).

The general purpose of seed priming is to partially hydrate the seed to appoint where germination processes are begun but not completed. Treated seeds with soaking in water (Hydro priming), Soaking in inorganic salt solutions (Halo priming) and different leaf extract (organic priming), osmotic stress (Osmopriming) are usually redried before use, but they would exhibit rapid germination when re-imbibed under normal or stress conditions. Each treatment may have varying effects depending upon plant species, stage of plant development, concentration/dose of priming agent, and incubation period (Ashraf *et al.,* 2005).

Seed Priming : Seed priming is a pre-sowing seed treatment that allows controlled hydration of seeds to imbibe water and go through the first stage of germination but does not allow radical protrusion through the seed coat (McDonald, 2000).

The critical stages during the growth of crops are the uniform seed germination, early seedling growth, and uniform plant stand. Low crop yield is attributed to uneven seed germination and seedling growth. Therefore, the quality of seed can be improved through priming in addition to the field management techniques for better

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Table-1 : Effect of priming of germination and seedling establishment of chickpea.

Treatment	Germination %	Speed of Germination	Seedling Length (cm)	Seedling dry weight (mg)	Vigour index I	Vigour index II
Control	65.33	66.93	24.50	116.66	1665	6818
Hydropriming for 12 hours	69.00	67.34	26.44	121.66	1833	7946
Rhizobium @ 10% for 12 hours	75.66	72.51	29.42	135.23	2456	9425
Pseudomonas fluorescens @ 10% for 12 hours	80.00	75.37	32.93	140.16	2833	11766
Trichoderma viridae @ 10% for 12 hours	71.00	71.43	27.58	127.06	2030	8850
$CaCl_2$ @ 2 % 12 hours	74.33	70.57	28.4	132.80	2225	10106
Rhizobium + Pseudomanas @ 10% for 12 hours	87.00	77.11	34.92	150.40	3026	13093
Rhizobium + Tricoderma viridae @ 10% for 12 hours	77.33	73.51	30.02	137.13	2605	10880
Mean	74.95	71.82	29.27	132.	2334	9860
CD at 5%	4.97	2.33	1.63	5.49	124	1011

Table-2 : Mean performance of chickpea for seedling characters.

Treatment	Germination (%)	Seed Vigour Index-I	Seed Vigour Index -II
Control	75.83	1613	58.09
KNO_3 100 ppm	93.75	2462	88.56
KNO_3 200 ppm	90.33	2209	79.63
PEG (6000) -1.2 Mpa	86.83	1998	71.97
Bavistin (2g/kg)	80.25	1666	61.42
Neem oil (3 %)	84.33	1852	66.52
Mean	85.22	1966	71.03
CD 5%	1.76	NS	NS

seed germination. Priming is a physiological technique of seed hydration and drying to enhance the pregerminative metabolic process for rapid germination, seedling growth, and final yield under normal as well as stressed conditions. The primed seeds show faster and uniform seed germination due to different enzyme activation, metabolic activities, biochemical process of cell repair, protein synthesis, and improvement of the antioxidant defense system as compared to unprimed seeds. There are many techniques of seed priming which are broadly divided into conventional methods (hydro-priming, osmo-priming, nutrient priming, chemical priming, bio-priming, and priming with plant growth regulators) and advanced methods (nano-priming and priming with physical agents). However, priming is strongly affected by various factors such as temperature, aeration, light, priming duration, and seed characteristics. The priming mechanism and the available technologies as a tool for superficial seed germination and crop stand. The present study is reviewed of investigations of different researchers on seed priming in chickpea as follows.

Ali and Sajed (2009) assessed the influence of priming types and times on growth and development of Chickpea (*Cicer arietinum* L.) in a saline soil. The seeds of Landrace Cultivar soaked by three treatment, NaCl (halopriming), Water (hydropriming), and Mannitol (osmopriming) for 8, 16, and 24 hours. Treated seeds had sown in agricultural research station (with salinity of 2.68 ds/m). Total dry matter accumulation between halo and hydro priming treatments had no differences until 80 days after sowing and the highest dry matter obtained from halo priming (increased with 37.9% and 16.7%, respectively relative to osmo and hydro priming). A similar Trend was observed for Leaf dry matter. Maximum leaf area (1489.7 cm^2) obtained from halo priming at 94 days after sowing. Results showed an increase of 63.6% and 44.7% in yield of halo priming compared to osmo priming and hydro priming, respectively.

To investigate the effect of seed priming on germination and seedling growth of chickpea, an experiment was conducted at greenhouse of Ferdowsi University of Mashhad during 2010 with factorial arrangement of treatment in a completely randomized design with 3 replications. Experimental factors were 5 priming with PEG solution potential (0, -4, -8, -12 and -16 bar) and 2 irrigation regimes (FC and 50% FC) and 5 harvesting date during seedling growth. By decrement of irrigation frequency, length of plumule and radicle were significantly decreased, but there wasn't significant difference in plumule and radicle weights. By decreasing of water potential in priming treatment, only the length of plumule significantly increased and the other traits didn't show any significant difference. Over time in harvesting stages, significant differences in all traits were observed. The results showed that under without stress conditions, radicle length for all priming levels was increased compare with to the control. On the other hand, the reverse result was occurred for stress conditions and

Table-3 : Mean performance of chickpea for seedling characters.

Treatment	Germination (%)	Speed of germination	Seed Vigour Index-I	Seed Vigour Index -II
Control	76.00	67.88	2182.24	105.45
Distilled water	78.63	71.69	2492.64	121.85
KCL (1%)	79.69	72.71	2719.85	131.85
KCL (2%)	81.44	73.88	2944.92	140.69
Polyethylene Glycol (PEG6000) 1%	84.29	82.63	3540.13	165.33
Polyethylene Glycol (PEG6000) 2%	88.00	84.13	3773.91	179.96
Neem Leaf Extract 5%	82.50	81.50	3212.37	152.41
Mean	81.51	76.34	2980.866	142.45
CD 5%	1.371	1.096	855.410	2.738

Table-4 : Effect of biopriming on per cent germination, per cent infection and seedling vigour index on chickpea.

Bioagents	Per cent Germination	Per cent seed Infection	Seedling vigour index
Pseudomonas fluorescens @ 0.8 % alone	70.00 (58.69)**	31.00 (33.83)	1211.66
Trichoderma harzianum @ 0.8 % alone	76.50 (61.00)	25.00 (30.00)	1321.81
Pseudomonas fluorescens @ 0.8 % + Vermiculite*	83.00 (65.65)	26.00 (30.66)	1394.02
Trichoderma harzianum @ 0.8 % + Vermiculite	85.50 (67.62)	20.00 (26.57)	1546.42
Vermiculite	72.50 (58.37)	33.50 (35.37)	1176.63
P. fluorescens @ 0.8 % + *T. harzianum* @ 0.8 % + Vermiculite	91.00 (72.54)	13.00 (21.13)	1753.13
Control	59.00 (50.18)	38.50 (38.35)	858.33
C.D. at 1%	3.06	2.44	66.88

*Vermiculite (2 parts of vermiculite and 1 part of seed)
**Figures in the parenthesis indicates the angular transformed values.

most of the radicle length was observed in the control, and radical length was decreased for the other priming levels and the least of the radicle length was perceived for priming at water potential of -8 and -4 bar Javad (2011).

Thakare *et al* (2011) an experiments were carried out to study the influence of Gibberellic Acid (50 ppm) and Oxygenated Peptone (1% aqueous solution) on chick pea (*Cicer arietinum* L. cv. Vijay) during germination by giving pre-sowing soaking treatment for 6 hours using petriplate method. Both the treatments enhanced the germination process. GA treatment was useful to increase shoot length, mobilization efficiency, emergence index, speed of germination and co-efficient of germination while oxygenated peptone showed an upper hand in root length, shoot/root ratio, biomass and vigour index. GA led to comparatively more synthesis of nucleic acids while oxygenated peptone showed more increase in total carbohydrates and soluble protein content. However, the activity of enzymes like amylase, catalase and protease showed upper hand with oxygenated peptone as compared to GA.

Seed priming with zinc (Zn) treatments were evaluated in chickpea (*Cicer arietinum* L.) cv. 'K-850' for seedling establishment under Zn deficient conditions in sand culture. Chickpea seeds were primed for 6 h in 0 (water), 20, 50 and 100 mg Zn L?1 as zinc sulfate ($ZnSO_4$). Seedlings were supplied with the nutrient solution at 0.001 ìM (low) Zn supply while a set of hydro-primed seeds was also supplied normal (1ìM) Zn. Priming of chickpea seeds with 20, 50 and 100 mg Zn L?1 effectively improved the Zn status of seedlings and their establishment in Zn deficient conditions by increasing the dry mass, seed Zn, Zn uptake and translocation at low Zn relative to hydro-primed seeds at normal Zn. Seed Zn treatments also increased the lowered activities of Zn containing enzymes, carbonic anhydrase and superoxide dismutase in leaves at low Zn and a reverse of it in that of acid phosphatase and peroxidase . Nautiyal and Sukla (2013).

Kandil *et al* (2012) studied the response of some chickpea (*Cicer arietinum* L.) cultivars to germination under salinity concentrations *i.e.* control treatment, 4, 8, 12, 16, and 20 dSm^{-1} NaCl and to confirm the seedling growth performance. Giza 3 cultivar exceeded other cultivars in germination percentage, germination index, seedling vigor index, shoot length, shoot and root dry weight followed by Giza 1 and Giza 2 cultivars. Increasing salinity levels from 0 to 20 dSm^{-1} significantly decreased germination percentage, germination index, seedling vigor index, shoot and root length, shoot and root fresh weight, shoot and root dry weight and relative dry weight. The control treatment recorded highest averages of these characters, vice versa mean germination time and seedling height reduction. Giza 3, Giza 1 and Giza 2 cultivars were more tolerant to salinity and recommended

Table-5 : Effect of priming treatments on germination and related attributes of chickpea.

Treatments	T50 (hr)	T90/10 (hr)	MGT (hr)	Germination energy	Germ (%)
Control	32.65^{a}	24.03^{a}	29.55^{a}	62.5^{d}	72.50^{c}
PEG -0.5 Mpa (24 hr)	28.85^{b}	20.77^{ab}	25.75^{b}	65.0^{cd}	90.00^{ab}
PEG -1.0 Mpa (24 hr)	26.20^{bc}	20.50^{ab}	26.40^{ab}	67.5b^{cd}	90.00^{ab}
PEG -1.5 Mpa (24 hr)	22.25^{d}	20.77^{ab}	21.90^{c}	92.5^{a}	95.00^{a}
Mannitol 2% (24 hr)	12.70^{f}	17.55^{ab}	13.70^{de}	87.5^{a}	87.50^{ab}
Mannitol 4% (24 hr)	23.30^{cd}	15.85^{ab}	23.00^{bc}	72.5^{bc}	85.00^{b}
Salicylic acid (17 hr)	11.30^{f}	19.90^{ab}	13.00^{de}	85.0^{a}	87.50^{ab}
Gibberellic acid (17 hr)	20.42^{d}	17.77^{ab}	20.16^{c}	73.5^{b}	86.33^{b}
Hydropriming (17 hr)	10.15^{f}	17.45^{ab}	11.95^{e}	85.0^{a}	95.00^{a}

Mean followed by similar alphabets indicates non-significant differences between the values at 0.05 level of significance.

to be used in breeding program for enhancing chickpea cultivation in newly reclaimed soils.

Mahootchi and Golezani (2013) studied of chickpea (*Cicer arietinum* L. cv.ILC482) seeds were kept as control and two other sub samples were aged at 40^{0}C for 3 and 5 days. Consequently, three seed lots with different levels of vigor were provided. These seed lots were soaked in distilled water at 15^{0}C for 12 and 18 hours and then dried back to initial moisture content at a room temperature of 20-22^{0}C. Then seeds were sown in the field as split plot factorial based on RCB design. Hydro-priming improved leaf chlorophyll content index of plants from different seed lots. Hydro-priming also enhanced stomatal conductance of plants from all seed lots under all irrigation levels, but this advantage for plants from low vigor seed lots particularly under limited irrigations was higher than that for other treatments. Plants from high vigor seed lot under different irrigation treatments had higher relative water content, compared with those from low vigor seed lots. Hydro-priming improved relative water content, membrane stability and grain yield of chickpea plants from different seed lots under various irrigation treatments. It was concluded that hydro-priming to some extent can repair aged seeds and improve their performance under different irrigation treatments.

Sori (2014) conducted a laboratory experiment with the objectives to determine the effectiveness of seed priming and variety on seed quality and stand establishment. Experimental factors were three priming media [H_2O, 0.5% KH_2PO_4, unprimed)] and six Chickpea varieties (DZ-10-4, Arerti, Habru, DZ-10-11, Akaki and Natoli) arranged in CRD with four replications. The laboratory results revealed significant differences ($p<0.01$) for all parameters except vigor index II, which was significant at ($p<0.05$) among different priming treatments and variety in seed germination, all seed vigor tests. Significant correlations were also observed between emergence index and most of the vigor parameters. Moreover, water priming enhanced the germination and vigor index I of all varieties except DZ-10-4 and Habru; speed of germination of Arerti and electrical conductivity of all varieties tested. Hydropriming decreased electrical conductivity of seeds by 20% as compared to osmopriming. Therefore, it can be concluded that hydro priming can step-up economical benefit of chickpea growing farmers.

Khairul *et al* (2015) studied the response of seed priming on growth, yield and seed quality of chickpea. The experiment comprised as one factor: seed priming with gibrallic acid (GA3) - 5 levels: GA3 75 ppm – T1, GA3 150 ppm – T2, GA3 225 ppm – T3, GA3 300 ppm – T4 and hydro-priming – T5. The experiment was laid out in Randomized Complete Block Design (RCBD) with five replications. The result indicated significant variations in date of emergence, date of first flowering, date of 50% flowering, plant height, number of branches/plant, total dry matter, number of pod/plant, date to pod maturity, pod length, weight of 1000 seed, grain yield, stover yield, biological yield, harvest index, germination percentage and vigor index due to seed priming. Among the treatment on maximum plant height and dry matter content recorded of plant in T3 irrespective of growing period. This treatment also exhibited maximum number of pods/plant, longest pod length and maximum number of seed/pod, where as required minimum duration for pod maturity. The maximum weight of 1000 seed, height grain yield, harvest index and also maximum found germination percentage and vigor index were found. When chickpea was primed with 225 ppm GA_3 then ensure the best production and seed quality.

A field experiment was conducted to know the effect of priming treatments on growth and seed yield of kabuli chickpea at UAS Raichur. The experiment consists of 11 treatments with three replications in RCBD design. The results revealed that seeds primed with GA_3 @ 50 ppm + seed coating of *Trichoderma harzianum* @ 15 g per kg of

Table-6 : Effect of priming treatments on biochemical changes in chickpea seeds.

Treatments	Total sugar (mg/g fresh seed)	Reducing sugar (mg/g fresh seed)	Non reducing sugar (mg/g fresh seed)
Control	6.66^{f}	3.61^{e}	3.05^{a}
PEG-0.5 Mpa	8.77^{c}	6.65^{b}	2.12^{b}
PEG-1.0 Mpa	11.16^{a}	8.22^{a}	2.94^{a}
PEG-1.5 Mpa	7.60^{de}	6.28^{b}	1.32^{c}
Mannitol 2%	7.60^{de}	6.32^{b}	1.28^{c}
Mannitol 4%	7.52^{e}	4.61^{d}	2.91^{a}
Salicylic acid	7.97^{d}	6.41^{b}	1.55^{c}
Gibberellic acid	9.44^{b}	6.55^{b}	2.89^{a}
Hydropriming	7.79^{de}	5.41^{c}	2.37^{b}

Mean followed by similar alphabets indicates non-significant differences between the values at 0.05 level of significance.

Table-7 : Effect of priming treatment on emergence and yield attributes of chickpea.

Treatments	Field emergence (%)	Plant height (cm)	No. of pods per plant	No. of seeds per plant	100-seed weight (g)	Yield (kg ha^{-1})
Control	47.83^{b}	40.18^{a}	17.73^{a}	16.89^{a}	47.74^{bc}	507.28^{c}
PEG (-0.5 Mpa)	68.17^{a}	40.10^{a}	17.94^{a}	17.55^{a}	53.79^{a}	733.09^{a}
PEG (-1.0 Mpa)	67.33^{a}	40.53^{a}	17.73^{a}	16.97^{a}	47.05^{bc}	713.00^{ab}
PEG (-1.5 Mpa)	62.33^{ab}	39.11^{a}	18.27^{a}	17.80^{a}	46.12^{c}	610.81^{abc}
Mannitol (2%)	67.67^{a}	38.42^{a}	19.47^{a}	19.63^{a}	53.13^{a}	607.18^{abc}
Mannitol (4%)	63.33^{ab}	36.94^{a}	16.15^{a}	16.90^{a}	54.56^{a}	552.58^{bc}
GA (50ppm)	59.50^{ab}	40.24^{a}	16.34^{a}	14.23^{a}	53.23^{a}	486.19^{c}
SA (50nm)	60.33^{ab}	40.36^{a}	16.43^{a}	15.20^{a}	52.63^{a}	579.39^{abc}
Hydropriming	68.67^{a}	41.15^{a}	17.94^{a}	16.80^{a}	49.52^{b}	717.98^{a}

Mean followed by similar alphabets indicates non-significant differences between the values at 0.05 level of significance.

seed recorded significantly higher plant height (17.80 cm, 38.50 cm and 59.60 cm) at 30 days, 60 days and at harvest, test weight (54.67 g), less number of days to 50 per cent flowering (66 days), more number of pods per plant (33). Whereas, seeds treated with mancozeb 50% + carbendazim 25% @ 3 g per kg of seed recorded significantly higher seed yield per plant (21 g), seed yield per hectare(1869 kg/ha), biomass (2878 kg/ha), harvest index (42.12) and lowest wilt (1.67 %) and Ascochyta blight incidence (4.66 PDI). Beedi et al (2017).

Vishwas *et al* (2017) studied on seed priming of chickpea, seed priming with Rhizobium + Pseudomanas @ 10% for 12 hours recorded significantly higher germination percent (87%), speed of germination (77.11), shoot length (20.33 cm), root length (16.14 cm), seedling length (34.92 cm), seedling fresh weight (1200.3 mg), dry weight (150.4 mg), seedling vigour index – I (2225.37), seedling vigour index-II (11766.67). which is followed by seed priming with Rhizobium @ 10% for 12 hours (T3) and lowest was recorded in T0 (control) Table-1.

Shariatmadari *et al* (2017) evaluate the effect of hormonal priming on emergence, growth, physiological traits and yield of chickpea under drought stress, two separate experiments were conducted. In the first experiment, the effect of gibberellic acid on the emergence and vigor of chickpea (cultivar ILC 6266) under drought stress was studied in glasshouse. Different gibberellic acid treatments including zero, 50, 100 and 150 ppm were used in the study. While different drought treatment levels used in the study were 70, 50 and 30 percent of field capacity. The second experiment was conducted under field conditions with drought stress levels as in the first experiment conducted in glasshouse. It was observed that hormonal priming with gibberellic acid increased seed emergence and plant vigor in glasshouse conditions. Moreover, application of gibberellic acid also resulted in improved growth and physiological traits under field condition but could not affect the seed yield. Gibberellic acid priming prominently reduced the adverse effects of drought. Of course, this positive effect was more pronounced at higher levels of stress than the control condition. In general, 150 ppm gibberellic acid treatment was the best priming level while with increasing concentration of priming agent, emergence and plant growth indicators also improved. They concluded that priming with appropriate concentration of gibberellin plays an important role in the induction of tolerance to drought and overcome limitations created by the environmental stress such as osmotic effects, ion toxicity and nutritional imbalance.

Kumar *et al* (2017) conducted an experiment in order to standardize the best method of Osmopriming specific to chickpea. One method of priming viz., osmopriming, on two duriations that is 6hrs and 12 hrs were evaluated by screening a range of durations and concentrations viz., T0 - Unprimed Control, T1–Polyethylene glycol (PEG) (for 6 hrs and 12 hrs), T2–Mannitol 4% (6 hrs and 12 hrs) T3–Glycerol 5% (6 hrs and 12 hrs). It was found that all the priming methods showed significance difference with the control and the highest germination %, seedling length (cm), seedling fresh weight (gm), seedling dry weight (gm) and vigour index were observed in T2 for PEG 6000 priming for 12 hrs. The study helps to improve the quality of seeds with the help of seed osmopriming treatments which are cost effective and economic, non toxic, eco friendly sources.

Seeds of chickpea were treated with various priming treatments recorded higher seed quality parameters compared to control for all the characters studied. It is concluded from the results of the experiment that among all the treatments, *Trichoderma harzianum* showed significant performance for field emergence, plant height, number of plants per plot, number of primary branches, number of pods per plant, seed weight per plant and seed yield per plot in organic priming followed by carbendazim in inorganic priming. Therefore, use of Trichoderma harzianum @ 0.6% and carbendazim @ 0.2% are recommended for treating chickpea for better quality, and quantity parameters (Chaurasia and Bara, 2018)

Chaurasia and Bara (2018) studied the efficiency of biopriming agents i.e. biocontrol agents (Trichoderma harzianum @ 0.6%, Pseudomonas fluorescens @ 0.6%), and fungicides (Carbendazium @ 0.2%, Mancozeb 50% + Carbendazim 25% WS @ 0.2%) in enhancing field emergence, seedling growth and yield were investigated in chickpea of GNG-1581variety. Five treatments gave the significant results. T1 (Trichoderma harzianum) showed significant performance for field emergence (85.83), plant height (77.8), number of plants per plot (24.5), number of primary branches (3.25), number of pods per plant (45), seed weight per plant (17.61) and seed yield per plot (135.89) in organic priming followed by T4 (Carbendazim) in inorganic priming compared to untreated control.

Seeds of chickpea were treated with various priming treatments recorded higher seed quality parameters compared to control.Seeds treated with KNO_3 100 ppm gave the significant results. It is concluded from the results of the experiment that among all the treatments, KNO_3 100 ppm showed significant performance for seed quality parameter, germination (%), root length (cm), shoot length (cm), seedling length (cm), Seedling fresh weight (g), seedling dry weight (g), seedling vigour index-I and seedling vigour index-II followed by other treatments. Therefore, as pre-sowing treatment KNO_3 100 ppm are recommended for treating chickpea seed for better seed quality parameters (Patil *et al*. 2018) Table-2.

Sohail *et al*. (2018) studied effect of different seed priming methods on germination and vigour of Kabuli Chickpea (*Cicer kabulium* L.) seeds and concluded that among all the seed priming treatments, seed priming with PEG 6000 (osmo priming) was found to be the best priming treatment followed by organic priming. Among all seed priming treatments PEG 2% having more pronounced effect on germination behavior and vigour in kabuli chickpea seeds Table-3.

Chickpea seed were bioprimed with vermiculite and later with biocontrol agents for their efficacy on seed borne infections and seedling vigour of the plant. Among the seven treatments tested, the treatment P. fluorescens @ 0.8 % + T. harzianum@ 0.8 % + Vermiculite shown the least seed infection of 13.00 per cent, highest seed germination of 91.00 per cent and vigour index of 1753.13 which was statistically superior over other treatments The difference in results was observed may be due to the presence of vermiculite which holds the moisture and provides when seed needs and also biocontrol agent may multiply substantially on seed during biopriming reducing the seed borne infections. Veenashri *et al* (2018) Table-4.

A field experiment was conducted to study the "Effect of seed priming with inorganics on growth, yield and physiological parameters of chickpea (*Cicer arietinum* L.) under drought". The chickpea var. pusa-362 was imposed with seven inorganic seed priming treatments *viz*., 2% KNO3, 2% $NaCl_2$, 2% $CaCl_2$, 2% KH_2PO_4, 2% KCl, water soaked for 8 Hours, and control. The treated seeds along with control were evaluated for their morpho-physiological, growth, yield, root parameters and biochemical parameters under laboratory and field conditions. The study revealed that seeds priming techniques with $CaCl_2$ @ 2% recorded highest in plant height (cm), seed yield (g), no. of pods/plant and root parameters of nodules/plant and other biochemical parameters. The increased seed yield in seed priming with $CaCl_2^-$ 2% attributed to increase in the total chlorophyll, chl-a. and chl-b, total chlorophyll content, proline content, relative water content, protein content as compare to control. Thus this study indicates that seed priming with inorganics modifies the physiological and biochemical nature of seeds so as to get the characters that are favorable for drought tolerance which more with

$CaCl_2^-$ 2% as compared to other treatments. Kumeera *et al* (2018)

Lamichaney *et al* (2018) chickpea seed was primed with different concentration of poly ethylene glycol, mannitol, salicylic acid, gibberellic acid and water for varying duration. Dry unprimed seed was used as control. Protein synthesis, sugar content, electrical conductivity of seed leachate, germination percent, time to 50% germination, uniformity of germination, germination energy, field emergence, hundred seed weight, seed yield were determined to understand the physiological basis of priming. The results revealed that seed priming reduced time to 50% germination, mean germination time and improved germination energy, final germination, field emergence and seed yield over control. Overall, the favourable effect of seed priming were related to protein synthesis, an improved membrane repair (revealed by low ion leakage) and germination substrates (increased sugar content) for vigorous and earlier production of seedlings. Out of nine treatments, seeds primed with water for 17 hrs and PEG -0.5 / -1.0 Mpa for 24 hrs were most effective in enhancing field emergence and seed yield of chickpea and can be therefore recommended for increasing productivity in chickpea Table-5 to 7.

Conclusions

From the above reviewed research articles it is concluded that seed priming of chickpea with GA_3 ensure the best production and seed quality. Priming with appropriate concentration of gibberellin plays an important role in the induction of tolerance to drought and overcome limitations created by the environmental stress such as osmotic effects, ion toxicity and nutritional imbalance. Pre-sowing treatment of KNO_3 are recommended for treating chickpea seed for better seed quality parameters. It helps to improve the quality of seeds with the help of seed osmopriming treatments which are cost effective and economic, non toxic, eco friendly sources. Seed priming with inorganics modifies the physiological and biochemical nature of seeds so as to get the characters that are favorable for drought tolerance. Seed priming is most effective in enhancing field emergence. It can step-up economical benefit of chickpea growing by priming.

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