EFFECT OF DIFFERENT SEED PRIMING TREATMENTS ON SEED YIELD AND ITS QUALITY IN GROUNDNUT (*Arachis hypogaea* L.)

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Dedicated to

My Beloved Parents

For their hopes & Endless prayers

Pratik…

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EFFECT OF DIFFERENT SEED PRIMING TREATMENTS ON SEED YIELD AND ITS QUALITY IN GROUNDNUT (*Arachis hypogaea* L.)

ABSTRACT

***Key words*:** Seed priming, Seed yield, Seed quality, Groundnut

The experiment entitled "Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)" was carried out in Sagdividi Farm, Department of Seed Science and Technology during *kharif*-2018 and laboratory experiment at Seed Testing Laboratory, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh. The field experiment was conducted in FRBD with three replications. There were two genotypes *viz.*, GG-20 and GJG-22 and nine priming treatments *viz.*, untreated seed (control), water, KH_2PO_4 (1%), $CaCl_2$ (1%), KCl (1%), Boron (0.5%), GA_3 (25 ppm), $MnSO_4$ (0.5%) and KNO_3 (1%) for 6 hours priming followed by shade drying.

The observations on different plant characteristics such as field emergence percentage, days to 50 per cent flowering, plant height, days to maturity, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare, harvest index and laboratory observations such as 100 seed weight, germination percentage, root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity were recorded.

All the field observations were recorded under the sun light in three replications. Plant height, number of mature pods per plant and seed yield per plant were observed from five tagged plants. GJG-22 genotype took lower days to 50 per cent flowering and days to maturity as compared to GG-20 genotype. Plots having seed primed with $CaCl_2$ (1%) recorded earlier flowering and days to maturity which was at par with seed primed with KCl (1%) and KH_2PO_4 (1%).

GJG-22 genotype showed significantly the highest field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index over genotype GG-20. Plots having seed primed with $CaCl_2$ (1%) significantly showed highest field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index which was at par with seed primed with KCl (1%) and KH_2PO_4 (1%).

The genotype GJG-22 primed with $CaCl_2$ (1%) was non-significantly highest in field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index; while non-significantly lowest in days to 50 per cent flowering and days to maturity.

In seed quality characters seeds of genotype GJG-22 was better in 100 seed weight, germination percentage, root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity than seeds of genotype GG-20.

Seed primed with $CaCl_2$ (1%) was better in 100 seed weight, germination percentage, root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity. The higher seed quality characters noticed in $CaCl_2$ primed seeds might due to the role of calcium in membrane stabilization and act as an enzyme cofactor.

Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) was better in root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity. While its non-significant effect on 100 seed weight and germination percentage.

It was observed that seed priming has a positive effect on the sowing quality of groundnut seeds, as well as performance, leading to higher yield. Seed priming with $CaCl_2$ (1%) followed by KCl (1%) and KH_2PO_4 (1%) for 6 hours followed by shade drying recorded higher values for growth and seed yield characters, while seed priming with $CaCl_2$ (1%) which recorded higher value for quality characters as compared to other priming treatments. The increase in the seed yield by $CaCl_2$ (1%) followed by KCl (1%) and KH_2PO_4 (1%) were mainly due to increase in field emergence percentage and number of pods per plant. The increases in growth, seed yield and quality characters due to the activities of numerous enzymes, enhanced metabolic activity, presence of growth promoters, make available high energy biomolecules, improved mobilization of nutrient and more food reserve materials in seeds.

It is concluded that the seeds of groundnut primed with the $CaCl_2$ (1%) for better field emergence percentage, successful establishment of seedlings and also to get better pod yield and quality of groundnut crop.

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CERTIFICATE – I

This is to certify that the thesis/project work report entitled **"EFFECT OF DIFFERENT SEED PRIMING TREATMENTS ON SEED YIELD AND ITS QUALITY IN GROUNDNUT (*Arachis hypogaea* L.)"** submitted by **PIPROTAR PRATIK VIJAYBHAI (Registration No.: 2010117103)** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **SEED SCIENCE AND TECHNOLOGY** to the Junagadh Agricultural University is a record of bonafide research work carried out by his under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title. The candidate had fulfilled all prescribe requirements. The assistance and help received during the course of investigation have been fully acknowledged. He has successfully completed the comprehensive/preliminary examination held on **March 25, 2019** as required under the regulation for post-graduate studies. He has submitted kachcha bound thesis on **June 3, 2019.**

Place: Junagadh

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CERTIFICATE – II

Date: 11/07/2019

This is to certify that the thesis/project work report entitled **"EFFECT OF DIFFERENT SEED PRIMING TREATMENTS ON SEED YIELD AND ITS QUALITY IN GROUNDNUT (*Arachis hypogaea* L.)"** submitted by **PIPROTAR PRATIK VIJAYBHAI (Registration No.: 2010117103)** to Junagadh Agricultural University, Junagadh in partial fulfilment of the requirements for award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **SEED SCIENCE AND TECHNOLOGY** after recommendation by the external examiners were defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination was satisfactory. We, therefore, forward with recommendation.

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"Gratitude is the most exquisite form of memory"

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Place: Junagadh

Date: 03/06/2019 **(Piprotar Pratik V.)**

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CHAPTER – I

INTRODUCTION

India is one of the largest producer of oilseed in the world and occupies an important position in the Indian agricultural economy. It is estimated that nine oilseeds namely groundnut, rapeseed-mustard, soybean, sunflower, safflower, sesame, niger, castor and linseed accounted for an area of 24.69 million hectare with the production of 30.63 million tonne (Anon., 2018b). Groundnut (*Arachis hypogaea* L.) is the 13th most important food crop and 4th most important oilseed crop of the world. It is commonly called as the king of vegetable oilseeds, poor man's nut, peanut, monkey nut, earthnut, goober pea, goober, pindas, jack nut, manila nut, pygmy nut and pig nut.

The cultivated groundnut (*Arachis hypogaea* L.) is a tetraploid (amphidiploid or allotetraploid) with a chromosome number 2n=4x=40. The genome has two sets of chromosomes from two different species, thought to be *A. duranensis* and *A. ipaensis*, which are believed to have combined to form a tetraploid species, *A. monticola*, which eventually gave rise to the domesticated groundnut, *A. hypogaea* (Krapovickas, 1973). It belongs to the family *papilionaceae*, largest and most important of the three division of *leguminosae*. Groundnut appears to have originated in the South America *i.e.* North-West of Brazil.

The botanical name for groundnut (*Arachis hypogaea* L.) is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning below ground referring to the formation of pods in the soil. Different cultivars of groundnut are broadly classified into the following two groups.

1. Virginia - having bunchy, semi-spreading or spreading growth habit.

2. Spanish - having bunch growth habit.

The groundnut is a slow growing annual geocarpic plant with a central upright stem. The plants grow from 30 to 60 cm height and produced angular, hairy stems with spreading or erect branches. The spreading varieties have pods scattered along their prostrate branches from base to top whereas, the pods are found in clusters at the base of the plant of the erect or bunch type. The flowers are borne at the axils of the leaves, either above or below the groundnut, it has a relatively deep tap root system with a well developed lateral root system.

Groundnut has gained prominence for its economic importance and nutritional value. Groundnut crop has superior edible oil quality and protein in the meal. It is rich source of edible oil (49.2%), protein (25.8%), carbohydrates (16.1%), minerals and vitamins (Arnarson, 2015). It has high oleic acid content and crop is valued for both edible oil and confectionery purposes. Groundnut kernels are consumed as raw, boiled, roasted or fried products and also used in variety of culinary preparations like peanut candies, butter, peanut milk and chocolates. The byproduct cake, left after extraction of oil is good source of quality protein, and thereby an excellent feed for livestock. In addition to this, groundnut biomass like leaf and stem are good source of nutritionally high quality fodder for livestock. About 12% of total groundnut production in India is used for seed purpose, 6% for domestic uses, 81% for oil extraction and only 1% for exporting (Desai *et al.*, 1999).

Groundnut is grown throughout the tropics and its cultivation is extended to the subtropical countries lying between 45° north and 35° south and up to an altitude of 1000 meters. Groundnut is grown on 26.4 million hectare worldwide with a total production of 37.1 million tonne and an average productivity of 1.4 t/ha (Anon., 2018a). Over 100 countries worldwide grown groundnut. Developing countries constitute 97% of the global area and 94% of the global production of this crops. The production of groundnut is concentrated in Asia and Africa (56% and 40% of the global area and 68% and 25% of the global production, respectively). The major groundnut producing countries in the world are India, China, Nigeria, Senegal, Sudan, Burma and United States of America. Out of the total area 18.9 million hectare and the total production of 17.8 million tonne in the world, these countries account for about 69% of the area and 70% of the production (Madhusudhana, 2013).

India occupies the first place in regard to the area and second place in production all over the world. In India major groundnut producing states are Gujarat, Andhra Pradesh, Rajasthan, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu and Uttar Pradesh. In India 4.15 million hectare area is under groundnut cultivation in *kharif*-2017 season with the production of 7.08 million tonne and an average productivity is 1704 kg/ha. In Gujarat 1.63 million hectare area is under groundnut cultivation in *kharif*-2017 season with the production of 3.05 million tonne and an average productivity is 1879 kg/ha (Anon., 2018a).

Seeds are most important factors in existence and proliferation of plants and their quality define plants productivity in agricultural ecosystems. Germination and seedling establishment are critical stages in the plant life cycle. In crop production, plant stand establishment determine plant density, uniformity and management options (Cheng and Bradford, 1999). In arid and semi-arid environments, the water needed for germination is available only for a short period, and consequently, successful crop establishment depends not only on the rapid and uniform germination of the seed, but also on the ability of the seed to germinate under low water availability (Fischer and Turner, 1978). However, if the stress effect can be alleviated at the germination stage, chance for attaining a good crop with economic yield production would be high (Ashraf and Rauf, 2001). Strategies for improving the growth and development of crop species have been investigated for many years. A simple, low-cost, low-risk technology called 'on-farm' seed priming has been shown to improve emergence, seedling vigour and yield in a range of crops, including legumes (Harris *et al*., 1999; Musa *et al*., 2001 and Kumar *et al*., 2002).

Seed priming is a controlled hydration technique in which seeds are soaked in water or low osmotic potential solution to a point where germination related metabolic activities begin in the seeds but radicle emergence does not occur. Priming allows some of the metabolic processes necessary for germination to occur without germination taking place. It is a simple and low-cost hydration technique which can easily be adopted by farmers for improving the performance of their seeds.

Priming can be achieved in several ways namely osmo-conditioning, hydropriming, solid matrix priming, hormonal priming, biopriming and on-farm priming. Seed priming is a technique to help viability and germination of seeds. The direct benefits of seed priming in all crops included faster emergence, better, more and uniform stands, less need to re-sow, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield. The indirect benefits reported were earlier sowing of crops and increased willingness to use of fertilizer because of reduce risk of crop failure (Harris *et al.,* 2001). According to Aziza *et al.* (2004), a significant decrease in emergence time and increase in final emergence count may be because of the fact that seed priming induces a range of biochemical changes such as hydrolysis, activation of enzymes and dormancy breaking in the seed which are required to start the germination process and it resulted in improvements in field emergence heading to better canopy development and crop growth rate.

Harris *et al*. (2007) reported that seed priming led to better establishment and growth, earlier flowering, increase seed tolerance to adverse environment and greater yield in maize. The beneficial effects of seed priming have been demonstrated for many field crops such as wheat, sweet corn, mungbean, barley, lentil, cucumber etc. Rehman *et al*. (2011) reported that seed priming is a cost effective technology that can enhance early crop growth leading to earlier and more uniform stand with yield associated benefits in many field crops including oilseeds.

Quality seed is one of major constraints for increasing the productivity of groundnut. Besides, the overall productivity of this crop in India is quite low. Usually, farmers are using their own seed. The poor vigour and viability many times combines with adverse environmental condition may result in poor crop establishment and ultimately the decrease yield. The sometimes non availability certified fresh seed may compel the use of old (revalidated) seed lot and coquetry result in poor yield. During storage, reduction in germination occurs due to physiological and chemical changes in seed, pest and disease attack etc. Under this circumstance, seed priming treatment may help in proper crop establishment and to avoid the substantially loss in the yield. Not only that any case of the seed *viz.,* breeder, foundation or certified can be given pre-sowing seed priming treatment. This is most vital practice when seed is costly input as in case of groundnut. A number seed priming treatment has shown better seedling performance and crop establishment and ultimately increased yield in several crop, including groundnut.

Keeping these aspects in view, the present investigation entitled "Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)" was carried out with the following objectives:

1. To study the effect of seed priming treatments on seed yield and yield contributing characters.
2. To find out the effect of seed priming treatments on seed quality.

CHAPTER – II

REVIEW OF LITERATURE

The literature pertaining influence of different seed priming treatments to improve the seed yield and seed quality with special reference to groundnut and other related crops are being reviewed and presented in this chapter under different headings.

Seed priming

Seed priming primarily aims to invigourate seed lots, enhance the speed and total seedling emergence potential, plant growth and relative storability of a particular crop. It involves certain physiological and biochemical processes which also interact with each other.

Heydecker (1973) defined seed priming as a pre-sowing treatment in which seeds are soaked in an osmotic solution that allows them to imbibe water and go through the first stage of germination, but does not permit radical protrusion through the seed coat. Various pre-sowing seed treatments have been used to enhance seed performance notably with respect to rate and uniformity of germination thereby enabling better crop establishment (Heydecker, 1978; Bradford, 1986). Generally, any type of priming treatment would cause an effective invigoration of the dry seed, which is the inception of metabolic processes that normally occur during imbibitions and subsequently fixed by drying the seed (Heydecker and Coolbear, 1977).

2.1 Effect of seed priming treatments on seed yield and yield contributing characters

Sashidhar *et al*. (1977) reported increased yield in groundnut when seeds were treated with 1% $CaCl_2$ for 8 hours with high free proline accumulation which is an adaptive mechanism of drought tolerance. This study concluded that the seed priming with 1% $CaCl_2$ gave the higher plant height (cm), number of pods per plant, seed yield per plant (g) and seed yield per hectare (q) in groundnut.

Chatterjee *et al.* (1982) reported that the groundnut crop rises from seed kernels treated with water appreciably increased the seed yield (30 to 50%), this is mainly due to increases in number of pods per plant and higher 100 seed weight of kernels. Water soaking treatment of seeds had significantly the highest pod yield (1476 kg/ha), number of pods per plant (9.80) and 100 kernels weight (192.30 g) as compared to control (899 kg/ha, 8.80 and 172.80 g, respectively).

Bhati and Rathore (1988) conducted a field trial, in which wheat seed soaked with $CaCl_2$ (2%) and KH_2PO_4 (5%) for 14 hours, significantly enhanced the number of seedlings per meter row length (13.42 and 14.37), dry matter accumulation (0.409 and 0.482 g) and plant height (41.23 and 40.23 cm), respectively as compared to water soaking (12.96, 0.402 g and 37.52 cm).

Arjunan and Srinivasan (1989) reported that seed hardening treatment of groundnut kernels with KH_2PO_4 (2%) gave significantly increased pod yield through increased field germination per cent, higher dry matter accumulation per cent, more number of matured pods per plant compared to control.

Lee (1990) recorded that soaking groundnut seed in solution of 0, 50 and 100 ppm gibberellic acid or 50, 100 and 200 ppm indole acetic acid prior to sowing produced plants with longer main stems, more branches, higher chlorophyll content, greater numbers of flowers, internodes and pods, and greater kernel weight per plant that in the control. Seedling emergence and time to flowering were also improved by growth regulator seed treatment.

Narayanaswamy and Shambulingappa (1998) stated the result of soaked seeds in KCl (0.50%), KH_2PO_4 (0.50%), $MnSO_4$ (0.50%), $CaCl_2$ (0.50%), Boron (0.50%) and a 1:1 mixture of bavistin and thiram in field trial with groundnuts cv. JL-24 and TMV-2 at Shimoga, Karnataka. $CaCl_2$ 0.50% and KH_2PO_4 0.50% showed significantly the higher 100 seed weight (41.18 and 37.58 g), no. of graded pod per plant, field emergence (81.50% and 81.33%) and graded pod yield (1614 and 1349 kg/ha), as compared to control (32.35 g, 79.00% and 1260 kg/ha respectively).

Bastia *et al*. (1999) reported that soaking of seeds of safflower cv. Bhima in water for 12 hours, found beneficial and registered grain yield of 11.65 q/ha, which was significantly higher over control (10.02 q/ha).

Musa *et al*. (1999) conducted an experiment in Bangladesh on chickpea for non-primed: where normal dry seeds were sown; while primed: where seeds were soaked in water overnight, surface dried, and then sown within that day. Priming of seeds resulted in an overall 47% grain yield advantage, with all yield contributing factors measured showing positive effects of priming (significantly for all characters *viz.*, emergence, early growth, plant height, number of diseased plants, pod borer damage, number of plants at harvest, number of pods, grain yield and residue yield except 1000 grain mass) on yield contributing characters.

Murungu *et al*. (2003) carried out a pot experiment with cotton and maize at Zimbabwe. They showed that priming improved emergence and early growth of maize and cotton in drying soils in the laboratory. Priming increase emergence from 75 to 99% at soil matric potentials. Primed cotton seedling had longer roots than non-primed seedling at all initial matric potentials. This work indicated that there was no direct effect of priming on growth, time to flowering and maturity or yield of plants. Instead, benefits from priming appeared to be indirect effects of improvements in crop stand and the advancement of germination and emergence.

Pawar *et al.* (2003) conducted a field experiment to find out influence of seed hardening on growth and yield of sunflower cv. KBSH-1. The treatment consisted of three chemicals $CaCl_2$, $MnSO_4$ @ 1%, 2%, 3% and $ZnSO_4$ @ 0.1%, 0.2%, 0.3% along with control. The study revealed that seed hardening with $CaCl_2$ @ 2% followed by $ZnSO_4$ @ 0.1% for 6 hours seed soaking recorded decreased transpiration rate, higher total dry matter production, photosynthetic rate, head diameter, stomatal diffusive resistance and grain yield (7.72 q/ha, 7.34 q/ha, respectively) as compared to control (6.32 q/ha).

Khin *et al.* (2005) conducted experiment to study the effect of seed priming on growth performance and yield of groundnut at oilseed crop section, DAR in 2002 monsoon and post monsoon seasons. Priming treatments for 4 hours, 6 hours, 8 hours and 10 hours of two groundnut varieties (Sinpadetha-6 and Sinpadetha-7) in comparing with non-primed dry seeds were evaluated using factorial experiment in randomized complete block design with four replications. The results indicated that higher number of primed seeds germinated, emerged, grew more vigorously and flowered earlier than non-primed dry seeds.

Mubshar *et al*. (2006) conducted a field study to evaluate the influence of seed priming techniques on the seedling establishment, yield and quality of hybrid sunflower. Hydropriming and osmopriming with NaCl resulted in lower time taken to 50 per cent emergence, mean emergence time, higher final emergence, energy of emergence, plant population, achene yield, yield contributing factors and achene proteins were affected significantly by different seed priming.

Dhedhi *et al.* (2007) studied on two seed lots of groundnut *viz.*, fresh seed having high germination, vigour and revalidated seed (low vigour) to pre-soaking seed treatments for evaluation of their efficacy during summer seasons of 2003, 2004 and 2005. Pre-sowing seed invigouration by hydration for 16 hours and air drying at room temperature followed by dressing with thiram @ 0.25% registered significantly higher pod yield than the untreated seeds of revalidated seeds. The higher pod yield was resulted from significantly improved germination, speed of emergence, per cent field emergence, ultimately the better crop establishment and in turn higher plant stand. The beneficial effect of hydration followed by thiram dressing where more pronounced in the low vigour seed lot than the high vigour lot (fresh).

Limbani (2007) reported the effect of twenty treatments combination involving two seed lots of groundnut with different germination percentage and ten invigouration treatments [T_1: hydration 16 hours (control), T_2: hydration + thiram, T_3: hydration with GA_3, T_4: hydration with GA_3 + thiram, T_5: hydration with kinetin, T_6: hydration with kinetin + thiram, T_7: hydration with $CaCl_2$, T_8: hydration with $CaCl_2$ + thiram, T_9: hydration with KH_2PO_4, T_{10}: hydration with KH_2PO_4 + thiram] significantly increased growth characters *viz.*, plant height and number of branches and seed yield characters *viz.*, seed yield per plant and hectare, 100 seed weight, shelling percentage. Growth, seed yield and quality were higher in seed lot having high germination over low germination seed lot.

Jahangir *et al*. (2008) carried out experiment to determine the effects of pre-sowing treatment of calcium chloride and phosphorus fertilization individually and combinely on the yield, oil content and physio-chemical properties of groundnut. This experiment consists of three pre-sowing treatments of calcium chloride solution (0%, 0.15%, 0.25%, 0.50%) and four doses of phosphorus (0, 30, 45, 60, 75 kg/ha) with control. Pod yield of groundnut found 2.25 t/ha was maximum at 0.50% calcium chloride pre-sowing treatment. The number of pods per plant (26.86) as well as, weight of 100 seeds (88.49) found significantly increased by applying 75 kg P_2O_5/ha when compared to the control. From the interaction of pre-sowing and fertilizer treatments, *i.e.* 0.50% pre-sowing of calcium chloride (T_3) with 75 kg P_2O_5/ha (P_4) produced significantly increased of pod yield (2.54 t/ha) and oil content (47.25%) of groundnut. Responses of pre-sowing and fertilization treatments on physio-chemical properties of groundnut oil such as refractive index, peroxide value, density remained unchanged throughout this experiment.

Murata *et al*. (2008) conducted a growth chamber experiment and a field experiment to investigate the effects of pelleting or priming groundnut seed with calcium (Ca), either as calcium sulphate ($CaSO_4$), calcium chloride ($CaCl_2$), calcium nitrate [$Ca(NO_3)_2$], calcium carbonate ($CaCO_3$) or calcimax on growth of groundnut seedlings in acid soils. In the growth chamber experiment, Ca-treated and non-treated groundnut seeds were planted in acid-washed sand and watered with a dilute nutrient solution of pH 4.0 or 5.5. In the field experiment, the seeds were planted in an acid sand clay loam of pH [potassium chloride (KCl)] 4.8. Generally, pelleting or priming the seed with a Ca compound significantly reduced seedling mortality. Also, pelleting groundnut seed with Ca enhanced plant growth. An additional effect of priming was earlier emergence. The most effective Ca compound was $CaSO_4$ among the priming treatments, whereas $CaCO_3$ was the most effective among the pelleting treatments to reduce seedling mortality.

Bejandi *et al*. (2009) determined the effects of seed priming and sulphur application on cell membrane characteristics, seedling emergence, chlorophyll content and grain yield of soybean (*Glycine max* L. Merill.) in saline soil. They reported that the seed priming had significant effects on mean emergence rate (MER), emergence percentage, time of maturity, shoot length and grain yield. The highest values for these variables were observed in the priming treatments, except for the time of maturity. Priming treatments provide greater emergence rates, grain yields and interact synergically with sulphur rates.

Berchie *et al*. (2010) studied on the effect of seed priming on seedling emergence and establishment of four Bambara groundnut landraces. Two hundred seedlot of Bambara groundnut landraces; Burkina, NAV 4, NAV red and black eye were soaked separately in tap water for 24 and 48 hours. The control was not soaked in water. Seeds were sown on the field at a spacing of 20×10 cm at approximately 5 cm depth using a measured dipper. Treatments were arranged in a randomized complete block design (RCBD) with three replicates of each treatment. Days to 50 per cent emergence were significantly different among the three treatments. No significant difference was however, observed among the landraces with respect to 50 per cent emergence. Final seedling establishment was significantly different among the landraces (p=0.02). Soaking Bambara groundnut seeds in water for 24 hours significantly enhanced final seedling establishment (p=0.001). Seedling emergence was delayed under the control treatment. Percentage seedling establishment was also significantly lowest under the control treatment. Seed priming also significantly affected the final percentage seedling establishment.

Manickam *et al.* (2010) studied on the effect of seed hardening in groundnut (0.5% $CaCl_2$ and normal seed) and weed management practices in castor. In respect of groundnut, seed hardening with 0.5% $CaCl_2$ treatment recorded the highest speed of emergence, field emergence, vigour index, plant height, number of matured pods, pod yield and haulm yield.

Patel *et al.* (2010) evaluated the effect pre-sowing seed treatments on two seed lots of groundnut *viz.*, fresh seed and revalidated seed and their efficacy was evaluated during summer seasons of 2005, 2006 and 2007. They also reported that the pre-sowing seed invigoration by hydration for 16 hours followed by dressing with thiram (75% DS) @ 0.25% registered consistently and significantly higher pod yield than the untreated seeds in revalidated seeds. The higher pod yield was resulted due to significantly improved germination, speed of emergence, per cent field emergence, ultimately the better crop establishment and in turn higher plant stand. The beneficial effects of hydration followed by thiram dressing was more pronounced in the low vigour seed lot (revalidated) than in the high vigour lot (fresh).

Ahmad and Lee (2011) studied the response of sesame (*Sesamum indicum* L.) cultivars to hydropriming of seeds. Improving seedling establishment of sesame cultivars by priming resulted in increasing their grain yield. However, the grain yield of sesame cultivars were differentially affected by seed priming where grain yield of TS_3 cultivar was improved more compared to other sesame cultivars. The highest yield increase was obtained with 16 hours hydropriming. Thus, it is conceivable to suggest that this priming duration is the best treatment for invigoration of sesame seeds.

Golezani *et al*. (2011) studied to evaluate the effect of priming on seed in vigouration and field performance of soybean. Results showed that pods per plant, seeds per plant and seed yield per plant were significantly enhanced by seed priming particularly with KNO_3.

Ousman and Aune (2011) reported that seed priming increased the groundnut pod and hay yields by 18 and 20%, respectively. Micro-dosing of 0.3, 0.6 and 0.9 g fertilizer per pocket increased as groundnut pod yield across the three years by 36.7, 67.6 and 50.8% respectively compared to the control. A combination of seed priming and micro-dosing of 0.6 g increased groundnut yield by 106%. In the on-farm trials, seed priming increased groundnut and cowpea yields by 18.2 and 25.5% respectively, and seed priming combined with 0.3 g fertilizer increased their yields by 42.2 and 54.5% respectively as compared to the control.

Aymen *et al.* (2012) conducted experiment to evaluate the effects of KCl priming on the growth traits and yield of tunisian safflower under salinity conditions. Seeds were primed with KCl (5 g/l) for 24 hours at 20°C. Primed (P) and unprimed (NP) seeds were directly sown in the field and followed during eight months of plant cycle. Experiments were conducted using various water irrigations concentrations induced by NaCl (0, 3, 6, 9 and 12 g/l). Results showed that plant height of primed seeds was greater than that of unprimed seeds. Numbers of branches per plant, fresh and dry weight, heads number per plant, petals and grains yield of plants derived from primed seeds were higher compared with unprimed seeds.

Golezani *et al.* (2012) conducted experiment in order to improve field performance of aged chickpea seeds by hydropriming under water stress. A sub-sample of chickpea (*Cicer arietinum* L. cv. ILC_{482}) seeds was kept as control (non-primed, P_1) and two other sub-samples were aged at 40°C for 10 and 12 days. Consequently, three seed lots with different levels of vigour were provided. These seed lots were soaked in distilled water at 15°C for 12 (P_2) and 18 (P_3) hours and then dried back to about 20% moisture content at a room temperature of 20-22°C. Improvement of grains per plant and grain yield per plant due to hydropriming was more evident under low water availability. Hydropriming also enhanced grains per plant, grain yield per plant and per unit area more in plants from low vigour than high vigour seeds. This result clearly indicated that hydropriming repaired deteriorated seeds and enhanced their performance in the field.

Narayanareddy and Biradarpatil (2012) conducted a field experiment during *kharif*-2007 to understand the consequence of pre-sowing seed treatments on crop establishment in sunflower hybrid KBSH-1. They reported that the seeds treated with 2% $CaCl_2$ for 12 hours recorded significantly lesser days for 50% flowering (58.2), higher field emergence (81.50%) and yield per hectare (11.83 q/ha).

Narayanaswamy *et al.* (2012) studied on the effect of pre-sowing seed treatments comprising of hydration (16 hours), hydration with cold water (72 hours at 10°C), GA_3 (50 ppm), PEG-6000, hydrated seeds treated with thiram (0.25%), $CaCl_2$ (0.5% for 32 hours) and KNO_3 (0.2% for 16 hours) in groundnut. They reported that pre-soaked seed treatment increased the field emergence (%), speed of emergence, days to 50% flowering, number of pods per plant, graded pod yield (q/ha), shelling (%) and sound matured kernel (%). Among the lots studied, fresh lot was found to be the best which was recorded high field emergence (73.08%), speed of emergence (10.75), days to 50% flowering (53.41), number of pods per plant (36.53), graded pod yield (22.85 q/ha), shelling (73.25%) and sound matured kernel (73.09%) compared to revalidated lot.

Ogbuehi *et al*. (2013) conducted experiment to study the effect of hydro priming duration on performance of morphological indices of Bambara groundnut. The treatments are 12 hours, 24 hours, 36 hours, 48 hours and 0 hours which served as control (untreated seeds). Result indicated that all studied traits such as percentage emergence, plant heights, leaf area, leaf area index, were significantly affected at 5% probability level. The 24 hours duration gave the highest percentage emergence (61.8%), leaf area (130.91 cm^2), plant height (25.67 cm), number of leaves (81.76). Control gave the highest leaf area index (0.126) while the 12 hours produced the highest net assimilation rate (0.0088 $mgcm^2$). In conclusion, 24 hours hydropriming duration improved the performance of growth indices measured whereas the 36 hours was the least effective. Therefore, the results suggest that hydropriming is a useful method of improving seedling emergence, stand establishment and yield of Bambara groundnut in the field hence should be recommended for poor farmers who are in engaged in production of Bambara groundnut.

Abdolahpour and Lotfi (2014) conducted experiment on seed priming affected physiology and grain yield of chickpea under salt stress. Results showed that the KNO_3 was proper trait than that of hydropriming to improving germination rate.

Priming seed by water and KNO_3 enhanced grain yield approximately 13% and 27%, respectively in comparison to control. As a result of this research chickpea was sensitive plant to salinity and priming especially by KNO_3 can be improved physiological characteristic and grain yield of this plant.

Arif *et al*. (2014) carried out the experiment to determine the effects of osmo and hydropriming on phenology, yield components and biomass yield of soybean (*Glycine max* L. Merill.) cv. William-82. They reported that the plants from primed seed flowered and matured faster than plants from non-primed seed. Primed seed gave taller plants. Averaged over all treatments, priming for 6 hours or with -1.1 MPa, were the most beneficial treatments. It is concluded that priming with PEG was much effective but priming with water alone was also better than control.

Chavan *et al.* (2014) conducted experiment to determine the importance seed priming on field performance and seed yield of soybean. The variety Phule Kalyani primed with $CaCl_2.2H_2O$ (0.5%) were superior in plant height, number of branches, number of pods per plant, number of seeds per pod, lesser days to 50% flowering, days to maturity, seed yield per plant and seed yield per hectare over those raised from the variety JS-335.

Singh *et al.* (2014) conducted an experiment to study the effect of osmopriming duration on germination, emergence and early growth of cowpea in Nigeria. The results showed that osmopriming with KNO_3 for different durations were superior to unprimed treatment in term of seed germination, emergence, plant height and dry matter accumulation in cowpea. Primed seeds (both osmopriming and hydropriming) increased performance of cowpea. However, osmopriming with KNO_3 salt (soaked in 1% KNO_3 salt solution and dried before sowing) for 6 hours could result in greater seed germination and seedling height than hydropriming.

Agawane and sachin (2015) carried out experiment to determine the effect of seed priming on crop growth and seed yield of soybean (*Glycine max* L. Merill.). The results exhibited that seeds primed with GA_3 @ 100 ppm (T_4), 0.5% KNO_3 (T_5) recorded significantly higher germination percentage *i.e.* 87.33% and 87.00% respectively over the untreated control T_1 (83.00%). The treatments (T_4) GA_3 100 ppm 12 hours (77.19), (T_8) hydration with IAA @ 80 ppm 12 hours (76.55) and (T_3) hydration with $CaCl_2$ (2.0%) 12 hours (76.22) maintained the optimum plant stand at harvest over untreated control (T_1). This may likely contributed for boosting up economic yield in soybean cultivar, JS-9305. The seed priming treatments (T_4) GA_3 100 ppm 12 hours, (T_7) hydration with water + Bavistin 3.0 g/kg found effective for improvement in dry matter content of seedling (g) in soybean variety JS-9305. The treatments (T_4) 100 ppm GA_3 12 hours (2078.00 g/plot), (T_8) hydration with IAA 80 ppm 12 hours (2008.67 g/plot), (T_5) hydration with 0.5% KNO_3 12 hours (1991.00 g/plant) seed yield per plot respectively over the untreated control T_1 (1647.67 g/plot) showing to the corresponding favourable improvement in number of pods per plant, number of seeds per pod, test weight (g), seed yield per plot (g), seed yield per ha (q), biological yield (g) and numerical harvest index (%).

Bhingarde *et al*. (2015) revealed that the seed priming significantly influenced the seed yield and yield contributing characters of groundnut than untreated seeds. The maximum seed yield was recorded due to seeds primed with $CaCl_2$ 1% followed by KCl 1%. The seeds primed with $CaCl_2$ 1% recorded the higher field emergence percentage, plant height (cm), number of pods per plant, seed yield per plant (g), and seed yield per hectare (q) followed by KCl 1%. In case of flowering and maturity, the seeds hydrated with $CaCl_2$ 1% had earlier for flowering and maturity than control. Among the genotypes studied RHRG-6083 recorded significantly higher field emergence, plant height, pods per plant, had earlier in flowering and maturity and produced higher seed yield per hectare (q) than TAG-24.

Mazed *et al.* (2015) conducted experiment to study the response of seed priming on growth and yield of chickpea. The experiment comprised as one factor: seed priming with gibberellic acid (GA_3)-5 levels: GA_3 75 ppm-T_1, GA_3 150 ppm-T_2, GA_3 225 ppm-T_3, GA_3 300 ppm-T_4 and hydropriming-T_5. The result indicated significant variations in date of emergence, date of first flowering, date of 50% flowering, plant height, number of branches per plant, total dry matter, number of pod per plant, date to pod maturity, pod length, weight of 1000 seed, grain yield, stover yield, biological yield and harvest index due to seed priming. Among the treatment on maximum plant height and dry matter content recorded of plant in T_3 irrespective of growing period. This treatment also exhibited maximum number of pods per plant, longest pod length and maximum number of seed per pod, whereas required minimum duration for pod maturity. The maximum weight of 1000 seed, high grain yield and harvest index were found. When chickpea was primed with 225 ppm GA_3 that ensure the best production.

Shahram (2015) reported that the priming methods and duration increased germination percentage, germination rate, number of pods per plant, seed numbers per pod, 1000-seed weight, biological and seed yields. According to the results of this experiment, seed priming by H_2O with 18 hours had an appropriate performance and could increase seed germination, seed yield and yield components to an acceptable level. Therefore, hydropriming is a simple, low cost and environmentally friendly technique for improving seed yield in soybean.

Aroubandi (2016) studied the effects of seed priming on yield components in pea (greenaro). Priming treatments including control (no priming), hydropriming, priming with calcium chloride, zinc sulphate, and potassium chloride were assigned to subplots. The results indicated a significant effect of the priming treatments on the average number of pod, pod fresh weight, number of grains per plant, average grain weight, germination percentage, the lowest pod distance from land, the biggest pod size, pod total weight, number of pods and grain fresh weight. While, the results indicated an insignificant effect of the priming treatments on the pod dry weight, grain dry weight, protein content, the highest pod distance from land, the smallest pod size. The maximum average number of pod, grain fresh weight, pod number and pod total weight were observed in the control treatment; the maximum pod weight and number of grains per plant in the calcium chloride treatment; the maximum grain weight average in the potassium chloride treatment; the maximum germination percentage in the zinc sulphate treatment and the maximum pod size in the hydropriming treatment.

Benton (2016) studied on the effectiveness of current boron application recommendations and practices on peanut (*Arachis hypogaea* L.) in the Virginia - Carolina region. This research examines if recommended B application rates and times are still necessary for optimal yield, plant health and seed quality for current cultivars. Two experiments in seven fields compared four total amounts of B applied (0, 0.3, 0.6 and 1.1 kg/ha), and application time (planting; beginning peg, R_2; full seed, R_6; planting and R_2; planting and R_6), and runner and Virginia market types, newer and obsolete cultivars, with or without B fertilization. Leaf B was elevated only directly after fertilization ($p=0.004$, $p<0.001$), and in relation to total B applied ($p<0.001$), but seed B content was unaffected. Yield was not impacted by B rate or application time. Yield was higher ($p=0.012$) for newer cultivars when B fertilized, but no different than obsolete cultivars with B. Seed from obsolete cultivars had higher ($p=0.010$) B, no difference between market types or B fertilization. Germination of all seeds were ≥97%.

Galahitigama and Wathugala (2016) conducted experiment to investigate the effect of different pre-sowing seed treatments on salinity tolerance of rice seedlings. rice variety At-362 was used for these experiments. Various organic and inorganic treatments such as coconut water, fermented milk water, fermented rice water, ascorbic acid, KCl, KNO_3, $ZnSO_4$, $CaCl_2$ and water (control) were used as treatments. Under saline condition plant height, number of leaves, root volume and shoot dry weight of seedlings were taken as growth characters. The results indicate from plant growth under saline condition revealed 2% $CaCl_2$ enhance the salinity tolerance of initial growth of rice seedlings. The highest plant height, number of leaves, root volume and shoot dry weights were recorded in 2% $CaCl_2$. However, considering with control treatment other chemical solutions have given positive effect on plant growth and development under saline conditions.

Kumar *et al.* (2016) studied the effect of different seed priming treatments on yield and yield components of wheat (*Triticum aestivum* L.) under irrigated and rainfed conditions with cv. HPW-236. The first factor was situation *i.e.* irrigated and rainfed situation and the second factor was priming treatments *viz.*, unprimed seed (control), tap water, KNO_3 (2.5%), KCl (2.0%) and KH_2PO_4 (1.0%). Results showed that situation and priming treatments significantly reduced the days to 75% field emergence, days to 75% flowering, days to maturity, increased the plant height (cm), leaf area (cm^2), spike length, number of tillers per plant, number of spikes per plant, number of spikelets per spike, number of grains per spike, 1000-grain weight, seed recovery percentage, straw yield and seed yield. Results of the experiment showed that seed priming with KNO_3 (2.5%) and water for 16 hours significantly increased seed germination, seed yield and yield components of wheat under both irrigated and rainfed situations.

Negewo (2016) conducted experiment to determine the effect of seed priming for improving chickpea variety productivity and to determine the effectiveness of seed priming treatment and variety on stand establishment. The study indicated that all the phenological and growth traits significantly differed as a result of priming treatment and variety. With respect to yield and yield related traits, only seed yield (kg/ha), harvest index (%), seeds per plant and seeds per pod were significantly affected by the main effect. While, the rest of yield related traits responded differently due to variety alone. However, all variables studied in the field were not significantly affected by the interactions of the main effects. Improvement made due to main effect of hydro and osmopriming was statistically similar for all phenological traits; seeds per plant and seeds per pod was considerably improved as a result of osmopriming than hydropriming. However, plant height, stand count at emergence and at harvest, seed yield (kg/ha) were substantially increased by 7, 10, 12 and 15%, respectively as a result of water priming over the control.

Beedi *et al.* (2017) conducted experiment on the effect of seed priming on growth and seed yield of kabuli chickpea cv. MNK-1 (*Cicer arietinum* L.) at UAS Raichur. The results revealed that seeds primed with GA_3 @ 50 ppm + seed coating of *Trichoderma harzianum* @ 15 g/kg of 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% flowering (66 days), more number of pods per plant (33). Whereas, seeds treated with mancozeb 50% + carbendazim 25% @ 3 g/kg of seed recorded significantly higher seed yield per plant (21 g) and seed yield per hectare (1869 kg/ha).

Fatemeh *et al.* (2017) conducted experiment on the effects of seed priming on chlorophyll content and yield components of pinto beans. The results showed that pre-treatments had a significant effect on yield and yield components ($P<0.05$). The highest 100 seed weight, number of seeds in pod, number of pods, pods length, biological yield, and grain yield were observed in water at 12 hours and calcium chloride at 3 hours. Pre-treatments were the most effective ways on yield and yield components.

Jadhav *et al*. (2017) reported the effect of seed priming contributed for boosting up economic yield in soybean cultivar, JS-335. Highest value for seed yield per hectare was recorded by treatment T_3-$CaCl_2$ @ 1% (20.12 q/ha) followed by treatment T_4-GA_3 @ 50 ppm (19.02 q/ha), T_5-KNO_3 @ 1% (18.35 q/ha). All other treatments recorded higher yield than untreated control (14.05 q/ha) showing to the corresponding favourable improvement in number of pods per plant, number of seeds per pod, test weight (g), seed yield per plot (g) and seed yield per hectare (q).

Mishra *et al.* (2017b) conducted the experiment in order standardize the best method of priming specific to pigeonpea bahar variety. Seed priming using various method like that *viz.,* hydropriming, halopriming, osmopriming and biopriming were evaluated by screening a range of duration and concentration *viz.,* control, hydropriming, osmopriming (PEG 20%), halopriming (KCl 1% and $CaCl_2$ 1%), biopriming (neem leaf extract 5% and eucalyptus extract 5%) for 14 hours. It was found that all the priming treatments showed significance difference with the control and the highest field emergence per cent and plant nodulation characters were observed for PEG_{6000} priming and highest nodulation was observed in PEG and KCl.

Tahir *et al.* (2017) studied the effect of seed priming with iron (Fe) and zinc (Zn) on growth and yield components of groundnut (cv. BARI-2011) was evaluated by using different doses of Fe (0.1% and 0.3%) and Zn (0.5% and 1.0%) in RCBD design with two factors factorial arrangement having three replications. Data revealed that plant height and number of plants were highest at 0.3% Fe in combination with 1.0% Zn. Similarly, numerical values for all measured yield characters *i.e.* number of pods per plant, kernel weight (kg/ha), 100 kernel weight (g), pod yield (kg/ha), biological yield (kg/ha), harvest index (HI) and shelling percentage were significantly higher at 0.3% Fe in combination with 1.0% Zn as compared to the control.

Das and Mohanty (2018) studied the effect of a few priming treatments on performance of groundnut. They used a partially deteriorated seeds were subjected to priming treatments, *viz.,* hydropriming of kernels for 2, 3, 4 and 5 hours and moist sand conditioning (MSC) of kernels for 24, 36, 48, 60 and 72 hours. An unprimed control was maintained for comparison. Highest field emergence of 75.60% was recorded in MSC-24 hours, followed by 74.4% in MSC-36 hours, as against 59.2% in unprimed seeds. The primed seeds also took less number of days to flowering initiation and maturity, with minimum number of days to flowering and maturity recorded in MSC-24 hours, followed by MSC-36 hours. MSC-24 hours produced highest pod yield of 1557.14 kg/ha followed by MSC-36 hours, hydropriming-3 hours and MSC-48 hours.

Kunghatkar *et al.* (2018) conducted experiment to study the influence of seed hardening techniques on growth and yield in chickpea [*Cicer arietinum* (L.)]. Seven treatment *i.e.* control (T_0), distilled water (T_1), hydration with KNO_3 (2%) (T_2), hydration with NaCl (2%) (T_3), hydration with $CaCl_2$ (2%) (T_4), hydration with

KH_2PO_4 (2%) (T_5), hydration with KCl (2%) (T_6) replicated three times each were carried out in the plot in randomized block design. Maximum increase in growth and yield contributing characters (plant height, days to 50% flowering, field emergence, number of pods per plant, number of grains per plants, test weight and grain yield in chickpea) was observed with seed hardening techniques. More over treatment T_4 [(hydration with $CaCl_2$ (2%)] showed better result.

Prabhu *et al.* (2018) studied the effect of pre-sowing chemical and organic seed hardening treatment on yield characters in rice cv. IR-36 seeds. They used seed treatment *viz.*, 1% $CaCl_2$, l% KCl, 1% KNO_3, l% NaCl, 10% cow dung and 3% panchakavya. The hardened seeds were evaluated field experiments for growth and yield attributing characters along with control. The results reveal that seeds hardened with 1% $CaCl_2$ recorded higher values for growth and yield characters.

Shete *et al*. (2018) carried out experiment to study the effect of seed priming on yield of soybean (*Glycine max* L. Merill.). Results indicated relatively higher mean performance of hydropriming for 1 hours in yield and yield contributing characters such as days to field emergence, number of pods per plant, seed yield per plant, seed yield per ha, test weight and harvest index.

Teggelli *et al.* (2018) studied the influence of seed priming with $CaCl_2$ (2%) in pigeonpea growth and yield characters. The result reveals that seed priming with $CaCl_2$ (2%) recorded higher plant height (185.7 cm), number of branches (17.3), total number of pods (293 pods/plant), number of seed per pod (4.2), 100 seed weight (10.7), seed yield (13.6 q/ha) and field emergence (87%) compared to control under drought condition.

Venkatesh *et al.* (2018) reported the effect of priming treatments on seedling vigour, growth and yield contributing characters in groundnut under rainfed conditions. The maximum seed yield (2255 kg/ha) was recorded due to seed primed with $CaCl_2$ 2% followed by $CaCl_2$ 1% (2036 kg/ha). The seed primed with $CaCl_2$ 2% recorded the higher field emergence percentage (89.67%), plant height (39.87 cm), number of pods per plant (27), and 100 seed weight (38 g) followed by $CaCl_2$ (1%). In case of flowering and maturity, the seeds hydrated with $CaCl_2$ 2% had earlier for flowering and maturity than control.

2.2 Effect of seed priming treatments on seed quality

Nalawadi *et al*. (1973) reported that the presoaking of soybean cultivars in water for 24 hours had significant effect on germination and seedling fresh weight. The increase in germination percentage was from 21.20 to 54.00 and seedling fresh weight from 1.74 g to 3.45 g. It concluded that hydropriming improve the germination percentage and seedling fresh weight.

Christiansen and Foy (1979) reported a seed primed with higher concentration of calcium salts to improve the germination percentage and act as a membrane integrity. Concentration of calcium salts and germination percentage were positively related suggesting the role of calcium as an important component in membrane stabilization and as an enzyme cofactor.

Kulkarni and Eshanna (1988) reported that 1% $CaCl_2$ seed treatment of maize seeds increased germination, speed of germination, emergence, vigour index and seedling vigour significantly over untreated seed.

Joseph and Nair (1989) studied the effect of seed hardening on germination and seedling vigour in paddy. They concluded that seed hardening in rice with 10% cow dung solution registered its superiority in early germination, root and shoot growth and vigour index.

Subbaraman and Slevaraj (1989) reported that soaking of groundnut (JL-24) seeds in 0.50% $CaCl_2$ solution for 32 hours followed by 10 hours drying resulted in higher germination (98%), field emergence (92.00%), vigour index (3372), and oil content (50.72%), compared to water soaking (77.00%, 91.60%, 3007, and 47.19%). It concluded that the seed priming with $CaCl_2$ (0.5%) give the higher results in germination, field emergence, vigour index and oil content.

Rangaswamy *et al.* (1993) studied that the pre-sowing soaking with calcium chloride at 0.4%, cycocel at 0.2% and KH_2PO_4 1.0% improved germination, vigour index and root shoot ratio in groundnut.

Anbazhagi (1997) found that soaking the groundnut kernels in solution of KH_2PO_4 (0.5, 0.75 and 1%), $CaCl_2$ (0.5 and 1%) and groundnut micronutrient mixture (0.25 and 0.5%) increased the germination potential, speed of germination, seedling length, dry matter production and vigour.

Narayanaswamy and Shambulingappa (1998) stated the result of soaked seeds in KCl (0.50%), KH_2PO_4 (0.50%), $MnSO_4$ (0.50%), $CaCl_2$ (0.50%), Boron (0.50%) and a 1:1 mixture of bavistin and thiram in field trial with groundnuts cv. JL-24 and TMV-2 at Shimoga, Karnataka. $CaCl_2$ 0.50% and KH_2PO_4 0.50% showed significantly the higher germination percentage (85.8% and 81.67%) as compared to control (78.50%).

Bose and Saxena (1999) made attempts to enhance the seedling performance of seeds through plant growth regulators pre-soaking treatments using four groundnut cultivars *viz.,* ICGS-11, ICGS-76, TG-22 and TKG-19A and reported that seed treatment with gibberellins and kinetin gave the best result in term of percentage germination (92.50 and 90.00%), seedling dry weight (0.886 and 0.880 g), seedling vigour index (83.60 and 79.60), compared to water soaking (82.50%, 0.615 g, 47.77, respectively).

Massawe *et al.* (1999) observed that the hydration for different durations in three cultivars of Bambara groundnut significantly increased the germination percentage (49.00 to 74.00%), seedling emergence (42.00 to 72.00%), and dry weight (160 to 250 mg). Un-soaked seeds started germination six days after sowing while hydrated seeds started germination on the fourth day. It concluded that the hydropriming give the best results in germination percentage, seedling emergence and dry weight than the unprimed seeds.

Sanjeeva Kumar (2000) invigorated seeds of soybean cultivar JS-335 having initial germination of 72% with different chemical solutions for three hours; KH_2PO_4 (2%) could enhance germination up to 88% and was found superior in maintaining seed viability and vigour and increased yield. Hence the seed priming with KH_2PO_4 (2%) give the higher germination percentage, viability, vigour and increased yield.

Basu and Choudhary (2005) reported that pre-sowing hydration treatment significantly enhanced field emergence (79.77%), rate of germination (32.59) and seedling dry weight (3.92 g) of parental lines in soybean hybrid seed production compared to control (61.90%, 29.27 and 3.73 g respectively) in both seasons, where in the treatment effect was more evident in winter season. It concluded that seed priming with water give the best results in field emergence, rate of germination and seedling dry weight.

Farooq *et al.* (2006) studied the effects of seed hardening treatments using different salt solutions on the germination, emergence and seedling vigour in coarse and fine rice. Seeds were hardened both using tap water (referred to as hardening) and with $CaCl_2$, KNO_3, KCl, NaCl solution (osmo hardening) in such way that osmotic potential of all the solutions were -1.25 MPa. In both coarse and fine rice, osmo hardening with $CaCl_2$ performed the best compared with all other treatments as indicated by lower values of time to start germination, mean germination time, time to get 50% germination and mean emergence time and higher values of final germination and emergence, speed and energy of germination, root and shoot length and seedling fresh and dry weight.

Limbani (2007) reported the effect of twenty treatments combination involving two seed lots of groundnut with different germination percentage and ten invigouration treatments [T_1: hydration 16 hours (control), T_2: hydration + thiram, T_3: hydration with GA_3, T_4: hydration with GA_3 + thiram, T_5: hydration with kinetin, T_6: hydration with kinetin + thiram, T_7: hydration with $CaCl_2$, T_8: hydration with $CaCl_2$ + thiram, T_9: hydration with KH_2PO_4, T_{10}: hydration with KH_2PO_4 + thiram] significantly increased seed quality characters *viz.,* germination, field emergence, root and shoot length, vigour index, oil content compared to control.

Bellur (2009) carried out the laboratory experiments to find out the influence of different calcium salts and their concentrations on crop growth, seed yield, quality and storability of soybean (cv. JS-335) and founded that the seeds treated with calcium chloride exhibit higher germination (74.42%) and seedling vigour index (2184), with less seed infestation (18.42%), moisture content (8.44%) and electrical conductivity (8.94 dSm^{-1}) over control throughout 12 month storage period. It was followed by calcium carbonate and calcium oxychloride. Similar significant higher germination (67.76%) and seedling vigour index (2295) were recorded in 1.0% concentration compared to 0.5% concentration irrespective of calcium salts throughout storage period. Likewise, better germination and vigour index were also noticed in calcium chloride with 1.0% concentration as compared to control during 12 months period.

Bajehbaj (2010) conducted experiment to evaluate the effects of NaCl priming with KNO_3 on the germination traits and seedling growth of four *Helianthus annuus* L. cultivars under salinity conditions. Seeds of four spring sunflower (Armawireski, Airfloure, Alestar and Ismailli) were primed with KNO_3 (-1.0 MPa) for 24 hours in continuous 30°C. Primed (P) and unprimed (NP) seeds were cultured in medium grade perlite and placed in greenhouse for 40 days. Experiments were conducted using various osmotic pressures induced by NaCl (5, 10, 15, 20 and 25 dSm^{-1}) in salinity experiment. Results showed that germination percentage of primed seeds were greater than that of unprimed seeds. Radicle length, seedling height and dry weight and leaf number of plants derived from primed seeds were higher compared with unprimed seeds.

Ahmad and Lee (2011) studied that the response of sesame (*Sesamum indicum* L.) cultivars to hydropriming of seeds. Results showed the hydropriming increased germination percentage, germination rate and seedling size, compared with non-primed seeds.

Assefa and Hunje (2011) reported that the speed of germination in soybean increased as the priming duration increased from 0 to 14 hours. The germination decreased with increased priming duration beyond 14 hours. In the early stage of germination seeds of a wide variety of plants can be dried back to 10% moisture without loss of viability, but if they are dried after radical emergence (as the duration increases) the seeds are not able to germinate. The priming duration affected the speed of germination more than the final percentage of germination. Significantly higher speed of germination (57.1), root length (16.3 cm), shoot length (13.8 cm) and vigour index (2933) were consistently in favour of 14 hours seed priming duration as compared to lesser and more duration.

Bassi *et al.* (2011) reported that priming with GA_3 @ 50 ppm for 2 hours enhanced emergence, germination and speed of germination in soybean as compared to non-primed seed lots. Hence the seed priming with GA_3 enhanced emergence, germination and speed of germination.

Abdolahi *et al.* (2012) reported that priming with KH_2PO_4 was more effective than $CaCl_2$ in reducing the electrolyte leakage, increase in mean germination rate, germination (%), shoot length, root length, seedling dry weight and seedling vigour index in aged seeds of all cultivars. The results of this research showed that use of KH_2PO_4 for priming enhances seed germination and seedling growth of rapeseed under difference aging levels.

Ahmadvand *et al.* (2012) conducted two laboratory and green house experiments to evaluate effect of seed priming with KNO_3 on germination and emergence traits of two soybean cultivars Gorgan-3 and Sahar. They reported that seed priming with KNO_3 caused a significant increase in germination and emergence percentage, radical and plumule length, seedling dry weight, plant height, plant leaf area and plant dry weight. Seed priming led to significant increase of leaf area per plant and leaf area of non-primed seeds was decreased by 78%.

Goudarz *et al.* (2012) conducted experiment on effects of seed priming on seed germination and seedling emergence of cotton under salinity stress. Results revealed that under introduced salinity stress, hydroprimed seeds and those primed with KNO_3 showed increased properties such as seed germination and seedling emergence, length of radicle and plumule, weight of dried seedling and plant, average length of plant and per plant leaf area. Average germination and emergence time were also reduced by priming. Meanwhile, priming with KNO_3 @ 6 g/l had the most positive effects on measured traits and at the highest level of salinity stress.

Kazem *et al*. (2012) were soaked chickpea seeds in distilled water at 15°C for 12 (P_2) and 18 (P_3) hours and then dried back to about 20% moisture content at a room temperature of 20-22°C. The lowest electrolyte leakage was recorded for primed seed lots. Increasing seed vigour due to less deterioration and hydropriming also resulted in increasing germination and seedling emergence rate and percentage and seedling dry weight.

Narayanareddy and Biradarpatil (2012) conducted a field experiment during *kharif*-2007 to understand the consequence of pre-sowing seed treatments on seed quality of sunflower hybrid KBSH-1. They reported that the seeds treated with 2% $CaCl_2$ for 12 hours recorded significantly higher germination percentage (86.6%) and seedling vigour index (2243).

Narayanaswamy *et al.* (2012) studied on the effect of pre-sowing seed treatments comprising of hydration (16 hours), hydration with cold water (72 hours at 10°C), GA_3 (50 ppm), PEG-6000, hydrated seeds treated with thiram (0.25%), $CaCl_2$ (0.5% for 32 hours) and KNO_3 (0.2% for 16 hours) in groundnut. They reported that fresh lot was found to be the best which was recorded high germination (82.43%), seedling dry weight (216 mg) and vigour index (1802) compared to revalidated lot.

Ganesh *et al.* (2013) studied the effect of pre-sowing hardening treatments using various plant growth hormones on seed germination and seedling establishment of two green gram varieties ADT-3 and VBN-1. The green gram seeds were pre-soaked in various solutions of 5 ppm and 10 ppm indole acetic acid (IAA), gibberellic acid (GA_3) and indole butyric acid (IBA), concentrations respectively. The soaked seeds were air dried for 12 hours and thereafter sown in petri plates lined with filter paper. The result of the study showed significant difference in percentage germination among the green gram varieties and hormone concentrations. Seeds treated with 5 ppm IAA, GA_3 and IBA showed significant increases in germination percentage and seedling growth in the two green gram varieties. Germination and seedling growth decreased markedly with increasing hormone concentration. Based on these results, 5 ppm concentrations of hormones were found to be the best for enhancing seedling growth in green gram.

Hamidi and Hadi (2013) studied to evaluate the effect of polyethylene glycol (PEG), urea and potassium nitrate (KNO_3) priming on sunflower germination traits and early growth. The study included two experiments based on completely randomized design (CRD) with four replicates. The first and second experiment consisted comparison urea with PEG and KNO_3 with PEG, respectively; which each priming method had four levels (0.00, -0.05, -0.10 and -0.15 bar). The result showed that urea and KNO_3 priming had no positive and significant effect on germination percentage, while significantly increased radicle and shoot length. Also PEG in both experiments significantly decreased germination percentage and increased seedling growth. Increasing effect of urea and KNO_3 seed priming on seedling growth was more than PEG, thus these increasing effects of urea and KNO_3 priming could be due to seed nutrition.

Pirmani *et al.* (2013) studied to evaluate the effect of hydropriming, halopriming with 2% KNO_3, and osmopriming with $ZnSO_4$ (200 mM Zn) and KH_2PO_4 (50 mM P) on seedling vigour and field emergence of sunflower. Priming significantly improved seed germination, germination rate, seed vigour index, shoot, root and seedling dry weights, and reduced mean germination time and electrical conductivity of seed leachates, compared to the unprimed control. Hydropriming was more effective in improving all studied characters compared to priming with chemical salts. Effect of priming with $ZnSO_4$ on germination trait, seed vigour and seedling dry weight were more pronounced than the effect of other halopriming and osmopriming treatments. Priming improved seedling emergence, emergence rate and emergence time. Priming with water and KH_2PO_4 resulted in higher seedling emergence and establishment in the field, compared to the control and priming with KNO_3 or $ZnSO_4$. Mean seedling emergence time was also reduced by priming, particularly hydropriming. Hydropriming is therefore a simple, low cost technique for improved seed germination and seedling emergence of sunflower.

Nazir *et al.* (2014) conducted experiment to check the effects of hydropriming and priming with potassium nitrate on cotton seed germination and seedling emergence. Different priming treatments used as hydropriming, KNO_3 and NaCl. Results showed that under salinity stress, hydro and potassium nitrate priming increased properties such as: germination of seed, emergence of seedling, radicle length, dry weight and plant leaf area. Priming with KNO_3 had the most positive effects on given traits under salinity stress.

Tiwari *et al*. (2014) conducted a field experiment over two consecutive years (2009-10 and 2010-11) at the research farm of DSR, Mau to study the effect of potassium nitrate and tap water on seed quality characters, growth and yield of pigeonpea (*Cajanus cajan* L.). Results based on two years data revealed that pigeonpea seeds primed with KNO_3 and tap water significantly enhanced the seed germination, seedling length, seedling dry weight, vigour index-I and II over unprimed control in all the varieties. Among KNO_3 concentrations, 0.30% showed significantly higher values in above characters over rest of KNO_3 concentrations including tap water.

Bhingarde *et al*. (2015) reported the seed priming significantly influenced the seed quality characters *viz.*, germination percentage (%), seedling dry weight (g) and vigour index-I, were enhanced by seeds primed with $CaCl_2$ 1% followed by KCl 1%. In case of electrical conductivity of seed leachate, the seeds hydrated with $CaCl_2$ 1% recorded lower electrical conductivity than unprimed seeds.

Chavan and Tagad (2015) conducted experiment to evaluate the influence of seed priming on resultant seeds of soybean [*Glycine max* (L.) Merill.] varieties. There were two varieties *viz.*, Phule Kalyani and JS-335 while six priming treatments *viz.*, control (unprimed seeds), hydropriming, KCl @ 10 ppm, $CaCl_2.2H_2O$ @ 0.5%,

KH_2PO_2 @ 50 ppm and GA_3 @ 20 ppm. The variety Phule Kalyani primed with $CaCl_2.2H_2O$ (0.5%) were superior in 100 seed weight, germination percentage, root length, shoot length, vigour index and electric conductivity of harvested seeds over those raised from the variety JS-335.

Jamadar and Chandrashekhar (2015) studied the effect of chemical and biological seed treatments on germination performance of GCH-7 hybrid castor (*Ricinus communis* L.) during 2013 and 2014. Statistical analysis indicated seed priming with 2% $CaCl_2$ solution significantly reduced mean germination time (5.16 and 5.17). Whereas, daily germination index (16.63 and 15.96), coefficient of velocity of germination (0.180 and 0.173), seed germination (94.14 and 94.33%), seedling root length (16.00 and 16.98 cm), shoot length (13.36 and 14.17 cm), seedling vigour index-I (2764 and 2938), seedling dry weight (174.7 and 176.7 mg) and seedling vigour index-II (16448 and 16668) were significantly improved during both 2013 and 2014 years of experiment respectively, compared to the untreated seeds, such improved seed germination performance is due to efficient repair of deteriorated seed parts in presence of Ca^{++} ion.

Mazed *et al.* (2015) conducted experiment to study the response of seed priming on seed quality of chickpea. The experiment comprised as one factor: seed priming with gibberellic acid (GA_3)-5 levels: GA_3 75 ppm-T_1, GA_3 150 ppm-T_2, GA_3 225 ppm-T_3, GA_3 300 ppm-T_4 and hydropriming-T_5. The result indicated significant variations in germination percentage and vigour index due to seed priming. Among the treatment maximum germination percentage and vigour index were found in T_3. It indicated that when chickpea was primed with 225 ppm GA_3 that ensure the best seed quality.

Galahitigama and Wathugala (2016) conducted experiment to investigate the effect of different pre-sowing seed treatments on seed germination of rice seedlings. rice variety At-362 was used for these experiments. Various organic and inorganic treatments such as coconut water, fermented milk water, fermented rice water, ascorbic acid, KCl, KNO_3, $ZnSO_4$, $CaCl_2$ and water (control) were used as treatments. Cumulative germinated seed count was taken to interpret germination percentage. Results revealed that highest seed germination was observed in KNO_3 primed seeds (95%) and lowest was recorded in ascorbic acid treated seeds (82%). Other chemicals such as $CaCl_2$, $ZnSO_4$ and KCl also showed positive response for seed germination compared to control treatment.

Jadhav *et al*. (2017) reported the effect of seed priming contributed for boosting up germination in soybean cultivar, JS-335. The results exhibited that seeds primed with $CaCl_2$ @ 1% (T_3) and GA_3 @ 500 ppm (T_4) recorded significantly higher germination percentage *i.e.* 84.67% and 83.33%, respectively over the untreated control T_1 (76.00%).

Kumari *et al.* (2017) conducted experiment to study the effect of halopriming and hormonal priming on seed germination and seedling vigour in maize (*Zea mays* L.) in order to standardize the suitable method of priming for maize seeds. Three methods of priming *viz.,* T_0-unprimed (control), T_1-hydropriming with distilled water, T_2-hormonal priming with GA_3 100 ppm, T_3-hormonal priming with salicylic acid 100 ppm, T_4-hormonal priming with ascorbic acid 100 ppm, T_5-halopriming with KNO_3 1% and T_6-halopriming with $CaCl_2$ hydration for 12 hours. It was found that among all the priming showed significance difference with the control and the highest germination percentage (%), germination index, energy of emergence, seedling length (cm), seedling fresh weight (g), seedling dry weight (g) and vigour indices were observed in GA_3 priming for 12 hours and also showed that seed priming with salicylic acid and $CaCl_2$ were found to increase the seedling characters.

Mishra *et al.* (2017a) conducted experiment in order standardize the best method of priming specific to red gram. Seed priming using various method like that *viz.,* hydropriming, halopriming osmopriming and biopriming were evaluated by screening a range of duration and concentration *viz.,* control, hydropriming, osmopriming (PEG 20%), halopriming (KCl 1% and $CaCl_2$ 1%), biopriming (neem leaf extract 5% and eucalyptus extract 5%) for 14 hours. It was found that all the priming method showed signification difference with the control and the highest percentage germination, seedling length, weight and germination index were observed for PEG priming for 14 hours.

Pal *et al*. (2017) carried out experiment to determine the effect of seed priming on germination behaviour, reserve mobilization, solute accumulation and antioxidative enzyme activities in germinating seeds of groundnut under salinity stress. Seeds of groundnut cv. TG-51 were treated with various priming agents *viz.,* gibberellic acid 50 ppm, hydrogen peroxide 60 mM, ascorbic acid 100 ppm, salicylic acid 25 ppm, mannitol 2.5% and sodium chloride 50 mM for 14 hours and were subjected to salinity stress (200 mM NaCl). Results indicated that the primed seed showed significant improvement in germination speed and growth of embryonic axis over the unprimed ones under salinity treatment. This might be attributed to higher water uptake ability and enhanced rate of reserve mobilization because of seed priming before germination. The priming treatment also showed enhanced accumulation of proline along with higher activities of antioxidant enzymes GPOX and CAT and alleviated levels of lipid peroxidation in the embryonic axis which might contribute to osmotic regulation and mitigation of oxidative stress under salinity stress during seed germination. Among all the priming agents, GA_3 50 ppm, mannitol 2.5% and NaCl 50 mM especially encouraging results.

Pradhan *et al.* (2017) conducted experiments to study influence of halopriming and organic priming on germination and seed vigour in black gram (*Vigna mungo* L.). The seeds were treated with un-soaked seed (control), hydropriming (soaked with distilled water for 12 hours), organic priming (cow urine, coconut water), halopriming with KNO_3, KCl, and $CaSO_4$ (1% solution) soaked for 12 hours, on seed of black gram. KCl @ 1% primed seed recorded higher germination per cent (83.25%), energy of emergence (78.75), seedling length (40.30 cm), seedling dry weight (0.452 g/10 seedlings), vigour index-I (3358.93) and vigour index-II (37.66) compared to control.

Sajjan *et al.* (2017) conducted experiment in the seed testing laboratory during 2013 and 2014 at RARS, UAS, Vijayapur, Karnataka. The seeds were primed by soaking in chemical solution for one hours and then decanted the extracts and seeds were air dried under the shade to bring back to their original moisture content and used for seed quality studies. In chemical treatment higher germination was seen in KNO_3 @ 0.5% but at par with $CaCl_2.2H_2O$ @ 2%. Lower seed germination was obtained with water soaked and control.

Sepehri and Rouhi (2017) studied on the ability of hydropriming to ameliorate seed deterioration in groundnut. Groundnut seeds were subjected to accelerated ageing for 96 hours at 40 °C and then hydroprimed at 25 °C for 6, 12 and 18 hours. Regardless of duration, hydropriming significantly improved final germination percentage, germination rate, seedling length, vigour index, antioxidant enzyme activities (catalase, superoxide dismutase and ascorbate peroxidase), soluble sugars and proteins of aged seeds. Mean germination time, electrolyte leakage and malondialdehyde content of primed seeds decreased compared to non-primed seeds. Hydropriming for 6, 12 and 18 hours increased final germination to 15.54, 31.56 and 89.7%, germination rate by 9.42, 66.6 and 95.6% and vigour index by 29.11, 82.2 and 204.6% compared to non-primed seed, respectively. Thus, hydropriming for 18 hours is the most suitable priming period to recover loss of seed quality and to improve germination characteristics of aged groundnut seeds.

Singh *et al.* (2017) studied the suitable method of priming for wheat seeds (var. DBW-17). Four methods of priming *viz.*, T_1-unprimed (control), T_2 and T_8 hydropriming with distilled water, T_3 and T_9 osmopriming with PEG 20%, T_4 and T_8 halopriming with NaCl 1%, T_5 and T_{11} halopriming with $CaCl_2$ 1%, T_6 and T_{12} organic priming with tulsi leaf extract 5% and T_7 and T_{13} organic priming with neem leaf extract 5% hydration for 8 and 12 hours respectively. It was found that among all the priming showed significance difference with the control and the highest germination percentage (%), germination index, energy of emergence, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg) and vigour indices were observed in $CaCl_2$ priming for 12 hours. This study also showed that seed priming with $CaCl_2$ were found to increase the seedling characters. The study helps to improve the seedling character, growth of seeds with the help of seed priming treatments which are cost effective, economic, non-toxic and eco-friendly sources.

Ullah *et al.* (2017) conducted the experiment on vigour and viability of osmoprimed harvested seeds of wheat varieties. They used fakhr-e-sarhad and pir sabaak varieties and treated with five priming levels *i.e.* distilled water (water soaked), $CaCl_2$ (22.2 g/l), KCl (20.7 g/l), NH_4SO_4 (20 g/l), NaCl (60 g/l) and control (dry seeds) for 8 hours at room temperature. Results showed that priming significantly improved germination percentage, growth rate, seedling dry weight, seed vigour index, shoot length, root length, shoot weight and root weight. It is concluded that calcium chloride treated seeds produced heavier seedlings (9 mg), rapid growth rate (9.6), highest seed vigour index (5092) and heavier roots (4.6 mg). Pir sabaak wheat variety showed maximum germination percentage (65%), fastest growth rate (9), maximum seedling dry weight (8 mg), heavier shoot weight (4.1 mg) and heavier root weight (3.8 mg).

Afrayeem *et al.* (2018) conducted the experiment in order standardize the best method of priming specific to black gram. Seed priming using various method like that *viz.,* hydropriming, halopriming and osmopriming were evaluated by screening a range of duration and concentration *viz.,* T_0-unprimed control, T_1-distilled water, halopriming T_2-NaCl (5%), T_3-$CaCl_2$ (1%), T_4-KCl (5%) and osmopriming T_5-PEG (25%) for 14 hours. It was found that all the priming method showed signification difference with the control and the highest germination %, seedling length, weight and germination index were observed for PEG priming for 14 hours.

Das and Mohanty (2018) studied the effect of a few priming treatments on enhancement of seed quality of groundnut. They used a partially deteriorated seeds were subjected to priming treatments, *viz.*, hydropriming of kernels for 2, 3, 4 and 5 hours and moist sand conditioning (MSC) of kernels for 24, 36, 48, 60 and 72 hours. An unprimed control was maintained for comparison. MSC-24 hours gave highest germination (82.5%), followed by MSC-36 hours (79.50%), an increase of 20.0% and 15.6%, respectively, over the unprimed control. Seeds without priming treatment gave the lowest germination of 68.75%. Priming treatments also resulted in higher SVI-I and lower EC of seed leachate.

Hasan and Ismail (2018) reported the response of the groundnut plants to four levels of GA_3 (0, 50, 100 and 150 mg/l) as foliar spray at 21 and 42 days after sowing. The treatments were laid out in a randomized complete block design and replicated thrice. The results showed that the treatment of 150 mg/l GA_3 significantly ($p<0.05$) increased total dry weight, 100 seed weight, % shelling, oil content, protein content, seed moisture and germination percentage during the wet and dry seasons. In conclusion, the 150 mg/l GA_3 concentration is the optimum level required to enhance the growth and yield in groundnuts during the wet and dry seasons.

James *et al.* (2018) conducted experiment to standardize the best method of priming specific to chickpea. Four methods of priming *viz.,* osmopriming, hydropriming, halopriming, and magneto priming were evaluated by screening a range of concentrations. It was found that all the priming methods showed significance difference with the control and treated with calcium chloride ($CaCl_2$) at 1% (T_5) recorded significantly higher values for seedling characters, *viz.*, seed germination percentage (95.67), speed of germination (33.75), root length (12.22), shoot length (15.03), seedling length (27.25), seedling fresh weight (1.08), seedling dry weight (0.23), seed vigour index-I (2606.89), seed vigour index-II (21.36), in compared with other treatments, and lowest recorded in control.

Jockovic *et al.* (2018) reported the effect of seed priming on germination characters of safflower and to compare different priming techniques: priming by soaking and priming on filter paper. The priming treatments included hydropriming (distilled water) and osmopriming with 0.1% and 0.5% solutions of KNO_3 for 8 and 16 hours. The experiment revealed significant difference between the priming treatments and the control. The highest germination (89.50%) was recorded within the priming treatments by soaking in the solution of 0.1% KNO_3 and priming on filter paper moistened with 0.5% KNO_3 for 8 hours. Considering germination index, mean germination time and time to 50% germination, the best results were obtained within hydropriming on filter paper for 16 hours.

Joycy *et al.* (2018) conducted the experiment in order to standardize the best method of priming specific to fenugreek. Four methods of priming *viz*., hydropriming, halopriming, osmopriming and organic priming were evaluated by screening a range of durations and concentrations *viz.*, T_0-control, T_1-distilled water, T_2-NaCl (2%), T_3-NaCl (1%), T_4-KCl (2%), T_5-KCl (1%), T_6-KNO_3 (2%), T_7-KNO_3 (1%), T_8-Neem leaf extract (2%), T_9-Moringa leaf extract (3%), T_{10}-curry leaf extract (3%) for 6 hours and found that all the priming methods showed significance difference with the control and the highest germination percentage, seedling length (cm), seedling fresh weight (g), seedling dry weight (g) and vigour index were observed in T_{10}-curry leaf extract 3%.

Kunghatkar *et al.* (2018) conducted experiment to study the influence of seed hardening techniques on vigour in chickpea [*Cicer arietinum* (L.)]. Seven treatments *i.e.* control (T_0), distilled water (T_1), hydration with KNO_3 (2%) (T_2), hydration with NaCl (2%) (T_3), hydration with $CaCl_2$ (2%) (T_4), hydration with KH_2PO_4 (2%) (T_5) and hydration with KCl (2%) (T_6). Maximum increase in seed vigour characters (germination per cent, root length, shoot length, seedling length, seedling fresh weight and seedling dry weight in chickpea) was observed with seed hardening techniques. More over treatment T_4 [(hydration with $CaCl_2$ (2%)] showed better result.

Patil *et al.* (2018) studied the effect of priming on seed quality characters with two chickpea varieties, GG-1 and GJG-3 for two consecutive years by giving different priming treatments *viz.*, KNO_3, PEG, Bavistin and Neem oil with different concentrations along with control. The result showed significantly higher seed quality characters when seeds were treated with KNO_3 @ 100 ppm for the year 2016-17, 2017-18 and pooled basis.

Prabhu *et al.* (2018) studied the effect of pre-sowing chemical and organic seed hardening treatment on seed quality characters in rice cv. IR-36 seeds. They were given chemical and organic seed hardening treatments with 1% $CaCl_2$, l% KCl, 1% KNO_3, l% NaCl, 10% cow dung and 3% panchakavya of seed. The hardened seeds were evaluated initially under laboratory for seed quality characters along with control. The results reveals that seeds hardened with 1% $CaCl_2$ recorded higher values for initial seed quality characters such as germination percentage, speed of germination, root length, shoot length, seedling length, dry matter production, vigour index-I and vigour index-II under laboratory evaluation.

Sohali *et al.* (2018) conducted the experiment in order to standardize the best method of priming *viz.,* hydropriming, halopriming, osmopriming and organic priming evaluated by screening a range of duration concentrations *viz.,* T_0-untreated (control), T_1-distilled water (hydration), T_2-potassium chloride (KCl) 1%, T_3-potassium chloride (KCl) 2%, T_4-polyethylene glycol (PEG_{6000}) 1%, T_5-polyethylene glycol (PEG_{6000}) 2% and T_6-neem leaf extract 5% for 8 hours. It was found that all the priming methods showed significance difference with the control and the highest germination percentage, speed of germination, root length, shoot length, seedling length, fresh weight, dry weight, vigour index-I and vigour index-II found in PEG_{6000}. It was observed that PEG_{6000} is best priming method. The highest were observed in PEG and neem leaf extract. In their solutions seeds priming for 8 hours and then dried for 24 hours in shade.

Teggelli *et al.* (2018) studied the influence of seed priming with $CaCl_2$ (2%) in pigeonpea quality characters under rainfed condition. The result reveals that seed priming with $CaCl_2$ (2%) recorded higher seed quality characters like seed germination (92%) and root length (11.3 cm).

Thiruppathi *et al.* (2018) conducted experiment to study the effect of seed priming techniques on germination and growth performance of castor. The seeds were subjected to priming in different concentration (1, 2 and 3 %) of solution *viz.*, $ZnSO_4$, KC1, KH_2PO_4, $CaCl_2$, cow dung slurry and water along with unprimed dry seed as a control. The result revealed that percentage of seed germination, germination index, speed of germination, seed vigour index, seedling shoot and root length, seedling root volume, seedling root and shoot dry weight and relative water content of castor were significantly higher with 2% $ZnSO_4$ primed seed, hydropriming with 2% $ZnSO_4$ is the most promising priming technique for enhancing seedling characters and drought tolerance.

Venkatesh *et al.* (2018) reported the effect of priming treatments on seed quality characters of groundnut *viz.*, germination percentage (94.17%), root length (12.28 cm), shoot length (18.41 cm), total seedling length (29.10 cm) and vigour index-I (2739.41), were enhanced by seeds primed with $CaCl_2$ 2% followed by $CaCl_2$ 1%. In case of electrical conductivity of seed leachate, the seeds hydrated with $CaCl_2$ 2% recorded lower electrical conductivity ($0.411 dsm^{-1}$) than unprimed seeds.

CHAPTER – III

MATERIALS AND METHODS

The field experiment was conducted at the Sagdividi Farm, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh, during *kharif*-2018 to study the **"Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)"** and the laboratory studies were carried out in the Seed Testing Laboratory, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Groundnut genotypes *viz.,* GG-20 and GJG-22 obtained from Junagadh Agricultural University, Junagadh. Geographically Junagadh is situated at 21.5º N latitude and 70.5º E longitudes with an altitude of 60 meters above the mean sea level. The soil of the experimental site was medium black, alluvial in origin and poor organic matter.

Meteorological data on maximum and minimum temperature, relative humidity and rainfall for *kharif*-2018 was obtained from the meteorological observatory, Junagadh Agricultural University, Junagadh (Appendix I).

Details of the materials used and methodologies adopted in the present investigation are described in this chapter.

3.1 Experimental Details

In order to study the "Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)", the present experiment was planned during *kharif* season of the year 2018.

3.1.1	**Location**	Field	:	Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh
		Laboratory	:	Seed Testing Laboratory, Department of Seed Science and Technology,

				College of Agriculture, Junagadh Agricultural University, Junagadh
3.1.2	**Year and season of experiment**		:	*Kharif*-2018 (Field trial, Plate 3.1)
3.1.3	**Experiment design**	Field	:	Randomized Block Design (Factorial)
		Laboratory	:	Completely Randomized Design (Factorial)
3.1.4	**Number of repetitions**		:	3 (Three)
3.1.5	**Spacing**		:	60 × 10 cm
3.1.6	**Name of genotypes**		:	(1) GG-20 (2) GJG-22
3.1.7	**Quantity**		:	8.7 kg.
3.1.8	**Gross plot size**		:	4 × 3.6 m^2
3.1.9	**Net plot size**		:	3.5 × 2.4 m^2

3.2 Treatment Details

Before the seed priming preconditioning was given to the seeds. In the preconditioning the seeds were kept in wet gunny bag for 6 hours. Later on seeds were hydrated in water and different chemicals for 6 hours (Plate 3.2).

T_1 - Control (No priming)

The untreated seeds were considered as control.

T_2 - Hydration with water for 6 hours

The seeds were soaked in water for the period of 6 hours followed by shade drying.

T_3 - Hydration with KH_2PO_4 (1%) for 6 hours

10 g of KH_2PO_4 was dissolved in 1000 ml of distilled water for preparation of 1% KH_2PO_4 solution and the seeds were soaked in KH_2PO_4 solution for the period of 6 hours followed by shade drying.

T_4 - Hydration with $CaCl_2$ (1%) for 6 hours

10 g of $CaCl_2$ was dissolved in 1000 ml of distilled water for preparation of 1% $CaCl_2$ solution and the seeds were soaked in 1% $CaCl_2$ solution for the period of 6 hours followed by shade drying.

T_5 - Hydration with KCl (1%) for 6 hours

10 g of KCl was dissolved in 1000 ml of distilled water for preparation of 1% KCl solution and the seeds were soaked in 1% KCl solution for the period of 6 hours followed by shade drying.

T_6 - Hydration with Boron (0.5%) for 6 hours

5 g of boron was dissolved in 1000 ml of distilled water for preparation of 0.5% boron solution and the seeds were soaked in 0.5% boron solution for the period of 6 hours followed by shade drying.

T_7 - Hydration with GA_3 (25 ppm) for 6 hours

0.025 g of GA_3 was dissolved in 1000 ml of distilled water for preparation of 25 ppm GA_3 solution and the seeds were soaked in 25 ppm GA_3 solution for the period of 6 hours followed by shade drying.

T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours

5 g of $MnSO_4$ was dissolved in 1000 ml of distilled water for preparation of 0.5% $MnSO_4$ solution and the seeds were soaked in 0.5% $MnSO_4$ solution for the period of 6 hours followed by shade drying.

T_9 - Hydration with KNO_3 (1%) for 6 hours

10 g of KNO_3 was dissolved in 1000 ml of distilled water for preparation of 1% KNO_3 solution and the seeds were soaked in 1% KNO_3 solution for the period of 6 hours followed by shade drying.

3.3 Layout

The experiment was laid out in a Randomized Block Design (Factorial) during *kharif* season of the year 2018 (Appendix II).

3.4 Cultural operations

3.4.1 Land preparation

The land was ploughed with mould board plough followed by two harrowing to bring the soil to fine tilth so as to facilitate sowing. The residues of the previous crop and weeds were collected and removed from the experimental area. The land was levelled with the help of plank.

3.4.2 Fertilizer application

The recommended dose of 12.5:25:00 kg NPK per hectare was supplied in the form of Diammonium Phosphate and Urea. Entire quantity of nitrogen and phosphorous were applied in the rows five centimetre away from the seed row as basal application.

3.4.3 Sowing

The primed seeds of two genotypes GG-20 and GJG-22 of each treatment were hand dibbled in the rows to row spacing 60 cm and plant to plant 10 cm.

3.4.4 Aftercare

In order to keep field weed free, intercultural operations and manual weeding were carried out throughout the life span of groundnut crop. Two hand weeding at 30 and 60 days after sowing were carried out during crop growth period.

3.4.5 Harvesting

The plants were uprooted from plot area of each treatment and in each replication separately. All dirt, impurities and immature pods were removed and harvested pods are kept for 7 days in field for drying and after drying the yield of dry pods (kg/plot) and haulm yield (kg/plot) was taken.

3.5 Observations recorded:

Following observations were recorded during experimentation.

3.5.1 Field observations

Five competitive plants per treatment in each replication were selected randomly for the purpose of recording observation on different characters and their averages were used in the statistical analysis but in case of field emergence percentage, days to 50 per cent flowering and days to maturity observation recorded on plot basis.

3.5.1.1 Field emergence percentage

Number of seedlings that emerged after seven days of sowing were counted. Field emergence percentages were calculated for each treatment using following formula.

$$\text{Field emergence percentage} = \frac{\text{Total number of emerged seedlings}}{\text{Total number of seeds sown}} \times 100$$

3.5.1.2 Days to 50 per cent flowering

For each genotype number of days taken from the date of sowing to the date on which 50 per cent of the plants of a plot showed flowering was recorded and expressed as the number of days taken for 50 per cent flowering.

3.5.1.3 Plant height (cm)

The height of five randomly selected plants were measured from the ground level to the growing tip of plant at harvest. The average height of the plant in centimetre was worked out.

3.5.1.4 Days to maturity

Number of days taken from date of sowing to physiological maturity of the plant was recorded as days to maturity.

3.5.1.5 Number of mature pods per plant

The mature pods on five consecutive plants were counted during harvest time to calculate the mean number of mature pods per plant.

3.5.1.6 Seed yield per plant (g)

The pods of five randomly selected plants were harvested, dried and threshed separately. The mean was worked out and recorded as yield per plant.

3.5.1.7 Seed yield per plot (kg)

Pods obtained from each net plot were sun dried and weighed and dry pod yield per plot was worked out.

3.5.1.8 Seed yield per hectare (q)

The pods harvested from the net plot were sun dried and cleaned thoroughly. Weight was recorded and multiplied by hectare factor and expressed in quintal per hectare.

3.5.1.9 Harvest Index (%)

The harvest index was calculated from net plot by using formula as given by Donald and Hamblin (1976).

$$\text{Harvest Index (\%)} = \frac{\text{Pods dry weight (kg)}}{\text{Total dry weight of haulm after harvest (kg)}} \times 100$$

3.5.2 Laboratory observations

Laboratory observations were taken after 45 days after harvesting in the field due to breaking of fresh seed dormancy.

3.5.2.1 100 Seed weight (g)

Hundred seeds were randomly drawn from the seeds material of each treatment and recorded in grams.

3.5.2.2 Germination percentage

Four repetitions of 100 seeds from each treatment were placed on sufficient moisture rolled papers (BP) at 25°C temperature with 90-95% relative humidity in the seed germinator. Final count was recorded on 10th day (Anon., 1999). Normal seedlings were expressed as per cent germination.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings germinated}}{\text{Total number of seeds placed for germination}} \times 100$$

3.5.2.3 Root length (cm)

Ten normal seedlings were randomly selected from germination test from each replication on 10th day and used for measuring root length. The root length was measured between collar region and tip of root with help of the scale. The mean values were calculated and expressed in centimetres.

3.5.2.4 Shoot length (cm)

Ten normal seedlings were used for measuring shoot length. The shoot length was measured from collar region to the tip of shoot. The mean values were calculated and expressed in centimetres.

3.5.2.5 Seedling dry weight (g)

Ten normal seedlings from each treatment and in each repetition were selected randomly immediately after germination test. The selected seedlings were put in metal dish. The dish kept in an oven maintained at 80 ± 1°C for 24 hours. After the weight of dry seedlings were recorded. The average of ten dry seedlings were worked out and these measured on grams.

3.5.2.6 Seedling vigour index-I

Ten normal seedlings from each treatment and in each replication were selected randomly immediately after germination test. The total root and shoot length was measured in centimetre. The average of ten seedlings were worked out for calculating the seedling vigour index.

The seedling vigour index-I was determined by using the formula given by Abdul-Baki and Anderson (1973) as below.

Vigour index-I = (Average root length in cm + Average shoot length in cm) × Germination percentage (%)

3.5.2.7 Seedling vigour index-II

The ten normal seedlings selected for calculating the seedling vigour index-II were oven dried and the oven dry weight of these seedlings were used for calculating the seedling vigour index-II.

Seedling vigour index-II was determined by using the formula given by Abdul-Baki and Anderson (1973) as below.

Vigour index-II = Seedling dry matter (g) × Germination percentage (%)

3.5.2.8 Electrical conductivity (dSm^{-1})

Three replications each of 25 seeds were randomly selected from each treatment and soaked in 75 ml of distilled water at 25°C for 24 hours. The solution and seeds were gently swirled for 10 to 15 second prior to evaluation. The electrical conductivity of the solution was measured by using conductivity meter having cell constant one and expressed as dSm^{-1} (Loeffler *et al*., 1988).

3.6 Statistical analysis:

Statistical analysis was carried out for the quantitative characters as per RBD (Factorial) and CRD (Factorial) under laboratory observations as per the method suggested by Cochran and Cox (1957).

3.6.1 Randomized Block Design (Factorial)

Analysis of variance for Randomized Block Design (Factorial) was computed as per the method of Cochran and Cox (1957), which is based on the following mathematical model:

$$Y_{ijk} = \mu + r_k + a_i + b_j + (ab)_{ij} + e_{ijk}$$

Where,

Y_{ijk} = Phenotypic expression of i^{th} level of genotype and the j^{th} level of priming treatment in k^{th} replication,

μ = Population mean,

r_k = Effect of the k^{th} replication

a_i = Effect of the i^{th} level of genotype,

b_j = Effect of the j^{th} level of priming treatment,

$(ab)_{ij}$ = Effect of the interaction between the i^{th} level of genotype and the j^{th} level of priming treatment, and

e_{ijk} = Random error associated with the k^{th} replication in cell (i, j).

The form of analysis of variance as presented in the Table 3.1 was constructed for individual characters *viz.*, field emergence percentage, days to 50 per cent flowering, plant height (cm), days to maturity, number of mature pods per plant, seed yield per plant (g), seed yield per plot (kg), seed yield per hectare (q) and harvest index (%).

Table 3.1: The structure of ANOAVA for RBD (Factorial)

Source of variation	d.f	S.S	M.S	Cal F
Replications	R-1	SS_R	MS_R	MS_R / MS_E
Genotypes (G)	G-1	SS_G	MS_G	MS_G / MS_E
Priming treatments (T)	T-1	SS_T	MS_T	MS_T / MS_E
Interaction	(G-1) (T-1)	SS_{GT}	MS_{GT}	MS_{GT} / MS_E
Error (E)	(GT-1) (R-1)	SS_E	MS_E	
Total	GTR-1			

Where,

R = Number of replications,

G = Number of genotypes,

T = Number of priming treatments,

SS_R = Sum of square due to replications,

SS_G = Sum of square due to genotypes,

SS_T = Sum of square due to priming treatments,

SS_{GT} = Sum of square due to interaction of genotypes and priming treatments,

SS_E = Sum of square due to error,

MS_R = Mean square due to replications,

MS_G = Mean square due to genotypes,

MS_T = Mean square due to priming treatments,

MS_{GT} = Mean square due to interaction of genotypes and priming treatments,

MS_E = Mean square due to error.

Mean squares due to different sources were tested against error mean square (MS_E) by calculating 'F' values.

The standard error of mean (S.Em.) was calculated using following formula.

$$\text{S.Em for genotype (G)} = \sqrt{\frac{ErrorM.S}{rT}}$$

$$\text{S.Em for priming treatment (T)} = \sqrt{\frac{ErrorM.S}{rG}}$$

$$\text{S.Em for genotype} \times \text{priming treatment interaction} = \sqrt{\frac{ErrorM.S}{r}}$$

The critical difference (C.D.) to compare the mean of any two treatment combination was calculated using following formula.

$$\text{C.D.} = \text{S.Em} \times \sqrt{2} \times t$$

Where,

't' = Table value of 't' at 5 per cent level of significant at error degree of freedom

The coefficient of variation (C.V.) was determined according to the following formula.

$$\text{C.V. (\%)} = \frac{\sqrt{ErrorM.S}}{\bar{x}} \times 100$$

Where,

$\bar{x}$ = General mean

3.6.2 Completely Randomized Design (Factorial)

Analysis of variance for Completely Randomized Design (Factorial) was computed as per the method of Cochran and Cox (1957), which is based on the following mathematical model:

$Y_{ijk} = \mu + a_i + bj + (ab)ij + e_{ijk}$

Where,

Y_{ijk} = Phenotypic expression of i^{th} level of genotype and the j^{th} level of priming treatment in k^{th} replication,

μ = Population mean,

a_i = Effect of the i^{th} level of genotype,

b_j = Effect of the j^{th} level of priming treatment,

$(ab)_{ij}$ = Effect of the interaction between the i^{th} level of genotype and the j^{th} level of priming treatment, and

e_{ijk} = Random error associated with the k^{th} replication in cell (i, j).

The form of analysis of variance as presented in the Table 3.2 was constructed for individual characters *viz.*, 100 seed weight (g), germination percentage, root length (cm), shoot length (cm), seedling dry weight (g), seedling vigour index-I, seedling vigour index-II and electrical conductivity (dSm^{-1}).

Table 3.2: The structure of ANOVA for CRD (Factorial)

Source of variation	d.f	S.S	M.S	Cal F
Genotypes (G)	G-1	SS_G	MS_G	MS_G / MS_E
Priming treatments (T)	T-1	SS_T	MS_T	MS_T / MS_E
Interaction	(G-1) (T-1)	SS_{GT}	MS_{GT}	MS_{GT} / MS_E
Error (E)	(GT) (R-1)	SS_E	MS_E	
Total	(GTR-1)			

Where,

R = Number of replications,

G = Number of genotypes,

T = Number of priming treatments,

SS_G = Sum of square due to genotypes,

SS_T = Sum of square due to priming treatments,

SS_{GT} = Sum of square due to interaction of genotypes and priming treatments,

SS_E = Sum of square due to error,

MS_G = Mean square due to genotypes,

MS_T = Mean square due to priming treatments,

MS_{GT} = Mean square due to interaction of genotypes and priming treatments,

MS_E = Mean square due to error.

Mean squares due to different sources were tested against error mean square (MS_E) by calculating 'F' values.

The standard error of mean (S.Em.) was calculated using following formula.

$$\text{S.Em for genotype (G)} = \sqrt{\frac{Error M.S}{rT}}$$

$$\text{S.Em for priming treatment (T)} = \sqrt{\frac{Error M.S}{rG}}$$

$$\text{S.Em for genotype} \times \text{priming treatment interaction} = \sqrt{\frac{Error M.S}{r}}$$

The critical difference (C.D.) to compare the mean of any two treatment combination was calculated using following formula.

$$\text{C.D.} = \text{S.Em} \times \sqrt{2} \times t$$

Where,

't' = Table value of 't' at 5 per cent level of significant at error degree of freedom

The coefficient of variation (C.V.) was determined according to the following formula.

$$\text{C.V. (\%)} = \frac{\sqrt{Error M.S}}{\bar{x}} \times 100$$

Where,

$\bar{x}$ = General mean

CHAPTER - IV

EXPERIMENTAL RESULTS

The present investigation taken under on **“Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)”** is described in this chapter. For field experiment the seeds of groundnut genotypes *viz.*, GG-20 and GJG-22 obtained and primed for 6 hours with water, KH_2PO_4 (1%), $CaCl_2$ (1%), KCl (1%), Boron (0.5%), GA_3 (25 ppm), $MnSO_4$ (0.5%), KNO_3 (1%) and untreated seed (control) followed by shade drying. Above primed treated seeds sown during *kharif*-2018. Laboratory experiment was performed after 45 days to harvesting in the field due to breaking of fresh seed dormancy. The results on individual characters are described below.

4.1 Analysis of variance for experimental design.

4.2 Effect of various factors and their interaction on different characters.

4.1 ANALYSIS OF VARIANCE FOR EXPERIMENTAL DESIGN

The analysis of variance revealed that the existence of significant difference among genotypes and seed priming treatments for seed yield and yield contributing characters studied (Table 4.1) and significant difference among genotypes and seed priming treatments for seed quality characters studied (Table 4.2).

Mean square due to interaction effect of genotypes × seed priming treatments were found non-significant for field emergence percentage, days to 50 per cent flowering, plant height (cm), days to maturity, number of mature pods per plant, seed yield per plant (g), seed yield per plot (kg), seed yield per hectare (q) and harvest index (%) (Table 4.1).

Mean square due to interaction effect of genotypes × seed priming treatments were found non-significant for germination percentage and 100 seed weight (g) and were found significant for root length (cm), shoot length (cm), seedling dry weight (g), seedling vigour index-I, seedling vigour index-II and electrical conductivity (dSm^{-1}) (Table 4.2).

Table 4.1: Analysis of variance for experimental design in seed treatments on seed yield and yield contributing characters in groundnut

Source of variation	d.f.	Field emergence percentage	Days to 50 per cent flowering	Plant height
Replications (R)	2	50.15	10.91	19.38
Genotypes (G)	1	69.59*	20.17*	43.34*
Priming treatments (T)	8	137.22**	21.18**	40.55**
G × T	8	0.30	0.13	0.92
Error	34	15.63	4.65	9.40

Source of variation	d.f.	Days to maturity	Number of mature pods per plant	Seed yield per plant
Replications (R)	2	60.96	6.81	8.34
Genotypes (G)	1	146.69*	14.94*	27.22*
Priming treatments (T)	8	77.30*	24.07**	35.20**
G × T	8	0.94	0.29	0.15
Error	34	34.51	2.16	4.03

Source of variation	d.f.	Seed yield per plot	Seed yield per hectare	Harvest index
Replications (R)	2	0.0030	0.42	6.85
Genotypes (G)	1	0.0778*	11.03*	32.64*
Priming treatments (T)	8	0.0291*	4.12*	22.85**
G × T	8	0.0001	0.02	0.21
Error	34	0.0123	1.75	4.86

*, ** Significant at 5% and 1% levels, respectively

Table 4.2: Analysis of variance for experimental design in seed treatments on different seed quality characters in groundnut

Source of variation	d.f.	100 seed weight	Germination percentage	Root length
Genotypes (G)	1	15.76*	29.63*	22.67**
Priming treatments (T)	8	6.40*	28.96**	7.79**
G × T	8	0.02	0.34	0.16*
Error	36	2.90	6.93	0.07

Source of variation	d.f.	Shoot length	Seedling dry weight	Seedling vigour index-I
Genotypes (G)	1	15.02**	0.05346**	757321.95**
Priming treatments (T)	8	6.24**	0.00833**	313982.67**
G × T	8	0.12*	0.00045*	5022.36*
Error	36	0.04	0.00016	1659.14

Source of variation	d.f.	Seedling vigour index-II	Electrical conductivity
Genotypes (G)	1	536.96**	0.01863**
Priming treatments (T)	8	103.33**	0.00125**
G × T	8	4.73*	0.00006*
Error	36	2.07	0.00003

*, ** Significant at 5% and 1% levels, respectively

4.2 EFFECT OF VARIOUS FACTORS AND THEIR INTERACTION ON DIFFERENT CHARACTERS

4.2.1 Effect of seed priming treatments on seed yield and yield contributing characters in groundnut.

4.2.1.1 Field emergence percentage

The data on field emergence percentage as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.3.

4.2.1.1.1 Effect of genotypes

The field emergence percentage was significantly influenced due to genotypes. Significantly the highest field emergence percentage was recorded in GJG-22 genotype (G_2) (77.65%); while significantly the lowest field emergence percentage was recorded in plots having sown with seeds of GG-20 genotype (G_1) (75.38%).

4.2.1.1.2 Effect of treatments

The field emergence percentage showed significant difference due to seed priming treatments (Figure 4.1). Significantly the highest field emergence percentage was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (82.88%), which was at par with a treatment having seed primed with KCl (1%) (T_5) (81.68%), KH_2PO_4 (1%) (T_3) (80.12%) and KNO_3 (1%) (T_9) (78.79%); while significantly the lowest field emergence percentage was recorded in unprimed seed (T_1) (69.38%).

4.2.1.1.3 Interaction effect

The field emergence percentage showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest field emergence percentage was recorded in G_2T_4 (83.92%) and the lowest field emergence percentage was recorded in G_1T_1 (68.59%).

4.2.1.2 Days to 50 per cent flowering

The result on days to 50 per cent flowering as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.3.

4.2.1.2.1 Effect of genotypes

The days to 50 per cent flowering was significantly influenced due to genotypes. Significantly lesser number of days to 50 per cent flowering was recorded in GJG-22 genotype (G_2) (37.85); while significantly the highest number of days to 50 per cent flowering was recorded in GG-20 genotype (G_1) (39.07).

4.2.1.2.2 Effect of treatments

The number of days to 50 per cent flowering showed significant difference due to seed priming treatments (Figure 4.2). Significantly minimum number of days to 50 per cent flowering was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (35.33), which was at par with treatment having seed primed with KCl (1%) (T_5) (36.17) and KH_2PO_4 (1%) (T_3) (37.83); while significantly the maximum number of days to 50 per cent flowering was recorded in control (T_1) (41.17).

4.2.1.2.3 Interaction effect

The number of days to 50 per cent flowering showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the minimum number of days to 50 per cent flowering was recorded in G_2T_4 (34.67) and the maximum number of days to 50 per cent flowering was recorded in G_1T_1 (42.00).

4.2.1.3 Plant height (cm)

The data regarding plant height as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.3.

4.2.1.3.1 Effect of genotypes

The plant height differed significantly due to genotypes. Significantly the highest plant height was recorded in genotype GJG-22 (G_2) (39.88 cm); while significantly the lowest plant height was recorded in GG-20 genotype (G_1) (38.09 cm).

4.2.1.3.2 Effect of treatments

The plant height showed significant difference due to seed priming treatments (Figure 4.3). Significantly the highest plant height was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (43.33 cm), which was at par with treatment having seed primed with KCl (1%) (T_5) (42.06 cm) and KH_2PO_4 (1%) (T_3) (40.48 cm) followed by KNO_3 (1%) (T_9) (39.39 cm); while significantly the lowest plant height was recorded in unprimed seed (T_1) (35.25 cm).

4.2.1.3.3 Interaction effect

The plant height showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest plant height was recorded in G_2T_4 (44.32 cm) and lowest plant height was recorded in G_1T_1 (33.76 cm).

Table 4.3: Effect of seed priming treatments to different genotypes and their interaction on field emergence percentage, days to 50 per cent flowering and plant height (cm) in groundnut

Treatments	Field emergence percentage	Days to 50 per cent flowering	Plant height (cm)
Genotypes (G)			
G_1 - GG-20	75.38	39.07	38.09
G_2 - GJG-22	**77.65**	**37.85**	**39.88**
S.Em±	0.76	0.42	0.59
CD at 5%	2.19	1.19	1.70
Priming treatments (T)			
T_1 - Control (No priming)	**69.38**	**41.17**	**35.25**
T_2 - Hydration with water for 6 hours	71.07	40.50	36.60
T_3 - Hydration with KH_2PO_4 (1%) for 6 hours	80.12	37.83	40.48
T_4 - Hydration with $CaCl_2$ (1%) for 6 hours	**82.88**	**35.33**	**43.33**
T_5 - Hydration with KCl (1%) for 6 hours	81.68	36.17	42.06
T_6 - Hydration with Boron (0.5%) for 6 hours	74.67	39.00	37.82
T_7 - Hydration with GA_3 (25 ppm) for 6 hours	77.19	38.50	38.54
T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours	72.89	39.50	37.31
T_9 - Hydration with KNO_3 (1%) for 6 hours	78.79	38.17	39.39
S.Em±	1.61	0.88	1.25
CD at 5%	4.64	2.53	3.60
Interaction (G × T)			
$G_1 \times T_1$	**68.59**	**42.00**	**33.76**
$G_1 \times T_2$	70.05	41.00	35.33
$G_1 \times T_3$	78.76	38.33	39.28
$G_1 \times T_4$	81.84	36.00	42.34
$G_1 \times T_5$	80.56	36.67	41.36
$G_1 \times T_6$	73.56	39.67	37.38
$G_1 \times T_7$	75.73	39.00	38.07
$G_1 \times T_8$	71.95	40.33	36.61

Table 4.4 continued…

$G_1 \times T_9$	77.40	38.67	38.68
$G_2 \times T_1$	70.16	40.33	36.94
$G_2 \times T_2$	72.09	40.00	37.87
$G_2 \times T_3$	81.48	37.33	41.68
$G_2 \times T_4$	**83.92**	**34.67**	**44.32**
$G_2 \times T_5$	82.81	35.67	42.77
$G_2 \times T_6$	75.78	38.33	38.26
$G_2 \times T_7$	78.65	38.00	39.00
$G_2 \times T_8$	73.82	38.67	38.01
$G_2 \times T_9$	80.17	37.67	40.09
S.Em±	**2.28**	**1.25**	**1.77**
CD at 5%	**NS**	**NS**	**NS**
CV %	**5.17**	**5.61**	**7.86**

4.2.1.4 Days to maturity

The result on days to maturity as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.4.

4.2.1.4.1 Effect of genotypes

The days to maturity was significantly influenced due to genotypes. Significantly lesser number of days to maturity was recorded in GJG-22 genotype (G_2) (113.59); while significantly the maximum number of days to maturity was recorded in genotype of GG-20 (G_1) (116.89).

4.2.1.4.2 Effect of treatments

The number of days to maturity showed significant difference due to seed priming treatments (Figure 4.4). Significantly minimum number of days to maturity was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (110.00), which was at par with KCl (1%) (T_5) (110.83), KH_2PO_4 (1%) (T_3) (112.67), KNO_3 (1%) (T_9) (114.33), GA_3 (25 ppm) (T_7) (115.33) and Boron (0.5%) (T_6) (116.50); while significantly the maximum number of days to maturity was recorded in control (T_1) (119.83).

4.2.1.4.3 Interaction effect

The number of days to maturity showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the minimum number of days to maturity was recorded in G_2T_4 (108.67) and the maximum number of days to maturity was recorded in G_1T_1 (121.67).

4.2.1.5 Number of mature pods per plant

The data on number of mature pods per plant as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.4.

4.2.1.5.1 Effect of genotypes

The number of mature pods per plant was significantly influenced due to genotypes. Significantly higher number of mature pods per plant was recorded in GJG-22 genotype (G_2) (19.77); while significantly lower number of mature pods per plant was recorded in GG-20 genotype (G_1) (18.72).

4.2.1.5.2 Effect of treatments

The number of mature pods per plant showed significant difference due to seed priming treatments (Figure 4.5). Significantly higher number of mature pods per plant was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (22.27), which was at par with treatment having seed primed with KCl (1%) (T_5) (21.47) and KH_2PO_4 (1%) (T_3) (20.70) followed by KNO_3 (1%) (T_9) (19.70); while significantly lower number of mature pods per plant was recorded in control (T_1) (16.17).

4.2.1.5.3 Interaction effect

The number of mature pods per plant showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly higher number of mature pods per plant was recorded in G_2T_4 (23.07) and lower number of mature pods per plant was recorded in G_1T_1 (15.60).

4.2.1.6 Seed yield per plant (g)

The data on seed yield per plant as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.4.

4.2.1.6.1 Effect of genotypes

The seed yield per plant was significantly influenced due to genotypes. Significantly the highest seed yield per plant was recorded in GJG-22 genotype (G_2)

(22.64 g); while significantly the lowest seed yield per plant was recorded in GG-20 genotype (G_1) (21.22 g).

4.2.1.6.2 Effect of treatments

The seed yield per plant showed significant difference due to seed priming treatments (Figure 4.6). Significantly the highest seed yield per plant was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (25.78 g), which was at par with treatment having seed primed with KCl (1%) (T_5) (24.41 g) and KH_2PO_4 (1%) (T_3) (23.65 g) followed by KNO_3 (1%) (T_9) (22.46 g); while significantly the lowest seed yield per plant was recorded in control (T_1) (18.18 g).

4.2.1.6.3 Interaction effect

The seed yield per plant showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest seed yield per plant was recorded in G_2T_4 (26.83 g) and the lowest seed yield per plant was recorded in G_1T_1 (17.50 g).

4.2.1.7 Seed yield per plot (kg)

The data on seed yield per plot as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.5.

4.2.1.7.1 Effect of genotypes

The seed yield per plot was significantly influenced due to genotypes. Significantly the highest seed yield per plot was recorded in GJG-22 genotype (G_2) (1.56 kg); while significantly the lowest seed yield per plot was recorded in GG-20 genotype (G_1) (1.48 kg).

4.2.1.7.2 Effect of treatments

The seed yield per plot showed significant difference due to seed priming treatments. Significantly the highest seed yield per plot was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (1.62 kg), which was at par with treatment having seed primed with KCl (1%) (T_5) (1.60 kg), KH_2PO_4 (1%) (T_3) (1.58 kg) and KNO_3 (1%) (T_9) (1.54 kg); while significantly the lowest seed yield per plot was recorded in control (T_1) (1.44 kg).

Table 4.4: Effect of seed priming treatments to different genotypes and their interaction on days to maturity, number of mature pods per plant and seed yield per plant (g) in groundnut

Treatments	Days to maturity	Number of mature pods per plant	Seed yield per plant (g)
Genotypes (G)			
G_1 - GG-20	116.89	18.72	21.22
G_2 - GJG-22	**113.59**	**19.77**	**22.64**
S.Em±	1.13	0.28	0.39
CD at 5%	3.25	0.81	1.11
Priming treatments (T)			
T_1 - Control (No priming)	**119.83**	**16.17**	**18.18**
T_2 - Hydration with water for 6 hours	119.17	17.20	19.51
T_3 - Hydration with KH_2PO_4 (1%) for 6 hours	112.67	20.70	23.65
T_4 - Hydration with $CaCl_2$ (1%) for 6 hours	**110.00**	**22.27**	**25.78**
T_5 - Hydration with KCl (1%) for 6 hours	110.83	21.47	24.41
T_6 - Hydration with Boron (0.5%) for 6 hours	116.50	18.70	21.20
T_7 - Hydration with GA_3 (25 ppm) for 6 hours	115.33	19.07	21.74
T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours	118.50	17.93	20.42
T_9 - Hydration with KNO_3 (1%) for 6 hours	114.33	19.70	22.46
S.Em±	2.40	0.60	0.82
CD at 5%	6.89	1.72	2.36
Interaction (G × T)			
$G_1 \times T_1$	**121.67**	**15.60**	**17.50**
$G_1 \times T_2$	121.00	16.73	19.01
$G_1 \times T_3$	113.67	19.93	22.94
$G_1 \times T_4$	111.33	21.47	24.72
$G_1 \times T_5$	112.33	20.67	23.82
$G_1 \times T_6$	118.33	18.47	20.57
$G_1 \times T_7$	116.67	18.80	21.06
$G_1 \times T_8$	120.33	17.53	19.69

Table 4.4 continued…

$G_1 \times T_9$	116.67	19.27	21.64
$G_2 \times T_1$	118.00	16.73	18.86
$G_2 \times T_2$	117.33	17.67	20.01
$G_2 \times T_3$	111.67	21.47	24.35
$G_2 \times T_4$	**108.67**	**23.07**	**26.83**
$G_2 \times T_5$	109.33	22.27	25.01
$G_2 \times T_6$	114.67	18.93	21.83
$G_2 \times T_7$	114.00	19.33	22.41
$G_2 \times T_8$	116.67	18.33	21.15
$G_2 \times T_9$	112.00	20.13	23.28
S.Em±	**3.39**	**0.85**	**1.16**
CD at 5%	**NS**	**NS**	**NS**
CV %	**5.10**	**7.64**	**9.16**

4.2.1.7.3 Interaction effect

The seed yield per plot showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest seed yield per plot was recorded in G_2T_4 (1.66 kg) and the lowest seed yield per plot was recorded in G_1T_1 (1.40 kg).

4.2.1.8 Seed yield per hectare (q)

The data on seed yield per hectare as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.5.

4.2.1.8.1 Effect of genotypes

The seed yield per hectare was significantly influenced due to genotypes. Significantly the highest seed yield per hectare was recorded in GJG-22 genotype (G_2) (18.49 q); while significantly the lowest seed yield per hectare was recorded in GG-20 genotype (G_1) (17.59 q).

4.2.1.8.2 Effect of treatments

The seed yield per hectare showed significant difference due to seed priming treatments (Figure 4.7). Significantly the highest seed yield per hectare was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (19.27 q), which was at par with treatment having seed primed with KCl (1%) (T_5) (19.03 q), KH_2PO_4 (1%) (T_3)

(18.83 q) and KNO_3 (1%) (T_9) (18.31 q); while significantly the lowest seed yield per hectare was recorded in control (T_1) (17.08 q).

4.2.1.8.3 Interaction effect

The seed yield per hectare showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest seed yield per hectare was recorded in G_2T_4 (19.80 q) and the lowest seed yield per hectare was recorded in G_1T_1 (16.71 q).

4.2.1.9 Harvest index (%)

The data on harvest index as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.5.

4.2.1.9.1 Effect of genotypes

The harvest index was significantly influenced due to genotypes. Significantly the highest harvest index was recorded in GJG-22 genotype (G_2) (33.60%); while significantly the lowest harvest index was recorded in GG-20 genotype (G_1) (32.05%).

4.2.1.9.2 Effect of treatments

The harvest index showed significant difference due to seed priming treatments (Figure 4.8). Significantly the highest harvest index was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (35.73%), which was at par with treatment having seed primed with KCl (1%) (T_5) (35.02%) and KH_2PO_4 (1%) (T_3) (34.67%); while significantly the lowest harvest index was recorded in control (T_1) (30.22%).

4.2.1.9.3 Interaction effect

The harvest index showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest harvest index was recorded in G_2T_4 (36.08%) and the lowest harvest index was recorded in G_1T_1 (29.50%).

Table 4.5: Effect of seed priming treatments to different genotypes and their interaction on seed yield per plot (kg), seed yield per hectare (q) and harvest index (%) in groundnut

Treatments	Seed yield per plot (kg)	Seed yield per hectare (q)	Harvest index (%)
Genotypes (G)			
G_1 - GG-20	1.48	17.59	32.05
G_2 - GJG-22	**1.56**	**18.49**	**33.60**
S.Em±	0.02	0.25	0.42
CD at 5%	0.06	0.73	1.22
Priming treatments (T)			
T_1 - Control (No priming)	**1.44**	**17.08**	**30.22**
T_2 - Hydration with water for 6 hours	1.45	17.28	30.91
T_3 - Hydration with KH_2PO_4 (1%) for 6 hours	1.58	18.83	34.67
T_4 - Hydration with $CaCl_2$ (1%) for 6 hours	**1.62**	**19.27**	**35.73**
T_5 - Hydration with KCl (1%) for 6 hours	1.60	19.03	35.02
T_6 - Hydration with Boron (0.5%) for 6 hours	1.47	17.52	31.90
T_7 - Hydration with GA_3 (25 ppm) for 6 hours	1.48	17.62	32.61
T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours	1.46	17.42	31.28
T_9 - Hydration with KNO_3 (1%) for 6 hours	1.54	18.31	33.10
S.Em±	0.05	0.54	0.90
CD at 5%	0.13	1.55	2.59
Interaction (G × T)			
$G_1 \times T_1$	**1.40**	**16.71**	**29.50**
$G_1 \times T_2$	1.41	16.79	30.06
$G_1 \times T_3$	1.54	18.37	33.82
$G_1 \times T_4$	1.57	18.73	35.38
$G_1 \times T_5$	1.56	18.61	34.28
$G_1 \times T_6$	1.43	17.02	31.02
$G_1 \times T_7$	1.44	17.18	31.62
$G_1 \times T_8$	1.42	16.94	30.36

Table 4.5 continued…

$G_1 \times T_9$	1.51	17.94	32.41
$G_2 \times T_1$	1.47	17.46	30.94
$G_2 \times T_2$	1.49	17.78	31.76
$G_2 \times T_3$	1.62	19.29	35.53
$G_2 \times T_4$	**1.66**	**19.80**	**36.08**
$G_2 \times T_5$	1.63	19.44	35.75
$G_2 \times T_6$	1.51	18.02	32.79
$G_2 \times T_7$	1.52	18.06	33.59
$G_2 \times T_8$	1.50	17.90	32.20
$G_2 \times T_9$	1.57	18.69	33.78
S.Em±	**0.06**	**0.76**	**1.27**
CD at 5%	**NS**	**NS**	**NS**
CV %	**7.32**	**7.32**	**6.71**

4.2.2 Effect of seed priming treatments on seed quality characters in groundnut.

4.2.2.1 100 seed weight (g)

The data on 100 seed weight as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.6.

4.2.2.1.1 Effect of genotypes

The 100 seed weight was significantly influenced due to genotypes. Significantly the highest 100 seed weight was recorded in GJG-22 genotype (G_2) (45.03 g); while significantly the lowest 100 seed weight was recorded in GG-20 genotype (G_1) (43.95 g).

4.2.2.1.2 Effect of treatments

The 100 seed weight showed significant difference due to seed priming treatments (Figure 4.9). Significantly the highest 100 seed weight was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (45.80 g), which was at par with treatment having seed primed with KCl (1%) (T_5) (45.73 g), KH_2PO_4 (1%) (T_3) (45.67 g) and KNO_3 (1%) (T_9) (44.97 g); while significantly the lowest 100 seed weight was recorded in control (T_1) (43.49 g).

4.2.2.1.3 Interaction effect

The 100 seed weight showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest 100 seed weight was recorded in G_2T_4 (46.41 g) and the lowest 100 seed weight was recorded in G_1T_1 (42.93 g).

4.2.2.2 Germination percentage

The data regarding germination percentage as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.6.

4.2.2.2.1 Effect of genotypes

The germination percentage was significantly influenced due to genotypes. Significantly the highest germination percentage was recorded in GJG-22 genotype (G_2) (92.52%); while significantly the lowest germination percentage was recorded in GG-20 genotype (G_1) (91.04%).

4.2.2.2.2 Effect of treatments

The germination percentage showed significant difference due to seed priming treatments (Figure 4.10). Significantly the highest germination percentage was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (95.33%), which was at par with treatment having seed primed with KCl (1%) (T_5) (94.00%), KH_2PO_4 (1%) (T_3) (93.00%) and KNO_3 (1%) (T_9) (92.50%); while significantly the lowest germination percentage was recorded in control (T_1) (88.33%).

4.2.2.2.3 Interaction effect

The germination percentage showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest germination percentage was recorded in G_2T_4 (96.33%) and the lowest germination percentage was recorded in G_1T_1 (87.33%).

4.2.2.3 Root length (cm)

The data on root length as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.6.

4.2.2.3.1 Effect of genotypes

The root length was significantly influenced due to genotypes. Significantly the highest root length was recorded in GJG-22 genotype (G_2) (9.88 cm); while significantly the lowest root length was recorded in GG-20 genotype (G_1) (8.59 cm).

Table 4.6: Effect of seed priming treatments to different genotypes and their interaction on 100 seed weight (g), germination percentage and root length (cm) in groundnut

Treatments	100 seed weight (g)	Germination percentage	Root length (cm)
Genotypes (G)			
G_1 - GG-20	43.95	91.04	8.59
G_2 - GJG-22	**45.03**	**92.52**	**9.88**
S.Em±	0.33	0.51	0.05
CD at 5%	0.94	1.45	0.14
Priming treatments (T)			
T_1 - Control (No priming)	**43.49**	**88.33**	**8.00**
T_2 - Hydration with water for 6 hours	43.58	89.83	8.21
T_3 - Hydration with KH_2PO_4 (1%) for 6 hours	45.67	93.00	9.84
T_4 - Hydration with $CaCl_2$ (1%) for 6 hours	**45.80**	**95.33**	**11.41**
T_5 - Hydration with KCl (1%) for 6 hours	45.73	94.00	10.43
T_6 - Hydration with Boron (0.5%) for 6 hours	43.75	90.67	8.52
T_7 - Hydration with GA_3 (25 ppm) for 6 hours	43.77	92.00	9.03
T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours	43.63	90.33	8.38
T_9 - Hydration with KNO_3 (1%) for 6 hours	44.97	92.50	9.31
S.Em±	0.69	1.07	0.11
CD at 5%	1.99	3.08	0.30
Interaction (G × T)			
$G_1 \times T_1$	**42.93**	**87.33**	**7.45**
$G_1 \times T_2$	43.05	89.00	7.68
$G_1 \times T_3$	45.07	92.67	9.30
$G_1 \times T_4$	45.19	94.33	10.42
$G_1 \times T_5$	45.13	93.00	9.84
$G_1 \times T_6$	43.32	90.00	7.99
$G_1 \times T_7$	43.27	91.33	8.39
$G_1 \times T_8$	43.11	89.67	7.76
$G_1 \times T_9$	44.43	92.00	8.46

Table 4.6 continued…

$G_2 \times T_1$	44.04	89.33	8.55
$G_2 \times T_2$	44.11	90.67	8.73
$G_2 \times T_3$	46.27	93.33	10.37
$G_2 \times T_4$	**46.41**	**96.33**	**12.39**
$G_2 \times T_5$	46.34	95.00	11.02
$G_2 \times T_6$	44.17	91.33	9.05
$G_2 \times T_7$	44.26	92.67	9.67
$G_2 \times T_8$	44.15	91.00	8.99
$G_2 \times T_9$	45.50	93.00	10.17
S.Em±	**0.98**	**1.52**	**0.15**
CD at 5%	**NS**	**NS**	**0.43**
CV %	**3.82**	**2.87**	**2.82**

4.2.2.3.2 Effect of treatments

The root length showed significant difference due to seed priming treatments (Figure 4.11). Significantly the highest root length was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (11.41 cm) followed by seed primed with KCl (1%) (T_5) (10.43 cm), KH_2PO_4 (1%) (T_3) (9.84 cm) and KNO_3 (T_9) (9.31 cm); while significantly the lowest root length was recorded in control (T_1) (8.00 cm).

4.2.2.3.3 Interaction effect

The root length showed significant difference due to interaction of genotypes and seed priming treatments (Figure 4.12). Significantly the highest root length was recorded in G_2T_4 (12.39 cm) followed by G_2T_5 (11.02 cm), G_1T_4 (10.42 cm), G_2T_3 (10.37 cm) and G_2T_9 (10.17 cm); while significantly the lowest root length was recorded in G_1T_1 (7.45 cm).

4.2.2.4 Shoot length (cm)

The data on shoot length as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.7.

4.2.2.4.1 Effect of genotypes

The shoot length was significantly influenced due to genotypes. Significantly the highest shoot length was recorded in GJG-22 genotype (G_2) (4.86 cm); while significantly the lowest shoot length was recorded in GG-20 genotype (G_1) (3.80 cm).

4.2.2.4.2 Effect of treatments

The shoot length showed significant difference due to seed priming treatments (Figure 4.13). Significantly the highest shoot length was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (6.03 cm) followed by seed primed with KCl (1%) (T_5) (5.43 cm), KH_2PO_4 (1%) (T_3) (5.15 cm) and KNO_3 (T_9) (4.48 cm); while significantly the lowest shoot length was recorded in control (T_1) (3.10 cm).

4.2.2.4.3 Interaction effect

The shoot length showed significant difference due to interaction of genotypes and seed priming treatments (Figure 4.14). Significantly the highest shoot length was recorded in G_2T_4 (6.68 cm) followed by G_2T_5 (6.09 cm), G_2T_3 (5.81 cm), G_1T_4 (5.37 cm) and G_2T_9 (5.14 cm); while significantly the lowest shoot length was recorded in G_1T_1 (2.76 cm).

4.2.2.5 Seedling dry weight (g)

The results on seedling dry weight as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.7.

4.2.2.5.1 Effect of genotypes

The seedling dry weight was significantly influenced due to genotypes. Significantly the highest seedling dry weight was recorded in GJG-22 genotype (G_2) (0.358 g); while significantly the lowest seedling dry weight was recorded in GG-20 genotype (G_1) (0.296 g).

4.2.2.5.2 Effect of treatments

The seedling dry weight showed significant difference due to seed priming treatments (Figure 4.15). Significantly the highest seedling dry weight was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (0.386 g) followed by seed primed with KCl (1%) (T_5) (0.370 g), KH_2PO_4 (1%) (T_3) (0.347 g) and KNO_3 (T_9) (0.335 g); while significantly the lowest seedling dry weight was recorded in control (T_1) (0.272 g).

4.2.2.5.3 Interaction effect

The seedling dry weight showed significant difference due to interaction of genotypes and seed priming treatments (Figure 4.16). Significantly the highest seedling dry weight was recorded in G_2T_4 (0.429 g), which was at par with G_2T_5

(0.412 g) followed by G_2T_3 (0.386 g), G_2T_9 (0.369 g), G_2T_7 (0.356 g) and G_2T_6 (0.345 g); while significantly the lowest seedling dry weight was recorded in G_1T_1 (0.253 g).

4.2.2.6 Seedling vigour index-I

The data regarding on seedling vigour index-I as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.7.

4.2.2.6.1 Effect of genotypes

The seedling vigour index-I was significantly influenced due to genotypes. Significantly higher seedling vigour index-I was recorded in GJG-22 genotype (G_2) (1368.16); while significantly lower seedling vigour index-I was recorded in GG-20 genotype (G_1) (1131.31).

4.2.2.6.2 Effect of treatments

The seedling vigour index-I showed significant difference due to seed priming treatments (Figure 4.17). Significantly higher seedling vigour index-I was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (1663.08) followed by seed primed with KCl (1%) (T_5) (1491.09), KH_2PO_4 (1%) (T_3) (1394.25) and KNO_3 (T_9) (1276.27); while significantly lower seedling vigour index-I was recorded in control (T_1) (981.56).

4.2.2.6.3 Interaction effect

The seedling vigour index-I showed significant difference due to interaction of genotypes and seed priming treatments (Figure 4.18). Significantly higher seedling vigour index-I was recorded in G_2T_4 (1837.29) followed by G_2T_5 (1624.37), G_2T_3 (1510.37), G_1T_4 (1488.87) and G_2T_9 (1424.17); while significantly lower seedling vigour index-I was recorded in G_1T_1 (890.76).

4.2.2.7 Seedling vigour index-II

The data regarding on seedling vigour index-II as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.8.

4.2.2.7.1 Effect of genotypes

The seedling vigour index-II was significantly influenced due to genotypes. Significantly higher seedling vigour index-II was recorded in GJG-22 genotype (G_2) (33.26); while significantly lower seedling vigour index-II was recorded in GG-20 genotype (G_1) (26.95).

Table 4.7: Effect of seed priming treatments to different genotypes and their interaction on shoot length (cm), seedling dry weight (g) and seedling vigour index-I in groundnut

Treatments	Shoot length (cm)	Seedling dry weight (g)	Seedling vigour index-I
Genotypes (G)			
G_1 - GG-20	3.80	0.296	1131.31
G_2 - GJG-22	**4.86**	**0.358**	**1368.16**
S.Em±	0.04	0.003	7.84
CD at 5%	0.12	0.007	22.48
Priming treatments (T)			
T_1 - Control (No priming)	**3.10**	**0.272**	**981.56**
T_2 - Hydration with water for 6 hours	3.32	0.288	1035.61
T_3 - Hydration with KH_2PO_4 (1%) for 6 hours	5.15	0.347	1394.25
T_4 - Hydration with $CaCl_2$ (1%) for 6 hours	**6.03**	**0.386**	**1663.08**
T_5 - Hydration with KCl (1%) for 6 hours	5.43	0.370	1491.09
T_6 - Hydration with Boron (0.5%) for 6 hours	3.74	0.320	1112.75
T_7 - Hydration with GA_3 (25 ppm) for 6 hours	4.20	0.325	1217.60
T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours	3.52	0.301	1075.43
T_9 - Hydration with KNO_3 (1%) for 6 hours	4.48	0.335	1276.27
S.Em±	0.09	0.005	16.63
CD at 5%	0.25	0.015	47.69
Interaction (G × T)			
$G_1 \times T_1$	**2.76**	**0.253**	**890.76**
$G_1 \times T_2$	2.97	0.265	947.79
$G_1 \times T_3$	4.49	0.307	1278.14
$G_1 \times T_4$	5.37	0.344	1488.87
$G_1 \times T_5$	4.76	0.327	1357.81
$G_1 \times T_6$	3.29	0.294	1015.53
$G_1 \times T_7$	3.65	0.294	1099.10
$G_1 \times T_8$	3.11	0.274	975.44
$G_1 \times T_9$	3.81	0.300	1128.37

Table 4.7 continued…

$G_2 \times T_1$	3.45	0.291	1072.37
$G_2 \times T_2$	3.66	0.312	1123.43
$G_2 \times T_3$	5.81	0.386	1510.37
$G_2 \times T_4$	**6.68**	**0.429**	**1837.29**
$G_2 \times T_5$	6.09	0.412	1624.37
$G_2 \times T_6$	4.20	0.345	1209.97
$G_2 \times T_7$	4.74	0.356	1336.09
$G_2 \times T_8$	3.92	0.327	1175.41
$G_2 \times T_9$	5.14	0.369	1424.17
S.Em±	**0.12**	**0.007**	**23.52**
CD at 5%	**0.35**	**0.021**	**67.45**
CV %	**4.87**	**3.920**	**3.26**

4.2.2.7.2 Effect of treatments

The seedling vigour index-II showed significant difference due to seed priming treatments (Figure 4.19). Significantly higher seedling vigour index-II was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (36.87) followed by seed primed with KCl (1%) (T_5) (34.80), KH_2PO_4 (1%) (T_3) (32.28) and KNO_3 (T_9) (30.96); while significantly lower seedling vigour index-II was recorded in control (T_1) (24.02).

4.2.2.7.3 Interaction effect

The seedling vigour index-II showed significant difference due to interaction of genotypes and seed priming treatments (Figure 4.20). Significantly higher seedling vigour index-II was recorded in G_2T_4 (41.30), which was at par with G_2T_5 (39.16) followed by G_2T_3 (36.08), G_2T_9 (34.29), G_2T_7 (32.95) and G_1T_4 (32.44); while significantly lower seedling vigour index-II was recorded in G_1T_1 (22.05).

Table 4.8: Effect of seed priming treatments to different genotypes and their interaction on seedling vigour index-II and electrical conductivity (dSm^{-1}) in groundnut

Treatments	Seedling vigour index-II	Electrical conductivity (dSm^{-1})
Genotypes (G)		
G_1 - GG-20	26.95	0.506
G_2 - GJG-22	**33.26**	**0.469**
S.Em±	0.28	0.001
CD at 5%	0.79	0.003
Priming treatments (T)		
T_1 - Control (No priming)	**24.02**	**0.507**
T_2 - Hydration with water for 6 hours	25.91	0.503
T_3 - Hydration with KH_2PO_4 (1%) for 6 hours	32.28	0.477
T_4 - Hydration with $CaCl_2$ (1%) for 6 hours	**36.87**	**0.467**
T_5 - Hydration with KCl (1%) for 6 hours	34.80	0.472
T_6 - Hydration with Boron (0.5%) for 6 hours	29.00	0.496
T_7 - Hydration with GA_3 (25 ppm) for 6 hours	29.93	0.489
T_8 - Hydration with $MnSO_4$ (0.5%) for 6 hours	27.17	0.500
T_9 - Hydration with KNO_3 (1%) for 6 hours	30.96	0.482
S.Em±	0.59	0.002
CD at 5%	1.68	0.007
Interaction (G × T)		
$G_1 \times T_1$	**22.05**	**0.530**
$G_1 \times T_2$	23.57	0.526
$G_1 \times T_3$	28.48	0.493
$G_1 \times T_4$	32.44	0.482
$G_1 \times T_5$	30.44	0.486
$G_1 \times T_6$	26.45	0.515
$G_1 \times T_7$	26.90	0.508
$G_1 \times T_8$	24.59	0.521
$G_1 \times T_9$	27.64	0.498

Table 4.8 continued…		
$G_2 \times T_1$	25.98	0.484
$G_2 \times T_2$	28.25	0.480
$G_2 \times T_3$	36.08	0.461
$G_2 \times T_4$	**41.30**	**0.451**
$G_2 \times T_5$	39.16	0.457
$G_2 \times T_6$	31.55	0.476
$G_2 \times T_7$	32.95	0.470
$G_2 \times T_8$	29.75	0.478
$G_2 \times T_9$	34.29	0.467
S.Em±	**0.83**	**0.003**
CD at 5%	**2.38**	**0.009**
CV %	**4.78**	**1.130**

4.2.2.8 Electrical conductivity (dSm^{-1})

The data on electrical conductivity as influenced by genotypes, seed priming treatments and their interaction effect are presented in Table 4.8.

4.2.2.8.1 Effect of genotypes

The electrical conductivity was significantly influenced due to genotypes. Significantly lower electrical conductivity was recorded in GJG-22 genotype (G_2) (0.469 dSm^{-1}); while significantly the higher electrical conductivity was recorded in GG-20 genotype (G_1) (0.506 dSm^{-1}).

4.2.2.8.2 Effect of treatments

The electrical conductivity showed significant difference due to seed priming treatments (Figure 4.21). Significantly the lowest electrical conductivity was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (0.467 dSm^{-1}), which was at par with treatment having seed primed with KCl (1%) (T_5) (0.472 dSm^{-1}) followed by seed primed with KH_2PO_4 (1%) (T_3) (0.477 dSm^{-1}) and KNO_3 (T_9) (0.482 dSm^{-1}); while significantly the highest electrical conductivity was recorded in control (T_1) (0.507 dSm^{-1}).

4.2.2.8.3 Interaction effect

The electrical conductivity showed significant difference due to interaction of genotypes and seed priming treatments (Figure 4.22). Significantly lowest electrical conductivity was recorded in G_2T_4 (0.451 dSm^{-1}), which was at par with G_2T_5 (0.457 dSm^{-1}) followed by G_2T_3 (0.461 dSm^{-1}), G_2T_9 (0.467 dSm^{-1}), G_2T_7 (0.470 dSm^{-1}) and G_2T_6 (0.476 dSm^{-1}); while significantly highest electrical conductivity was recorded in G_1T_1 (0.530 dSm^{-1}).

CHAPTER – V

DISCUSSION

The present investigation entitled **"Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)"**, was conducted at the Sagdividi Farm, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh during *kharif*-2018 to study the effect of different seed priming treatments on seed yield and seed quality characters.

The purpose of seed priming treatment is to maintain the seed quality and produced higher seed yield. Neither the losses in germination percentage and vigour can be stopped nor they can be reverted. However, the process of seed deterioration can be retarted with seed priming treatment. In the recent days plant population per unit area is one of the most important factors determining the crop yield. The optimum plant population per hectare needs to maintain for getting higher yield. Poor crop stands leads to reduce crop yield. Rapid germination and seedling emergence are an important factor for successful establishment. It is reported that the seed priming is one of the most important development to help in rapid and uniform germination, seedling emergence and to increase the seed tolerance to adverse environmental factors.

Therefore the present research was carried out to evaluate the effect of different seed priming treatments on seed yield and its quality in groundnut. The results obtained in the present investigation are discussed in this chapter. For the sake of convenience, the entire framework of the discussion has been divided under following broad topics:

5.1 Analysis of variance for experimental design

5.1.1 Effect of genotypes on seed yield and yield contributing characters

5.1.2 Effect of seed priming treatments on seed yield and yield contributing characters

5.1.3 Interaction effect on seed yield and yield contributing characters

5.1.4 Effect of genotypes on seed quality characters

5.1.5 Effect of seed priming treatments on seed quality characters

5.1.6 Interaction effect on seed quality characters

5.1 ANALYSIS OF VARIANCE FOR EXPERIMENTAL DESIGN

(a) Effect of seed priming treatments on seed yield and yield contributing characters

The analysis of variance revealed the existence of significant difference among genotypes for the yield and its contributing characters studied during *kharif*-2018.

The analysis of variance also revealed that there was existence of significant difference among seed priming treatments for seed yield and its contributing characters studied during *kharif*-2018. It is suggested that the seed priming treatments were differed to each other.

The analysis of variance also revealed that there was no significant difference among interaction of genotypes and seed priming treatments for seed yield and its contributing characters studied during *kharif*-2018.

(b) Effect of seed priming treatments on seed quality characters

The analysis of variance revealed the existence of significant difference among genotypes for all the seed quality characters studied during laboratory experiment.

The analysis of variance also revealed that there was existence of significant difference among seed priming treatments for all the seed quality characters studied during laboratory experiment. It is suggested that the seed priming treatments were differed to each other.

The analysis of variance also revealed that there was existence of significant difference among interaction of genotypes and seed priming treatments for all the seed quality characters studied during laboratory experiment except 100 seed weight and germination percentage.

5.1.1 Effect of genotypes on seed yield and yield contributing characters

Irrespective of seed priming treatments, yield and its characters of seed differed significantly due to genotypes.

The effect of genotypes on field emergence percentage were significant (Table 4.3). Significantly the highest field emergence percentage was recorded in GJG-22 genotype (G_2) (77.65%); while significantly the lowest field emergence percentage was recorded in GG-20 genotype (G_1) (75.38%). Similar works on field emergence percentage reported by Narayanaswamy and Shambulingappa (1998), Massawe *et al.* (1999), Khin *et al.* (2005), Dhedhi *et al.* (2007), Limbani (2007), Murata *et al.* (2008), Manickam *et al.* (2010), Patel *et al.* (2010), Narayanaswamy *et al.* (2012), Bhingarde *et al.* (2015) and Venkatesh *et al.* (2018) in groundnut; Basu and Choudhary (2005), Bassi *et al.* (2011), Ahmadvand *et al.* (2012) and Shete *et al.* (2018) in soybean.

The perusal of data given in table 4.3 indicated that number of days to 50 per cent flowering was significantly influenced due to genotypes. Significantly lesser number of days to 50 per cent flowering was recorded in GJG-22 genotype (G_2) (37.85); while significantly the highest number of days to 50 per cent flowering was recorded in GG-20 genotype (G_1) (39.07). Similar work on days to 50 per cent flowering reported by Lee (1990), Khin *et al.* (2005), Narayanaswamy *et al.* (2012), Bhingarde *et al.* (2015), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Chavan *et al.* (2014) in soybean.

The data presented in table 4.3 showed that the plant height was influenced significantly due to genotypes. Significantly the highest plant height was recorded in genotype GJG-22 (G_2) (39.88 cm); while significantly the lowest plant height was recorded in GG-20 genotype (G_1) (38.09 cm). Similar results on plant height reported by Limbani (2007), Bhingarde *et al.* (2015), Tahir *et al.* (2017) and Venkatesh *et al.* (2018) in groundnut; Ogbuehi *et al.* (2013) in Bambara groundnut; Ahmadvand *et al.* (2012) and Chavan *et al.* (2014) in soybean.

The days to maturity differed significantly due to genotypes (Table 4.4). Significantly lesser number of days to maturity was recorded in GJG-22 genotype (G_2) (113.59); while significantly the maximum number of days to maturity was recorded in genotype of GG-20 (G_1) (116.89). Similar results on days to maturity reported by Bhingarde *et al.* (2015), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Bejandi *et al.* (2009) and Chavan *et al.* (2014) in soybean.

The effect of genotypes on number of mature pods per plant were significant (Table 4.4). Significantly higher number of mature pods per plant was recorded in GJG-22 genotype (G_2) (19.77); while significantly lower number of mature pods per plant was recorded in GG-20 genotype (G_1) (18.72). Similar significant results on number of mature pods per plant reported by Narayanaswamy and Shambulingappa (1998), Narayanaswamy *et al.* (2012), Bhingarde *et al.* (2015), Tahir *et al.* (2017) and Venkatesh *et al.* (2018) in groundnut; Chavan *et al.* (2014), Agawane and Sachin (2015), Shahram (2015), Jadhav *et al.* (2017) and Shete *et al.* (2018) in soybean.

The results revealed that different genotypes exerted their significant influence on seed yield per plant (Table 4.4). Significantly the highest seed yield per plant was recorded in GJG-22 genotype (G_2) (22.64 g); while significantly the lowest seed yield per plant was recorded in GG-20 genotype (G_1) (21.22 g). Similar results on seed yield per plant reported by Limbani (2007) and Bhingarde *et al.* (2015) in groundnut; Bejandi *et al.* (2009), Chavan *et al.* (2014) and Shete *et al.* (2018) in soybean.

The data recorded on seed yield per plot are presented in table 4.5. Significantly the highest seed yield per plot was recorded in GJG-22 genotype (G_2) (1.56 kg); while significantly the lowest seed yield per plot was recorded in GG-20 genotype (G_1) (1.48 kg). Similar results on seed yield per plot recorded by Narayanaswamy and Shambulingappa (1998), Limbani (2007), Patel *et al.* (2010), Narayanaswamy *et al.* (2012), Bhingarde *et al.* (2015), Tahir *et al.* (2017), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Chavan *et al.* (2014), Shahram (2015) and Jadhav *et al.* (2017) in soybean.

The seed yield per hectare differed significantly due to genotypes (Table 4.5). Significantly the highest seed yield per hectare was recorded in GJG-22 genotype (G_2) (18.49 q); while significantly the lowest seed yield per hectare was recorded in GG-20 genotype (G_1) (17.59 q). Similar significant results on seed yield per hectare reported by Narayanaswamy and Shambulingappa (1998), Limbani (2007), Patel *et al.* (2010), Narayanaswamy *et al.* (2012), Bhingarde *et al.* (2015), Tahir *et al.* (2017), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Chavan *et al.* (2014), Shahram (2015), Jadhav *et al.* (2017) and Shete *et al.* (2018) in soybean.

The data presented in table 4.5 indicated that the genotypes were significantly influenced on harvest index. Significantly the highest harvest index was recorded in GJG-22 genotype (G_2) (33.60%); while significantly the lowest harvest index was recorded in GG-20 genotype (G_1) (32.05%). Similar results on harvest index reported by Tahir *et al.* (2017) in groundnut and Shete *et al.* (2018) in soybean.

5.1.2 Effect of seed priming treatments on seed yield and yield contributing characters

Irrespective of genotypes, yield and its parameter of seed differed significantly due to seed priming treatments.

The field emergence percentage showed significant difference due to seed priming treatments (Table 4.3). Significantly the highest field emergence percentage was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (82.88%), which was at par with a treatment having seed primed with KCl (1%) (T_5) (81.68%), KH_2PO_4 (1%) (T_3) (80.12%) and KNO_3 (1%) (T_9) (78.79%); while significantly the lowest field emergence percentage was recorded in unprimed seed (T_1) (69.38%). Bhingarde *et al.* (2015) reported that increase in field emergence percentage due to hydration with $CaCl_2$ aided in initiation of early sprouting and resulted in accelerated the germination. Similar work reported by Narayanaswamy and Shambulingappa (1998), Limbani (2007), Manickam *et al.* (2010), Narayanareddy and Biradarpatil (2012), Kunghatkar *et al.* (2018), Teggelli *et al.* (2018) and Venkatesh *et al.* (2018) in $CaCl_2$; Pradhan *et al.* (2017) in KCl; Pirmani *et al.* (2013) in KH_2PO_4; Ahmadvand *et al.* (2012), Nazir *et al.* (2014) and Singh *et al.* (2014) in KNO_3.

The data presented in table 4.3 indicated the days to 50 per cent flowering showed significant difference due to seed priming treatments. Significantly minimum number of days to 50 per cent flowering was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (35.33), which was at par with treatment having seed primed with KCl (1%) (T_5) (36.17) and KH_2PO_4 (2%) (T_3) (37.83); while significantly the maximum number of days to 50 per cent flowering was recorded in control (T_1) (41.17). This positive reduction in days to 50 per cent flowering is mainly due to the earlier and uniform emergence of seedlings, which was evident from the present study and might be also due to the role of calcium in plant growth and development (Pawar *et al.*, 2003). Similar results reported by Narayanareddy and Biradarpatil (2012), Chavan *et al.* (2014), Bhingarde *et al.* (2015), Jadhav *et al.* (2017), Prabhu *et al.* (2018) and Venkatesh *et al.* (2018) in $CaCl_2$; Kunghatkar *et al.* (2018) in KCl; Negewo *et al.* (2016) in KH_2PO_4.

The different seed priming treatments significantly influence on the plant height (Table 4.3). Significantly the highest plant height was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (43.33 cm), which was at par with treatment having seed primed with KCl (1%) (T_5) (42.06 cm) and KH_2PO_4 (1%) (T_3) (40.48 cm); while significantly the lowest plant height was recorded in unprimed seed (T_1) (35.25 cm). Bhingarde *et al.* (2015) reported that the enhancement in plant height with $CaCl_2$ might be due to cell enlargement and increase in normal cell division. Above significant results on plant height reported by Kunghatkar *et al.* (2018) and Venkatesh *et al.* (2018) and also similar work reported by Limbani (2007), Manickam *et al.* (2010), Chavan *et al.* (2014), Galahitigama and Wathugala (2016), Prabhu *et al.* (2018) and Teggelli *et al.* (2018) in $CaCl_2$; Aymen *et al.* (2012) in KCl.

The perusal of data given in table 4.4 indicated the days to maturity showed significant difference due to seed priming treatments. Significantly minimum number of days to maturity was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (110.00), which was at par with KCl (1%) (T_5) (110.83), KH_2PO_4 (1%) (T_3) (112.67), KNO_3 (1%) (T_9) (114.33), GA_3 (25 ppm) (T_7) (115.33) and Boron (0.5%) (T_6) (116.50); while significantly the maximum number of days to maturity was recorded in control (T_1) (119.83). Similar results revealed by Chavan *et al.* (2014) and Bhingarde *et al.* (2015) in $CaCl_2$; Kumar *et al.* (2016) in KNO_3; Bejandi *et al.* (2009), Agawane and Sachin (2015) and Mazed *et al.* (2015) in GA_3.

The result on number of mature pods per plant showed significant difference due to seed priming treatments given in table 4.4. Significantly higher number of mature pods per plant was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (22.27), which was at par with treatment having seed primed with KCl (1%) (T_5) (21.47) and KH_2PO_4 (1%) (T_3) (20.70); while significantly lower number of mature pods per plant was recorded in control (T_1) (16.17). Bhingarde *et al.* (2015) reported that more number of mature pods per plant might be due to calcium improves pod filling, which resulted in increase the number of well-filled pods. Above same significant results on number of mature pods per plant reported by Kunghatkar *et al.* (2018) and also similar work reported by Narayanaswamy and Shambulingappa (1998), Manickam *et al.* (2010), Chavan *et al.* (2014), Fatemeh *et al.* (2017), Jadhav *et al.* (2017), Teggelli *et al.* (2018) and Venkatesh *et al.* (2018) in $CaCl_2$; Arjunan and Srinivasan (1989) in KH_2PO_4.

The different seed priming treatments significantly influence on the seed yield per plant (Table 4.4). Significantly the highest seed yield per plant was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (25.78 g), which was at par with treatment having seed primed with KCl (1%) (T_5) (24.41 g) and KH_2PO_4 (1%) (T_3) (23.65 g); while significantly the lowest seed yield per plant was recorded in control (T_1) (18.18 g). Bhingarde *et al.* (2015) revealed that the calcium has been found to be beneficial in the fruiting medium for the production of filled fruits and for development of kernels therefore, increased in the seed yield per plant. Above same significant results on seed yield per plant reported by Kunghatkar *et al.* (2018) and also similar result revealed by Limbani (2007), Chavan *et al.* (2014), Jadhav *et al.* (2017) and Prabhu *et al.* (2018) in $CaCl_2$; Aymen *et al.* (2012) and Aroubandi (2016) in KCl.

The seed yield per plot showed significant difference due to seed priming treatments (Table 4.5). Significantly the highest seed yield per plot was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (1.62 kg), which was at par with treatment having seed primed with KCl (1%) (T_5) (1.60 kg), KH_2PO_4 (1%) (T_3) (1.58 kg) and KNO_3 (1%) (T_9) (1.54 kg); while significantly the lowest seed yield per plot was recorded in control (T_1) (1.44 kg).

An appraisal of data presented in (Table 4.5) revealed that treatment $CaCl_2$ (1%) (T_4) recorded significantly the highest seed yield per hectare (19.27 q), which was at par with treatment having seed primed with KCl (1%) (T_5) (19.03 q), KH_2PO_4 (1%) (T_3) (18.83 q) and KNO_3 (1%) (T_9) (18.31 q); while significantly the lowest seed yield per hectare was recorded in control (T_1) (17.08 q). Increase in yield with $CaCl_2$ invigouration can be attributed to increased yield and yield contributing characters such as field emergence percentage, number of mature pods per plant and seed yield per plant. Similar work on seed yield per plot and seed yield per hectare reported by Narayanaswamy and Shambulingappa (1998), Limbani (2007), Jahangir *et al.* (2008), Manickam *et al.* (2010), Narayanareddy and Biradarpatil (2012), Chavan *et al.* (2014), Bhingarde *et al.* (2015), Fatemeh *et al.* (2017), Jadhav *et al.* (2017), Teggelli *et al.* (2018) and Venkatesh *et al.* (2018) in $CaCl_2$; Arjunan and Srinivasan (1989) in KH_2PO_4; Abdolahpour and Lotfi (2014), Kumar *et al.* (2016) and Jockovic *et al.* (2018) in KNO_3.

The result on harvest index showed significant difference due to seed priming treatments given in table 4.5. Significantly the highest harvest index was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (35.73%), which was at par with treatment having seed primed with KCl (1%) (T_5) (35.02%) and KH_2PO_4 (1%) (T_3) (34.67%); while significantly the lowest harvest index was recorded in control (T_1) (30.22%). Similar work reported by Bhingarde *et al.* (2015) in $CaCl_2$ and Golezani *et al.* (2011) in KH_2PO_4.

Table 5.1: List of best genotype, seed priming treatments and their interaction on seed yield and yield contributing characters

Character	G	T	G × T
Field emergence percentage	G_2	T_4; T_5; T_3; T_9	G_2T_4
Days to 50 per cent flowering	G_2	T_4; T_5; T_3	G_2T_4
Plant height (cm)	G_2	T_4; T_5; T_3	G_2T_4
Days to maturity	G_2	T_4; T_5; T_3; T_9; T_7; T_6	G_2T_4
Number of mature pods per plant	G_2	T_4; T_5; T_3	G_2T_4
Seed yield per plant (g)	G_2	T_4; T_5; T_3	G_2T_4
Seed yield per plot (kg)	G_2	T_4; T_5; T_3; T_9	G_2T_4
Seed yield per hectare (q)	G_2	T_4; T_5; T_3; T_9	G_2T_4
Harvest index (%)	G_2	T_4; T_5; T_3	G_2T_4

Where;

G: Genotype, **T:** Seed priming treatments

G × T: Interaction of genotype and seed priming treatments

5.1.3 Interaction effect on seed yield and yield contributing characters

Interaction effect between genotypes and seed priming treatments were found non-significantly differ on all seed yield and yield contributing characters.

The results presented in table 4.3 indicated that the field emergence percentage was non-significantly influenced by interaction effect of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed non-significantly the highest field emergence percentage (83.92%) and genotype GG-20 without priming (G_1T_1) expressed the lowest field emergence percentage (68.59%).

The results on days to 50 per cent flowering showed non-significant difference due to interaction of genotypes and seed priming treatments given in table 4.3. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) recorded non-significantly the minimum number of days to 50 per cent flowering (34.67) and genotype GG-20 without priming (G_1T_1) recorded the maximum numbers of days to 50 per cent flowering (42.00).

The perusal of data given in table 4.3 indicated that the plant height showed non-significant difference due to interaction of genotypes and seed priming treatments. Non-significantly the highest plant height was recorded in the plots having seeds of genotype GJG-22 primed with $CaCl_2$ (1%) G_2T_4 (44.32 cm); while non-significantly the lowest plant height was recorded in the plots having seeds of genotype GG-20 without priming G_1T_1 (33.76 cm).

The days to maturity showed non-significant difference due to interaction of genotypes and seed priming treatments (Table 4.4). Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) recorded non-significantly the minimum number of days to maturity (108.67) and genotype GG-20 without priming (G_1T_1) recorded the maximum numbers of days maturity (121.67).

The data presented in table 4.4 indicated that the interaction effect of genotypes and seed priming treatments were non-significantly influenced on number of mature pods per plant. Non-significantly the highest number of mature pods per plant was recorded in the plots having seeds of genotype GJG-22 primed with $CaCl_2$ (1%) G_2T_4 (23.07); while non-significantly the lowest number of mature pods per plant was recorded in the plots having seeds of genotype GG-20 without priming G_1T_1 (15.60).

The results on seed yield per plant showed non-significant difference due to interaction of genotypes and seed priming treatments given in table 4.4. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed non-significantly the highest seed yield per plant (26.83 g) and genotype GG-20 without priming (G_1T_1) expressed the lowest seed yield per plant (17.50 g).

The results presented in table 4.5 indicated that the seed yield per plot was non-significantly influenced by interaction effect of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed non-significantly the highest seed yield per plot (1.66 kg) and genotype GG-20 without priming (G_1T_1) expressed the lowest seed yield per plot (1.40 kg).

The perusal of data given in table 4.5 indicated the seed yield per hectare showed non-significant difference due to interaction of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed non-significantly the highest seed yield per hectare (19.80 q) and genotype GG-20 without priming (G_1T_1) expressed the lowest seed yield per hectare (16.71 q).

The results on harvest index showed non-significant difference due to interaction of genotypes and seed priming treatments given in table 4.5. Non-significantly the maximum harvest index was recorded in the plots having seeds of genotype GJG-22 primed with $CaCl_2$ (1%) G_2T_4 (36.08%); while non-significantly the minimum harvest index was recorded in the plots having seeds of genotypes GG-20 without priming G_1T_1 (29.50%).

Similar result on field emergence percentage, plant height, number of mature pods per plant, seed yield per plant and seed yield per hectare reported by Limbani (2007) and Bhingarde *et al.* (2015) in groundnut.

5.1.4 Effect of genotypes on seed quality characters

Irrespective of seed priming treatments, the quality characters of seed differed significantly due to genotypes.

The 100 seed weight differed significantly due to genotypes (Table 4.6). Significantly the highest 100 seed weight was recorded in GJG-22 genotype (G_2) (45.03 g); while significantly the lowest 100 seed weight was recorded in GG-20 genotype (G_1) (43.95 g). Similar significant result on 100 seed weight in different groundnut cultivar reported by Chatterjee *et al.* (1982), Narayanaswamy and Shambulingappa (1998), Limbani (2007), Jahangir *et al.* (2008), Tahir *et al.* (2017), Hasan and Ismail (2018) and Venkatesh *et al.* (2018); Chavan and Tagad (2015) and Shete *et al.* (2018) in soybean.

The effect of genotypes on germination percentage was significant (Table 4.6). Significantly the highest germination percentage was recorded in GJG-22 genotype (G_2) (92.52%); while significantly the lowest germination percentage was recorded in GG-20 genotype (G_1) (91.04%). Similar significant result on germination percentage reported by Subbaraman and Slevaraj (1989), Rangaswamy *et al.* (1993), Anbazhagi (1997), Narayanaswamy and Shambulinggappa (1998), Bose and Saxena (1999), Khin *et al.* (2005), Dhedhi *et al.* (2007), Limbani (2007), Bhingarde *et al.* (2015), Sepehri and Rouhi (2017), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Massawe *et al.* (1999) in Bambara groundnut; Bellur (2009), Ahmadvand *et al.* (2012), Chavan and Tagad (2015) and Shahram (2015) in soybean; Patil *et al.* (2018) in chickpea.

The data presented in table 4.6 indicated that the genotypes were significantly influenced on root length. Significantly the highest root length was recorded in GJG-22 genotype (G_2) (9.88 cm); while significantly the lowest root length was recorded in GG-20 genotype (G_1) (8.59 cm). Similar results on root length reported by Anbazhagi (1997), Limbani (2007), Bhingarde *et al.* (2015), Sepehri and Rouhi (2017) and Venkatesh *et al.* (2018) in groundnut; Ahmadvand *et al.* (2012) and Chavan and Tagad (2015) in soybean; Patil *et al.* (2018) in chickpea.

The shoot length differed significantly due to genotypes (Table 4.7). Significantly the highest shoot length was recorded in GJG-22 genotype (G_2) (4.86 cm); while significantly the lowest shoot length was recorded in GG-20 genotype (G_1) (3.80 cm). Similar results on shoot length reported by Anbazhagi (1997), Limbani (2007), Bhingarde *et al.* (2015), Sepehri and Rouhi (2017) and Venkatesh *et al.* (2018) in groundnut; Ahmadvand *et al.* (2012), Chavan and Tagad (2015) in soybean; Patil *et al.* (2018) in chickpea.

The data recorded on seedling dry weight is presented in table 4.7. Significantly the highest seedling dry weight was recorded in GJG-22 genotype (G_2) (0.358 g); while significantly the lowest seedling dry weight was recorded in GG-20 genotype (G_1) (0.296 g). Similar results on seedling dry weight recorded by Bose and Saxena (1999) and Bhingarde *et al.* (2015) in groundnut; Massawe *et al.* (1999) in Bambara groundnut; Ahmadvand *et al.* (2012) in soybean; Patil *et al.* (2018) in chickpea.

The results revealed that different genotypes exerted their significant influence on seedling vigour index-I (Table 4.7). Significantly higher seedling vigour index-I was recorded in GJG-22 genotype (G_2) (1368.16); while significantly lower seedling vigour index-I was recorded in GG-20 genotype (G_1) (1131.31). Similar results on seedling vigour index-I reported by Subbaraman and Slevaraj (1989), Rangaswamy *et al.* (1993), Anbazhagi (1997), Limbani (2007), Manickam *et al.* (2010), Bhingarde *et al.* (2015), Sepehri and Rouhi (2017), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Sanjeeva Kumar (2000), Bellur (2009), Chavan and Tagad (2015) in soybean; Patil *et al.* (2018) in chickpea.

The effect of genotypes on seedling vigour index-II was significant (Table 4.8). Significantly higher seedling vigour index-II was recorded in GJG-22 genotype (G_2) (33.26); while significantly lower seedling vigour index-II was recorded in GG-20 genotype (G_1) (26.95). Similar significant results on seedling vigour index-II reported by Rangaswamy *et al.* (1993), Anbazhagi (1997), Bose and Saxena (1999), Manickam *et al.* (2010) and Bhingarde *et al.* (2015) in groundnut; Sanjeeva Kumar (2000) in soybean; Patil *et al.* (2018) in chickpea.

The data presented in table 4.8 indicated that the genotypes were significantly influenced on electrical conductivity. Significantly lower electrical conductivity was recorded in GJG-22 genotype (G_2) (0.469 dSm^{-1}); while significantly the higher electrical conductivity was recorded in GG-20 genotype (G_1) (0.506 dSm^{-1}). Similar results on electrical conductivity reported by Bhingarde *et al.* (2015), Das and Mohanty (2018) and Venkatesh *et al.* (2018) in groundnut; Bellur (2009), Chavan and Tagad (2015) in soybean.

Table 5.2: List of best genotype, seed priming treatments and their interaction on seed quality characters

Character	G	T	G × T
100 seed weight (g)	G_2	T_4; T_5; T_3; T_9	G_2T_4
Germination percentage	G_2	T_4; T_5; T_3; T_9	G_2T_4
Root length (cm)	G_2	T_4	G_2T_4
Shoot length (cm)	G_2	T_4	G_2T_4
Seedling dry weight (g)	G_2	T_4	G_2T_4; G_2T_5
Seedling vigour index-I	G_2	T_4	G_2T_4
Seedling vigour index-II	G_2	T_4	G_2T_4; G_2T_5
Electrical conductivity (dSm^{-1})	G_2	T_4; T_5	G_2T_4; G_2T_5

Where;

G: Genotype, **T:** Seed priming treatments

G × T: Interaction of genotype and seed priming treatments

5.1.5 Effect of seed priming treatments on seed quality characters

Irrespective of genotypes, the quality characters of seed differed significantly due to seed priming treatments.

An appraisal of data on 100 seed weight of groundnut (Table 4.6) revealed that different seed priming treatments significantly influenced the 100 seed weight. Seed primed with $CaCl_2$ (1%) (T_4) recorded the highest 100 seed weight (45.80 g), which was at par with treatment having seed primed with KCl (1%) (T_5) (45.73 g), KH_2PO_4 (1%) (T_3) (45.67 g) and KNO_3 (1%) (T_9) (44.97 g); while significantly the lowest 100 seed weight was recorded in control (T_1) (43.49 g). Similar result reported by Narayanaswamy and Shambulingappa (1998), Limbani (2007), Chavan and Tagad (2015), Fatemeh *et al.* (2017), Jadhav *et al.* (2017), Kunghatkar *et al.* (2018), Teggelli *et al.* (2018) and Venkatesh *et al.* (2018) in $CaCl_2$; Kumar *et al.* (2016) in KNO_3.

The results revealed that different seed priming treatments exerted their significant influence on germination percentage (Table 4.6). Seed primed with $CaCl_2$ (1%) (T_4) recorded the highest germination percentage (95.33%), which was at par with treatment having seed primed with KCl (1%) (T_5) (94.00%), KH_2PO_4 (1%) (T_3) (93.00%) and KNO_3 (1%) (T_9) (92.50%); while significantly the lowest germination percentage was recorded in control (T_1) (88.33%). Highest germination percentage noticed in $CaCl_2$ (1%) (T_4) may be due to the benefits of priming which may be due to number of physio chemical changes occur that modify the protoplasmic characters, increasing the embryo physiological activity and associated structures (Ganesh *et al.,* 2013). The improvement in germination by $CaCl_2$ priming seeds may be attributed to stimulation of hydrolytic enzyme activity known to be induced by $CaCl_2$ agents. Since, $CaCl_2$ improving cell water status and also act as cofactors in the activities of numerous enzymes (Joseph and Nair, 1989). Prabhu *et al.* (2018) reported the most of which are active when reserve metabolization and radical protrusion were in progress. Subsequent improved in germination of $CaCl_2$ priming seed could be due to the fact that such advanced seed would retain viability to carry on where they left off upon germination. Rangaswamy *et al.* (1993), Anbazhagi (1997), Narayanaswamy and Shambulingappa (1998), Bellur (2009), Narayanareddy and Biradarpatil (2012), Bhingarde *et al.* (2015), Chavan and Tagad (2015), Jamadar and Chandrashekhar (2015), Jadhav *et al.* (2017), Singh *et al.* (2017), Ullah *et al.* (2017), James *et al.* (2018), Kunghatkar *et al.* (2018) and Teggelli *et al.* (2018) in $CaCl_2$. Similar results also reported by Pradhan *et al.* (2017) in KCl; Sanjeeva Kumar (2000) and Abdolahi *et al.* (2012) in KH_2PO_4; Bajehbaj (2010), Ahmadvand *et al.* (2012), Goudarz *et al.* (2012), Narayanaswamy *et al.* (2012), Nazir *et al.* (2014), Singh *et al.* (2014), Tiwari *et al.* (2014), Agawane and Sachin (2015), Galahitigama and Wathugala (2016), Kumar *et al.* (2016), Sajjan *et al.* (2017) and Jockovic *et al.* (2018) in KNO_3.

The effect of seed priming treatments on root length was significant (Table 4.6). Significantly the highest root length was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (11.41 cm); while significantly the lowest root length was recorded in control (T_1) (8.00 cm). Similar results on root length reported by Rangaswamy *et al.* (1993), Anbazhagi (1997), Limbani (2007), Bhingarde *et al.* (2015), Chavan and Tagad (2015), Jamadar and Chandrashekhar (2015), Singh *et al.* (2017), James *et al.* (2018), Prabhu *et al.* (2018), Teggelli *et al.* (2018) and Venkatesh *et al.* (2018).

The data presented in table 4.7 indicated that the seed priming treatments were significantly influenced on shoot length. Significantly the highest shoot length was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (6.03 cm); while significantly the lowest shoot length was recorded in control (T_1) (3.10 cm). Similar results on shoot length reported by Rangaswamy *et al.* (1993), Anbazhagi (1997), Limbani (2007), Bhingarde *et al.* (2015), Chavan and Tagad (2015), Jamadar and Chandrashekhar (2015), Singh *et al.* (2017), James *et al.* (2018), Kunghatkar *et al.* (2018), Prabhu *et al.* (2018), Teggelli *et al.* (2018) and Venkatesh *et al.* (2018). Ganesh *et al.* (2013) reported the improvement in seedling length (both root length and shoot length) may due to the enhanced metabolic activity and enzyme activity which hydrolysis the stored reserved food material and make available high energy bio molecules and vital components to growing point and also due to the presence of growth promoting substance auxin, IAA which induce elongation of cells there by increasing root and shoot length.

Different seed priming treatments significantly influenced on the seedling dry weight given in table 4.7. Significantly the highest seedling dry weight was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (0.386 g); while significantly the lowest seedling dry weight was recorded in control (T_1) (0.272 g). Prabhu *et al.* (2018) reported the increased seedling dry weight might due to simultaneous effect of repair mechanism induced by priming and synchronized earlier germination that makes seedling entry into the autotrophic state well in advance to produced more photo assimilate from source to sink there by increases the seedling dry weight. Similar results on seedling dry weight reported by Anbazhagi (1997), Bhingarde *et al.* (2015), Jamadar and Chandrashekhar (2015), Jadhav *et al.* (2017), Singh *et al.* (2017), Ullah *et al.* (2017), James *et al.* (2018) and Kunghatkar *et al.* (2018).

The data presented in table 4.7 indicated that the seedling vigour index-I showed significant difference due to seed priming treatments. Significantly higher seedling vigour index-I was recorded in treatment having seed primed with $CaCl_2$ (1%) (T_4) (1663.08); while significantly lower seedling vigour index-I was recorded in control (T_1) (981.56). Similar work on seedling vigour index-I reported by Kulkarni and Eshanna (1988), Subbaraman and Slevaraj (1989), Rangaswamy *et al.* (1993), Anbazhagi (1997), Limbani (2007), Bellur (2009), Manickam *et al.* (2010), Narayanareddy and Biradarpatil (2012), Bhingarde *et al.* (2015), Chavan and Tagad (2015), Jamadar and Chandrashekhar (2015), Jadhav *et al.* (2017), Singh *et al.* (2017), James *et al.* (2018), Prabhu *et al.* (2018) and Venkatesh *et al.* (2018).

The perusal of data given in table 4.8 indicated that seedling vigour index-II was significantly influenced by the seed priming treatments. Significantly higher seedling vigour index-II was recorded in treatment having seed primed with $CaCl_2$ (1%)

(T_4) (36.87); while significantly lower seedling vigour index-II was recorded in control (T_1) (24.02). Similar results on seedling vigour index-II reported by Kulkarni and Eshanna (1988), Rangaswamy *et al.* (1993), Anbazhagi (1997), Manickam *et al.* (2010), Bhingarde *et al.* (2015), Jamadar and Chandrashekhar (2015), Jadhav *et al.* (2017), Singh *et al.* (2017), James *et al.* (2018) and Prabhu *et al.* (2018). Both seedling vigour index increased due to increase germination percentage, root length, shoot length and seedling dry weight. The $CaCl_2$ activities synthesis of protein and soluble sugar in first phase of germination which have advantages for earlier germination and in turn produces longer seedlings there by increase the vigour of seedling (Farooq *et al.*, 2006).

The result revealed that different seed priming treatments exerted their significant influence on electrical conductivity given in table 4.8. Seed primed with $CaCl_2$ (1%) (T_4) recorded the lowest electrical conductivity (0.467 dSm^{-1}), which was at par with treatment having seed primed with KCl (1%) (T_5) (0.472 dSm^{-1}); while significantly the highest electrical conductivity was recorded in control (T_1) (0.507 dSm^{-1}). Bhingarde *et al.* (2015) revealed that the lower electrical conductivity of seed leachate for $CaCl_2$ treated seeds might be due to beneficial effect of $CaCl_2$ in strengthening the cell membrane integrity and permeability. Similar results on electrical conductivity also reported by Bellur (2009) and Chavan and Tagad (2015) in $CaCl_2$.

The improved seed quality of resultant seeds might also due to the more food reserved materials in seeds and reduced stress condition during seed maturation and development favoured this positive effect.

5.1.6 Interaction effect on seed quality characters

Interaction effect between genotypes and seed priming treatments were found non-significant for 100 seed weight and germination percentage; while significant for root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity.

The results presented in table 4.6 indicate the 100 seed weight was non-significantly influenced by interaction effect of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed non-significantly the highest 100 seed weight (46.41 g) and genotype GG-20 without priming (G_1T_1) expressed the lowest 100 seed weight (42.93 g).

The data presented in table 4.6 revealed that the germination percentage was non-significantly influenced by the interaction effect of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed non-significantly the highest germination percentage (96.33%) and genotype GG-20 without priming (G_1T_1) expressed the lowest germination percentage (87.33%).

The root length was significantly influenced by the interaction effect of genotypes and seed priming treatments (Table 4.6). Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed significantly the highest root length (12.39 cm) and genotype GG-20 without priming (G_1T_1) expressed the lowest root length (7.45 cm).

The interaction effect of genotypes and seed priming treatments on shoot length was significant (Table 4.7). Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed significantly the highest shoot length (6.68 cm) and genotype GG-20 without priming (G_1T_1) expressed the lowest shoot length (2.76 cm).

The interaction effect of genotypes and seed priming treatments on seedling dry weight was significant (Table 4.7). Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed significantly the highest seedling dry weight (0.429 g), which was at par with G_2T_5 (0.412 g); while seeds of genotype GG-20 without priming (G_1T_1) expressed significantly the lowest seedling dry weight (0.253 g).

The results presented in table 4.7 indicate the seedling vigour index-I was significantly influenced by interaction effect of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed significantly the highest seedling vigour index-I (1837.29) and genotype GG-20 without priming (G_1T_1) expressed the lowest seedling vigour index-I (890.76).

The perusal of data given in table 4.8 indicated that the seedling vigour index-II was significantly influenced by the interaction effect of genotypes and seed priming treatments. Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed significantly the highest seedling vigour index-II (41.30), which was at par with G_2T_5 (39.16); while seeds of genotype GG-20 without priming (G_1T_1) expressed significantly the lowest seedling vigour index-II (22.05).

Electrical conductivity was significantly influenced by the interaction effect of genotypes and seed priming treatments (Table 4.8). Seeds of genotype GJG-22 primed with $CaCl_2$ (1%) (G_2T_4) expressed significantly the lowest electrical conductivity

(0.451 dSm^{-1}), which was at par with G_2T_5 (0.457 dSm^{-1}); while seeds of genotype GG-20 without priming (G_1T_1) expressed significantly the highest electrical conductivity (0.530 dSm^{-1}).

Similar results on root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity reported by Bhingarde *et al.* (2015) in groundnut.

CHAPTER – VI

SUMMARY AND CONCLUSION

The present investigation on **"Effect of different seed priming treatments on seed yield and its quality in groundnut (*Arachis hypogaea* L.)"** was under taken with a view,

1. To study the effect of seed priming treatments on seed yield and yield contributing characters.
2. To find out the effect of seed priming treatments on seed quality.

The seeds of groundnut genotypes GG-20 and GJG-22 obtained from Junagadh Agricultural University, Junagadh and primed for 6 hours with water, KH_2PO_4 (1%), $CaCl_2$ (1%), KCl (1%), Boron (0.5%), GA_3 (25 ppm), $MnSO_4$ (0.5%), KNO_3 (1%) and untreated seed (control) followed by shade drying. The field experiment was conducted at Sagdividi Farm, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh during *kharif*-2018. Laboratory experiment was conducted at Seed Testing Laboratory, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh and performed after 45 days to harvesting in the field due to breaking of fresh seed dormancy. Field observations on field emergence percentage, days to 50 per cent flowering, plant height (cm), days to maturity, number of mature pods per plant, seed yield per plant (g), seed yield per plot (kg), seed yield per hectare (q), harvest index (%) were recorded and laboratory observations on 100 seed weight (g), germination percentage, root length (cm), shoot length (cm), seedling dry weight (g), seedling vigour index-I, seedling vigour index-II and electrical conductivity (dSm^{-1}) were recorded. The results obtained and discussed in preceding chapter are summarized below.

6.1 SUMMARY

6.1.1 Effect of seed priming treatments on seed yield and yield contributing characters of groundnut

1. Genotype GJG-22 (G_2) significantly highest in field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index as compared to GG-20 (G_1) genotype.

2. The seeds of genotype GJG-22 (G_2) took significantly lesser days to 50 per cent flowering and days to maturity as compared to genotype GG-20 (G_1).
3. The treatment having seed primed with $CaCl_2$ (1%) (T_4) took significantly lesser days to 50 per cent flowering and days to maturity, which was at par with KCl (1%) (T_5) and KH_2PO_4 (1%) (T_3) primed seeds.
4. $CaCl_2$ (1%) (T_4) also significantly highest in field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index, which was at par with KCl (1%) (T_5) and KH_2PO_4 (1%) (T_3) primed seeds.
5. Significantly delayed 50 per cent flowering and days to maturity were observed in control (T_1) and also significantly lowest in field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index.
6. The interaction effect non-significant influence with the highest field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index recorded by GJG-22 (G_2) seeds primed with $CaCl_2$ (1%) (T_4) and the lowest field emergence percentage, plant height, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index was shown in GG-20 (G_1) seeds with control (T_1).
7. The interaction effect non-significant influence with the lowest days 50 per cent flowering and days to maturity recorded by GJG-22 (G_2) seeds primed with $CaCl_2$ (1%) (T_4) and the highest days to 50 per cent flowering and days to maturity recorded by GG-20 (G_1) seeds with control (T_1).

6.1.2 Effect of seed priming treatments on seed quality of groundnut

1. Genotype GJG-22 (G_2) was significantly highest in 100 seed weight, germination percentage, root length, shoot length, seedling dry weight, seedling vigour index-I and seedling vigour index-II as compared to genotype GG-20 (G_1).
2. Genotype GJG-22 (G_2) showed the significantly lowest electrical conductivity as compared to genotype GG-20 (G_1).
3. The treatment having seed primed with $CaCl_2$ (1%) (T_4) significantly the highest in 100 seed weight, germination percentage, root length, shoot length,

seedling dry weight, seedling vigour index-I and seedling vigour index-II.

4. Electrical conductivity was significantly lowest in seeds primed with $CaCl_2$ (1%) (T_4).
5. Significantly lowest 100 seed weight, germination percentage, root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and also significantly highest electrical conductivity recorded in control (T_1).
6. The interaction effect was significantly influence with highest root length, shoot length, seedling dry weight, seedling vigour index-I and seedling vigour index-II recorded by GJG-22 (G_2) seeds primed with $CaCl_2$ (1%) (T_4) and the lowest root length, shoot length, seedling dry weight, seedling vigour index-I and seedling vigour index-II recorded by GG-20 (G_1) seeds with control (T_1).
7. The interaction effect was significantly influence with lowest electrical conductivity recorded by GJG-22 (G_2) seeds primed with $CaCl_2$ (1%) (T_4); while the highest electrical conductivity recorded by GG-20 (G_1) seeds with control (T_1).
8. The interaction effect was non-significantly influence with highest 100 seed weight and germination percentage recorded by GJG-22 (G_2) seeds primed with $CaCl_2$ (1%) (T_4) and the lowest 100 seed weight and germination percentage recorded by GG-20 (G_1) seeds with control (T_1).

6.2 CONCLUSION

Seeds of groundnut treated with various priming treatments recorded higher growth, seed yield and seed quality characters compared to control. Genotype GJG-22 found to be superior in seed yield characters *viz.*, field emergence percentage, days to 50 per cent flowering, plant height, days to maturity, number of mature pods per plant, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index and seed quality characters *viz.*, 100 seed weight, germination percentage, root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II and electrical conductivity.

It was observed that seed priming has a positive effect on the sowing quality of groundnut seeds, as well as performance, leading to higher yield. Seed priming with $CaCl_2$ (1%) followed by KCl (1%) and KH_2PO_4 (1%) for 6 hours followed by shade drying recorded higher values for growth and seed yield characters, while seed priming with $CaCl_2$ (1%) which recorded higher value for quality characters as compared to other priming treatments. The increase in the seed yield by $CaCl_2$ (1%) followed by KCl (1%) and KH_2PO_4 (1%) were mainly due to increase in field emergence percentage and number of pods per plant. The increases in growth, seed yield and quality characters due to the activities of numerous enzymes, enhanced metabolic activity, presence of growth promoters, make available high energy biomolecules, improved mobilization of nutrient and more food reserve materials in seeds.

It is concluded that the seeds of groundnut primed with the $CaCl_2$ (1%) for better field emergence percentage, successful establishment of seedlings and also to get better pod yield and quality of groundnut crop.

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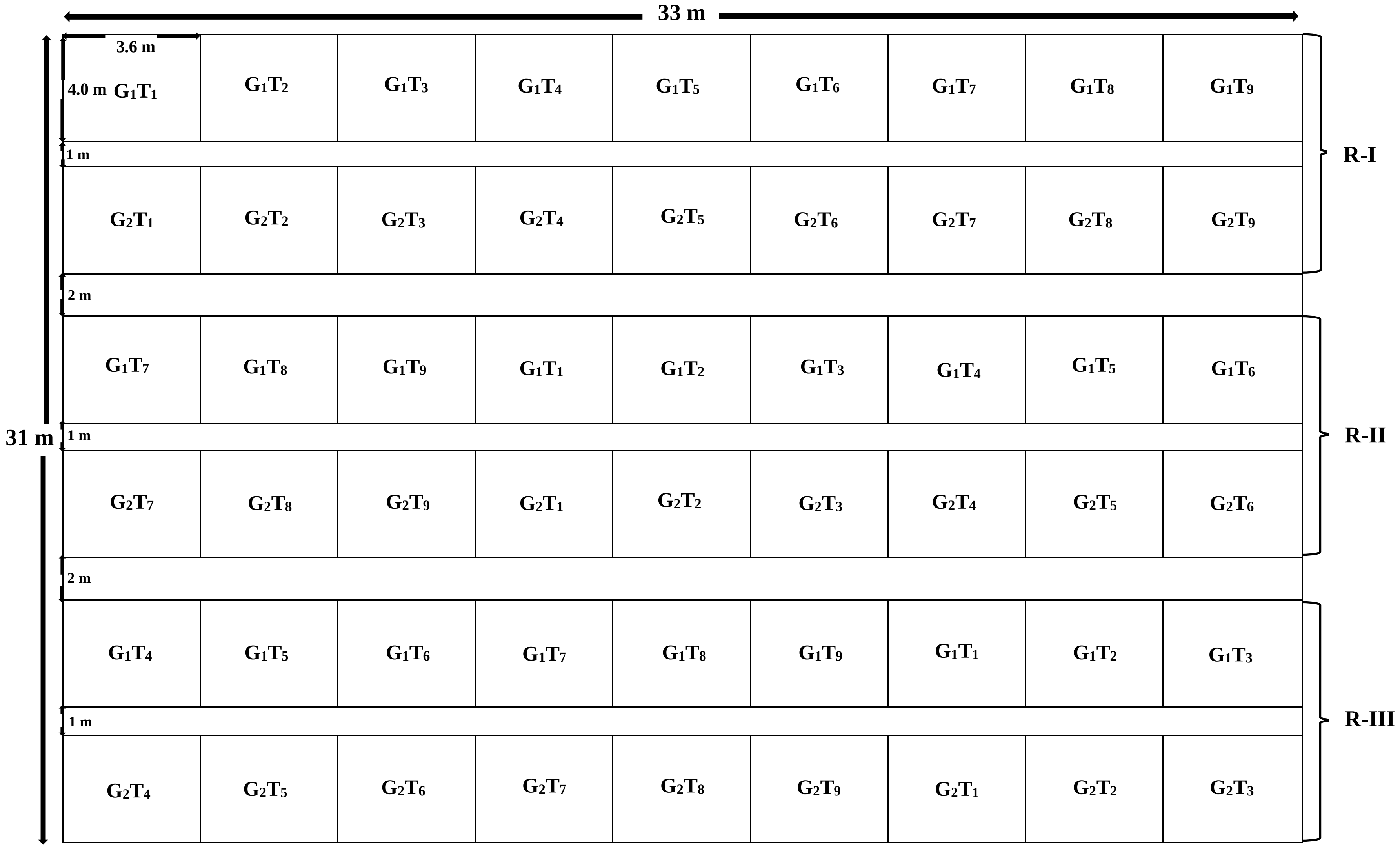
Appendix I: Mean weekly meteorological data recorded during the crop growth period (July 2018 to November 2018) at Meteorological Observatory, College of Agriculture, Junagadh Agricultural University, Junagadh

Month	Standard Week	Total Rainfall (mm)	Number of Rainy Days	Temperature (^0C)		Relative Humidity (%)	
				Max.	Min.	Morning	Evening
July 2018	27	23.9	2.0	34.3	26.6	88	63
	28	447.8	6.0	30.0	25.5	95	87
	29	166.7	6.0	27.8	25.1	98	93
	30	1.8	0.0	30.2	26.1	90	76
	31	4.5	1.0	32.1	26.1	88	63
August 2018	32	8.8	1.0	31.5	25.4	87	72
	33	10.0	3.0	30.1	25.1	91	76
	34	50.3	5.0	29.0	24.2	94	84
	35	31.3	4.0	29.5	24.0	92	78
September 2018	36	27.4	1.0	30.1	23.4	89	66
	37	2.1	0.0	31.3	23.6	87	59
	38	6.2	2.0	33.5	23.9	84	54
	39	0.0	0.0	34.7	23.1	76	38
October 2018	40	0.0	0.0	37.4	22.9	76	32
	41	0.0	0.0	37.9	23.1	66	29
	42	0.0	0.0	36.7	21.1	74	28
	43	0.0	0.0	37.5	20.2	64	22
	44	0.0	0.0	37.0	19.8	60	23
November 2018	45	0.0	0.0	36.7	18.0	68	22
	46	0.0	0.0	35.4	18.7	75	27
	47	0.0	0.0	35.9	18.0	67	21
	48	0.0	0.0	34.0	16.6	67	30

Appendix II: Layout of experiment



Abstract

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Appendices

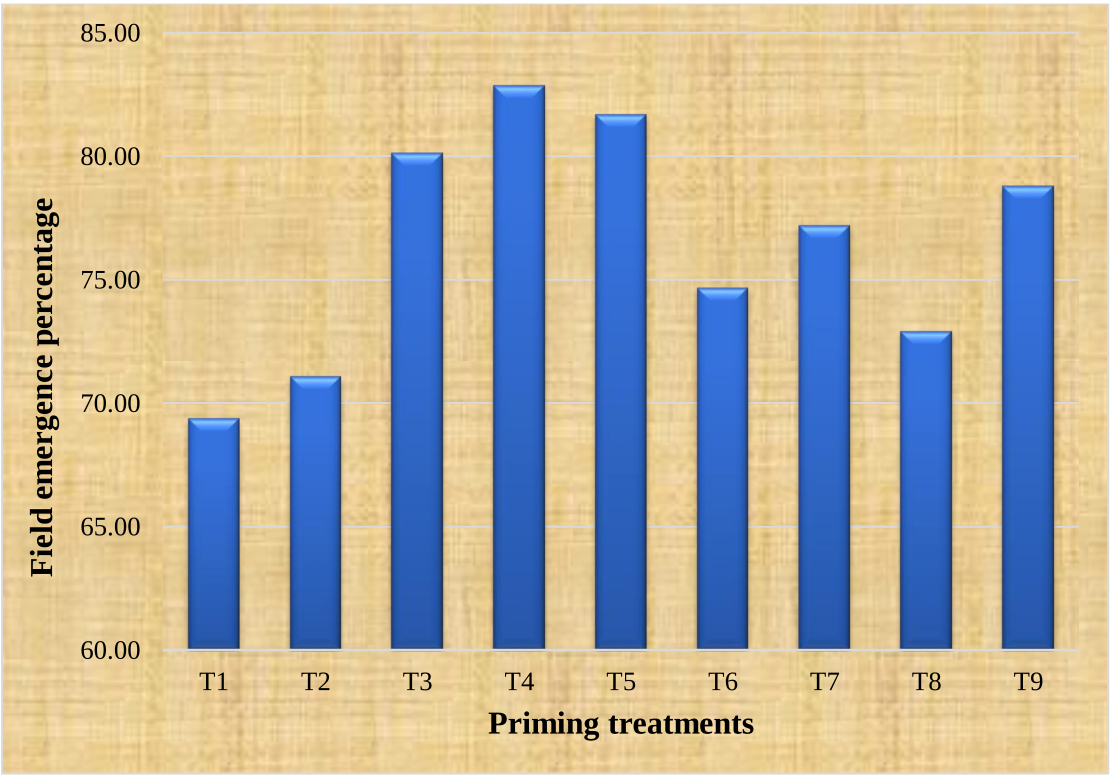

Figure 4.1: Effect of seed priming treatments on field emergence percentage in groundnut

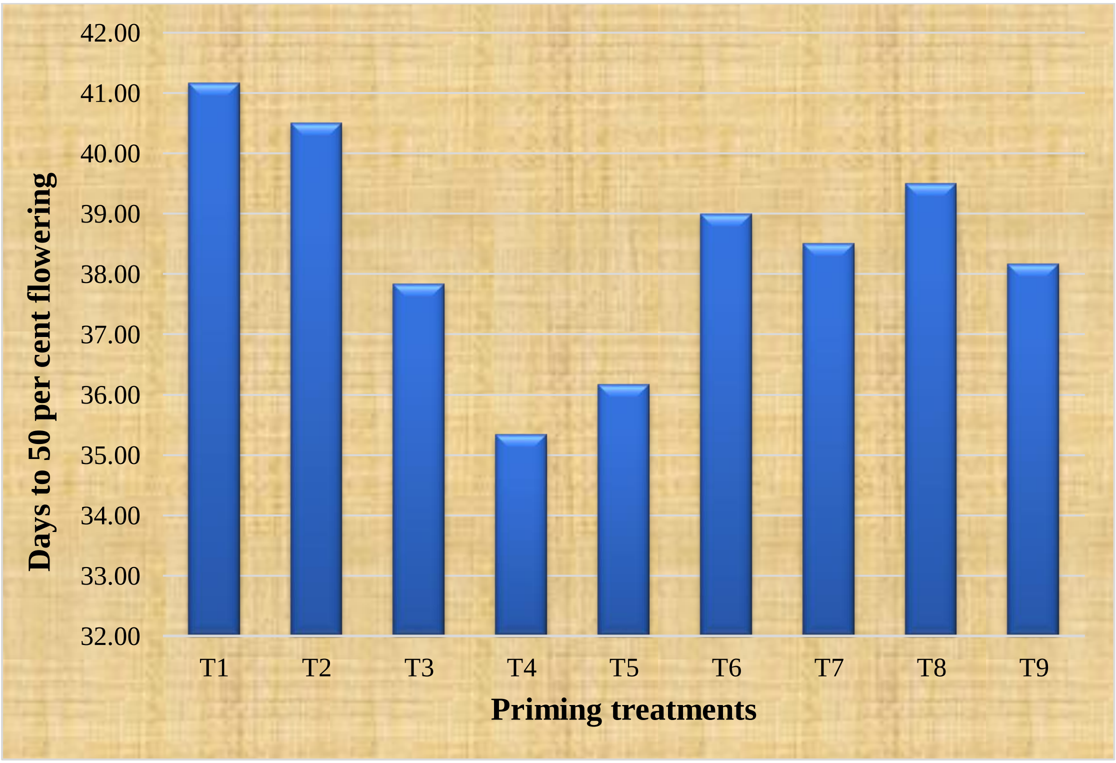

Figure 4.2: Effect of seed priming treatments on days to 50 per cent flowering in groundnut

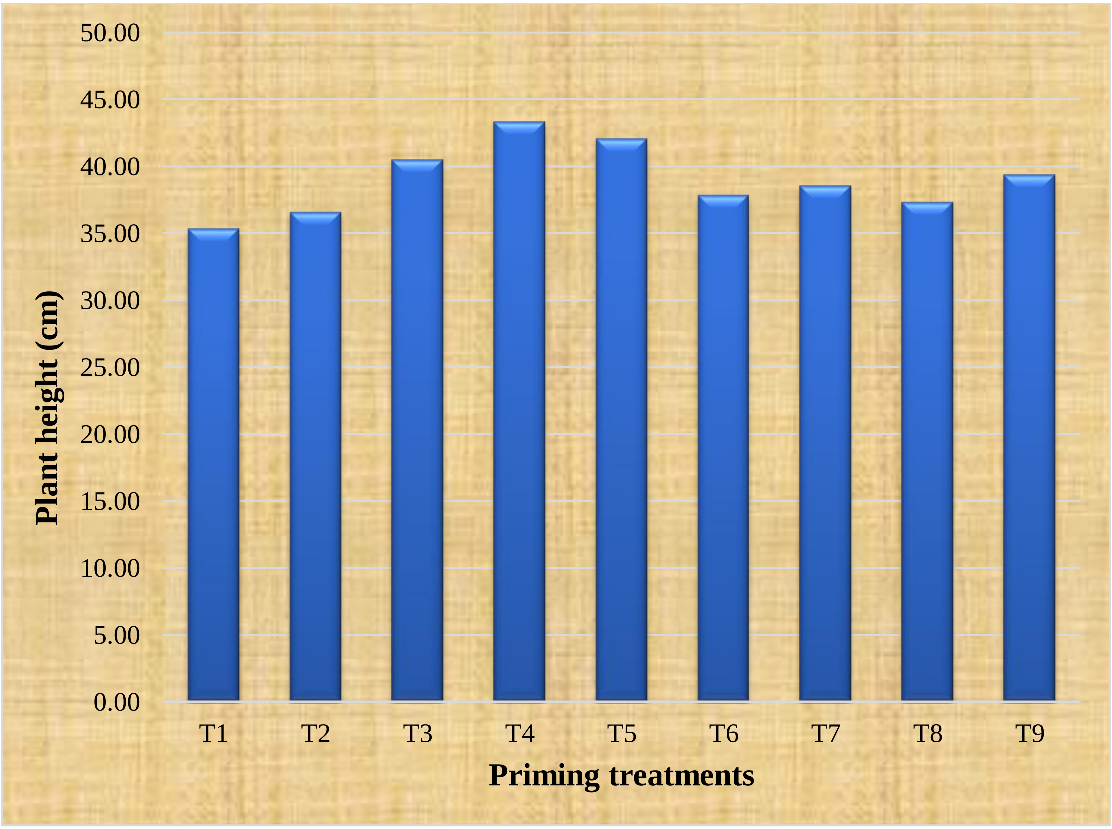

Figure 4.3: Effect of seed priming treatments on plant height in groundnut

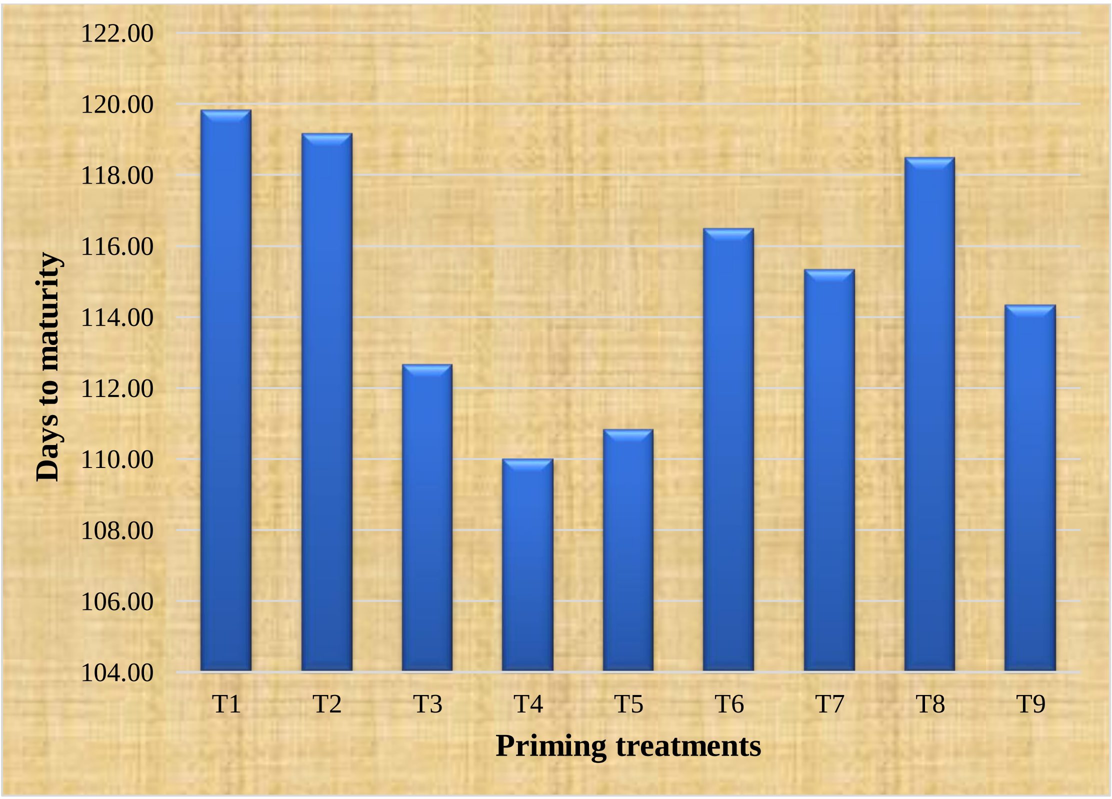

Figure 4.4: Effect of seed priming treatments on days to maturity in groundnut

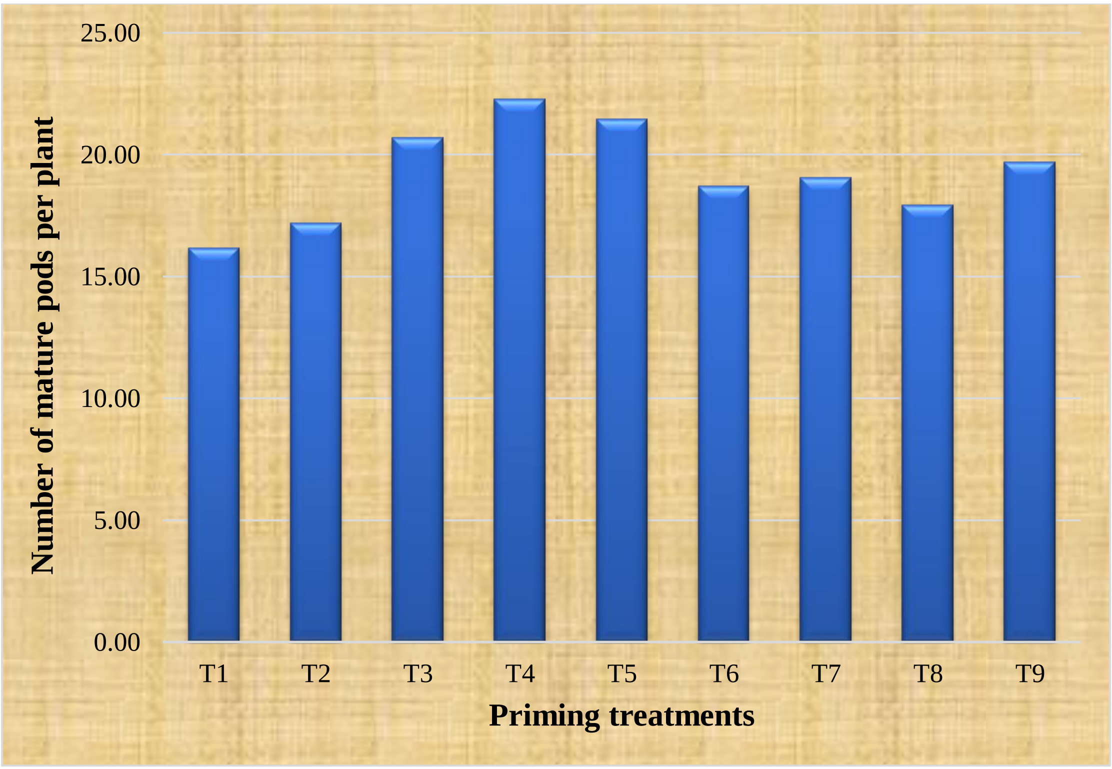

Figure 4.5: Effect of seed priming treatments on number of mature pods per plant in groundnut

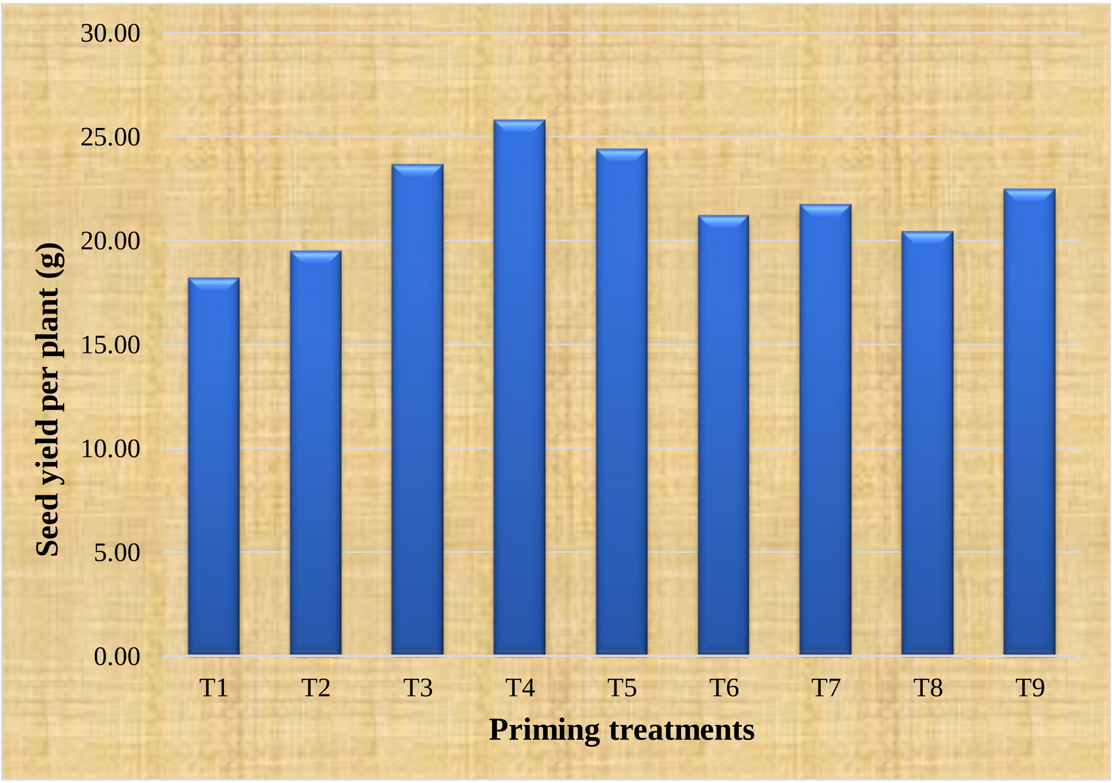

Figure 4.6: Effect of seed priming treatments on seed yield per plant in groundnut

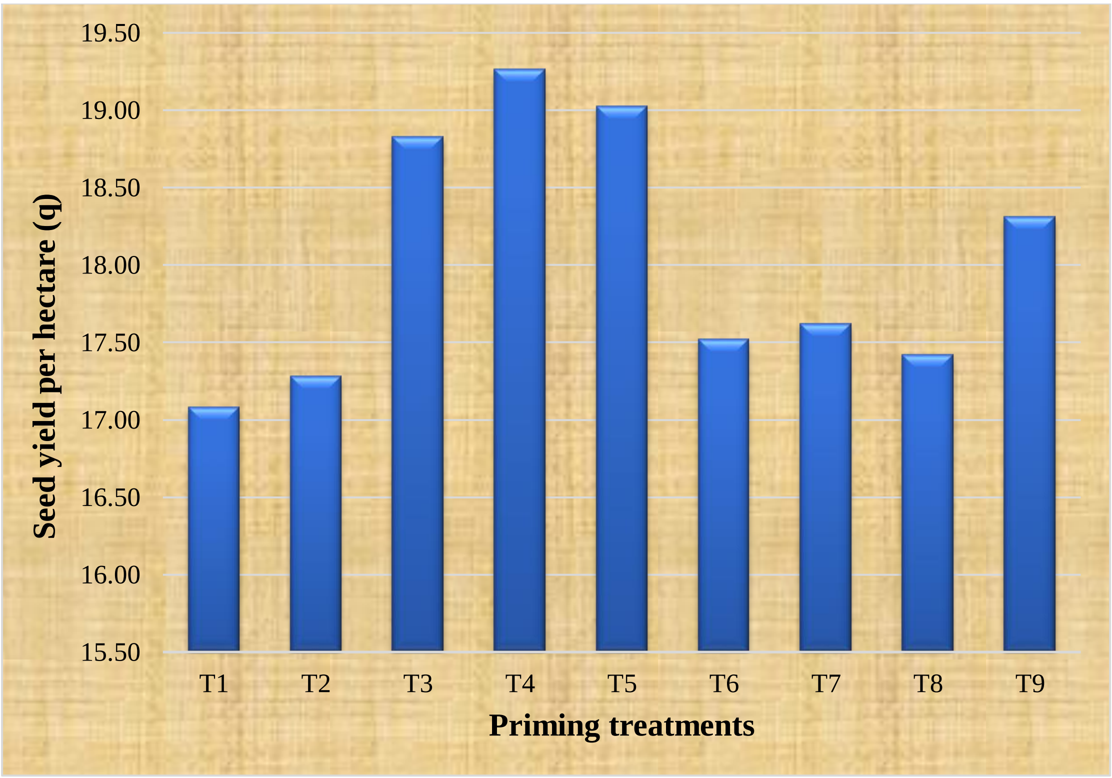

Figure 4.7: Effect of seed priming treatments on seed yield per hectare in groundnut

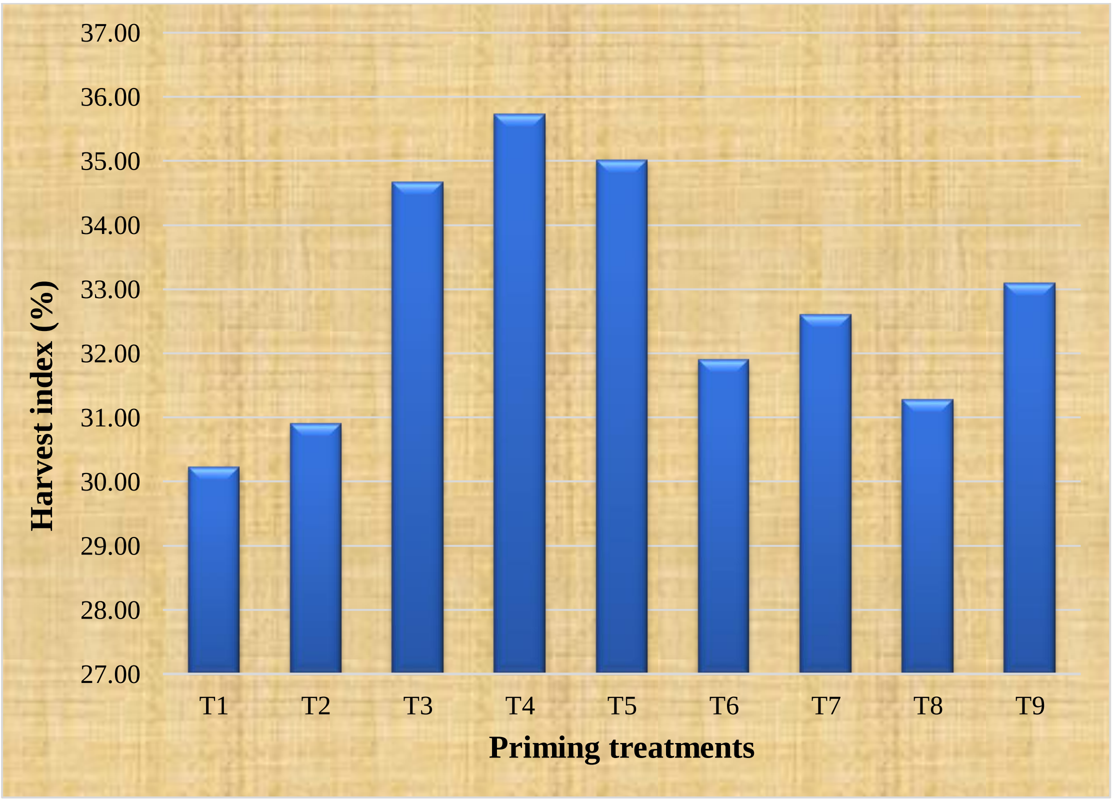

Figure 4.8: Effect of seed priming treatments on harvest index in groundnut

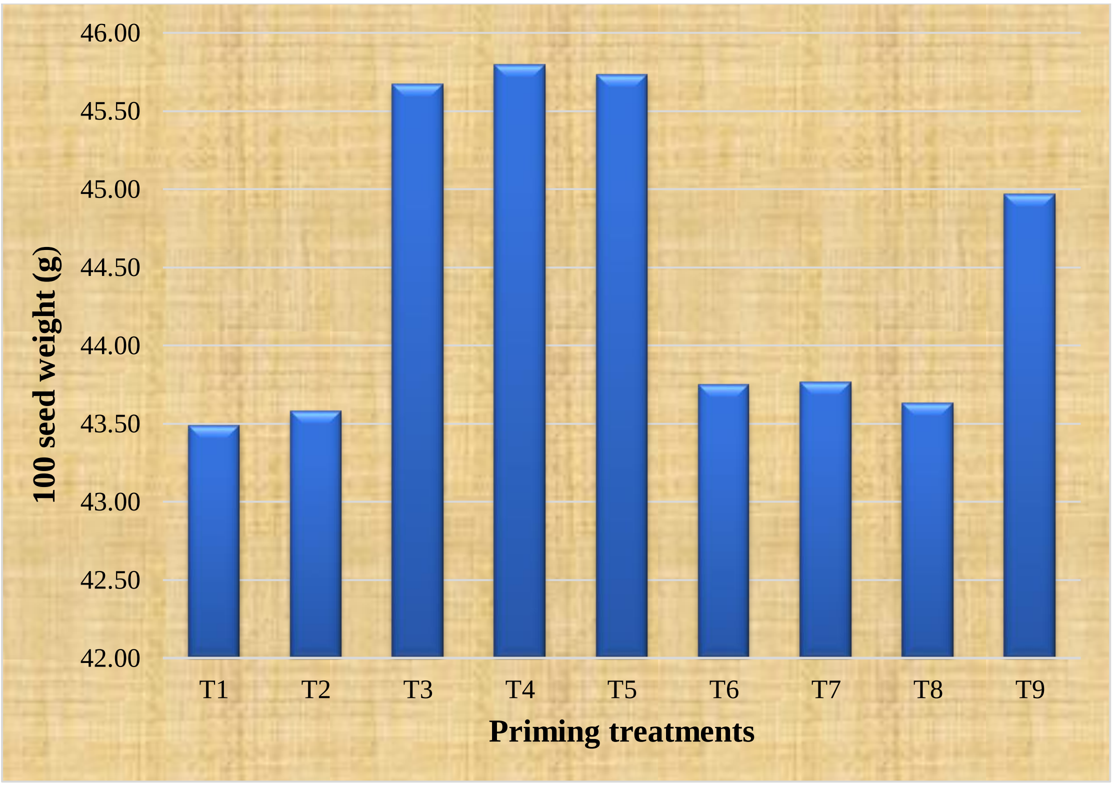

Figure 4.9: Effect of seed priming treatments on 100 seed weight in groundnut

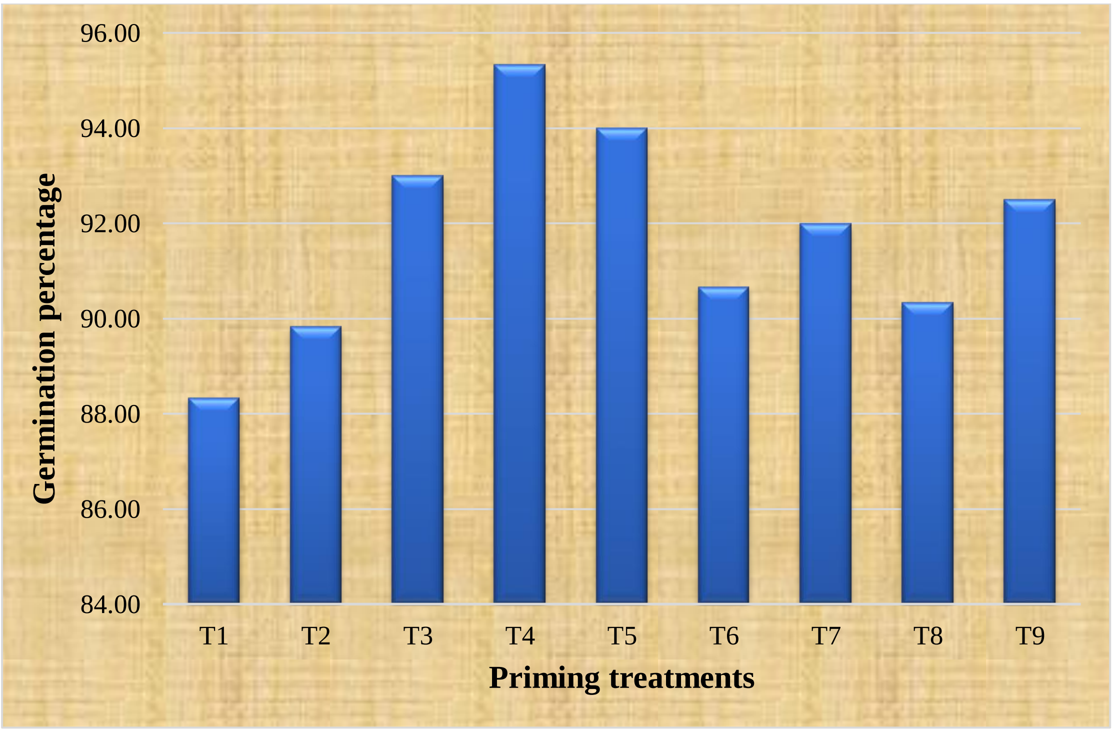

Figure 4.10: Effect of seed priming treatments on germination percentage in groundnut

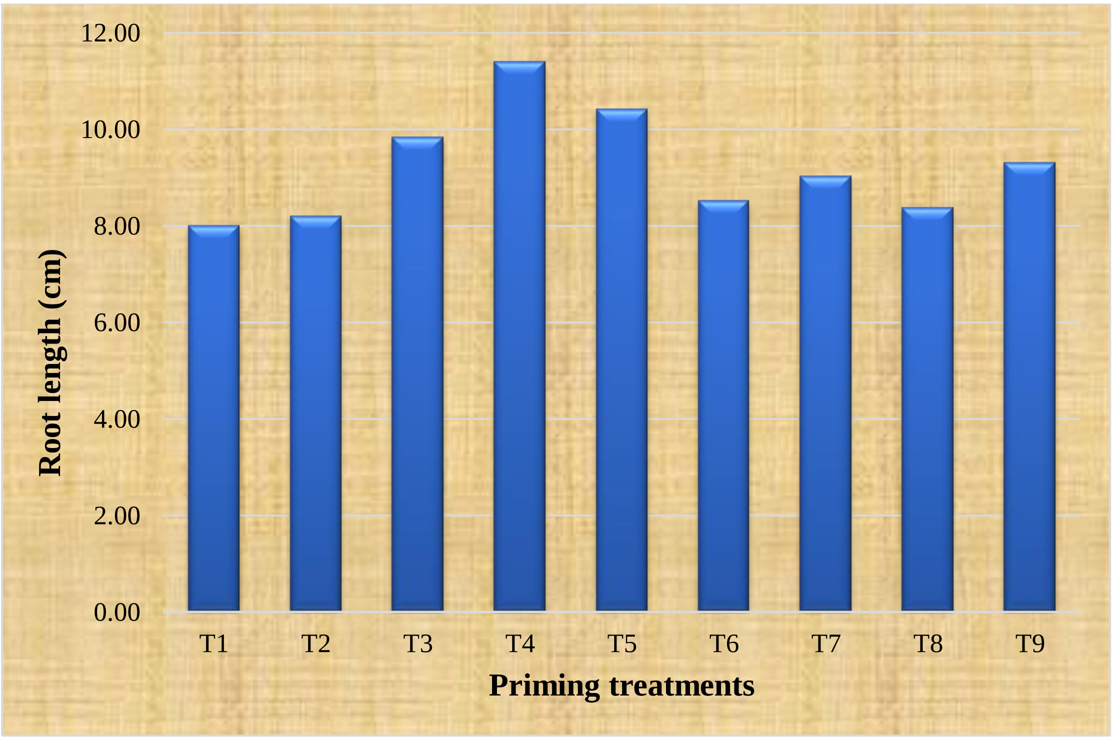

Figure 4.11: Effect of seed priming treatments on root length in groundnut

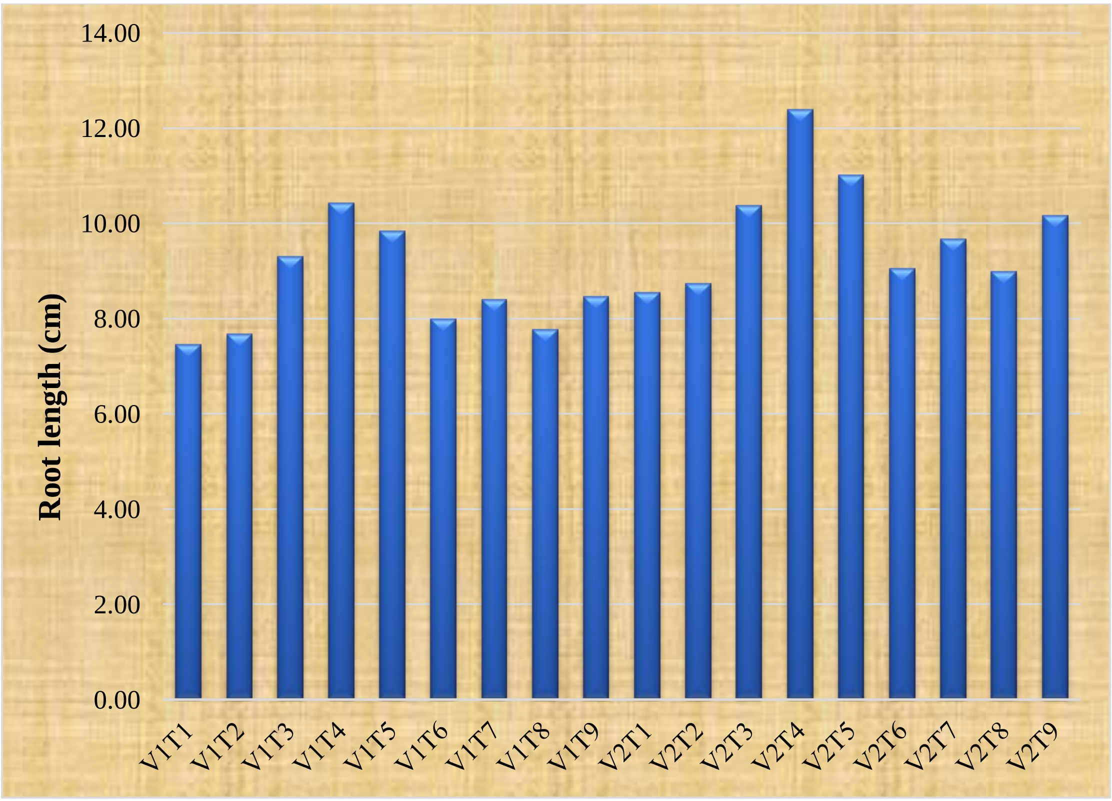

Figure 4.12: Interaction effect of genotypes and seed priming treatments on root length in groundnut

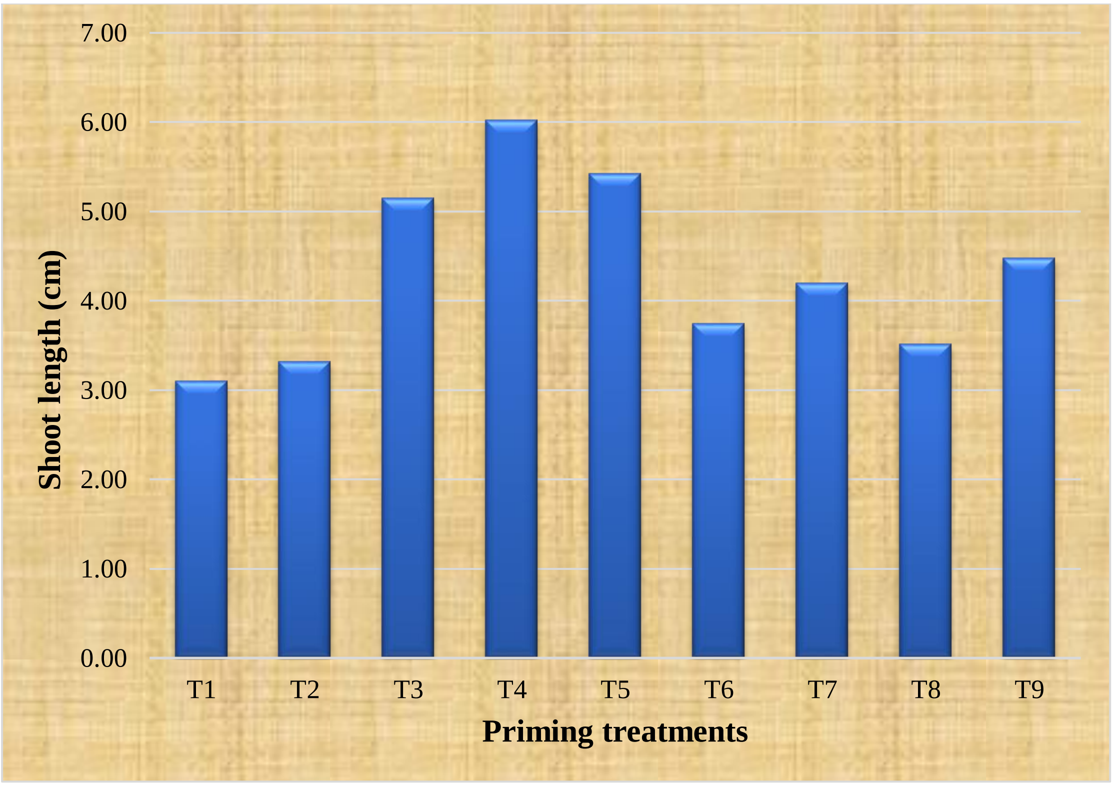

Figure 4.13: Effect of seed priming treatments on shoot length in groundnut

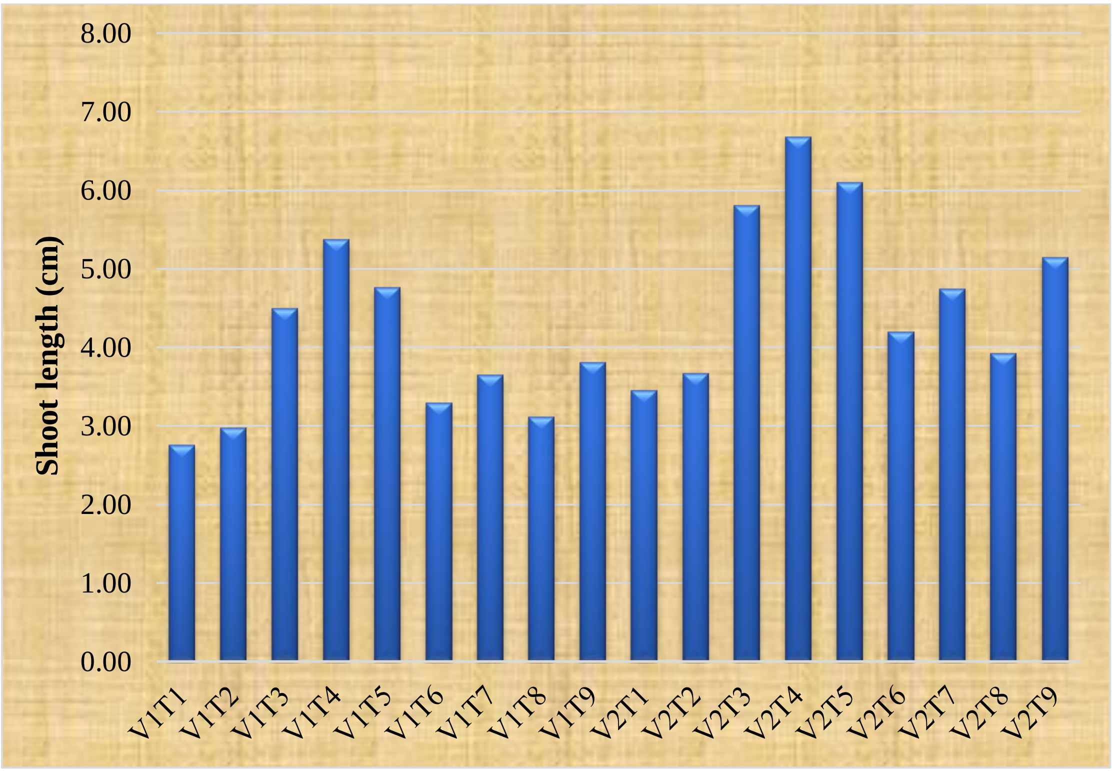

Figure 4.14: Interaction effect of genotypes and seed priming treatments on shoot length in groundnut

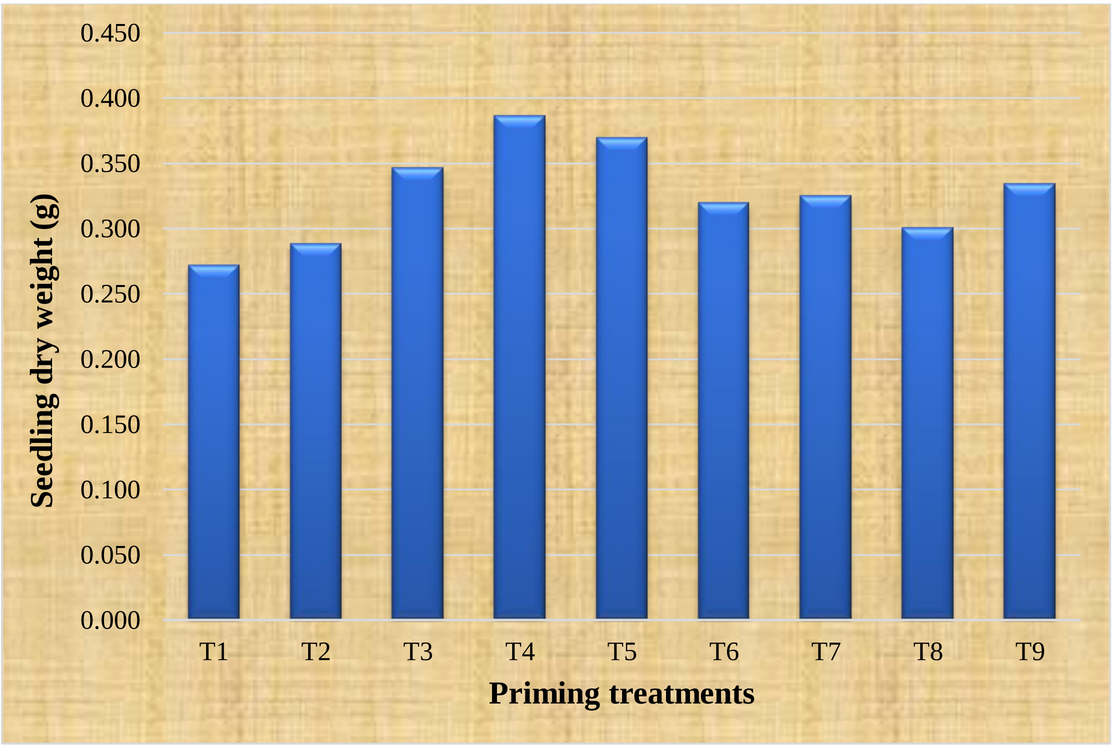

Figure 4.15: Effect of seed priming treatments on seedling dry weight in groundnut

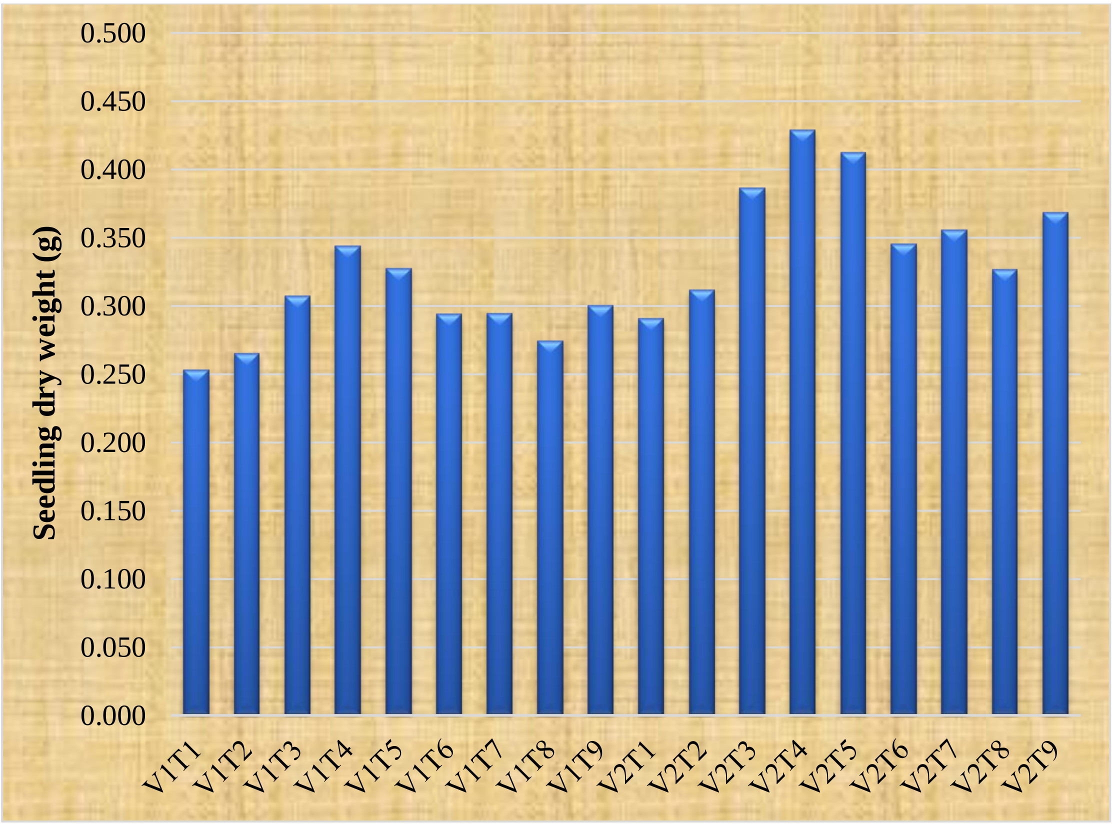

Figure 4.16: Interaction effect of genotypes and seed priming treatments on seedling dry weight in groundnut

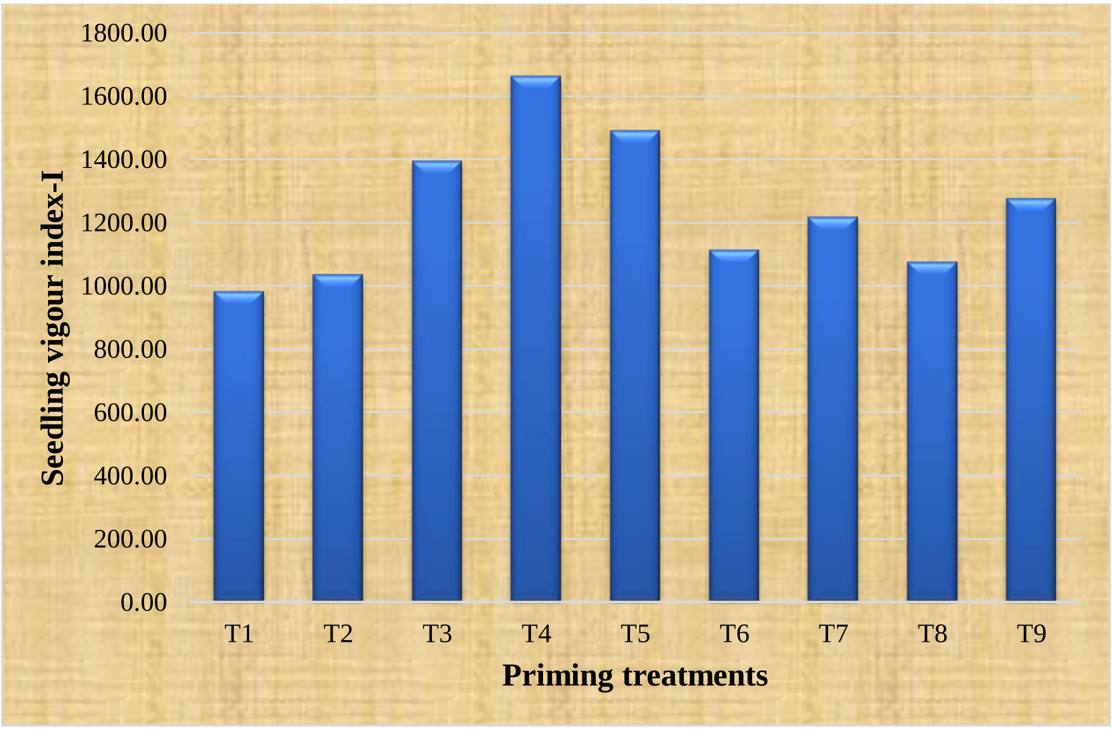

Figure 4.17: Effect of seed priming treatments on seedling vigour index-I in groundnut

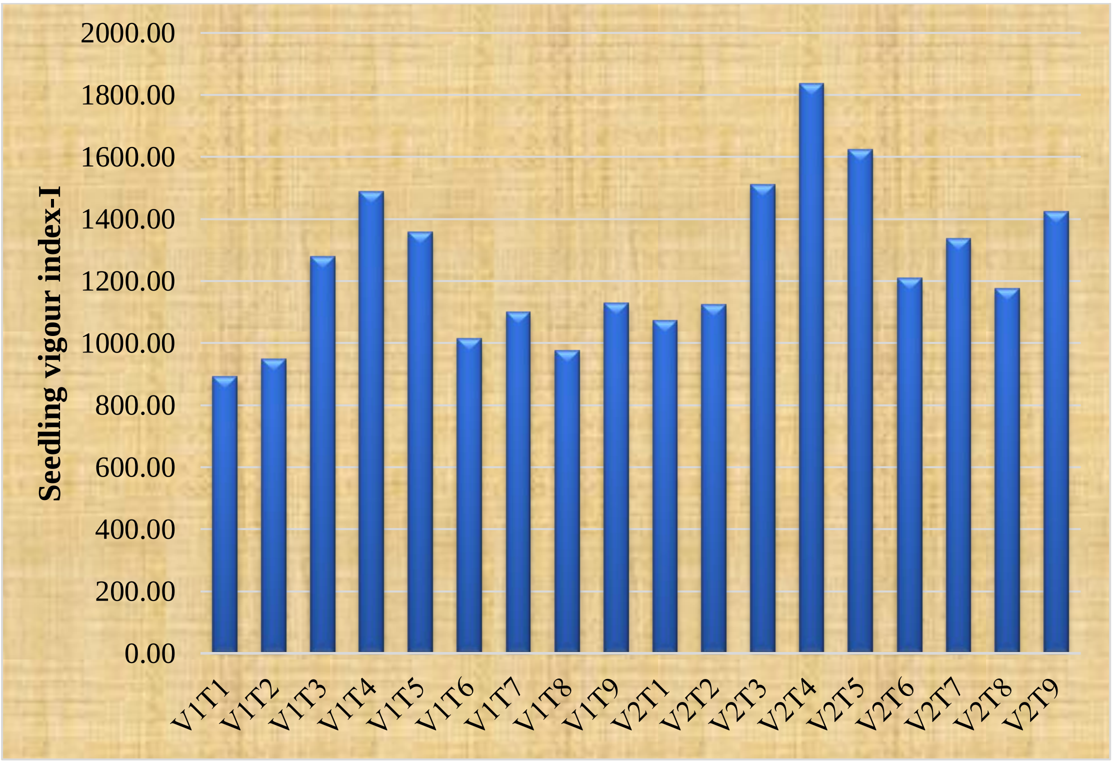

Figure 4.18: Interaction effect of genotypes and seed priming treatments on seedling vigour index-I in groundnut

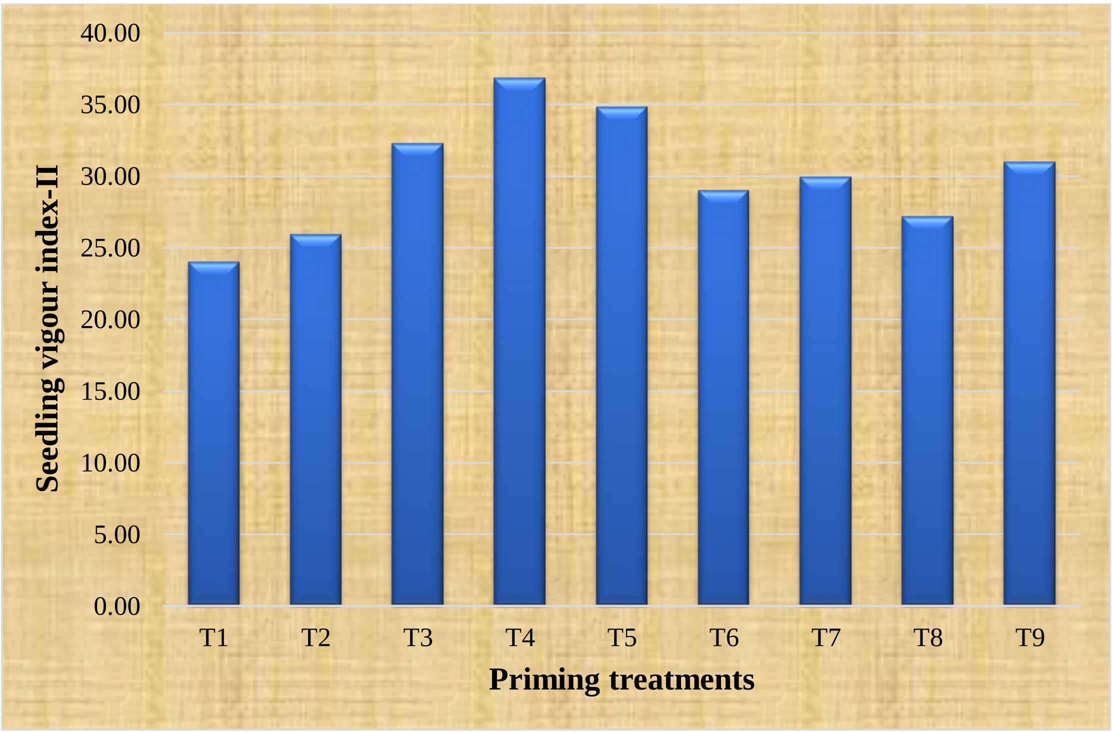

Figure 4.19: Effect of seed priming treatments on seedling vigour index-II in groundnut

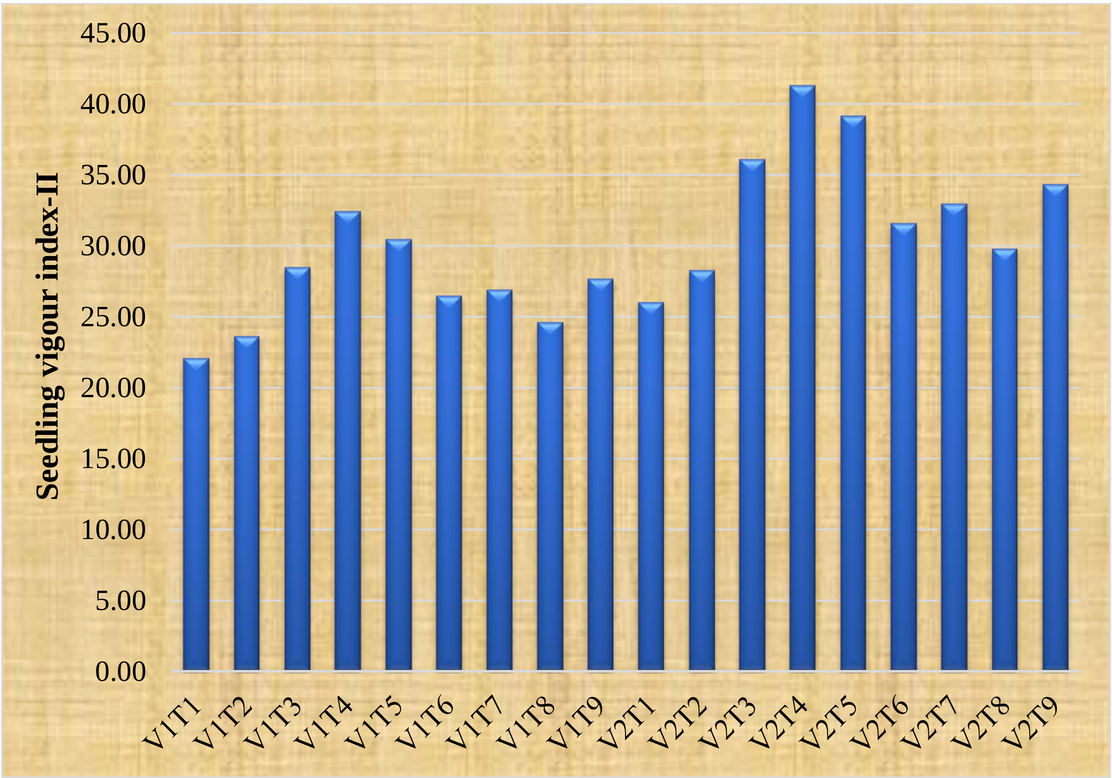

Figure 4.20: Interaction effect of genotypes and seed priming treatments on seedling vigour index-II in groundnut

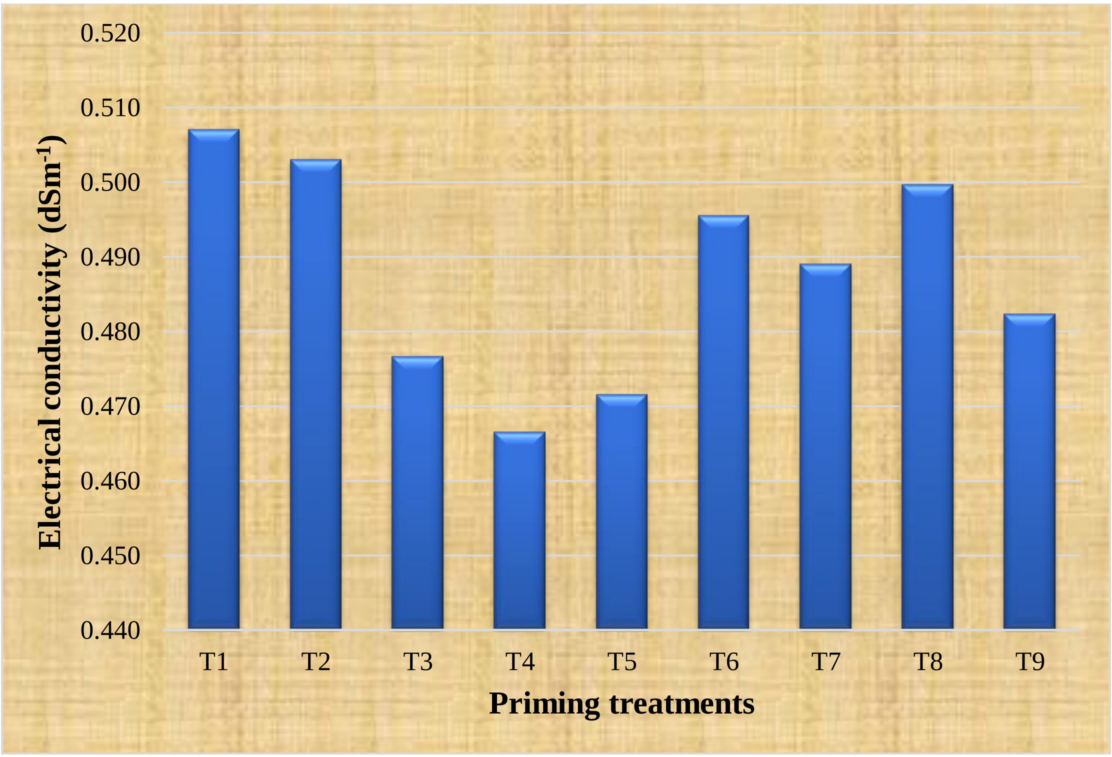

Figure 4.21: Effect of seed priming treatments on electrical conductivity in groundnut

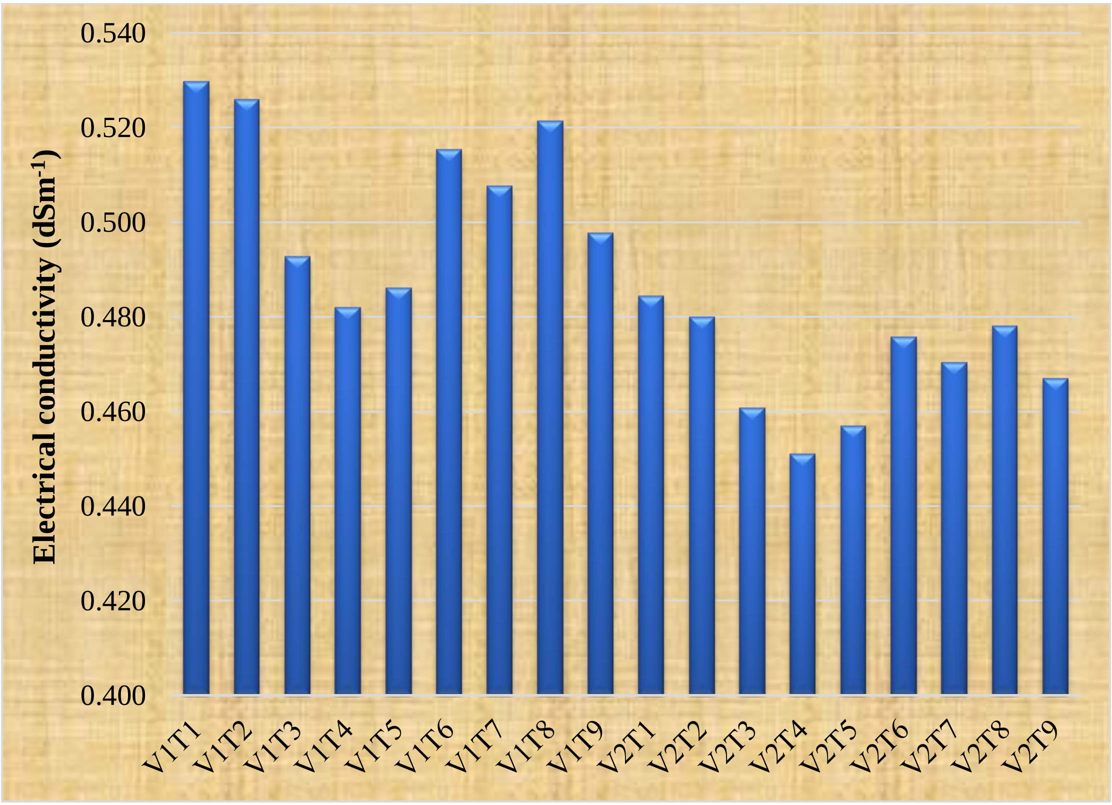

Figure 4.22: Interaction effect of genotypes and seed priming treatments on electrical conductivity in groundnut

Plate 3.1: General view of field experiment

Plate 3.2: Method of seed priming