Development of priming technology for enhanced planting value of seeds in kabuli chickpea (*Cicer arietinum* L.)

**INTRODUCTION**

Chickpea (*Cicer arietinum* L.), commonly called gram, bengal gram, or garbanzo bean, is the most vital food grain legume cultivated in South Asia. It is also one of the first grain crops cultivated by man and has been uncovered in Middle Eastern archaeological sites dated to the eighth millennium BC (Zohary and Hopf, 2000). Two diverse market types, desi and kabuli, prevail in chickpea (Pundir et al., 1985). The desi types cover about 85% of chickpea area with common characteristics like small, angular shaped, dark-colored seeds with a rough surface, pink flowers, anthocyanin pigmentation on the stems, and either semi-erect or semi-spreading growth habit and the remaining 15% area is covered by kabuli type, wherein we find large rams head shaped smooth surface seeds, lack of anthocyanin pigmentation, and semi-spreading growth habit (Ahmad et al., 2005).

Global yields of chickpea are low (700–800 kg ha⁻¹), and have been fairly stagnant for the last two decades. Various biotic and abiotic factors hinder the realization of chickpea yield potential. The lower production and productivity trend of chickpea in India can be attributed to...
to: (i) the shift in crop area from favourable to marginal environments; (ii) the slow varietal replacement rate and other production technologies; and (iii) chickpea cultivation in poor soils under inconsistent rainfall conditions (Parthasarathy et al., 2010). Apart from these constraints, the establishment of kabuli chickpea under these resource-poor dryland conditions is problematic. The above-mentioned problems impart a serious threat to kabuli chickpea cultivation. Hence, it necessitates developing the appropriate technology to improve seed viability and vigour. Seed priming is one of the potential techniques for enhancing the seed and seedling performance, starting from uniform and faster seed germination, early seedling establishment, better final stand establishment that enables the initial germination process, and restricting the final phase of seed germination i.e., radicle emergence (Umesha et al., 2014).

In recent years, several approaches are being employed in order to induce abiotic stress tolerance in plants. Seed priming is an effective, practical and facile technique to enhance rapid and uniform emergence, high seedling vigour, and better yields in many field crops, particularly under unfavourable environmental conditions (Paparella et al., 2015). The word priming was given by Heydecker in 1973 for the soaking drying seed treatments. Theophrastus (372-287 BC) had proposed presoaking of cucumber seeds in milk or water to enable them to germinate earlier and vigorously (Michael Evanari, 1984). Heydecker (1973) effectively practiced seed priming to enhance germination and seedling emergence under various stress conditions. The seed priming treatments trigger metabolic processes activated during the phase II of germination, which are then temporally stopped before a loss of desiccation occurs (Paparella et al., 2015).

Various researchers reported the beneficial effects of seed priming treatments to improve seeds vigour and viability under a wide range of environment. Seed priming with various agents including organic and inorganic substituents, bioagents, phytohormones have been found superior for improving seed performance. (Umesha et al., 2014). The overall consequence of seed priming comprises augmented seed vigour defined as the whole set of properties conditioning seed lots performance in an extensive range of environments (Zhang et al., 2015). The studies related to the development of seed priming technology in kabuli chickpea are very meagre. Keeping in view, the present investigation was undertaken to identify suitable priming treatments for fresh and aged seeds to improve their seed viability, vigour and seed quality.

**MATERIALS AND METHODS**

The experiment was conducted at the National Seed Project (Crops), Seed Unit, University of Agricultural Sciences, Raichur, Karnataka, India during 2018 and 2019. The seed material of kabuli chickpea variety MNK-1 with two vigour levels (Fresh seeds: Lot 1, One year old seeds: Lot 2) was collected from Seed Unit, UAS, Raichur and used for the experiment. These low and high vigour seeds were subjected to priming with different treatments mentioned in table 1. The microbial consortia were procured from ICAR-Indian Institute of Seed Science, Mau, India (Accession numbers awaited).

**Method/dosage of treatment of microbial consortia**

100 ml of liquid formulation BioNPK, Biogrow, Biophos, Drought Alleviating Bacteria (containing 1 x 10^9 cfu) was diluted in 1000 ml water. To this diluted suspension, 10 grams of sucrose was added. The final suspension was sprinkled over the seeds (two hours before sowing). Then the seeds were mixed with hands and kept for 45 minutes, shade dried and sown. Both fresh and aged seeds were used to conduct viability and vigour tests. Each test was conducted in a completely randomized design. The moisture content of seed before and after seed priming was determined by the oven dry method as per the ISTA Rules.

**Table 1. Details of priming treatments used in the experiment.**

| T1 | Control (Untreated) |
| T2 | Thiiram seed treatment @ 2g/Kg |
| T3 | Hydropriming – Soaking in water for 4h (at 20°C) and air-drying at 25°C for 48h |
| T4 | Halopriming- Soaking in KNO₃(@0.3%) solution and drying |
| T5 | Halopriming- Soaking in Mg(NO₃)₂(@2%) solution and drying |
| T6 | Halopriming- Soaking in K₂HPO₄(@0.5%) solution and drying |
| T7 | Halopriming- Soaking in ZnSO₄ (@0.3%) solution |
| T8 | Halopriming- Soaking in MnSO₄ (@0.5%) solution |
| T9 | Halopriming- Soaking in ZnSO₄ (@0.3%) + MnSO₄ (@0.5%) solution for and drying |
| T10 | Seed coating (on hydro primed seeds) with Trichoderma harzianum (CFU – 2 X 10^6 per gm) @ 15 g / kg seed (15g in 50 ml of water and applied on 1 kg of seed uniformly. Later seeds were shade dried for 20 – 30 |
| T11 | Seed coating (on hydro primed seeds) with Trichoderma viride (CFU – 2 X 10^5 per gm) @ 10 g / kg seed |
| T12 | Seed coating (on hydro primed seeds) with BioNPK |
| T13 | Seed coating (on hydro primed seeds) with Biogrow |
| T14 | Seed coating (on hydro primed seeds) with Biophos |
| T15 | Seed coating (on hydro primed seeds)) with Drought Alleviating Bacteria + BioNPK |
| T16 | Seed coating (on hydro primed seeds) with Drought |
| T17 | Seed coating (on hydro primed seeds) with Drought Alleviating Bacteria + Biophos |
Saad and Azhar (2020) who demonstrated the significant increase (at 1% level of significance) in normal seedlings at first count, percent germination in aged seeds (56.00 %, 85.75 % respectively). There was a 88.75 %, respectively) as compared to unprimed seeds (Table 2). These results agree with Saad and Azhar (2020) who demonstrated the significant effect of seed priming on first count (%) in mung bean, which is an important parameter of seed vigour. Hydro-priming is a simple and low cost-effective priming technology that does not involve any specific apparatus as it involves the use of distilled water as a priming medium. Fujikura et al. (1993) presented hydropriming as a simple and inexpensive method of seed priming. The characteristic features of primed seeds are augmented germination rate, better uniformity in germination, and in some cases higher seed germination percent (Basra et al., 2005), enhanced germination under unfavorable conditions (Lin and Sung, 2001). Improved germination rate and uniformity have been ascribed to metabolic repair during first phase of seed germination i.e., imbibition (Bray et al., 1989), accumulation of germination augmenting metabolites (Basra et al., 2005), osmotic modification (Bradford, 1986), and, for seeds that are not subjected to drying back to original moisture content after treatment, a simple reduction in imbibition lag time (Bradford, 1986). The aged seeds performed better regarding increasing germination percent compared to fresh seeds because seeds intact with all quality characteristics, obviously the prospect of enhancing seed quality, are restricted compared to seeds of lower quality with physiological deficiencies (Umesha et al., 2014).

In the present investigation, it was observed that percent improvement in seed quality due to seed priming in old lot (aged seeds) is more as compared to fresh lot (Table 2). Umesha et al., (2016) opined that seed deterioration can be rectified to the extent possible by the technique of seed priming. Their study of biochemical investigations on vigour enhancement in aged seeds upon seed priming in onion clearly indicated that priming would reestablish the lost seed vigour in aged seeds due to reactivation of enzyme activity in old seeds. The germination percentage improved from 60% to 79.5% and 72.5% in GA$_3$ and hydroprimed, respectively. Priming also restored the lost seed vigour in aged seeds due to recurrence of proteins and increased enzyme activity in old seeds and the appearance of these proteins in priming treatments are related to priming persuaded proteins in contrast to their absence in the aged seeds, which are essential for germination and longevity of seeds. The shift in the enzyme activities upon priming indicates that the mobilization of storage material may be accountable for improved germination and vigour in primed seeds than unprimed aged seeds.

**Effect of seed priming on seedling length and seedling dry weight**

Seed quality in particular seed viability and vigor can have a significant impact on the crop establishment and the yield of a crop. Healthy plants with appropriate
Table 2. Effect of seed priming treatments and lots on first count (%) and seed germination (%) in kabuli chickpea variety MNK-1.

| Treatments | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean |
|------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2018       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Pooled     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| First count (%) |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| T1         | 55.25 | 41.50 | 48.38 | 56.75 | 46.50 | 51.63 | 56.00 | 44.00 | 50.00 | 85.50 | 56.25 | 70.88 | 86.00 | 58.75 | 72.38 | 85.75 |
| T2         | 60.75 | 48.50 | 54.63 | 62.75 | 49.75 | 56.25 | 61.75 | 49.13 | 55.44 | 88.00 | 59.75 | 73.88 | 87.75 | 64.50 | 76.13 | 87.88 |
| T3         | 65.50 | 61.50 | 63.50 | 67.25 | 62.25 | 64.75 | 66.38 | 61.88 | 64.13 | 92.00 | 71.00 | 81.50 | 93.00 | 77.25 | 85.13 | 92.50 |
| T4         | 61.00 | 51.50 | 56.25 | 63.00 | 53.25 | 58.13 | 62.00 | 52.38 | 57.19 | 86.50 | 62.00 | 74.25 | 87.00 | 70.50 | 78.75 | 86.75 |
| T5         | 62.25 | 34.25 | 48.25 | 63.75 | 51.75 | 57.75 | 63.00 | 43.00 | 53.00 | 85.25 | 64.25 | 74.75 | 86.25 | 69.00 | 77.63 | 85.75 |
| T6         | 63.25 | 47.00 | 55.13 | 65.50 | 49.50 | 57.50 | 64.38 | 48.25 | 56.31 | 89.75 | 64.00 | 76.88 | 87.75 | 68.50 | 78.13 | 88.75 |
| T7         | 59.00 | 51.25 | 55.13 | 60.00 | 50.75 | 55.88 | 60.00 | 51.00 | 55.50 | 85.00 | 70.00 | 77.50 | 86.00 | 70.00 | 78.00 | 85.50 |
| T8         | 59.50 | 48.50 | 54.00 | 61.50 | 47.25 | 54.38 | 60.50 | 47.88 | 54.19 | 85.50 | 69.25 | 77.38 | 86.25 | 70.25 | 78.25 | 85.85 |
| T9         | 61.25 | 48.75 | 55.00 | 62.00 | 50.75 | 56.38 | 61.63 | 49.75 | 55.69 | 89.00 | 64.75 | 76.88 | 89.75 | 71.75 | 80.75 | 89.38 |
| T10        | 54.50 | 47.50 | 51.00 | 56.25 | 49.25 | 52.75 | 55.38 | 48.38 | 51.88 | 87.25 | 61.25 | 74.25 | 88.75 | 66.75 | 77.75 | 88.00 |
| T11        | 58.00 | 48.25 | 53.13 | 59.50 | 50.75 | 55.13 | 58.75 | 49.50 | 54.13 | 86.75 | 64.75 | 75.75 | 87.75 | 62.75 | 75.25 | 87.25 |
| T12        | 55.00 | 49.25 | 52.13 | 56.00 | 47.00 | 51.50 | 55.50 | 48.13 | 51.81 | 86.00 | 65.75 | 75.88 | 86.75 | 69.00 | 77.88 | 86.38 |
| T13        | 56.50 | 45.50 | 51.00 | 58.00 | 48.75 | 53.38 | 57.25 | 47.13 | 52.19 | 87.50 | 62.25 | 74.88 | 85.75 | 65.75 | 75.75 | 86.63 |
| T14        | 59.00 | 49.00 | 54.00 | 62.00 | 48.00 | 55.00 | 60.50 | 48.50 | 54.50 | 86.50 | 65.25 | 75.88 | 87.75 | 68.50 | 78.13 | 87.13 |
| T15        | 48.25 | 47.25 | 47.75 | 50.25 | 48.75 | 49.50 | 49.25 | 48.00 | 48.63 | 85.25 | 64.50 | 74.88 | 84.75 | 69.25 | 77.00 | 85.00 |
| T16        | 49.00 | 46.75 | 47.88 | 51.50 | 48.50 | 50.00 | 50.25 | 47.63 | 48.94 | 86.25 | 65.25 | 75.75 | 84.75 | 63.75 | 74.25 | 85.50 |
| T17        | 46.25 | 47.25 | 46.75 | 48.50 | 46.00 | 47.25 | 47.38 | 46.63 | 47.00 | 87.00 | 63.00 | 75.00 | 86.50 | 67.50 | 77.00 | 86.75 |
| SEm (±)    | 2.12  | 2.21  | 2.16  | 1.02  | 1.79  | 1.17  |       |       |       |       |       |       |       |       |       |       |
| CD (p<0.01)| 7.88  | 8.23  | 8.03  | 3.79  | 6.66  | 4.36  |       |       |       |       |       |       |       |       |       |       |

**F test**

Treatments details mentioned in Materials and Methods; Lot 1: Fresh seeds, Lot 2: Old seeds; Mean values in each parameter are average of Lot 1 and Lot 2. The values in lot 1 and lot 2 are mean of 4 replications.
Table 3. Effect of seed priming treatments and lots on seedling vigour index-1 and seedling vigour index-II in kabuli chickpea variety MNK.

| Treatments | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean |
|------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| T1         | 1156 | 497  | 826  | 1208 | 563  | 885  | 1183 | 518  | 850  | 49823 | 27680 | 38752 | 56912 | 33238 | 45075 | 54308 | 30008 | 42158 |
| T2         | 1230 | 605  | 918  | 1220 | 656  | 938  | 1225 | 621  | 923  | 54742 | 31184 | 42963 | 65016 | 39755 | 52385 | 58383 | 35439 | 46911 |
| T3         | 1608 | 972  | 1290 | 1652 | 1094 | 1373 | 1665 | 1038 | 1352 | 63287 | 42247 | 52767 | 74850 | 48890 | 61870 | 69095 | 45258 | 57176 |
| T4         | 1375 | 625  | 1000 | 1360 | 754  | 1057 | 1367 | 669  | 1018 | 55669 | 34603 | 45136 | 62460 | 42212 | 52336 | 59515 | 38698 | 49107 |
| T5         | 1161 | 686  | 924  | 1211 | 733  | 972  | 1183 | 703  | 943  | 53964 | 38840 | 46402 | 61231 | 42384 | 51808 | 57683 | 40461 | 49072 |
| T6         | 996  | 833  | 914  | 1044 | 718  | 881  | 1008 | 777  | 893  | 55543 | 38332 | 46937 | 60905 | 41382 | 51144 | 58320 | 40092 | 49206 |
| T7         | 1388 | 947  | 1168 | 1382 | 730  | 1056 | 1386 | 855  | 1121 | 54769 | 40764 | 47767 | 64963 | 42959 | 53961 | 58650 | 41844 | 50247 |
| T8         | 1283 | 908  | 1096 | 1318 | 787  | 1052 | 1304 | 861  | 1082 | 51183 | 38061 | 44622 | 62332 | 42833 | 52582 | 57299 | 40340 | 48819 |
| T9         | 1492 | 658  | 1075 | 1454 | 870  | 1162 | 1502 | 757  | 1129 | 58375 | 34918 | 46647 | 67570 | 45057 | 56313 | 63677 | 39726 | 51702 |
| T10        | 1221 | 679  | 950  | 1286 | 683  | 984  | 1261 | 665  | 963  | 53223 | 32798 | 43011 | 63761 | 42778 | 53270 | 58518 | 36520 | 47519 |
| T11        | 1257 | 778  | 1018 | 1294 | 745  | 1019 | 1265 | 764  | 1014 | 52850 | 34923 | 43887 | 63590 | 37016 | 50303 | 57354 | 36727 | 47041 |
| T12        | 1335 | 676  | 1005 | 1389 | 763  | 1076 | 1347 | 715  | 1031 | 51096 | 34728 | 42912 | 64836 | 42039 | 53437 | 57946 | 38203 | 48074 |
| T13        | 1282 | 646  | 964  | 1268 | 660  | 964  | 1286 | 659  | 973  | 51581 | 30620 | 41100 | 60046 | 40740 | 50393 | 55780 | 35353 | 45567 |
| T14        | 1329 | 741  | 1035 | 1397 | 729  | 1063 | 1364 | 731  | 1048 | 52045 | 33425 | 42735 | 62688 | 42346 | 52517 | 57653 | 37378 | 47696 |
| T15        | 1254 | 665  | 959  | 1264 | 786  | 1025 | 1237 | 707  | 972  | 55644 | 34503 | 45074 | 60995 | 42313 | 51654 | 58137 | 38073 | 48105 |
| T16        | 1306 | 794  | 1050 | 1302 | 713  | 1008 | 1302 | 752  | 1027 | 52837 | 33144 | 42991 | 59967 | 38960 | 49464 | 56131 | 35978 | 46054 |
| T17        | 1331 | 785  | 1058 | 1602 | 806  | 1204 | 1419 | 789  | 1104 | 50520 | 36331 | 42076 | 63313 | 42285 | 52799 | 56210 | 37306 | 46758 |

SEm (±) 88 71 69 2119 2213 1666
CD (p=0.01) - - - - - -
F test NS NS NS NS NS

Treatments details mentioned in Materials and Methods; Lot 1: Fresh seeds, Lot 2: Old seeds; Mean values in each parameter are average of Lot 1 and Lot 2. The values in lot 1 and lot 2 are mean of 4 replications.
root systems can better survive even under unfavourable conditions and early vigorous seedling establishment has been associated with higher yields (Harris et al., 2000). Significant variations in root length, shoot length, mean seedling length, mean seedling dry weight were noticed among the seed lots and priming treatments. Among seed lots, higher root length (9.84 cm), shoot length (5.19 cm) mean seedling length (15.05 cm), seedling dry weight (671 mg) was registered in fresh seeds and it was lower in old seeds (11.15 cm, 4.45 cm, 11.15 cm and 575 mg respectively). Among the priming treatments, hydroprimed fresh seeds recorded highest root length (11.85 cm), shoot length (6.16 cm) mean seedling length (18.01 cm), seedling dry weight (747 mg) whereas, old seeds subjected to hydropriming exhibited higher seedling vigour parameters (8.15 cm, 5.85 cm, 14.00 cm and 611 mg respectively) (Fig. 1 to Fig. 4). The findings of the study are in agreement with, Shantha Nagarajan and Panditha (2001) who also observed that hydropriming of tomato seeds lead to enhanced germination, speed of germination and seedling dry weight of aged seeds to a smaller extent as compared to osmopriming. Surekha (2002) also described that hydration dehydration treatment had a positive impact on seed quality in onion cultivars. Vigorous seedling growth manifested through the greater seedling length and seedling dry weight is essential for better plant establishment, plant growth and ultimately higher yield. Shaila et al., (2019) opined that bitter gourd seeds subjected to hydropriming enhanced the seed germination, accelerated the seedling growth through higher shoot length, ultimately increase the yield.

### Effect of seed priming on seedling vigour indices

Seed priming in kabuli chickpea showed a positive correlation between germination, seedling vigour index. The fresh seeds hydroprimed exhibited higher seedling vigour index (SVI-I and II) (1665, 69095 respectively) than other priming treatments. Old seeds that undergone priming with water (1038, 45258 respectively) recorded highest seedling vigour index-I and II due to increased seedling length and seedling dry weight by seed priming (Table 3). The results comply with Umesha et al. (2014), who also opined that priming of onion seeds with different chemicals resulted in an increased length of seedlings. The seedling vigour index of fresh seeds was significantly higher than the aged seeds. The increase in seedling length by priming treatments can be due to the beneficial effect in uniform

| Figure | Description |
|--------|-------------|
| Fig. 1 | Effect of seed priming treatments and lots on root length (cm) in kabuli chickpea variety MNK-1. |
| Fig. 2 | Effect of seed priming treatments and lots on shoot length (cm) in kabuli chickpea variety MNK-1. |
| Fig. 3 | Effect of seed priming treatments and lots on mean seedling length (cm) in kabuli chickpea variety MNK-1. |
| Fig. 4 | Effect of seed priming treatments and lots on seedling dry weight (mg) in kabuli chickpea variety MNK-1. |
germination, due to intensified hydrolytic process and better uptake of moisture. Nascimento et al. (2004) reported that priming increased the germination of seed of low vigour and response was cultivar dependent. Avila et al., (2008) evaluated the effect of hydration (distilled water) and pre- osmotic treatments (-1.5MPa of osmotic potential in manitol solution for four periods of treatment (12, 24, 48 and 72 hours) at 10°C) on the quality of high and low vigour canola seeds. They opined that pre-osmotic conditioning with manitol solution was not efficient in improving the germination and vigour of the rape seeds. However, hydro-priming was a suitable priming technique in canola seeds and was effective in the low vigour lot. Christos et al., (2019) opined that hydropriming faba bean seeds produced more vigorous seedlings than non-primed seeds in seedling vigor index.

Effect of seed priming on seed infection
All the priming treatments improved the seed quality parameters when compared to control. Among the various priming treatments, hydropromised seeds and seeds treated with thiram @ 2g/Kg recorded less infection in both fresh seeds (1.75 %) compared to unprimed seeds (6.13%) and other treatments. In the case of old seeds, seeds treated with thiram @ 2g/Kg and hydropromised seeds recorded less infection (2.50, 2.63 %, respectively) compared to unprimed seeds. The lesser infection in thiram treated seeds is due to the well-known effect of fungicidal activity on fungal organisms.

Effect of seed priming on speed of emergence
Faster and uniform emergence of seedlings in the field is very critical in ensuring better crop growth and yield in any crop. In addition, the period between sowing and plant establishment is important in the production cycle of a crop. Therefore, it would be desirable to reduce the period between sowing and seedling emergence and to decrease the time between the emergences of the first and last seedlings (Heydecker et al., 1973). The less time gap between the emergence of the first and last seedlings would reduce the competition with seeds and increases both uniformity at plant maturity and yield. High seedling vigour at an early stage of the crop yields

| Treatments | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean | Lot 1 | Lot 2 | Mean |
|------------|------|------|------|------|------|------|------|------|------|
| T1         | 0.326| 0.276| 0.301| 0.298| 0.290| 0.294| 0.3169| 0.3064| 0.3116|
| T2         | 0.339| 0.292| 0.315| 0.281| 0.270| 0.275| 0.3066| 0.3139| 0.3102|
| T3         | 0.394| 0.379| 0.387| 0.387| 0.364| 0.375| 0.3992| 0.3814| 0.3903|
| T4         | 0.259| 0.303| 0.281| 0.281| 0.277| 0.282| 0.2588| 0.2871| 0.2729|
| T5         | 0.328| 0.327| 0.328| 0.313| 0.296| 0.305| 0.3304| 0.3104| 0.3204|
| T6         | 0.335| 0.328| 0.332| 0.307| 0.292| 0.299| 0.3224| 0.3194| 0.3209|
| T7         | 0.317| 0.353| 0.335| 0.316| 0.303| 0.310| 0.3229| 0.3099| 0.3164|
| T8         | 0.299| 0.298| 0.299| 0.316| 0.357| 0.337| 0.3008| 0.3146| 0.3077|
| T9         | 0.359| 0.307| 0.333| 0.383| 0.343| 0.363| 0.3982| 0.3443| 0.3713|
| T10        | 0.346| 0.286| 0.316| 0.279| 0.273| 0.276| 0.3182| 0.3065| 0.3124|
| T11        | 0.338| 0.333| 0.336| 0.298| 0.275| 0.287| 0.3141| 0.3225| 0.3183|
| T12        | 0.334| 0.292| 0.313| 0.289| 0.260| 0.275| 0.3117| 0.3116| 0.3117|
| T13        | 0.353| 0.346| 0.349| 0.303| 0.295| 0.299| 0.3127| 0.3436| 0.3282|
| T14        | 0.358| 0.344| 0.351| 0.294| 0.278| 0.286| 0.3123| 0.3395| 0.3259|
| T15        | 0.320| 0.320| 0.320| 0.283| 0.261| 0.272| 0.3015| 0.3018| 0.3016|
| T16        | 0.333| 0.308| 0.321| 0.307| 0.292| 0.299| 0.2997| 0.3408| 0.3202|
| T17        | 0.324| 0.325| 0.324| 0.317| 0.280| 0.299| 0.3041| 0.3368| 0.3205|

SEm (±) 0.011 0.02 0.010
CD (p=0.01) 0.031 - -
F test * NS NS

Table 4. Effect of seed priming treatments and lots on speed of emergence in kabuli chickpea variety MNK-1.
good returns to farmers. Studies conducted by several workers showed the beneficial effects of seed priming on speed, synchronization and uniformity of germination, often leading to improved stand establishment. In the present investigation, primed seeds germinated faster as compared to unprimed seeds, as evident from the higher speed of emergence in hydroprimed seeds both in fresh and aged seeds (0.3992, 0.3814 respectively) compared to un-primed seeds (0.3169, 0.3064 respectively) (Table 4). During seed priming, the hydration process enables the most primitive physiological stages of germination to complete at the earliest time and perhaps physiological repair of membranes and organelles affected during seed storage ensuing in more speedy and uniform seedling emergence (Copeland and Mc Donald, 1995). Casenave and Toselli (2007) demonstrated that hydropriming increased the speed of germination significantly, compared to control seeds, reduced the thermal time required for radicles to emerge and improved seed vigour in cotton. Hydropriming is a very simple, economical and environmentally friendly type of seed priming (Jamil et al., 2016). Several studies have established that hydropriming enhanced germination of various crop species resulting in higher values of germination, root growth, shoot growth and seedling vigour index. Shaila et al. (2019) opined that hydropriming of bitter gourd seeds enhanced seed germination, seedling growth and other growth parameters. Christos et al. (2019) found that the hydro-priming of faba bean seeds enhanced the germination speed by 16.2%, germination synchrony by 20.7%, and seedling vigor index 13.4%, but did not affect significantly final germination percentage and mean daily germination compared with non-primed seeds. Our study shows that seedlings from primed seeds emerge faster and produce more vigorous seedlings, as it is evident from higher values of speed of emergence, seedling vigour indices in hydroprimed seeds than from non-primed seeds. As evidenced by higher seedling growth parameters in this experiment due to seed priming, the increased seed vigour was similar to the findings of Shaila et al. (2019) in bittergourd.

Conclusion

The priming treatments evaluated in the present study enhanced the seed quality parameters of kabuli chickpea significantly when compared to control. Hydro priming for 4 hours (at 20°C) and air drying for 72 hours showed better results than the rest of the fresh and old seeds treatments. The fresh seeds hydromprimed exhibited significantly (at 1 % level of significance) higher percentage of normal seedlings in the first count (66.38 %), germination percentage (92.50%), followed by Halopriming- soaking in KH₂PO₄ (@0.5%) solution and drying (64.38, 88.75 % respectively) as compared to un-primed seeds (56.00, 85.75 % respectively). There was a significant increase in normal seedlings at first count, percent germination in the aged seed lot, which had undergone priming with water (61.88, 74.13% respectively) compared to un-primed seeds. The present data further indicates that the aged seeds have recorded 29 per cent increase in germination percentage in contrast to 8 per cent increase in fresh seeds. Kabuli chickpea seeds could be hydro-primed as a pre-sowing seed enhancement technique, a cost-effective, affordable alternative for improving germination and seed vigour.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Abdul-Baki, A.A. & Anderson, J.D. (1973). Vigour determination in soybean seed by multiple criteria. Crop Science, 13(3), 630-633.
2. Ahmad, F., Gaur, P.M. & Croser, J.S. (2005). Chickpea (Cicer arietinum L.) In: Genetic Resources, Chromosome Engineering and Crop Improvement. Taylor & Francis, London, UK, pp. 229-267.
3. Anonymous. (2010). International rules for seed testing, Zurich, Switzerland.
4. Ávila, M.R., Braccini, A.L., Scapim, C.A., Albrecht, L.P., Rodovalho, M. & Fracaro, M. (2008). Hydration and presomatic treatments on canola rape seeds (Brassica napus L.). Seed Science and Technology, 36, 218-224.
5. Basra, S.M.A., Farooq, M. & Tabassum, R. (2005). Physiological and biochemical aspects of seed vigor enhancement treatments in fine rice (Oryza sativa L.). Seed Science and Technology, 33, 25-29.
6. Bradford, K. J. (1986). Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. Hort. Sci., 21, 1105-1112.
7. Bray, C.M., Davison, P.A., Ashraf, M. & Taylor, R.M. (1989). Biochemical changes during osmopriming of leek seeds. Annals of Botany, 63, 185-193.
8. Casenave, E.C. & Toselli, M.E. (2007). Hydropriming as a pre-treatment for cotton germination under thermal and water stress conditions. Seed Science and Technology, 35, 88-89.
9. Christos A., Spyridon D. K. & Sideris, F. (2019). Hydropriming effects on seed germination and field performance of faba bean in spring sowing. Agriculture, 9, 201. doi:10.3390/agriculture9090201.
10. Copeland, L.O. & M.C. Donald, M.B. (1995). Principles of seed science and technology 3rd edition., Chapman and Hall, New York.
11. Ellis, R.H. & Roberts, E.H. (1981). The quantification of ageing and survival in orthodox seeds. Seed Science and Technology, 9, 373-409.
12. Fujikura, Y., Kraakh, L.A., Basra, S. & Karssen, C.M. (1993). Hydropriming, a simple and inexpensive priming method. Seed Science and Technology, 21, 411-415.
13. Harris, D., Tripathi, R.S. & Joshi A. (2000). On-farm priming to improve crop establishment and yield in direct-seeded rice. p.164 in IRRI: International Workshop on Dry-seeded Rice Technology, Bangkok, 25 – 28 January 2000. The international Rice Research institute, Manila, Philippines.

14. Heydecker, W.J., Heydecker, J., Higgins. & Gulliver, K. (1973). Accelerated germination by osmotic seed treatment. Nature, 246, 42-46.

15. Jamil, E., Zeb, S. Ali, Q. S. Ahmad, N. Sajis, M. Siddique, S. & Saleem, S.M. (2016). Effect of seed soaking on seed germination and growth of bitter gourd cultivars. Pure and Applied Biology, 5(1), 31–36. https://doi.org/10.19045/bspab.2016.50005.

16. Lin, J.M. & Sung, J.M. (2001). Pre-sowing treatment for improving emergence of bittergourd seedling under optimal and sub-optimal temperatures. Seed Science and Technology, 29, 39-50.

17. Michael Evanari. (1984). Seed Physiology: Its History from antiquity to the beginning of the 20th century. Bot. Rev, 50, 119-142.

18. Nascimento, W.M. & Arago, F.S. (2004). Muskmelon seed priming in relation seed vigour. Scientia Agric., 61, 114-117.

19. Parthasarathy Rao P., Birthal P.S., Bhagavatula, S. & Bantilan, M.C.S. (2010). Chickpea and Pigeonpea Economies in Asia: Facts, Trends and Outlook, Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics, pp 76.

20. Paparella, S., Araújo, S. S., Rossi, G., Wijayasinghe, M., Carbonera, D. & Balestrazzi, A. (2015). Seed riming: state of the art and new perspectives. Plant Cell Rep. 34, 1281–1293. doi:10.1007/s00299-015-1784-y.

21. Pundir, R.P.S., Rao, N.K. & Van der Maesen, L.J.G. (1985). Distribution of qualitative traits in the world germplasm of chickpea (Cicer arietinum L.). Euphytica, 34, 697-703.

22. Saad, J.K. Al-Salhy & Azhar A. Rasheed (2020). Effect of mung bean seed priming methods and duration on seed germination and seedling vigour. Plant Arch., 20(1), 27-31.

23. Shaila Shermin Tania, Md, Mokter Hossain, M. & Abul Hossain (2019). Effects of hydropriming on seed germination, seedling growth and yield of bitter gourd. Journal of Bangladesh Agricultural University, 17(3), 281–287.

24. Shantha Nagarajan & Pandita, V.K. (2001). Improvement in germination characteristics in artificially aged seeds of tomato by osmoconditioning. Seed Res, 29(2), 136-140.

25. Sundarrajnan, N., Nagaraju, S., Venkataramana, S. & Jaganatha, M.H. (1972). Design and analysis of experiments. University of Agricultural Sciences, Hebbal, Bangalore.

26. Surekha, M. (2002). Studies on the influence of seed invigouration treatments on seed quality and storability in onion (Allium cepa L.). M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore.

27. Umesh., Vasudevan, S.N., Bhanuprakash, K., Shakunta-la, N.M. & Arvindkumar, P.R. (2014) Standardization of suitable chemicals, methodology and vigour enhancement through seed priming technique in onion seeds. Green Farming, 5 (2), 177-181.

28. Umesh., Vasudevan, S.N., Bhanuprakash, K., Manjunatha, B., Sarika, G. & Amruta, N. (2016). Biochemical investigations on vigour enhancement in aged seeds upon seed priming in onion. Journal of Applied and Natural Science, 8 (2), 855 – 859.

29. Zhang, F., Yu, J., Johnston, C.R., Wang, Y., Zhu, K., Lu, F., Zhang, Z. and Zou, J. (2015). Seed priming with polyethylene glycol induces physiological changes in sorghum (Sorghum bicolor L. Moench) seedlings under suboptimal soil moisture environments. PLoS One, 0: e0140620. DOI: 10.1371/journal.pone.0140620.

30. Zohary, D. & Hopf, M. (2000). Pulses. In domestication of plants in the old world: The origin and spread of cultivated plants in West Asia, Europe, and the Nile Valley, 3rd Edition, Oxford University Press, New York, pp 108.