SEED TECHNOLOGICAL STUDIES IN CHICKPEA VARIETIES (*Cicer arietinum* L.)

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1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is commonly known as bengalgram, gram, chana, kadle *etc.* and is the third most important pulse crop in the world after beans and peas. Anatolia in Turkey was the area where chickpea was believed to has originated (Van Der Maesen, 1984). Chickpea is popularly cultivated in sub tropical and semi arid to warm temperate regions under dry season.

Chickpea is predominantly consumed in the form of whole grain or dhal, sprouted grain, green or matured dry seeds and is used in the preparation of variety of snacks, sweets and condiments. It has highly digestible protein (21.1%), carbohydrate (61.5%), fat (4.5%), relatively free from anti nutritional factors and is rich in phosphorous, iron, niacin and calcium compared to other pulses (Saxena, 1990). Its tender leaves are used as vegetable while, its acid exudates (mainly oxalic and malic acid) as a popular refreshing drink and medicinally for blood purification (Bahl and Salimath, 1996). Soaked grains and husk are fed to animals as concentrate and roughage respectively. Further, it also accounts for efficient soil enrichment by symbiotic nitrogen fixation, it has ability to meet more than 70 per cent of its nitrogen requirement from symbiotic nitrogen fixation, besides being drought tolerant.

The average world production of chickpea is 8.58 million tonnes from an area of 11.5 million hectares with an average productivity of 769 kg per ha (Anon., 2004).

In Asia, India is the largest producer of chickpea contributing over 70 per cent of the world production occupying an area of 7.49 million hectares with a production of 6.33 million tonnes and with productivity of 780 kg per ha (Anon., 2009). The major chickpea growing states of our country are Madhya pradesh, Uttar pradesh, Rajasthan, Maharashtra, Andhra pradesh and Karnataka and is mainly grown under rainfed situations.

In Karnataka, Gulbarga, Bidar, Dharwad, Bellary and Raichur are the major chickpea growing districts with an area of 0.65 million hectares, production of 0.31 million tonnes and with 477 kg per ha productivity (Anon., 2009).

The two most commonly cultivated types of chickpea are white seeded “Kabuli” being grown in northern parts and brown seeded “Desi” grown in other parts of our country. The per hectare productivity of chickpea in our county is very less (780 kg/ha) in comparison with the other countries like Maxico (1600 kg/ha), Myanmar (1105 kg/ha)) and Australia (1008 kg/ha). The lower productivity may be attributed to its cultivation in larger area under rainfed conditions, lack of quality seeds of high yielding varieties, instability of yield, inadequate agronomic cultivation practices, non availability of improved seed production practices *etc.*, Some physiological constraints such as intensive flower dropping (18 to 20%), poor pod filling, higher pod shedding (26 to 43%) and low dry matter accumulation have been also related to poor yields (Jirali, 1983 and Singh *et al.,* 1991) in Desi and Kabuli varieties of chickpea respectively.

Since, chickpea has greater economic and nutriative value much emphasis is being given for increasing its area, production and productivity which is possible only through use of quality seeds of high yielding varieties. Non availability of high quality seeds of bengalgram in adequate quantity may be attributed to lesser area under seed production on account of drought conditions; lower seed yield and non availability of high yielding varieties; non adoption of seed production practices by farmers *etc*. Hence, there is a need to increase seed yield and quality of both Kabuli and Desi types of bengalgram.

Among several seed production approaches, bud nipping is being commonly practiced in several crops to increase the seed yield and quality. In chickpea, nipping of young tender top shoots though traditionally practiced by the farmer but its associated beneficial effects are not scientifically documented. Apical bud nipping is known to alter the source-sink relationship by arresting the vegetative growth and hastening the reproductive phase. It also helps in production of more pod bearing branches with luxuriant foliage thus resulting in increased photosynthetic activity, accumulation of more photosynthates, ultimately resulting in better seed quality with higher seed yield (Thakral *et al.,* 1991). The studies on influence of nipping on seed yield and quality in chickpea varieties are absolutely very scanty.

Plant growth regulators are widely used for regulating plant architecture, biomass production, flower behavior and control of flower and pod drop and enhancing yield potential of field crops. Hormones like auxins, gibberlins, ethylene, cytokinin and abscisic acid are required in proper proportion to combat imbalance in the hormonal content to arrest abscission process and shedding of reproductive organs. Among several growth hormones Napthelene acetic acid (NAA) and Traicontanol are known to reduce greatly the abscission of flowers and control the flower and pod drops and help in accumulation of higher dry matter besides increasing seed yield (Gali,1995).

Apart from synthetic growth regulators, use of organics such as panchagavya consisting of ghee, milk, curd, cow dung and urine has added beneficial influence on plant growth, flower behaviour and yielding ability (Swaminathan *et al.,* 2007a). The studies on combined influence of nipping, growth regulators on seed yield and quality in chickpea varieties are meager.

Seed size *per se* is an important aspect of seed vigour which is manifested through higher plant stand, plant growth and yield. Generally big seeds with higher amount of initial food reserves emerge early and uniformly and grow vigorously in field and exhibit early advantage of plant vigour with respect to plant performance and yielding ability compared to small and medium seeds in several crops (Poma *et al.,* 1990). On the contrary in some crops even medium, small and bulk seeds were also found to have equal beneficial effects as that of big seeds with respect to field performance. The small and medium seeds require less moisture for germination, emerge early, establish early, grow vigorously and yield equally as that of big seeds. (Kurdikeri, 1991). As the seed size *per se* is still a controversial issue and there is a need to study the influence of seed size on plant growth, seed yield and quality in Kabuli and Desi chickpea varieties as they show much variations in seed size.

In modern agriculture, success of seed industry and seed programmes depends on how carefully seeds are stored for next planting without loss of seed viability and vigour. "A seed saved is seed produced" an old adage also still holds good even today. The storage losses of seeds interms of quality and quantity may range from zero to even 100 per cent under unhygienic storage conditions.

Storability of seeds mainly depends on several factors such as genetic, initial seed quality, seed size, provenance, storage environment, pest and disease *etc*. It has been also hypothesized that well developed seeds with ample initial capital of food reserves store for longer period than undersized seeds with less food reserves (Oxley, 1948). On the contrary, small seeds have also been proved to store for longer period equal to big and medium seeds (Mohanrao, 1993). As greater variations are evident with respect to seed size both in Kabuli and Desi varieties, the research on storage potential of different sized seeds is felt necessary.

In almost all field crops, the seed yield and quality are greatly influenced by mother plant nutrition. Seed crop nourished with adequate quantity of major and minor nutrients give higher seed yield and quality. Among micronutrients, Ca, B, Zn, Fe, Mg play paramount role on plant growth, flowering, source to sink relationship, biological nitrogen fixation, seed yield and quality. Besides these micronutrients also play prominent role in increasing protein content of seed due to activation of associated enzymes (Lee *et al.,* 1967, Nayak, 1989, Thalooth *et al.,* 1989 and Gupta and Vyas, 1994).

Similarly bio-fertilizers such as Rhizobium and Phosphorous Solubilizing Bacteria (PSB) also have beneficial influence on plant growth, seed yield and quality as they fix large quantity of biological nitrogen. The application of micronutrient and bio-fertilizers through seed treatment not only economies the cost of nutrients but also are readily available to the young seedlings for their vigorous growth and this initial early benefit would help to obtain higher seed yield and quality. However, studies on influence of seed treatments with micronutrients and bio-fertilizers on plant growth, seed yield and quality in chickpea are lacking.

Harvest of seed crop at right stage of maturity bear significant influence on seed yield and quality as seeds harvested at right stage of physiological maturity are higher in seed quality on account of lesser field weathering (Bharud and Patil, 1990). Yield losses due to pod drop and shattering are more common with delayed harvest in chickpea (Delouche, 1998).

Since Kabuli and Desi chickpea varieties differ in days to maturity depending upon environmental factors, there is a need to ascertain the optimum stage of harvesting to obtain higher quality seeds and enable chickpea seed growers for harvest of seed crop at right stage of maturity.

In recent past years, several high yielding varieties of chickpea are being released by many private and public sectors. Hence, there is a need for maintenance of genetic purity of chickpea varieties. Identification and characterization of varieties based on simple distinct seed and seedling morphological characters for grow-out test of genetic purity in Kabuli and Desi varieties has became most essential. Such diagnostic characterization studies in chickpea varieties are very limited.

Keeping these entire back drop the systematic seed technological studies were initiated in chickpea varieties with the following broad objectives.

i. To study the effect of nipping and growth regulators on plant growth, seed yield and quality in chickpea.

ii. To ascertain the effect of seed size on plant growth, seed yield and quality in chickpea varieties.

iii. To ascertain the influence of seed size on storage potential of chickpea varieties.

iv. To study the influence of seed treatment with micronutrients and bio-fertilizers on plant growth, seed yield and quality of chickpea varieties.

v. To ascertain the influence of stages of harvest on seed quality parameters in chickpea varieties.

vi. To identify the distinct seed, seedling and plant diagnostic morphological characters of chickpea varieties.

2. REVIEW OF LITERATURE

The related literature on the effect of nipping of apical bud, growth regulator, seed treatment with different micronutrients and bio-fertilizer, seed size on storability and field performance, stages of harvesting on seed quality and varietal identification through seed, seedling and plant characters in chickpea genotypes were collected. The research carriedout in India and elsewhere in recent years on chickpea and other related crops are reviewed and presented in this chapter.

2.1 Effect of Nipping and Foliar Spray of Growth Regulators on Seed Yield and Quality in Chickpea

2.1.1 Influence of nipping

Nipping is an important agronomic practice of removal of apical bud which helps to reduce the apical dominance, increase the number of branches, per cent pod set and better source-sink relationship and enhances the yield of a plant.

2.1.1.1 Influence of nipping on plant growth parameters

Reddy and Patil (1981) noticed an increase in leaf thickness, rate of dry matter accumulation, total dry matter content and root dry matter in groundnut due to nipping of terminal bud.

Olasanthan (1986) noticed in that removal of apical bud in Okra at 5 to7 weeks after sowing increased the vegetative growth and dry matter accumulation, further he noticed an early removal of apical bud helps to increase number of branches.

Thakral *et al*. (1991) revealed that in coriander, with no leaf cutting (control) recorded highest plant height of 89.7 cm. While, leaf cutting at 30 days after sowing recorded highest number of branches per plant. (9.0).

Singh and Singh (1992) reported in pea that, plant height at different stages of plant growth was affected by nipping at 60, 75, 90 DAS and at harvest. The maximum height at harvest was observed with control (104.5 cm), which clearly indicated that the energy which was provisionally used by the plant was diverted towards branching and higher pod formation.

In coriander, 25 per cent leaf plucking at 50 DAS recorded highest plant height (38.3 cm) and number of branches per plant (4.0). However, the effect of leaf plucking on number of branches was non-significant (Rema Menon and Md. Abdul Khader, 1997).

Gill *et al*. (2001) stated that removal of apical bud in fenugreek had significant effect on plant height and herb yield. Delay in removal of herb from 50 to 70 DAS decreased the plant height from 94.55 to 85.05 cm and increased the herb yield from 18.8 to 13.2 q.

Apical pinching of okra at 20 DAS resulted in significant increase in leaf area index (0.769) and number of branches per plant (2.62) as compared to no pinching treatment (Sajjan *et al*., 2002).

Pinched plants recorded significantly lesser plant height, more number of branches and took significantly less (34.67) number of days to 50 per cent flowering and days to maturity (77.17) as compared to non pinched plants in coriander (Iyyangouda, 2003).

Sharma *et al*. (2003) studied the effect of apical bud nipping at 50, 70 and 90 DAS on seed yield of pigeon pea cv. TS-37. The results revealed that nipping of the terminal bud at 50 DAS significantly reduced the height of the plant and increased the number of primary and secondary branches and pods per plant with maximum seed yield of 1560 kg per ha.

Reddy (2005) revealed in cowpea that, nipping of tendrils recorded significantly lower plant height (74.70 cm), more dry weight (8.97 g), maximum number of leaves (95.66), number of branches (4.5), seed yield (12.50 q/ha) and higher protein content (22.17) compared to control (75.70, 6.07, 77.00, 3.7, 11.11 q/ha and 22.00 respectively).

2.1.1.2 Influence of nipping on seed yield and yield parameters

In a field trial with four capsicum cultivars, Mc Creaw and Greig (1986) concluded that transplanting of pruned plants at 11 weeks resulted in increase in the number of fruits in all cultivars compared to non pruned plants.

Huang (1987) opined that seed yield of *Vicia faba* was higher when topped at early flowering and pod filling stage compared to control, besides increased pods (15.8/plant) and 100 seed weight (10.6 g). Topping at pod filling stage resulted in higher leaf area, early podding and less pod shedding. The plants topped at early and late flowering stage had 3.6 per cent lower seed yield compared to the topping at peak flowering stage.

Bhati (1988) observed that 50 per cent leaf plucking in coriander at 60 and 75 DAS significantly reduced the seed yield over no leaf plucking but increased gross returns from Rs. 6,139/- in non plucking to Rs. 6,449/- and Rs. 8,430/-with leaf plucking at 60 and 75 DAS respectively because of additional vegetative yield.

Kohnt *et al*. (1988) reported that the field bean topped immediately after flowering increased the seed yield by 0.16 to 1.92 t per ha. The differences in yield were due to differences in number of pods per plant, number of seeds per pod and 1000 seed weight.

Patel and Patel (1990) studied the effect of nipping in gram Cv. 'Dohad yellow' and reported increase in yield attributing characters like pods per plant, test weight and seed yield per plant. They opined that the higher yield might be due to higher number of pods per plant, test weight and seed weight per plant.

Roy and Singh (1992) reported that seed yield and net returns of *Cicer arictinum* were maximum with nipping at 30 or 40 days after sowing application of 20 kg N + 40 kg P per ha.

Bhat (1994) observed that, in okra apical bud pinching after retaining the required number of fruits resulted in significantly higher girth of fruit (1.91 cm), seed weight (3.1 g/fruit), 100 seed weight (6.68), seed recovery (79.8%) and seed yield (1047kg/ha).

Shankargoud and Patil (1994) noticed that nipping of the side branches in sunflower between 45 to 50 days after sowing increased seed yield from 796 to 1838 kg per ha. Seed size increased from length 5.68 to 6.44 mm; weight 3.4 to 5.7 g, seed set from 67.2 to 78.6 per cent and yield per plant from 17.1 to 36.8 g, and processing losses were reduced by 30-40 per cent in sunflower restorer line RHA-274.

Venkata Reddy *et al*. (1997) observed that apical bud pinching in okra seed crop increased seed yield by 9.6 per cent over control. Retaining 12 fruits per plant with pinching resulted in higher (1.24 t/ha) seed yield and other yield attributes with better seed quality.

Nipping of terminal bud at 25 DAS significantly increased the seed yield (764 kg/ha) over no nipping (658 kg/ha) of sesame cv. TMV-4 (Ramanath and Chandrashekharam, 1998).

Gill *et al*. (2001) observed that the removal of herb in fenugreek had significant effect on seed yield and yield attributes. The seed yield and yield attributes were maximum when the crop was not harvested for fresh herb. The number of pods per plant, number of seeds per pod and seed yield per ha were decreased from 30.81, to 26.21, 12.01 to 11.60 and 8.65 to 6.20 per ha respectively by each delay in removal of herb from 50 to 70 days after sowing.

Sajjan *et al*. (2002) observed that apical bud pinching of okra at 20 DAS recorded maximum number of fruits per plant (6.67), number of seeds per fruit (45.73) and seed yield per ha (782.8 kg) over no pinching treatment (5.02, 42.25, 698 kg, respectively).

Aziz (2002) reported in chickpea that among pinching levels (30, 40, 60 and 75 days after emergence), pinching at 30 DAE gave the maximum number of branches per plant but it was statistically similar to pinching at 45 DAE. The maximum number of pods per plant was found with pinching at 30 days with maximum yield (2394 kg/ha) than other treatments and control (2018 kg/ha).

Sudarshan (2004) recorded less plant height, higher number of branches, pods, seeds per pod and maximum seed yield and yield attributing parameters, when apical bud pinching was done at 30 DAS in fenugreek.

Sarkar and Pal (2005) observed that nipping the terminal bud at 25 DAS improved growth parameters *viz.* leaf area index (0.421) biomass production (76.80 g/plant), crop growth rate (0.223 g/plant/day), relative growth rate (0.028 g/day), net assimilation rate (1.13 g/cm^2/day), yield attributes *viz.* capsules per plant (80.80), seeds per capsule (67.67) and consequently seed yield (1.45 t. /ha) of sesame over no nipping.

Khan *et al.* (2006) reported in chickpea that, nipping at 94 days after emergence recorded significant difference in number of productive branches per plant (8.9), pods per pant (36.3), seeds per pod (1.66), 100 seed weight (16.4 g) and seed yield (2532 kg/ha) compared to control (4.2, 24.5, 1.6, 18.0 g and 1656 kg/ha) respectively

Singh and Devi (2006) recorded significantly higher number of branches per plant, pods per plant, and seed yield when plants were nipped at 30 DAS in Makhyatmubi pea compared to nipping at 15, 20, 25, 35 40 and 45 DAS and the highest net returns Rs. 13,799/- per ha was obtained from the nipped plants at 30 DAS compared to other stage of nipping and control.

2.1.1.3 Influence of nipping on seed quality parameters

Bhat (1994) observed that in okra with apical pinching after retaining required number of fruits plants gave maximum girth of fruits (1.91 cm), seed weight (3.1 g/fruit) and 100 seed weight (6.6 g).

In okra, apical bud pinching at 30 DAS recorded numerically higher germination and seedling vigour parameters compared to pinching at 20 DAS (Sajjan *et al.*, 2002).

Vyakaranahal *et al.* (2002) nipped axillary flower buds between 40 to 68 DAS at 7 days intervals in sunflower restorer line and recorded greater capitulum diameter, number of filled seeds per capitulum, 100 seed weight, per cent seed set, seed germination, seedling vigour and seed oil content with the removal of auxiliary flower buds with early planting (July and December).

Iyyanagouda (2003) reported that, pinched plants recorded significantly higher values of all quality parameters *viz.* test weight (10.34 g), germination (84.42%), seedling dry weight (51 mg), vigour index (1536) and lower EC value (1.125 dSm^{-1}) in fenugreek.

Sudarshan (2004) observed that plant pinched at 30 DAS recorded highest values for quality parameters like test weight (4.25 g), germination (92.83%), shoot length (12.54 cm), root length (9.50 cm), seedling dry weight (10.81 mg), vigour index (2046) and speed of germination (34.02) in fenugreek.

Singh and Devi (2006) nipped pea plants at different levels and observed higher 1000 seed weight in nipped plants at 30 DAS compared to early and late nipped plants.

2.1.2 Influence of growth regulators

The seed yield of any crop is a complex heritable character and influenced by many morphological and physiological characteristics of the plant interplaying with environment and crop management practices. Several growth regulators are known to influence these characteristics in several ways and an overview of available reports are presented here.

2.1.2.1 Influence of growth regulators on plant growth parameters

Baghel and Yadav (1994) found significantly higher plant height in blackgram with the application of 30 ppm NAA as compared to control. Similarly Lakshmamma and Rao (1996) also recorded significantly higher plant height in blackgram due to the foliar application of 20 ppm NAA at 50 per cent flowering and one week later.

Upadhayay (1994) reported that application of NAA and kinetin (10, 20, 30 ppm) at bud initiation and pod formation stages to chickpea crop showed significant increase in the plant height, branches number, early flowering, more flower retention and yield of chickpea crop compared to control. The maximum seed yield was recorded with 20 ppm NAA foliar spray than other concentration.

Shinde and Jadhav (1995) found that in cowpea, foliar application of 20 ppm NAA at flowering stage increased markedly leaf area and specific leaf weight and seed yield compared to control.

Sarma (1995) reported that twice spraying of NAA and triacontanol individually increased plant height, number of branches per plant in soybean. .

Wasnik and Bagga (1996) revealed that, in chickpea foliar application of miraculan before flowering increased root and stem dry weight in BG-384 (prostate variety), number of secondary and tertiary branches, leaf area, but no such effects were observed in Pusa 261, an erect type chickpea variety.

Shukla *et al.* (1997) recorded increased plant height (52.7 cm), number of branches per plant (4.93) and resulted in marked increase of leaf area and specific leaf weight by spraying NAA (20 ppm) over control in soybean.

Prabhu (2000) reported that application of NAA and miraculan significantly increased the plant height while, mapiquat chloride decreased the same. Application of mepiquat chloride (500 and 1000 ppm) recorded significantly higher number of trifoliates, number of branches and nodes per plant followed by NAA (20 and 40 ppm) in blackgram. The application of NAA @ 40 ppm was more effective and significantly increased the seed yield followed by NAA @ 20 ppm and miraculan @ 200 ppm.

Saishankar (2001) stated that foliar spray with NAA @ 40 ppm in greengram, twice at the time of flowering and 15 DAF increased the plant height, number of branches and flowers per plant over control.

Reddy (2002) observed significant increase in plant height, dry matter in leaf, stem reproductive parts and total dry matter due to application of NAA in chickpea. He also observed that the seed yield increased significantly with application of NAA 40 and 60 ppm followed by Lihocin (500 ppm) compared to control.

Tripathi and Mithlesh (2006) observed higher plant height, number of branches, leaves, leaf area, total dry matter production, net assimilation rate and total chlorophyll content in pea plants sprayed with triacontanol @ 10 ppm during 35 and 75 DAS.

Kumar *et al.* (2008) reported in blackgram that foliar application of NAA @ 40 ppm at the flowering stage influenced growth characteristics by showing increased plant height, more number of branches, higher leaf area index and leaf area duration but maximum photosynthetic efficiency was observed in Brassinolide @ 0.1 ppm treated plants.

2.1.2.2 Influence of growth regulators on seed yield and yield parameters

Bhangel *et al.* (1982) reported that foliar spray of NAA (50 ppm) found to record maximum seed weight per plant (12.19 and 11.33 g), pod number per plant (68.44 and 64.33 g), seed number per plant (1.15 and 1.09) and 100 seed weight (14.40 and 14.28 g) compared to control in chickpea.

Deshpande (1983) observed an increase in 100 seed weight along with significant increase in seed yield of pigeonpea with 10 ppm NAA twice application, one at flower initiation and second at 50 per cent flowering stage. Spraying time had no significant effect on seed yield.

Kalita (1984) revealed that NAA 50 ppm significantly increased number of pods per plant, seeds per pod and ultimately seed yield over control in green gram.

In greengram and blackgram, two sprays of NAA @ 40 ppm increased the number of pods per plant and seed yield over control (Subbian and Chamy, 1984).

Kandgal (1988) observed an increase in the seed yield of mungbean to an extent of 18.53 per cent with 50 ppm NAA at flower initiation stage. They also noticed an increase in the number of pods per plant, number of seeds per pod and 1000 seed weight, but the increase in harvest index was not significant.

Nawalagatti (1988) observed that foliar spray of NAA on groundnut increased the pod yield 2.22 t per ha as compared to 1.75 t per ha in control.

Karan Singh *et al.* (1989) observed higher yield of 2.59 t per ha in chickpea cv. C-235 with 100 mg triacontanol per litre compared to control and foliar treatment of 50 mg chloromepiquat.

Sharma *et al*. (1989) noticed that Napthalene acetic acid improved yield and yield components significantly over control whereas, triacontanol and mixtalol were ineffective and inhibitory for all yield components in mungbean.

Patil *et al*. (1990) reportd in chickpea cv. Annigeri-1, that foliar application of 20 ppm NAA and 50 ppm TIBA at 45 DAS recorded average seed yield of 1.89 and 1.82 t per ha respectively compared with 1.60 t per ha in control. The 100 seed weight was unaffected by these treatments.

Karan Singh *et al*. (1991) opined that foliar spray of 4 mg triacontanol per litre at pre flowering stage increased flower and fruit retention, per cent seed setting and 100 seed weight in chickpea cv. L-144.

Upadhayay *et al*. (1993) concluded that foliar application of NAA 30 ppm was most effective in improving the sugar content. The highest seed yield (25.26 q/ha) and 1000 seed weight (342.18 g) were recorded with 30 ppm NAA in chickpea.

Baghel and Yadav (1994) reported that seed yield in blackgram was higher due to the application of 30 ppm NAA. Spraying NAA and miraculan at flower initiation and seed filling stages increased the seed yield in greengram and blackgram (Chaplot *et al*., 1992).

Patel and Saxena (1994a) found that in blackgram, seed treatment with NAA (10^{-6} M/L) increased the pod numbers per plant, mean pod weight, test weight and seed yield per plant over control. The application of NAA @ 20 ppm reduced the per cent flower drop and lead to increased seed yield in blackgram

Gali (1995) obtained higher chickpea seed yield and yield components with 50 ppm NAA at 30 DAS compared to 75 ppm CCC and control.

According to Wasnik and Bagga (1996), miraculan sprayed before flowering increased root and stem dry weight in BG-384, number of secondary and tertiary branches, leaf area, number of pods per plant, pod weight, seed weight per plant and seed yield, but no such effect was observed in Pusa-261 variety in chickpea.

Khandagave and Kagi (1997) reported the positive response of different regulators in yield attributing characters in different pulses. The increase in seed yield to the extent of 10 per cent in chickpea, and 36 per cent in blackgram were observed with the foliar application of NAA 200 ppm and NAA 25 ppm respectively and was further attributed to the improved canopy efficiency and total dry matter production.

Shukla *et al*. (1997) found that two sprays of 50 ppm NAA and triacontanol indicated the significantly higher seed yield over the control in soybean.

Jeyakumar and Thangaraj (1998) found that the application of (0.1%) triacontanol gave the higher stover and seed yield in soybean. Similarly, double spray of 25 ppm NAA and (0.1 %) triacontanol individuly increased the number of pods per plant, pod weight and finally seed yield in soybean over control (Shukla *et al*., 1997).

Merwade (2000) found that foliar application of NAA @ 40 ppm at flowering stage increased the number of pods per plant and seed yield per plant in chickpea followed by cycocyl and mepiquat chloride over control.

Saishankar (2001) stated that folia foliar spray with NAA (40 ppm) in greengram, twice at the time of flowering and 15 days after flowering increased the pod number and seed yield per plant over control.

Tripathi *et al*. (2001) reported in chickpea, that foliar spray with triacontanol at 5 ppm on 30 DAS, resulted in more number of flowers per plant (248), per cent pod set (50.64%), number of pods per plant (125), number of seeds per pod (2.11), 1000 seed weight (204.10 g) and seed yield (27.67) q/ha.

Upadhayay (2002) recorded the higher length of pods (2.13 cm), circumference (2.76 cm), number of seeds per pod (1.33), pods per plant (28.12), 1000 seed weight (330.35 g) and seed yield (20.50 q/ha) with two foliar sprays of 30 ppm NAA first at one week earlier to bud initiation and second at pod formation stage compared to other concentrations and other growth regulators in chickpea.

Srikant (2003) observed in clusterbean, foliar spray with NAA (40 ppm) increased the plant height number of branches, number of clusters, number of pods per plant, number of seeds per pod, pod yield and seed yield per hectare. The seed quality parameters were not influenced by foliar spray of growth regulators.

Karim and Fattah (2007) noticed that, chickpea plants sprayed with 20 ppm NAA resulted in higher crude protein content in seeds (20.49%) over control (19.65%).

Dixit *et al*. (2008) recorded highest plant height (32.27 cm), branches per plant (4.17) and 1000 seed weight with treatment of DAP 2 per cent + NAA 40 ppm + boron (0.2 %)+ molybdenum (0.05 %) compared to other treatments in mungbean.

Kumar *et al*. (2008) recorded significantly higher number of pods per plant, number of seeds per plant, seed yield and seed protein in plants sprayed with NAA @ 40 ppm than with other growth regulators in blackgram.

Yadav *et al*. (2008) revealed that, maximum plant height (77.30 cm) and number of branches (5.00) was obtained in NAA 50 ppm treated plants compared to control (62.50 and 4.40, respectively). The yield parameters were also higher in plants sprayed with NAA 50 ppm at flowering *viz*., pods per plant, seeds per pod, seed weight per plant and 100 seed weight (77.00, 7.50, 59.10 and 22.92 g, respectively) compared to control (70.00, 5.50, 47.20 and 21.01 g, respectively) in field pea.

Dixit *et al*. (2008) recorded highest plant height (32.27 cm), branches (4.17), nodules per plant (32) more number of pods per plant (5.86) in plants received with DAP 2 per cent + NAA 40 ppm + B 0.2 per cent + Mo 0.05 per cent followed by NAA 40 ppm + B 0.2 per cent. They have also recorded higher value of 1000 seed weight with the first said treatment in mungbean.

Chaurasia and Chaurasia (2008) observed maximum productivity upto 16.88 q per ha, net return up to Rs. 25290, seed protein (18.70%) and protein yield (316.02 kg/ha) in treatments sprayed with triacontanol at 30 DAS in chickpea.

2.1.2.3 Influence of growth regulators on seed quality parameters

Deshpande (1983) in pigeonpea noticed that the seeds obtained from spray of 60 ppm NAA recorded maximum 100 seed weight, field emergence, germination percentage and minimum electrical conductivity indicating the better seed quality as compared to control.

Ravi Kumar and Kulkarni (1988) stated that soybean seeds obtained from foliar spray of 20 ppm NAA at 50 per cent flowering stage in three soybean genotypes showed marked increase in germination, field emergence and seedling vigour index compared to 40 ppm TIBA and water spray.

Merwade (2000) recorded higher germination percentage and seedling and vigour parameters in plants sprayed by NAA @ 40 ppm in chickpea compared to other growth regulators and control.

Srikant (2003) reported higher germination percentage, seedling length, vigour index with less electrical conductivity in seeds obtained from plants sprayed with 40 ppm NAA in cluster bean.

2.1.3 Panchagavya

In recent years, the use of panchagavya is gaining more importance in improving the yield potential and also the quality of produce in several crops. Panchagavya is known act as growth regulator and helps in increasing the seed yield and quality. The reviews on influence of panchagavya on seed yield and quality are presented here.

2.1.3.1 Influence of Panchagavya on seed yield and yield attributes.

Kalarani (1991) reported that the action of the growth regulators in plant system stimulated the necessary growth and development in plants, leading to better yield in soybean.

Yadav and Christopher (2006) reported in rice that, panchagavya (5%) spray significantly increased the productive tillers per hill (10.06), panicle length (19.89 cm), filled seed per panicle (97.18), seed test weight (16.55 g), seed yield (5433 kg/ha) and straw yield

(7325 kg/ha) compared to without panchagavya spray (8.54, 18.66, 83.53, 15.59 g, 5002 kg/ha and 6781 kg/ha, respectively).

Somasundaram *et al*. (2007) recorded higher seed yield of greengram under recommended fertilizer treatments but it was comparable with panchagavya. Among different organic sources tried, biogas slurry (BGS) + panchagavya spray proved to be a better source than others.

Swaminathan *et al*. (2007b) recommended that, application of panchagavya at 3 per cent as foliar spray on 15, 25 and 40 DAS recorded significantly highest seed yield (1195 kg /ha) in blackgram.

2.1.3.2 Influence of Panchagavya on seed quality parameters

Yadav and Christopher (2006) reported that panchagavya spray recorded significantly higher rice seed length (8.05 cm) and breadth (2.49 cm) as well as 1000 seed weight (16.55 g) as compared to without panchagavya spray (7.98 cm, 2.45 cm and 15.59 g, respectively).

Yadav and Lourdraj (2006) concluded that, foliar spray of panchagavya (3%) during flowering period in rice, showed higher seed quality compared to recommended NPK through fertilizer application.

2.2 Effect of Seed Size on plant growth, Seed Yield and Quality in Chickpea varieties.

2.2.1 Influence of seed size

Seed size is a relative term and has been interpreted differently. One research worker may classify a particular seed size as medium, the other worker may classify as large or small according to the scale adopted by him. Seed size is also classified in several ways *viz.,* based on seed weight, seed density, specific gravity, size and shape etc. The review on influence of seed size on plant growth, seed yield and quality are presented here

2.2.1.1 Influence of seed size on growth parameters

Vadivelu and Ramakrishanan (1983) recorded higher plant height (40.1 cm), branches per plant (8.1), dry matter production per plant (15.5 g), number of pods per plant (46.8), seeds per plant (51.5), seed weight per plant (4.6 g), yield per ha (22.35 q) in (4x4 mm R) medium size seeds compared to big (5x5 mm R) and ungraded seeds in chickpea.

Kurdikeri *et al*. (1998) revealed that the seed size in maize hybrids had no influence on growth attributes and yield and opined that even small seeds retained on 6.75 mm sieve may be used for sowing without any loss in yield and quality.

Veera Swamy *et al.* (1998) studied the performance of different seed size grades of Ganga-5 hybrid maize and concluded that the large seeds at various depth of sowing showed significantly superior over small seeds in field performance.

Khare and Satpute (1999) reported that germination seedling and plant vigour were significantly influenced by seed size but not the days to maturity. Small and medium seeded genotypes had better germination and mobilization efficiency than the bold seeded genotypes, with higher vigour index in pigeonpea.

Nagaraju (2001) observed higher plant height (97.83 g), number of leaves (7.58) and stem girth (6.98 cm) in plants raised by large size (3.0 mm oblong hole screen) followed by medium (seeds passed through 3.00 mm screen) compared to small seeds (passed through 2.8 mm) (90.50, 6.53 and 6.30 cm, respectively) in sunflower.

Munir *et al.* (2002) noticed that plant height and primary branches per plant and seed yield were not significantly affected by seed size in faba bean.

Verma and Bajpai (2002) reported in pigeonpea that, the ungraded and large seed grade showed higher performance for yield and primary branches per plant in all eight genotypes than small seed grade.

Yogeesha *et al*. (2005) reported that in french bean cv. Arka Komal, the seed size of >4.35 mm can be used for better field performance instead of seeds with >4.75 size as presently practicing. By doing so the rejection level during seed processing could be brought down from 34 to 12 per cent in same seed lot.

In mustard pronounced effect of seed size was observed, in large seed size category by having higher values of yield attributing parameters. Even the ungraded seed category was observed to be better for sowing purpose than small size of seed in mustard (Kumar *et al.,* 2005).

Tuba Bicer (2009) observed that seed size did not affect plant height, initiation of first pod, number of pods per plant, number of seeds per pod and seed yield per plant. These yield components were comparatively lower in plants produced from medium and small seeds than from large seeds in chickpea. While, he observed positive correlation with seed size to 100 seed weight and yield, lastly concluded that large seeded varieties produced more large seeds than plants produced from medium and small seeds of same variety.

2.2.1.2 Influence of seed size on seed yield parameters

Sahoo *et al*. (1988) observed no significant difference due to different seed size grades on days to 50 per cent flowering, plant height, number of pegs per plant, number of branches and pod yield per ha in groundnut but bold seeds performed comparatively better than other.

Bhor *et al*. (1988) recorded higher number of pods per plant, seed yield with higher 100 seed weight in bulk seed size compared to small and medium in gram.

Borale *et al*. (1993) recorded significantly maximum seed yield per plant, increase dry pod yield, pods per plant, pod weight, 100 seed weight and shelling percentage in the plants produced from the larger seeds than small seeds in groundnut.

Bhingarde and Dumbre (1993) reported in greengram, that the plants raised from large seeds had more pods at first (21.9 g) and second picking (15.8 g), higher number of seeds per pod (8.1) and higher seed quality parameters than the small and ungraded seeds. But, the large seeds took significantly more number of days for field emergence (4.6) than other seed grades.

Ahmed *et al*. (1994) reported in sunflower cv. Morden that bigger seeds had positively influenced the seed yield and yield components, and seed quality parameters over medium and small seeds.

Gontia and Awasthi (1999) noticed that among five soybean genotypes and seed grades, bold seeds of JS-81-1625 possessed early pod initiation and maximum pod length (3.29 cm) and ultimately maximum seed yield (5.66 g/plant and 66.66 g/m^2). They concluded that, bold seeds proved superiority over other grading for all seed vigour traits, growth parameters and recorded 55.67 per cent higher seed yield over small seeds.

Nagaraju (2001) recorded significantly higher yield and yield traits in sunflower with large seeds (retained over 3.00 mm sieve) the higher head diameter (15.08 cm), number of filled seeds per head, total number of seeds per head (619.41), per cent seed filling (84.17), seed yield per plant (22.31 g) and per ha (10.99 q) recorded in bold seeds followed by medium sized seeds (passed through 3.00 mm sieve) and significantly lower in small sized seeds (passed through 2.8 mm sieve).

Kumar and Seth (2004) observed that seed size affected the seed yield significantly. Medium, bold and ungraded seed were on par with seed yield but significantly greater over small seeds. Significantly lower number of pods per metre square and decreased 1000 seed weight resulted in small seeds in fodder cowpea.

Sulochanamma and Reddy (2007) reported in groundnut cv. TMV-2 that among different seed size, field emergence percentage at 10 DAS was significantly highest in medium size than small and shrivelled seed. The number of leaves upto 40 DAS were significantly higher in bold seed and no significant difference was observed in number of pegs per plant, root length, pod yield and shelling percentage in all seed sizes.

2.2.1.3 Influence of seed size on seed quality parameters

Vadivelu and Ramakrishnan (1983) reported that the large size (retained on 6x6 mm screen) and medium size seeds (retained on 5x5 mm screen) showed significantly higher seed recovery, 1000 seed weight, germination, seedling dry matter, vigour index and field emergence compared to small size 4 x 4 mm screen and ungraded seeds in bengalgram.

Shashidhar *et al*. (1987) reported in cowpea that the lowest germination (90%) recorded was from the seeds graded on 2.78 mm sieve while, the seeds retained on 3.98 mm sieve showed highest germination (94%) and seedling dry weight increased significantly with the increase in seed size.

Bhor *et al*. (1988) recorded non-significant differences in germination and vigour index due to different seed size graded between 7.50 and 8.00 mm sieves. The seedlings produced from bolder seeds (retained above 8.00 mm sieve) showed higher fresh and dry weight compared to the smaller (passed through 7.50 mm sieve) and ungraded seeds in bengalgram.

Sinha *et al*. (1988) opined that germination percentage, germination rate index, shoot and root length, seedling, dry weight and vigour index were higher in large seeds (retained on 4.00 mm square sieve), followed by medium seeds compared to the small and ungraded seeds in cowpea.

Kurdikeri (1991) reported that medium size seeds of maize exhibited better seed quality compared to bold and small seeds. However, non-significant effect of seed size on germination, vigour and field performance was noticed in maize.

Raveendranath and Gopal Singh (1991) reported that seeds retained on 4.75 mm and above (up to 6.00 mm) showed higher seed germination, field emergence, seedling dry matter and vigour index compared to those retained on 4.50 mm and ungraded in three sunflower cultivars.

Merwade *et al*. (1992) concluded that the medium size achienes followed by large size achienes had significantly recorded the highest values for test weight, germination percentage, seedling length and vigour index compared to ungraded bulk in sunflower.

Verma and Singh (1992) opined that, the germination and seedling vigour increased progressively as the size of the seed increase. The highest germination, root length, shoot length and seedling dry weight were exhibited by larger seeds compared to medium, small and ungraded bulk in pea.

Bhingarade and Dumbre (1993) reported higher germination, seedling length, dry weight and vigour index in the large seeds compared to the small and bulk seeds in greengram.

Borale *et al*. (1993) reported that the speed of field emergence decreased with increase in seed size and large seeds showed significantly higher value of vigour index and significantly more seedling dry matter content than small seeds in groundnut.

Srimathi and Vanangamudi (1993) size graded cowpea cv. CO-2 seeds using 12/64'' round perforated sieves. The per cent germination of smaller seed (passed 12/60") was more than bigger size seeds in accelerated ageing test. The medium sized seeds that retained on 12/64" were also found better than longer and smaller seeds.

Khare *et al*. (1995) reported that seed weight, seedling length and dry weight were significantly higher in the large size seeds than small size seeds in soybean.

Chavan (1998) recorded higher seed quality parameters *viz.,* germination percentage, shoot length, seedling vigour index and field emergence in bold seeds (retained over 2.00 mm round screen) compared to medium and small size seeds in sesame.

Gontia and Awasthi (1999) concluded that bold seeds (>6.28 mm) proved superiority over medium seeds (5.46-6.24 mm) and small seeds (<5.45 mm) for germination, speed of germination, vigour index, seedling length and dry weight in five soybean genotypes.

Ramarao *et al*. (1999) noticed significantly higher value for 1000 seed weight and field emergence rate in the large seeds (>4.35 mm) compared to small (3.5-4.35 mm) and ungraded seed lot of sorghum hybrid SPH-504.

Suryavanshi *et al*. (1999) evaluated chickpea genotypes for 100 seed weight and germination traits. Brown seeded cv. PGS recorded the highest seed weight (33.04 g/100 seeds) followed by yellow seed cv. Vishal. These two cultivars were also superior in terms of germination, emergence and dry matter content than the under sized seeds.

Nagaraju (2001) noticed higher germination percentage (93.95%), seedling length (25.26 cm), seedling vigour index (2379), dry weight (0.23 mg) and field emergence (83.00%) in large size seeds compared to small seeds (87.16%, 22.33 cm, 1941,0.22mg and 77.83%), respectively in sunflower.

Verma *et al*. (2005) reported in pigeonpea genotypes that hundred seed weight and seedling vigour index differed significantly among seed grades of all the varieties. Large seeds expressed high seedling vigour index than the small size seeds in all the varieties.

Vishvanath *et al*. (2006) noticed significantly higher seed quality parameters *viz*. 100 seed weight, field emergence, seedling length, vigour index with the increase in sieve size in french bean.

Sulochanamma and Reddy (2007) observed that in groundnut, seedling vigour in shrivelled and small seeds was less than bold seeds. Whereas, abnormal seedlings observed in bold seeds were more (34.9%) than small and shrivelled seed (10.6%).

2.3 Effect of Seed Size on Storage Potential in Chickpea Varieties

Among several seed quality attributes, seed size is recognized as an important trait of seed vigour that influences storage potential and field performance in many field crops. It also indicates the availability of reserve food materials during the time of germination, field emergence and stress conditions. The literature pertaining to the influence of seed size on storage potential of chickpea varieties on seed quality traits is reviewed and presented below.

Knittle and Burris (1976) studied soybean hypocotyl development in relation to seed size and reported that seedlings from small seeds had reduced redial enlargement and increased rate of elongation of hypocotyls compared to that of large seeds.

Singh *et al*. (1980) reported that seed coat thickness in desi (small seeded) was found to be 115-205 µ (av. 144 µ) whereas, in kabuli (large seeded) was 37-106 µ (av. 58 µ). Further, seeds of desi type stored better compared to kabuli types.

Gaspar and Bus (1981) opined that the lighter seeds have poorer germination capacity and shorter longevity, the relationship between 1000 seed weight and germination capacity can be described by saturation function. Above a certain weight, the germination capacity showed no further increase, so that above the limit it has not profitable to result to select the seeds of heavier in white clover seeds.

Tewari and Gupta (1981) noticed in sunflower that seeds of Perevik varieties maintained higher seed quality parameters at the end of eight months of storage than variety Sunrise under cold room condition. Similarly among seed grades larger seeds proved better in maintenance of viability and vigour than the smaller or mixed seeds.

Hoy and Gamble (1987) reported that the single seed leachate conductivity levels were high for large and low density seeds of soybean indicating low vigour. Bulk conductivity tests indicated high levels of leakage in large seeds, but failed to detect differences between seeds of high and low density.

Negi *et al.* (1988) observed that the wrinkled and ruptured seeds of soybean were larger, had more breaks in the embryonic axis and other important seed parts than the smooth and small seeds and therefore showed poor germination as well as viability as compared to the smooth small seeds.

Vanangamudi (1988) stored soybean seeds for 16 months and observed varietal differences in seed longevity. Seeds of cultivars, Hill, Co-l, Nirnsoy 7, DS 74-37 and PB-1 had better storage potential. Whereas, Bragg was a poor storer. He also observed that small seeds retained their viability longer than the large seeds.

Singh (1988) observed that in sorghum seed germination, rate of germination, vigour index and seedling growth, significantly decreased with increase of storage period. The hybrid CSH-64 its parents (2219A and CS 3541) were observed to be superior over other genotypes for germination and vigour. However, the medium grades maintained superior throughout the storage period than small. Over all findings indicated that large and medium seed size grades retained over 3.00 mm screen were better for storability and sowing.

Verma and Ram (1989) reported that seed size was negatively correlated with electrical conductivity of seed leachate and concluded that in big seeds leachate were more than small seeds in Soybean.

Vyas *et al*. (1990) worked on three soybean cultivars and observed that decrease in germination was accompanied by an increase in the leaching of electrolytes in large sized seeds. Small seeds showed better performance than large seeds.

Mohanrao (1993) studied on five soybean genotypes with four grades of seed size, the result of experiment revealed that small seeds of all the varieties maintained higher germination and field emergence in all the month of storage period. While the seedling vigour parameters were maximum in big seeds of all the varieties.

Ahamed *et al*. (1994) reported in sunflower cv. Morden that the storability of 4.75 mm size graded seed was only for nine months while seeds of 5.00 mm size stored for about one year. They have also reported higher germination in bolder seeds indicating that bold seeds during storage deteriorate slower than small seeds.

Kant and Tomar (1995) noticed significant differences in the 1000 seed weight of large, medium and small seeds which was 8.0, 5.7 and 2.6 g, respectively. The germination percentage both at initial and after storage showed significant difference however, small seeds showed significantly lower germination, field emergence, root length and seedling length than large and medium seeds in mustard cv. Pusa Bold. They have also reported that the seed size influenced germination during storage. The net loss of germination for small seed was upto 11 per cent while it was 0.9 and 3.7 per cent respectively for large and medium size seeds in mustard.

According to Poonam *et al*. (2002), the seed size did not significantly affect germination but it was observed that seeds lost their germination when stored at room temperature (18-20 ^{0}C) whereas, at low temperature (6-8 ^{0}C) they maintained higher germination (90%) up to one year in Toonaciliata (*Frona ciliate*) seed.

Santosh *et al*. (2005) studied the effects of soybean seed size on physiological quality during storage. The seed quality was evaluated by the tests of germination, AA, Tz percentage and speed of seedling emergence. In general, the physiological quality was influenced by seed size during storage. The seeds retained on screen 14 and 13 mm showed the highest storage potential whereas, the seeds retained over 16 and 11 mm screen showed lower germination and vigour at the end of ten months storage. Germination percentage and speed of seedling emergence in the field decreased markedly with increase storage period.

2.4 Effect of Seed Treatment on Plant Growth, Seed Yield and Quality in Chickpea Varieties.

In recent years, the use of micronutrients is gaining more importance in improving the yield potential and also the quality of the produce in several crops. Micronutrients though required in minute quantity, their role is one of the most deciding factor on yield and quality of many crops in general and chickpea in specific.

2.4.1 Influence of $ZnSO_4$

$ZnSO_4$ required for the activity of various types of enzymes, including dehydrogenase, aldolase, isomerases, transphosphorylases and RNA and DNA polymerases. Therefore the zinc deficiency is associated with an impairement of carbohydrate metabolism and protein synthesis (Hazra and Son, 1999).

2.4.1.1 Influence $ZnSO_4$ on growth parameter

Wv and Xiao (1992) reported that low concentration of zinc (0.3 ppm) increased plant height, number of branches and green leaves in soybean.

Singh *et al*. (1994) reported that, foliar application of zinc resulted in more vigorous vegetative growth and early flowering in vegetable pea.

Singh and Yadav (1997) reported that, application of zinc sulphate 5 kg per hectare increased the plant height, primary branches per plant, and functional leaves per plant in greengram.

Singh *et al*. (1998) revealed that the more plant height (28.5 cm), number of branches (5.5) and number of leaves (12.8) were obtained with foliar spray of $ZnSO_4$ @ 0.5 per cent while, control showed less plant height (27.7 cm), number of branches (5.3) and number of leaves (12.2) in mungbean.

Hugar and Kurdikeri (2000) reported that application of 0.5 per cent zinc sulphate increased the plant height (34.4 cm) and number of leaves (45.6) in soybean.

Shivakumar (2001) noticed the increase in plant height and number of branches of groundnut due to application of $ZnSO_4$ @ 12 kg per ha. Application of 80 kg sulphur + 40 kg P_2O_5 per ha significantly improved the plant height, dry matter and branches per plant in chickpea.

Foliar spray of $ZnSO_4$ (0.5%) to vegetable pea produced highest plant height (43.2 cm) over control (40.2 cm) (Raghav and Sharma, 2003).

2.4.1.2 Influence $ZnSO_4$ on yield parameters

Dwivedi *et al*. (1990) in their field experiment on soybean at Ranichuri, UP recorded the highest seed yield (13.8 q ha^{-1}) with 0.5 per cent zinc foliar spray over control (8.8 q ha^{-1}).

Yadav *et al*. (1991) noticed significantly increased pod (141.0 g/plot), kernel yield (188.2 g/plot) and root length (11.9 cm) of groundnut over control with foliar application of zinc @ 5 ppm.

Increase in yield was noticed with foliar spray of 0.1 per cent ZnSO4 in soybean over control (Selim, 1992).

Kushwaha(1993) concluded that the application of zinc (0.5 %) significantly increased the seed yield as compared to control in urdbean.

Bhanavase *et al*. (1994) found that the application of 25 kg $ZnSO_4$ per hectare significantly increased the seed yield (4.41 g/plant) in soybean over control (2.50 g/plant).

Higher yield (18.50 g/ha) of soybean was obtained with application of 15 kg $ZnSO_4$ per hectare (Gupta and Vyas, 1994).

Krishna (1995) obtained more number of pods per plant and higher seed yield (1206 and 1239 kg per ha respectively) in mungbean with application of 60 kg sulphur + 15 kg zinc sulphate per hectare.

Vijaya and Ponnusamy (1997) stated that cowpea seeds fortified with $ZnSO_4$ + $MnSO_4$ followed by pelleting with DAP, registered higher field emergence, per cent dry matter production, pod production, number of seeds per pod and also increased seed yield per ha to 24.7 per cent over control (19.2 q).

In a field experiment on mungbean, Singh *et al*. (1998) recorded highest number of pods per plant (33.1), pod weight per plant (18.4 g), seeds per pod (9.2) and seed yield (12.13 q ha^{-1}) with 0.5 per cent $ZnSO_4$ foliar spray. While, the control had the lowest number of pods per plant (26.6), pod weight per plant (12.6 g), seeds per pod (8.1) and seed yield (988 kg/ha)

Gupta *et al*., (1999) reported that, seed yield increased with increase in application of zinc from 0 to 10 mg per kg soil in lentil, methi, gram and peas (125%, 63%, 37% and 22%, respectively) over control.

Hugar and Kurdikeri (2000) revealed that foliar application of zinc sulphate @ 0.5 per cent recorded the highest number of pods per plant (34) seeds per pod (2.6) and seed yield (23.4 q/ha) compared to control in soybean.

Shelge *et al*. (2000) noticed the increased seed yield due to application of $ZnSO_4$ @ 5 kg per ha (2203 kg/ha) and borax @ 0.5 kg per ha (1973 kg/ha) in soybean

Singh *et al*. (2001) made a study on effect of micronutrient application on yield of cluster bean. He revealed that higher dry matter yield per plot (9.98 g) was obtained when applied with zinc 5 mg per kg soil as against control (3.55 g).

Halepyati (2001) revealed that, application of zinc sulphate and molybdenum increased the pods per plant, seeds per pod, 1000 seed weight and seed yield (23.4 and 24.7 q/ha, respectively) in soybean. Application of $ZnSO_4$ @ 12 kg per ha increased the pods per plant and pod yield (13.1 q/ha) in groundnut.

Khurana and Chatterjee (2002) reported that, foliar application of zinc sulphate @ 0.065 mg per litre increased the pods per plant, seeds per plant and seed weight per plant in pea.

In a field experiment on mungbean at Kanpur, Vedram *et al*. (2002) stated that soil application of 15 kg zinc per hectare gave the highest seed yield (909.38 kg/ ha), while control recorded the least seed yield (866.40 kg/ ha).

Sundara (2002) noted that, higher yield components *viz*., pods per plant (7.79), dry pod weight (7.09 g), seeds per pod (5.53), 100 seed weight (18.56 g) and seed yield (1777 kg/ha) were recorded with application of 20 kg per ha $ZnSO_4$ in pea.

In pea, Raghav and Sharma (2003) recorded highest fruit weight (19.2 g) and yield (38.9 q /ha) compared to control (16.0 g and 31.2 g/ha respectively), when crop was sprayed with $ZnSO_4$ (0.5%).

Macha (2004) reported in cluster bean that, number of pods per plant significantly were more (51.16) with $ZnSO_4$ @ 0.5% followed by $FeSO_4$ @ 0.5 % (48.78) whereas, number of seeds per pod did not shown significant effect.

Shrivastava *et al*. (2006) observed that, 50 kg Zn dose was found to be effective in increasing total nodules; root and shoot dry weight, dry matter, seed yield at maturity in frenchbean.

2.4.1.3 Influence of $ZnSO_4$ on seed quality parameters

Reddy (1983) observed the increased 1000 seed weight, crude protein content, seed germination (9.40%), dry weight of seedling, shoot length, root length and vigour index of alfalfa due to foliar spray of 0.5 per cent Zinc sulphate.

The seeds obtained from the plants receiving 10 ppm zinc sulphate showed higher germination percentage, germination rate index, shoot length, root length, seedling dry weight and seedling vigour of safflower (Shekhargouda, 1983).

Foliar application of 0.5 per cent $ZnSO_4$ recorded highest 100 seed weight (13.4 g), germination (88%) and vigour index (874) as compared to control in soybean (Hugar and Kurdikeri, 2000).

Vedram *et al*. (2002) conducted an experiment on mungbean at Karipur and registered the highest 1000 seed weight (28.79 g) when $ZnS0_4$ was applied at the rate of 15 kg per hectare to soil.

2.4.2 Influence of $CaCl_2$

One of the fundamental roles of Ca in plants is the maintenance of membrane integrity and the membrane stability has important consequences for several physiological processes like iron transport (Handley *et al*., 1965). Calcium is also an integral component of the pectin protein of the middle lamella along with maintenance of membrane integrity (Ginzburg, 1961).

2.4.2.1 Influence $CaCl_2$ on growth parameters

Mariakulandai and Manickam (1975) reported on the role of calcium in plants on the development of root system, translocation of carbohydrates, proteins and their storage during seed formation. Ca found necessary for the normal activities of micro-organisms and it prevents the accumulation of excess quantities of Al, Mn and Fe in harmful concentration.

2.4.2.2 Influence of $CaCl_2$ on yield parameters

Gogoi *et al*. (2000) opined that calcium requirement of groundnut plants is quite heavy and its application causes better nodulation and pod development particularly in acidic soils.

Kumarswamy (2003) recorded higher number of pods (36.1), pods per plant (29.3), pod yield per plant (12.88) and pod yield per ha (32.89) and better seed quality parameters with soil application of calcium at 45 per cent saturation compared to other treatments in groundnut.

2.4.2.3 Influence of $CaCl_2$ on seed quality parameters

Brewbaker and Kwaek (1963) found that calcium was found to be essential for germination and growth of pollen tube.

Legge *et al*. (1982) proposed that calcium might also prevent membrane deterioration. Calcium renders structural integrity of membrane is that it links the phosphate and carboxylic groups of phospholipid and proteins and increases the hydrophobicity of membrane (Ochial, 1977).

Sankara Reddy (1982) reported in groundnut, that adequate calcium is essential to produce high yield of quality seed as it is a component of calcium pectate which cements cells together and is required in cell division.

Sankar and Reddy (1987) revealed that the addition of calcium to the nutrient solution increases the root and shoot of groundnut seedlings compared to seedlings growth without addition of calcium.

Sandhya and Gopal Singh (1994) reported that groundnut seeds fail to reach seedling stage when calcium supply is not adequately met since it sufficiency reduces the damage caused to plumule during seedling emergence.

Geetha *et al*. (1996) reported that, germination per cent of groundnut were significantly increased by seed treatment with Ca+Zn + Mo @ 8 g per kg of seed + inoculation with *Rhizobium* produced the highest oil content 49.10 per cent compared with other treatments.

2.4.3 Influence of $FeSO_4$

Iron has been regarded as a necessary element for the synthesis and maintenance of chlorophyll and related photosynthetic activity in plants. Iron is an essential component of many enzymes such as catalase, peroxidase, cytochrome and ferrodoxin and performs an essential role in nucleic acid metabolism. Iron plays a key role in plant nutrition. It is a constituent of peroxidase, catalase, cytochrome oxidase enzymes. Iron is also involved in nucleic acid metabolism, photosynthesis, nitrogen fixation and respiratory linked dehydrogenase (Hazra and Som, 1999).

2.4.3.1 Influence of $FeSO_4$ on growth parameters

Patil (1975) revealed an increase in plant height, number of branches per plant and dry matter accumulation with the foliar spray of 0.5 per cent iron sulphate. Foliar application of $FeSO_4$ (0.5%) was significantly superior to $FeSO_4$ (10 kg/ha) soil application in groundnut.

Seelinger and Moss (1976) noticed that foliar spray of ferrous sulphate twice first at 40 and second 60 DAS increased the plant height and number of branches per plant in pea compared to control.

Symbiotic nitrogen fixation has a greater iron requirement than host plant growth and the effect of iron on symbiosis is direct (Robson, 1983).

Tang *et al*. (1990) reported that iron deficiency in acid soil caused poor nodule formation and concluded that the adequate supply of iron is essential for initiation of nodulation in lupines seed.

In pot studies, with an increase in Fe content there was an increase in dry matter accumulation in greengram (Prakasa Rao, 1998)

Singh *et al.* (1998) made a study on the effect of micronutrients and method of application on mungbean, and recorded maximum plant height (29.8 cm), number of branches (6.2) and number of leaves (13.9) with foliar spray of $FeSO_4$ @ 2 per cent as against control (27.7 cm, 5.3 and 12.8 respectively)

2.4.3.2 Influence of $FeSO_4$ on yield parameters

Selim (1992) revealed that foliar spray of $FeSO_4$ @ 0.5 per cent increased soybean yield over control.

Pod yield of groundnut was highest with foliar application of 3 per cent $FeSO_4$ (Pande *et al*, 1993).

Pande *et al*., (1993) recorded highest pod yield of groundnut with foliar application of three per cent $FeSO_4$.

The application of $FeSO_4$ and $ZnSO_4$ individually showed significant increase in seed yield in soybean (Bhanavase *et al*., 1994)

Christopher *et al*. (1997) found that the foliar application of $FeSO_4$ @ 0.1 per cent on 45th day recorded higher dry pod yield, shelling percentage, test weight and per cent matured kernel in groundnut.

Singh *et al*., (2001) recorded maximum dry matter, yield per plot (5.01 g) when iron was applied @ 10 mg per kg soil to clusterbean crop as against control (3.55 g).

2.4.4 Influence of Boron (B)

Acts in a similar way to P and it facilitates sugar translocation. Boron has a beneficial influence on membranes. Boron inhibits the IAA oxidase and RNAase activity and improves the root development (Handley *et al.,* 1965). Boron has direct effect on pollen producing capacity of the anthers, viability of the pollen grains pollen germination and pollen tube growth.

2.4.4.1 Influence of Boron on growth parameters

Patil and Malewar (1994) reported that foliar application of 0.2 per cent boron in combination with Fe and Zn to cotton proved its superiority in the production of chlorophyll 'a' and 'b'.

Singh *et al.* (1998) reported that foliar spray of boron @ 0.1 per cent in mungbean increased the plant height (29.3 cm), number of branches (6.3) and number of leaves (12.6) as against control (27.7 cm, 5.31 and 12.2, respectively).

Macha (2004) recorded higher plant height (88.96 cm) in cluster bean cv. Navabahar with foliar application of boron (0.1 %) compared to $MnSO_4$ and control (84.50 and 73.56 cm).

2.4.4.2 Influence Boron on yield parameters

Singh *et al*. (1988) conducted a pot experiment in calcareous soils to study the effect of micronutrient on yield of groundnut. Foliar application of boron @ 2 kg per hectare at 20, 40 and 60 days after emergence increased the pod and fodder yield of groundnut.

Galrao (1989) reported increase in seed yield of soybean with the application of boron @ 1 kg per hectare as compared to control.

Dwivedi *et al*. (1990) recorded the maximum seed yield (13.3 q/ ha) with foliar spray of boron @ 0.2 per cent to soybean crop at 60 and 90 DAS as against control (8.8 q/ha).

Singh *et al.* (1998) recorded the maximum pod weight (15.7 g), pods per plant (32), seeds per pod (8.5) and seed yield (1293 kg/ ha) when mungbean crop was sprayed with 0.1 per cent boron compared to control (12.6 g, 26.6, 8.1 and 988 kg/ ha respectively).

Sinha *et al*. (1999) concluded that foliar application of boron @ 0.33 mg/lit, resulted in significantly higher dry matter yield per plant (18.96 g) and pod weight (7.23 g) per plant over 0.011, 0.033, 0.165, 1.65 and 3.3 mg per litre boron in pea.

Shelge *et al*. (2000) noticed the increased seed yield (1973 kg/ha) due to foliar application of borax @ 0.5 kg per hectare in soybean compared to control.

Foliar spray of 0.2 per cent borax at 50 and 60 DAS recorded maximum seeds per pod (1.3) and seed yield (17.96 kg/ ha over control (1.2 and 1180 kg/ha, respectively) in chickpea (Masoodali and Mishra, 2001).

Mishra *et al*. (2001) noticed that foliarly applied boron @ 1 kg per hectare had a positive effect on number of pods per plant (50.66), seed weight per plant (8.68 g), seed yield (12.39 q/ha) over control (28.83, 4.11 g and 8.99 q/ha respectively) in chickpea.

Naik *et al*. (2002) observed that application of boron @ 12 kg per hectare significantly improved the seed yield in soybean.

2.4.4.3 Influence of Boron on seed quality parameters

Singh *et al*.(1998) reported maximum 100 seed weight (53 g) was recorded with boron (0.1%) spray in mungbean as against control (42.3 g).

Masoodali and Mishra (2001) observed that application of borax (0.2%) to chickpea crop recorded highest 100 seed weight (20.7 g) over control (20.5 g).

Deo sarkar *et al*. (2002) observed an increase in test weight, germination, vigour index and protein content due to application of boron and zinc in soybean.

Manonmani *et al*. (2002) reported that, application of borax + zinc sulphate each @ 0.3 per cent showed its superiority by recording higher 100 seed weight with good germination percentage seed vigour index with lower seed leachate.

2.4.5 Influence of Magnesium

Magnesium is a key element of chlorophyll molecule. It plays important role in phosphate nutrition and acts as a carrier for phosphorus, particularly in the seeds. It is a specific activator of a number of enzymes like transphorylase, dehydrogenase and carboxylase. It is involved in carbohydrate metabolism, synthesis of nucleic acid *etc*. and helps in translocation of sugars within plants (Hazra and Som, 1999).

2.4.5.1 Influence Magnesium on growth parameters

Peterson and Berger (1950) noticed, maximum growth of pea Cv. Alaska when treated with high concentration (50 ppm) of magnesium in the nutrient solution and it also caused earlier blooming (3 to 7 days) compared to 5 ppm magnesium (8 to 10 days).

Rubes (1984) reported that, soil application of magnesium to pea crop could show the marked increase in the nitrogen content of seeds.

Sztuder and Swierczewska (1998) reported that foliar application of magnesium to peas at 6 to 8 leaf stages and prior to flower initiation stage has shown significant increase in plant height and number of branches per plant over the control.

Boaro *et al*. (1999) studied the growth parameters of *Phaseolus vulgaris* cv. Carica plants sown in pots containing magnesium nutrient solution with low (2.4 or 24.3 mg /lit) content. Plants grown with low magnesium content had lower magnesium concentrations in roots, stem and leaves. While, those with highest magnesium levels had higher magnesium concentrations in leaves indicating its absorption and translocations from roots to shoots.

Patil (2002) recorded higher plant height, number of branches and less number of days for 50 per cent flowering in seeds treated with 2 per cent $MgSO_4$ compared to 2 per cent $ZnSO_4$ in gardenpea.

2.4.5.2 Influence of Magnesium on yield parameters

Peterson and Berger (1950) reported that seed yield of Alaska pea crop was influenced greatly by the amount of magnesium available to the plants and the quality was largely dependent upon yield and maturity. They recorded maximum yield with 50 ppm of magnesium compared to 5 ppm. Klacan (1962) reported significant increase in podding parameters due to application of magnesium and phosphorus nutrition to pea crop. Increase in pod number was attributed partly to increased uptake of magnesium and partly to increased uptake and translocation of phosphorus nutrients.

Rubes (1984). observed increase in seed yield due to magnesium application in garden pea Cv. Bohatyr and Smaragd .

Kiss (1997) studied the combined effect of seed treatment and foliar dressing of magnesium on seed yield of two gardenpea Cv. Bohtyr and Smaragd and observed the marked increase in the number of pods per plant, number of seeds per pod and yield per ha under combined treatments.

Sztuder and Swierczewska (1998) reported that foliar application of magnesium to peas at 6 to 8 leaf stage and just before flowering stage could increase the yield attributes and seed yield significantly compared to control.

Patil (2002) reported that seeds treated with $MgSO_4$ in pea recorded significantly more number of pods per plant, pod weight per plant, number of seeds per pod,seed yield per plant and per hectare and pod to seed ratio as compared to $ZnSO_4$.

2.4.5.3 Influence of Magnesium on seed quality parameters

Peterson and Berger (1950) reported slow germination of pea seed produced in the low magnesium treatment (5 ppm) and it was 100 per cent with higher magnesium levels (50 ppm).

Rubes (1984) reported that magnesium applied as a soil application to pea crop could show the marked increase in the nitrogen content of seeds.

Patil (2002) noticed that pea seeds treated with $MgSo_4$ recorded maximum germination percentage, seedling length, vigour index and seedling dry weight compared to $ZnSO_4$ treated seeds.

2.4.6 Influence of Bio-fertilizers

The benefits of *Rhizobium* and Phosphorus solubilizing bacteria (PSB) inoculation on nodulation, nitrogen fixation, dry matter accumulation, seed yield and seed quality of legumes in soils devoid of any Rhizobial strain is well established (Bushby *et al*., 1983). In the absence of natural inoculum, Rhizobial inoculation of chickpea may be expected to produce higher yield. The reviews related to *Rhizobium* and phosphorus solubilizing bacteria in chickpea and other related crops are presented here.

2.4.6.1 Influence of Bio-fertilizers on plant growth

Alagawadi and Gaur (1988) in chickpea revealed that combined inoculation of *Rhizobium* and phosphate solubilizing bacteria *pseudomonas striata* increased the dry matter content and resulted in saving 10 kg N per ha. This may be attributed to increased nodulation, nitrogen fixation and yield of crop by *Rhizobium* and PSB which utilizes organic compounds as carbon and energy source and produces organic acids, there by solubilizing the insoluble inorganic phosphates. Bacteria may produce growth-promoting substances such as auxins, gibberllins and cytokinin, which improve plant growth and stimulate the microbial development.

Upadhayay *et al*. (1999) studied the effect of *Rhizobium* and phosphorous on summer greengram and results showed that 40 kg P_2O_5 per ha with *Rhizobium* inoculation gave maximum plant height, dry matter, branching pattern, nodulation and seed yield.

Gupta *et al*. (2004) reported that *Rhizobium* inoculated plants showed increased plant growth at 30 and 60 DAS however, the inoculation of 2 ml culture resulted into increased growth of root and shoot resulting into more biomass than 1 ml inoculated plants. Significant in the contents of chlorophyl and carotenoids in *Cicer arietinum* var (SG-8962 and C-235 at different growth period was observed.

In chickpea, seeds inoculated with *Rhizobium* + phosphotica significantly enhanced the growth parameters *viz*., plant height, branches per plant, nodules per plant and seed yield compared to control (Kushwaha, 2007).

Singh *et al*. (2008) obtained significantly higher seed yield (651 kg/ha) due to application of PSB with DAP in blackgram. The increase in seed yield was attributed mainly due to increase in nodulation, plant height, branches per plant, leaves per plant and pods per plant.

2.4.6.2 Influence of Bio-fertilizers on seed yield parameters

Inoculation of bengalgram with P-solubilizing *Bacillus megaterium* and *B. circulans* in arid red loam soil was found to increase the yield and P uptake of plants but the inoculation effect was more pronounced in the presence of FYM (Wani *et al*., 1978).

Tiwari *et al*. (1989) recorded increase in nodulation and seed yield of chickpea due to inoculation with *Pseudomonas striata, Bacillus polymyxa* and *Aspergillus awamoii* in combination with rock phosphate and super phosphate as P-sources.

Tippannavar *et al*. (1992) observed increase in nodule number, nodule dry weight, pod number, pod weight per plant and seed yield per ha, due to inoculation of phosphate solubilizing bio-fertilizers (PSB) in chickpea.

Kumpawat and Manohar (1994) reported, *Rhizobium* inoculation significantly increased the number and dry weight of nodules per plant, protein content and increased seed yield from 8.59 (control) to 10.5 q in gram.

D'souza (1996) obtained higher yield parameters *viz*., number of pods per plant (36.37, 35.83 and 32.58), pod weight per plant (12.33, 11.75 and 10.24 g), seed yield per plant (11.03, 10.41 and 8.66 g) and seed yield per ha (18.42, 17.97 and 16.78 q/ha) in seed treated with *B-polymyxa* and *B-biophos* P-solubilizer strains and control respectively in chickpea.

Dubey (1996) obtained good response of soybean with respect to dry matter, seed yield and P content when inoculated with *Pseudomonas stiata* alone or in conjunction with super phosphate or rock phosphate.

Rajput and Singh (1996) revealed that seed inoculation with Rhizobium has significantly increased the seed, fodder yield (by 10.85%) and saved the nitrogen 9.50 kg per ha than uninoculation in cowpea.

Srivastava *et al.,* (1998) reported that dual inoculations with Rhizobium *leguminosanum* and PSB (*Bacillus polymyxa*) resulted in significant increase in yield attributes compared to individual inoculation in pea. This could be due to increased and balanced availability of both N and P in dual inoculation plots.

Srinivas and Shaik (2002) opined that, seed inoculation with *Rhizobium* to greengram had no significant yield advantage compared to the uninoculated crop but application of 20 kg N per ha along with *Rhizobium* significantly raised the seed yield from 1033 kg per ha (control) to 1105 kg per ha.

Jat (2004) reported that, seed treatment with *Rhizobium* +PSB, and *Rhizobium* alone increased the dry matter and seed yield (15.30 and 15.08 q, respectively) in fenugreek compared to control (14.76 q/ha).

Singh and Yadav (2008) recorded significantly higher plant height (198.7 cm), maximum number of branches (18.9), dry matter (156.4 g) and seed yield (2060 kg/ha) in pigeon pea seeds, inoculated with *Rhizobium* + PSB compared to uninoculation and alone treatment.

Kumar and Majumdar (2008) concluded that, application of 2.5 tons per ha of vermicompost with inoculation of bio-fertilizers significantly increased yields than its application without inoculation of bio-fertilizer in mungbean.

2.4.6.3 Effect of Bio-fertilizers on seed quality parameters

Rhizobium inoculation resulted in significant increase in protein content of seed over no inoculation in greengram (Srinivas and Shaik, 2002).

Pawar *et al*. (2008) observed maximum number of nodules and 100 seed weight in plants treated with Rhizobium, phosphate solubilizing bacteria, *Bacillus subtitis*. The highest protein content in the seed was recorded in these same treatments.

2.5 Influence of Harvesting Stages on Seed Quality in Chickpea Varieties.

The harvest of seed crop at optimum stage of crop maturity is one of the most important operations to obtain higher seed yield and quality. The seeds harvested as right stage of maturity shall have maximum seed viability and vigour. The reviews on influence of physiological maturity in chickpea are limited and as such the investigation done on other related crops have also been included.

Ramaiah (1983) noticed maximum pod length (15.5 cm), number of seeds per pod (14.9), 100 seed weight (7.6 g), germination (96.5%), vigour index (5.7) and less moisture content (33.5%) in cowpea when harvested at 31 days after anthesis.

Delouche (1988) reported that, yield losses due to pod drop and shattering up to 15 per cent can be expected in late harvested crops. It is well recognized that excessive delay in harvest, increase yield losses due to pod dehiscence and shattering in desi chickpea.

Arulnandhy and Senanayak (1990) noticed that seeds harvested at physiological maturity followed by drying in open shed were significantly better in viability and vigour than the seeds harvested at harvest maturity in three soybean cultivars grown in the wet season. Delayed harvest by two weeks beyond harvest maturity significantly reduced the seed quality.

Bharud and Patil (1990) observed in chickpea that, dry matter accumulation increased upto 56 days after anthesis (DAA) with gradual progress towards maturity of crop while, the seed moisture content decreased from 79 to 14 per cent at 56 DAA. The germination potential on 21 DAA was 3 to11 per cent and it increased gradually and attained maximum on 56 DAA, there after no further increase in germination was observed.

Kharb *et al*. (1993) reported that pigeonpea seeds acquired the ability to germinate after 23-26 days after anthesis and attained maximum potential germination (96-98%) at 45-49 DAA. Complete loss of green colour of pod was found useful indicator for judging the optimum physiological maturity stage in the field whereas the harvestable maturity was induced by dry brown pods.

Biradar (1994) reported that seed germination, shoot and root length and vigour index were maximum in seeds harvested on 74 day after anthesis in brinjal.

Shridhar (1994) indicated that in conditions like outbreak of disease, bird damage, excess rainfall, the pods may be harvested at brown pod colour stage without compromising the viability and vigour to a great extent. He also observed significantly increased germination, 100 seed weight, shoot length, root length, vigour index and total biomass in cowpea cv. Pusa Barsati and brown seeded local with harvesting at brown pod stage.

Suryavanshi and Patil (1995) revealed that the stage of physiological maturity varies with crop and also with variety. In case of mungbean cultivars by considering dry weight, germination per cent and vigour index reported that the seeds attained physiological maturity at 25-30 days after anthesis.

Indira and Dharmalingam (1996) observed that in fenugreek, pod length (10.70 cm), fresh weight of pod (83.3 g/100) and germination (72.0%) were maximum when they were harvested at 30 days after anthesis.

Naik *et al*. (1996) reported that chilli fruits harvested at green maturity stage recorded only 48 per cent germination which increased successively to 88 per cent at the full maturity of the fruits, such improvement in the quality of the seeds was also reflected in the higher shoot and root length, dry weight and seed vigour.

Gore *et al*. (1997) revealed that the dry matter content of seed, 100 seed weight, germination percentage and vigour index showed an increasing trend upto maturity stage and attained their maximum value prior to field maturity. All the parameters reached their maximum at 46 DAF in soybean.

Sheth *et al*. (1999) observed that harvesting of fodder cowpea at 23 days after anthesis was found to be optimum stage to get maximum dry weight (6.31 g), germination percentage (86.66%) and vigour index (812) and less moisture content (32.5%).

Timing of an early harvest of a chickpea crop will depend largely on maturation of seeds in apical pods, it is recommended that harvesting should commence when late maturity seeds in the apical pods dried to 15 per cent moisture content to reduce the level of green immature seeds (Cassells and Caddick, 2000).

Kumar (2001) reported that harvesting of french bean at 42 days after flowering recorded higher fresh and dry weight of pod, 100 seed weight along with higher seed germination (89.66%) field emergence (85.00%), shoot length (18.85 cm), root length (15.23 cm) and seedling vigour index (3047) than other stages of harvest.

Rama Rao (2001) noticed that under black cotton soils of rainfed situation, pigeonpea seeds attained physiological maturity at 41-43 days after anthesis. Complete loss of green colour of pod was found to be useful indicator for judging the optimum physiological maturity stage.

Reddy *et al*. (2001) noticed that chilli fruits harvested at 35 days after anthesis were having maximum pod length (9.3 cm), pod girth (1.01 cm) and pod weight (2.30 g) with higher seed quality parameters compared to the fruits harvested before or after 35 days after anthesis.

Shivankar *et al*. (2001) revealed that soybean seeds collected at physiological maturity (90 DAS) were found to be higher in germination than those collected from prior and after physiological maturity. Delayed harvesting badly affected the seed quality due to field weathering under high atmospheric humidity and pod shattering in the field and seed moisture content reduced down to 13 per cent in soybean.

Significantly maximum 1000 seed weight (2.20 g), germination (90.11%), shoot length (5.90 cm), root length (3.21 cm), vigour index (822) and seedling dry weight (1.90 mg) with minimum electrical conductivity (1.17 dSm-1) were noticed when tomato fruits were harvested at full red colour stage followed by half red and turning yellow colour stage (Hamsaveni, 2002).

Sureshbabu *et al*. (2003) opined that, brinjal fruits harvested at complete yellow colour maturity stage and kept upto six days of post harvest ripening recorded higher fruit weight, seed weight per fruit, 1000 seed weight, germination, field emergence, vigour index, seedling dry weight with lower E.C of seed leachate.

Timmannavar *et al*. (2003) reported that groundnut pods harvested at their normal date of harvesting were found to yield more with highest test weight and germination compared to harvesting either one week early or later to their normal harvesting time.

Sudarshan (2004) in fenugreek recorded significantly maximum pod length (10.70 cm), number of pods per plant (31.18), number of seeds per pod (16.25), seed yield per plant and per ha (20.78 and 692.51 kg) with higher seed quality parameter in pods harvested at 51 days after 50 per cent flowering.

Murthy and Dushyenthkumar (2004) reported that field bean Cv. Hebbal avare attained physiological maturity at 90 DAS. The seeds harvested at their physiological maturity around 35 days from anthesis or 94 days from sowing showed highest dry seed weight, germination percentage and vigour index.

2.6 Characterization of Chickpea varieties.

The exploitation of genetic potential of a variety of pure seed at genetic level is pre requisite. For maintenance of genetic purity of varieties during seed production, quality control and certification, documentation of diagnostic features of varieties with their accurate identification keys (on comparative basis), with features of distinctness has become most essential and inevitable. Testing of genetic purity at seed level requires detailed information about the expression of morphological traits at seed, seedling and plant stages.

The literature on identification of crop cultivars through seed, seedling morphology, floral biology and plant morphological characteristics has been reviewed here.

2.6.1 Seed morphology

The useful distinct and stable morphological traits for varietal identification of a number of crops based on seed coat colour, hilum colour, shape, size and test weight were developed in various crop varieties by breeder and seed technologists.

Srikantarady (1980) classified sixty varieties of soybean based on seed coat colour. Among them, thirteen varieties were found black, three varieties were found brown to brick red and rest were cream to dull white.

Chakrabarty and Agarwal (1989a) developed seed keys for the identification of 16 blackgram varieties on the basis of seed size and colour of the seeds. The seed size varied from small to medium and colour from shiny black to dull black.

The 44 chickpea cultivars collected from different locations of Uttar Pradesh were grouped, based on their size (small, medium to large), seed shape (round and wrinkled) and seed colour (light to dark brown yellow, pink and white) (Anon., 1992).

Copeland and Mc Donald (1995) identified soybean cultivars of chippewa 64 based on the absence of black hilum compared to other varieties.

Upadhayay *et al.* (2002) classified 1956 accessions of chickpea of which 1465 were desi, 433 kabuli and 88 intermediate types. All the three types differed significantly for flower colour, plant colour, dots on seed testa, testa texture, plant width, days to maturity, 50 per cent flowering, pods per plant, 100 seed weight and plot yield. The kabuli and intermediate types not differed significantly for growth habit and seed colour. But, were significantly different from desi type for both morphological and agronomic characters.

Prashanth (2003) categorized based on seed size, shape and colour as cylindrical, kidney and oval shape and based on seed size, grouped into large, medium and small size. Prominent seed coat colours observed were black, brown and white and some more classes on the different intensities of these colour were also done. Based on the seed shape RSJ-288 was individually categorized as cylindrical, large size with black seed coat colour in frenchbean.

Chandrashekhar (2005) categorized 12 frenchbean genotypes based on seed (seed size, shape, colour, test weight), seedling (hypocotyl colour, pigmentation etc.), plant characters (plant height, branches etc.), flowering behavior (flower colour, days to flower initiation and 50% flowering) and pod characters (length, breadth, shape *etc.*) into different groups.

2.6.2 Seedling morphology

Seedling characters like fragmentations on hypocotyls radicle length and seedling pubescence, etc were used in varietal identification.

Wanger and Mc. Donald (1982) classified 36 genotypes of soybean into two groups based on hypocotyls colour. Among them, 27 genotypes were having purple hypocotyl and nine genotypes were having green hypocotyl.

Kozykowski and Burgoon (1983) differentiated 64 soybean cultivars based on distinguishable characters of hypocotyls pigmentation colour, pubescence colour and pubescence angle.

Chakrabarthy and Agarwal (1989b) developed seed keys for identification of 16 blackgram genotypes using seedling characters like pigmentation (strong, medium, week), stem hairiness (glabrous, pubescent), leaflet shape (lanceolate, obovate), hypocotyls and radicle length.

Agarwal and Pawar (1990) classified 13 soybean genotypes in to three groups on the basis of hypocotyls length (long, medium and short), two groups based on seedling pigmentation (dark, purple and green) and two groups based on seedling pubescence (intense and sparse).

Prashanth (2003) characterized six French bean genotypes based on seedling pubescence (glabrous and dense).

Chandrashekhar (2005) indicated that hypocotyls colour expressed in different genotypes were as purple, light green and pale green in French bean.

2.6.3 Plant morphological characters

The soybean varieties were classified based on spreading types, presence of pubescence on stem, leaf shape and size, flower colour, pod colour at maturity and days taken for maturity (Agarwal, 1984).

Bahrenfus and Fehr (1984) observed differences in two soybean cultivars *viz*., Cumberland and Harper based on flower colour, pubescence, pod colour etc. Harper cultivar has purple flower tawny pubescence, brown pods at maturity and higher seed yield compared to Cumberland but both cultivars were similar in days to maturity and plant height.

Forty four chickpea cultivars collected from different locations of Uttar Pradesh, exhibited variation with regard to seeds per pod (1-3) , foliage colour (green, purple and half green), plant height (20-35 cm) and number of branches per plant (4-10) (Anon., 1992).

Ravikumar and Narayanswamy (1999) evaluated ten soybean cultivars for seven seed traits. Seed coat colour, hilum colour, seed shape and seed size were stable traits and could be used for development of a varietal identification key.

The characterization was carriedout in 32 French bean cultivars. The parameters observed ranged for leaf length (5-12 cm), branches per plant (2-6), pod length (6.5-15.0 cm), seeds per pod (3.4-8.2) and 100 seed weight (18.4 – 50.6 g) (Anon., 2000).

Khare *et al*. (2006) reported that expression of seed coat testa mottling and seedling pigmentation were designated as the most stable, uniform and distinguishable traits. Expression of the seed size was not stable for medium and bold seeded varieties in lentil. They categorized 25 varieties of lentil based on test weight as small, medium and bold (<2.1, 2.1 to 2.6 g and >2.6 g) respectively, seed coat colour (Gray, brown, pink and black), testa mottling into presence or absence of testa mottling and cotyledon colour into orange and yellow.

Lokare *et al*. (2007) studied for genetic divergence for seed yield and quality traits in 60 kabuli chickpea genotypes. Significantly wide range of variation for 100 seed weight and moderate variation was observed for protein content and cooking time among the genotypes.

Chandrashekhar (2008) recorded significant differences in days to 50 per cent flowering, pod length, pod shape and number of seeds per pod and found that they were found most reliable characters for classifying French bean genotypes.

3. MATERIAL AND METHODS

The field experiments were conducted to study the influence of nipping, growth regulators, seed size, micronutrients and stages of harvest on seed yield and quality in chickpea varieties during *rabi* 2007 and 2008 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The storage potential and characterization of chickpea varieties were carriedout in the Department of Seed Science and Technology, College of Agriculture, Dharwad during 2007-08. The details of the materials used and techniques adopted during the course of the investigations are presented in this chapter.

3.1 General Descriptions

3.1.1 Geographical location of experimental site

Dharwad comes under the Agro climatic zone-8 (Northern transitional tract) of Karnataka State and is located between 15^0 26' North latitude and 76^0 27' East longitude and at an altitude of 678 m above the mean sea level.

The field experiments were conducted in 'E' Block of the Main Agricultural Research Station Farm, University of Agricultural Sciences, Dharwad.

The storage experiment on influence of seed size on storage potential and characterization of chickpea varieties was carriedout in the laboratory of the Seed Science and Technology Department, College of Agriculture, University of Agricultural Sciences, Dharwad.

3.1.2 Soil conditions

The soil of the experimental site was medium black clayey loam, deep, porous in nature and well drained. The various physical and chemical properties of experimental site is given in Appendix I.

3.1.3 Climatic conditions

Dharwad district comes under agro-climatic zone-8 of the region-2 of Karnataka. It receives rainfall from both southwest and northeast monsoon. Dharwad is considered to be mild tropical rainy region. The outside mean maximum temperature during the period of experimentation ranged from 26.9 to 35.0^0C, whereas the mean minimum temperature ranged from 13.3 to 21.0^0C. The mean relative humidity ranged from 45 to 92 per cent. The highest rainfall during the period of experimentation was in September (162.40) followed by June (101.6 mm). The meteorological data for the period of experiment from April 2008 to March 2009 are presented in Appendix II.

3.1.4 Previous crop on the experimental site

The groundnut crop was previously grown on the experimental site during *kharif* season of 2007-08 and soybean crop was previously grown during *kharif* season of 2008-09.

3.1.5 Seed source

The breeder seeds of A-1, ICCV-2, BGD-103, Bheema and KAK-2 chickpea varieties were obtained from the Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, Dharwad for conducting field and laboratory studies.

3.2 Experiment – I : Effect of Nipping and Foliar Spray of Growth Regulators on Seed Yield and Quality in Chickpea

3.2.1 Treatment details

The field experiment consisted of totally 16 treatments involving two chickpea varieties , two nipping treatments and four growth regulators. The details of the treatments are shown below.

Factor – A : Varieties (V)

V_1 - A -1

V_2 - ICCV-2

Factor – B : Nipping (N)

N_1 - Nipping at 30 DAS (days after sowing)

N_2 - No nipping

Factor – C : Growth regulators sprays (S)*

S_1 - NAA @ 50 ppm

S_2 - Triacontanol @ 1 ml / litre

S_3 - Panchagavya (3%)

S_4 - Water spray (control)

* The growth regulators sprayed once at 45 DAS

Treatment combinations

$V_1N_1S_1$	$V_1N_1S_3$	$V_1N_2S_1$	$V_1N_2S_3$
$V_1N_1S_2$	$V_1N_1S_4$	$V_1N_2S_2$	$V_1N_2S_4$

3.2.2 Design and plan of layout

The field experiment was laid in RCBD with factorial concept in three replications. The plan of experiment is depicted in Fig. 1.

3.2.3 Plot size

Gross plot : 2.25 x 1.50 m

Net plot : 1.65 x 1.20 m

3.2.4 Cultural operations

The experimental plot was brought to fine tilth by once deep ploughing and repeated harrowings. The required number of plots were laidout with small bunds and irrigation channels. The seed rows were marked and drawn at a distance of 30 cm apart in each plots.

3.2.5 Application of fertilizer

The recommended dose of fertilizers (20:50:00 kg NPK/ha) were applied as basal dose for each plots in the form of Urea and Diammonium phosphate and incorporated well into the soil.

3.2.6 Method of Sowing

The chickpea seeds were sown by dibbling at the congenial field conditions in *rabi* season on 25-10-2007 and 8-11-2008 during the years 2007-08 and 2008-09, respectively. Prior to the sowing, the chickpea seeds were treated with *Trichoderma harizianum* culture @ 8 g per kg of seeds. The seeds were hand dibbled at two to three cm deep in the earlier marked rows at 15 cm intra row spacing. Soon after sowing, the experimental plots were lightly irrigated to ensure adequate uniform germination and plant stand.

3.2.7 Preparation of chemical solutions

Naphthalene acetic acid (NAA) 50 ppm: Fifty milligram of NAA was dissolved in two to three mililitre of alcohol and the final volume was made upto 1000 ml of distilled water.

Triacontorial (1%): Ten gram of triacontrol was dissolved in the two to three ml of alcohol and the final volume was made upto 1000 ml of distilled water.

Panchagavya (3%): Thirty ml of panchagavya was mixed in 1000 ml of distilled water.

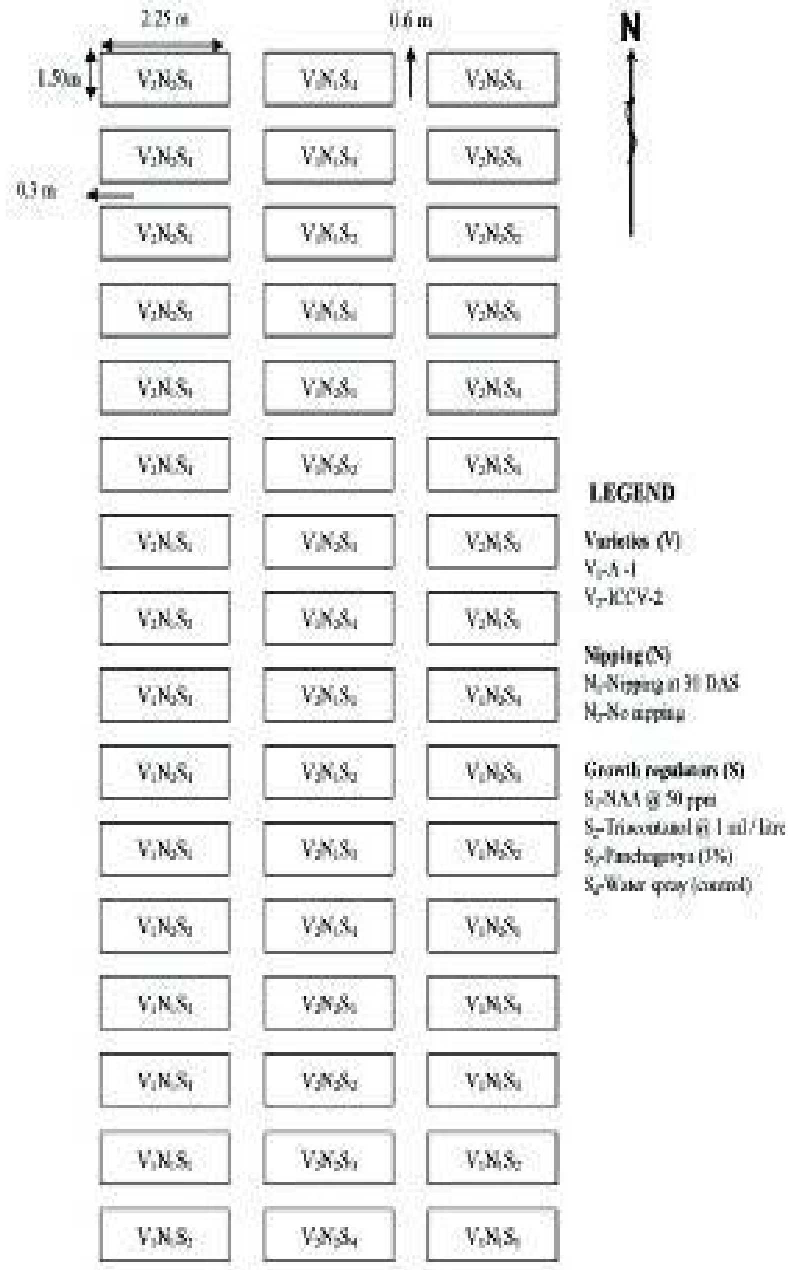


Fig.1: Plan of layout of the experimental site (Experiment –I)

Plate 1: General view of nipping and growth regulators experimental plot

3.2.8 Time of spray of growth regulators and panchagavya

The spraying operation of growth regulators, panchagavya (3%) and water spray was taken up after 45 days after sowing of the crop.

3.2.9 After care

The necessary after care operations such as thinning, hand weeding, inter cultivation and plant protection measures were carriedout as and when required to maintain good and healthy seed crop. The crop was also given with protective irrigation depending upon the water requirement. The crop was sprayed with Dithane M-45 @ 2.5 mg per litre at 35, 45, 75 days after sowing to control infestation of Aschoyta blight and Fusarium wilt. Endosulfan 35 EC @ 1.5 ml per litre was spayed at 35, 50, 70 and 90 days after sowing (DAS) for control of pod borer and other sucking pests.

3.2.10 Harvesting, threshing and cleaning

The crop was harvested when plants started drying, the colour of leaflets turned pale and pods to yellow colour. The border row plants were first uprooted manually from the sides of each plots and then crop was harvested from the net plot area excluding five tagged plants used for recording the observations. The harvested plants were dried in the shade for seven days. The seeds were separated manually by gently beating the dried plants with the wooden stick. The seeds were cleaned and dried in the shade until the seed moisture content reduced upto 8.5 per cent.

3.2.11 Collection of experimental data

3.2.11.1 Sampling procedure

The biometric observations on growth parametres were recorded at three stages of plant growth *viz*., 30, 60, DAS and at harvest. Five plants at random from net plot area were selected and tagged in each plot for taking observations on plant height, number of branches, days to 50 per cent flowering, number of pods per plant, number of seeds per pod, test weight, seed yield per plant and per hectare.

3.2.12 Observations on growth parametres

3.2.12.1 Plant height (cm)

The height of the five randomly selected and tagged plants were measured at 30, 60 DAS and at harvest from the ground level to the tip of the plant and average was workedout and expressed in centimetre for each treatments.

3.2.12.2 Number of branches per plant

The number of main and fruiting branches were counted on the five earlier tagged plants and their average was recorded as number of branches per plant at 30, 60 DAS and at harvest for each treatments.

3.2.12.3 Observations on flowering, seed yield and yield components

3.2.12.3.1 Days to 50 per cent flowering

The number of days taken for 50 per cent of the plants to produce first flower in each plot was recorded by counting the days from the date of sowing.

3.2.12.3.2 Number of pods per plant

The number of filled pods present in five tagged plants were counted individually and the average was workedout and expressed as number of pods per pant at harvest.

3.2.12.3.3 Number of seeds per pod

After separating the filled seeds from five randomly selected pod from each treatment, the filled seeds were counted and average was expressed as number of seeds per pod.

3.2.12.3.4 Pod yield per plant (g)

All pods were separately picked by hand from five tagged plants individually at the harvest and weight of pods of individual plant was taken separately to compute pod weight per plant in grams.

3.2.12.3.5 Seed yield per plant (g).

At harvest, all pods were separated manually from five tagged plants individually and dried, shelled and cleaned. The seed weight from each plant was recorded and average of five plants was expressed as seed yield per plant in grams.

3.2.12.3.6 Seed yield per plot (kg)

All the plants from net plot area of each treatment were uprooted, dried seeds were separated and weight was recorded separately in kilogram

3.2.12.3.7 Seed yield per hectare (q)

The seed yield obtained from the net plot area was cleaned, dried in the shade for seven days and weighed in kilogram. The seed weight from five plants used for taking observations was also added for computing the seed yield per ha. On the basis of net plot seed yield, the seed yield per hectare was computed and expressed in quintals per hectare.

3.2.13 Seed quality parameters

3.2.13.1 Hundred seed weight (g)

One hundred seeds in 8 replications were manually counted from seeds of five plants in each treatment and 100 seed weight was recorded by adopting ISTA procedure (Anon., 1999) and was expressed in grams.

3.2.13.2 Germination percentage

The seeds obtained from different treatments were tested for germination by adopting between paper towel method kept at optimum conditions of temperature ($25^0C \pm 1^0C$) and relative humidity (95 ± 1% RH) in four replications of 100 seeds each (Anon., 1999). The number of normal seedlings was counted at the end of 8 days (II count) and the germination percentage was calculated.

3.2.13.3 Speed of germination

One hundred seeds in four replications of each variety were placed in rolled towel and incubated at 25 ± 1^0C. Daily count on germinated seeds was made upto 8^{th} day. The speed of germination was calculated by using formula (Haydecker, 1969).

$$\text{Speed of germination} = \frac{N_1}{D_1} + \frac{N_2}{D_2} + \ldots\ldots \frac{Nn}{Dn}$$

Where,

N_1 , N_2 and Nn were the number of seeds germinated on D_1, D_2 and D_n.

D_1, D_2 and Dn were the days on which observation was made.

3.2.13.4 Seedling length (cm)

Ten normal seedlings from each of the replications from the germination test were carefully removed on 8^{th} day and used for measuring seedling length. The seedling length from tip of shoot to tip of root was measured and the average length of the seedling was expressed in centimetre.

3.2.13.5 Seedling dry weight (mg)

The same ten seedlings used for measuring seedling length were kept in a butter paper packet and dried in hot air oven maintained at 80^0C for 48 hours. Then the seedlings were cooled in desiccator for one hour and the weight of the dry seedlings was recorded using electronic balance and was expressed in milligram per seedling.

3.2.13.6 Seedling vigour index

Seedling vigour index was computed by using the formula suggested by Abdul-Baki and Anderson (1973).

SVI= Germination (%) x Seedling length (cm)

3.2.13.7 Electrical conductivity of seed leachate (EC)

Five gram of seeds in four replications were washed in acetone for half a minute and later thoroughly washed in distilled water for five minutes. The seeds were soaked in 25 ml of distilled water and kept in an incubator maintained at temperature of 25^0C $\pm$ 1^0C for 24 hours. The seed leachate was collected and volume was made upto 25 ml by adding distilled water. The electrical conductivity of seed leachate was measured by using the electrical bridge (ELICO) with a cell constant 1.0 and leachate values were expressed in desi Simans per metre (dSm^{-1}).

3.3 Experiment – II: Effect of Seed Size on Seed Yield and Quality in Chickpea Varieties

3.3.1 Experimental details

Treatments

The field experiment consisted of totally 20 treatments with 5 chickpea varieties and four seed sizes. The details of the treatments are furnished as detailed below.

Factor – I: Varieties (V)

V_1 – A-1

V_2 – ICCV-2

V_3 – KAK-2

V_4 – Bheema

V_5 – BGD - 103

Factor – II: Seed size (G)

G_1 – Small size

G_2 – Medium

G_3 – Large size

G_4 – Bulk

Variety	Sieves size (mm)			G_4
	G_1	G_2	G_3	
A-1	6.40*	7.00	7.50	Bulk
ICCV-2	6.80	7.50	8.00	Bulk
KAK-2	7.00	8.00	9.00	Bulk
Bheema	7.00	8.00	9.00	Bulk
BGD-103	7.00	8.00	9.00	Bulk

*Seeds retained over the above round sieves mm were used in present experiment.

3.3.2 Design and plan of layout

The field experiment was laidout as per the method described under 3.2.2. The plan of layout of the experiment is presented in Fig. 2 and general view of the experimental plot is depicted in Plate

3.3.3 Cultural operations

The cultural operations were carriedout as explained under section 3.2.4.

3.3.4 Plot size

The experimental plot size was as mentioned under section 3.2.3.

3.3.5 Application of fertilizer

The fertilizer application was carriedout as explained under section 3.2.5.

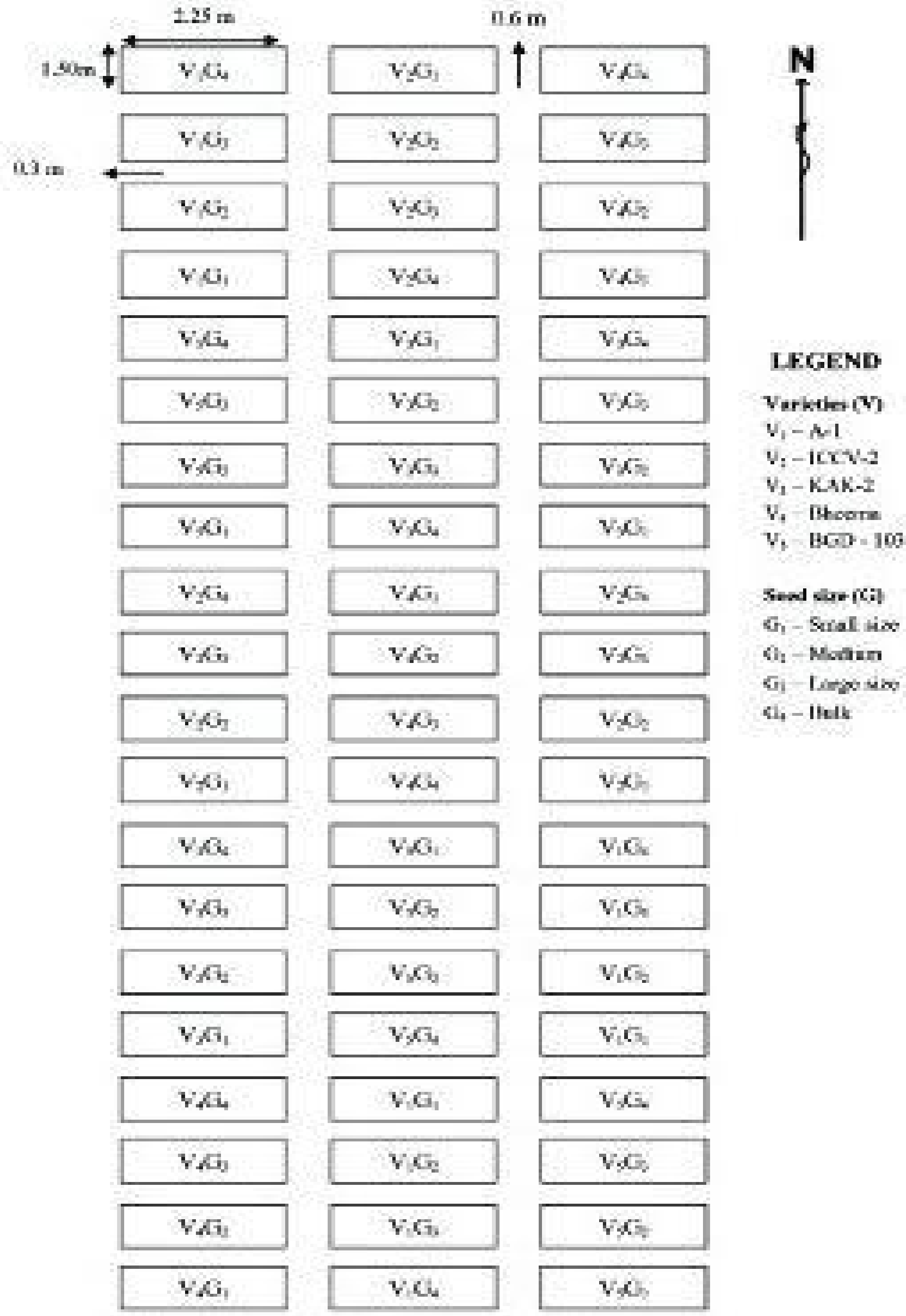


Fig 2. Plan of layout of the experimental site (Experiment –II)

Plate 2:General view of seed size experimental plot

3.3.6 Method of sowing

Method of sowing was followed as per the earlier procedure described in section 3.2.6.

3.3.7 After care

After care of chickpea crop was attended as per the method explained under section 3.2.9.

3.3.8 Harvesting, threshing and cleaning

Harvesting, threshing and cleaning operations were carriedout as per the procedures furnished under section 3.2.110.

3.3.9 Collection of experimental data

The various observations on morphological, growth, phenological, seed yield and seed quality parametres were recorded as per the procedure and methods described earlier under section 3.2.11.

3.3.10 Plant height (cm)

The chickpea plant height was measured as explained under section 3.2.12.1.

3.3.11 Number of branches per plant

Number of branches per plant at 30, 60 DAS and at harvest were counted and recorded as per the procedure explained under section 3.2.12.2.

3.3.12 Observations on flowering, seed yield and yield components

3.3.12.1 Days to 50 per cent flowering

Flowering period was computed as per the procedure furnished section 3.2.12.4.

3.3.12.2 Number of pods per plant

The number of pods per plant at harvest was recorded by following the procedure furnished under section 3.2.12.5.

3.3.12.3 Pod weight (g) per plant

The pod weight per plant at harvest was recorded by following the procedure furnished under section 3.2.12.8.

3.3.13.4 Number of seeds per pod

The number of filled seeds per pod was recorded as per the section 3.2.13.6.

3.3.13.5 Seed yield per pant (g)

The seed yield per plant was computed in grams as per the procedure explained in 3.2.13.7.

3.3.13.6 Seed yield per hectare (q)

Seed yield per hectare was computed in quintals as per the procedure mentioned under section 3.2.13.10.

3.3.13.7 Hundred seed weight (g)

Hundred seed eight was workedout in grams as per the procedure described under section 3.2.14.1.

3.3.13.8 Seed germination (%)

Seed germination percentage was recorded as per earlier mentioned procedure in section 3.2.14.2.

3.3.13.9 Speed of germination

The speed of germination was recorded as per mentioned procedure of section 3.2.14.3.

3.3.13.10 Seedling length (cm)

The mean seedling length as recorded in centimetres was recorded per the procedure furnished under section 3.2.14.4.

3.3.13.11 Seedling dry weight (g)

The mean seedling dry weight of 10 seedlings were recorded as per the procedure mentioned in section 3.2.14.5.

3.3.13.12 Seedling vigour index (SVI)

Seedling vigour index was calculated as per procedure mentioned in section 3.2.14.6.

3.3.13.13 Electrical conductivity of seed leachate (dSm^{-1})

Electrical conductivity of seed leachate was recorded as per the procedure mentioned in section 3.2.14.7.

3.4 Experiment - III: Effect of Seed Size on Storage Potential in Chickpea Varieties

The storage studies were conducted on five chickpea varieties graded into four different sizes and were treated with captan (2 g/kg of seeds) and kept in cloth bags under ambient condition for 12 months in the department of Seed Science and Technology, College of Agriculture, UAS, Dharwad. The details of the materials used and experimental techniques adopted during the course of investigations are presented as below.

Treatment details

Factor – I: Varieties (V)

V_1 – A-1
V_2 – ICCV-2
V_3 – KAK-2
V_4 – Bheema
V_5 – BGD - 103

Factor – II: Seed size (G)

G_1 – Small size
G_2 – Medium
G_3 – Large size
G_4 – Bulk

Seeds were graded as explained in section 3.3.1

3.4.1 Seed source

Fresh seeds of five varieties of A-1, ICCV-2, KAK-2, Bheema and BGD – 103 were collected from separately produced seed plots during *rabi* (2007-08) season and seeds were graded (small, medium, big and bulk) as explained in section 3.3.1.

3.4.2 Observations

Monthly observations were made on various seed quality parameters from February 2008 to January, 2009 as detailed below.

3.4.2.1 Germination percentage

The germination test was conducted as per the procedure detailed in Section 3.2.13.2.

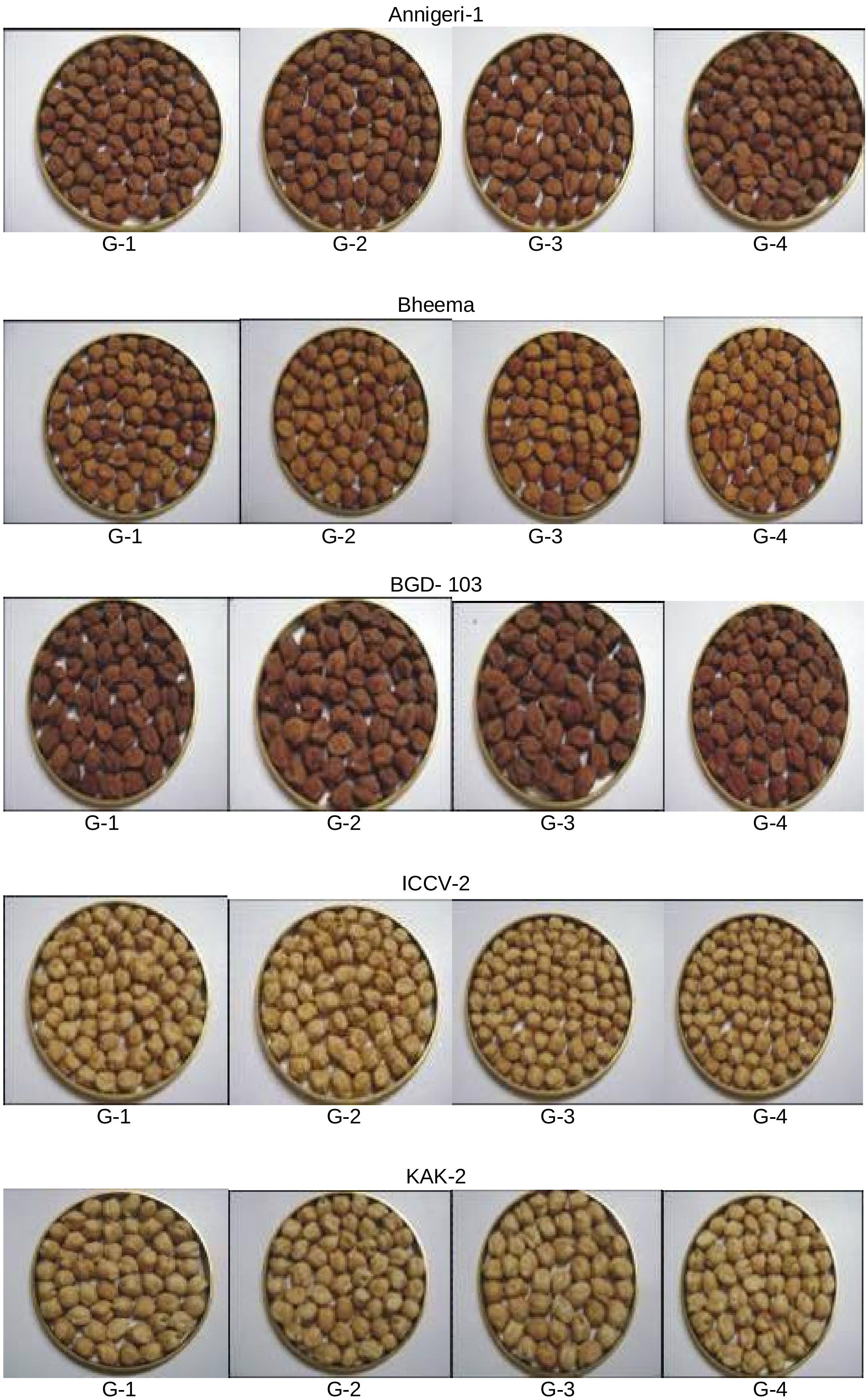


Plate 3: Different seed grades based on size of chickpea varieties

3.4.2.2 Speed of germination

The speed of germination was recorded as per procedure mentioned in section 3.2.14.3.

3.4.2.3 Field emergence

The seeds obtained from different treatments were tested for field emergence in four replications of 100 seeds each. The number of normal plants were counted at the end of 14 days and the field emergence percentage was calculated.

3.4.2.4 Seedling length (cm)

The seedling length was determined as per the procedure explained in section 3.2.13.4.

3.4.2.5 Seedling vigour index (SVI)

The seedling vigour index was determined as per the procedure detailed in section 3.2.13.6.

3.4.2.6 Seedling dry weight (mg)

The seedling dry weight was determined as per the procedure detailed in section 3.2.13.5.

3.4.2.7 Electrical conductivity of seed leachate (dSm^{-1})

The electrical conductivity was determined as per the procedure detailed in section 3.2.13.7.

3.4.2.8 Moisture content

The moisture content of seed was determined by the oven dry method as per the ISTA Rules (Anon., 1999). Five grams of seeds were taken in metal containers and dried in the oven at 103 ± 2^0C for 17 +1 hours. After oven drying, the metal container along with seeds were cooled in a desiccator for 30 minutes and the weight was recorded. The moisture content was expressed on weight basis using the following formula.

$$\text{Mois ture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where, W_1 – Weight of the empty container (g)

W_2 – Weight of container + seed material before drying (g)

W_3 – Weight of the container + seed material after drying (g)

3.5 Experiment IV : Effect of Seed Treatments on Plant Growth, Seed Yield and Quality in Chickpea Varieties

3.5.1 Experiment details

3.5.1.1 Treatment details

The field experiment totally consisted of 16 treatments with two chickpea varieties , eight seed treatments involving five micronutrients, two biofertilizers, one panchagavya and control. The details of the treatments are mentioned below.

Factor – I : Varieties (V)
- V_1 – A-1 (Desi variety)
- V_2 – ICCV-2 (Kabuli variety)

Factor – II : Seed treatments (T)
- T_1 – Zinc sulphate (1 g/kg of seed)
- T_2 – Calcium chloride (1 g/kg of seed)
- T_3 – Ferrous sulphate (1 g/kg of seed)

T_4 – Boron (1 g/kg of seed)
T_5 – Magnesium sulphate (1 g/kg of seed)
T_6 – *Rhizobium* (20 g/kg seeds)
T_7 – Phosphorus solubilizing bacteria (PSB) (20 g/kg seeds)
T_8 – Panchagavya (soaking)
T_9 – Control

3.5.1.2 Design and layout of the experiment

The field experiment was laidout as per the method described under section 3.2.2. The plan of layout of the experiment is presented in Fig. 3 and general view of the experimental plot is depicted in Plate.

3.5.1.3 Cultural operation

The cultural operations were carriedout as explained under section 3.2.4.

3.5.1.4 Application of fertilizer

The fertilizer applications were carriedout as explained under section 3.2.5.

3.5.1.5 Sowing

Seeds were sown at appropriate field condition on 25-10-2007 during 2007-08 *rabi* season and 08-11-2008 during *rabi* 2008-09 season.

3.5.1.6 Method of sowing

Prior to the sowing, the chickpea seeds were treated with different micronutrients, biofertilizers and panchagavya as per the treatment details. Method of sowing was followed as mentioned in section 3.2.7.

3.5.1.7 After care

After care of chickpea crop was attended as per the method explained under section 3.3.0.

3.5.1.8 Harvesting, threshing and cleaning

Harvesting, threshing and cleaning operation were carriedout as per the procedure mentioned in section 3.3.1.

3.5.1.9 Collection of experimental data

The observations on morphological, growth, phonological, seed yield and quality parametres were recorded as per the procedure furnished earlier under section 3.4.

3.5.1.9.1 Plant height (cm)

The plant height of chickpea at 30, 60 DAS and at harvest was measured as mentioned in section

3.5.1.9.2 Number of branches

Number of branches per plant at 30, 60 DAS and at harvest were recorded as per the procedure explained under section

3.5.1.9.3 Days to 50 per cent flowering

Days to 50 per cent flowering was recorded as detailed in section 3.2.13.4.

3.5.1.9.4 Number of pods per plant

The number of pods per plant was recorded at harvest as per the procedure explained in 3.2.13.15.

3.5.1.9.5 Pod weight per plant (g)

The pod weight per plant was determined as explained under section 3.3.13.3.

3.5.1.9.6 Number of seeds per pod

The number of filled seeds per pod was recorded as explained under section 3.3.13.6.

3.5.1.9.7 Seed yield per plant (g)

Seed yield per plant was computed in grams as per procedure mentioned under section 3.3.13.7.

3.5.1.9.8 Seed yield per ha (q)

Seed yield per hectare was calculated in quintals as described in section

3.5.1.9.9 Hundred seed weight (g)

Hundred seed weight was recorded in grams as explained in section 3.2.14.1.

3.5.1.9.10 Germination percentage

Seed germination percentage was recorded as per the procedure mentioned in section 3.2.14.2.

3.5.1.9.11 Speed of germination

Speed of germination was recorded as per mentioned in section 3.2.14..3.

3.5.1.9.12 Seedling length (cm)

Mean seedling length of 10 seedlings were recorded in centimetres according to the procedure followed under section 3.2.14.4.

3.5.1.9.13 Electrical conductivity (dSm^{-1})

Electrical conductivity was recorded as per the procedure explained under section 3.2.14.7.

3.5.1.9.14 Seedling dry weight (g)

Dry weight of 10 seedling were recorded as per the procedure reported in section 3.2.14.4.

3.5.1.9.15 Vigour index

Seedling vigour index was calculated as per the procedure furnished in section 3.2.14.6.

3.6 Experiment – V : Influence of Harvesting Stages on Seed Quality in Chickpea Varieties

The field experiment consisted totally 15 treatments with five chickpea varieties and three stages of harvest. The details of the treatments are furnished below.

3.6.1 Treatment details

Factor- I : Varieties (V)

V_1 – A-1
V_2 – ICCV-2
V_3 – KAK-2
V_4 – Bheema
V_5 – BGD-103

Factor – II : Harvesting stage (H)

H_1 – Dark green colour pod stage (70-75 DAS)
H_2 – Green to yellow colour stage (Breaking stage) (90-95 DAS)
H_3 – Full yellow pod colour stage (105-110 DAS)
H_4 – copper brown pod colour stage (120-125 DAS)

3.6.2 Design and plan of layout

In this experiment, seeds of each variety were sown in 10 lines of 30 metre long with spacing of 30 x 15 cm between rows and plants respectively. The pods were harvested from each variety at different pod colour stages *viz.* dark green, green to yellow, full yellow pod colour stages and copper brown pod colour stage.

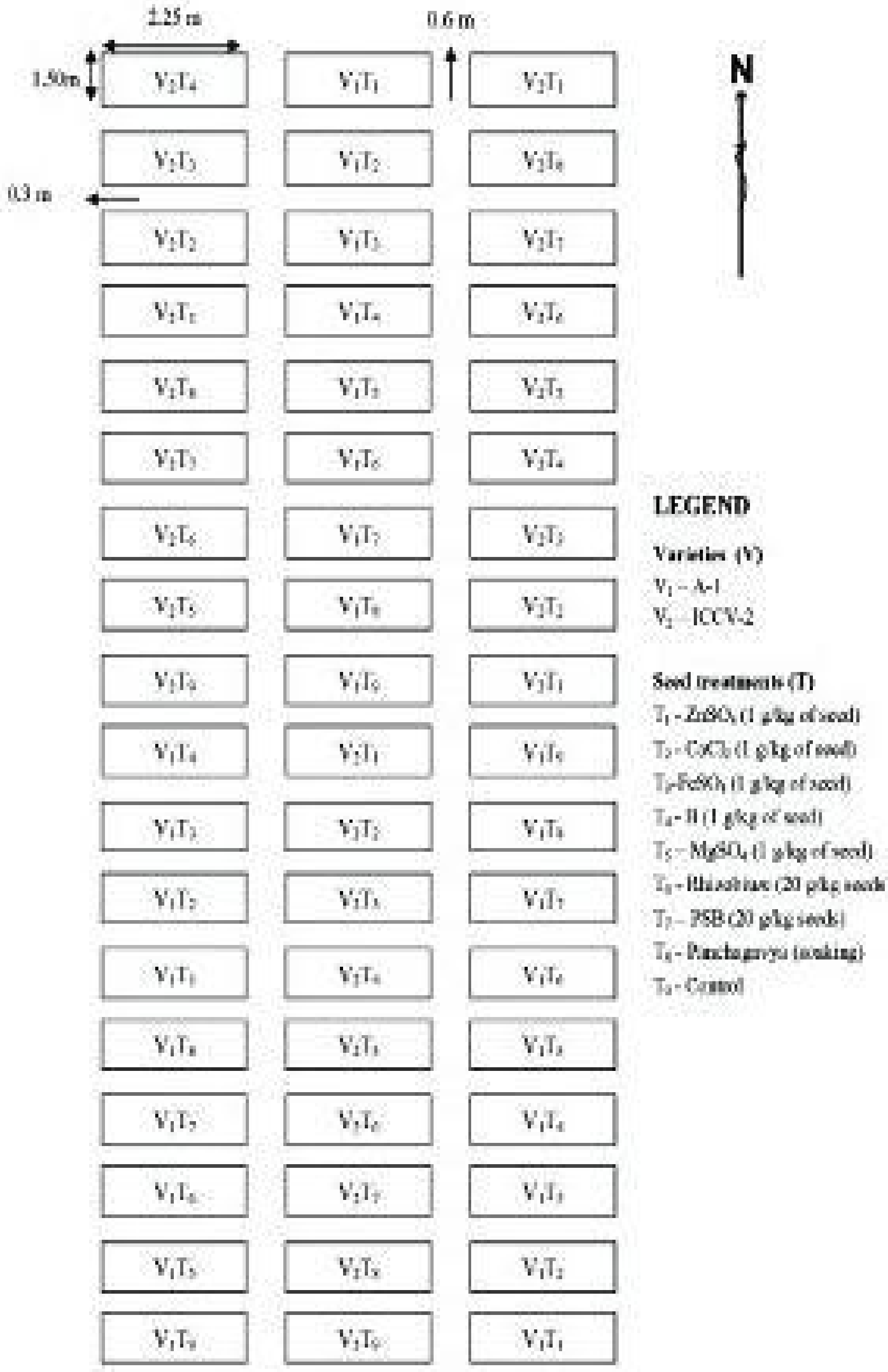


Fig. 3: Plan of layout of the experimental site (Experiment –VI)

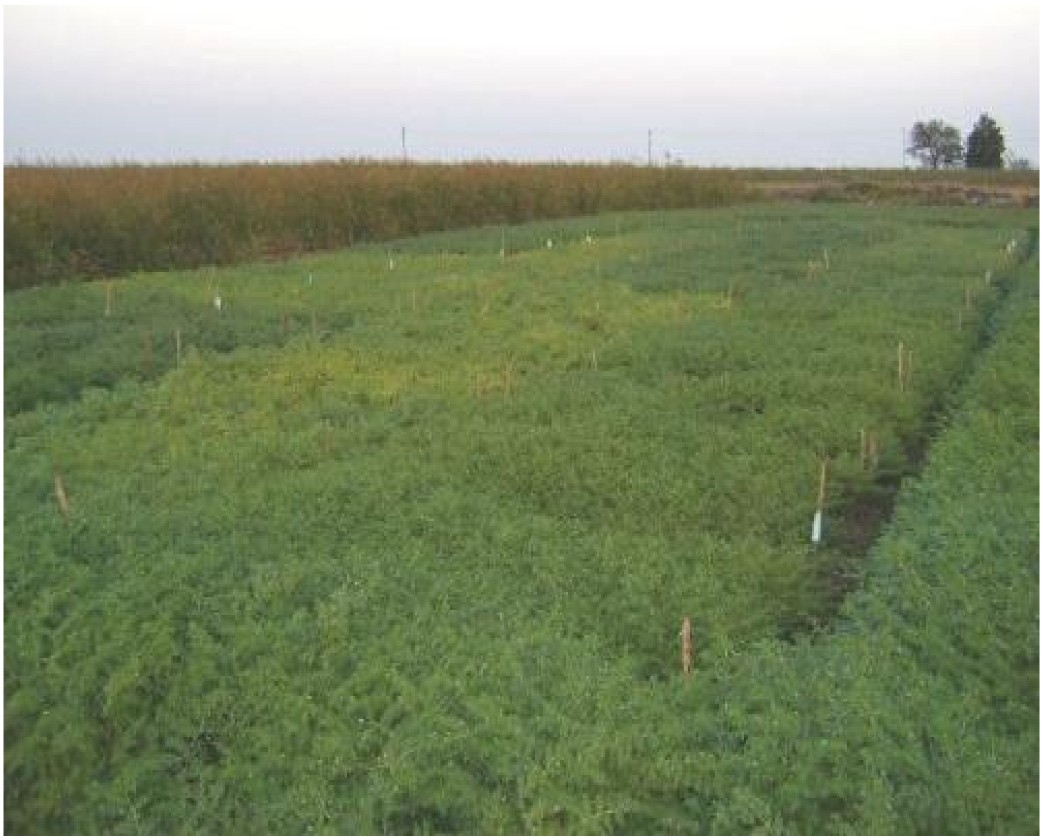


Plate 4: General view of seed treatment experimental plot

3.6.3 Cultural operations

The cultural operations were carriedout as explained under section 3.2.4.

3.6.4 Application of fertilizer

Required quantity of fertilizer were applied as mentioned in section 3.2.5.

3.6.5 Method of sowing

Followed the procedure as explained uner 3.2.7 section.

3.6.6 After care

After care of chickpea crop was attended as explained in section 3.3.0.

3.6.7 Collection of experimental data

3.6.7.1 Fresh weight of hundred pods (g)

At each stage of harvesting, randomly 100 pods were weighed and average weight of pod was recorded in grams.

3.6.7.2 Hundred pods dry weight (g)

After taking the observation on the fresh weight of 100 pods, the pods were dried until they attained constant weight and hundred pod dry weight was recorded.

3.6.7.3 Fresh hundred seed weight (g)

At each stage of harvest, hundred seeds from each treatment with three replications were counted manually and the average weight was recorded in gram.

3.6.7.4 Hundred seed dry weight (g)

After taking the observation on the fresh weight of 100 seeds, the seeds were dried until they attained constant weight and the average was workedout in grams.

3.6.7.5 Moisture content of seed

The moisture content of seeds were recorded as per the ISTA Rules as explained in section of 3.5.2.1.

3.6.7.6 Hundred seed weight (g)

Hundred seed weight of each variety and harvested at different stages was determined as explained in section 3.4.4.1.

3.6.7.7. Seed germination (%)

Seed germination percentage was recorded as detailed in section 3.4.4.2

3.6.7.8 Seedling length (cm)

The mean seedling length was recorded as per the procedure furnished in section 3.4.4.4.

3.6.7.9 Seedling dry weight (mg)

Seedling dry weight was recorded by adopting the procedure explained in section 3.4.4.6.

3.6.7.10 Seedling vigour index

Seedling vigour index was calculated as per the procedure detailed in 3.4.4.5 section.

3.6.7.11 Electrical conductivity of seed leachate (dSm^{-1})

Electrical conductivity of seed leachate was recorded as per the procedure detailed in section 3.4.4.7.

3.6.7.12 Moisture content (%)

The moisture content of seeds were recorded as per the ISTA Rules as explained in section of 3.5.2.1.

Green pod stage

Green to yellow pod stage

Yellow pod stage

Copper brown pod stage

Plate 5: Different stages of pod harvest

3.7.1 Statistical analysis

The data collected from the storage experiment were analysed statistically by the procedure described by Sundararajan *et al*. (1972). Critical differences were calculated at 10 per cent level wherever 'F' test was significant. The data on percentage of germination are transformed into arcsine square root percentage values.

3.7 Experiment - VI : Characterization of Chickpea Varieties

Genetically pure and fresh seeds of five chickpea varieties *viz.,* A-1, ICCV-2, KAK-2, Bheema and BGD-103 produced during *rabi* season of 2007 were obtained from the department of Genetics and Plant Breeding, College of Agriculture, UAS, Dharwad.

3.7.1 Experimental details

The chickpea varieties were sown separately in 10 lines of 30 metre length with 30 x 15 cm spacing in three replications for recording plant growth and phonological characters.

3.7.2 Cultural operations

The cultural operations were carriedout as mentioned in section 3.2.4.

3.7.2.1 Application of fertilizer

General recommended dose of fertilizer was applied as explained in section 3.2.5.

3.7.2.2 Method of sowing

Sowing of each variety was done as detailed in section 3.2.7.

3.7.2.3 After care

After care of chickpea crop was attended as per the methods explained in section 3.3.0.

3.7.3 Experimental observations

3.7.3.1 Seed morphological characters

The studies pertaining to identification of chickpea varieties based on seed, seedling, plant morphological and floral biological characters were studied in the field and laboratory at Agricultural College,UAS, Dharwad.

3.7.3.1.1 Seed coat colour

The seed coat colours of all the five varieties were observed visually after one month of harvest under natural day light condition and grouped in to following colour groups viz., beige (kabuli), brown beige, green, yellow, pink, brown and dark brown (desi) based on seed coat colour.

3.7.3.1.2 Seed shape

The seeds of five chickpea varieties were observed after one month of harvest under magnifying lens and grouped as pea-shaped owl's head and angular.

3.7.3.1.3 Surface of seed

The seeds of different varieties were observed under magnifying lense and feeling by touch grouped as rough and smooth based on surface texture.

3.7.3.1.4 Mottles on testa

The seeds of different varieties were observed under magnifying lens under light and categorized them as presence or absence of mottles on their testa.

3.7.3.1.5 Seed length (mm)

Seed length of different varieties were measured from the base to tip portion of the seed in millimetre using screw gauge and classified into three categories *viz*., small (<7.00 mm), medium (7-10 mm) and large (>10 mm).

3.7.3.1.6 Seed breadth (mm)

Seed breadth of five chickpea varieties were measured in millimetres and classified into three categories viz., low (<18 mm), medium (18-30 mm) and high (> 30 mm).

3.7.3.1.7 Seeds per pod

The number of seeds per pod were counted and average was worked out of 10 pods and expressed as number of seeds per pod.

3.7.3.1.8 Hundred seed weight (g)

Hundred seeds in four replications from each variety were counted and weight was recorded by using electronic balance as per the procedure of ISTA (Anon., 1999). The average weight was recorded in grams. Based on seed weight, genotypes were categorized into light, medium and heavy groups.

3.7.3.2 Seedling morphology

The fifty seeds each five chickpea varieties were sown in sand media for germination of which ten normal seedlings were taken for recording seedling morphological characters.

3.7.3.2.1 Hypocotyl colour

The hypocotyl colour of the seedling was observed under natural day light condition, after eight days sowing in the sand media and classified into light purple, green and light green based cotyledon colour.

3.7.3.2.2 Cotyledon colour

Cotyledon colour was observed on five days old seedling of different varieties under natural day light condition and classified into, pale yellow and light yellow based on cotyledon colour.

3.7.3.2.3 Pubescence on hypocotyl

Pubescence on hypocotyl was observed on eight days old seedlings of different varieties under natural day light condition and grouped them as glabrous and dense.

3.7.3.3 Plant morphological characters

The plant morphological characters like plant height, leaf colour, days to 50 per cent flowering, days to pod initiation, days to pod maturity, pod colour and number of seeds per pod were observed in the field.

3.7.3.3.1 Plant height (cm)

The height of five plants were recorded at fully developed green foliage stage and catogeriesed in to short (<50 cm), medium (50-60 cm) and tall (> 60 cm) groups.

3.7.3.3.2 Number of branches

The number of main and fruiting branches were counted on the five earlier tagged plants and their average was recorded as number of branches per plant and grouped as less (<20), medium (20-25) and more (>25).

3.7.3.3.3 Stem colour

The colour of the stem was observed for five varieties under natural day light and grouped into pink and pale yellow.

33.7.3.3.4 Hairiness on the stem

All the five varieties were observed for hairiness on stem on five days old seedling under natural day light condition and classified into glabrous and dence.

3.7.3.3.5 Foliage colour

The leaves of different varieties were observed under natural day light colour and characterized into dark green and light green.

3.7.3.4 Flower characters

3.7.3.4.1 Flower colour

The ten tagged plants of each variety were observed during flowering and categorized into white and pink groups.

3.7.3.4.2 Days to flower initiation

The data on which the first flower appeared was noted on the five randomly selected plants and days were calculated from the date of sowing. The average was calculated and expressed as days to flower initiation and grouped into early (30-40 days), medium (40-50 days) and late (>50 days) types.

3.7.3.4.3 Days to 50 per cent flowering

The flower initiation was regularly recorded on the earlier tagged ten random plants. The 50 per cent flowering was noted when the flower initiation in five plants started and days to 50 per cent flowering was workedout from the date of sowing and expressed in days and categorized them into early (<45 days), medium (45-50 days) and late (>50 days) types.

3.7.3.5 Pod characters

3.7.3.5.1 Days to pod initiation

In earlier randomly tagged ten plants close observations were made for pod initiation. The dates on which initiation of pod formation occurred from the day of anthesis was recorded as days for pod initiation and expressed in days.

3.7.3.5.2 Days to pod maturity

The formation of pinkish to copper brown layer on the pods was taken as indication of the physiological maturity. The observations were made on the earlier tagged ten random plants in each treatment and days to physiological maturity from the date of sowing was recorded and the average was computed and expressed in days.

3.7.3.5.3 Pod length (cm)

The pod length was measured from the base to the tip of pod on ten randomly selected pods from each treatment and average was computed and expressed in centimetre, and categorized into small(<2 cm) medium (2-2.5 cm) and long (>2.5 cm).

3.7.3.5.4 Pod breadth (cm)

Pod breadth of five varieties were measured in centimetre, and classified as small (<3cm), medium (3-4 cm) and large (>4 cm)

3.7.3.5.5 Pigmentation on pod

Pods of different varieties were observed in the natural day light condition for presence or absence of pigment and grouped as pigment present and absence.

3.7.3.5.6 Hairiness on pod

The hairiness on the pod was observed in day light and were grouped as glabrous and dense.

3.7.3.5.7 Pod colour at harvest

The pod colour of ten randomly tagged plants from each varieties at the time of harvest was observed and varieties were grouped into brown, copper brown and yellowish brown.

3.7.3.5.8 Number of pods per plant

The total number of pods per plant were counted and average was worked out and groped as less (<40) medium (40-50) and high (>50).

3.7.3.6 Seed yield per plant

At harvest, all pods were individually separated manually from five tagged plants and dried, shelled and cleaned. The seed weight from each plant was recorded and average of five plants was expressed as seed yield per plant in grams and classified as less (<12 gm) medium (12-13 gm) and high (>13 gm).

A-1

Bheema

BGD-103

ICCV-2

KAK-2

Plate 6: Different Flower colour of chickpea varieties

4. EXPERIMENTAL RESULTS

4.1 Experiment –I: Effect of Nipping and Foliar Spray of Growth Regulators on Seed Yield and Quality in Chickpea Varieties

4.1.1 Growth parameters

4.1.1.1 Plant height (cm)

The plant height at 30, 60 DAS and at harvest as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 1.

Irrespective of variety, nipping and growth regulator sprays, the mean plant height increased from 19.48 cm at 30DAS to 43.24 cm at harvest.

Due to varieties (V)

The plant height at 30 DAS between chickpea varieties differed significantly. The maximum (19.88 cm) plant height was recorded in ICCV-2 (V_2) variety over A-1 (19.08 cm).

The significant difference was found on plant height at 60 DAS between varieties. The ICCV-2 recorded significantly highest (38.63 cm) plant height compared to as A-1 (35.72 cm).

The plant height at harvest differed significantly due to varieties. Significantly more (44.30 cm) plant height at harvest was recorded in ICCV-2 (V_2) compared to A-1 (V_1) (42.18 cm).

Due to nipping (N)

Nipping influence was non-significant on plant height at 30 DAS. However, numerically maximum (19.56 cm) plant height was recorded in N_2 (no nipping) treatment over nipping (N_1) with 19.40 cm.

The significantly higher plant height at 60 DAS was observed in N_2 (no nipping) (37.78 cm) compared to nipping (N_1) (36.57 cm).

The significantly higher (44.23 cm) plant height at harvest was observed in N_2 (no nipping) treatment while nipping treatment recorded lower (42.25 cm).

Due to growth regulators (S)

No significant differences were recorded on plant height at 30 DAS due to growth regulator sprays. However, numerically higher (19.54 cm) plant height was recorded in S_1 (NAA-50ppm) and lower (19.42 cm) in control ($S_{4)}$.

The plant height at 60 DAS was singly higher (40.03 cm) in S_1 (NAA 50 ppm) followed by 0.1 per cent triacontanol spray (38.49 cm) and lower (33.80 cm) in control (water spray).

The plant height at harvest was significantly highest (47.47 cm) in S_1 (NAA 50 ppm) treatment followed by S_2 (45.46 cm) and S_3 (41.54 cm) and was lower (38.50 cm) in S_4 (water spray).

Due to interaction of variety and nipping (VxN)

No significant difference was seen due to interaction of variety and nipping (VxN) on plant height at 30 DAS. However, numerically more (19.92 cm) plant height was recorded in V_2N_2 treatment and low (18.95 cm) in V_1N_1.

No significant difference was noticed due to interaction of variety and nipping (VxN) on plant height at 60 DAS. While, numerically maximum (39.06 cm) and minimum (34.94 cm) plant height at 60 DAS was recorded in V_2N_2 and V_1N_1 respectively.

Significant difference was recorded due to interaction of variety and nipping treatments (VxN) on plant height at harvest. The plants of ICCV-2 variety with no nipping treatment recorded significantly higher (44.97 cm) followed by V_2N_1 (43.64 cm) and it was on par with V_1N_2 (43.50 cm) and significantly lower (40.86 cm) plant height was recorded in V_1N_1 (A-1 with nipping).

Due to interaction of variety and growth regulators (VxS)

Plant height at 30 DAS did not differ significantly due to interaction of VxS. Numerically more (20.09 cm) plant height recorded in V_2S_3 and less (18.91 cm) in V_1S_3 combination.

The interaction effect due to variety and growth regulator spray did not differ significantly on plant height at 60 DAS. However, numerically more plant height was registered in V_2S_1 (41.57 cm) followed by V_2S_2 (40.09 cm) and less (32.55 cm) in V_1S_4 treatment.

No significant difference was seen on plant height at harvest due to interaction of VxS. While, maximum (48.76 cm) plant height was recorded in V_2S_1 followed by V_2S_2 (46.70 cm) and minimum (37.86 cm) in V_1S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The interaction of nipping and growth regulators spray on plant height at 30 DAS did not differ significantly. However, maximum (19.65 cm) plant height was recorded in treatment combinations of N_2S_1 and N_2S_3 and minimum (19.36 cm) in N_1S_3 treatment.

At 60 DAS, the plant height due to interaction of nipping and growth regulators spray was found to be non-significant while numerically more (41.04 cm) plant height was recorded in N_2S_1 treatment followed by N_2S_2 (39.28 cm) and was less (33.77 cm) in N_1S_4 treatment.

At harvest, the plant height did not differ significantly due to interaction of nipping and growth regulators spray. However, numerically the non nipped with NAA 50 ppm sprayed plants recorded highest (48.97 cm) plant height followed by N_2S_2 (46.35 cm) and was lowest (37.51 cm) in N_1S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to VxNxS showed non-significant difference for plant height at 30 DAS. However, numerically more (20.22 cm) plant height was recorded in $V_2N_2S_3$ treatment and less (19.01 cm) in $V_1N_1S_4$ treatment combination.

The interaction effect due to variety, nipping and growth regulators spray showed non-significant difference on plant height at 60 DAS. In three way interaction, $V_2N_2S_1$ treatment recorded numerically more (42.45 cm) plant height followed by 40.75 cm in $V_2N_2S_2$ and less (32.05 cm) in $V_1N_1S_4$ treatment.

At harvest, the interaction effect due to VxNxS was found to be non-significant on plant height. However, the ICCV-2 variety with no nipping and sprayed with NAA 50 ppm ($V_2N_2S_{1)}$ recorded numerically maximum (50.27 cm) plant height followed by $V_1N_2S_1$ (47.67 cm), $V_2N_2S_2$ (47.53 cm). The minimum (36.17 cm) plant height was recorded in $V_1N_1S_4$ treatment.

4.1.1.2 Number of branches

The number of branches at 30, 60 DAS and at harvest as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 2 and depicted in Fig. 4.

Due to varieties (V)

The number of branches at 30 DAS was found to differ significantly due to the varieties. Significantly higher (3.70) number of branches were recorded in A-1 over ICCV-2 (V_2) with 3.62.

The significant difference was seen between the varieties on number of branches at 60 DAS. Significantly more (23.39) number of branches were recorded in V_1 variety over ICCV-2 (18.86).

Number of branches differed significantly due to varietal influence at harvest. Significantly more (25.58) branches were recorded in A-1 variety over ICCV-2 (21.97).

Table 1. Effect of nipping, growth regulators spray on plant height in chickpea varieties (pooled analysis)*

Treatments		Plant height (cm)														
		30DAS					60 DAS					At harvest				
		V x N x S				V x N	V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	19.05	18.98	18.75	19.01	18.95	37.35	35.95	34.42	32.05	34.94	44.68	43.25	39.33	36.17	40.86
	N_2	19.20	19.27	19.08	19.27	19.21	39.63	37.82	35.50	33.05	36.50	47.67	45.18	41.58	39.55	43.50
V_2	N_1	19.83	19.87	19.97	19.72	19.85	40.70	39.43	37.08	35.58	38.20	47.25	45.87	42.60	38.85	43.64
	N_2	20.10	19.70	20.22	19.64	19.92	42.45	40.75	38.52	34.50	39.06	50.27	47.53	42.63	39.43	44.97
V x S	V_1	19.10	19.12	18.91	19.16	19.08	38.49	36.88	34.96	32.55	35.72	46.17	44.21	40.45	37.86	42.18
	V_2	19.96	19.78	20.09	19.68	19.88	41.57	40.09	37.80	35.04	38.63	48.76	46.70	42.61	39.14	44.30
N x S	N_1	19.42	19.42	19.36	19.38	19.40	39.02	37.69	35.75	33.77	36.57	45.96	44.56	40.96	37.51	42.25
	N_2	19.65	19.48	19.65	19.45	19.56	41.04	39.28	37.01	33.81	37.78	48.97	46.35	42.10	39.49	44.23
	Mean	19.54	19.46	19.51	19.42	19.48	40.03	38.49	36.38	33.80	37.17	47.47	45.46	41.54	38.50	43.24
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%				S.Em±	CD at 5%		
Vareities (V)			0.18	0.51				0.21	0.58				0.19	0.53		
Nipping(N)			0.18	NS				0.21	0.58				0.19	0.53		
Sprays (S)			0.26	NS				0.29	0.83				0.26	0.75		
V x N			0.26	NS				0.29	NS				0.26	0.75		
V x S			0.37	NS				0.41	NS				0.37	NS		
N x S			0.37	NS				0.41	NS				0.37	NS		
V x N x S			0.52	NS				0.58	NS				0.53	NS		

** (2007 and 2008 *rabi* season)
NS- Non Significant

Varieties (v) :	V_1- A-1	V_2- ICCV-2	Nipping (N):	N_1-Nipping	N_2-No nipping
Sprays (S) :	S_1- NAA 50 ppm	S_2- Triacontanol (1ml/lit)	S_3- Panchagavya	S_4- Water spray (Control)	

Due to nipping (N)

No significant difference was noticed on number of branches at 30 DAS due to nipping treatment. Numerically higher (3.68) number of branches were recorded in nipping (N_1) over no nipping (N_2) with 3.64.

At 60 DAS, the number of branches differed significantly due to nipping treatment. Between nipping and no nipping significantly more (22.44) number of branches were recorded in nipping treatment compared to no nipping (19.81).

At harvest, significant differences were noticed on number of branches due to nipping treatment. The number of branches at harvest were maximum (25.12) in nipped plants while, minimum (22.43) were recorded in non nipped plants.

Due to growth regulators (S)

Growth regulators spray on number of branches at 30 DAS did not differ significantly. While, numerically more (3.71) number of branches were recorded in S_2 (Triacontanol @ 1ml / lit.) treatment and less (3.61) in S_4 treatment.

Among different growth regulators spray, significantly more number of branches at 60 DAS were noticed in NAA 50 ppm treatment (23.10) followed by Triacontanol 1 ml / lit (21.72) and less (19.09) number of branches were recorded in water spray treatment.

Among the growth regulators spray, number of branches were significantly more (26.13) with S_1 (50 ppm NAA) and less (21.36) in treatment S_4 (water spray) at harvest.

Due to interaction of variety and nipping (VxN)

The number of branches at 30 DAS did not differ significantly due to interaction effects of varieties and nipping. However, number of branches were relatively more (3.73) with V_1N_1 followed by V_1N_2 (3.67) and less (3.62) in V_2N_2 treatment.

No significant result was recorded due to interaction effect of variety and nipping on number of branches at 60 DAS. However, numerically maximum (24.53) number of branches were recorded in V_1N_1 treatment and less (17.37) in V_2N_2.

No significant differences were noticed on number of branches at harvest due to interaction of variety and nipping treatment. However, relatively more number of branches were noticed in V_1N_1 (26.87) followed by V_1N_2 (24.29) and less (20.57) in V_2N_2 treatment.

Due to interaction of variety and growth regulators (VxS)

Number of branches did not differ significantly due to interaction of variety and growth regulator spray on number of branches at 30 DAS. However, numerically more (3.76) number of branches were recorded in V_1S_2 and less (3.57) in V_2S_4 treatment combination.

Number of branches at 60 DAS did not differ significantly due to interaction of variety and growth regulators spray. However, relatively more (25.17) number of branches were recorded in V_1S_1 treatment followed by V_1S_2 (24.25) and less (17.06) in V_2S_4 treatment.

The number of branches at harvest did not show significant difference due to interaction of variety and growth regulators spray. While, numerically maximum (27.80) branches recorded were in V_1S_1 treatment and minimum (19.26) in V_2S_4 treatment.

Due to interaction of nipping and growth regulators spray (NxS)

No significant difference was seen due to interaction of nipping and growth regulators spray on number of branches. However, numerically maximum (3.76) and minimum (3.58) number of branches were recorded in N_1S_2 and N_2S_4 treatment respectively.

Number of branches did not show any significant difference due to interaction of nipping and growth regulators spray at 60 DAS. However, numerically maximum (24.34) branches at 60 DAS were recorded in N_1S_1 combination and minimum (17.96) in N_2S_4.

The interaction between nipping and growth regulators spray showed no significant difference on number of branches at harvest. Number of branches were relatively more (27.42) with N_1S_1 followed by N_1S_2 (25.99) and less (20.16) with N_2S_4.

Table 2. Effect of nipping, growth regulators spray on number of branches in chickpea varieties (pooled analysis)

Treatments		Number of branches														
		30DAS					60 DAS					At harvest				
		V x N x S				V x N	V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	3.60	3.90	3.73	3.70	3.73	26.02	25.53	24.27	22.30	24.53	28.88	27.63	26.30	24.67	26.87
	N_2	3.70	3.63	3.73	3.60	3.67	24.32	22.97	21.75	19.93	22.24	26.73	24.52	23.67	22.22	24.29
V_2	N_1	3.67	3.63	3.63	3.57	3.63	22.67	20.87	19.75	18.12	20.35	25.97	24.35	22.70	20.43	23.36
	N_2	3.67	3.67	3.57	3.56	3.62	19.40	17.50	16.57	16.00	17.37	22.93	22.05	19.20	18.10	20.57
V x S	V_1	3.65	3.76	3.73	3.65	3.70	25.17	24.25	23.01	21.11	23.39	27.80	26.07	24.98	23.44	25.58
	V_2	3.67	3.65	3.63	3.57	3.62	21.03	19.18	18.16	17.06	18.86	24.45	23.20	20.95	19.26	21.97
N x S	N_1	3.63	3.76	3.68	3.63	3.68	24.34	23.20	22.01	20.21	22.44	27.42	25.99	24.50	22.55	25.12
	N_2	3.68	3.65	3.65	3.58	3.64	21.86	20.23	19.16	17.96	19.81	24.83	23.28	21.43	20.16	22.43
	Mean	3.66	3.71	3.67	3.61	3.66	23.10	21.72	20.59	19.09	21.12	26.13	24.64	22.97	21.36	23.77
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.022	0.06				0.172	0.49				0.209	0.59		
Nipping(N)			0.022	NS				0.172	0.49				0.209	0.59		
Sprays (S)			0.032	NS				0.243	0.69				0.296	0.84		
V x N			0.032	NS				0.243	NS				0.296	NS		
V x S			0.045	NS				0.344	NS				0.418	NS		
N x S			0.045	NS				0.344	NS				0.418	NS		
V x N x S			0.064	NS				0.487	NS				0.592	NS		

** (2007 and 2008 *rabi* season)
NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

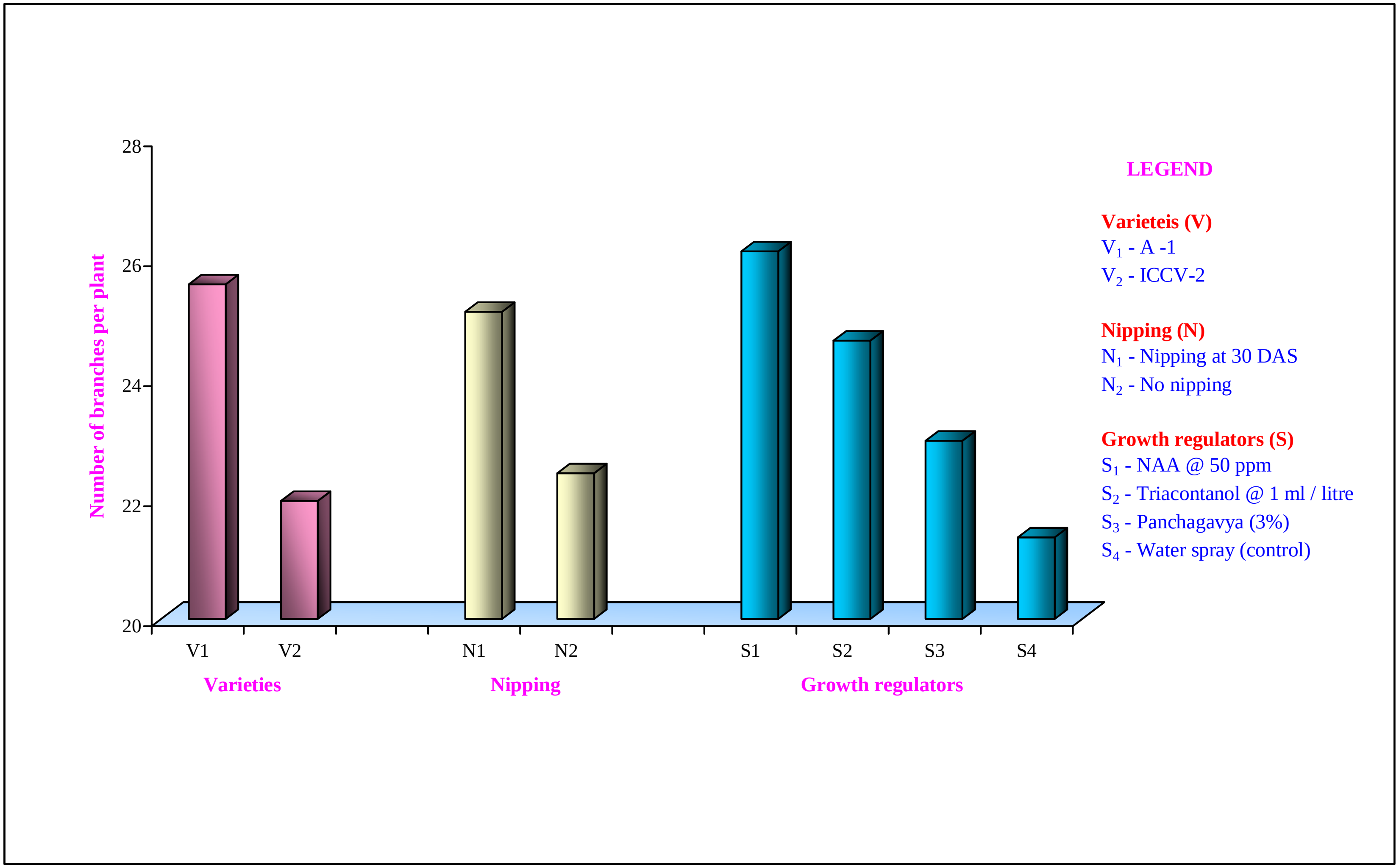


Fig. 4 : Effect of nipping, growth regulators on number of branches per plant at harvest in chickpea varieties

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

Number of branches at 30 DAS due to interaction effect of variety, nipping and growth regulators spray did not differ significantly. Number of branches at 30 DAS were relatively more (3.90) with $V_1N_1S_2$ treatment and less (3.56) with $V_2N_2S_4$ treatment.

The no significant difference was observed due to interaction of nipping and growth regulators spray on number of branches at 60 DAS. While, relatively more (26.02) number of branches were recorded in $V_1N_1S_1$ treatment combination followed by $V_1N_1S_2$ (25.53) and $V_1V_2S_1$ (24.32) and less (16.00) in $V_2N_2S_4$ treatment.

At harvest, number of branches did not show significant difference due to interactions of nipping and growth regulators spray. However, numerically maximum (28.88) branches were with $V_1N_1S_1$ followed by $V_1N_1S_2$ (27.63) and $V_1N_2S_2$ (26.73). The minimum (18.10) branches were recorded with $V_2N_2S_4$.

4.1.2. Flower, seed yield and yield components

4.1.2.1 Days to 50 per cent flowering

The data on days to 50 per cent flowering as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 3.

Due to varieties (V)

Days to 50 per cent flowering differed significantly due to varieties and were significantly more (53.09 days) in A-1 variety (V_1) compared to ICCV-2 (46.56 days).

Due to nipping (N)

Significant difference was noticed on days to 50 per cent flowering due to nipping. Significantly maximum (50.38) days were taken for 50 per cent flowering in nipped plants compared to no nipping (49.27 days).

Due to growth regulators (S)

Marked differences were noticed among growth regulators spray on days to 50 per cent flowering. Markedly maximum (50.63) days were taken for days to 50 per cent flowering by S_4 followed by S_3 (50.00) while minimum (49.00) days with S_1.

Due to interaction of variety and nipping (VxN)

Days to 50 per cent flowering did not differ significantly due to interaction effect of variety and nipping. However, numerically more (53.59) days were taken for 50 per cent flowering with V_1N_1 followed byV_1N_2 (52.59) days and less (45.96) days by V_2N_1.

Due to interaction of variety and growth regulators (VxS)

The interaction effect of varieties and growth regulators spray showed non-significant differences on days to 50 per cent flowering. However, numerically more (53.75) days were taken for 50 per cent flowering by V_1S_4 followed by V_1S_3 (53.08) days and less (45.58) days by V_2S_1.

Due to interaction of nipping and growth regulators spray (NxS)

No significant differences were noticed due to interaction of nipping and growth regulators sprays. Relatively more (51.25) days were taken for 50 per cent flowering by N_1S_4 followed by N_1S_3 (50.75) days and less (48.58) days by N_2S_1.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to varieties, nipping and growth regulators spray showed non-significant difference on days to 50 per cent flowering. However, relatively more (54.5) days were taken for 50 per cent flowering by $V_1N_1S_4$ followed by $V_1N_1S_3$ (54.00) days and less (45.00) days by $V_2N_2S_1$.

4.1.2.2 Number of pods per plant

The number of pods per plant as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 4 and depicted in Fig. 5.

Table 3. Effect of nipping, growth regulators spray on days to 50 per cent flowering in chickpea varieties (pooled analysis)

Treatments		Days to 50% flowering				
		V x N x S				V x N
		S_1	S_2	S_3	S_4	
V_1	N_1	52.67	53.17	54.00	54.5	53.59
	N_2	52.17	53.00	52.17	53.00	52.59
V_2	N_1	46.17	47.00	47.50	48.00	47.17
	N_2	45.00	45.50	46.33	47.00	45.96
V x S	V_1	52.42	53.05	53.08	53.75	53.09
	V_2	45.58	46.25	46.91	47.50	46.56
N x S	N_1	49.42	50.08	50.75	51.25	50.38
	N_2	48.58	49.25	49.25	50.00	49.27
	Mean	49.00	49.67	50.00	50.63	49.82
For comparison means of			S.Em±	CD at 5%		
Vareities (V)			0.284	0.81		
Nipping(N)			0.284	0.81		
Sprays (S)			0.401	1.14		
V x N			0.401	NS		
V x S			0.567	NS		
N x S			0.567	NS		
V x N x S			0.802	NS		

** (2007 and 2008 *rabi* season)
NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Table 4. Effect of nipping, growth regulators spray on number of pods per plant, pod weight per plant and Seeds per pod in chickpea varieties (pooled analysis)

Treatments		Number of pods per plant					Pod weight per plant (g)					Seeds per pod				
		V x N x S				V x N	V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_1	S_2		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	58.19	55.16	52.33	44.70	52.60	21.83	19.20	18.35	17.07	19.11	1.73	1.60	1.53	1.43	1.57
	N_2	48.6	45.27	41.95	35.83	42.91	19.06	17.85	17.10	16.50	17.63	1.67	1.60	1.53	1.50	1.57
V_2	N_1	44.52	40.85	38.82	33.72	39.48	18.82	17.82	16.70	15.93	17.32	1.43	1.57	1.40	1.30	1.41
	N_2	35.73	32.07	28.05	26.77	30.66	17.06	16.49	15.25	13.85	15.66	1.40	1.40	1.37	1.27	1.38
V x S	V_1	53.39	50.21	47.14	40.26	47.75	20.44	18.52	17.72	16.78	18.37	1.70	1.60	1.53	1.46	1.57
	V_2	40.12	36.46	33.43	30.24	35.07	17.94	17.15	15.97	14.89	16.49	1.41	1.48	1.38	1.28	1.39
N x S	N_1	51.35	48.00	45.57	39.21	46.04	20.32	18.51	17.52	16.50	18.22	1.58	1.58	1.46	1.40	1.50
	N_2	42.16	38.67	35.00	31.30	36.78	18.06	17.17	16.17	15.17	16.65	1.53	1.50	1.45	1.35	1.46
	Mean	46.76	43.34	40.29	35.26	41.41	19.19	17.84	16.85	15.84	17.43	1.56	1.54	1.46	1.38	1.48
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%				S.Em±	CD at 5%		
Vareities (V)			0.256	0.73				0.127	0.36				0.027	0.08		
Nipping(N)			0.256	0.73				0.127	0.36				0.027	NS		
Sprays (S)			0.362	1.03				0.179	0.51				0.038	0.11		
V x N			0.362	NS				0.179	NS				0.038	NS		
V x S			0.512	1.46				0.253	NS				0.054	NS		
N x S			0.512	NS				0.253	NS				0.054	NS		
V x N x S			0.724	NS				0.358	NS				0.077	NS		

** (2007 and 2008 *rabi* season)
NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

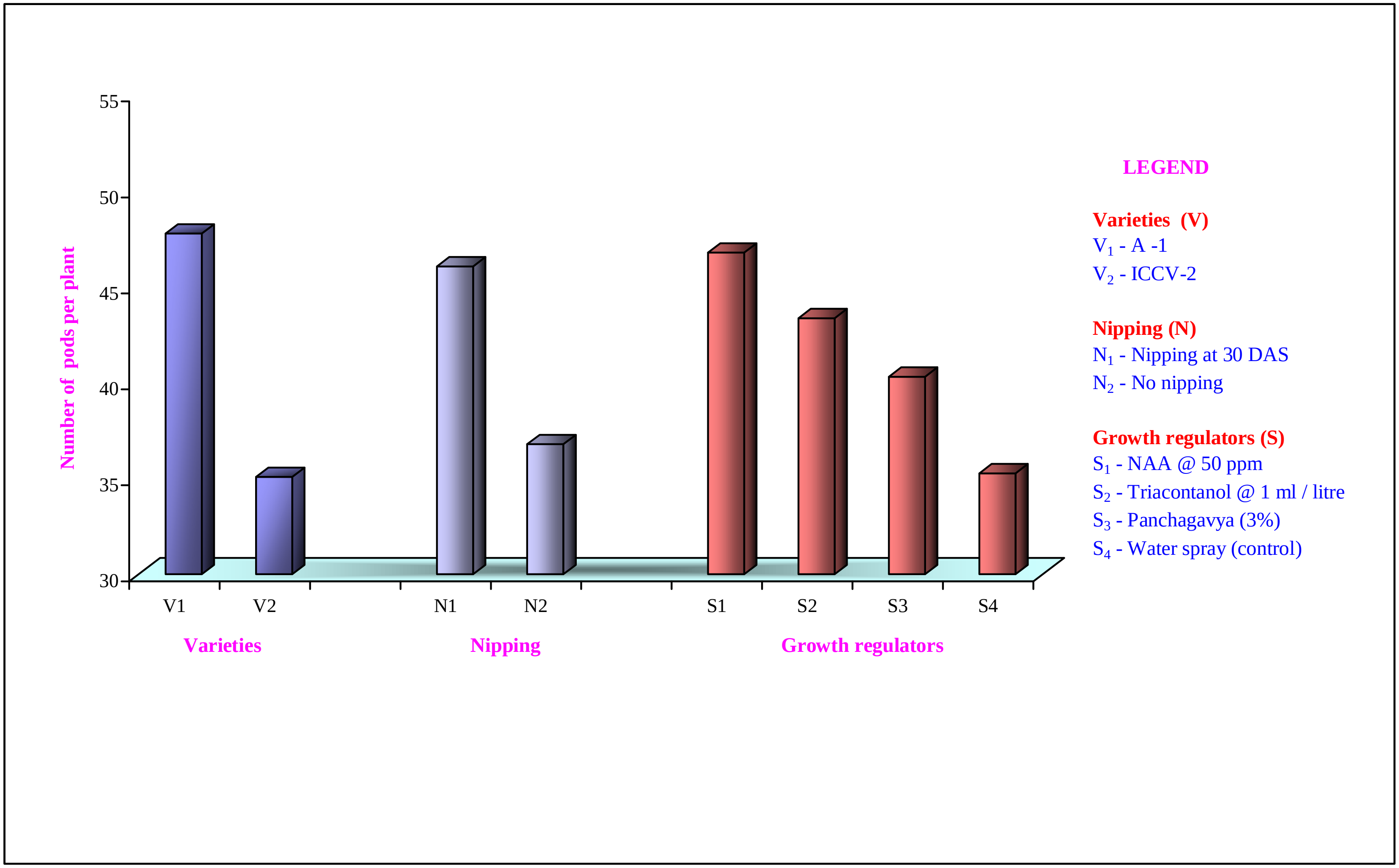


Fig. 5 : Effect of nipping, growth regulators on number of pods per plant in chickpea varieties

Due to varieties (V)

The number of pods per plant differed significantly due to varieties and were significantly more (47.75) with A-1 compared to ICCV-2 (35.07),

Due to nipping (N)

Number of pods per plant differed significantly due to nipping and were more (46.04) with nipped plants compared to no nipped (36.78).

Due to growth regulators (S)

Number of pods per plant found to differ significantly among growth regulators spray. Significantly maximum (46.76) number of pods were recorded with S_1 followed by S_2 (43.34) and minimum (35.26) in S_4 treatment.

Due to interaction of variety and nipping (VxN)

No significant differences were noticed on number of pods per plant due to interaction of varieties and nipping. However, numerically more (52.60) number of pods per plant were recorded in V_1N_1 followed by V_1N_2 (42.91) and less (30.66) in V_2N_2.

Due to interaction of variety and growth regulators (VxS)

The interaction effect of variety and growth regulators spray showed significant differences on number of pods per plant. Significantly more (53.39) pods recorded were with V_1S_1 followed by V_1S_2 (50.21) and less (30.24) in V_2S_4.

Due to interaction of nipping and growth regulators spray (NxS)

Number of pods per plant did not differ significantly due to interaction effect of nipping and growth regulators sprays. Relatively number of pods per plant were maximum (51.35) with N_1S_1 and minimum (31.30) with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to varieties, nipping and growth regulators spray showed no significant differences on number of pods per plant. However, maximum (58.19) number of pods were recorded with $V_1N_1S_1$ followed by $V_1N_1S_2$ (55.16) and minimum (26.77) with $V_2N_2S_4$.

4.1.2.3 Pod weight per plant

The results on pod weight per plant as influenced by varieties, nipping, growth regulators spray and their interaction effects are presented in Table 4.

Due to varieties (V)

Significant differences were noticed on pod weight per plant and maximum (18.37 g) pod weight was recorded with A-1 (V_1) variety compared to ICCV-2 (V_2) (16.49 g).

Due to nipping (N)

The pod weight per plant due to nipping was found to differ significantly. It was significantly more (18.22 g) in nipped plant (N_1) compared to non nipped (N_2) (16.65 g) plant.

Due to growth regulators (S)

Marked differences were noticed among growth regulators spray on pod weight per plant. Markedly more (19.19 g) pod weight per plant was noticed with S_1 followed S_2 (17.84 g) and less (15.84 g) with S_4.

Due to interaction of variety and nipping (VxN)

The interaction effect due to varieties and nipping showed non-significant difference with respect to pods weight per plant. Relatively more (19.11 g) pod weight was recorded with V_1N_1 followed by V_1N_2 (17.63 g) and less (15.66 g) with V_2N_2.

Due to interaction of variety and growth regulators (VxS)

The interaction effect due to variety and growth regulators spray was non-significant with respect to pod weight per plant. Relatively more (20.44 g) pod weight was recorded in V_1S_1 followed by V_1S_2 (18.52 g) and was less (14.89 g) with V_2S_4.

Due to interaction of nipping and growth regulators spray (NxS)

No significant differences were seen due to nipping and growth regulators sprays on pod weight. Numerically maximum (20.32 g) pod weight was recorded with N_1S_1 followed by N_1S_2 (18.51 g) and minimum (15.17 g) with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due varieties, nipping and growth regulators spray was non-significant with respect to pod weight per plant. However, relatively more (21.83 g) pod weight was recorded with $V_1N_1S_1$ followed by $V_1N_1S_2$ (19.2 g) and minimum (13.85 g) with $V_2N_2S_4$.

4.1.2.4 Seeds per pod

The results on number of seeds per pod as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 4.

Due to varieties (V)

The significant differences were seen on seeds per pod between varieties. Markedly maximum (1.57) seeds per pod was recorded in variety A-1 compared to ICCV-2 (1.39).

Due to nipping (N)

No significant differences were recorded on number of seeds per pod due to nipping levels. While, relatively more (1.50) seeds per pod were recorded in N_1 treatment compared to N_2 treatment (1.46).

Due to growth regulators (S)

Seeds per pod found to differ significantly due to growth regulators spray and markedly more (1.56) seeds per pod was recorded in S_1 followed by S_2 (1.54) treatment and was markedly less (1.38) in control.

Due to interaction of variety and nipping (VxN)

No significant difference was seen due to interaction of VxN on seeds per pod. While, numerically more (1.57) seeds per pod was recorded both in V_1N_1 and V_1N_2 treatments and was less (1.38) with V_2N_2.

Due to interaction of variety and growth regulators (VxS)

Seeds per pod did not show marked differences due to interactions of variety and growth regulators spray. However, relatively more (1.70) seeds per pod were recorded with V_1S_1 followed by V_1S_2 (1.60) and less (1.28) with V_2S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The interaction of nipping and growth regulators sprays did not show marked difference on number of seeds per pod. While, numerically highest (1.58) seeds per pod were recorded in N_1S_1 and N_1S_2 and lowest (1.35) with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

No significant differences were seen due to varieties, nipping and growth regulators spray on seeds per pod. While, relatively maximum (1.73) seeds per pod was noticed in $V_1N_1S_1$ treatment combination followed by $V_1N_2S_1$ (1.67), $V_1N_1S_2$ and $V_1N_2S_2$ (1.60) and minimum (1.27) with $V_2N_2S_4$

4.1.2.5 Seed yield per plant (g)

The data on seed yield per plant as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 5.

Due to varieties (V)

Significant differences were noticed on seed yield per plant due to varieties. Significantly more (14.66 g) seed yield per plant was recorded with variety A-1 (V_1) compared to ICCV-2 (13.33 g).

Due to nipping (N)

The seed yield per plant found to differ significantly due to nipping treatment and was more (14.59 g) in nipped plants (N_1) over (13.33 g) non nipped plants (N_2).

Due to growth regulators (S)

Marked differences were noticed among the growth regulators spray on seed yield per plant. Significantly maximum (15.67 g) and minimum (12.05 g) seed yield per plant was recorded in S_1 and S_4 treatments respectively.

Due to interaction of variety and nipping (VxN)

The seed yield per plant due to interactions of varieties and nipping levels did not differ markedly. However, relatively maximum (15.19 g) seed yield per plant was recorded with V_1N_1 followed by V_1N_2 (14.12 g) and minimum (12.68 g) with V_2N_2.

Due to interaction of variety and growth regulators (VxS)

The interaction effect due to variety and growth regulators spray was not significant with respect to seed yield per plant. It was numerically more (16.23 g) with V_1S_1 followed by V_1S_2 (15.64 g) and V_2S_1 (15.10 g). However, seed yield was relatively less (11.27 g) in V_2S_4,

Due to interaction of nipping and growth regulators spray (NxS)

The seed yield per plant did not differ significantly due to nipping and growth regulators sprays. However, more (16.46 g) seed yield per plant was recorded in N_1S_1 followed by (15.42 g) N_1S_2 and less (11.44 g) in N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to varieties, nipping and growth regulators spray was non-significant with respect to seed yield per plant. Relatively more (16.92 g) seed yield per plant was recorded with $V_1N_1S_1$ followed by $V_1N_1S_2$ (16.03 g) and $V_2N_1S_1$ (15.55 g) and less (10.59 g) with $V_2N_2S_4$.

4.1.2.6 Seed yield per plot (kg)

Seed yield per plot as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 5.

Due to varieties (V)

Seed yield per plot differed significantly due to varieties and was markedly highest (1.03 kg) in A-1 variety compared to ICCV-2 (0.92 kg).

Due to nipping (N)

Significant differences were noticed on seed yield per plot between nipping treatments. Significantly maximum (1.02 kg) seed yield per plot was recorded in N_1 (nipping) compared to no nipping (0.93 kg).

Due to growth regulators (S)

Marked differences were noticed among the growth regulators spray on seed yield per plot. Markedly maximum (1.06 kg) seed yield was recorded in S_1 followed by S_2 (1.01 kg) and minimum (0.89 kg) with S_4.

Due to interaction of variety and nipping (VxN)

The interaction effect of varieties and nipping showed non-significant differences on seed yield per plot. Numerically more (1.08 kg) seed yield per plot was recorded in V_1N_1 followed by V_1N_2 (0.98 kg) and less (0.87 kg) in V_2N_2.

Due to interaction of variety and growth regulators (VxS)

The interaction effect of variety and growth regulators spray showed non-significant differences on seed yield per plot. However, relatively more (1.12 kg) seed yield was recorded with V_1S_1 followed by V_1S_2 (1.06 kg) and less (0.82 kg) by V_2S_4.

Due to interaction of nipping and growth regulators spray (NxS)

Seed yield per plot did not differ markedly due to nipping and growth regulators sprays. Relatively more (1.09 kg) seed yield was recorded with N_1S_1 followed with N_1S_2 (1.07 kg) and less (0.83 kg) with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to varieties, nipping and growth regulators on seed yield per plot did not differ significantly. $V_1N_1S_1$ recorded numerically more (1.15 kg) seed yield per plot followed by $V_1N_1S_2$ (1.14 kg) and less (0.78 kg) with $V_2N_2S_4$.

4.1.2.7 Seed yield per hectare (q)

The results on seed yield per ha as influenced by varieties, nipping, growth regulators spray and their interaction effects are presented in Table 5 and depicted in Fig. 6.

Due to varieties (V)

The seed yield per ha differed significantly due to varieties and it was markedly more (28.75 q) with A-1 (V_1) compared to ICCV-2 (25.52 q).

Due to nipping (N)

Marked differences were noticed due to nipping levels on seed yield per ha. Markedly maximum (28.50 q) seed yield per ha was with N_1 compared to N_2 (25.77 q).

Due to growth regulators (S)

Significant differences were noticed on seed yield per ha due to growth regulators spray. Significantly maximum (29.91 q) seed yield was recorded with S_1 followed by S_2 (27.80 q) and was minimum (24.68 q) with S_4.

Due to interaction of variety and nipping (VxN)

The seed yield per ha did not differ significantly due to varieties and nipping. However, relatively more (30.22 q) seed yield was recorded in V_1N_1 followed by V_1N_2 (27.28 q) and was less (24.26 q) in V_2N_2.

Due to interaction of variety and growth regulators (VxS)

The interaction effect of variety and growth regulators spray showed marked differences on seed yield per ha. Markedly maximum (32.29 q) seed yield per ha was with V_1S_1 followed by V_1S_2 (29.14 q) and minimum (22.91 q) with V_2S_4.

Due to interaction of nipping and growth regulators spray (NxS)

Significant differences were not noticed on seed yield per ha due to nipping and growth regulators sprays. However, maximum (31.45 q) seed yield per ha was recorded with N_1S_1 followed by N_1S_2 (29.20 q) and N_2S_1 (28.36 q) while, minimum (23.12 q) was with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to varieties, nipping and growth regulators spray showed no significant differences on seed yield per ha. Seed yield per ha was relatively more (34.07 q) with $V_1N_1S_1$ followed by $V_1N_1S_2$ (30.72 q) and $V_1N_2S_1$ (30.52 q) however less yield (21.57 q) was recorded with $V_2N_2S_4$.

4.1.3 Seed quality parameters

4.1.3.1 100 seed weight (g)

The data on 100 seed weight as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 6.

Table 5. Effect of nipping, growth regulators spray on seed yield per plant, per plot and per hectare in chickpea varieties (pooled analysis)

Treatments		Seed yield per plant (g)					Seed yield per plot (kg)					Seed yield per ha (q/ha)				
		V x N x S				V x N	V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	16.92	16.03	14.46	13.35	15.19	1.15	1.14	1.00	1.02	1.08	34.07	30.72	27.86	28.24	30.22
	N_2	15.55	15.26	13.38	12.29	14.12	1.10	0.99	0.95	0.89	0.98	30.52	27.57	26.34	24.67	27.28
V_2	N_1	16.00	14.81	13.16	11.95	13.98	1.04	1.00	0.95	0.87	0.97	28.84	27.68	26.34	24.25	26.78
	N_2	14.20	13.73	12.18	10.59	12.68	0.94	0.91	0.86	0.78	0.87	26.20	25.23	24.03	21.57	24.26
V x S	V_1	16.23	15.64	13.92	12.82	14.66	1.12	1.06	0.97	0.95	1.03	32.29	29.14	27.10	26.45	28.75
	V_2	15.10	14.27	12.67	11.27	13.33	0.99	0.95	0.90	0.82	0.92	27.52	26.45	25.18	22.91	25.52
N x S	N_1	16.46	15.42	13.81	12.65	14.59	1.09	1.07	0.97	0.94	1.02	31.45	29.20	27.10	26.24	28.50
	N_2	14.87	14.49	12.78	11.44	13.40	1.02	0.95	0.90	0.83	0.93	28.36	26.40	25.18	23.12	25.77
	Mean	15.67	14.96	13.30	12.05	13.99	1.06	1.01	0.94	0.89	0.97	29.91	27.80	26.14	24.68	27.13
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%				S.Em±	CD at 5%		
Vareities (V)			0.284	0.81				0.01	0.03				0.185	0.53		
Nipping(N)			0.284	0.81				0.01	0.03				0.185	0.53		
Sprays (S)			0.401	1.14				0.013	0.04				0.263	0.75		
V x N			0.401	NS				0.013	NS				0.263	NS		
V x S			0.567	NS				0.018	NS				0.372	1.06		
N x S			0.567	NS				0.018	NS				0.372	NS		
V x N x S			0.802	NS				0.026	NS				0.743	NS		

** (2007 and 2008 *rabi* season)
NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping
Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

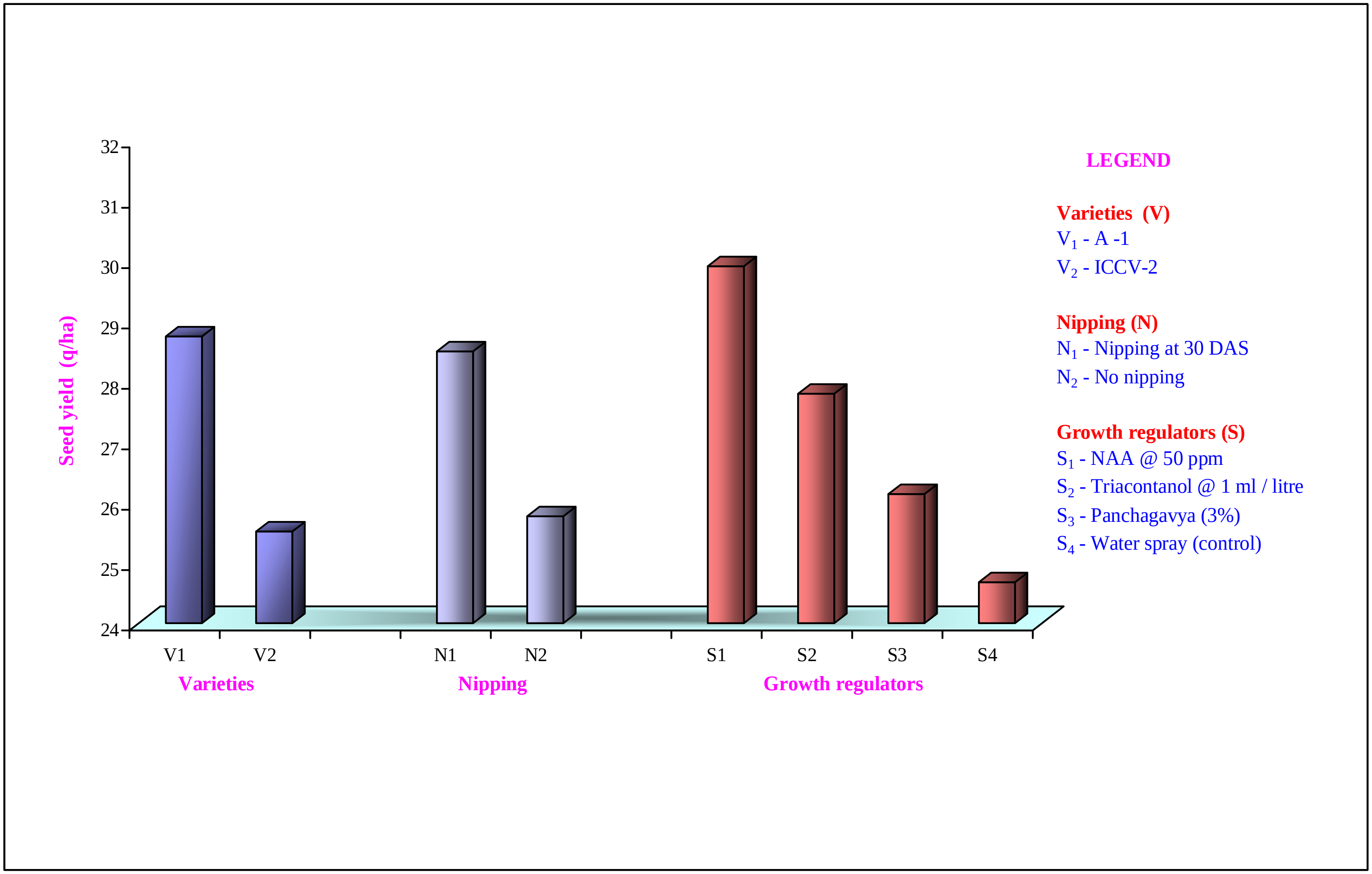


Fig. 6 : Effect of nipping, growth regulators on seed yield per hectare (q) in chickpea varieties

Due to varieties (V)

Significantly maximum (23.46 g) 100 seed weight was recorded in ICCV-2 compared to A-1 (22.30 g).

Due to nipping (N)

The 100 seed weight did not differ significantly due to nipping and it was numerically more (23.19 g) in N_1 compared to N_2 (22.57 g).

Due to growth regulators (S)

The 100 seed weight differed significantly due to growth regulators spray. Significantly maximum (24.48 g) 100 seed weight was recorded with S_1 followed by S_2 (23.57 g) and minimum (21.32 g) with S_4.

Due to interaction of variety and nipping (VxN)

The interaction effect of variety and nipping showed no marked differences on 100 seed weight. However, more (23.86 g) 100 seed weight was recorded with V_2N_1 followed by V_2N_2 (23.06 g) and less (22.07 g) with V_1N_2.

Due to interaction of variety and growth regulators (VxS)

No significant differences were noticed on 100 seed weight due variety and growth regulators spray. However, maximum (25.35 g) 100 seed weight was recorded with V_2S_1 followed by V_2S_2 (24.26 g) and V_1S_1 (23.61 g) and minimum (20.97 g) with V_1S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The 100 seed weight did not differ significantly due to nipping and growth regulators sprays. While, relatively more (24.96 g) 100 seed weight was recorded in N_1S_1 and less (21.02 g) in N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

No marked differences were noticed among interactions of varieties, nipping and growth regulators spray on 100 seed weight. However, numerically highest (26.00 g) 100 seed weight was noticed with $V_2N_1S_1$ treatment followed by $V_2N_2S_1$ (24.70 g) and $V_2N_1S_2$ (24.55 g) and lowest (20.80 g) with $V_1N_2S_4$.

4.1.3.2 Germination (%)

The results on germination percentage as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 6 and depicted in Fig. 7.

Due to varieties (V)

The germination percentage did not found to differ significantly between the varieties. It was relatively more (94.38 %) with A-1 compared ICCV-2 (93.70%).

Due to nipping (N)

Significant differences were noticed between nipping and no nipping treatment on per cent germination. Significantly higher (93.68%) germination was recorded in nipping (N_1) treatment than N_2 (no nipping) (92.40 %).

Due to growth regulators (S)

Significant differences were noticed among the growth regulators sprays on germination percentage. Significantly highest (96.37%) germination was recorded in S_1 followed by S_2 (94.77%) and lowest (91.29%) in S_4.

Due to interaction of variety and nipping (VxN)

The interaction effect due to varieties and nipping did not show marked difference on germination percentage. Numerically higher (95.04%) germination was recorded in V_1N_1 treatment followed by V_2N_1 (94.31%) and was lower (93.08%) in V_2N_2.

Due to interaction of variety and growth regulators (VxS)

The interaction between variety and growth regulators spray showed no significant difference on germination percentage. The germination percentage was relatively more (96.82%) in V_1S_1 and less (91.09%) in V_2S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The significant differences were recorded on per cent germination due to interaction of nipping and growth regulators sprays. However, numerically highest (96.05%) germination was seen in N_1S_1 and lowest (89.61%) in N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

No marked differences were noticed due to interactions of varieties, nipping and growth regulators spray. While, maximum (97.55%) germination was recorded in $V_1N_1S_1$ followed by $V_1N_2S_1$ (96.09%) and $V_1N_1S_2$ (95.96%) and minimum (90.38%) was with $V_2N_2S_4$.

4.1.3.3 Speed of germination

The results on speed of germination as influenced by varieties, nipping, growth regulators spray and their interaction effects are presented in Table 6.

Due to varieties (V)

Significantly highest (49.12) speed of germination was recorded in variety ICCV-2 compared to A-1 (47.36).

Due to nipping (N)

Significantly maximum (48.76) speed of germination was recorded in nipped plants (N_1) treatment over N_2 (47.72).

Due to growth regulators (S)

Speed of germination found to differ markedly among the growth regulators spray. Significantly higher (50.99) speed of germination was noticed in S_1 treatment followed by S_2 and S_3 (48.55 and 46.90) respectively. The lower (46.52) speed of germination was recorded in S_4.

Due to interaction of variety and nipping (VxN)

No significant interaction effect was seen due to varieties and nipping on speed of germination. However, relatively more (49.45) speed of germination was recorded in V_2N_1 followed by V_2N_2 (48.79) and V_1N_1 (48.07) and less (46.66) with V_1N_2.

Due to interaction of variety and growth regulators (VxS)

No significant differences were found due to interaction between variety and growth regulators spray on speed of germination. However, maximum (52.02) speed of germination was recorded in V_2S_1 and minimum (45.35) in V_1S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The speed of germination found to differ significantly due to nipping and growth regulators sprays. The nipped plants sprayed with NAA @ 50 ppm (N_1S_1) recorded significantly highest (51.34) speed of germination followed by N_2S_1 (50.64) and lowest (45.01) was with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

No significant difference was seen due to varieties, nipping and growth regulators spray with respect to speed of germination. While, relatively more (52.38) speed of germination was recorded in combination of $V_2N_1S_1$ followed by $V_2N_2S_1$ (51.67) and $V_1N_1S_1$ (50.30) and less (43.30) with $V_1N_2S_4$.

4.1.3.4 Seedling length (cm)

The data on seedling length as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 7.

Table 6.Effect of nipping, growth regulators spray on 100 seed weight, germination percentage and speed of germination in chickpea varieties (pooled analysis)

Treatments		100 Seed weight (g)					Germination %					Speed of germination				
		V x N x S				V x N	V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	23.92	23.20	21.80	21.15	22.52	97.55 (80.96)*	95.96 (78.37)	94.55 (76.47)	92.11 (73.66)	95.04 (77.10)	50.30	48.78	45.79	47.40	48.07
	N_2	23.30	22.55	21.64	20.80	22.07	96.09 (78.56)	94.29 (76.14)	93.67 (75.40)	90.84 (72.35)	93.72 (75.46)	49.62	47.33	46.37	43.30	46.66
V_2	N_1	26.00	24.55	22.79	22.08	23.86	96.55 (79.56)	95.03 (77.09)	93.85 (75.01)	91.81 (73.34)	94.31 (76.17)	52.38	49.27	47.50	48.63	49.45
	N_2	24.70	23.97	22.34	21.24	23.06	95.28 (77.42)	93.78 (75.53)	92.89 (74.51)	90.38 (74.90)	93.08 (74.72)	51.67	48.82	47.95	46.73	48.79
V x S	V_1	23.61	22.87	21.72	20.97	22.30	96.82 (79.70)	95.12 (77.21)	94.11 (75.92)	91.47 (72.90)	94.38 (76.26)	49.96	48.05	46.08	45.35	47.36
	V_2	25.35	24.26	22.56	21.66	23.46	95.91 (78.31)	94.40 (76.26)	93.37 (75.05)	91.09 (72.67)	93.70 (75.43)	52.02	49.04	47.72	47.68	49.12
N x S	N_1	24.96	23.87	22.29	21.61	23.19	96.05 (80.08)	94.49 (77.71)	93.20 (76.03)	90.96 (73.50)	93.68 (76.63)	51.34	49.02	46.64	48.01	48.76
	N_2	24.00	23.26	21.99	21.02	22.57	94.68 (77.98)	93.03 (78.83)	92.28 (74.95)	89.61 (72.13)	92.40 (75.09)	50.64	48.07	47.16	45.01	47.72
	Mean	24.48	23.57	22.14	21.32	22.88	96.37 (78.98)	94.77 (76.74)	93.74 (75.48)	91.29 (70.80)	94.04 (75.84)	50.99	48.55	46.90	46.52	48.24
For comparison means of				S.Em±	CD at 5%				S.Em±	CD at 5%				S.Em±	CD at 5%	
Varieties (V)				0.232	0.66				0.262	NS				0.248	0.71	
Nipping(N)				0.232	NS				0.262	0.75				0.248	0.71	
Sprays (S)				0.328	0.93				0.371	1.06				0.351	0.10	
V x N				0.328	NS				0.371	NS				0.351	NS	
V x S				0.463	NS				0.525	NS				0.496	NS	
N x S				0.463	NS				0.525	NS				0.496	1.41	
V x N x S				0.655	NS				0.742	NS				0.702	NS	

** (2007 and 2008 *rabi* season) NS- Non Significant * Figures in the parenthesis are arcsined values

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

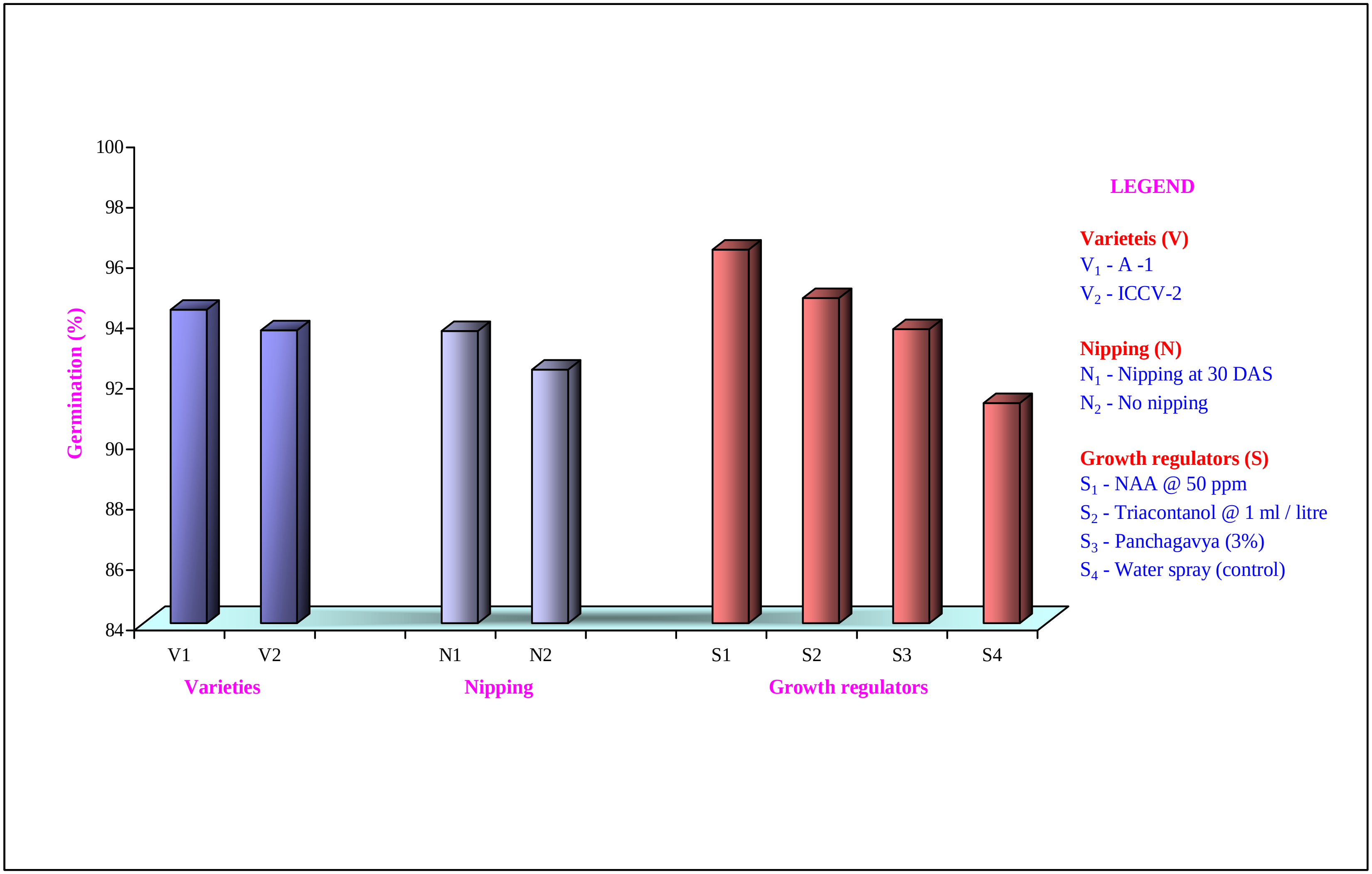


Fig. 7 : Effect of nipping, growth regulators on germination percentage in chickpea varieties

Due to varieties (V)

The seedling length found to differ significantly between varieties.It was significantly more (27.54 cm) with ICCV-2 compared to A-1 (25.79 cm).

Due to nipping (N)

Seedling length differed significantly due to nipping and was more (27.06 cm) with N_1 (nipping) than no nipping (N_2) (26.27 cm).

Due to growth regulators (S)

Significantly maximum (28.37 cm) seedling length was recorded with S_1 followed by S_2 (27.10 cm) and minimum (25.10 cm) with S_4.

Due to interaction of variety and nipping (VxN)

The interaction effect of varieties and nipping was significant on seedling length. Significantly more (28.18 cm) seedling length was recorded in V_2N_1 treatment followed by V_2N_2 (26.90 cm) and was less (25.65 cm) with V_1N_2.

Due to interaction of variety and growth regulators (VxS)

Seedling length did not differ significantly due to variety and growth regulators spray. Relatively more (29.47 cm) seedling length was recorded with V_2S_1 followed by V_2S_2 (27.99 cm) and less (24.37 cm) with V_1S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The interaction effect due to nipping and growth regulators sprays on seedling length was non significant. The seedling length was comparatively more (29.20 cm) with N_1S_1 followed by N_2S_1 (27.53 cm) and N_1S_2 (27.42 cm) while it was less N_1S_4 (24.91 cm).

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

The interaction effect due to varieties, nipping and growth regulators spray showed no marked differences on seedling length. The seedling length was comparatively maximum (30.86 cm) with $V_2N_1S_1$ followed by $V_2N_1S_2$ (28.51 cm) and minimum (24.23 cm) with $V_1N_2S_4$.

4.1.3.5 Seedling dry weight (mg)

The results on seedling dry weight as influenced by varieties, nipping, growth regulators spray and their interaction effects are reported in Table 7.

Due to varieties (V)

Seedling dry weigh differed markedly due to varieties. It was markedly maximum (180.37 mg) in ICCV-2 compared to A-1 (166.80 mg).

Due to nipping (N)

Significant differences were noticed due to nipping on seedling dry weigh. Significantly more (179.12 mg) seedling dry weight was recorded in N_1 treatment over N_2 (168.04 mg).

Due to growth regulators (S)

The seedling dry weight found to differ markedly among growth regulators spray. It was markedly more (182.18 mg) with S_1 followed by S_2 (177.08 mg) and less (163.93 mg) with S_4.

Due to interaction of variety and nipping (VxN)

The interaction effect of varieties and nipping showed significant differences on seedling dry weight. Significantly maximum (187.62 mg) seedling dry weight recorded was with V_2N_1 treatment followed by V_2N_2 (173.12 mg) and minimum (162.97 mg) with V_1N_2.

Due to interaction of variety and growth regulators (VxS)

Marked differences were noticed on seedling dry weight due to interactions effects of variety and growth regulators spray. Markedly more (185.44 mg) seedling dry weight was

Table 7. Effect of nipping, growth regulators spray on seedling length and seedling dry weight in chickpea varieties (pooled analysis)

Treatments		Seedling length (cm)					Seedling dry weight (mg)				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	27.54	26.33	25.33	24.52	25.93	181.31	174.05	167.78	159.35	170.62
	N_2	26.98	26.08	25.32	24.23	25.65	176.52	165.74	158.68	150.93	162.97
V_2	N_1	30.86	28.51	27.32	26.04	28.18	193.34	190.20	186.05	180.90	187.62
	N_2	28.08	27.48	26.42	25.60	26.90	177.54	178.33	172.06	164.53	173.12
V x S	V_1	27.26	26.20	25.32	24.37	25.79	178.91	169.89	163.23	155.14	166.80
	V_2	29.47	27.99	26.87	25.82	27.54	185.44	184.26	179.05	172.71	180.37
N x S	N_1	29.20	27.42	26.32	25.28	27.06	187.32	182.12	176.91	170.12	179.12
	N_2	27.53	26.78	25.87	24.915	26.27	177.03	172.03	165.37	157.73	168.04
	Mean	28.37	27.10	26.10	25.10	26.67	182.18	177.08	171.14	163.93	173.58
For comparison means of			S.Em±	CD at 5%					S.Em±	CD at 5%	
Vareities (V)			0.161	0.46					0.879	2.50	
Nipping(N)			0.161	0.46					0.879	2.50	
Sprays (S)			0.227	0.65					1.243	3.54	
V x N			0.227	0.65					1.243	3.54	
V x S			0.322	NS					1.757	5.00	
N x S			0.322	NS					1.757	NS	
V x N x S			0.455	NS					2.48	NS	

** (2007 and 2008 *rabi* season)
NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Table 8. Effect of nipping, growth regulators spray on seedling vigour index and electrical conductivity in chickpea varieties (pooled analysis)

Treatments		Vigour index					Electrical conductivity (dSm^{-1})				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	2688	2527	2395	2227	2459	0.368	0.372	0.370	0.388	0.375
	N_2	2593	2458	2370	2202	2405	0.400	0.410	0.422	0.430	0.416
V_2	N_1	2919	2652	2509	2338	2604	0.452	0.465	0.487	0.505	0.477
	N_2	2618	2522	2402	2264	2451	0.475	0.505	0.512	0.528	0.505
V x S	V_1	2640	2492	2382	2214	2432	0.384	0.391	0.396	0.409	0.395
	V_2	2768	2587	2455	2301	2528	0.463	0.485	0.499	0.516	0.491
N x S	N_1	2803	2589	2452	2282	2531	0.410	0.418	0.428	0.446	0.426
	N_2	2605	2490	2386	2233	2428	0.437	0.457	0.467	0.479	0.460
	Mean	2704	2539	2419	2257	2480	0.424	0.438	0.448	0.463	0.443
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Vareities (V)			18.30	52.07				0.002	0.006		
Nipping (N)			18.30	52.07				0.002	0.006		
Sprays (S)			25.88	73.64				0.002	0.006		
V x N			25.88	NS				0.002	0.006		
V x S			36.60	NS				0.004	NS		
N x S			36.60	NS				0.004	NS		
V x N x S			51.76	NS				0.005	NS		

** (2007 and 2008 *rabi* season) NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

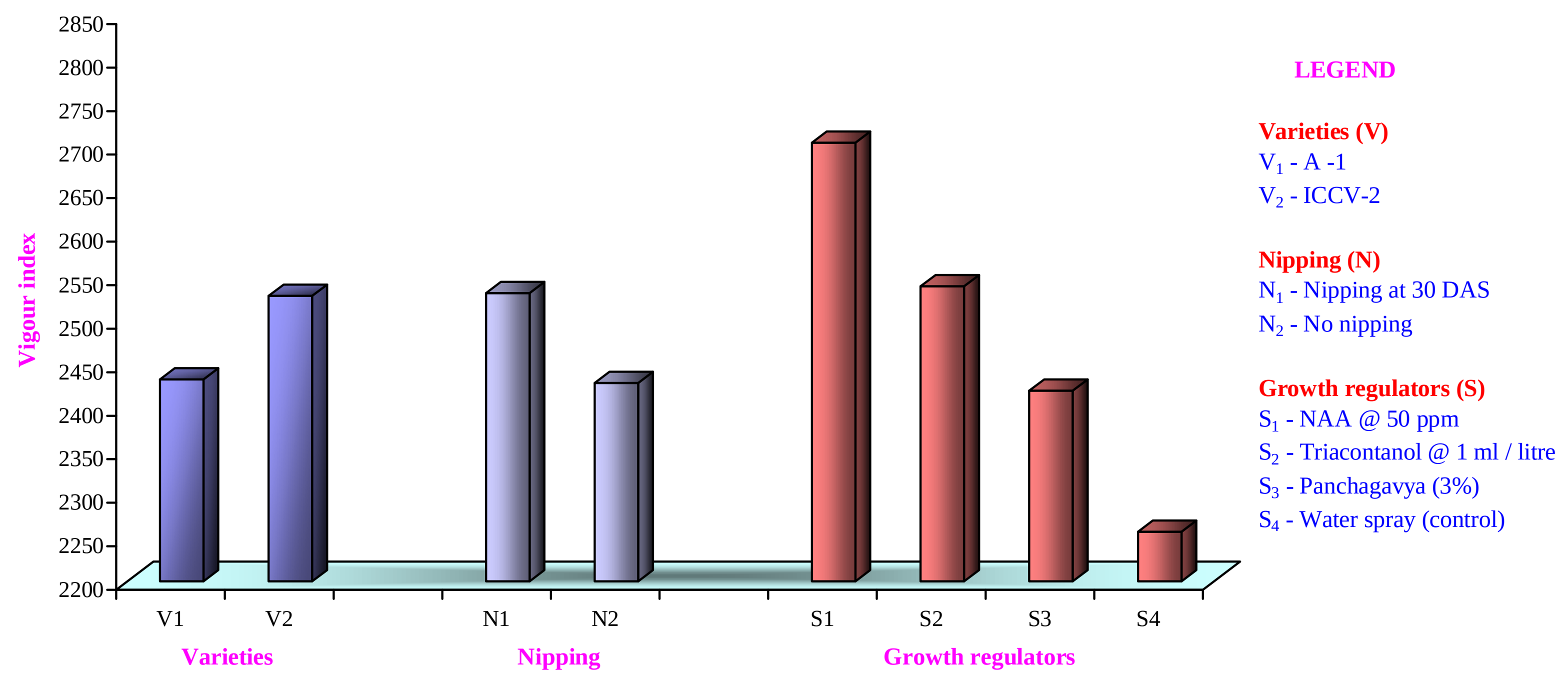


Fig. 8 : Effect of nipping, growth regulators on seedling vigour index in chickpea varieties

recorded in combination of V_2S_1 followed by V_2S_2, V_2S_3 and V_1S_1 (184.26, 179.05 and 178.91 mg) respectively. The less (155.14 mg) seedling dry weight was recorded in V_1S_4.

Due to interaction of nipping and growth regulators spray (NxS)

No significant differences were noticed on seedling dry weight between interactions of nipping and growth regulators sprays. Numerically more (187.32 mg) seedling dry weight was noticed with N_1S_1 and less (157.73 mg) with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

Seedling dry weight did not differ markedly due to interactions of varieties, nipping and growth regulators spray. Relatively maximum (193.34 mg) seedling dry weight was recorded with $V_2N_1S_1$ followed by $V_2N_1S_2$ (190.20 mg), $V_2N_1S_3$ (186.05 mg) and minimum (150.93 mg) in $V_1N_2S_4$.

4.1.3.6 Vigour index

The data on vigour index as influenced by varieties, nipping, growth regulators spray and their interaction effects are presented in Table 8 and depicted in Fig. 8.

Due to varieties (V)

Significant difference on vigour index was noticed between varieties. ICCV-2 recorded significantly higher (2528) vigour index over A-1 (2432).

Due to nipping (N)

Significant difference was noticed due to nipping treatment with respect to vigour index. Markedly maximum (2531) vigour index was noticed in nipping treatment (N_1) over no nipping (2428) N_2.

Due to growth regulators (S)

Vigour index found to differ markedly among the growth regulators spray. Markedly maximum (2704) vigour index was noticed with S_1 treatment followed by S_2 (2539) and was minimum (2257) with S_4.

Due to interaction of variety and nipping (VxN)

No significant differences were noticed on vigour index due to interaction of varieties and nipping. However, relatively higher and lower (2604 and 2405) vigour index was recorded in V_2N_1 and V_1N_2 respectively.

Due to interaction of variety and growth regulators (VxS)

Vigour index did not markedly differ due to variety and growth regulators spray. While, relatively more (2768) vigour index was noticed in V_2S_1 and less (2214) in V_1S_4.

Due to interaction of nipping and growth regulators spray (NxS)

The interaction between nipping and growth regulators sprays did not differ significantly on vigour index. While, numerically maximum (2803) vigour index was recorded in N_1S_1 and minimum (2233) with N_2S_4.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

Significant differences were not noticed on vigour index due to interactions of varieties, nipping and growth regulators spray. The vigour index was comparatively more (2919) with $V_2N_1S_1$ followed by $V_1N_1S_1$ (2688), $V_2N_1S_2$ (2652) and minimum (2202) with $V_1N_2S_4$.

4.1.3.7 Electrical conductivity (dSm^{-1})

The results on electrical conductivity as influenced by varieties, nipping, growth regulators spray and their interaction effects are presented in Table 8.

Due to varieties (V)

The electrical conductivity found to differ significantly between varieties. It was significantly more (0.491 dSm^{-1}) with ICCV-2 compared to A-1 (0.395 dSm^{-1}).

Due to nipping (N)

Nipping treatment found to differ significantly on electrical conductivity. In no nipping (N_2) treatment maximum (0.460 dSm^{-1}) EC was recorded over nipping (N_1) (0.426 dSm^{-1}) treatment.

Due to growth regulators (S)

Electrical conductivity was found to differ markedly due to growth regulators spray. It was maximum (0.463 dSm^{-1}) with S_4 followed by S_3 (0.448 dSm^{-1}) and minimum (0.424 dSm^{-1}) with S_1 treatment.

Due to interaction of variety and nipping (VxN)

The interaction between varieties and nipping showed significant differences on EC. Significantly more (0.505 dSm^{-1}) EC was recorded with (V_2N_2) followed by V_2N_1 (0.477dSm^{-1}) and significantly less (0.375 dSm^{-1}) was recorded in V_1N_1 treatment.

Due to interaction of variety and growth regulators (VxS)

No significant differences were seen on EC due to interaction of variety and growth regulators spray. However, relatively more (0.516 dSm^{-1}) EC was recorded in V_2S_4 and less (0.384 dSm^{-1}) with V_1S_1.

Due to interaction of nipping and growth regulators spray (NxS)

The EC did not differ significantly due to interaction of nipping and growth regulators sprays. Relatively maximum (0.479 dSm^{-1}) EC was recorded with N_2S_4 followed by N_2S_3 (0.467dSm^{-1}) and minimum (0.410 dSm^{-1}) with N_1S_1.

Due to interaction of varieties, nipping and growth regulators spray (VxNxS)

EC did not differ significantly due to interactions varieties, nipping and growth regulators spray. Numerically maximum (0.528 dSm^{-1}) EC was recorded with $V_2N_2S_4$ and minimum (0.368 dSm^{-1}) with $V_1N_1S_1$.

4.2 Experiment - II : Influence of Seed Size on Plant Growth, Seed Yield and Quality Parameters in Chickpea Varieties

4.2.1 Plant height (cm)

The data on plant height at 30, 60 DAS and at harvest as influenced by varieties, seed sizes and their interaction are presented in Table 9.

The average plant height was found to increase from 22.46 cm at 30 DAS to 51.14 cm at harvest

Due to Varieties (V)

The plant height at 30 DAS differed significantly due to varieties irrespective of seed size and the highest (23.52 cm) plant height was recorded in BGD-103 (V_5) variety followed by Bheema (23.18 cm) and was lowest (20.55 cm) in A-1 (V_1).

At 60 DAS, the plant height differed significantly due to varieties. Irrespective of seed sizes BGD-103 (V_5) recorded significantly higher (46.59 cm) plant height closely followed by Bheema (46.52 cm) and KAK-2 (45.08 cm) and lower (36.98 cm) plant height was recorded in V_1 (A-1).

Plant height at harvest showed significant difference between varieties irrespective of seed sizes. BGD-103 (V_5) recorded significantly the highest plant height (53.93 cm), while A-1 (V_1) recorded significantly lowest (46.13 cm) plant height.

Due to seed size

Irrespective of varieties, the significant differences on plant height were recorded at 30 DAS. Among the seed sizes, big seeds recorded highest (23.14 cm) plant height followed by medium (22.62 cm) and lowest (21.79 cm) in small seed grade (G_1).

Table 9. Effect of seed size on plant height in chickpea varieties

Treatments	Plant height (cm)														
	30 DAS					60 DAS					At harvest				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	19.70	20.77	21.47	20.27	20.55	34.50	36.83	38.43	38.17	36.98	43.17	46.73	47.93	46.70	46.13
V_2	21.19	22.33	23.13	22.27	22.23	38.00	39.00	38.00	37.00	38.00	48.00	50.70	51.57	49.00	49.82
V_3	22.37	23.27	23.83	21.77	22.81	43.50	45.60	46.70	44.50	45.08	51.13	52.93	53.67	51.87	52.40
V_4	22.90	23.03	23.20	23.57	23.18	44.63	46.23	48.33	46.87	46.52	52.53	53.83	54.47	52.87	53.44
V_5	22.80	23.70	24.07	23.50	23.52	46.17	47.20	48.73	44.27	46.59	53.53	54.27	54.53	53.43	53.93
Mean	21.79	22.62	23.14	22.27	22.46	41.23	42.84	43.92	42.02	42.63	49.67	51.69	52.43	50.77	51.14

Comparison for means of	30 DAS S.Em±	30 DAS CD (5%)	60 DAS S.Em±	60 DAS CD (5%)	At harvest S.Em±	At harvest CD (5%)
V	0.21	0.59	0.57	1.63	1.35	0.47
G	0.18	0.53	0.51	1.46	1.21	0.42
VxG	0.41	NS	1.14	NS	2.71	NS

NS- Non Significant

Varieties (V)	Seed size (G)
V_1- A-1	G_1- Small
V_2- ICCV-2	G_2- Medium
V_3- KAK-2	G_3- Big
V_4- Bheema	G_4- Bulk
V_5- BGD -103	

At 60 DAS, big seeds recorded significantly higher plant height (43.92 cm) and was on par with medium (42.84 cm). The lowest plant height of 41.23 cm was recorded in small seeds (G_1).

Seeds of different sizes varied significantly for plant height at harvest. The big seeds recorded significantly higher plant height (52.43 cm) over other treatments. But it was on par with medium (51.69 cm) and bulk (50.77 cm) seeds while, small seeds recorded lowest (49.67 cm) plant height at harvest.

Due to interaction of varieties and seed size

Interaction effect of varieties and seed size (VxG) on plant height at 30 DAS was not significant. However, V_5G_3 recorded numerically maximum plant height (24.07 cm) followed by V_5G_2 (23.70 cm) and V_5G_4 (23.50 cm) and was minimum in case of V_1G_1 (19.70 cm).

No significant difference was seen on plant height at 60 DAS due to interaction of varieties and seed size. However, numerically higher plant height (48.73 cm) was recorded in big seeds of BGD-103 (V_5G_3) followed by V_4G_3 (48.33 cm) while, lowest 34.50 cm plant height was seen with $V_1G_{1.}$

The interaction of varieties and seed size did not differ significantly on plant height at harvest. Among different combinations, V_5G_3 recorded highest (54.53 cm) followed by V_4G_3 (54.47 cm) and V_3G_3 (53.67 cm) and lowest (43.17 cm) plant height was in V_1G_1 at harvest.

4.2.2 Number of branches

The data on number of branches at 30, 60 DAS and at harvest as influenced by varieties, seed size and their interaction are presented in Table 10 and depicted in Fig. 9.

Due to varieties

Irrespective of seed sizes, the number of branches at 30 DAS due to varietal differences did differ significantly. The highest number of branches (4.00) was recorded with BGD-103 variety followed by Bheema (3.97) and lowest (3.58) in ICCV-2 at 30 DAS.

Number of branches at 60 DAS showed significant difference among varieties irrespective of seed sizes. A-1 (V_1) recorded significantly the highest number of branches (18.80) and was on par with BGD-103 (18.52) and Bheema (18.32) while, ICCV-2 (V_2) recorded significantly the lowest (15.91) number of branches at 60 DAS.

Significant differences were seen on the number of branches at harvest due to the varieties irrespective of seed sizes. Among the varieties, A-1 (V_1) recorded significantly maximum (23.52) number of branches at harvest followed by BGD-103 and Bheema (22.43 and 22.04 respectively). Significantly minimum (19.77) number of branches were noticed in variety ICCV-2 (V_2).

Due to seed size

No significant differences on number of branches at 30 DAS was noticed among the seed size. However, numerically highest (3.91) number of branches at 30 DAS was recorded in big seeds and lowest (3.72) in small seeds.

At 60 DAS, big seeds (G_3) recorded significantly highest number of branches (18.67) followed by bulk and medium (17.79 and 17.65) seeds respectively. The lowest (16.41) number of branches was recorded in small seeds (G_1).

The number of branches at harvest showed significant differences due to seed sizes. Irrespective of seed size, the big seeds recorded maximum (23.51) number of branches followed by medium seeds (22.43) and minimum (20.13) were recorded in small seeds.

Due to interaction of varieties and seed size

The interaction effect due to varieties and seed size (VxG) on number of branches at 30 DAS was not significant. However, $V_4G_{3,}$ V_5G_3 recorded numerically more number of branches (4.07 each) followed by $V_4G_{4,}$ $V_5G_{2,}$ $V_5G_{4,}$ and V_2G_1 (4.0 each) and V_2G_1 recorded less (3.47) at 30 DAS.

The interaction effect between varieties and seed size showed non-significant differences on number of branches at 60 DAS. However, treatment V_1G_3 recorded

Table 10. Effect of seed size on number of branches in chickpea varieties

Treatments	Number of branches														
	30 DAS					60 DAS					At harvest				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	3.53	3.67	3.67	3.67	3.63	18.00	19.40	19.67	18.13	18.80	21.93	23.73	24.33	24.07	23.52
V_2	3.47	3.60	3.73	3.53	3.58	14.57	15.73	16.73	16.60	15.91	18.53	18.47	21.73	21.33	19.77
V_3	3.80	3.87	4.00	3.80	3.87	15.73	16.53	17.47	16.67	16.60	19.13	22.33	22.67	21.07	21.30
V_4	3.87	3.93	4.07	4.00	3.97	17.20	18.33	19.20	18.53	18.32	19.07	23.37	24.00	21.73	22.04
V_5	3.93	4.00	4.07	4.00	4.00	16.57	18.23	20.27	19.00	18.50	21.00	23.27	23.80	21.67	22.43
Mean	3.72	3.81	3.91	3.80	3.81	16.41	17.65	18.67	17.79	17.63	20.13	22.43	23.51	21.97	22.01
Comparison for means of	S.Em±		CD (5%)			S.Em±		CD (5%)			S.Em±		CD (5%)		
V	0.06		0.18			0.26		0.76			0.34		0.96		
G	0.06		NS			0.24		0.68			0.30		0.86		
VxG	0.12		NS			0.53		NS			0.67		NS		

NS- Non Significant

Varieties (V)	Seed size (G)
V_1- A-1	G_1- Small
V_2- ICCV-2	G_2- Medium
V_3- KAK-2	G_3- Big
V_4- Bheema	G_4- Bulk
V_5- BGD -103	

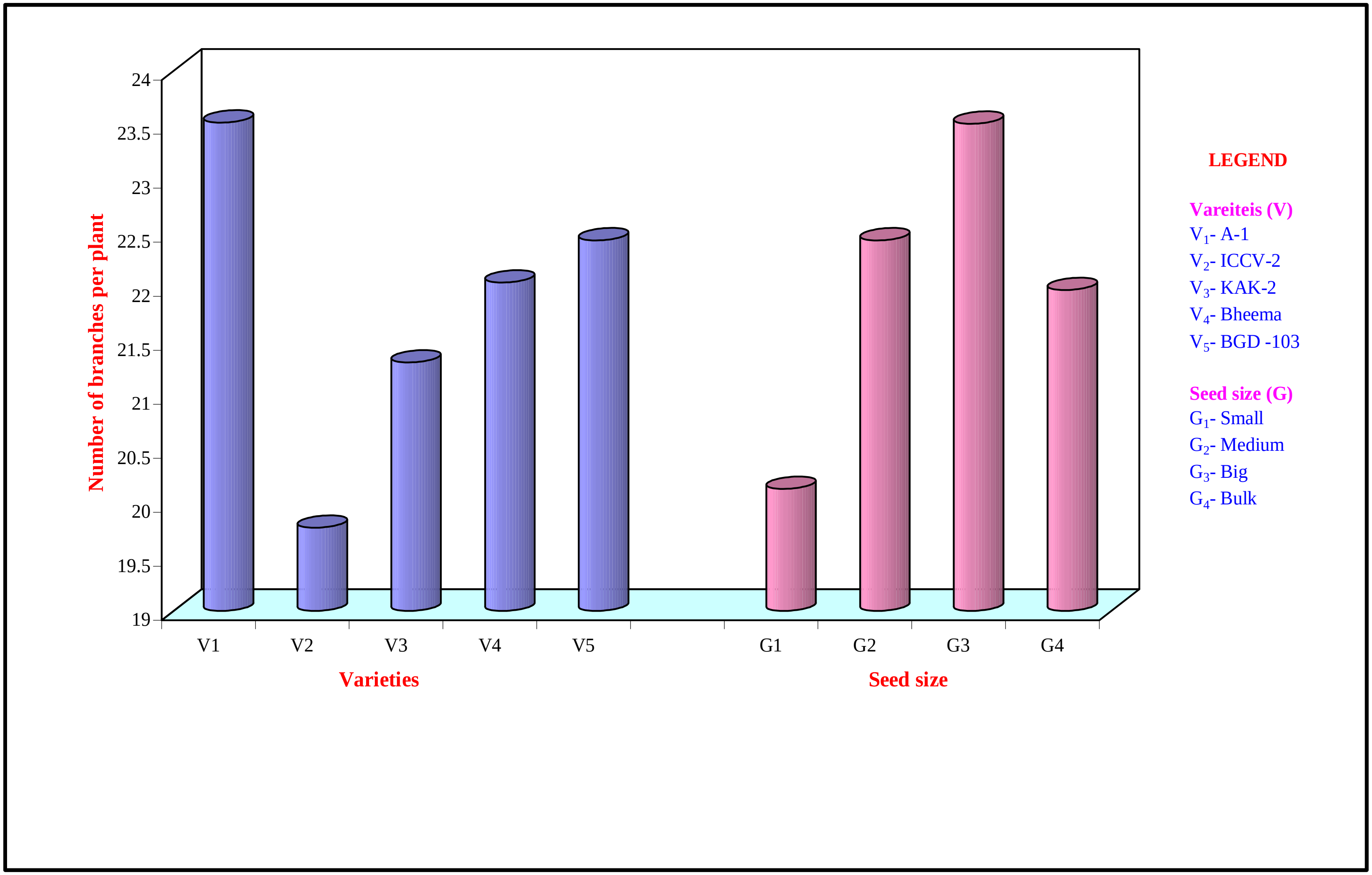


Fig. 9 : Effect of seed size on number of branches per plant in chickpea varieties

Table: 11. Effect of seed size on days to 50 per cent flowering in chickpea genotypes

Treatments	50 % Flowering				
	G_1	G_2	G_3	G_4	Mean
V_1	52.33	52.67	52.00	52.67	52.42
V_2	47.00	46.00	44.67	45.33	45.75
V_3	48.67	48.67	46.67	48.00	48.00
V_4	54.67	54.67	53.67	54.33	54.33
V_5	54.00	54.33	53.00	53.67	53.75
Mean	51.33	51.27	50.00	50.80	50.85
Comparison for means of		S.Em±		CD (5%)	
V		0.48		1.37	
G		0.43		NS	
VxG		0.96		NS	

NS- Non Significant

V_1- A-1 V_2- ICCV-2 V_3- KAK-2 V_4- Bheema V_5- BGD -103

G_1- Small G_2- Medium G_3- Big G_4- Bulk

numerically higher (20.27) number of branches at 60 DAS followed by V_5G_3 and V_3G_3 (19.67 and 19.47) respectively. The minimum (14.57) number of branches was recorded in treatment V_2G_1 at 60 DAS.

The interaction of varieties and seed size did not show significant influence on number of branches at harvest, however were numerically higher in V_1G_3 (24.33) and closely followed by V_1G_4 (24.07), V_4G_3 (24.00) and V_5G_3 (23.80) and lower (18.47) in V_2G_2 treatment.

4.2.3 Days to 50 per cent flowering

The data on days to 50 per cent flowering as influenced by varieties, seed sizes and their interaction are presented in Table 11.

Days to 50 per cent flowering differed significantly due to varieties. More number (54.33 days) of days was taken for 50 per cent flowering in Bheema (V_4), and less in ICCV-2 (45.75 days).

Among the seed size numerically more (51.33) number of days were taken by small seeds to attain 50 per cent flowering and numerically less (50.00) days by big seeds irrespective of varieties.

The number of days to 50 per cent flowering did not differ significantly due to interactions of varieties and the seed size. However, numerically more number of days (54.67) to attain 50 per cent flowering were taken by V_4G_1 followed by V_4G_2 (54.33) and less (44.67) days by V_2G_1.

4.2.4 Number of pods per plant

The results on number of pods per plant as influenced by varieties, seed sizes and their interaction are presented in Table 12 and depicted in Fig. 10.

Among the varieties, BGD-103 (V_5) recorded significantly higher number of pods per plant (68.98) followed by Bheema (66.59) and significantly lower (38.65) number of pods per plant were recorded in ICCV-2 (V_2).

The seed size differed significantly for number higher pods per plant and were more (55.47) in big size seeds followed by medium and bulk (54.74 and 54.58 respectively) and lower (51.93) in small size seeds (G_1).

The interaction effects due to varieties and seed size were found non-significant for number of pods per plant. The V_5G_2 recorded numerically higher (70.33) number of pods per plant followed by V_5G_3 (69.17), V_5G_4 (69.73) combinations. The minimum (36.60) pods per plant was observed in V_2G_1 treatment.

4.2.5 Pod weight (g) per plant

The results on pod weight per plant as influenced by varieties, seed sizes and their interaction are presented in Table 12.

The pod weight per plant showed significant differences among the varieties irrespective of seed sizes. Significantly more (32.85 g) pod weight per plant was recorded in variety BGD-103 (V_5) followed by Bheema (32.21 g) while less (19.14 g) was recorded in variety ICCV-2.

Among the different seed size, big seeds recorded significantly highest (26.69 g) pod weight per plant followed by bulk and medium (26.07 and 26.05 g, respectively). While, lowest (24.46 g) pod weight was recorded in small seeds.

Interaction effect due to varieties and seed sizes were found non-significant on pod weight per plant. However, V_5G_2 recorded numerically maximum (33.46g) by V_5G_3 (33.22 g) and V_4G_3 (32.95 g) and minimum (18.27 g) pod weight per plant was in V_1G_1 treatment.

4.2.6 Number of seeds per pod

The data on number of seeds per pod as influenced by varieties, seed size and their interactions are presented in Table 12.

Table: 12. Effect of seed size on number of pods per plant, pod weight per plant and seeds per pod in chickpea genotypes

Treatments	Number of pods per plant					Pod weight (gm)per plant					Seeds per pod				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	51.53	56.80	59.00	58.23	56.39	18.27	21.21	21.81	19.93	20.30	1.56	1.60	1.67	1.56	1.60
V_2	36.60	39.07	38.43	40.50	38.65	18.56	18.63	20.01	19.37	19.14	1.33	1.44	1.60	1.44	1.46
V_3	40.10	41.33	42.33	38.57	40.58	21.17	26.16	25.47	25.53	24.58	1.00	1.00	1.00	1.00	1.00
V_4	64.73	66.53	68.43	66.67	66.59	32.31	30.80	32.95	32.77	32.21	1.00	1.00	1.00	1.00	1.00
V_5	66.67	70.33	69.17	69.73	68.98	32.01	33.46	33.22	32.73	32.85	1.00	1.00	1.00	1.00	1.00
Mean	51.93	54.81	55.47	54.74	54.24	24.46	26.05	26.69	26.07	25.82	1.18	1.21	1.25	1.20	1.21
Comparison for means of		S.Em±		CD (5%)			S.Em±		CD (5%)			S.Em±		CD (5%)	
V		0.85		2.44			0.44		1.25			0.04		0.10	
G		0.76		2.18			0.39		1.12			0.03		NS	
VxG		1.70		NS			0.88		NS			0.07		NS	

NS- Non Significant

V_1- A-1 V_2- ICCV-2 V_3- KAK-2 V_4- Bheema V_5- BGD -103

G_1- Small G_2- Medium G_3- Big G_4- Bulk

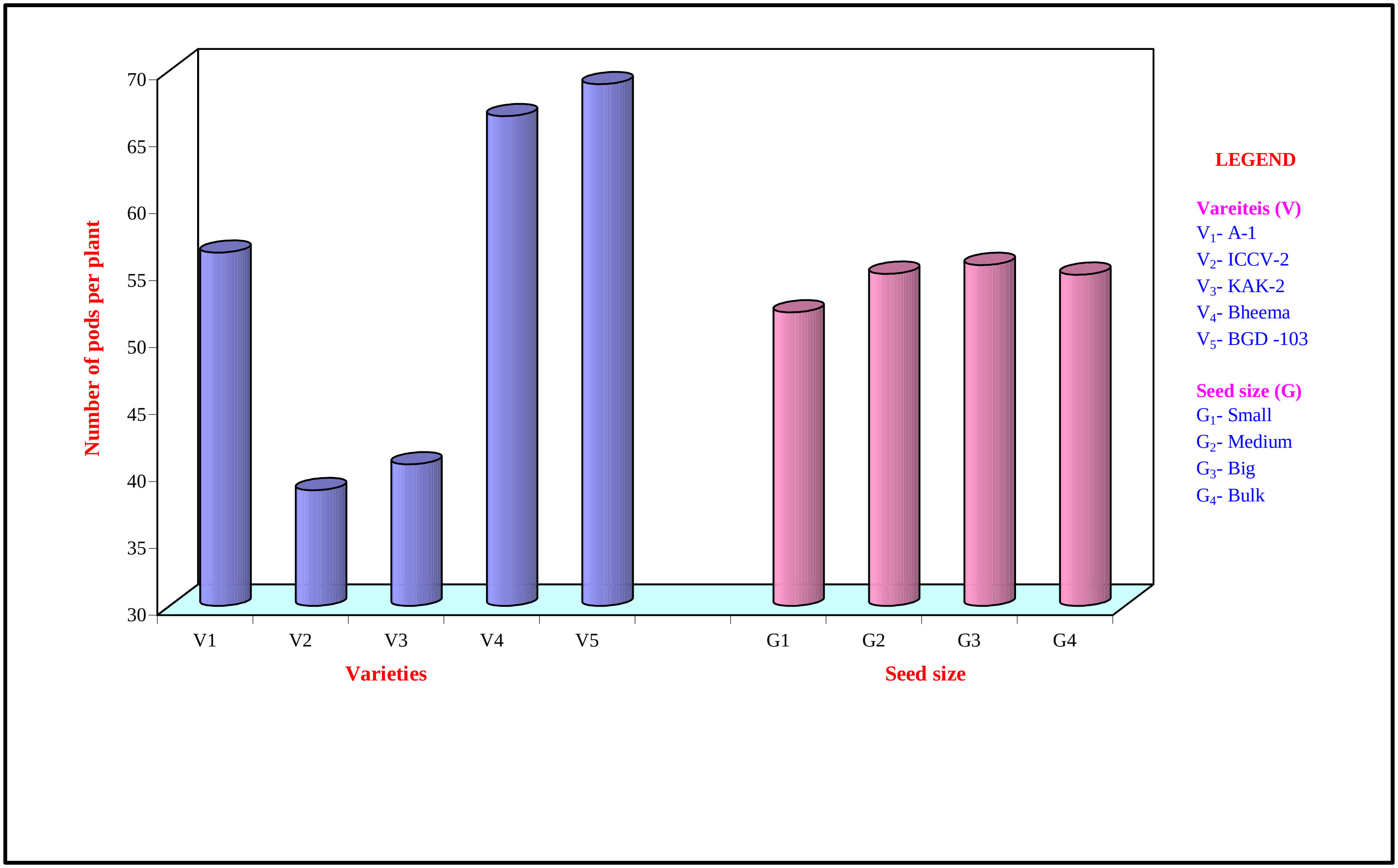


Fig. 10 : Effect of seed size on number of pods per plant in chickpea varieties

Among the varieties, A-1 (V_1) recorded significantly maximum (1.60) number of seeds per pod while the minimum (1.00) seeds per pod were recorded in BGD-103, Bheema and KAK-2 respectively.

The number of seeds per pod did not differ significantly due to seed size. However, big size seeds recorded numerically higher (1.25) seeds per pod while, small size seeds recorded numerically lower (1.18) seeds per pod.

The interaction effect due to varieties and seed size recorded non-significant differences on number of seeds per pod. However, numerically maximum (1.67) seeds per pod were recorded in V_1G_3 while, treatment combinations of V_3G_1 to V_5G_4 recorded each one seed per pod.

4.2.7 Seed yield per plant (g)

The result on seed yield per plant as influenced by variety, seed size and their interactions are presented in Table 13.

The seed yield per plant differed significantly due to varieties irrespective of seed sizes. Among the different chickpea varieties BGD-103 recorded highest (14.15 g) seed yield followed by Bheema (14.00 g) while, ICCV-2 recorded significantly lowest (11.00 g) seed yield per plant.

Among the seed sizes, big size seeds showed significant difference and recorded more (13.63 g) seed yield per plant followed by medium (13.29 g). However, small size seeds recorded significantly less (12.29 g) seed yield per plant.

Interaction effects due to varieties and seed sizes were found significant for seed yield per plant. The treatment combination of V_5G_3 recorded highest (14.92 g) followed by V_4G_3 (14.62 g), V_5G_2 (14.42 g) and V_4G_3 (14.13 g) seed yield per plant. While, significantly lowest seed yield per plant (10.02 g) was recorded in small seeds of ICCV-2 variety (V_2G_1).

4.2.8 Seed yield per plot (kg)

The data on seed yield per plot as influenced by variety, seed size and their interactions are presented in Table 13.

The varieties differed significantly for seed yield per plot. BGD-103 (V_5) recorded maximum seed yield per plot (1.25 kg) followed by Bheema (1.23 kg). While, the minimum (1.00 kg) was recorded in ICCV-2 (V_2).

The seed yield per plot differed significantly due to seed sizes. The big seeds recorded significantly highest (1.19 kg) seed yield per plot over other seed sizes and it was followed by medium size (1.16 kg). The lowest (1.10 kg) seed yield per plot was recorded in small seeds.

The interaction due to varieties and seed size did not show significant differences for seed yield per plot. However, it was relatively higher (1.28 kg) in V_5G_2 followed by $V_5G_{4,}$ V_3G_3 (1.26 kg) and lower (0.97 kg) seed yield per plot in V_2G_1 and V_2G_3 treatment.

4.2.9 Seed yield per hectare (q)

The results on seed yield per ha as influenced by varieties, seed sizes and their interactions are presented in Table 13 and depicted in Fig. 11.

The varieties varied significantly for seed yield per ha wherein BGD-103 (V_5) recorded significantly higher seed yield per ha (34.72.q) followed by Bheema (34.14 q) and KAK-2 (32.73q). However, lower (27.66 q) seeds per ha was observed in ICCV-2 (V_2) variety.

Significant differences were seen on the seed yield per ha due to seed sizes. Among the seed size, big seeds recorded significantly more (33.11 q) seed yield per ha followed by medium (32.05), bulk (31.37 q) and less (30.52 q) in small seeds irrespective of the varieties.

Seed yield per ha did not differ significantly due to interaction of varieties and seed sizes. It was numerically maximum (35.46 q) inV_5G_3 and was followed by V_5G_2 (35.09 q) and 35.00 q in V_3G_3. The minimum seed yield per ha was recorded in V_1G_4 (26.30 q).

Table: 13. Effect of seed size on seed yield per plant, per plot and per hectare in chickpea genotypes

Treatments	Seed yield per plant (g)					Seed yield per plot (kg)					Seed yield per hectare (q)				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	11.50	13.07	13.63	12.50	12.68	1.02	1.09	1.20	0.95	1.06	28.24	30.28	33.43	26.30	29.56
V_2	10.02	11.56	11.69	10.74	11.00	0.97	0.98	0.97	1.07	1.00	26.85	27.13	27.04	29.63	27.66
V_3	12.08	13.27	13.27	12.71	12.83	1.10	1.20	1.26	1.15	1.18	30.65	33.24	35.00	32.04	32.73
V_4	13.50	14.13	14.62	13.75	14.00	1.20	1.24	1.25	1.22	1.23	33.43	34.54	34.63	33.98	34.14
V_5	13.37	14.42	14.92	13.88	14.15	1.20	1.28	1.26	1.26	1.25	33.43	35.09	35.46	34.91	34.72
Mean	12.29	13.29	13.63	12.92	13.03	1.10	1.16	1.19	1.13	1.14	30.52	32.05	33.11	31.37	31.76
Comparison for means of		S.Em±		CD (5%)			S.Em±		CD (5%)			S.Em±		CD (5%)	
V		0.34		0.99			0.02		0.06			0.62		1.78	
G		0.31		0.88			0.02		NS			0.56		NS	
VxG		0.69		1.97			0.04		NS			1.76		NS	

NS- Non Significant

V_1- A-1 V_2- ICCV-2 V_3- KAK-2 V_4- Bheema V_5- BGD -103

G_1- Small G_2- Medium G_3- Big G_4- Bulk

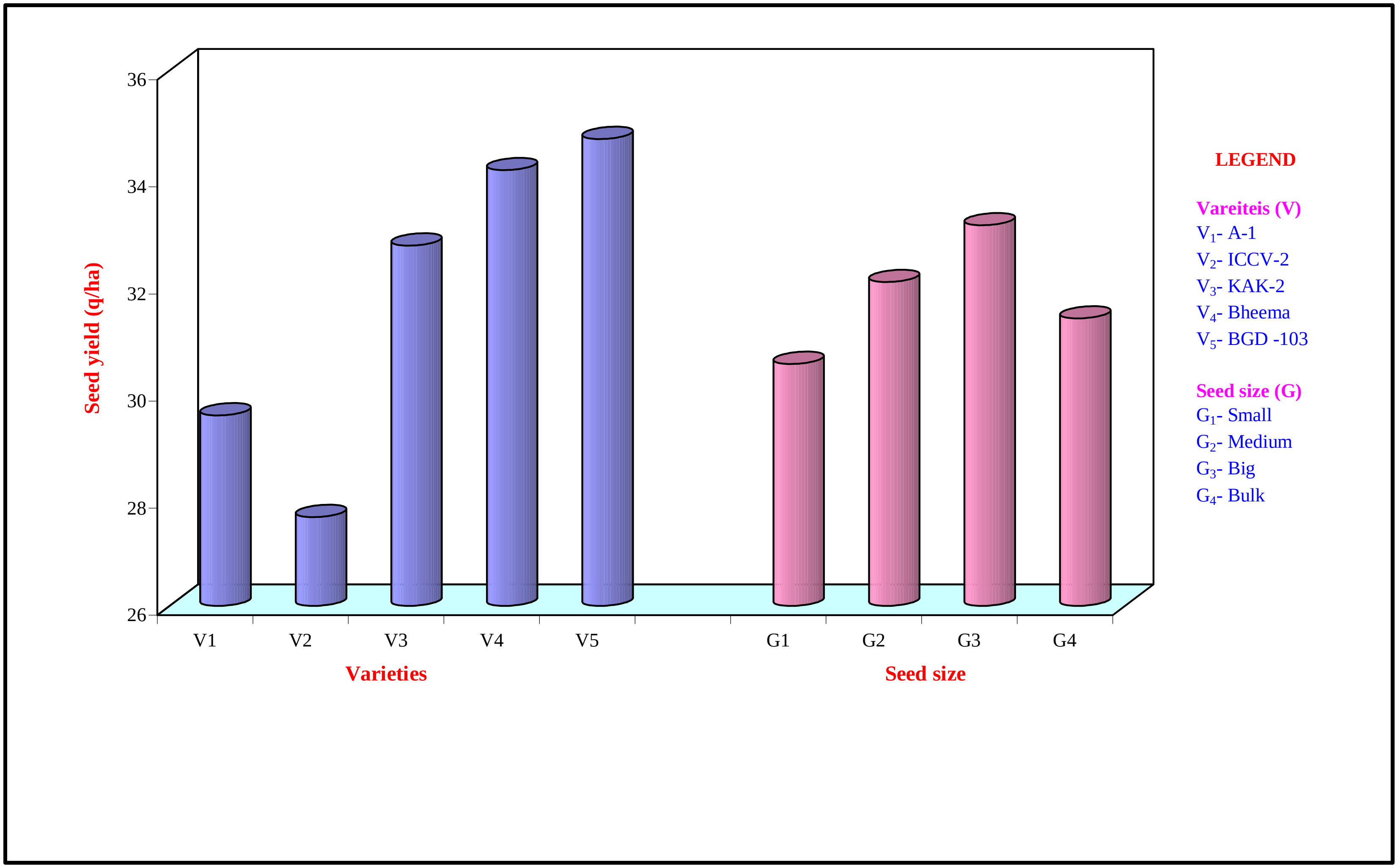


Fig. 11 : Effect of seed size on seed yield per hectare (q) in chickpea varieties

Table: 14. Effect of seed size on hundred seed weight, germination percentage and speed of germination in chickpea genotypes

Treatments	100 seed weight (gm)					Germination (%)					Speed of germination				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	23.03	23.92	24.03	23.83	23.70	94.67 (75.02)	95.00 (76.21)	97.33 (79.54)	96.89 (78.78)	95.97 (77.39)	49.23	47.30	46.76	48.07	47.84
V_2	25.86	26.2	26.69	26.17	26.23	93.78 (77.23)	94.00 (78.49)	94.11 (78.77)	93.78 (78.17)	93.92 (78.16)	52.50	48.53	46.37	49.12	49.13
V_3	36.77	37.8	38.21	37.65	37.61	94.78 (76.77)	95.56 (77.80)	95.78 (78.21)	95.44 (77.65)	95.39 (77.61)	47.87	48.90	49.79	49.27	48.96
V_4	37.34	38.77	39.36	38.11	38.40	95.22 (77.34)	96.22 (78.77)	96.44 (79.36)	95.78 (78.11)	95.92 (78.40)	45.33	45.33	44.63	45.61	45.23
V_5	37.4	39.27	39.59	38.33	38.65	95.22 (77.40)	96.54 (79.27)	96.67 (79.59)	95.89 (78.33)	96.08 (78.65)	45.94	46.38	47.70	46.71	46.68
Mean	32.08	33.19	33.58	32.82	32.92	94.73 (76.75)	95.46 (78.11)	96.07 (79.09)	95.56 (78.21)	95.45 (78.04)	48.17	47.29	47.05	47.75	47.57
Comparison for means of		S.Em±		CD (5%)			S.Em±		CD (5%)			S.Em±		CD (5%)	
V		0.27		0.78			0.37		NS			0.83		NS	
G		0.24		NS			0.33		0.99			0.74		NS	
VxG		0.54		NS			0.74		NS			1.66		NS	

NS- Non Significant

V_1- A-1 V_2- ICCV-2 V_3- KAK-2 V_4- Bheema V_5- BGD -103

G_1- Small G_2- Medium G_3- Big G_4- Bulk

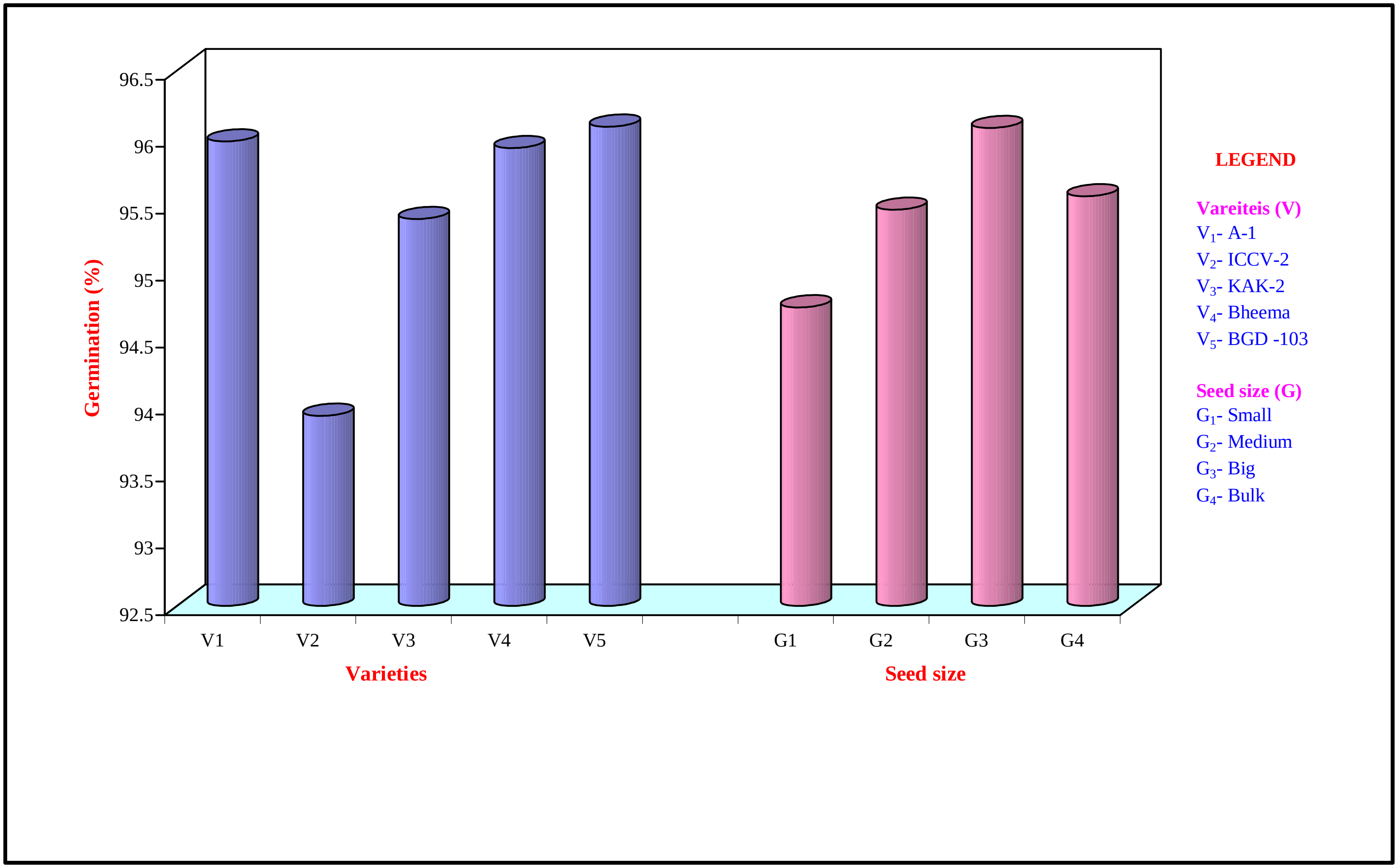


Fig. 12 : Effect of seed size on germination percentage in chickpea varieties

4.2.10 Hundred seed weight (g)

The data on 100 seed weight as influenced by varieties, seed size and their interactions are presented in Table 14.

The varieties showed significant differences on seed weight irrespective of seed size. Among the varieties BGD-103 recorded significantly higher seed weight (38.65 g) over all other varieties. Whereas, lower (23.71 g) 100 seed weight was recorded in A-1 variety (V_1).

There was no significant difference for 100 seed weight among the seed size but numerically maximum 100 seed weight (33.58 g) was recorded in big seeds than other seed size. While, minimum (32.82 g) 100 seed weight was noticed in bulk seeds.

No significant difference was seen due to interaction of varieties and seed size on 100 seed weight. While, numerically higher (39.59 g) test weight was recorded in V_5G_3 and was on par with V_4G_3 (39.36 g), V_5G_2 (39.27 g) and lower (23.03) in V_1G_1 treatment.

4.2.11 Germination (%)

The data recorded on germination percentage as influenced by varieties, seed size and their interactions effects are presented in Table 14 and depicted in Fig. 12.

Varieties showed non-significant effect on germination percentage. Numerically maximum germination was recorded in V_5 (96.08%) while, minimum (93.92%) germination percentage was observed in ICCV-2 varieties.

Significant difference in germination percentage was observed due to seed size irrespective of varieties. Significantly highest (96.07%) germination was recorded in big seeds (G_3). While, lowest (94.73%) was seen in small size seeds (G_1).

Interaction between varieties and seed size did not show any significant effect on germination. However, BGD-103 variety of big size seeds recorded numerically higher (96.67%) germination percentage while, lower (93.78%) germination was with small seeds of ICCV-2 variety.

4.2.12 Speed of germination

The data on speed of germination as influenced by variety, seed size and their interactions effects are presented in Table 14.

The varieties showed no significant difference on speed of germination. However ICCV-2 variety recorded numerically highest (49.13) speed of germination followed by KAK-2 (48.96) and lowest (45.23) was with Bheema variety.

Among the seed size, relatively highest (48.17) speed of germination was recorded in small size seeds followed by bulk (47.75) and lowest (47.05) in big size seeds.

Speed of germination due to interaction of variety and seed size did not differ significantly. Among the different combination of treatments, numerically maximum (52.50) speed of germination was recorded in V_2G_1 followed by V_3G_3 (49.79) and minimum (45.33) in V_4G_1 and V_4G_2 treatment.

4.2.13 Seedling length (cm)

The seedling length as influenced by variety, seed size and their interactions effects are presented in Table 15.

Irrespective of seed sizes, significant difference was seen in seedling length among the different varieties. Significantly higher (33.23 cm) seedling length was observed in BGD-103 variety followed by Bheema (32.99 cm) and lower (27.54 cm) in A-1 variety.

Among various seed sizes, maximum seedling length was recorded in big seeds (32.02 cm) followed by medium and bulk (31.60 and 31.26 cm respectively) and was minimum (30.28 cm) in small seeds (30.28 cm).

The interaction effect due to variety and seed size was not significant on seedling length. However, the longest seedling length was observed in V_5G_3 (34.20 cm) followed by V_5G_2 (33.89 cm), V_4G_3 (32.39 cm). While, lowest seedling length (25.87 cm) was recorded in V_1G_1 treatment.

Table 15. Effect of seedling length, dry weight and vigour index in chickpea varieties

Treatments	Seedling length (cm)					Seedling dry Weight (mg)				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	25.87	26.83	28.23	29.21	27.54	176.00	178.33	199.89	186.56	185.19
V_2	29.22	30.39	30.44	29.61	29.92	202.56	212.33	215.78	206.89	209.39
V_3	31.98	33.28	33.44	32.39	32.77	215.33	220.56	224.78	218.22	219.72
V_4	32.13	33.61	33.78	32.44	32.99	220.33	226.33	234.11	223.44	226.06
V_5	32.18	33.89	34.20	32.67	33.23	222.67	227.78	231.19	224.65	226.57
Mean	30.28	31.60	32.02	31.26	31.29	207.38	213.07	221.15	211.95	213.39

Comparison for means of	S.Em±	CD (5%)	S.Em±	CD (5%)
V	0.32	0.92	1.28	3.66
G	0.29	0.82	1.14	3.27
VxG	0.64	NS	2.56	NS

**iiirr

NS- Non Significant

Varieties (V)	Seed size (G)
V_1- A-1	G_1- Small
V_2- ICCV-2	G_2- Medium
V_3- KAK-2	G_3- Big
V_4- Bheema	G_4- Bulk
V_5- BGD -103	

4.2.14 Seedling dry weight (mg)

The seedling dry weight as influenced by variety, seed size and their interactions effects are presented in Table 15.

Among the varieties, BGD-103 (V_5) recorded significantly higher (226.57 mg) seedling dry weight and was on par with Bheema (226.06 mg) followed by KAK-2 (219.72 mg) and lower (185.19 mg) was recorded in A-1 variety.

The seed size showed significant variations for the seedling dry weight. The big size seeds (G_3) recorded significantly higher (221.15 mg) followed by medium (213.07 mg) and lower (207.38 mg) was recorded in small size seeds (G_1).

Significant difference was not seen for seedling dry weight due to interactions of variety and seed size. However, relatively highest (234.11 mg) seedling dry weight was recorded in V_4G_3 treatment and was on par with V_5G_3 (231.19 mg) and lowest (176.00 mg) was seen in V_1G_1 treatment.

4.2.15 Seedling vigour index (SVI)

The data on vigour index as influenced by variety, seed size and their interactions effects are presented in Table 16 and depicted in Fig. 13.

The seedling vigour index among the varieties showed significant differences, wherein the maximum(3193) vigour index was recorded in BGD-103 (V_5), followed by Bheema (3164) and KAK-2 (3126) while, minimum (2643) vigour index observed was in A-1.

Among different seed size, significantly higher vigour index was observed in big seeds irrespective of varieties. The maximum (3076) vigour index was recorded in big seeds followed by medium and bulk. Significantly lower (2868) vigour index was recorded with small seeds (G_1)

The interaction effects due to varieties and seed size show significant difference on vigour index. Markedly higher (3306) vigour index was recorded in big seeds of BGD-103 (V_5G_3), followed by $V_5G_{2,}$ V_4G_3 and was lower (2449) with small seeds of A-1 (V_1G_1)

4.2.16 Electrical conductivity (dSm^{-1})

The data on electrical conductivity as influenced by variety, seed size and their interactions effects are presented in Table 16.

The significant difference was seen on EC among different varieties. Significantly lowest (0.450 dSm^{-1}) EC was recorded in V_1 variety and highest (0.520) EC was in KAK-2 variety.

The seed size showed significant differences on EC values irrespective of varieties. Among the seed size, small size seeds recorded minimum (0.500 dSm^{-1}) EC followed by bulk (0.480 dSm^{-1}) while, big seeds recorded higher (0.507 dSm^{-1}).

Non significant difference was seen due to interaction of varieties and seed size on electrical conductivity. Numerically higher EC was recorded in V_3G_3 (0.53 dSm^{-1}) followed by V_5G_2 (0.52 dSm^{-1}) and lower (0.40 dSm^{-1}) in V_1G_1 treatment.

4.3 Experiment III : Effect of Seed Size on Storage Potential of Chickpea Varieties

4.3.1 Germination (%)

The data on germination percentage as influenced by varieties, seed size and their interactions are presented in Table 17 and depicted in Fig. 14.

Due to varieties (V)

The germination percentage at initial month did not show significant differences among the varieties. However, the maximum germination percentage recorded in BGD-103 and closely followed by Bheema (99.00%), A-1 (98.16%) and numerically less (97.75%) with KAK-2.

Table 16. Effect of seed size on electrical conductivity in chickpea varieties

Treatments	Vigour index					Electrical Conductivity (dSm^{-1})				
	G_1	G_2	G_3	G_4	Mean	G_1	G_2	G_3	G_4	Mean
V_1	1941	2045	2301	2245	2133	0.460	0.453	0.440	0.443	0.449
V_2	2257	2385	2396	2315	2338	0.517	0.507	0.510	0.517	0.513
V_3	2455	2589	2615	2515	2544	0.527	0.523	0.523	0.530	0.526
V_4	2485	2648	2677	2535	2586	0.517	0.517	0.507	0.520	0.515
V_5	2491	2687	2720	3142	2760	0.513	0.513	0.493	0.517	0.509
Mean	2326	2471	2542	2550	2472	0.507	0.503	0.495	0.505	0.502

Comparison for means of	S.Em±	CD (5%)	S.Em±	CD (5%)
V	24.00	72.00	0.01	0.041
G	22.00	65.00	0.01	NS
VxG	48.00	145.00	0.03	NS

NS- Non Significant

Varieties (V)	Seed size (G)
V_1- A-1	G_1- Small
V_2- ICCV-2	G_2- Medium
V_3- KAK-2	G_3- Big
V_4- Bheema	G_4- Bulk
V_5- BGD -103	

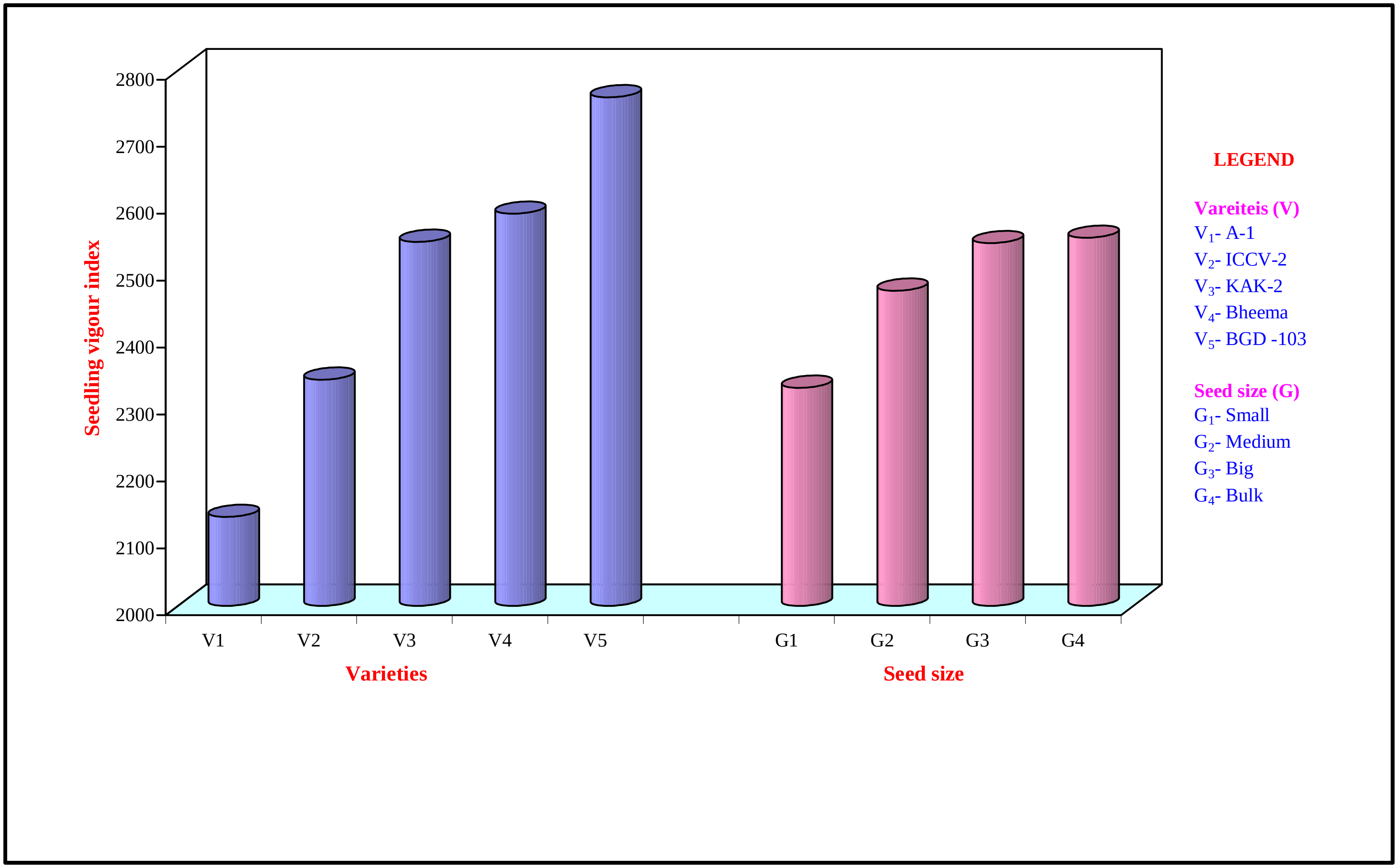


Fig. 13 : Effect of seed size on seedling vigour index in chickpea varieties

Table 17. Effect of seed size on seed germination in different chickpea genotypes during storage.

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	Germination (%)												
A-1 (V_1)	98.16 (83.00)*	97.50 (81.21)	96.42 (78.54)	95.83 (77.24)	93.58 (75.40)	90.97 (72.51)	89.92 (71.48)	88.67 (70.35)	86.33 (68.29)	85.20 (67.28)	83.33 (65.89)	79.83 (63.31)	75.50 (60.33)
ICCV-2 (V_2)	98.08 (82.52)	95.83 (78.37)	94.92 (77.16)	93.92 (75.78)	92.38 (74.12)	89.28 (70.87)	88.75 (70.42)	86.08 (68.15)	83.83 (66.30)	82.50 (65.29)	79.75 (63.24)	76.33 (60.89)	71.33 (57.63)
KAK-2 (V_3)	97.75 (82.32)	95.83 (78.39)	94.50 (76.52)	93.25 (74.98)	91.92 (73.58)	88.22 (70.00)	87.00 (68.89)	85.16 (67.41)	83.33 (65.92)	81.83 (64.80)	79.58 (63.13)	70.17 (60.10)	70.25 (56.95)
Bheema (V_4)	99.00 (85.67)	97.50 (81.32)	96.00 (78.54)	95.50 (77.99)	93.15 (74.89)	90.08 (71.65)	89.83 (71.42)	87.95 (69.73)	85.17 (67.35)	83.58 (66.10)	80.92 (64.09)	72.67 (61.84)	72.17 (58.15)
BGD-103 (V_5)	99.08 (86.21)	97.75 (81.56)	96.83 (80.24)	95.08 (78.37)	93.83 (75.62)	90.25 (71.82)	90.12 (71.73)	87.96 (69.68)	86.17 (68.16)	84.92 (67.18)	81.83 (64.79)	72.92 (61.28)	74.33 (59.56)
S.Em±	0.41	0.33	0.36	0.28	0.29	0.19	0.18	0.25	0.17	0.24	0.17	0.18	0.47
CD@1%	NS	1.27	1.37	1.08	1.12	0.74	0.69	0.96	0.66	0.90	0.64	0.69	1.81
Seed size													
Small (G_1)	98.90 (87.19)	97.20 (80.58)	96.13 (79.15)	95.07 (77.35)	93.47 (75.33)	90.73 (72.30)	89.80 (71.41)	87.65 (69.53)	85.53 (67.66)	84.13 (66.59)	81.87 (64.80)	75.13 (62.03)	74.40 (59.60)
Medium (G_2)	98.27 (83.34)	97.27 (81.04)	96.13 (78.84)	95.13 (77.43)	93.38 (75.18)	89.87 (71.45)	89.40 (71.05)	87.68 (69.50)	85.13 (67.33)	83.27 (65.86)	80.87 (64.06)	74.93 (61.84)	72.47 (58.37)
Big (G_3)	97.47 (81.04)	96.20 (79.00)	95.13 (77.51)	94.00 (75.97)	92.33 (74.01)	88.83 (70.49)	88.40 (70.19)	86.23 (68.23)	84.53 (66.85)	83.07 (65.76)	80.73 (63.99)	73.53 (60.90)	71.13 (57.51)
Bulk (G_4)	98.53 (84.20)	96.87 (80.03)	95.53 (77.92)	94.67 (76.74)	92.71 (74.38)	89.50 (71.16)	89.00 (70.66)	87.10 (68.99)	84.67 (66.98)	83.80 (66.28)	80.87 (64.07)	73.93 (61.16)	72.87 (58.62)
S.Em±	0.82	0.66	0.71	0.56	0.59	0.39	0.80	0.50	0.34	0.47	0.33	0.36	0.42
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Figures in parenthesis are transferred values

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	98.50 (84.34)	97.67 (81.40)	97.00 (78.95)	96.33 (78.07)	93.67 (75.33)	92.33 (73.90)	90.33 (71.86)	89.00 (70.71)	87.00 (68.85)	84.33 (66.67)	83.33 (65.88)	78.67 (62.51)	76.00 (60.66)
V_1G_2	98.33 (83.93)	98.00 (82.02)	96.67 (79.63)	96.00 (77.97)	94.33 (76.42)	91.33 (72.86)	90.33 (71.89)	89.67 (71.25)	86.33 (68.30)	84.33 (66.67)	83.00 (65.63)	80.33 (63.65)	76.33 (60.90)
V_1G_3	97.00 (80.09)	96.67 (79.90)	96.00 (77.09)	95.33 (75.82)	93.00 (74.65)	89.87 (71.42)	89.33 (70.93)	87.33 (69.15)	86.00 (68.02)	86.00 (68.19)	84.00 (66.40)	80.33 (63.66)	74.00 (59.32)
V_1G_4	98.33 (82.63)	97.67 (81.50)	96.00 (78.49)	95.67 (77.09)	93.33 (75.02)	90.33 (71.86)	89.67 (71.22)	88.67 (70.30)	86.00 (68.01)	85.33 (67.47)	83.00 (65.63)	80.00 (63.41)	75.67 (6046)
V_2G_1	98.50 (84.34)	96.33 (78.95)	95.33 (77.68)	94.00 (75.82)	93.00 (74.90)	90.00 (71.55)	89.00 (70.64)	86.00 (68.19)	84.33 (66.69)	83.33 (65.95)	80.67 (63.91)	75.67 (60.47)	74.00 (59.34)
V_2G_2	97.67 (82.80)	96.00 (78.82)	95.33 (77.84)	94.67 (76.74)	92.95 (74.59)	89.33 (70.99)	89.00 (70.65)	86.67 (68.11)	84.67 (66.93)	81.67 (64.65)	79.00 (62.90)	76.67 (61.11)	70.00 (56.77)
V_2G_3	97.00 (80.09)	95.00 (77.22)	94.00 (75.90)	93.00 (74.73)	91.67 (73.50)	88.33 (70.00)	88.33 (70.03)	85.67 (67.76)	84.00 (66.44)	82.00 (64.91)	79.00 (62.70)	75.33 (60.20)	69.00 (56.16)
V_2G_4	97.33 (81.04)	96.00 (78.49)	95.00 (77.22)	94.00 (75.88)	91.88 (73.47)	89.43 (70.01)	88.67 (70.35)	86.00 (68.03)	82.33 (65.13)	83.00 (65.64)	80.33 (63.65)	77.67 (61.78)	72.33 (58.17)
V_3G_1	98.53 (84.40)	96.00 (78.49)	94.67 (76.70)	93.33 (75.07)	92.67 (74.55)	89.67 (71.24)	88.00 (69.73)	85.67 (67.86)	83.67 (66.15)	83.33 (65.96)	81.00 (64.15)	70.67 (60.45)	72.67 (58.50)
V_3G_2	98.00 (82.02)	96.67 (79.57)	95.00 (77.19)	94.00 (75.82)	91.67 (73.31)	88.00 (69.71)	87.00 (68.88)	85.67 (67.80)	84.00 (66.50)	82.33 (65.14)	80.00 (63.41)	70.33 (60.20)	69.00 (56.15)
V_3G_3	97.67 (81.50)	95.00 (77.09)	94.00 (75.92)	92.67 (74.37)	91.67 (73.23)	87.53 (69.30)	86.33 (68.31)	84.13 (66.10)	83.00 (65.64)	80.33 (63.65)	79.00 (62.72)	70.00 (59.99)	68.00 (55.54)
V_3G_4	97.67 (81.22)	95.67 (78.03)	94.33 (76.82)	93.00 (74.65)	91.67 (73.23)	87.67 (69.74)	86.67 (68.64)	85.17 (67.47)	82.67 (65.38)	81.33 (64.42)	78.33 (62.25)	69.67 (59.76)	71.33 (57.64)

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_4G_1	99.00 (85.34)	98.00 (82.04)	96.33 (80.09)	96.00 (78.82)	94.00 (75.82)	91.00 (72.53)	90.67 (72.26)	88.90 (76.61)	86.33 (68.30)	84.33 (66.72)	81.00 (64.14)	76.67 (64.71)	74.00 (59.32)
V_4G_2	98.33 (82.63)	97.67 (82.80)	96.67 (79.47)	95.33 (77.84)	93.93 (75.74)	90.33 (71.89)	90.00 (71.55)	88.25 (69.97)	85.33 (67.47)	83.00 (65.63)	80.67 (63.89)	73.33 (62.24)	72.00 (58.05)
V_4G_3	98.00 (82.02)	97.00 (80.09)	95.00 (79.10)	95.00 (77.22)	92.00 (73.62)	89.00 (70.61)	88.67 (75.30)	87.00 (68.90)	84.00 (66.42)	83.00 (65.64)	81.67 (64.65)	70.00 (60.00)	70.00 (56.77)
V_4G_4	99.67 (88.05)	97.33 (80.61)	96.00 (78.64)	95.67 (78.07)	92.67 (74.37)	90.00 (71.55)	90.00 (71.45)	87.67 (69.43)	85.00 (67.22)	84.00 (66.40)	80.33 (63.67)	70.67 (60.42)	72.67 (58.46)
V_5G_1	99.00 (85.34)	98.00 (82.02)	97.33 (82.34)	95.67 (78.97)	94.00 (75.82)	90.67 (72.26)	91.00 (72.53)	88.67 (70.34)	86.33 (68.31)	85.33 (66.67)	83.33 (65.13)	74.00 (62.02)	75.33 (60.20)
V_5G_2	98.50 (85.04)	98.00 (82.02)	97.00 (80.09)	95.67 (78.82)	94.00 (75.82)	90.33 (71.89)	90.67 (72.26)	88.17 (69.85)	85.33 (67.46)	85.00 (67.19)	81.67 (64.65)	74.00 (62.01)	75.00 (60.00)
V_5G_3	97.67 (81.50)	97.33 (80.70)	96.67 (79.57)	94.00 (77.68)	93.33 (75.02)	89.40 (71.12)	89.33 (70.94)	87.00 (68.85)	85.67 (67.73)	84.00 (66.40)	80.00 (63.46)	72.00 (60.60)	74.67 (59.76)
V_5G_4	99.17 (87.75)	97.67 (81.50)	96.33 (78.95)	95.00 (78.03)	94.00 (75.82)	90.07 (71.64)	90.00 (71.55)	88.00 (69.71)	87.33 (69.72)	85.33 (67.46)	82.33 (65.13)	71.67 (6043)	72.33 (58.27)
MEAN	98.42 (83.94)	96.88 (80.16)	95.73 (78.35)	94.72 (76.87)	92.97 (74.72)	89.73 (71.35)	89.15 (70.80)	87.17 (69.06)	84.97 (67.20)	83.57 (66.12)	81.08 (64.13)	74.38 (61.48)	72.72 (58.53)
S.Em±	1.84	1.48	1.59	1.26	1.31	0.87	0.80	1.12	0.77	1.05	0.74	0.80	0.95
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

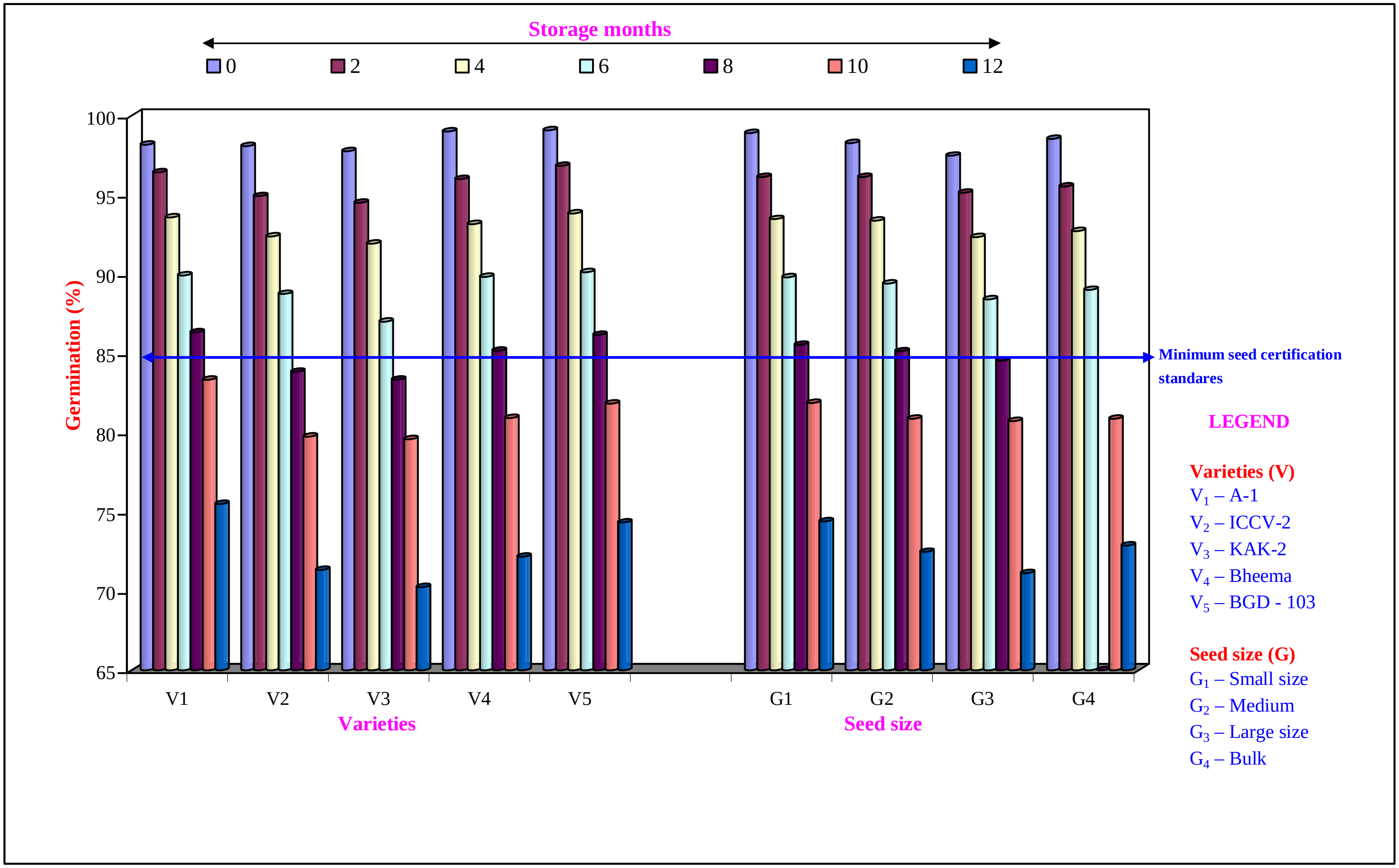


Fig. 14 : Effect of seed size on germination percentage in different chickpea varieties

In the subsequent months of storage period, the germination percentage decreased with increase in to storage period in all the varieties. The A-1 variety recorded significantly higher (75.50%) germination followed by BGD-103 (74.33%) and was lower (70.25%) with KAK-2 at the end of twelve months of storage period.

Due to seed size (G)

The germination of chickpea seeds declined progressively with increase in the storage period in all the seed size. The germination percentage did not shown significant difference among seed size in all the months of storage. Relatively small seeds maintained higher (98.90 and 74.40%) germination at initial and end of storage period respectively compared to other seed grades.

Due to interaction of varieties and seed size (VxG)

The interaction between VxG did not show any significant differences on germination percentage. Numerically A-1, BGD-103 and Bheema seeds of small size recorded higher (98.50%) germination followed by V_1G_2 (98.33 and 76.00%) and lower (97.67 and 68.00%) was in KAK-2 seeds of big size (V_3G_3) at initial and at the end of twelve months of storage period respectively.

4.3.2 Speed of germination

The data on speed of germination as influenced by varieties, seed size and their interactions are presented in Table 18.

Due to varieties (V)

Chickpea variety differed significantly on speed of germination in all the months of storage irrespective of seed size.

Significantly the highest (50.06) speed of germination was recorded in ICCV-2 and was on par with KAK-2 (50.01) and lowest (46.67) was in Bheema at initial month after storage. The similar trend was seen in subsequent months of storage. Significantly higher (21.25) speed of germination was noticed in ICCV-2 followed by KAK-2 (20.11) and lower (17.63) in Bheema at the end of twelve months of storage.

Due to seed size (G)

The significant variations among seed size on speed of germination was observed and it degreased progressively during storage. It was found to decrease from 48.65 in initial months of storage to 19.39 at the end of twelve months of storage irrespective of varieties. Among the seed size, small seeds recorded maximum (50.78 and 20.31) followed by bulk (48.69 and 19.56) while, big seeds recorded lower (46.85 and 18.55) speed of germination at the initial and after twelve months of storage respectively.

Due to interaction of varieties and seed size (VxG)

The speed of germination due to interaction between VxG did not differ significantly in all the months of storage. However, the small seeds of varieties found to record numerically higher speed of germination compared to other seed size in all the months of storage.

4.3.3 Seedling length (cm)

The data on seedling length as influenced by varieties, seed size and their interactions are presented in Table 19.

Due to varieties (V)

Significant varietal differences on seedling length was noticed in all the months of storage period. The mean seedling length decreased from 27.99 (initial month) to 18.49 cm (at the end of twelve month). Among varieties, BGD-103 recorded significantly more (30.99 and 20.39 cm) seedling length followed by Bheema (29.41 and 18.83 cm) and KAK-2 (28.03 and 18.58 cm) while, A-1 recorded significantly less (25.60 and 17.18 cm) seedling length at the initial and twelve month of storage respectively.

Table 18. Effect of seed size on speed of germination in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes(V)	speed of germination												
A-1 (V_1)	48.75	47.28	44.33	41.90	39.57	37.88	35.83	34.04	30.56	27.32	24.70	21.75	19.41
ICCV-2 (V_2)	50.06	48.32	44.88	42.62	40.04	38.27	36.18	34.69	32.36	29.00	26.28	23.61	21.25
KAK-2 (V_3)	50.01	48.18	44.80	42.37	39.73	38.15	36.13	34.20	31.35	27.16	24.83	22.50	20.11
Bheema (V_4)	46.67	45.12	42.06	39.98	37.58	35.73	33.92	31.58	29.29	25.42	22.72	19.99	17.63
BGD-103 (V_5)	47.78	45.92	42.91	40.41	37.83	36.00	34.01	31.78	29.41	25.88	22.78	20.41	18.57
S.Em±	0.45	0.47	0.34	0.42	0.42	0.35	0.28	0.42	0.38	0.40	0.37	0.31	0.28
CD@1%	1.73	1.81	1.30	1.63	1.59	1.35	1.06	1.62	1.45	1.53	1.41	1.21	1.06
Seed size													
Small (G_1)	50.78	49.03	45.91	43.46	40.75	39.06	36.84	34.96	31.97	28.57	25.73	22.86	20.31
Medium (G_2)	48.28	46.75	43.41	41.11	38.63	36.92	34.88	32.91	30.34	26.68	24.06	21.32	19.16
Big (G_3)	46.85	45.12	42.03	39.66	37.21	35.47	33.62	31.77	29.31	25.35	22.91	20.69	18.55
Bulk (G_4)	48.69	46.95	43.84	41.58	39.20	37.36	35.51	33.39	30.75	27.23	24.35	21.73	19.56
S.Em±	0.40	0.42	0.30	0.38	0.37	0.31	0.25	0.38	0.34	0.36	0.33	0.28	0.25
CD@1%	1.55	1.62	1.17	1.46	1.43	1.20	0.95	1.45	1.30	1.37	1.26	1.08	0.95

Contd………

reatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	51.45	49.96	46.97	44.30	41.70	40.07	37.80	35.73	32.10	28.50	25.67	23.03	20.20
V_1G_2	48.34	46.87	43.97	41.57	39.43	37.80	35.40	33.47	30.30	27.23	24.43	21.50	19.23
V_1G_3	46.08	44.57	41.77	39.30	37.23	35.60	33.83	32.97	29.43	26.00	23.73	20.57	18.77
V_1G_4	49.14	47.73	44.63	42.43	39.90	38.03	36.27	34.00	30.40	27.53	24.97	21.90	19.43
V_2G_1	50.95	49.27	46.23	43.63	41.27	39.50	39.23	37.53	35.00	31.50	28.77	25.30	22.17
V_2G_2	49.92	48.33	44.47	42.30	39.43	37.77	35.73	34.17	32.10	28.80	25.90	23.13	21.23
V_2G_3	49.11	47.27	43.40	41.33	38.87	37.03	33.43	32.17	29.73	26.47	24.40	22.20	20.07
V_2G_4	50.27	48.40	45.40	43.20	40.60	38.77	36.30	34.90	32.60	29.23	26.07	23.80	21.53
V_3G_1	54.87	52.70	49.00	46.53	43.10	41.77	37.23	35.93	32.53	29.03	26.83	23.93	21.40
V_3G_2	49.47	47.87	44.43	41.77	39.43	37.65	35.77	33.87	30.97	26.57	24.43	22.10	19.57
V_3G_3	45.91	44.23	41.33	39.17	36.50	35.00	35.07	32.43	30.17	25.23	23.13	21.53	19.23
V_3G_4	49.79	47.92	44.43	42.00	39.90	38.17	36.47	34.57	31.73	27.80	24.93	22.43	20.23
V_4G_1	47.74	46.17	42.97	40.73	38.30	36.47	34.50	32.77	30.20	26.90	23.63	20.67	18.37
V_4G_2	46.32	45.07	42.07	40.03	37.50	35.83	33.87	31.63	28.90	25.23	22.67	19.77	17.57
V_4G_3	46.05	44.30	41.17	39.07	36.53	34.57	32.77	30.53	28.17	23.90	21.73	19.43	16.77
V_4G_4	46.57	44.93	42.03	40.07	37.97	36.03	34.53	31.40	29.90	25.63	22.83	20.10	17.83
V_5G_1	48.94	47.07	44.37	42.10	39.40	37.50	35.43	32.83	30.03	26.90	23.77	21.37	19.40
V_5G_2	47.36	45.60	42.10	39.90	37.37	35.57	33.63	31.43	29.43	25.57	22.87	20.10	18.20
V_5G_3	47.13	45.23	42.47	39.43	36.93	35.13	33.00	30.77	29.03	25.13	21.53	19.73	17.90
V_5G_4	47.67	45.77	42.70	40.20	37.63	35.80	33.97	32.07	29.13	25.93	22.97	20.43	18.77
MEAN	48.65	46.96	43.79	41.45	38.95	37.20	35.21	33.26	30.59	26.96	24.26	21.65	19.39
S.Em±	0.90	0.94	0.68	0.85	0.83	0.70	0.55	0.84	0.76	0.87	0.73	0.63	0.55
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 19. Effect of seed size on seedling length in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	Seedling length (cm)												
A-1 (V_1)	25.60	24.89	24.05	22.78	22.34	21.84	21.05	20.36	19.89	19.18	18.58	17.88	17.18
ICCV-2 (V_2)	25.90	25.35	24.58	23.59	23.40	22.76	22.13	21.22	20.05	19.48	18.92	18.10	17.45
KAK-2 (V_3)	28.03	26.94	25.78	24.70	24.18	23.67	22.79	22.28	21.76	21.23	20.23	19.45	18.58
Bheema (V_4)	29.41	28.37	27.23	26.11	25.73	25.23	24.51	23.85	23.08	22.39	21.42	20.31	18.83
BGD-103 (V_5)	30.99	29.16	27.44	26.44	26.00	25.65	25.13	24.69	24.01	23.25	22.48	21.25	20.39
S.Em±	0.31	0.35	0.24	0.27	0.29	0.22	0.27	0.27	0.22	0.21	0.20	0.18	0.19
CD@1%	1.17	1.34	0.93	1.24	1.10	0.85	1.05	1.02	0.85	0.80	0.78	0.68	0.73
Seed size													
Small (G_1)	27.04	26.13	25.01	23.92	23.56	23.12	22.45	21.65	21.00	20.59	19.56	18.67	17.83
Medium (G_2)	28.27	27.20	26.09	24.95	24.47	23.89	23.22	22.61	21.78	21.13	20.38	19.40	18.42
Big (G_3)	29.16	27.86	26.59	25.42	25.08	24.59	23.95	23.43	22.87	22.04	21.33	20.34	19.27
Bulk (G_4)	27.47	26.57	25.58	24.61	24.21	23.73	22.87	22.23	21.37	20.68	19.87	19.18	18.43
S.Em±	0.27	0.31	0.22	0.24	0.26	0.20	0.25	0.24	0.20	0.19	0.18	0.16	0.17
CD@1%	1.05	1.20	0.83	0.93	0.98	0.76	0.94	0.91	0.76	0.72	0.70	0.61	0.65

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	24.40	23.97	23.20	22.10	21.87	21.27	20.50	19.73	19.23	18.97	17.93	17.27	16.47
V_1G_2	25.70	24.90	24.10	22.60	22.20	21.90	21.20	20.50	20.00	19.27	18.97	17.70	17.00
V_1G_3	26.37	25.63	24.70	23.50	22.93	22.43	21.60	21.07	20.83	19.73	19.23	18.77	18.20
V_1G_4	25.93	25.07	24.20	22.93	22.37	21.77	20.90	20.13	19.50	18.77	18.17	17.80	17.07
V_2G_1	25.10	24.47	23.77	22.87	22.57	21.80	21.10	19.57	19.03	18.73	18.23	17.40	16.90
V_2G_2	26.17	25.67	24.77	23.70	23.40	22.83	22.33	21.60	19.83	19.20	18.50	18.23	17.20
V_2G_3	27.30	26.47	25.70	24.53	24.60	23.97	23.50	22.70	21.73	20.83	20.30	18.73	18.33
V_2G_4	25.03	24.80	24.10	23.27	23.03	22.43	21.57	21.00	19.60	19.17	18.63	18.03	17.37
V_3G_1	27.33	26.20	25.17	24.07	23.57	23.20	22.37	21.80	21.23	20.90	19.47	18.73	17.83
V_3G_2	28.17	27.23	26.20	25.27	24.40	23.63	22.83	22.23	21.83	21.03	20.17	19.20	18.30
V_3G_3	29.00	27.97	26.53	25.00	24.70	24.30	23.60	23.23	22.87	22.07	21.77	20.83	19.47
V_3G_4	27.60	26.37	25.23	24.47	24.03	23.53	22.37	21.83	21.10	20.93	19.50	19.03	18.73
V_4G_1	28.33	27.50	26.57	25.10	24.77	24.47	23.80	23.10	22.13	21.80	20.87	19.50	18.50
V_4G_2	30.13	29.07	27.73	26.53	25.97	25.37	24.57	23.83	23.07	22.37	21.57	20.53	18.97
V_4G_3	31.17	29.70	28.13	27.13	26.87	26.17	25.50	24.87	24.13	23.50	22.17	21.47	19.37
V_4G_4	28.00	27.20	26.50	25.67	25.33	24.93	24.17	23.60	22.97	21.90	21.07	19.73	18.50
V_5G_1	30.03	28.53	26.37	25.47	25.03	24.87	24.47	24.03	23.37	22.53	21.63	20.47	19.47
V_5G_2	31.17	29.13	27.63	26.67	26.40	25.70	25.17	24.87	24.17	23.77	22.90	21.33	20.63
V_5G_3	31.97	29.53	27.90	26.93	26.30	26.07	25.53	25.27	24.80	24.07	23.30	21.90	21.00
V_5G_4	30.80	29.43	27.87	26.70	26.27	25.97	25.33	24.60	23.70	22.63	22.07	21.30	20.47
MEAN	27.98	26.94	25.82	24.73	24.33	23.83	23.12	22.48	21.76	21.11	20.32	19.40	18.49
S.Em±	0.61	0.70	0.48	0.54	0.57	0.44	0.55	0.53	0.44	0.42	0.41	0.36	0.38
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Due to seed size (G)

The seedling length differed significantly due to seed size in all the month of storage. Irrespective of varieties, the seedling length was found to decrease gradually in subsequent months of storage. Among different seed size, significantly more (29.16 and 19.27 cm) seedling length was observed in big size seeds followed by medium (28.27 and 18.42 cm) and bulk (27.47 and 18.42 cm) while, small size seeds recorded significantly lower (27.04 and 17.83 cm) seedling length at the initial and twelve month of storage respectively.

Due to interaction of varieties and seed size (VxG)

The seedling length due to interaction between varieties and seed size (VxG) did not differ significantly in all the moths of storage period. However, all varieties of big seeds found to record numerically higher seedling length compared to those of medium, bulk and small seeds of all varieties during entire period of storage.

4.3.4 Seedling dry weight (g)

The data on seedling dry weight as influenced by varieties, seed size and their interactions are presented in Table 20.

Due to varieties (V)

The seedling dry weight differed significantly due to varieties and the mean seedling dry weight decreased from 211.73 to 165.35 mg at the initial and end month of storage period respectively. Among the varieties, BGD-103 recorded significantly highest (232.17 and 183.50 mg) followed by Bheema (222.83 and 181.25 mg), while A-1 recorded lowest (186.92 and 137.58 mg) seedling dry weigh at initial and last month of storage period respectively.

Due to seed size (G)

Irrespective of varieties, the seedling dry weight was found to decrease gradually from 211.73 mg at initial month to 165.35 mg at the end twelve months of storage. Among seed size, significantly highest (216.46 and 169.53 mg) seedling dry weight was recorded in big seeds followed by medium (212.53 and 166.80 mg) at initial and twelve months of storage period respectively. While, lowest (208.00 and 162.27 mg) seedling dry weight was recorded in small size seeds at initial and last month of storage respectively.

Due to interaction of varieties and seed size (VxG)

There was no significant difference on seedling dry weight due to interaction of varieties and seed size in all the months of storage. However, the mean seedling dry weight was found to decrease from 211.73 to 165.35 mg from initial to end of twelve month of storage. Numerically more (236.00 to 187.67 mg) seedling dry weight was recorded in big seeds of BGD-103 seeds at initial and after twelve month of storage period respectively. In general, big seeds of all genotypes recorded highest seedling dry weight in all the months of storage.

4.3.5 Vigour index

The data on seedling vigour index as influenced by varieties, seed size and their interactions are presented in Table 21 and depicted in Fig. 15.

Due to varieties (V)

Significantly highest (2947) seedling vigour index was recorded in BGD-103 followed by Bheema (2786), KAK-2 (2609) and lowest (2410) with ICCV-2 at initial month of storage. The similar trend was noticed in subsequent months of storage. Significantly maximum (1407) seedling vigour index was noticed at the end of twelve month of storage in BGD-103 and minimum (1132) was recorded in A-1.

Due to seed size (G)

The seedling vigour index differed significantly among seed size in all the months of storage. Among the seed size, significantly maximum and minimum seedling vigour index was recorded in big (2724 and 1245) and bulk seeds (2582 and 1221) respectively at the initial and at the end of storage period.

Table 20. Effect of seed size on Seedling dry weight in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	Seedling dry weight (mg)												
A-1 (V_1)	186.92	181.42	176.08	178.08	175.92	174.08	172.42	166.00	164.33	159.58	153.67	149.50	137.58
ICCV-2 (V_2)	200.17	198.33	196.58	180.33	189.92	174.08	183.42	175.75	174.25	170.00	168.42	163.17	146.33
KAK-2 (V_3)	216.58	215.33	212.08	194.42	204.92	203.33	198.50	193.42	186.08	185.33	183.00	176.25	178.08
Bheema (V_4)	222.83	220.58	214.58	209.58	205.42	203.67	199.75	193.75	188.58	186.67	185.92	183.33	181.25
BGD-103 (V_5)	232.17	229.75	221.75	210.33	213.17	210.25	203.42	194.42	190.67	190.67	188.67	185.00	183.50
S.Em±	1.37	1.27	1.84	1.64	1.73	1.35	1.88	1.83	1.77	1.47	1.19	1.15	1.13
CD@1%	5.26	4.8/6	7.06	6.28	6.63	5.16	7.19	7.01	6.78	5.65	4.55	4.40	4.34
Seed size													
Small (G_1)	209.00	205.93	200.80	187.60	192.40	191.47	186.73	181.07	178.67	176.13	173.60	168.67	162.27
Medium (G_2)	212.53	210.47	205.07	193.67	199.13	196.13	192.60	186.53	183.27	181.27	177.47	173.47	166.80
Big (G_3)	216.46	215.47	212.47	200.33	205.87	204.07	199.40	191.60	186.73	183.87	180.00	175.13	169.53
Bulk (G_4)	208.93	204.47	198.53	194.80	194.07	191.80	187.27	180.67	174.47	172.53	172.67	168.53	162.80
S.Em±	1.23	1.13	1.65	1.47	1.55	1.20	1.68	1.64	1.58	1.32	1.06	1.03	1.01
CD@1%	4.71	4.35	6.32	5.62	5.53	4.62	4.43	6.27	6.07	5.06	4.07	3.93	3.88

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	183.67	179.00	170.00	168.33	167.33	167.33	163.33	157.33	165.67	152.33	150.00	148.33	136.00
V_1G_2	189.67	183.33	178.67	177.00	175.67	173.33	175.00	168.00	164.67	165.00	155.00	149.67	138.67
V_1G_3	191.00	186.00	186.33	182.33	181.33	179.00	177.00	174.33	171.33	170.00	161.00	154.67	140.00
V_1G_4	183.33	177.33	169.33	184.67	179.33	176.67	174.33	164.33	155.67	151.00	148.67	145.33	135.67
V_2G_1	200.00	196.00	192.67	169.67	188.67	167.33	180.33	175.33	172.33	169.67	168.00	159.33	144.33
V_2G_2	201.67	198.33	195.00	181.00	188.33	173.33	183.00	179.00	175.33	172.33	168.67	166.67	148.00
V_2G_3	201.67	204.00	202.67	186.67	195.00	179.00	188.67	178.33	178.00	172.33	171.33	168.00	151.33
V_2G_4	197.33	195.00	196.00	184.00	187.67	176.67	181.67	170.33	171.33	165.67	165.67	158.67	141.67
V_3G_1	214.33	212.00	210.00	190.33	200.00	197.33	192.67	189.00	181.00	184.67	181.00	175.00	174.33
V_3G_2	215.00	216.67	213.33	192.33	210.00	206.67	201.67	194.00	190.67	188.00	184.67	176.33	179.00
V_3G_3	225.00	223.67	220.00	201.00	214.67	211.67	206.33	198.33	196.33	188.67	186.67	181.67	182.33
V_3G_4	212.00	209.00	205.00	194.00	195.00	197.67	193.33	192.33	176.33	180.00	179.67	172.00	176.67
V_4G_1	219.33	217.33	211.33	206.00	198.33	199.33	196.33	193.00	184.33	185.67	183.67	179.67	177.67
V_4G_2	222.67	221.67	214.33	212.33	208.33	206.33	201.67	195.00	192.33	189.00	188.33	187.00	182.67
V_4G_3	228.67	227.33	221.00	217.00	213.33	216.00	210.00	201.00	193.00	192.33	189.33	185.33	186.33
V_4G_4	220.67	216.00	211.67	203.00	201.67	193.00	191.00	186.00	184.67	179.67	182.33	181.33	178.33
V_5G_1	227.67	225.33	220.00	205.00	207.67	206.67	201.00	189.67	190.00	188.33	185.33	181.00	179.00
V_5G_2	233.67	232.33	224.00	209.67	213.33	209.33	201.67	195.00	193.33	192.00	190.67	187.67	185.67
V_5G_3	236.00	236.33	232.33	219.00	225.00	220.00	215.00	203.00	195.00	196.00	191.67	186.00	187.67
V_5G_4	231.33	225.00	210.67	207.67	206.67	205.00	196.00	190.00	184.33	186.33	187.00	185.33	181.67
MEAN	211.73	209.08	204.21	194.55	197.86	193.08	191.5	157.33	180.78	178.45	175.93	171.45	165.35
S.Em±	2.75	2.53	3.68	3.28	3.46	2.69	3.75	3.66	3.45	2.95	2.37	2.29	2.26
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 21. Effect of seed size on seedling vigour index in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	seedling vigour												
A-1 (V_1)	2450	2383	2267	2126	2041	1945	1833	1730	1638	1544	1438	1289	1132
ICCV-2 (V_2)	2410	2359	2267	2150	2097	1989	1878	1728	1602	1530	1367	1277	1187
KAK-2 (V_3)	2609	2507	2366	2237	2155	2043	1918	1792	1722	1653	1490	1330	1206
Bheema (V_4)	2786	2688	2551	2423	2337	2226	2107	1986	1876	1783	1656	1436	1239
BGD-103 (V_5)	2947	2771	2581	2461	2368	2263	2171	2081	1970	1859	1695	1510	1407
S.Em±	32	36	27	27	27	19	25	28	20	18	19	14	18
CD@1%	122	138	105	102	105	75	97	107	78	70	71	55	69
Seed size													
Small (G_1)	2582	2495	2362	2234	2159	2065	1950	1828	1741	1673	1512	1383	1243
Medium (G_2)	2670	2570	2435	2304	2216	2099	1992	1878	1765	1669	1534	1376	1227
Big (G_3)	2724	2602	2456	2319	2246	2134	2031	1912	1820	1708	1574	1393	1245
Bulk (G_4)	2585	2500	2372	2260	2177	2076	1953	1835	1720	1645	1496	1321	1221
S.Em±	29	32	25	34	25	17	23	25	18	16	17	13	16
CD@1%	109	123	94	91	94	66	86	95	70	62	64	50	62

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	2367	2317	2212	2092	2034	1928	1805	1705	1622	1542	1420	1272	1161
V_1G_2	2476	2390	2281	2117	2041	1957	1851	1757	1647	1542	1403	1280	1095
V_1G_3	2505	2427	2297	2162	2064	1971	1865	1754	1688	1572	1494	1338	1137
V_1G_4	2498	2398	2275	2133	2028	1923	1811	1705	1596	1521	1433	1263	1136
V_2G_1	2410	2308	2226	2104	2054	1933	1807	1612	1555	1511	1366	1264	1169
V_2G_2	2477	2387	2287	2173	2105	1994	1898	1765	1600	1491	1404	1288	1190
V_2G_3	2566	2435	2339	2208	2181	2069	1983	1831	1717	1605	1385	1280	1220
V_2G_4	2361	2306	2217	2117	2047	1962	1825	1702	1536	1515	1314	1274	1171
V_3G_1	2624	2463	2332	2206	2137	2049	1916	1788	1720	1686	1473	1342	1224
V_3G_2	2676	2551	2410	2299	2163	2033	1919	1792	1738	1647	1472	1312	1165
V_3G_3	2745	2573	2415	2242	2190	2078	1968	1839	1780	1662	1567	1396	1207
V_3G_4	2613	2443	2305	2202	2131	2012	1871	1749	1651	1618	1449	1269	1225
V_4G_1	2758	2640	2524	2368	2270	2194	2079	1969	1852	1780	1634	1508	1275
V_4G_2	2893	2752	2598	2450	2372	2240	2113	1984	1877	1767	1660	1464	1247
V_4G_3	2950	2792	2616	2496	2418	2277	2159	2041	1915	1834	1707	1438	1220
V_4G_4	2707	2566	2465	2378	2288	2194	2077	1950	1860	1752	1622	1335	1215
V_5G_1	2923	2749	2514	2402	2303	2221	2145	2066	1955	1847	1666	1528	1387
V_5G_2	2971	2768	2598	2480	2402	2270	2181	2093	1965	1901	1733	1537	1437
V_5G_3	3037	2786	2613	2487	2376	2277	2179	2097	2000	1870	1716	1511	1442
V_5G_4	2988	2786	2601	2474	2390	2286	2178	2067	1960	1818	1663	1463	1360
MEAN	2640	2541	2406	2279	2199	2093	1981	1863	1761	1673	1529	1368	1234
S.Em±	63	72	55	53	55	39	50	56	41	36	37	29	36
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

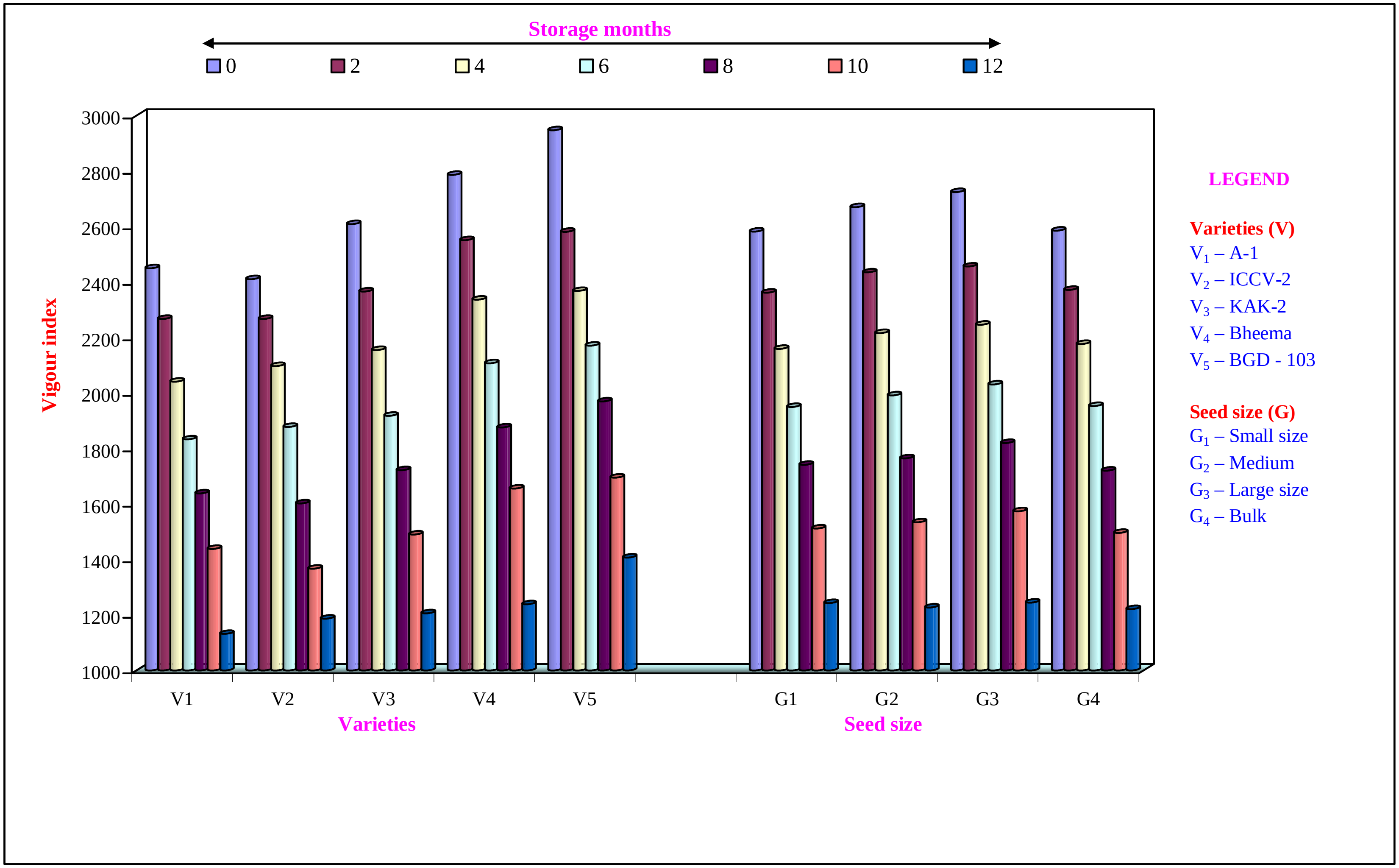


Fig. 15 : Effect of seed size on vigour index in different chickpea varieties

Table 22. Effect of seed size on electrical conductivity in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	Electrical conductivity (dSm^{-1})												
A-1 (V_1)	0.353	0.370	0.384	0.397	0.411	0.461	0.509	0.547	0.568	0.630	0.728	0.801	0.943
ICCV-2 (V_2)	0.405	0.413	0.438	0.472	0.521	0.553	0.633	0.671	0.743	0.819	0.895	0.963	1.127
KAK-2 (V_3)	0.473	0.483	0.495	0.503	0.544	0.573	0.628	0.672	0.733	0.769	0.868	0.972	1.247
Bheema (V_4)	0.382	0.384	0.425	0.444	0.487	0.522	0.561	0.607	0.623	0.672	0.782	0.862	1.040
BGD-103 (V_5)	0.354	0.378	0.403	0.413	0.436	0.467	0.518	0.573	0.597	0.669	0.768	0.848	1.036
S.Em±	0.05	0.009	0.006	0.004	0.008	0.012	0.015	0.010	0.011	0.010	0.009	0.014	0.020
CD@1%	0.019	0.034	0.024	0.017	0.032	0.046	0.056	0.040	0.043	0.037	0.035	0.055	0.077
Seed size													
Small (G_1)	0.379	0.395	0.407	0.429	0.458	0.487	0.531	0.577	0.622	0.673	0.752	0.812	0.987
Medium (G_2)	0.393	0.407	0.429	0.445	0.485	0.527	0.587	0.625	0.660	0.725	0.815	0.874	1.095
Big (G_3)	0.410	0.430	0.458	0.467	0.500	0.539	0.595	0.647	0.667	0.741	0.845	0.945	1.164
Bulk (G_4)	0.391	0.411	0.423	0.442	0.476	0.507	0.566	0.606	0.663	0.707	0.821	0.925	1.067
S.Em±	0.004	0.008	0.006	0.004	0.008	0.011	0.013	0.009	0.010	0.009	0.008	0.013	0.018
CD@1%	0.017	0.030	0.021	0.015	0.029	0.041	0.050	0.035	0.038	0.033	0.031	0.049	0.069

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	0.340	0.350	0.357	0.370	0.383	0.400	0.470	0.510	0.533	0.587	0.677	0.727	0.893
V_1G_2	0.357	0.360	0.380	0.390	0.407	0.483	0.523	0.547	0.570	0.647	0.743	0.783	0.937
V_1G_3	0.367	0.380	0.420	0.437	0.443	0.507	0.530	0.580	0.603	0.647	0.767	0.833	0.987
V_1G_4	0.347	0.390	0.380	0.390	0.410	0.453	0.513	0.550	0.563	0.640	0.723	0.860	0.953
V_2G_1	0.393	0.400	0.413	0.463	0.483	0.520	0.577	0.650	0.727	0.763	0.863	0.890	0.977
V_2G_2	0.400	0.403	0.447	0.470	0.520	0.557	0.673	0.690	0.763	0.847	0.900	0.917	1.197
V_2G_3	0.420	0.430	0.473	0.483	0.537	0.580	0.687	0.700	0.743	0.863	0.900	1.020	1.217
V_2G_4	0.407	0.417	0.420	0.470	0.533	0.553	0.593	0.643	0.740	0.803	0.917	1.027	1.117
V_3G_1	0.453	0.463	0.477	0.483	0.517	0.553	0.587	0.640	0.700	0.740	0.793	0.913	1.183
V_3G_2	0.473	0.483	0.493	0.500	0.550	0.587	0.657	0.680	0.743	0.777	0.880	0.953	1.247
V_3G_3	0.493	0.507	0.520	0.527	0.570	0.593	0.637	0.693	0.760	0.783	0.923	1.047	1.323
V_3G_4	0.470	0.480	0.490	0.503	0.540	0.557	0.633	0.673	0.730	0.777	0.877	0.973	1.233
V_4G_1	0.370	0.380	0.407	0.430	0.480	0.513	0.543	0.553	0.579	0.647	0.717	0.783	0.983
V_4G_2	0.377	0.377	0.423	0.447	0.507	0.523	0.553	0.627	0.633	0.677	0.787	0.857	1.050
V_4G_3	0.400	0.393	0.447	0.457	0.510	0.523	0.580	0.643	0.630	0.700	0.823	0.910	1.150
V_4G_4	0.380	0.387	0.423	0.443	0.460	0.527	0.567	0.603	0.633	0.663	0.800	0.897	0.977
V_5G_1	0.340	0.370	0.383	0.397	0.427	0.447	0.477	0.530	0.550	0.630	0.710	0.747	0.900
V_5G_2	0.357	0.393	0.400	0.417	0.440	0.487	0.530	0.580	0.590	0.680	0.763	0.860	1.043
V_5G_3	0.370	0.387	0.430	0.433	0.440	0.490	0.543	0.620	0.600	0.713	0.813	0.917	1.143
V_5G_4	0.350	0.363	0.400	0.403	0.437	0.443	0.523	0.560	0.647	0.653	0.787	0.870	1.057
MEAN	0.393	0.406	0.429	0.448	0.479	0.505	0.570	0.614	0.653	0.712	0.808	0.889	1.078
S.Em±	0.010	0.018	0.012	0.009	0.017	0.024	0.029	0.021	0.022	0.019	0.018	0.029	0.040
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Due to interaction of varieties and seed size (VxG)

No significant differences were noticed on seedling dry weight due to the interaction of varieties and seed size. However, big seeds of all the varieties recorded numerically higher seedling vigour index compared to other seed size. Among varieties, big seeds of BGD-103 recorded higher vigour index in all the months of storage period.

4.3.6 Electrical conductivity (dSm^{-1})

The data on electrical conductivity as influenced by varieties, seed size and their interactions are presented in Table 22.

Due to varieties (V)

The electrical conductivity differed significantly due to varieties during storage period. The mean EC increased from 0.393 (initial months) to 1.078 dSm^{-1} (at the end of twelve month). Among varieties A-1 recorded significantly lowest (0.353 and 0.943 dSm^{-1}) while, KAK-2 recorded the highest (0.473 and 1.247 dSm^{-1}) electrical conductivity at initial and at twelve months after storage respectively.

Due to seed size (G)

Significant variations on electrical conductivity were recorded due to seed size in all the months of storage. Among seed size, the small seeds recorded significantly less (0.379 and 0.987 dSm^{-1}) followed by bulk (0.391 and 1.067 dSm^{-1}) and more (0.410 and 1.164 dSm^{-1}) electrical conductivity at the initial and at twelve months after storage respectively.

Due to interaction of varieties and seed size (VxG)

No significant differences were observed on electrical conductivity due to interactions of varieties and seed size. However, small seeds of all the varieties recorded numerically less electrical conductivity followed by bulk size seeds and was more in big seeds of all varieties. However numerically less (0.34 and 0.89 dSm^{-1}) EC was record in V_1G_1 combination followed by V_1G_2 (0.36 and 0.94 dSm^{-1}), V_1G_4 (0.35 and 0.95 dSm^{-1}) and more (0.49 and 1.32 dSm^{-1}) electrical conductivity was recorded in V_3G_3 (KAK-2 big seeds) at the initial and at the end of twelve months of storage respectively.

4.3.7 Moisture content (%)

The data on moisture content as influenced by varieties, seed size and their interactions are presented in Table 23.

Due to varieties (V)

The moisture content found to differ significantly in all the varieties in all the months of storage except at 2nd, 3rd, 4rd, 5th, 6th and 7th months. The moisture content increased gradually with the mean of 8.98 to 10.42 per cent during initial and at the end of twelve months of storage respectively. Irrespective of seed size significantly minimum (8.85 and 10.23%) moisture content was recorded in A-1 variety followed by Bheema (8.96 and 10.63%), while, KAK-2 recorded significantly higher (9.07 and 10.77%) moisture content at the initial and at the end of twelve months of storage period respectively.

Due to seed size (G)

Significant variation on moisture content of seeds was seen due to seed size in all the months of storage except at initial and at first month. The mean moisture content increased gradually from 8.99 per cent to 10.42 per cent at initial and last months of storage respectively. Significantly lower (8.95 and 10.33%) moisture content was recorded in small seeds size followed by bulk (8.97 and 10.41) and higher (9.03 and 10.51%) in big seed at initial and at end of twelve months of storage respectively.

Due to interaction of varieties and seed size (VxG)

No significant differences on moisture content were noticed due to interactions of varieties and seed grades. However, in all the varieties, small seeds recorded lower moisture content followed by bulk and was higher in big seeds. Numerically lower (8.82 and 10.21%) moisture content was recorded in V_1G_1 treatment and higher (9.08 and 10.88%) in V_3G_3 treatment at initial and at the end of twelve months of storage period.

Table 23. Effect of seed size on moisture content in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	Moisture content (%)												
A-1 (V_1)	8.85	7.61	8.98	9.06	9.11	9.16	9.29	9.39	9.43	9.57	9.75	9.90	10.23
ICCV-2 (V_2)	9.07	9.06	9.08	9.10	9.13	9.22	9.30	9.41	9.48	9.59	9.79	10.02	10.25
KAK-2 (V_3)	9.05	9.11	9.11	9.12	9.18	9.23	9.33	9.43	9.57	9.71	9.84	10.19	10.77
Bheema (V_4)	8.96	9.00	9.07	9.10	9.12	9.20	9.30	9.39	9.45	9.59	9.71	10.04	10.63
BGD-103 (V_5)	9.02	9.04	9.01	9.04	9.10	9.18	9.21	9.39	9.41	9.56	9.69	9.91	10.23
S.Em±	0.02	0.30	0.30	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.06	0.03
CD@1%	0.09	1.16	NS	NS	NS	NS	0.07	NS	0.05	0.04	0.09	0.22	0.10
Seed size													
Small (G_1)	8.95	8.98	8.98	9.04	9.08	9.15	9.24	9.34	9.42	9.53	9.69	9.90	10.33
Medium (G_2)	9.00	9.05	9.07	9.11	9.15	9.22	9.29	9.42	9.48	9.60	9.76	10.06	10.44
Big (G_3)	9.03	8.01	9.12	9.14	9.18	9.23	9.33	9.46	9.52	9.67	9.78	10.17	10.51
Bulk (G_4)	8.97	9.02	9.03	9.05	9.11	9.19	9.29	9.40	9.45	9.61	9.79	9.92	10.41
S.Em±	0.02	0.27	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.05	0.02
CD@1%	NS	NS	0.10	0.07	0.07	0.06	0.06	0.05	0.05	0.04	0.08	0.19	0.09

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	8.82	8.88	8.90	9.00	9.08	9.12	9.25	9.33	9.35	9.49	9.69	9.85	10.21
V_1G_2	8.87	9.00	9.00	9.07	9.13	9.17	9.29	9.40	9.44	9.57	9.73	9.96	10.23
V_1G_3	8.90	9.03	9.10	9.12	9.15	9.18	9.33	9.47	9.52	9.66	9.80	9.93	10.27
V_1G_4	8.82	8.95	8.93	9.07	9.08	9.17	9.28	9.35	9.41	9.58	9.76	9.87	10.22
V_2G_1	9.05	9.00	9.03	9.08	9.08	9.17	9.23	9.36	9.45	9.52	9.69	9.90	10.20
V_2G_2	9.08	9.08	9.10	9.12	9.13	9.29	9.31	9.42	9.50	9.57	9.78	10.07	10.27
V_2G_3	9.10	9.12	9.17	9.15	9.18	9.25	9.34	9.44	9.52	9.68	9.86	10.20	10.32
V_2G_4	9.05	9.03	9.03	9.07	9.13	9.18	9.33	9.41	9.44	9.59	9.83	9.90	10.22
V_3G_1	8.97	9.08	9.07	9.08	9.12	9.18	9.28	9.38	9.51	9.68	9.78	10.17	10.65
V_3G_2	9.07	9.12	9.12	9.15	9.20	9.20	9.35	9.41	9.58	9.70	9.85	10.20	10.78
V_3G_3	9.08	9.15	9.13	9.17	9.25	9.30	9.38	9.47	9.62	9.74	9.89	10.28	10.88
V_3G_4	9.08	9.08	9.12	9.08	9.17	9.25	9.32	9.47	9.55	9.71	9.84	10.12	10.78
V_4G_1	8.93	8.97	9.02	9.05	9.10	9.15	9.28	9.28	9.40	9.49	9.64	9.82	10.45
V_4G_2	8.98	8.98	9.07	9.13	9.13	9.22	9.28	9.43	9.47	9.59	9.72	10.13	10.64
V_4G_3	9.03	9.08	9.12	9.13	9.15	9.23	9.30	9.46	9.48	9.66	9.75	10.32	10.80
V_4G_4	8.88	8.98	9.07	9.07	9.10	9.18	9.33	9.40	9.45	9.63	9.71	9.90	10.62
V_5G_1	8.97	8.98	8.90	8.98	9.03	9.15	9.15	9.32	9.38	9.50	9.65	9.77	10.16
V_5G_2	9.02	9.05	9.05	9.07	9.13	9.20	9.22	9.41	9.42	9.59	9.73	9.92	10.27
V_5G_3	9.04	9.10	9.08	9.13	9.17	9.20	9.28	9.47	9.44	9.62	9.59	10.13	10.28
V_5G_4	9.03	9.03	9.02	8.98	9.07	9.15	9.20	9.37	9.41	9.55	9.78	9.83	10.20
MEAN	8.98	9.03	9.05	9.08	9.13	9.20	9.29	9.40	9.47	9.61	9.75	10.01	10.42
S.Em±	0.05	0.61	0.06	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.05	0.11	0.05
CD@1%	NS	2.32	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 24. Effect of seed size on 100 seed weight in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	100 seed weight (g)												
A-1 (V_1)	24.10	24.03	23.68	23.29	22.92	22.65	22.43	22.20	21.70	21.16	20.31	19.55	18.30
ICCV-2 (V_2)	26.00	25.96	25.74	25.21	24.81	24.52	24.23	23.96	23.37	22.68	21.71	20.48	18.79
KAK-2 (V_3)	34.02	33.94	33.74	32.99	32.67	31.95	31.75	31.87	30.77	29.75	28.74	27.42	25.35
Bheema (V_4)	37.63	37.50	37.35	36.48	36.04	35.63	35.26	35.10	33.66	32.73	31.61	30.15	28.20
BGD-103 (V_5)	38.59	38.43	38.21	37.18	36.80	36.35	36.18	35.88	34.76	33.88	32.79	31.33	29.07
S.Em±	0.22	0.18	0.17	0.17	0.17	0.19	0.21	0.18	0.22	0.26	0.25	0.21	0.25
CD@1%	0.84	0.69	0.64	0.64	0.64	0.72	0.79	0.70	0.85	1.01	0.95	0.80	0.95
Seed size													
Small (G_1)	30.08	30.00	29.82	29.28	28.94	28.57	28.37	28.14	27.36	26.62	25.69	24.51	22.99
Medium (G_2)	32.01	31.91	31.65	30.92	30.57	30.07	29.83	29.67	28.69	27.86	26.91	25.66	23.97
Big (G_3)	33.93	33.83	33.61	32.79	32.37	31.97	31.69	31.52	30.32	29.49	28.40	27.12	25.13
Bulk (G_4)	32.25	32.15	31.89	31.13	30.71	30.26	30.00	29.87	29.04	28.19	27.13	25.85	23.68
S.Em±	0.20	0.16	0.15	0.15	0.15	0.17	0.18	0.16	0.20	0.24	0.22	0.19	0.22
CD@1%	0.75	0.62	0.58	0.57	0.57	0.65	0.70	0.62	0.76	0.90	0.85	0.72	0.85

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	22.33	22.27	22.00	21.73	21.43	21.20	21.03	20.80	20.42	20.10	19.30	18.50	17.53
V_1G_2	23.93	23.87	23.40	23.00	22.63	22.37	22.13	21.93	21.57	21.07	20.30	19.43	18.27
V_1G_3	26.43	26.37	26.07	25.53	25.10	24.80	24.53	24.23	23.67	22.90	22.00	21.07	19.50
V_1G_4	23.70	23.63	23.23	22.90	22.50	22.23	22.03	21.83	21.17	20.57	19.63	19.22	17.90
V_2G_1	24.07	24.03	23.83	23.47	23.23	22.97	22.70	22.13	21.75	20.97	20.10	18.83	17.40
V_2G_2	26.07	26.03	25.83	25.30	24.93	24.60	24.33	24.10	23.45	22.63	21.67	20.57	18.87
V_2G_3	27.37	27.33	27.17	26.53	26.13	25.83	25.53	25.37	24.63	24.20	23.17	21.97	20.17
V_2G_4	26.50	26.43	26.13	25.53	24.93	24.67	24.37	24.23	23.65	22.93	21.92	20.53	18.73
V_3G_1	32.17	32.13	32.00	31.37	31.03	30.47	30.37	30.47	29.50	28.43	27.47	26.20	24.62
V_3G_2	34.07	34.03	33.90	33.10	32.83	32.00	31.80	31.90	30.70	29.72	28.67	27.33	25.63
V_3G_3	35.93	35.83	35.57	34.80	34.43	33.80	33.60	33.70	32.30	31.27	30.20	28.63	26.60
V_3G_4	33.90	33.77	33.50	32.70	32.37	31.53	31.23	31.40	30.57	29.60	28.63	27.50	24.57
V_4G_1	35.70	35.57	35.43	34.80	34.43	34.07	33.47	33.57	32.33	31.47	30.47	29.13	27.75
V_4G_2	37.57	37.43	37.23	36.37	35.90	35.43	35.17	34.93	33.33	32.33	31.38	29.87	27.83
V_4G_3	39.20	39.07	38.97	37.83	37.30	36.97	36.63	36.37	34.60	33.77	32.58	31.30	28.75
V_4G_4	38.07	37.93	37.77	36.90	36.53	36.03	35.77	35.53	34.37	33.37	32.02	30.30	28.47
V_5G_1	36.13	36.00	35.83	35.03	34.57	34.13	34.27	33.73	32.80	32.15	31.13	29.87	27.67
V_5G_2	38.43	38.20	37.90	36.83	36.53	35.97	35.70	35.47	34.42	33.55	32.52	31.12	29.23
V_5G_3	40.73	40.53	40.30	39.23	38.87	38.47	38.17	37.93	36.40	35.32	34.07	32.63	30.65
V_5G_4	39.07	39.00	38.80	37.63	37.23	36.83	36.60	36.37	35.43	34.50	33.43	31.68	28.72
MEAN	32.07	31.97	31.74	31.03	30.65	30.22	29.97	29.80	28.85	28.041	27.033	25.78	23.94
S.Em±	0.44	0.36	0.34	0.33	0.33	0.38	0.41	0.36	0.44	0.53	0.50	0.42	0.50
CD@1%	1.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.3.8 100 seed weight (g)

The data on 100 seed weight as influenced by varieties, seed size and their interactions are presented in Table 24.

Due to varieties (V)

The 100 seed weight differed significantly due to varieties and the mean hundred seed weight decreased from 32.07 g (at initial month) to 23.94 g (at the end of twelve months of storage). Among five chickpea varieties, BGD-103 recorded significantly higher (38.59 and 29.07g) followed by Bheema (37.63 and 28.20 g). While, A-1 recorded significantly lower (24.10 and 18.30 g) hundred seeds weight at initial and last months of storage respectively

Due to seed size (G)

Irrespective of varieties, the hundred seed weight was found to decrease due to seed sizes during storage. Among the seed size, big seeds of recorded significantly maximum (33.93 g) 100 seeds weight followed by medium and bulk (32.25 and 32.01 g) respectively and it was lower (30.08 g) in small size seeds at initial month of storage. At the end of twelve month of storage period big seeds recorded higher (25.13 g) test weight and was lower (22.99 g) in small size seeds.

Due to interaction of varieties and seed size (VxG)

No significant differences were noticed on hundred seed weight due to interactions of variety and seed size. The big seeds of BGD-103 (V_5G_3) recorded numerically higher (40.73 and 30.65 g) followed by V_5G_4 (39.07 and 28.72 g) and lower (22.33 and 17.53 g) hundred seed weight in small size seeds of A-1 variety at the initial and twelve months after storage respectively.

4.3.9 Pest infestation (%)

The data on pest infestation as influenced by varieties, seed size and their interactions are presented in Table 25.

Due to varieties (V)

At initial and first month after storage no infestation was seen in all the five chickpea varieties. During 2nd months onwards pest infestation was recorded in different chickpea varieties. The bruchid infestation per cent increased from 2nd month to 12th month of storage period and maximum (31.17%) pest infestation was seen in variety KAK-2 followed by ICCV-2 (29.42%) and minimum (25.92%) in A-1 at the last month of storage.

Due to seed size (G)

No significant differences were recorded on pest infestation due to seed size except at 10th, 11th and 12th month after storage. At initial and 1st month after storage, no pest infestation was recorded among seed size irrespective of varieties. Among seed size, the per cent infestation was significantly maximum (30.07%) in big seeds followed by bulk (29.60%) and medium (28.27%) while, minimum (25.93%) infestation was seen in small seeds of all varieties at the end of twelve months of storage.

Due to interaction of varieties and seed size (VxG)

No significant differences were noticed on per cent pest infestation in all the months of storage period except 12th month. Significantly minimum (23.33%) pest infestation was seen in V_1G_1 treatment followed by V_5G_1 (24.00%) and V_1G_2 (25.67%) and maximum (33.00%) pest infestation was seen in V_3G_3 at last month of storage.

4.3.10 Field emergence (%)

The data on field emergence percentage as influenced by varieties, seed size and their interactions are presented in Table 26.

Due to varieties (V)

Irrespective of seed size, field emergence percentage differed significantly among the varieties during the entire period of storage. Significantly maximum (84.25%) field emergence was recorded in variety A-1, followed by BGD-103 (83.75%) and minimum (78.25%) in KAK-2

Table 25. Effect of seed size on pest infestation in different chickpea genotypes

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes	pest infestation (%)												
A-1 (V_1)	0.00	0.00	2.83	4.17	5.50	7.17	8.50	11.33	15.42	17.58	21.00	23.75	25.92
ICCV-2 (V_2)	0.00	0.00	3.08	5.33	6.33	8.17	9.25	13.00	18.50	22.00	24.25	26.42	29.42
KAK-2 (V_3)	0.00	0.00	3.42	5.75	6.58	8.33	9.42	13.67	19.58	22.92	26.00	27.50	31.17
Bheema (V_4)	0.00	0.00	3.83	4.42	6.67	7.83	8.75	12.42	17.50	20.25	22.17	24.83	28.50
BGD-103 (V_5)	0.00	0.00	3.75	4.42	6.42	7.50	8.58	12.17	17.00	19.33	21.83	24.00	27.33
S.Em±	0.00	0.00	0.34	0.61	0.60	0.41	0.44	0.41	0.71	0.57	0.49	0.55	0.55
CD@1%	0.00	0.00	NS	NS	NS	NS	NS	1.59	2.73	2.18	1.86	2.12	2.12
Seed size													
Small (G_1)	0.00	0.00	2.87	4.33	5.87	7.07	8.40	11.53	16.13	19.53	21.80	23.80	25.93
Medium (G_2)	0.00	0.00	3.27	4.80	6.33	7.67	8.87	12.60	17.53	20.47	22.73	25.13	28.27
Big (G_3)	0.00	0.00	3.53	5.00	6.47	8.27	9.33	13.07	18.47	21.13	24.27	26.73	30.07
Bulk (G_4)	0.00	0.00	3.87	5.13	6.53	8.20	9.00	12.87	18.27	20.53	23.40	25.53	29.60
S.Em±	0.00	0.00	0.31	0.54	0.54	0.37	0.39	0.37	0.64	0.51	0.43	0.49	0.49
CD@1%	0.00	0.00	NS	NS	NS	NS	NS	NS	NS	NS	1.67	1.90	1.90

Contd………

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
V_1G_1	0.00	0.00	2.33	3.33	4.67	6.33	8.00	11.00	13.67	16.33	19.67	22.00	23.33
V_1G_2	0.00	0.00	2.67	4.33	5.33	7.33	8.33	11.33	14.33	17.67	20.33	23.67	25.67
V_1G_3	0.00	0.00	3.00	4.33	6.00	7.67	9.00	11.67	15.67	18.33	22.67	25.33	27.33
V_1G_4	0.00	0.00	3.33	4.67	6.00	7.33	8.67	11.33	18.00	18.00	21.33	24.00	27.33
V_2G_1	0.00	0.00	2.33	5.00	6.33	7.67	8.33	10.67	17.00	21.33	23.33	24.67	27.33
V_2G_2	0.00	0.00	3.00	5.33	6.33	8.00	8.67	13.33	18.67	22.33	24.00	26.33	29.67
V_2G_3	0.00	0.00	3.33	5.33	6.33	8.67	10.00	13.67	19.67	22.67	25.33	27.67	31.00
V_2G_4	0.00	0.00	3.67	5.67	6.33	8.33	10.00	14.33	18.67	21.67	24.33	27.00	29.67
V_3G_1	0.00	0.00	3.00	5.33	6.67	7.33	8.67	13.00	18.67	22.00	25.00	25.67	28.67
V_3G_2	0.00	0.00	3.33	5.67	6.67	8.33	9.67	13.67	19.67	22.67	26.00	27.33	31.00
V_3G_3	0.00	0.00	3.67	6.00	6.33	9.00	10.00	14.33	20.33	23.67	27.00	29.33	33.00
V_3G_4	0.00	0.00	3.67	6.00	6.67	8.67	9.33	13.67	19.67	23.33	26.00	27.67	32.00
V_4G_1	0.00	0.00	3.33	3.67	5.67	7.33	8.67	11.67	14.67	19.33	21.00	23.67	26.33
V_4G_2	0.00	0.00	3.67	4.33	7.00	7.67	9.00	12.33	18.00	20.00	22.00	24.33	27.67
V_4G_3	0.00	0.00	4.00	4.67	7.00	8.00	9.33	13.00	19.33	21.00	23.00	26.33	29.33
V_4G_4	0.00	0.00	4.33	5.00	7.00	8.33	8.00	12.67	18.00	20.67	22.67	25.00	30.67
V_5G_1	0.00	0.00	3.33	4.33	6.00	6.67	8.33	11.33	16.67	18.67	20.00	23.00	24.00
V_5G_2	0.00	0.00	3.67	4.33	6.33	7.00	8.67	12.33	17.00	19.67	21.33	24.00	27.33
V_5G_3	0.00	0.00	3.67	4.67	6.67	8.00	8.33	12.67	17.33	20.00	23.33	25.00	29.67
V_5G_4	0.00	0.00	4.33	4.33	6.67	8.33	9.00	12.33	17.00	19.00	22.67	24.00	28.33
MEAN	0.00	0.00	3.38	4.82	6.30	7.80	8.90	12.52	17.60	20.42	23.05	25.30	28.47
S.Em±	0.00	0.00	0.69	1.21	1.20	0.83	0.88	0.83	1.42	1.14	0.97	1.11	1.11
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 26. Effect of seed size on field emergence in different chickpea genotypes during storage.

Treatments	Storage months												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Genotypes (V)	Field emergence (%)												
A-1 (V_1)	84.25 (66.62)*	83.08 (65.72)	82.17 (65.01)	81.00 (64.15)	79.50 (63.09)	76.42 (60.93)	75.17 (60.12)	73.50 (59.02)	73.00 (58.68)	71.25 (57.56)	68.42 (55.79)	67.08 (55.01)	63.83 (53.03)
ICCV-2 (V_2)	79.50 (63.12)	78.33 (62.27)	77.17 (61.44)	76.00 (60.65)	74.92 (59.94)	73.58 (59.07)	71.50 (57.73)	70.42 (57.04)	69.17 (56.26)	67.50 (55.23)	64.58 (53.46)	61.75 (51.78)	57.33 (49.20)
KAK-2 (V_3)	78.25 (62.20)	77.25 (61.51)	76.17 (60.78)	75.00 (59.98)	74.50 (59.69)	72.08 (58.12)	71.17 (57.52)	70.17 (56.90)	69.50 (56.47)	66.75 (54.78)	62.50 (52.23)	59.75 (50.61)	56.00 (48.43)
Bheema (V_4)	82.17 (65.02)	81.92 (64.83)	81.50 (64.52)	79.58 (63.16)	77.92 (61.98)	74.83 (59.89)	73.75 (59.18)	72.42 (58.34)	71.42 (57.67)	69.83 (56.69)	67.67 (55.34)	65.75 (54.18)	62.67 (52.32)
BGD-103 (V_5)	83.75 (66.24)	83.00 (65.67)	80.92 (64.09)	80.33 (63.69)	78.25 (62.19)	76.08 (60.73)	74.42 (59.62)	72.67 (58.47)	71.58 (57.79)	70.17 (56.89)	68.08 (55.59)	67.00 (54.93)	63.92 (53.07)
S.Em±	0.18	0.21	0.17	0.20	0.23	0.23	0.22	0.27	0.18	0.22	0.16	0.23	0.22
CD@1%	0.69	0.81	0.65	0.77	0.87	0.88	0.85	NS	0.71	0.85	0.62	0.87	0.83
Seed size													
Small (G_1)	82.13 (65.05)	80.87 (674.16)	80.20 (63.62)	78.40 (62.36)	77.80 (61.93)	74.40 (59.66)	73.33 (58.95)	72.93 (58.70)	72.13 (58.14)	69.73 (56.65)	67.07 (54.98)	64.80 (53.61)	61.40 (51.59)
Medium (G_2)	81.87 (64.86)	80.93 (64.13)	79.67 (62.11)	78.47 (62.39)	77.13 (61.45)	74.93 (59.95)	73.53 (59.04)	72.07 (58.08)	71.07 (57.45)	69.47 (56.44)	66.53 (54.65)	64.53 (53.47)	60.60 (51.12)
Big (G_3)	81.20 (64.36)	80.47 (63.80)	79.13 (62.84)	78.07 (62.08)	76.13 (60.76)	74.20 (59.48)	72.73 (58.52)	71.00 (57.42)	70.20 (56.92)	68.60 (55.92)	66.13 (54.41)	63.67 (52.94)	60.13 (50.84)
Bulk (G_4)	81.13 (64.28)	80.60 (63.91)	79.33 (62.99)	78.60 (62.48)	77.00 (61.37)	74.87 (59.91)	73.20 (58.82)	71.33 (57.62)	70.33 (56.99)	68.60 (55.91)	65.27 (53.89)	64.07 (53.17)	60.87 (51.28)
S.Em±	0.36	0.42	0.34	0.40	0.45	0.46	0.44	0.54	0.37	0.45	0.32	0.45	0.43
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Figures in parenthesis are transferred values

Contd………

Treatments	Storage Months												
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
V_1G_1	83.00 (65.72)	82.33 (65.13)	82.67 (65.41)	81.33 (64.42)	79.67 (63.20)	75.67 (60.45)	76.33 (60.97)	76.00 (60.70)	72.67 (58.58)	71.00 (57.42)	68.33 (55.75)	65.67 (54.11)	63.00 (52.53)
V_1G_2	86.00 (68.02)	83.33 (65.89)	82.00 (64.88)	81.33 (64.39)	80.00 (63.42)	77.00 (61.32)	75.00 (59.98)	73.00 (58.68)	73.00 (58.67)	71.33 (57.61)	68.00 (55.53)	69.33 (56.41)	65.67 (54.11)
V_1G_3	84.67 (66.94)	83.00 (65.63)	81.67 (64.62)	80.00 (63.41)	78.33 (62.274)	76.00 (60.64)	74.33 (59.54)	72.00 (58.05)	73.33 (58.90)	71.33 (57.61)	68.33 (55.74)	66.67 (54.75)	63.00 (52.53)
V_1G_4	84.00 (66.40)	83.00 (65.65)	82.33 (35.12)	81.33 (64.38)	80.00 (63.44)	77.00 (61.32)	75.00 (59.98)	73.00 (58.67)	73.00 (58.68)	71.33 (57.61)	69.00 (56.15)	66.67 (54.75)	63.67 (52.93)
V_2G_1	83.67 (66.17)	78.67 (62.53)	78.33 (62.24)	76.67 (61.12)	76.00 (60.69)	73.67 (59.17)	73.67 (59.14)	73.00 (58.69)	69.33 (56.37)	67.33 (55.16)	65.67 (54.11)	62.33 (52.12)	58.00 (49.60)
V_2G_2	78.67 (62.48)	78.00 (62.02)	76.67 (61.10)	75.33 (60.21)	74.00 (59.33)	72.67 (58.46)	70.67 (57.19)	70.00 (56.77)	71.00 (57.40)	67.33 (55.12)	64.33 (53.31)	61.33 (51.53)	56.67 (48.81)
V_2G_3	77.33 (61.58)	78.67 (64.48)	77.00 (61.32)	76.00 (60.64)	74.33 (59.54)	72.67 (58.46)	70.67 (57.19)	68.67 (55.95)	68.67 (55.95)	68.00 (55.53)	64.00 (53.12)	61.67 (51.74)	57.33 (49.20)
V_2G_4	78.33 (62.24)	78.00 (62.04)	76.67 (61.10)	76.00 (60.64)	75.33 (60.21)	75.33 (60.21)	71.00 (57.40)	70.00 (56.77)	67.67 (55.33)	67.33 (55.13)	64.33 (53.31)	61.67 (51.73)	57.33 (49.20)
V_3G_1	78.33 (62.28)	77.67 (61.83)	76.67 (61.16)	75.00 (59.99)	77.67 (61.87)	74.00 (59.42)	73.00 (58.69)	72.00 (58.09)	72.67 (58.46)	68.67 (55.95)	64.00 (53.11)	60.33 (50.95)	56.67 (48.82)
V_3G_2	78.00 (62.02)	78.00 (62.01)	76.67 (61.10)	75.33 (60.20)	74.33 (59.54)	72.67 (58.46)	71.33 (57.63)	71.33 (57.61)	68.67 (55.95)	68.67 (55.95)	64.33 (53.31)	59.67 (50.56)	55.00 (47.85)
V_3G_3	77.67 (61.78)	76.33 (60.87)	75.67 (60.43)	75.00 (59.98)	73.00 (58.67)	70.33 (56.99)	69.33 (56.36)	68.67 (55.97)	66.67 (54.72)	64.00 (53.11)	62.00 (51.93)	59.33 (50.37)	56.00 (48.43)
V_3G_4	79.00 (62.72)	77.00 (61.32)	75.67 (60.43)	74.67 (59.77)	73.00 (58.67)	71.33 (57.61)	71.00 (57.40)	68.67 (55.94)	70.00 (56.77)	65.67 (54.12)	59.67 (50.55)	59.67 (50.56)	56.33 (48.62)

Treatments	Storage months												
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
V_4G_1	82.00 (64.91)	81.67 (64.69)	82.00 (64.91)	79.00 (62.76)	77.00 (61.37)	73.00 (58.72)	71.00 (57.43)	71.67 (57.96)	71.00 (57.40)	69.00 (56.21)	69.67 (56.59)	68.67 (55.96)	64.33 (53.32)
V_4G_2	82.67 (65.38)	82.67 (65.38)	81.67 (64.63)	80.00 (63.48)	78.67 (62.49)	75.33 (60.21)	74.67 (59.76)	73.00 (58.67)	72.00 (58.04)	70.33 (56.99)	67.33 (55.14)	65.00 (53.71)	62.00 (51.93)
V_4G_3	83.33 (65.88)	82.00 (64.89)	80.67 (63.91)	79.67 (63.20)	78.00 (62.01)	76.00 (60.64)	75.00 (59.96)	72.67 (58.48)	72.33 (58.27)	70.67 (57.19)	67.00 (54.93)	64.67 (53.53)	62.33 (52.12)
V_4G_4	80.67 (63.89)	81.33 (64.38)	81.67 (64.63)	79.67 (63.19)	78.00 (62.03)	75.00 (59.98)	74.33 (59.55)	72.33 (58.25)	70.33 (56.98)	69.33 (56.36)	66.67 (54.72)	64.67 (53.51)	62.00 (51.92)
V_5G_1	84.33 (66.75)	83.33 (66.01)	81.33 (64.39)	80.00 (63.51)	78.67 (62.48)	75.67 (60.55)	72.67 (58.51)	72.00 (58.08)	75.00 (60.00)	72.67 (58.49)	67.67 (55.33)	67.00 (54.92)	65.00 (53.71)
V_5G_2	84.00 (66.40)	82.67 (65.37)	81.33 (64.39)	80.33 (63.66)	78.67 (62.48)	77.00 (61.32)	76.00 (60.65)	73.00 (58.67)	70.67 (57.19)	69.67 (56.56)	68.67 (55.95)	67.33 (55.14)	63.67 (52.92)
V_5G_3	83.00 (65.63)	82.33 (65.13)	80.67 (63.89)	79.67 (63.18)	77.00 (61.32)	76.00 (60.64)	74.33 (59.54)	73.00 (58.69)	70.00 (56.77)	69.00 (56.15)	69.33 (56.36)	66.00 (54.31)	62.00 (51.94)
V_5G_4	83.67 (66.16)	83.67 (66.17)	80.33 (63.69)	81.33 (64.40)	78.67 (62.48)	75.67 (60.42)	74.67 (59.76)	72.67 (58.46)	70.67 (57.19)	69.33 (56.36)	66.67 (54.71)	67.67 (55.33)	65.00 (53.72)
MEAN	81.58 (64.64)	80.72 (64.00)	79.58 (63.17)	78.38 (62.33)	77.02 (61.38)	74.60 (55.75)	73.20 (58.83)	71.83 (57.96)	70.93 (57.38)	69.10 (56.23)	66.25 (54.48)	64.27 (53.30)	60.75 (51.20)
S.Em±	0.80	0.94	0.76	0.90	1.01	1.03	0.99	1.21	0.83	1.00	0.72	1.01	0.97
CD@1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

variety during initial month of storage. The same trend was followed in all the subsequent months of storage period. The field emergence percentage was highest (63.83%) in A-1 and lowest (56.00%) in KAK-2 at 12th month after storage.

Due to seed size (G)

No significant differences on field emergence among seed size grades were seen in all the months of storage. The mean percentage of field emergence decreased from 81.58 at initial month to 60.75 per cent at twelve month after storage. Numerically higher (82.13 and 61.40%) field emergence was recorded in small size seeds and lower (81.20 and 60.13%) field emergence was recorded in big size seeds at initial and twelve months after storage period respectively.

Due to interaction of varieties and seed size (VxG)

No significant differences were recorded in field emergence due to interaction of varieties and seed size in all months of storage. However, relatively maximum per cent field emergence 86.00 and 65.67 was recorded in V_1G_1 at initial and at the end of twelve months after storage respectively. The minimum (77.67 and 55.00%) field emergence was recorded in V_3G_3 at initial and last month after storage respectively.

4.4 Experiment – IV: Effect of Seed Treatments on Plant Growth, Seed Yield and Quality in Chickpea Varieties

4.4.1 Plant height (cm)

The data recorded on plant height at 30, 60 DAS and at harvest as influenced by varieties, micronutrients, seed treatments and their interactions are presented in Table 27.

Between the variety, significantly higher (20.65 cm) plant height was recorded in ICCV-2 (V_2) compared to A-1 (V_1) (20.03 cm) at 30 DAS.

Plant height at 60 DAS differed significantly due to the varietal influence. Maximum (41.77 cm) plant height was recorded in ICCV-2 (V_2) compared to A-1 (40.04 cm).

Due to varieties, plant height at harvest was significantly more (49.65 cm) with V_2 compared to V_1 (47.78 cm).

The plant height at 30 DAS showed significant difference due to seed treatment with micronutrients and biofertilizers. Markedly maximum (20.86 cm) plant height was recorded in T_6 (Rhizobium) followed by $ZnSo_4$ (T_1) (20.70 cm) and T_7 (20.25 cm) and the other treatments were on par with each other. Minimum plant height was recorded in control (19.72 cm).

At 60 DAS, plant height found to differ significantly due to the seed treatments with micronutrients and biofertilizers. Among different seed treatments, plant height recorded was more (42.94 cm) in T_6 treatment followed by T_7 (42.22 cm) and T_1, T_2, T_4 and T_5 were on par with each other and less (39.19 cm) was recorded in T_9.

At harvest, among different micronutrients and biofertilizers seed treatments, significantly higher (50.36 cm) plant height was recorded in treatment T_6 followed by T_7 (49.56 cm) and while T_1 to T_4 seed treatments were on par with each other and significantly lower (46.86 cm) was recorded with T_9 (control).

No significant differences were recorded due to interaction of varieties and seed treatment (VxT) on plant height at 30 DAS. However, numerically maximum (21.45 cm) plant height was recorded in V_2T_1 followed by V_2T_6 (21.33 cm) and minimum (19.48 cm) in V_2T_9.

Due to interaction of varieties and seed treatments, plant height at 60 DAS showed marked difference. Among the different interactions, markedly higher (43.28 cm) plant height was recorded in V_2T_6 followed by V_2T_7 (42.95 cm), V_2T_1 (43.01 cm) and lower (38.25 cm) in V_1T_9.

Due to interaction of varieties and seed treatments with micronutrients and biofertilizers, the plant height at harvest did not show marked difference. However, relatively more (51.33 cm) plant height was recorded in V_2T_6 followed by V_2T_4 (50.78 cm) and V_2T_5 (50.45 cm) and less (46.83 cm) with V_1T_9.

Table 27. Effect of seed treatment on plant height in chickpea genotypes (Pooled analysis)**

Treatments	Plant height (cm)								
	30 DAS			60 DAS			At harvest		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	19.95	21.45	20.70	39.98	43.01	41.50	48.08	50.30	49.19
T_2	20.07	20.97	20.52	39.35	41.97	40.66	47.58	48.67	48.13
T_3	20.00	20.73	20.37	38.85	40.62	39.74	47.17	49.47	48.32
T_4	19.98	20.42	20.20	40.40	41.28	40.84	46.95	50.78	48.87
T_5	20.10	20.93	20.52	40.18	41.73	40.96	47.75	50.45	49.10
T_6	20.38	21.33	20.86	42.60	43.28	42.94	49.38	51.33	50.36
T_7	19.97	20.53	20.25	41.48	42.95	42.22	48.88	50.23	49.56
T_8	19.88	20.02	19.95	39.25	41.13	40.13	47.40	48.70	48.05
T_9	19.95	19.48	19.72	38.35	40.03	39.19	46.83	46.88	46.86
Mean	20.03	20.65	20.34	40.04	41.77	40.91	47.78	49.65	48.71
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.12	0.33		0.16	0.47		0.21	0.60
T		0.25	0.70		0.34	0.99		0.44	1.27
V x T		0.35	NS		0.49	1.40		0.63	NS

*(2007-08 and 2008-09 *rabi* season)
NS – Non Significant

Varieties : V_1: A-1
V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$ (1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

Table 28. Effect of seed treatment on number of branches in chickpea genotypes (Pooled analysis)**

Treatments	Number of branches								
	30 DAS			60 DAS			At harvest		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	3.87	3.87	3.87	22.00	19.10	20.55	24.13	22.03	23.08
T_2	3.80	3.70	3.75	20.70	18.13	19.42	23.47	21.53	22.50
T_3	3.90	3.77	3.84	20.70	17.32	19.01	23.07	20.53	21.80
T_4	3.77	3.67	3.72	21.20	18.08	19.64	23.07	20.90	21.99
T_5	4.00	3.80	3.90	21.23	18.90	20.07	24.20	20.53	22.37
T_6	3.90	3.90	3.90	23.03	19.97	21.50	25.40	22.47	23.94
T_7	3.87	3.80	3.84	22.13	19.35	20.74	25.60	21.53	23.57
T_8	3.77	3.67	3.72	20.53	16.77	18.65	23.53	19.37	21.45
T_9	3.73	3.65	3.69	19.30	16.00	17.65	21.07	18.50	19.79
Mean	3.85	3.76	3.80	21.20	18.18	19.69	23.73	20.82	22.27
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.02	0.07		0.14	0.39		0.16	0.45
T		0.05	0.15		0.29	0.82		0.33	0.94
V x T		0.07	NS		0.41	NS		0.46	NS

*(2007-08 and 2008-09 *rabi* season) NS – Non Significant

Varieties : V_1: A-1 V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

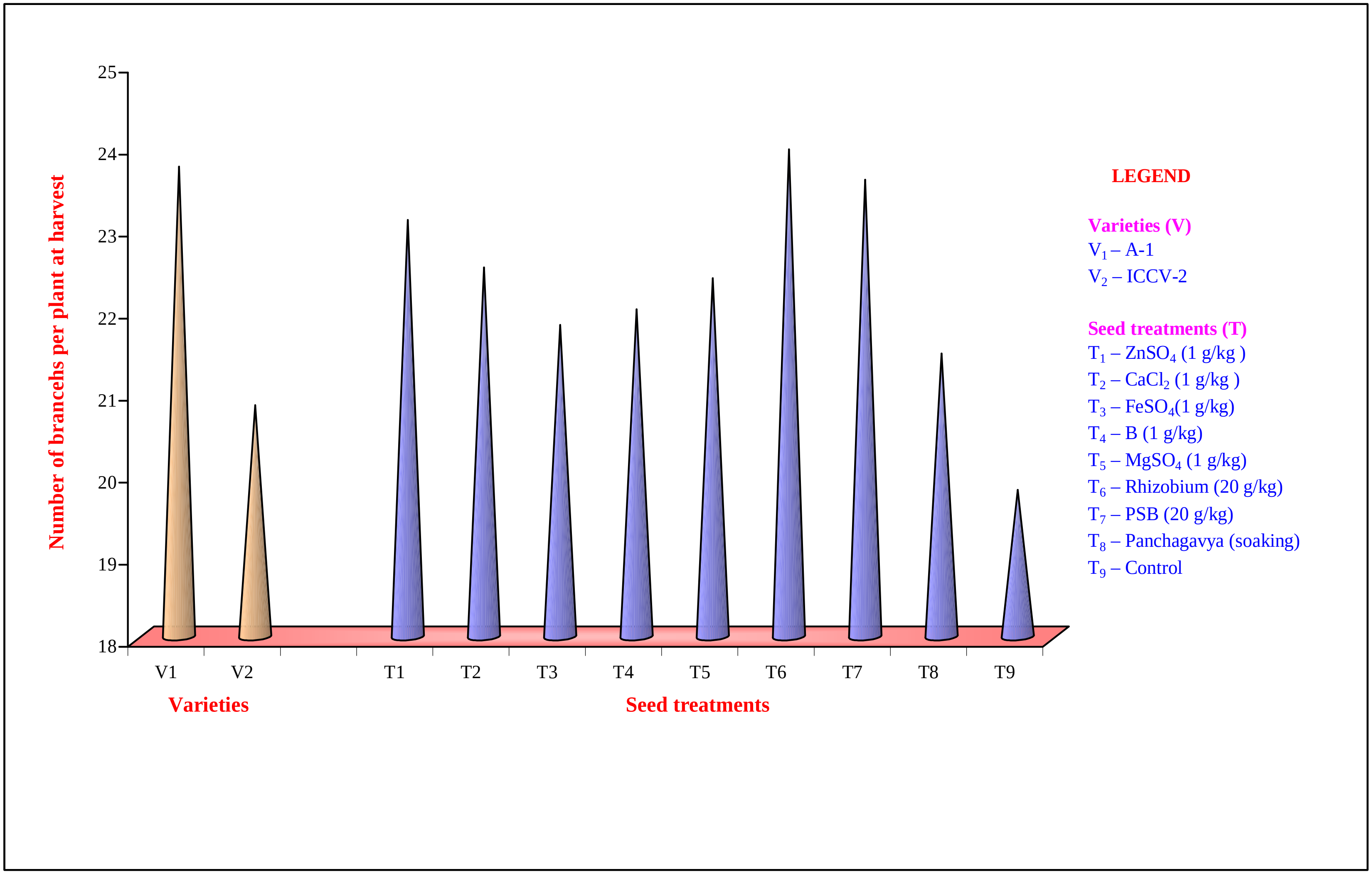


Fig. 16 : Effect of seed treatment on number of branches per plant at harvest in chickpea varieties

4.4.2 Number of branches

The data on number of branches at 30, 60 DAS and at harvest as influenced by varieties, micronutrients, seed treatments and their interactions are presented in Table 28 and depicted in Fig. 16.

Number of branches at 30 DAS showed significant differences due to varietal influence. Significantly, maximum (3.85) branches were noticed in V_1 compared to V_2 (3.76).

Significant difference was seen on number of branches at 60 DAS due to varietal influence. Significantly higher (21.20) branches were recorded in A-1 variety compared to ICCV-2 (18.18) (V_2).

Between varieties, A-1 recorded significantly higher (23.73) number of branches over ICCV-2 (20.82) at harvest.

Significant differences were recorded due to the micronutrients, and biofertilizers seed treatment on number of branches at 30 DAS. Maximum (3.90) number of branches were recorded in treatment T_5 and T_6 and minimum (3.69) with T_9.

Number of branches at 60 DAS differed markedly due to the seed treatment with micronutrients and biofertilizers. Markedly maximum (21.50) number of branches were recorded in T_6 followed by T_7 (20.74) and T_1, T_2, T_4 and T_5 were on par with each other and significantly minimum (17.65) with T_9.

Among the different seed treatments, Rhizobium (T_6) recorded significantly higher (23.94) number of branches followed by PSB (T_7) 23.57 and T_1, T_2, T_4 and T_3 were on par with each other. While, significantly lower (19.79) branches were recorded with T_9 (control) at harvest.

No significant difference was recorded on number of branches at 30 DAS due to interaction of varieties and micronutrients and biofertilizers seed treatment. However, numerically more (4.00) number of branches were recorded in V_1T_5 and less (3.65) with V_2T_9.

Number of branches did not differ significantly due to interaction of varieties and seed treatments with micronutrients and biofertilizers at 60 DAS. However, relatively more (23.03) branches were recorded with V_1T_6 followed by V_1T_7 (22.13) and V_1T_1 (22.00) and less (16.00) in V_2T_9.

At harvest, no significant difference was seen due to interaction of varieties and micronutrient and biofertilizers seed treatment on number of branches. Relatively more (25.60) branches were recorded in V_1T_7 followed by V_1T_6 (25.40) and less (18.50) with V_2T_9.

4.4.3 Days to 50 per cent flowering

The data on days to 50 per cent flowering as influenced by varieties, seed treatments and their interactions are presented in Table 29.

Due to variety, significant difference was found on days to 50 per cent flowering. Between varieties A-1 took more (51.78) days to 50 per cent flowering while ICCV-2 recorded less (45.98) days.

Days required to 50 per cent flowering differed significantly due to micronutrients and biofertilizers seed treatments. More number of days were taken to 50 per cent flowering with (control) T_9 (50.50 days) while significantly less (47.58 days) with Rhizobium (T_6).

The number of days to 50 per cent flowering did not differ significantly due to interaction of varieties and seed treatment with micronutrients and biofertilizers. However, numerically more number of days (53.50) were taken for 50 per cent flowering in V_1T_9 and less (44.83) with V_2T_6.

4.4.4 Number of pods per plant

The data on number of pods per plant as influenced by varieties, seed treatments and their interactions are presented in Table 30.

Between the varieties, A-1 (V_1) recorded markedly higher number of pods per plant (44.03) over ICCV-2 (V_2) (35.75).

Table 29. Effect of seed treatment on days to 50 per cent flowering in chickpea genotypes (Pooled analysis)**

Treatments	Days to 50% flowering		
	V_1	V_2	Mean
T_1	51.17	45.17	48.17
T_2	51.33	46.50	48.92
T_3	52.17	46.33	49.25
T_4	52.33	46.50	49.42
T_5	52.00	45.83	48.92
T_6	50.33	44.83	47.58
T_7	50.50	45.00	47.75
T_8	52.67	46.17	49.42
T_9	53.50	47.50	50.50
Mean	51.78	45.98	48.88
Comparison for means of		S.Em±	CD (5%)
V		0.13	0.37
T		0.27	0.77
V x T		0.38	NS

*(2007-08 and 2008-09 *rabi* season) NS – Non Significant

Varieties : V_1: A-1 V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

Table 30. Effect of seed treatment on number of pods per plant, pod yield per plant and number of seeds per pod in chickpea genotypes (Pooled analysis)**.

Treatments	Number of pods per plant			Pod yield per plant (g)			Number of seeds per pod		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	46.37	36.91	41.64	19.00	16.25	17.63	1.76	1.43	1.60
T_2	43.90	35.07	39.49	18.13	16.05	17.09	1.52	1.43	1.48
T_3	43.88	34.20	39.04	18.20	15.67	16.94	1.63	1.34	1.49
T_4	42.87	36.17	39.52	18.52	16.13	17.33	1.60	1.46	1.53
T_5	44.05	35.62	39.84	18.47	16.30	17.39	1.54	1.49	1.52
T_6	48.75	38.42	43.59	19.47	17.03	18.25	1.70	1.49	1.60
T_7	47.58	37.83	42.71	19.03	17.20	18.12	1.54	1.50	1.52
T_8	41.13	34.93	38.03	18.00	15.62	16.81	1.51	1.50	1.51
T_9	37.70	32.58	35.14	17.27	14.77	16.02	1.38	1.36	1.37
Mean	44.03	35.75	39.89	18.45	16.11	17.28	1.57	1.45	1.51
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.27	0.77		0.11	0.33		0.02	0.05
T		0.57	1.64		0.24	0.69		0.04	0.11
V x T		0.80	2.31		0.34	NS		0.06	NS

*(2007-08 and 2008-09 *rabi* season) NS – Non Significant

Varieties : V_1: A-1 V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$ (1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

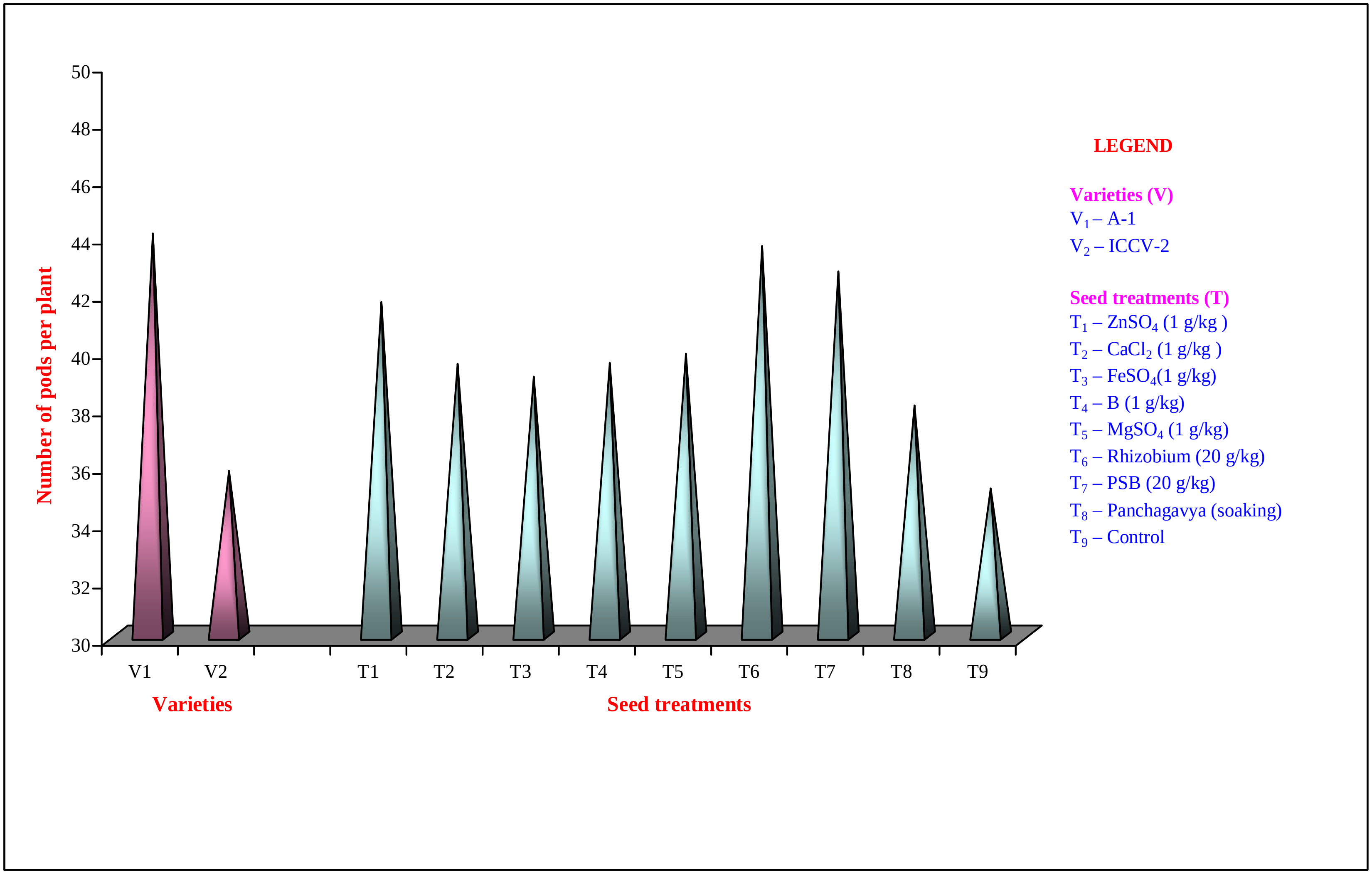


Fig. 17 : Effect of seed treatment on number of pods per plant in chickpea varieties

The seed treatments varied significantly for number of pods per plant. Significantly maximum number of pods per plant was recorded in Rhizobium (T_6) (43.59) and PSB (T_7) (42.71) and minimum (35.14) in control and all other treatments were on par with each other.

Interaction effects due to varieties and seed treatments with micronutrients and biofertilizers differed significantly on number of pods per plant. Significantly maximum pods per plant was observed in V_1T_6 (48.75) followed by V_1T_7 (47.58) and V_1T_1 (46.37) combination. The minimum pods per plant (32.58) was recorded in V_2T_9.

4.4.5 Pod yield per plant (g)

The data on pod yield per plant as influenced by varieties, seed treatments and their interactions are presented in Table 30.

The varieties differed significantly for pod yield per plant. A-1 recorded higher (18.45 g) pod yield per plant while lowest (16.11 g) was in ICCV-2.

The pod yield per plant differed significantly due to the seed treatment with micronutrients and biofertilizers. The seeds treated with Rhizobium recorded maximum (18.25 g) pod weight per plant followed by PBS (18.12 g). The treatments T_1, T_2, T_4 and T_5 were on par with each other and significantly lower (16.02 g) pod yield per plant was with T_9 (control).

No significant difference was recorded due to interaction of varieties and seed treatments with micronutrients and biofertilizers on pod yield per plant. However, numerically more (19.47 g) pod yield was recorded in V_1T_6 followed by V_1T_7 (19.03 g) and was on par with V_1T_1 (19.00 g) and less (14.77 g) with V_2T_9.

4.4.6 Number of seeds per pod

The data on number of seeds per pod as influenced by varieties, seed treatments and their interactions are presented in Table 30.

The number of seeds per pod differed significantly due to varieties. A-1 (V_1) recorded more (1.57) seeds per pod compared to ICCV-2 (1.45).

The micronutrients and biofertilizer seed treatments found to differ significantly on number of seeds per pod. Among different treatments T_6 and T_1 recorded more (1.60) seeds per pod followed by T_4 (1.53) and T_5 and T_7 (1.52) and were less (1.37) with control (T_9).

The number of seeds per pod due to interaction effect of varieties and seed treatments with micronutrients and biofertilizers did not differ markedly. While, relatively more (1.76) seeds per pod were recorded in V_1T_1 treatment followed by V_1T_6 (1.70) and less (1.36) with V_2T_9.

4.4.7 Seed yield per plant (g)

The data on seed yield per plant as influenced by varieties, seed treatments and their interactions are presented in Table 31.

A-1 variety recorded significantly higher (13.35 g) seed yield per plant compared to ICCV-2 (11.77 g).

Significant difference was found due to seed treatments with micronutrients and biofertilizers on seed yield per plant. Significantly maximum (14.15 g) seed yield per plant was observed in Rhizobium (T_6) treatment followed by PSB (T_7) (13.73 g) and minimum (11.10 g) with control (T_9).

No significant difference was recorded due to interaction of varieties and seed treatments with micronutrients and biofertilizers on seed yield. Numerically higher (15.01) seed yield per plant was recorded with V_1T_6 combination followed by V_1T_7 (14.74 g) and less (10.72 g) with V_2T_9.

4.4.8 Seed yield per plot (g)

The data on seed yield per plot as influenced by varieties, seed treatments and their interactions are presented in Table 31.

The seed yield per plot differed significantly due to varietal difference. A-1 recorded maximum (1.09 kg) seed yield per plot compared to ICCV-2 (0.95 kg).

Table 31. Effect of seed treatment on seed yield per plant, per plot and per hectare in chickpea genotypes (Pooled analysis)**

Treatments	Seed yield per plant (g)			Seed yield per plot (Kg)			Seed yield per hectare (q)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	13.63	11.82	12.73	1.12	1.00	1.06	31.39	26.85	29.12
T_2	13.51	11.36	12.44	1.11	0.94	1.03	30.87	26.20	28.54
T_3	13.05	11.31	12.18	1.04	0.94	0.99	29.03	26.02	27.53
T_4	13.03	11.58	12.31	1.11	0.97	1.04	30.77	26.39	28.58
T_5	13.32	11.67	12.50	1.10	0.95	1.03	30.69	27.18	28.94
T_6	15.10	13.20	14.15	1.15	1.05	1.10	31.07	29.07	30.07
T_7	14.74	12.72	13.73	1.15	0.98	1.07	31.25	27.68	29.47
T_8	12.27	11.53	11.90	1.02	0.91	0.97	28.15	25.22	26.69
T_9	11.47	10.72	11.10	1.00	0.84	0.92	27.82	23.81	25.82
Mean	13.35	11.77	12.56	1.09	0.95	1.02	30.12	26.49	28.30
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.11	0.33		0.01	0.02		0.23	0.67
T		0.24	0.69		0.02	0.05		0.49	1.42
V x T		0.34	NS		0.02	NS		0.70	NS

*(2007-08 and 2008-09 *rabi* season)
NS – Non Significant

Varieties : V_1: A-1 V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$ (1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

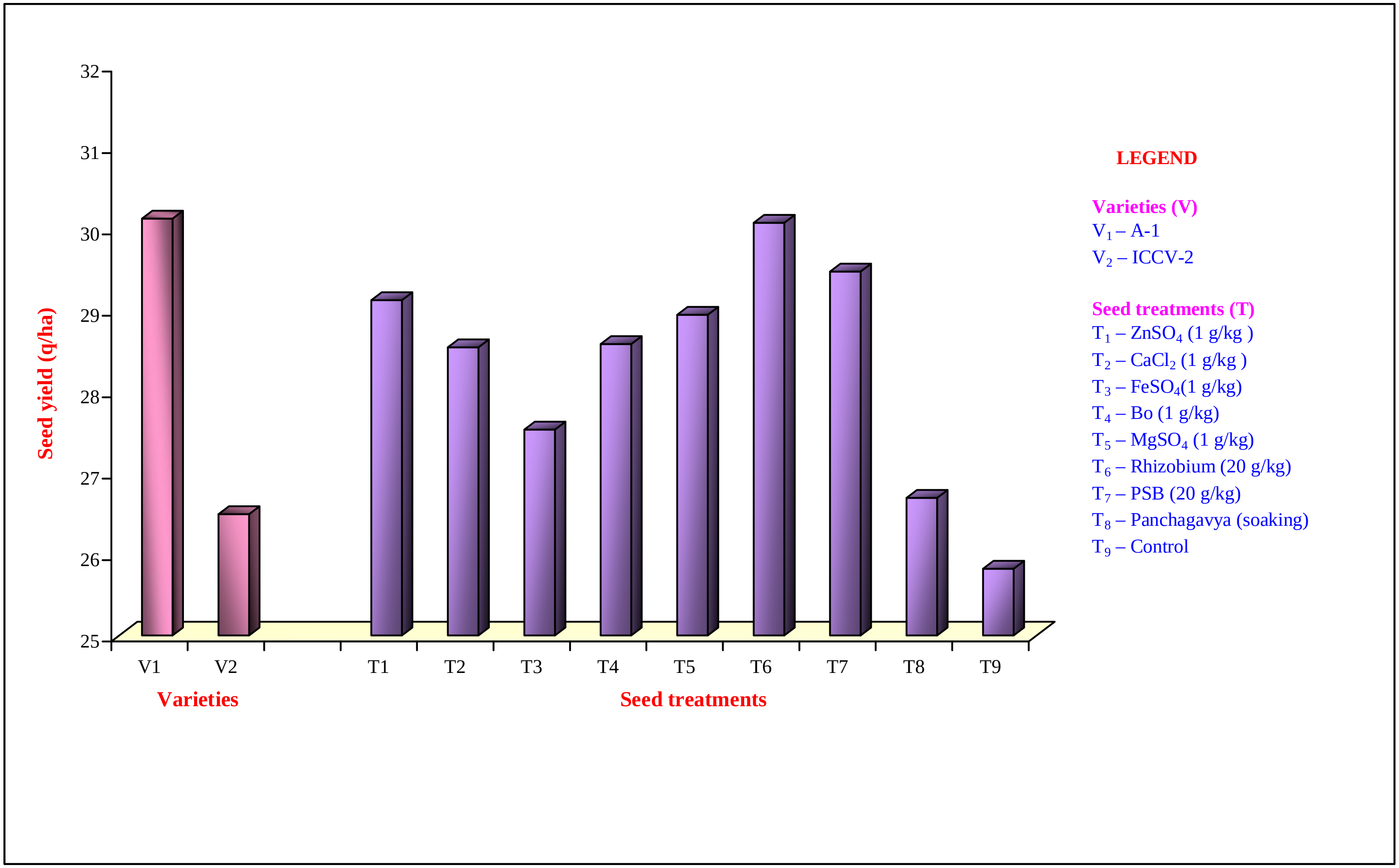


Fig. 18 : Effect of seed treatment on seed yield per hectare in chickpea varieties

The seed yield per plot differed significantly due to seed treatment with different micronutrients and biofertilizers. Among different seed treatments T_6 recorded maximum (1.10 kg) seed yield per plot followed by T_7 (1.07 kg) and minimum (0.92 kg) was with control (T_9).

Interactions between interaction varieties and seed treatments with micronutrients and biofertilizers did not differ significantly on seed yield per plot. However numerically higher (1.15 kg) seed yield per plot was recorded with V_1T_6 and V_1T_7 followed by V_1T_1 (1.12 kg) and V_1T_2 and V_1T_4 (1.11 kg) and lower (0.84 kg) with V_2T_9.

4.4.9 Seed yield per hectare (q)

The data on seed yield per hectare as influenced by varieties, seed treatments and their interactions are presented in Table 31 and depicted in Fig. 18.

The seed yield per hectare differed significantly due to varieties. Significantly higher (30.12 q) seed yield per ha was recorded with A-1 compared to ICCV-2 (26.49 q).

The seed treatment with micronutrients and biofertilizers showed significant difference on seed yield per ha. Rhizobium treatment recorded significantly more (30.07 q) seed yield per ha and T_1, T_2, T_4, and T_7 treatments were on par with each other. While, seed yield was less (25.82 q) with control (T_9).

No significant difference was seen on seed yield per ha due to interaction of varieties and seed treatments. However, seed yield per ha was numerically maximum (31.39 q) with V_1T_1 followed by V_1T_7 (31.25 q) and minimum (23.81 q) with V_2T_9.

4.4.10 100 seed weight (g)

The data on 100 seed weight as influenced by varieties, seed treatments and their interactions are presented in Table 32.

No significant difference was noticed on 100 seed weight between the varieties. However, it was numerically more (25.11 g) with ICCV-2 over (23.71 g) A-1.

100 seed weight did not differ significant due to different seed treatments. Relatively more 100 seed weight was recorded in T_6 (25.66 g) followed by T_7 (25.02 g) and lower (23.08 g) with T_9.

No significant difference was seen due to interactions of varieties and seed treatments on 100 seed weight. However, numerically more (26.38 g) 100 seed weight was observed with V_2T_6 followed by V_2T_1 (25.68 g) and less (22.08 g) with V_1T_9.

4.4.11 Germination (%)

The data on germination percentage as influenced by varieties, seed treatments and their interactions are presented in Table 32 and depicted in Fig. 19.

A-1 and ICCV-2 varieties did not differ significantly on germination percentage. However A-1 recorded relatively highest (95.45%) germination compared to ICCV-2 (95.21%).

Among various seed treatments, significantly more (97.16%) germination was recorded in T_6 followed by T_7 (96.61%) and T_1, T_4 and T_5 were on par with each other. While, minimum (92.67%) was with (T_9) control.

No significant difference was recorded due to interactions between varieties and seed treatments on germination percentage. However, numerically maximum (97.31%) germination was recorded in V_1T_6 treatment followed by V_1T_7 (96.64%) and was minimum (92.30%) with V_2T_9.

4.4.12 Speed of germination

The data on speed of germination as influenced by varieties, seed treatments and their interactions are presented in Table 32.

The speed of germination differed significantly due to varieties. Significantly higher (49.92) speed of germination was recorded in ICCV-2 compared to A-1 (47.97).

Table 32 . Effect of seed treatment on 100 seed weight, germination percentage and speed of germination in chickpea genotypes (Pooled analysis)**

Treatments	100 seed weight (g)			Germination (%)			Speed of germination		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	24.20	25.68	24.94	95.83 (78.19)	95.50 (77.72)	95.66 (77.95)	47.23	48.73	46.98
T_2	23.66	25.30	24.48	95.48 (77.69)	94.51 (76.42)	94.99 (77.04)	47.73	49.14	48.44
T_3	23.26	24.52	23.89	94.66 (76.61)	94.52 (76.43)	94.59 (76.52)	46.87	48.34	47.61
T_4	23.30	24.78	24.04	95.88 (78.26)	95.61 (77.87)	95.74 (78.08)	47.87	49.37	48.62
T_5	24.15	25.10	24.63	95.44 (77.64)	95.62 (77.89)	95.53 (77.76)	47.92	49.79	48.86
T_6	24.93	26.38	25.66	97.31 (80.53)	97.01 (80.01)	97.16 (80.27)	48.63	54.56	51.60
T_7	24.54	25.49	25.02	96.64 (79.41)	96.59 (79.33)	96.61 (79.37)	49.96	51.44	50.70
T_8	22.74	24.63	23.69	94.77 (76.75)	95.26 (77.39)	95.01 (77.07)	44.95	45.87	45.41
T_9	22.08	24.08	23.08	93.05 (74.68)	92.30 (73.86)	92.67 (74.27)	44.57	46.08	45.33
Mean	23.71	25.11	24.66	95.45 (77.65)	95.21 (77.33)	95.33 (77.49)	47.97	49.92	47.95
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.43	NS		0.15	NS		0.27	0.77
T		0.90	NS		0.32	0.93		0.57	1.64
V x T		1.28	NS		0.46	NS		0.81	NS

*(2007-08 and 2008-09 *rabi* season) NS – Non Significant Arcsine transformed values in parenthesis

Varieties : V_1: A-1 V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

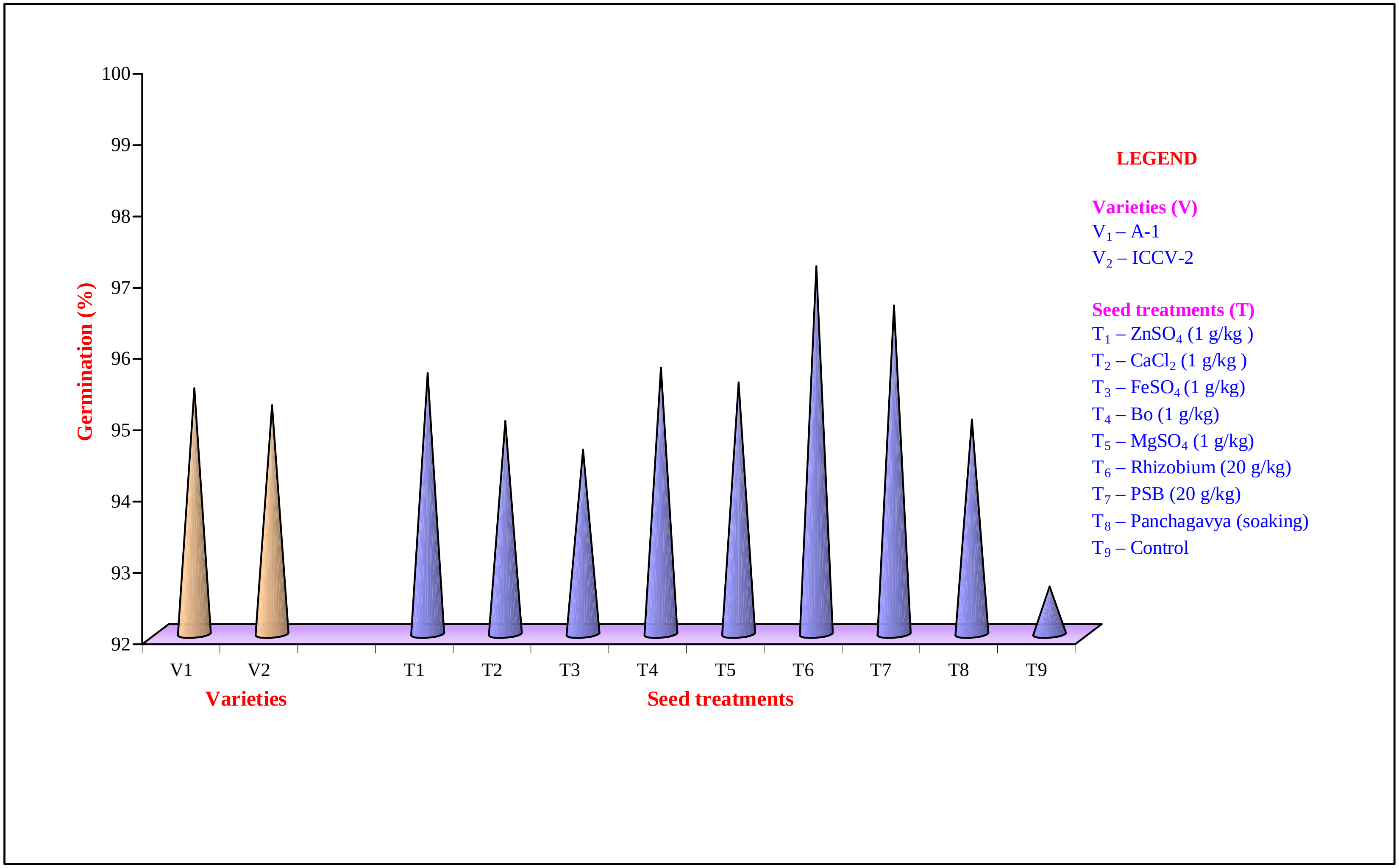


Fig. 19 : Effect of seed treatment on germination percentage in chickpea varieties

Table 33 . Effect of seed treatment on seedling length and seedling dry weight in chickpea genotypes (Pooled analysis)**

Treatments	Seedling length (cm)			Seedling Dry Weight (mg)		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	28.63	30.14	29.39	193.67	205.67	199.67
T_2	27.77	29.13	28.45	188.83	196.00	192.42
T_3	27.34	28.42	27.88	188.83	193.67	191.25
T_4	28.78	29.05	28.92	189.67	192.17	190.92
T_5	27.62	28.60	28.11	193.33	197.17	192.42
T_6	29.76	30.71	30.24	198.00	207.00	202.50
T_7	29.38	29.54	29.46	195.67	204.83	200.25
T_8	27.50	27.51	27.51	178.17	188.33	183.25
T_9	26.46	26.94	26.70	177.50	182.17	179.84
Mean	28.14	28.89	28.52	189.30	196.33	192.82
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.14	0.41		1.05	3.01
T		0.31	0.88		2.22	6.38
V x T		0.43	NS		3.14	NS

*(2007-08 and 2008-09 *rabi* season)
NS – Non Significant

Varieties : V_1: A-1
V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

The seed treatment with micronutrients and biofertilizers was significant on speed of germination. Significantly maximum (51.60) speed of germination was recorded in T_1 treatment and it was on par with T_6 (50.70) treatment and minimum (45.33) was with T_9 treatment.

No significant difference was seen due to varieties and seed treatments on speed of germination. However, numerically more (54.56) speed of germination was recorded with V_2T_1 treatment followed by V_2T_7 (51.44) and less (44.57) with V_1T_9.

4.4.13 Seedling length (cm)

The data on seedling length as influenced by varieties, seed treatments and their interactions are presented in Table 33.

Varieties showed significant effect on seedling length. The highest (28.89 cm) seedling length was recorded by ICCV-2 compared to A-1 (28.14 cm).

Significant difference in seedling length was recorded due to seed treatments with micronutrients and biofertilizers. T_6 treatment recorded significantly higher (30.24 cm) seedling length followed by T_7 (29.46 cm) and was on par with $T_{1.}$ Significantly lower (26.70 cm) seedling length was observed with control (T_9).

Due to interaction effect of varieties and seed treatments with non-significant difference was recorded on seedling length. Numerically more (30.71 cm) seedling length was recorded with V_2T_6 followed by V_2T_1 (30.14 cm) and less (26.46 cm) with V_1T_9.

4.4.14 Seedling dry weight (mg)

The data on seedling dry weight as influenced by varieties was recorded. Seed treatments and their interactions are presented in Table 33.

The significant difference for seedling dry weight between varieties in ICCV-2 (V_2) recorded markedly higher seedling dry weight (196.33 mg) over A-1 (189.30 mg).

The various seed treatments showed significant difference on seedling dry weight. Among the different treatments, T_6 recorded significantly highest (202.50 mg) dry weight and was on par with T_1 and T6 (200.25 and 199.67 mg respectively) and was lower with T_9 (179.84 mg).

The interaction effect between varieties and seed treatments with micronutrients and biofertilizers on seedling dry weight was non-significant. V_2T_6 treatment recorded numerically highest (207.00 mg) seedling dry weight and was lowest (177.50 mg) with V_1T_9.

4.4.15 Seedling vigour index

The data on seedling vigour index as influenced by varieties, seed treatments and their interactions are presented in Table 34 and depicted in Fig. 20.

No significant difference was seen on vigour index due to varieties. Numerically higher (2703) vigour index was recorded in ICCV-2 compared to A-1 (2687).

Significant difference in vigour index was noticed due to seed treatments. The higher (2922 mg) vigour index was recorded in T_6 treatment followed by T_7 (2832) and lower (2462) with T_9.

The interaction effect between varieties and seed treatments with micronutrients and biofertilizers did not show any significant effect on vigour index. However, V_2T_6 recorded numerically higher vigour index (2949) followed by V_2T_1 (2848) and V_2T_7 (2824) and lower (2464) was with V_1T_9.

4.4.16 Electrical conductivity (dSm^{-1})

The data on electrical conductivity as influenced by varieties, seed treatments and their interactions are presented in Table 34.

Significant difference was observed on electrical conductivity (EC) due to varieties. Markedly higher (0.454 dSm^{-1}) EC was recorded in ICCV-2 compared to A-1 (0.409 dSm^{-1}).

Table 34. Effect of seed treatment on vigour index and electrical conductivity in chickpea genotypes (Pooled analysis)**

Treatments	Vigour index			Electrical conductivity (dSm^{-1})		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	2744	2848	2796	0.407	0.425	0.416
T_2	2651	2557	2604	0.403	0.440	0.422
T_3	2589	2657	2623	0.412	0.473	0.443
T_4	2637	2699	2668	0.417	0.467	0.442
T_5	2759	2748	2753	0.405	0.453	0.429
T_6	2895	2949	2922	0.393	0.422	0.408
T_7	2840	2824	2832	0.387	0.432	0.410
T_8	2607	2593	2600	0.425	0.483	0.454
T_9	2464	2460	2462	0.430	0.488	0.459
Mean	2687	2703	2695	0.409	0.454	0.431
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		22.12	NS		0.003	0.007
T		46.92	134.85		0.005	0.015
V x T		66.36	NS		0.008	NS

*(2007-08 and 2008-09 *rabi* season)
NS – Non Significant

Varieties : V_1: A-1
V_2 : ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$ (1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)
T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

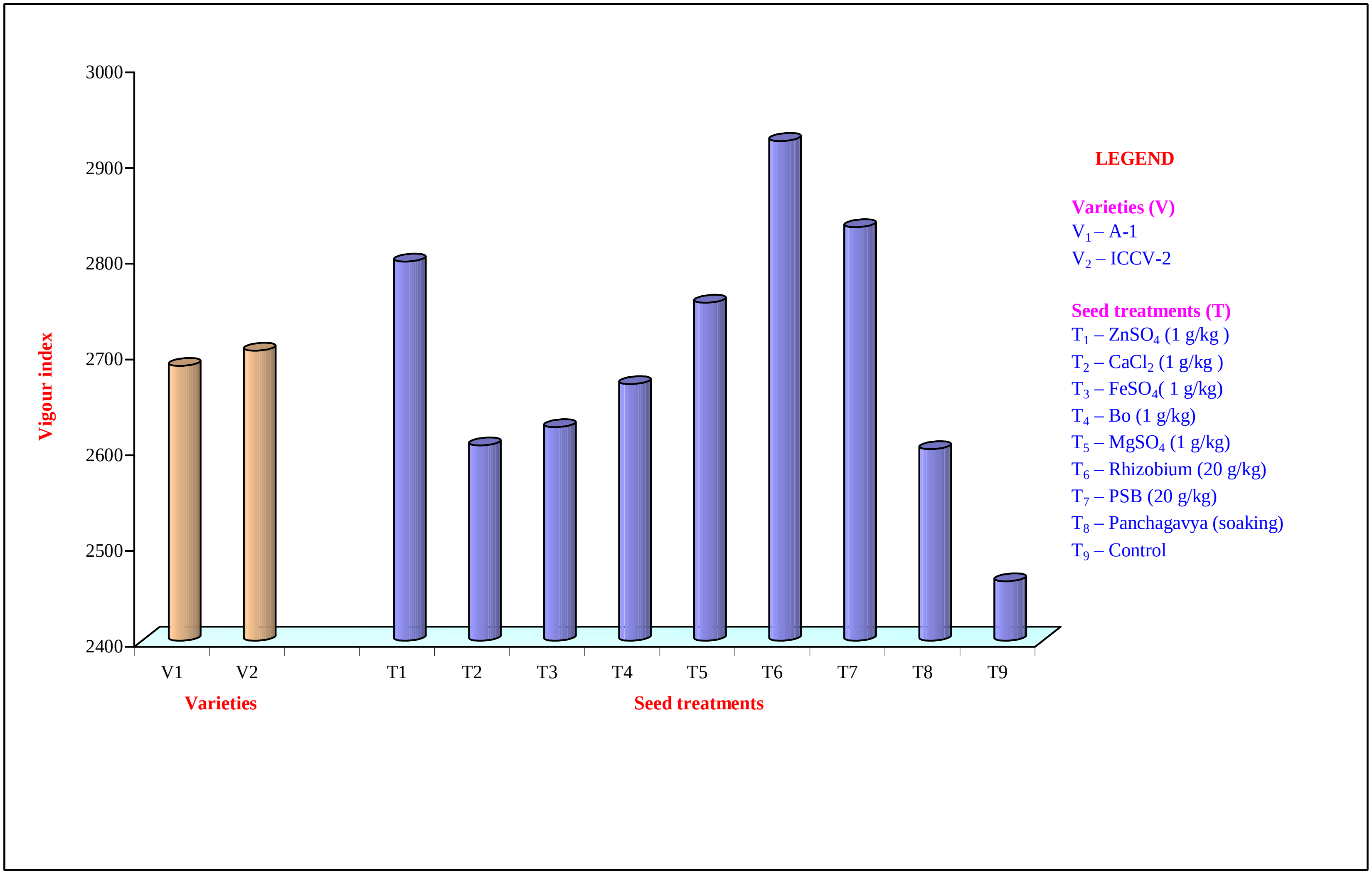


Fig. 20 : Effect of seed treatment on vigour index in chickpea varieties

The electrical conductivity found to differ markedly due to the seed treatments with micronutrients and biofertilizers. Markedly maximum EC was recorded in T_9 (0.459 dSm^{-1}) followed by T_8 (0.454 dSm^{-1}) and minimum (0.408 dSm^{-1}) with Rhizobium treatment (T_6).

The interaction between varieties and seed treatments did not differ significantly on EC. However, relatively maximum (0.488 dSm^{-1}) EC was recorded in V_2T_9 treatment combination followed by V_2T_8 (0.483 dSm^{-1}) and was lower (0.387 dSm^{-1}) in treatment T_1V_7.

4.5 Experiment - V: Influence of Stages of Harvest on Seed Quality in Chickpea Varieties

4.5.1 Fresh weight of pod (g)

The results on fresh weight of pod as influenced by varieties, harvesting stages and their interactions are presented in Table 35.

Among different varieties of chickpea, significant difference was noticed on 100 fresh pod weight. Significantly highest (57.86 g) 100 fresh pod weight was recorded in BGD-103 and was on par with Bheema (57.73 g) and lowest (46.53 g) in A-1.

The fresh pod weight at different stage of harvest showed marked differences. Significantly more (62.56 g) fresh pod weight was noticed with H_2 (green to yellow pod stage) harvesting stage followed by 58.66 g with H_1 (full green pods stage) and lowest (41.44 g) with H_4 (at copper brown pod stage).

Interaction due to varieties and stages of harvesting were found to differ significantly on fresh weight of 100 pods. The combination of V_5H_2 recorded more (67.73 g) fresh weight of pods followed by V_4H_2 (66.83 g) and less (34.10 g) with V_1H_4.

4.5.2 Dry weight of pod

The data on dry weight of pod as influenced by varieties, stages of harvest and their interactions are presented in table 35.

Significant difference was noticed on dry weight of pods in different chickpea varieties. Significantly higher (36.91 g) pod dry weight was recorded in Bheema and on par with KAK-2 (26.73g) and BGD-103 (36.65 g) and significantly lower (24.20) in A-1.

Among different stages of harvest, significantly maximum (37.07g) pod weight was recorded in H_3 (full yellow pod stage) followed by H_4 (35.24g) and was minimum (26.73g) with H_1 treatment.

The interaction between varieties and stages of harvest, showed significant difference on dry weight pod. The maximum (41.70 g) dry weight of pod was with V_5H_3 followed by V_5H_4 (41.17 g) while significantly less (20.20 g) in V_1H_1.

4.5.2 Fresh weight of seed (g)

The results on fresh weight of seed as influenced by varieties, harvesting stages and their interactions are presented in Table 36.

Significant difference on fresh weight of 100 seed was observed among chickpea varieties. Irrespective of harvesting stages, the fresh weight of 100 seed was more (50.51 g) in case of BGD-103 followed by Bheema (48.65 g) and KAK-2 (45.65 g) and less (36.30 g) with A-1.

Irrespective of varieties, significantly highest (48.75 g) fresh weight of 100 seed was recorded when harvested at green to yellow pod stage (H_2) followed by green pod stage (48.01 g) and the minimum was recorded with harvesting at copper brown pod stage (H_4) (35.93 g).

Among interaction effects of varieties and harvesting stages significantly maximum (54.73 g) fresh seed weight was in V_5H_2 followed by V_5H_1 (53.07 g) and V_4H_1 (52.13 g). Significantly, minimum fresh weight of 100 seed was registered in V_1H_4 (27.50 g).

4.5.3 Dry weight of seed (g)

The results on dry weight of seed as influenced by varieties, harvesting stages and their interaction are presented in Table 36 and depicted in Fig. 21.

Table 35. Influence of stages of harvest on fresh weight and dry weight of 100 pods in chickpea varieties

Treatments	Fresh weight of 100 pods (g)				Mean	Dry weight of 100 pods (g)				Mean
	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4	
V_1	49.93	53.5	48.6	34.1	46.53	20.20	22.27	28.10	26.21	24.20
V_2	60.23	60	51.17	35.87	51.82	25.60	27.43	34.10	30.73	29.47
V_3	59.13	64.73	54.3	46.27	56.11	32.40	34.10	41.30	39.10	36.73
V_4	62.43	66.83	56.23	45.43	57.73	34.30	34.23	40.13	38.97	36.91
V_5	61.6	67.73	56.57	45.53	57.86	29.17	34.57	41.70	41.17	36.65
Mean	58.66	62.56	53.37	41.44	54.01	26.73	28.92	37.07	35.24	32.04
Comparison for means of		S.Em±	CD (5%)				S.Em±	CD (5%)		
V		0.39	1.12				0.49	1.40		
H		0.35	1.01				0.44	1.26		
V X H		0.79	2.25				0.98	2.81		

Varieties : V_1 : A-1 V_2 : ICCV-2 V_3 : KAK-2 V_4 : Bheema V_5 : BGD 103

Stages of harvest : H_1 : Full green pod harvest stage H_2 : Green to yellow pod stage H_3 : Full yellow pod stage H_4 : Copper brown pod stage

Table 36. Influence of stages of harvest on fresh weight and dry weight of 100 seeds in chickpea varieties

Treatments	Fresh weight of 100 seeds (g)				Mean	Dry weight of 100 seeds (g)				Mean
	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4	
V_1	41.00	42.87	33.83	27.5	36.30	16.60	19.77	25.73	24.03	21.53
V_2	44.77	46.53	37.17	28.40	39.22	17.67	21.53	28.37	24.67	23.06
V_3	49.10	47.50	46.17	39.83	45.65	20.33	26.23	36.00	35.00	29.39
V_4	52.13	52.10	48.87	41.50	48.65	21.04	26.32	40.03	37.13	30.18
V_5	53.07	54.73	51.83	42.40	50.51	20.25	25.77	38.13	36.57	31.13
Mean	48.01	48.75	43.57	35.93	44.07	19.18	23.92	33.65	31.48	27.06
Comparison for means of		S.Em±	CD (5%)				S.Em±	CD (5%)		
V		0.34	0.97				0.23	0.65		
H		0.30	0.87				0.20	0.58		
V X H		0.68	1.94				0.46	1.31		

Varieties : V_1 : A-1 V_2 : ICCV-2 V_3 : KAK-2 V_4 : Bheema V_5 : BGD 103

Stages of harvest : H_1 : Full green pod harvest stage H_2 : Green to yellow pod stage H_3 : Full yellow pod stage H_4 : Copper brown pod stage

Table 37. Influence of stages of harvest on moisture content in chickpea varieties

Treatments	Moisture content				Mean
	H_1	H_2	H_3	H_4	
V_1	59.63	53.93	23.93	12.60	37.53
V_2	60.53	53.70	23.70	13.13	37.77
V_3	58.60	54.73	22.03	12.07	36.86
V_4	61.13	50.50	21.97	11.88	36.39
V_5	60.37	51.90	22.72	12.42	36.85
Mean	60.05	52. 95	22.87	12.42	37.07
Comparison for means of		S.Em±	CD (5%)		
V		0.23	0.64		
H		0.20	0.58		
V X H		0.45	1.29		

Varieties : V_1 : A-1 V_2 : ICCV-2 V_3 : KAK-2 V_4 : Bheema V_5 : BGD 103

Stages of harvest : H_1 : Full green pod harvest stage H_2 : Green to yellow pod stage H_3 : Full yellow pod stage H_4 : Copper brown pod stage

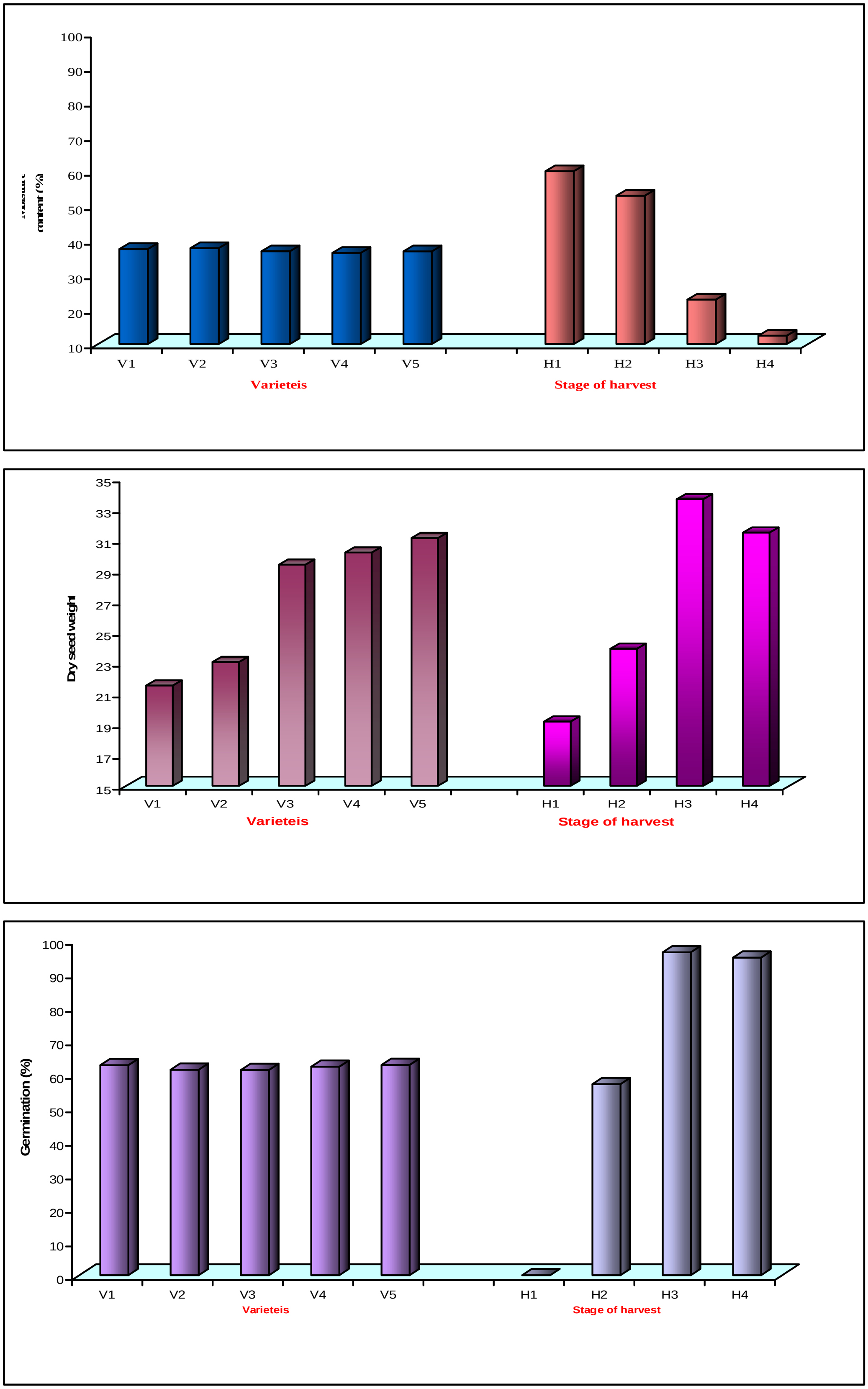


Fig. 21 : Influence of stages of harvest on moisture content (%), dry seed weight and germination (%) in chickpea varieties

Dry weight of 100 seed was found to differ significantly and was maximum (31.13 g) with V_5 (BGD-103) followed by Bheema and KAK-2 (30.18 and 29.39 g, respectively). Significantly minimum (21.53 g) dry weight of seed was recorded with A-1.

Among different stages of harvests, significantly higher (33.65 g) dry weight of 100 seeds was observed in H_3 (yellow pod stage) followed by brown pod stage (31.48 g) and minimum (19.18 g) with H_1 (green pod stage).

The interaction of varieties and stages of pod harvest was significant on dry weight of seeds. Among different combinations V_4H_3 recorded highest (40.03 g) seed dry weight followed by V_5H_3 (38.13 g) and V_5H_4 (37.13 g) and lowest (16.60 g) was with green pod sage (H_1).

4.5.4 Moisture content (%) of seed

The results on moisture content as influenced by varieties, harvesting stages and their interactions are presented in Table 37 and depicted in Fig. 21

Significant difference on seed moisture content was seen among the varieties and significantly higher (37.77 %) moisture content was recorded in variety ICCV-2 (V_2) followed by A-1 (37.53 %) and lower (36.39 %) with Bheema (V_3).

Among the different stages of harvest, significantly maximum (60.05%) moisture content of seed was recorded in seeds harvested at green pods (H_1) stage followed by green to yellow pod stage (H_2) (52.95%) and minimum (12.42%) in copper brown pod stage harvest (H_4).

The interaction effects due to varieties and stages of harvest showed significant difference on moisture content of seeds. The treatment combination of V_4H_1 recorded significantly more (61.13%) moisture content followed by V_2H_1 (60.53%) and were on par with V_5H_1 (60.37%) while significantly less (11.88%) moisture content was noticed with Bheema seeds harvested at brown pod stage (V_4H_4).

4.5.5 Germination (%)

The results on germination percentage as influenced by varieties, harvesting stages and their interactions are presented in Table 38 and depicted in Fig. 21.

Germination percentage differed significantly due to varieties and was maximum (62.75%) in BGD-103 followed by A-1 (62.70) and was on par with Bheema (62.25%) and lower in KAK-2 (61.25%).

Irrespective of varieties, the harvesting stages differed significantly on germination and was maximum (96.40%) in H_3 (full yellow pod stage) followed by H_4 (94.80%) while pods harvested at green pod stage did not germinate (0.00 %).

Interaction effect of varieties and harvesting stages was significant on germination percentage. Significantly more germination (97.67%) was seen in V_1H_3 treatment and was on par with V_5H_3 (97.33%) and V_4H_3 (97.00 %). While nil (0.00%) germination was recorded in all the varieties harvested at green pod stage.

4.5.6 Seedling length (cm)

The results on seedling length as influenced by varieties, harvesting stages and their interactions are presented in Table 38.

Significant difference was noticed on seedling length among the varieties. Significantly more (22.04 cm) seedling length was recorded in variety BGD-103 followed by Bheema and KAK-2 (21.50 and 21.46 cm, respectively) while less (19.29 cm) was with A-1.

Different stages of harvest showed significant difference on seedling length. It was maximum (31.90 cm) in H_3 (full yellow pods stage) harvest compared to other H_4 and H_2 (30.38 and 21.23 cm, respectively). While nil in all the varieties of H_1 stage.

The interaction effect due to varieties and stages of harvest showed significant difference on seedling length. Significantly maximum (33.00 cm) seedling length was recorded in V_5H_3 and V_3H_3 treatment followed by V_4H_3 (32.83cm) and V_3H_4 (32.00 cm) treatment combinations compared to other treatment combinations.

Table 38. Influence of stages of harvest on germination and seedling length in chickpea varieties

Treatments	Germination (%)				Mean	Seedling length (cm)				Mean
	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4	
V_1	0	58.33 (49.78)	97.67 (81.19)	95.00 (77.05)	62.70 (52.34)	0	19.33	29.50	28.33	19.29
V_2	0	58.00 (49.58)	94.67 (76.62)	92.67 (74.26)	61.34 (51.53)	0	20.83	31.17	30.30	20.58
V_3	0	55.33 (48.04)	95.33 (77.49)	94.33 (76.19)	61.25 (51.48)	0	20.83	33.00	32.00	21.46
V_4	0	56.66 (48.81)	97.00 (79.99)	95.33 (77.49)	62.25 (52.07)	0	21.83	32.83	31.33	21.50
V_5	0	57.00 (49.00)	97.33 (80.56)	96.67 (79.45)	62.75 (52.37)	0	23.00	33.00	32.17	22.04
Mean	0	57.06 (49.04)	96.40 (79.03)	94.80 (76.79)	62.07 (51.96)	0	21.23	31.90	30.83	20.97
Comparison for means of		S.Em±	CD (5%)				S.Em±	CD (5%)		
V		0.35	0.99				0.23	0.66		
H		0.31	0.89				0.21	0.59		
V X H		0.69	1.98				0.46	1.33		

Arcsine transformed values in parenthesis

Varieties : V_1 : A-1 V_2 : ICCV-2 V_3 : KAK-2 V_4 : Bheema V_5 : BGD 103

Stages of harvest : H_1 : Full green pod harvest stage H_2 : Green to yellow pod stage H_3 : Full yellow pod stage H_4 : Copper brown pod stage

4.5.7 Vigour index

The results on vigour index as influenced by varieties, harvesting stages and their interactions are presented in Table 39.

Significant differences on vigour index were noticed due to varieties. Significantly higher (1154) vigour index was recorded in BGD-103 (V_5) followed by Bheema (1119) and lower (1010) was in V_1 (A-1).

Vigour index differed significantly due to stages of harvest. Significantly maximum (2521) vigour index was recorded with H_3 (seeds harvested at full yellow pod stage) followed by copper brown pods stage (2367) compared to other two stages.

Vigour index was significantly higher (2659) in treatment combinations of V_5H_3 followed by V_4H_3 (2626) and V_3H_3 (2557).

4.5.8 Electrical conductivity (dSm^{-1})

The results on electrical conductivity as influenced by varieties, harvesting stages and their interactions are presented in Table 39.

Significant difference was observed among varieties on electrical conductivity of seed leachate. Significantly higher (1.826 dSm^{-1}) EC was recorded with V_3 (KAK-2) followed by ICCV-2 (1.741 dSm^{-1}) and lower (1.514 dSm^{-1}) with V_5 (BGD-103).

Different stages of harvest differed significantly on electrical conductivity and was higher (2.665 dSm^{-1}) in seeds harvested at green pod stage (H_1) followed by H_2 (2.033 dSm^{-1}) and lower (0.993 dSm^{-1}) with H_3.

Significant difference was seen due to interaction of varieties and stages of harvest on electrical conductivity of seed leachate. Markedly maximum (2.943 dSm^{-1}) EC was recorded with combination of V_3H_1 followed by V_2H_1 (2.843 dSm^{-1}) and V_4H_1 (2.800 dSm^{-1}). While, minimum (0.977 dSm^{-1}) EC was recorded with V_5H_3 treatment.

4.6 Experiment – VI : Characterization of Chickpea Varieties

4.6.1 Seed morphological characters

Based on seed morphological characters like seed coat colour, seed shape, seed surface, seed length, seed breadth, hilum colour, mottled testa colour, 100 seed weight and thickness of seed coat of five chickpea varieties were characterized into different groups. The details of morphological characters of each variety recorded are presented in Table 40.

4.6.2 Seed coat colour

The five chickpea varieties based on seed coat colour were grouped individually into two categories as brown and creamy white and details are presented in Table 40.

Varieties A-1, BGD-103 and Bheema were grouped in brown whereas, ICCV-2 and KAK-2 were grouped in creamy white groups.

4.6.3 Seed shape

The seed shape of five varieties of chickpea are presented in Table 40.

The seed of variety A-1, BGD-103 and Bheema were of angular shape and ICCV-2 and KAK-2 were Owl's shape.

4.6.4 Seed surface

The seed surface of five varieties are presented in Table 40.

The Desi chickpea varieties *viz.,* A-1, BGD-103 and Bheema were having rough surface while Kabuli types ICCV-2 and KAK-2 were smooth in seed surface.

4.6.5 Hilum colour

The hilum colour of all the five chickpea varieties are presented in Table 40.

No variation was observed with respect to hilum colour and as such no groups for hilum colour were made.

Table 39. Influence of stages of harvest on seedling vigour index and electrical conductivity in chickpea varieties

Treatments	Seedling Vigour Index				Mean	Electrical conductivity (dSm1)				Mean
	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4	
V_1	0	962	2395	2183	1010	2.647	1.977	0.923	0.997	1.628
V_2	0	1033	2388	2250	1061	2.843	2.077	1.007	1.037	1.741
V_3	0	1001	2557	2438	1105	2.943	2.183	1.077	1.100	1.826
V_4	0	1065	2626	2428	1119	2.800	1.977	0.980	1.040	1.699
V_5	0	1127	2659	2556	1154	2.093	1.953	0.977	1.033	1.514
Mean	0	1041	2521	2367	1090	2.665	2.033	0.993	1.035	1.682
Comparison for means of		S.Em±	CD (5%)				S.Em±	CD (5%)		
V		20.32	58.18				0.080	0.230		
H		18.18	52.04				0.072	0.205		
V X H		40.64	116.36				0.160	0.459		

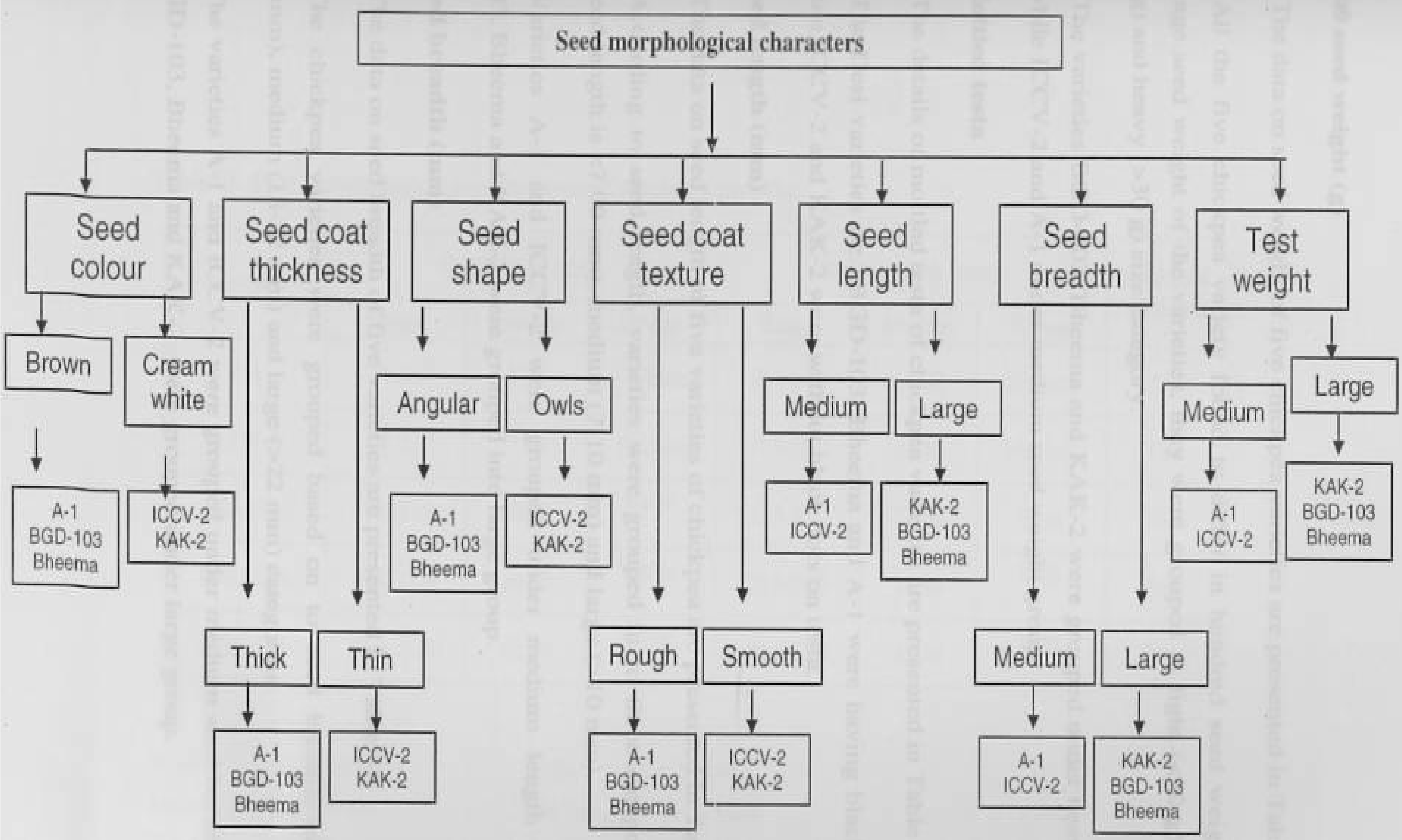
Varieties : V_1 : A-1 V_2 : ICCV-2 V_3 : KAK-2 V_4 : Bheema V_5 : BGD 103

Stages of harvest : H_1 : Full green pod harvest stage H_2 : Green to yellow pod stage H_3 : Full yellow pod stage H_4 : Copper brown pod stage

Table 40. Morphological characters of seed in chickpea varieties

Varieties	Seed coat colour	Seed shape	Seed surface	Mottles on testa	Hilum colour	100 seed weight(g)		
						Range	Average	Group
A-1	Brown	Angular	Rough	Small black spots are present	Pale yellow	20.73-25.67	23.92	Medium
ICCV-2	Creamy white	Owl's	Smooth	Absent	Pale yellow	25.52-26.99	25.52	Medium
KAK-2	Creamy white	Owl's	Smooth	Absent	Pale yellow	36.81-38.32	36.68	Heavy
BHEEMA	Brown	Angular	Rough	Small black spots are present	Pale yellow	37.11-39.02	37.34	Heavy
BGD-103	Brown	Angular	Rough	Small black spots are present	Pale yellow	36.10-37.23	37.81	Heavy

Light : < 20 gm
Medium : 20 – 30 gm
Heavy : >30 gm


Seed morphological characters
Seed colour
Brown
A-1 BGD-103 Bheema
Cream white
ICCV-2 KAK-2
Seed coat thickness
Thick
A-1 BGD-103 Bheema
Thin
ICCV-2 KAK-2
Seed shape
Angular
A-1 BGD-103 Bheema
Owls
ICCV-2 KAK-2
Seed coat texture
Rough
A-1 BGD-103 Bheema
Smooth
ICCV-2 KAK-2
Seed length
Medium
A-1 ICCV-2
Large
KAK-2 BGD-103 Bheema
Seed breadth
Medium
A-1 ICCV-2
Large
KAK-2 BGD-103 Bheema
Test weight
Medium
A-1 ICCV-2
Large
KAK-2 BGD-103 Bheema

4.6.6 100 seed weight (g)

The data on seed weight of five chickpea varieties are presented in Table 40.

All the five chickpea variety found to differ in hundred seed weight. Based on average seed weight of the varieties, they were grouped as light (<20 g), medium (20-30 g) and heavy (>30 g) size category.

The varieties BGD-103, Bheema and KAK-2 were grouped under heavy weight group while ICCV-2 and A-1 under medium seed weight group.

4.6.7 Mottled testa

The details of mottled testa of chickpea varieties are presented in Table 40.

The Desi varieties *viz*., BGD-103, Bheema and A-1 were having black dots on testa while ICCV-2 and KAK-2 were without black dots on testa.

4.6.8 Seed length (mm)

The data on seed length of five varieties of chickpea are presented in Table 41.

According to seed length, varieties were grouped in to three categories *viz*., small (seed length is <7.00 mm), medium (7-10 mm) and large (>10 mm).

Varieties A-1 and ICCV-2 were grouped under medium length whereas, BGD-103, Bheema and KAK-2 were grouped into large group.

4.6.9 Seed breadth (mm)

The data on seed breadth of five varieties are presented in Table 41.

The chickpea varieties were grouped based on to seed breadth into small (<18.00 mm), medium (18-22 mm) and large (>22 mm) categories.

The varieties A-1 and ICCV-2 were grouped under medium seed breadth group while BGD-103, Bheema and KAK-2 were grouped under large group.

4.6.10 Seedling morphological characters

Based on the seedling morphological characters like hypocotyl colour, cotyledon colour, presence of pubescene on hypocotyl and pigmentation on seedlings, the five varieties of chickpea were grouped in to different categories. The details of morphological characters of each varieties are presented of in Table 42.

4.6.10.1 Hypocotyl colour

The data on hypocotyl colour of five chickpea varieties are presented in Table 42.

The varieties that were studied varied for seedling hypocotyl colour. The hypocotyl colour of variety A-1 was pale green, ICCV-2 and KAK-2 were creamy whereas, BGD-103 and Bheema were light green colour.

4.6.10.2 Cotyledon colour

The varieties of chickpea were classified based on cotyledon and details are presented in Table 42.

The varieties A-1, BGD-103 and Bheema were classified under pale yellow cotyledons while ICCV-2 and KAK-2 are grouped in to light yellow.

4.6.10.3 Pubescence on hypocotyl

Based on presence of pubescence on hypocotyl chickpea varieties were grouped into dence (hairiness) and glabrous (non hairs) and data are presented in Table 42.

The pubescence on hypocotyl were present in all the five chickpea varieties and here no categories were for pubescence on hypocotyle. .

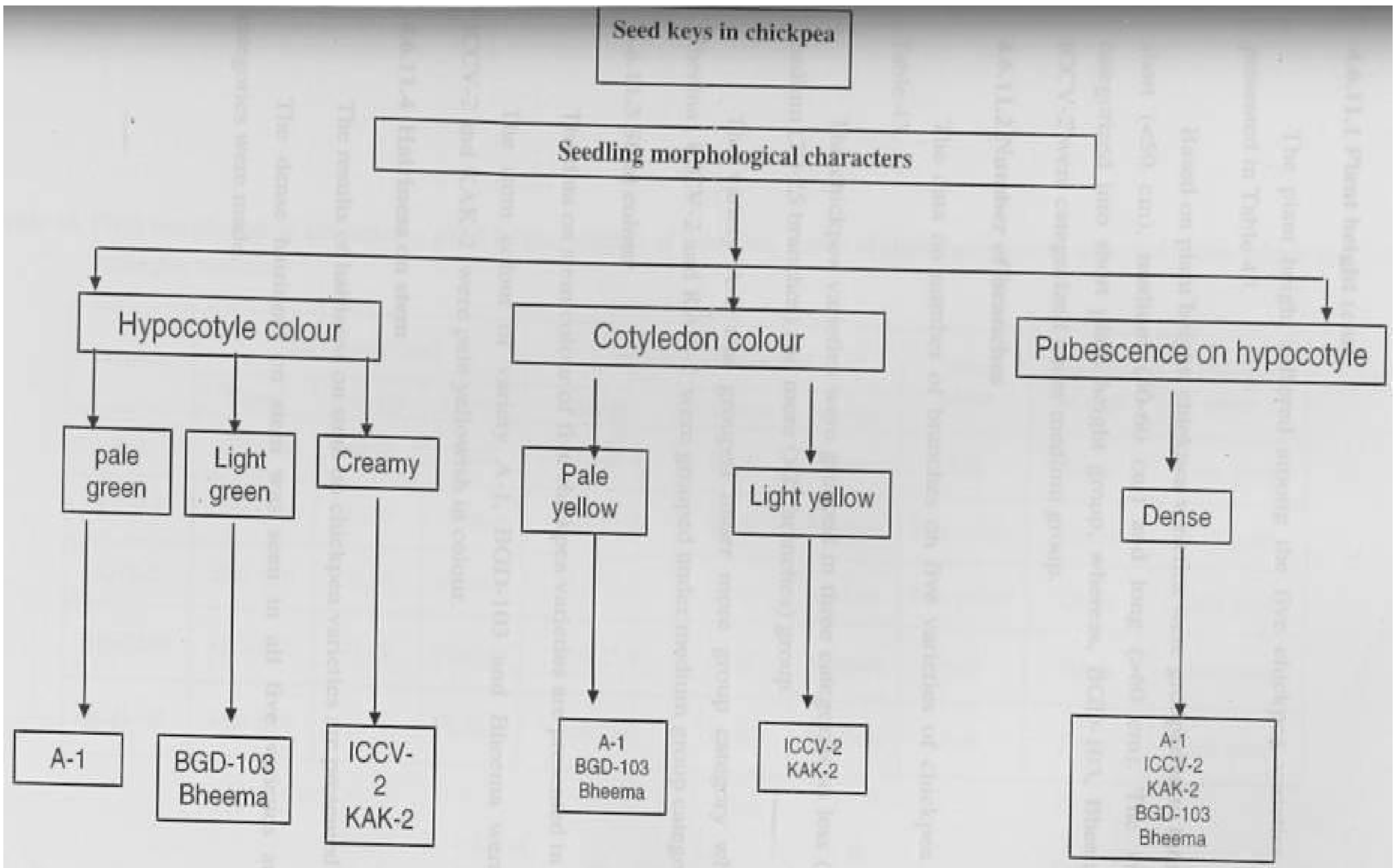
Table 41. Seed morphological measurement of chickpea varieties

Varieties	Seed length (mm)			Seed breadth (mm)			Seed coat thickness
	Range	Average	Group	Range	Average	Group	
A-1	7.0-8.5	7.70	Medium	17.0-21.0	19.00	Medium	Thick
ICCV-2	7.5-9.0	7.90	Medium	21.0-23.0	21.70	Medium	Thin
KAK-2	10.0-11.0	10.40	Large	23.5-25.0	23.90	High	Thin
BHEEMA	10.0-11.0	10.40	Large	23.0-26.0	24.70	High	Thick
BGD-103	10.0-11.50	10.50	Large	24.0-27.0	25.30	High	Thick

Small	:	< 7.00 mm	Light	:	< 18 mm
Medium	:	07 – 10 mm	Medium	:	18 – 22 mm
Large	:	>10 mm	Large	:	>22 mm

Table 42. Seedling morphological characters of chickpea varieties

Varieties	Hypocotyle colour	Cotyledon colour	Pubescence on hypocotyle
A-1	Pale green with pigmentation	Pale yellow	Dense
ICCV-2	Creamy without pigmentation	Light yellow	Dense
KAK-2	Creamy without pigmentation	Light yellow	Dense
BHEEMA	Light green with pigmentation	Pale yellow	Dense
BGD-103	Light green with pigmentation	Pale yellow	Dense


Seed keys in chickpea
Seedling morphological characters
Hypocotyle colour
Cotyledon colour
Pubescence on hypocotyle
pale green
Light green
Creamy
Pale yellow
Light yellow
Dense
A-1
BGD-103 Bheema
ICCV-2 KAK-2
A-1 BGD-103 Bheema
ICCV-2 KAK-2
A-1 ICCV-2 KAK-2 BGD-103 Bheema

4.6.11 Plant morphological characters

The different plant morphological characters like plant height at harvest, number of branches, stem colour, hairiness on stem, pigmentation on stem and foliage colour were considered to differentiate the different chickpea varieties and the result of these characters are presented in Table 43.

4.6.11.1 Plant height (cm)

The plant height differed among the five chickpea varieties and the data is presented in Table 43.

Based on plant height, chickpea varieties were grouped in to three categories *viz*. short (<50 cm), medium (50-60 cm) and long (>60 cm). The variety A-1 was categorized into short plant height group, whereas, BGD-103, Bheema, KAK-2 and ICCV-2 were categorized under medium group.

4.6.11.2 Number of branches

The data on number of branches on five varieties of chickpea is presented in Table 43.

The chickpea varieties were grouped in three categories as less (<20 branches), medium (20-25 branches) and more (>25 branches) group.

The variety A-1 was grouped under more group category while BGD-103, Bheema , ICCV-2 and KAK-2 were grouped under medium group category.

4.6.11.3 Stem colour

The data on stem colour of five chickpea varieties are presented in Table 43.

The stem colour of variety A-1, BGD-103 and Bheema were pink while, ICCV-2 and KAK-2 were pale yellowish in colour.

4.6.11.4 Hairiness on stem

The results of hairiness on stem on chickpea varieties are presented in Table 43.

The dense hairiness on stem was seen in all five varieties and hence no categories were made.

4.6.11.5 Foliage colour:

Based on foliage colour, chickpea varieties were categorized into Dark green, Green and Light green colour (Table 43).

All the varieties of Desi (A-I, BGD-103 and Bheema) were grouped under dark green foliage colour and kabuli types (ICCV-2 and KAK-2) were grouped under light green foliage colour.

4.6.11.6 Based on flower characteristics

The results of the varietal identification based on flower characteristics such as flower colour, flower size, days to flower initiation and days to 50 per cent flower of five chickpea varieties are presented in Table 44.

4.6.11.7 Flower colour

The observations on flower colour of five chickpea varieties are presented in Table 44.

The flower colour of A-1, BGD-103 and Bheema were pink while, ICCV-2 and KAK-2 were having white flower.

4.6.11.8 Days to flower initiation

The data on days to flower in chickpea varieties are initiation presented in Table 44.

Based on the days to flower initiation, the five chickpea varieties were grouped into early (30-40 days), medium (40.50 days) and late (>50 days) category. The varieties ICCV-2

Table 43. Plant morphological characters - plant height, number of branches, colour of stem, hairiness on stem and flower colour in chickpea varieties

Varieties	Plant height (cm)			Number of branches			Stem colour	Hairiness on stem	Foliage colour
	Range	Average	Group	Range	Average	Group			
A-1	45.0-53.0	49.10	Small	20.0-28.0	26.20	More	Pink	Dense	Dark green
ICCV-2	47.0-53.50	51.30	Medium	18.0-22.50	20.60	Medium	Pale yellow	Dense	Light green
KAK-2	49.0-55.0	52.50	Medium	18.0-23.0	21.40	Medium	Pale yellow	Dense	Light green
BHEEMA	48.0-56.0	51.60	Medium	20.0-25.0	22.60	Medium	Pink	Dense	Dark green
BGD-103	48.0-58.0	52.70	Medium	20.0-26.0	23.40	Medium	Pink	Dense	Dark green

Small : < 50 cm
Medium : 50 – 60 cm
Large : >60 cm

Less : < 20
Medium : 20 – 25
More : >25

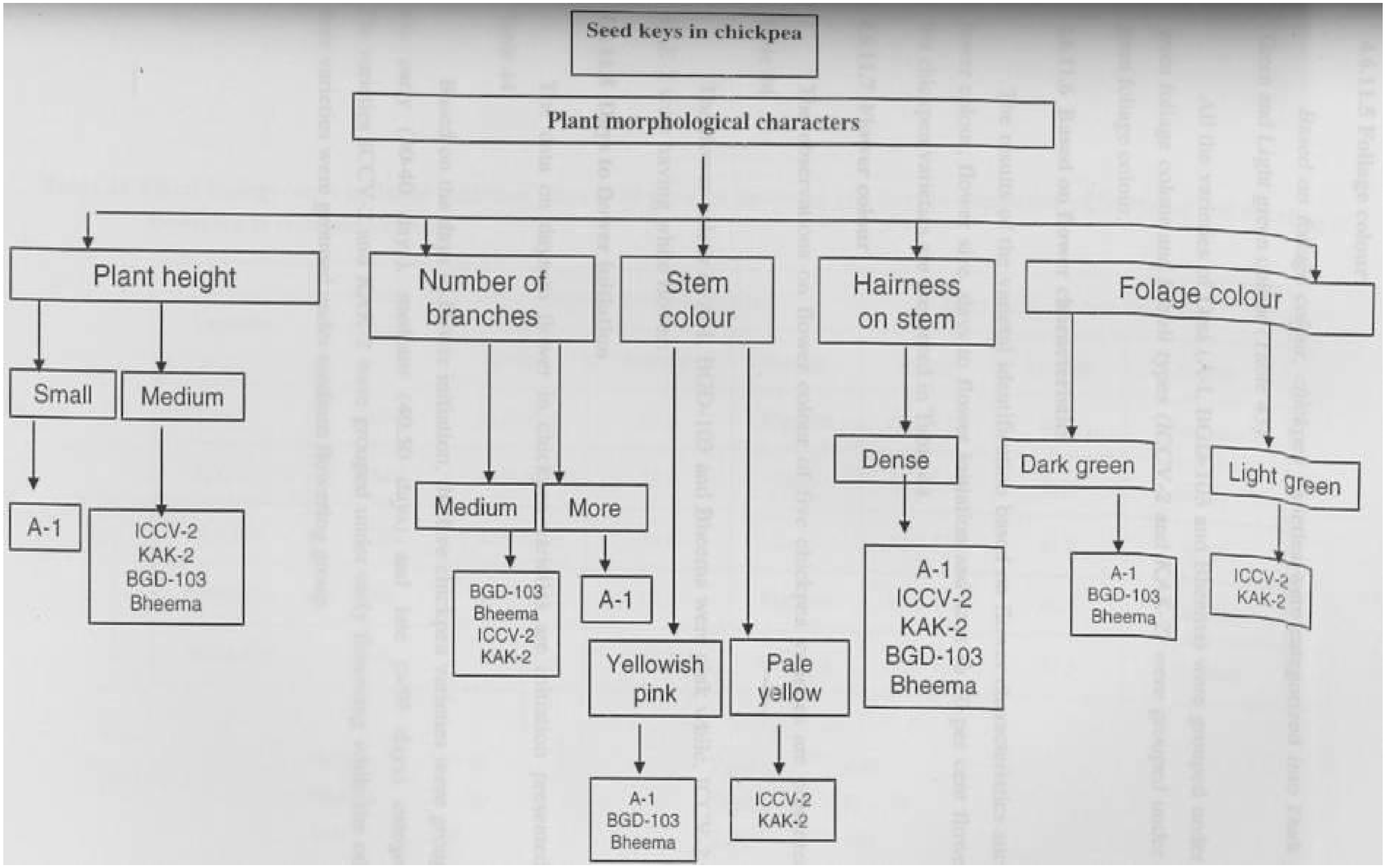
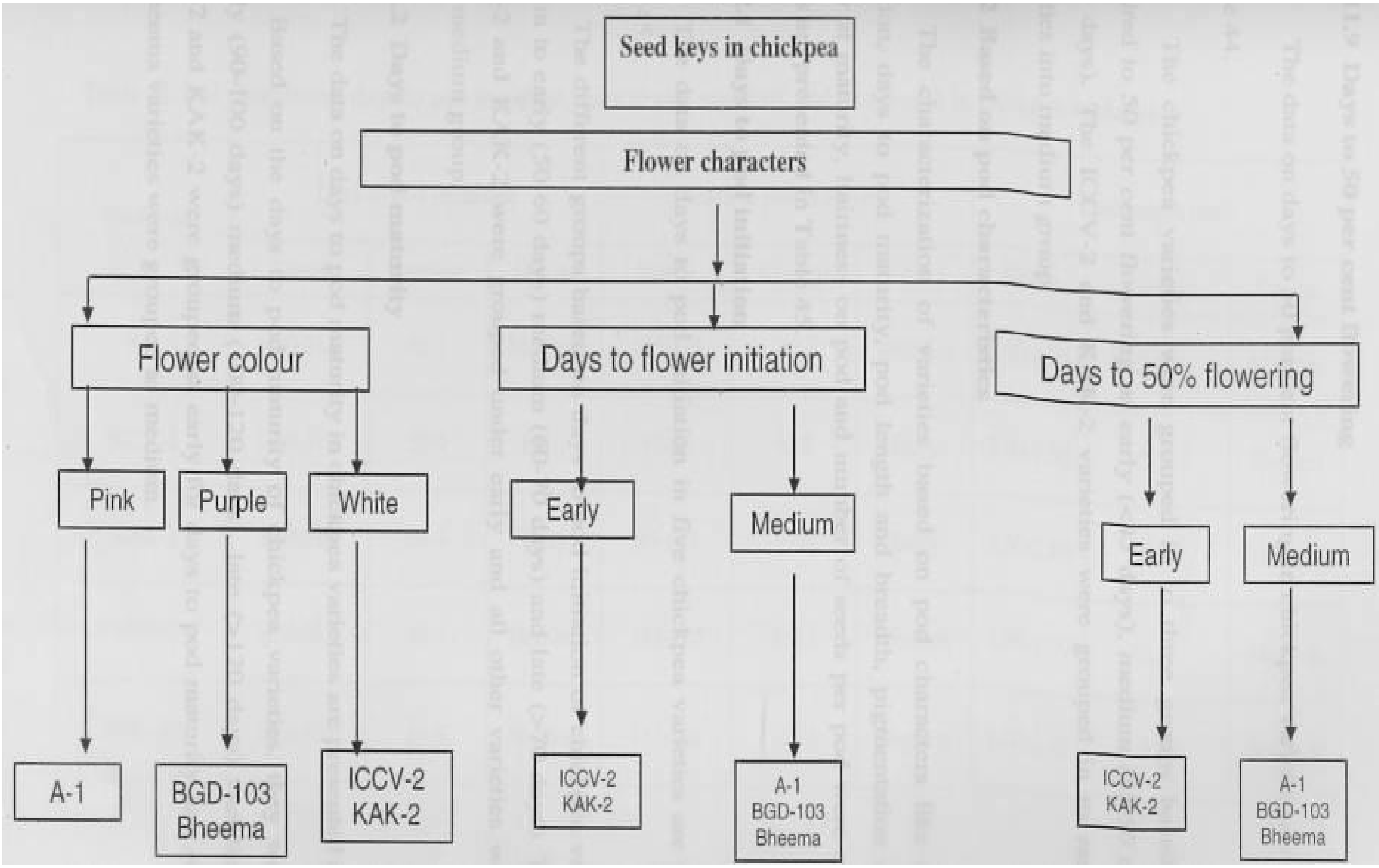

Seed keys in chickpea
Plant morphological characters
Plant height
Small
Medium
A-1
ICCV-2 KAK-2 BGD-103 Bheema
Number of branches
Medium
More
BGD-103 Bheema ICCV-2 KAK-2
A-1
Stem colour
Yellowish pink
Pale yellow
A-1 BGD-103 Bheema
ICCV-2 KAK-2
Hairness on stem
Dense
A-1 ICCV-2 KAK-2 BGD-103 Bheema
Folage colour
Dark green
Light green
A-1 BGD-103 Bheema
ICCV-2 KAK-2

Table 44. Floral biology- days to flower initiation, days to 50 per cent flowering and days to completion of flowering and duration of flowering in chickpea varieties

Varieties	Flower colour	Days to flower initiation			Days to 50 per cent flowering		
		Range	Average	Group	Range	Average	Group
A-1	Pink	42.0-45.0	43.5	Medium	45.0-47.0	46.0	Medium
ICCV-2	White	38.0-40.0	39.0	Early	40.0-42.0	41.0	Early
KAK-2	White	38.0-40.0	39.0	Early	40.0-43.0	41.5	Early
BHEEMA	Pink	43.0-46.0	44.5	Medium	45.0-48.0	46.5	Medium
BGD-103	Pink	44.0-47.0	45.5	Medium	46.0-49.0	47.5	Medium

Early : 30 - 40
Medium : 40 - 50
Late : >50

Early : < 45
Medium : 45 – 50
Late : >50


Seed keys in chickpea
Flower characters
Flower colour
Days to flower initiation
Days to 50% flowering
Pink
Purple
White
Early
Medium
Early
Medium
A-1
BGD-103
Bheema
ICCV-2
KAK-2
ICCV-2
KAK-2
A-1
BGD-103
Bheema
ICCV-2
KAK-2
A-1
BGD-103
Bheema

and KAK-2 were grouped under early flowering while the other three varieties were grouped under medium flowering group.

4.6.11.9 Days to 50 per cent flowering

The data on days to 50 per cent flowering in chickpea varieties are presented in

Table 44.

The chickpea varieties were grouped in to three groups based on the days required to 50 per cent flowering as early (<45 days), medium (45-50 days) and late (>50 days). The ICCV-2 and KAK-2 varieties were grouped in to early and other varieties into medium group.

4.6.12 Based on pod characteristics

The characterization of varieties based on pod characters like days to pod initiation, days to pod maturity, pod length and breadth, pigmentation on pod, pod colour at maturity, hairiness on pod and number of seeds per pod were made and the results are presented in Table 45.

4.6.12.1 Days to pod initiation

The data on days to pod initiation in five chickpea varieties are presented in Table 45.

The different groups based on days to pod initiation of chickpea varieties were made in to early (50-60 days) medium (60-70 days) and late (>70 days). The varieties ICCV-2 and KAK-2 were grouped under early and all other varieties were grouped under medium group.

4.6.12.2 Days to pod maturity

The data on days to pod maturity in chickpea varieties are presented in Table 45.

Based on the days to pod maturity of chickpea varieties, they were grouped as early (90-100 days) medium (100-120 days), late (>120 days) varieties. Varieties ICCV-2 and KAK-2 were grouped as early for days to pod maturity and A-1, BG-103 and Bheema varieties were grouped as medium.

4.6.12.3 Pod length (cm)

The data on pod length of five chickpea varieties is presented in Table 45.

Based on pod length variation of five chickpea varieties they were grouped as small (<2 cm), medium (2-2.5 cm) and long (>2.5 cm).

All the chickpea varieties were grouped under medium pod length group.

4.6.12.4 Pod breadth (cm)

The data on pod girth of different chickpea varieties is presented in Table 46.

Based on the pod breadth chickpea varieties were grouped into small (<3.5 cm), medium (3 - 4 cm) and large (>4 cm), pod breadth groups.

All the chickpea varieties were grouped under medium pod breadth group.

4.6.12.5 Pigmentation on pod

The results of pigmentation on pod are presented in Table 46.

Among the five different varieties of chickpea A-1, BGD-103 and Bheema showed the anthocynin pigmentation on the pods while ICCV-2 and KAK-2 did not show pigmentation.

4.6.12.6 Hairiness on pod

The results on hairiness on pod in different chickpea varieties is presented in Table 46.

All the five varieties of chickpea showed dence hairs on their pods hence no groups were made for this character.

4.6.12.7 Pod colour at harvest

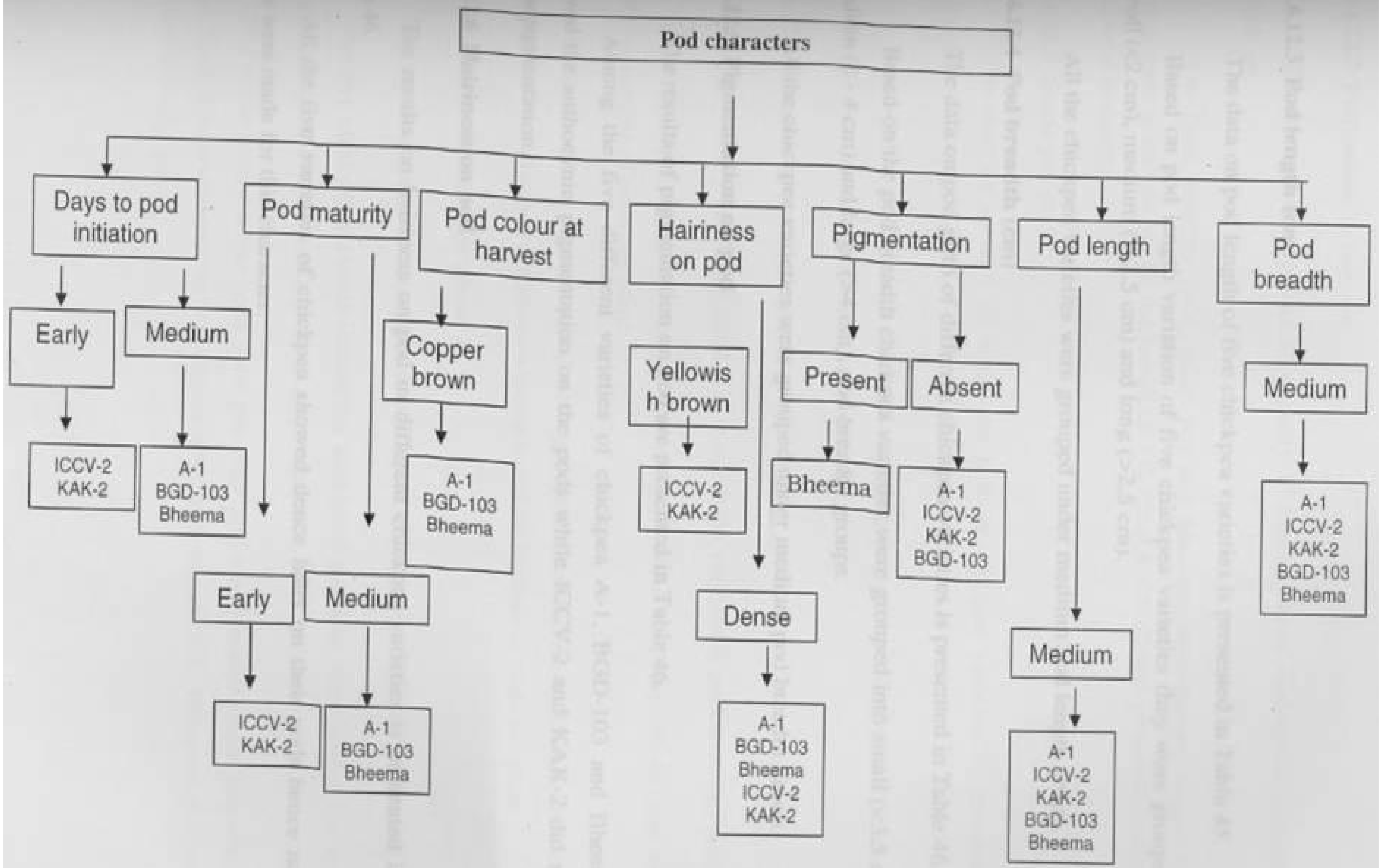
The data on pod colour at maturity of five chickpea varieties is presented in Table 46.

Table 45. Pod characters - days to pod initiation, days to pod maturity and pod length in chickpea varieties

Varieties	Days to pod initiation			Days to pod maturity			Pod length (cm)		
	Range	Average	Group	Range	Average	Group	Range	Average	Group
A-1	60.0-64.0	62.2	Medium	110-115	113.4	Medium	1.80-2.20	2.06	Medium
ICCV-2	54.0-57.0	55.4	Early	90-95	92.8	Early	2.00-2.30	2.30	Medium
KAK-2	55.0-58.0	56.4	Early	95-100	97.0	Early	2.30-2.60	2.46	Medium
BHEEMA	62.0-68.0	65.4	Medium	115-120	118.2	Medium	2.00-2.30	2.16	Medium
BGD-103	62.0-65.0	64.8	Medium	117-122	119.5	Medium	2.00-2.40	2.18	Medium

Early :	50 - 60	Early :	90 - 100	Small :	< 2 cm
Medium :	60 – 70	Medium :	100 – 120	Medium :	2-2.5 cm
Light :	>70	Late :	>120	Large :	>2.5 cm:

Seed keys in chickpea



The Desi varieties (A-1, BGD-103 and Bheema) were having copper brown colour pods at harvest while, the kabuli (KAK-2 and ICCV-2) had yellowish brown pod colour at maturity.

4.6.12.8 Seeds per pod

The data on number of seeds per pod in chickpea varieties is presented in Table 46.

Variety A-1 and ICCV-2 recorded 1-2 seeds per pod while, BGD-103, Bheema and KAK-2 recorded only one seed per pod.

4.6.12.9 Number of pods per plant

The data on number of pods per plant of five chickpea varieties is presented in Table 46.

The chickpea varieties were grouped as less (<30) medium (30-40) and more (>40) for number of pods per plant.

Varieties ICCV-2 and KAK-2 were grouped under medium and A-1, BGD-103 and Bheema were grouped under more group based on number of pods per plant.

4.6.12.10 Seed yield (g) per plant

The data on seed yield per plant of chickpea varieties is presented in Table 47.

The five chickpea varieties studied for seed yield per plant were grouped as less (<12 g), medium (12-13 g) and high (>13 g) groups.

ICCV-2 recorded lower seed yield per plant and was grouped under less while A-1 and KAK-2 were grouped under medium and Bheema and BGD-103 were grouped under high yielding group.

Table 46. Pod characters - pod breadth, pigmentation on pod, pod colour, hairiness on pod and number of pods per plant in chickpea varieties

Varieties	Pod breadth (cm)			Pigmentation on pod	Pod colour at harvest	Hairiness on pod	Number of pods per plant			Seeds per pod
	Range	Average	Group				Range	Average	Group	
A-1	3.00-3.50	3.26	Medium	Absent	Copper brown	Dense	51-65	58	High	1-2
ICCV-2	3.60-3.90	3.74	Medium	Absent	Yellowish Brown	Dense	36-46	42	Medium	1-2
KAK-2	3.70-4.00	3.82	Medium	Absent	Yellowish Brown	Dense	36-43	45	Medium	1
BHEEMA	3.30-3.70	3.46	Medium	Anthocynin pigment present	Copper brown	Dense	50-67	60	High	1
BGD-103	3.40-4.00	3.68	Medium	Anthocynin pigment present	Copper brown	Dense	52-78	68	High	1

Small : < 3.0
Medium : 3 – 4
Large : > 4

Less : < 40
More : 40 – 50
High : > 50

Table 47. Seed yield per plant in chickpea varieties

Sl. No.	Varieties	Seed yield per plant (gm)		
		Range	Average	Group
1	A-1	11.50-13.80	12.50	Medium
2	ICCV-2	11.02-12.86	11.74	Less
3	KAK-2	12.08-13.43	12.71	Medium
4	BHEEMA	13.50-14.79	13.75	High
5	BGD-103	13.37-15.09	13.88	High

Less : <12 gm
Medium : 12 – 13 gm
High : >13 gm

5. DISCUSSION

Chickpea is an important leguminous crop of our country, grown mainly under rainfed conditions. In recent year several Kabuli and Desi types of Bengal gram varieties are released for cultivation. The area under chickpea is increasing every year but the required quantity of quality seeds are not available for sowing mainly because of lesser area under seed production. The seed yield and quality needs to be enhanced by adopting certain agronomic practices and scientific seed production techniques. Hence, research on influence of nipping, growth regulators, micronutrients on seed yield and quality seems to be quiet inevitable. Similarly, much investigations are needed on influence of seed size on storage potential of Kabuli and Desi chickpea varieties. For obtaining higher seed yield and quality harvesting of seed crop at appropriate time of maturity is most important and hence studies in this aspect seems to be essential to the seed growers. Further, in executing quality control and seed certification programmes, the varietal characterization is pivotal and as such it is necessary to identify varieties based on certain seed, seedling and plant morphological characters. Keeping all these aspects field and laboratory studies were made in both Kabuli and Desi varieties of chickpea varieties at the University of Agricultural Sciences, Dharwad and the results are discussed in detail in this chapter.

5.1 Experiment – I : Effect of Nipping and Growth Regulators Spray on Plant Growth, Seed Yield and Quality in Chickpea Varieties

The field experiment consisted of 16 treatments combinations involving two varieties (A-1and ICCV-2), two levels of nipping (N_1- nipping and N_2 – no nipping) at 30 DAS and four foliar spray of growth regulators *viz*., S_1- NAA (50 ppm), S_2 (Triacontanol 1 ml/ L), S_3 – *Panchagauya* (3%) and S_4- Control (water spray) and experiment was laidout in RCBD with factorial concept in three replications. The results of this study are discussed as below.

5.1.1 Influence of varieties

The plant growth, flowering, seed yield and quality parameters generally are influenced by several biotic, abiotic, agronomic and management practices besides genetic makeup of variety.

In the present study, varietal differences with respect to field performance have been noticed in chickpea. Significant variation in plant height at 60 DAS and at harvest were observed in chickpea varieties irrespective of nipping and growth regulators. In general ICCV-2 (V_2) variety registered more plant height (38.63 cm and 44.30 cm) at 60 DAS and at harvest respectively (Table 1) which may be mainly due to efficient accumulation of photosynthates in the vegetative plant parts. Besides the plant height is also a genetic character of varieties (Poma *et al*., 1990).

On the contrary, the number of branches were maximum (25.58) in A-1 compared to ICCV-2 (21.97) (Table 2) such varietal differences in number of branches were also reported by Merwade (2000) in chickpea.

The days to 50 per cent flowering is under genetic control and influenced by the environment prevailing during crop growth period. ICCV-2 (V_2) took significantly less (47.5) compared to A-1which took more (53.73) days for 50 per cent flowering (Table 3). Similar reports on varietal variation on days to 50 per cent flowering were made in chickpea by Merwade (2000).

In the present study, significant differences were seen between the chickpea varieties with respect to number of pods per plant, number of seeds per pod, seed yield per plant, per plot and per hectare (Table 4 and 5; Fig. 5 and 6) irrespective of nipping and foliar spray of growth regulators. Between varieties, A-1(V_1) recorded significantly more number of pods per plant (47.75), number of seed per pod (1.46), pod yield per plot (16.78 g), seed yield per plant (14.66 g), per plot (1.03 kg) and per ha (28.75 q). The differences on seed yield and yield parameters observed between varieties in the present study may be attributed to their differences in growth habit and genetic yielding ability. Similar varietal difference in chickpea with respect to plant growth was reported by Aziz and Rahman (1996) and on seed yield and yield attributes by Siag and Verma (1995) and Mewade (2000) in chickpea and in cowpea by Reddy (2005).

It is an established fact that seed quality attributes are reported to vary among varieties of several crop species owing to genetic and environmental factors. In the present investigation, all the seed quality parameters were found to differ between chickpea varieties (Table 6, 7 and 8). The 100 seed weight (21.66 g), seedling length (27.54 cm), dry weight (180.37 g), vigour index (2301) and electrical conductivity (0.491 dSm^{-1}) were more in ICCV-2 (V_2) compared to A–1 (V_1). While, A-1 recorded relatively more germination (94.38%) and lower EC (0.395dSm^{-1}) compared to ICCV-2. The differences in seed quality attributes observed between chickpea varieties may be attributed to varietal differences in seed development and accumulation of reserved food material. The similar results were reported by Ramteke (1995) and Merwade (2000) in chickpea.

5.1.2 Influence of nipping

The advantages of nipping on increase in number of productive branches, number of flowers, pods per plant and higher yield have been noticed in several field crops.

In the present study, the terminal shoot tip of plant was nipped at 30 DAS to restrict growth and enhance horizontal growth and to derive such added benefits of nipping.

Between nipping and no nipping treatments, non-nipped (N_2) plants recorded significantly more plant height at 60 DAS and at harvest (37.78 and 44.23 cm, respectively) compared to nipped plant (N_1). While, nipped plants (N_1) recorded significantly higher number of pod bearing branches (22.44 and 25.12) at 60 DAS and at harvest respectively compared to non-nipped plant (19.81 and 22.43) (Table 2).

The higher plant height noticed with non-nipping (N_2) treatment was mainly due to the fact that plants were not nipped and as such seeds plants grew to their original height without reduction unlike nipped plants. While, number of branches per plant were more in case of nipped plants. This may be due to nipping effect of apical buds which resulted in production of more secondary branches and cessation of vertical growth on account of effective translocation of growth regulators particularly auxins being diverted to the potential and tertiary shoot buds which in normal conditions remain dormant. Sing and Singh (1992) indicated that the energy which was provisionally used by the plant was diverted towards branching. Similar reports were made by Khan *et al*. (2006) in chickpea, Shankargoud and Patil (1994) in sunflower, Sharma *et al*. (2003) in pigeonpea and Singh and Devi (2006) in pea.

With respect to days to 50 per cent flowering nipped plants took more (50.36) number of days compared to non nipped plant (49.27 days). The delay in flowering in nipping may be due to the fact that nipping of apical buds temporarily hinders the multiplication of meristematic cells in the growing tip. The results are in conformity with Gujar and Srivatsava (1972) and Sajjan (2000) in okra, Sudarshan (2004) in fenugreek.

The seed yield is a function of plant population, number of pod bearing branches, number of pod per plant, number of seeds per pod, test weight *etc*. Arresting of vertical growth of plants by nipping apical bud always results in production of more number of productive branches. In the present study, plants nipped (N_1) at 30 DAS recorded significantly highest values for all the seed yield parameters. The number of pods per plant (46.04), pod yield per plant (18.22 g), seed yield per plant (12.65 g), per plot (1.02 kg) and per ha (28.50 q) were more with nipping treatment (Table 4 and 5). While, number of seeds per pod and 100 seed weight did not show significant difference on account of genetic factor but were numerically higher (1.40 and 23.19 g respectively) in nipped plants.

The increase in seed yield and yield attributing parameters noticed with nipping was mainly due to production of more number of productive branches (Khan *et al*., 2006) in chickpea. The nipping is known to accumulate more photosynthates which are utilized for production of more number of pod bearing branches and more number of seeds per pod in pea (Singh and Singh, 1992 and Singh and Devi, 2006). Seed yield itself is a complex genetic trait and several other parameters like branches per plant, days to flowering, number of pods per plant *etc*. have significant role on final yield. Khan *et al*. (2006) opined that although the correlation between number of branches and seed yield is always positive and their magnitude has been increased considerably in chickpea with nipping. Similar increase in seed yield and yield parameters with nipping were also reported by Aziz (2002) in chickpea, Sharma *et al*. (2003) in pegion pea and Reddy (2005) in cowpea.

Plants nipped at 30 DAS (N_1 recorded significantly highest seed quality parameters like germination (93.68%), seedling length (27.06 cm), seedling dry weight (179.12 mg) and vigour index (2282) while, electrical conductivity was significantly the lowest (0.426 dSm^{-1}) compared to no nipping treatment (Table 14 and 16; Fig. 7 and 8). The higher seed quality parameters noticed with nipping at 30 DAS may be due to increase in photosynthetic area leading to higher photosynthetic rate, better assimilation and accumulation of more photosynthates resulting into better seed development as evident with higher test weight. Similar increase in germination and lesser electric conductivity of seed leachate with apical bud nipping was earlier revealed by Venkatreddy *et al*. (1997) and Sajjan *et al*. (2003) in okra, Mc.Creaw and Greig (1986) in capsicum, Sudarshan (2004) in fenugreek and Iyyanagouda (2003) in coriander.

5.1.3 Influence of growth regulators

The growth regulators are known to exert significant influence on plant structure, crop growth, seed yield and quality attributes in different pulses. In the present study also, growth regulators have shown the marked stimulatory effect on various crop growth, flowering, seed yield and quality characteristics irrespective of variety and nipping treatment.

The plant height and number of branches at 60 DAS and at harvest were significantly higher in NAA (50 ppm) (S_1) followed by triacontanol (1ml/l) (S_2) and panchagavya (3%) (S_3) and was least in control (S_4). The plant height at 60 DAS and harvest was markedly maximum (38.49 and 47.47 cm, respectively) with NAA 50 ppm spray compared to other treatments and control. This increase in plant height is attributed to their influence on increased cell division, elongation and growth promoting nature of the chemicals (Setia *et al*., 1991) and maximum synthesis of auxin at tip branches leads to increase in plant height (Upadhayay, 1994).

Similar significant influence on plant height and number of branches with the spraying of different regulators were noticed in chickpea (Wasnik and Bagga, 1996 and Merwade, 2000), in greengram and blackgram (Patel and Saxena, 1994b and Prabhu, 2000) in vegetable cowpea (Hunje, *et al*., 1995), in pea (Tripathi and Mithlesh, 2006) and Jeyakumar *et al.* (2008) in blackgram.

The days to 50 per cent flowering were significantly less in NAA (49.00 days) followed by triacontanol (49.67 days) compared to control (50.63 days). The similar results were also reported in chickpea by Upadhayay (2002), Karan Singh *et al*. (1991) and Merwade (2000).

In the present study, the foliar spray of growth regulators showed significant differences on seed yield and yield attributes. The maximum number of pods (46.76), pod weight per plant (19.19 g), seed yield per plant (15.67 g), per plot (1.06 kg) and per ha (29.91 q) with higher test weight (24.48 g) were observed in plant sprayed with 50 ppm NAA followed by triacontanol 1ml/l (43.34, 17.84 g, 14.96 g, 1.01 kg, 27.80 q and 23.57 g, respectively) compared to control (35.26, 15.84 g, 12.05 g, 0.89 kg, 24.68 q and 21.32 g, respectively). The significant increased seed yield and yield attributes obtained with the application of growth regulators may be attributed to more number of productive branches per plant, pods per plant and 100 seed weight. Further, growth regulators influence carbon cycle in plant with higher CO_2 fixation and efficient translocation of synthates towards developing seed (Menon and Shrivastava, 1984, Tripathi, *et al*., 2001) in chickpea. The similar higher seed yield due to application of growth regulators in different pulses was related to the increased vegetative growth, number of branches, flowers and pod numbers (Upadhayay *et al*., 1999 and Patel and Sexena, 1994b and Prabhu, 2000); higher pod numbers, seeds per pod, seed weight (Ravichandran and Ramaswami, 1993 and Shah *et al*., 1994); reduced plant height, delayed leaf senescence, increased lateral branches, seeds per pod and 100 seed weight (Hunje *et al*., 1995). Further, NAA has beneficial role on preventing flower drop in chickpea which may be due to creation of favourable balance of endogenous hormone related to flowering which inturn results in increase of seed yield (Mishriky *et al*, 1990 ; Patil *et al*., 1990 and Upadhayay , 2002) in chickpea.

The seed quality parameters like seed germination, seedling length, seedling dry weight, vigour index were markedly maximum with minimum electrical conductivity with foliar spray of NAA followed by triacontanol and panchagavya compared to control. These growth regulators are known to increase sink and source relationship due to increase translocation of assimilates towards the seeds leading to more number of well developed, matured pods per plant with higher test weight and germination performance (Tonapi and Kulkarni, 1986 and Upadhayay , 1994). Similar benefits were also reported in pigeonpea (Deshpande, 1983 and Reddy *et al*., 2000) and in blackgram (Lakshmamma and Rao, 1996) with foliar spray of growth regulators.

Due to interaction of variety x nipping (VxN)

The plant height at harvest differed significantly but not in number of branches due to interaction effect of varieties and nipping. The plant height at harvest was maximum (44.97 cm) in ICCV-2 variety in non nipping treatment whereas, nipped plants showed less plant height in both the variety. Among the different treatment combination ICCV-2 variety sprayed with triacontanol (V_2N_2) recorded highest plant height (39.06 and 44.97 cm) at 60 DAS and harvest respectively.

The number of branches at all the stages of crop growth though did not differ markedly they were relatively higher (24.83 and 26.87) in nipped plants of A-1vareity (V_1N_1) at 60 DAS and at harvest while, were less (17.37 and 20.57) in ICCV-2 in non nipped treatment at 60DAS and at harvest respectively.

Similarly increase in number of branches due to nipping treatments were also reported by Sudarshan (2004) in fenugreek, Iyyangouda, (2003) in coriender, Sajjan and Jamadar (2003) in bhendi and was related to production of auxin, which inturn stimulates buds sprouting.

Likewise, days to 50 per cent flowering did not show any significant variation due to interactions of varieties and nipping.

In the present investigation, the seed yield and yield parameters were not influenced by the interactions of varieties and nipping treatment. However, it was evident that the nipping treatment in A-1and ICCV-2 chickpea varieties has resulted in production of higher number of pods per plant (52.60 and 39.48), pods weight per plant (19.11 and 17.32) seed yield per plot (1.08 and 0.97 kg) and per ha (30.22 and 26.78 q/ha) respectively (Table 12 and 13). Although, nipping treatment in both the varieties has not shown any significant influence on any of seed yield parameters and yield, the nipping in chickpea was found beneficial to enhance these yield traits. Similar increase in seed yield traits and yield were reported by Khan *et al*. (2006) in chickpea, Shankargoud and Patil (1994) in sunflower and Sharma *et al*. (2003) in pigeonpea.

Most of the seed quality parameters were found to be not significantly influenced by nipping in both the chickpea varieties except seedling length, dry weight and electrical conductivity values. Seedling length and dry weight was significantly more (28.18 cm and 18.62 mg respectively) with ICCV-2 plants sprayed with NAA 50 ppm (V_2N_1) compared to other interactions. The EC though differed significantly did not show any definite trend of inverse relationship with seed quality parameters. However, nipping in both the varieties showed relatively higher test weight, germination, speed of germination and seedling vigour parameters and similar results were made by Venkatreddy *et al*. (1997) and Sajjan (2001) in bhendi, Sudarshan (2004) in fenugreek and Iyyangouda (2003) in coriander.

Due to interaction variety and growth regulators spray (VxS)

The interactions influence of varieties and foliar spray of growth regulators was found to be non significant with respect to plant height and number of branches at various stages of crop growth period. However in general it was observed that foliar spray of NAA 50 ppm in A-1 and ICCV-2 recorded relatively more plant height (46.17 and 48.76 cm) and number of branches (27.80 and 24.45) respectively at harvest compared to other foliar sprays of growth regulator and control (water spray). This marginal increase observed in these two growth parameters in the present study may be related to poor varietal responses for foliar sprays of growth regulators owing to limited genetical potential of varieties.

Likewise days to 50 per cent flowering was not influenced by foliar spray of growth regulators in none of the chickpea varieties which is also due to genetic trait of the variety.

In the present study the combination effect of variety and growth regulators spray (VxS) was found significant on seed yield per ha. The final seed yield per ha was maximum (32.29 and 27.52 q/ha) in both the chickpea varieties sprayed with NAA 50 ppm and was followed by triacontanol (1 ml/l) compared to control. Similar increase in final yield was reported by Patil *et al.* (1990), Upadhayay (1994), Merwade (2000) and Reddy (2002) in chickpea,

All the seed quality parameters except seedling dry weight were not found to differ significantly due to interactions of varieties and foliar spray of growth regulators. The seedling dry weight was significantly maximum (187.32 mg) in ICCV-2 with NAA 50 ppm (V_2S_1) followed by Tricontalol (1ml/l) (V_2S_2) (184.26 mg) and was minimum (155.14 mg) in water spray in A-1 variety(V_1S_4). The higher seedling length and dry weight noticed may be related to higher test weight. As these seeds shall have maximum food reserves which are utilized for better seedling growth. Similar beneficial results were also noticed with foliar spray with NAA and triacontanol in ICCV-2 variety by Merwade (2000) in chickpea.

Influence of interaction between nipping and growth regulators (NxS)

In the present investigation, the plant height and number of branches at various stages were not influenced by the combined effects of nipping and foliar sprays. However, the plant height was relatively more at all the stages of growth in non nipped plants with all the growth regulators sprays compared to control as expected, while number of branches were more at harvest in nipped plants with all the foliar sprays of the growth regulators which was also expected with these treatments, since nipping results in arresting vertical growth and stimulates shoot auxiliary buds. The results are in accordance with the earlier reports made by Khan *et al*. (2006) with respect to nipping and Merwade (2000) with respect to growth regulators in chickpea.

The days to 50 per cent flowering was not found to be influenced much due to nipping and growth regulators irrespective of varieties, since flower behaviour seems to be varietal character.

Over all, the seed yield and yield parameters due to interaction effects of nipping and growth regulators spray were not influenced much. However, among the interactions of NxS, it was evident that in nipped plants and sprayed with growth regulators increased final yield compared to non nipped plants without growth regulators spray.

Similarly, the various seed yield traits were also higher in nipped plants and sprayed with growth regulator. The present investigation has indicated a relatively more beneficial influence of both nipping and growth regulators on final yield and yield attributes. The present results are also in agreement with the findings of Khan *et al*. (2006) in chickpea, Sudarshan (2004) in fenugreek and Iyyangouda (2003) in coriender with respect to nipping. While, Merwade (2000), Upadhayay *et al*. (1993) and Patel and Sexena (1994a&b) in chickpea with respect to growth regulators spray.

All the seed quality parameters were not significantly influenced by the interaction of nipping and foliar spray with growth parameters. However, with nipping and foliar sprays of NAA 50 ppm and Triacontanol (1 ml/lit.) found to record higher test weight, germination, seedling length, vigour index, seedling dry weight with less EC values. Similar beneficial effects were also obtained by Merwade (2000) in chickpea Sudarshan (2004) in fenugreek with respect to growth regulators spray and nipping respectively.

Influence of interaction of variety, nipping and growth regulators spray (VxNxS)

The three way interactions of varieties, nipping and growth regulators spray was found significant on plant height at harvest but not on flowering, seed yield and yield attributes and seed quality parameters. However, the results of the present study has shown relatively beneficial influence of nipping and growth regulators spray in both the chickpea varieties on all these parameters. Similar beneficial effects were reported with nipping by Sudarshan (2004) in fenugreek, Iyyangouda (2003) in coriander and Merwade (2000) with growth regulators spray in chickpea.

5.2 Experiment – II : Effect of Seed Size on Plant Growth, Seed Yield and Quality in Chickpea Varieties

Seed size *per se* is positively related to seed quality, seed vigour and field performance in several crop species. Generally, big seeds with high amount of endospermic food reserves germinate early and rapidly, grow vigorously and more resistant to stress conditions, pest and diseases and produce higher yield (Styer *et al.,* 1980 and Tiwari *et al.*, 1978). It has been considered since long that planting of bold and medium seeds generally give higher yields than small and shriveled (Bremner *et al*., 1963). While, Khare and Satpute (1999) reported that small and medium seeded varieties of pigeonpea showed better germination and mobilization efficiency than bold seeded varieties with higher vigour index. The seedling vigour and yield of cereals and legumes seemed to be influenced by chemical composition (Dhillon and Kler, 1976). However, in practice majority of the farmers invariably use their own ungraded saved seeds in acute shortage of seeds. In chickpea several high yielding varieties have been developed in both Kabuli and Desi type show greater variations in seed size. In order to ascertain the influence of seed size on plant growth, seed yield and quality the present investigation was carried out in chickpea varieties and the results of these investigations are discussed here.

The seeds of five chickpea varieties were categorized in to four seed size groups by using hand sieves *viz*., small (G_1), medium (G_2), big (G_3) and bulk (G_4). The field experiment was conducted on these seed size groups of five chickpea varieties during *rabi* 2007-08 and the results are discussed here.

Influence of varieties on growth, seed yield and yield attributes

It is well established fact that varieties differ in several growth parameters in field owing to their difference in genetic makeup and environmental influences.

In the present study also all the growth parameters were found to differ significantly among the chickpea varieties. The plant height and number of branches at 30, 60 DAS and at harvest differed significantly among the varieties (Table 9). Significantly higher plant height (23.52, 46.59 and 53.93 cm) at 30, 60 DAS and at harvest was observed in variety BGD-103 and lower plant height (20.55, 36.98 and 46.13 cm, respectively) in A-1. The higher number of branches (4.00, 20 and 23.52) were recorded at 30, 60 DAS and at harvest in A-1and lower (3.58, 15.91 and 21.30) number of branches respectively were noticed in KAK-2 variety. The difference in plant height and number of branches noticed among varieties may be due to their varietal differences. Similar results were also reported by Poma *et al*. (1990), Aziz and Rehman (1994), Ramteke (1995) and Merwade (2000) in chickpea.

The days to 50 per cent flowering differed markedly among chickpea varieties. ICCV-2 variety took significantly less (45.75) days to produce 50 per cent flowering followed by KAK-2 (48.00) days while, remaining three varieties took markedly more days. Difference in days to 50 per cent flowering is mainly because flowering habit which is a varietal character and results are in accordance with Bhor *et al*. (1988), Merwade (2000) in chickpea. Veeraswamy *et al*. (1998) in maize, Macha (2004) in clusterbean.

With respect to seed yield and yield components chickpea varieties differed significantly irrespective of seed sizes (Table 13). Significantly maximum values for seed yield components were recorded by BGD-103 (V_5) except number of seeds per pod. Significantly maximum number of pods per plant (68.98), pod weight per plant (32.85 g), seed yield per plant (14.15 g), per plot (1.26 kg) and per ha (34.72 q) were noticed in BGD-103 (V_5) irrespective of seed sizes. It was followed by Bheema (V_4) and A-1 (V_1) varieties, whereas, all these parameters were minimum with ICCV-2 (V_2). While, number of seeds per pod were highest in A-1 (V_1). The significant increase in seed yield per plant and per ha noticed in BGD-103 variety in the present investigation may be attributed to higher number of branches, pods per plant and pod weight per plant. Similar varietal differences for seed yield components were noticed in chickpea by Poma *et al*. (1990), Singh and Verma (1995), Aziz and Rehman (1996) and Merwade (2000).

Irrespective of seed sizes, the chickpea varieties revealed significant differences on seed quality parameters except germination and speed of germination (Table 14, 15 and 16 ; Fig. 12 and 13). Significantly superior seed quality parameters were seen in BGD-103, followed by Bheema and KAK-2 compared to ICCV-2 and A-1. It is observed that, numerically higher germination percentage was recorded in BGD-103 (96.00%) and speed of germination with ICCV-2 (49.04). Among varieties, maximum 100 seed weight (37.01 g), seedling length (33.23 cm), dry weight (226.57 mg), vigour index (2760) were seen in BGD-103. The higher seed quality parameters noticed is may be due to the bold seededness of these varieties. However, similar significant variations noticed among varieties on seed quality parameters were also reported in chickpea by Poma *et al*. (1990), Singh and Verma (1995), Aziz and Rehman (1996) and Merwade (2000).

Among varieties EC value was less (0.449 dSm^{-1}) in BGD-103 and was more (0.52 dSm^{-1}) in KAK-2. The difference in EC values among varieties may be accounted for difference in seed quality, seed development, seed size *etc*. Similar variation in EC among varieties were also reported by Merwade (2000) in chickpea, Macha (2004) in cluster bean, Chandrashekhar (2005) in frenchbean.

Influence of seed size on growth, seed yield and yield parameters

Seed size is an important seed quality parameter which influences field performance, seed yield and quality. Bigger seeds with large initial food reserves germinate early, growth rapidly and vigourous compared to medium and small seeds (Styer *et al*., 1980; Tiwari *et al.,* 1978). The early vigour often persists to increase seed yield. However, in few cases small seeds have also been shown to perform equally well as that of big and medium seeds in field as they germinate better and show higher mobilization efficiency (Khare and Satpute, 1999) because of early imbibition and lower impedance of cotyledon during germination in field. Further, seedling vigour and yield of legumes seamed to be influenced by protein content. Small seeds of legumes except soybean contain more protein and were better in field performance (Dhillon and Kler, 1976).

In the present study irrespective of varieties, the seed size found to influence significantly the plant height at 30, 60 DAS and at harvest. Significantly more (23.14, 44.78 and 52.48 cm) plant height at 30, 60 DAS and at harvest was observed in plants raised from big seeds. Similarly, the higher number of branches per plant at 30, 60 DAS and at harvest were noticed with the increase in seed size irrespective of varieties. At harvest, big seeds (G_3) recorded more (23.47) number of branches followed by medium (22.43) and bulk (22.03) while, were significantly less (20.13) with small seeds. Medium and bulk seeds were on par with each other. The higher plant height and number of branches noticed with big, medium and bulk seed may be due to the availability of more food reserves in these seeds at initial stage of plant growth resulting into increase in plant height and number of branches at all the stages. Similar benefits with bigger seeds on plant growth were reported by Kurdikeri (1991) in maize, Shashidhar *et al.* (1987) in cowpea and Verma and Bajapai (2002) in pigeonpea.

The days to 50 per cent flowering did not found to differ significantly among the seed grades irrespective of varieties. However, bold seeds took relatively less (50.00) days for 50 per cent flowering while small seeds took more (51.33) days. The plants with vigorous growth will be more efficient in utilization of food material and attain early reproductive phase. The results of present study are in agreement with the results of Bhor *et al*. (1988) in chickpea and Joginakatti (2004) in radish.

Number of pods per plant were more (54.81, 55.87 and 54.74) in big, medium and bulk seeds respectively while, were less in small (51.49). Similarly, pod weight per plant was also more in these seed size groups and less in small seeds. The seed yield per plant recorded was significantly more (13.83 g) with big seeds, followed by medium (13.49 and bulk (12.92) and less (12.29 g) with small seeds.

Similarly, more number of seeds per pod, 100 seed weight, seed yield per plot and per ha were recorded in bold seeds closely followed by medium and bulk size seed and were less in small seeds (G_1). Higher seed yield and yield parameters noticed big size seeds followed by medium and bulk seeds may be due to increased growth parameters like plant height, number of branches, and number of pods per plant with more number of seeds of higher test weight. Similar increase in seed yield and yield parameters with planting of big seeds have been reported by Bhor *et al*. (1988) and Tuba Bicer (2009) in chickpea. Kumar and Seth (2004) in fodder cowpea, Verma and Bajpai (2002) in pegeonpea, Sahoo *et al*. (1988) in groundnut Kurdikeri (1998) in maize.

With respect to seed quality parameters, significantly more germination (96.07%), seedling length (32.69 cm), seedling dry weight (221.09 mg) and seedling vigour index (3027) were recorded in big sized seeds and were on par with medium size (G_2) followed by bulk seeds and were significantly less with small seeds (G_1).The speed of germination was numerically higher (48.03) with big seeds (G_3) compared to other seed grades. Efficient utilization and translocation of food reserves to the growing plants (Dighe and Paitl, 1986). Higher seed quality parametes noticed in plant raised from big, medium and bulk seeds may be due to vigourous growth plants which inturn produce healthy, well developed seeds with higher test weight (Burris *et al*., 1971) revealed that the seed size indicates the amount of reserve food supply for germination, seedling growth and vigour of seedlings. Small and shriveled seed do not contain much food as that of big (Bremner *et al*., 1963 and Kurdikeri, 1991).

Electrical conductivity is a good indicator of seed quality which is inversely proportional to the quality. Lesser (0.492 dSm^{-1}) EC values were noticed in seeds obtained from plants raised from big seeds compared to medium bulk and small seeds, which may be also due to fact that vigourous growing plants produced from big seeds produce well developed quality seeds.

In the present study small seeds obtained from the plants of small seeds were found to be low in seed quality with respect to germination, seedling vigour parameters as expected owing to lesser availability food reserves to the growing plants compared to big medium and bulk seeds. Similar beneficial influence of big, medium, bulk seeds on seed quality over small seeds were reported by Kurdikeri (1991) in maize.

Influence interaction of variety and seed sizes

The plant growth parameters did not differ significantly with respect to plant height and number of branches at 30, 60 DAS and at harvest. However, the bold seeds of BGD-103 (V_5G_3) recorded relatively higher plant height and number of branches at various stages of plant growth. Increased plant height and number of branches may be due to the varietal influence and bigger seeds with higher initial food reserves contribute towards better growth of plants with more number of branches.

Generally well developed big seeds will contribute for vigourous growth of plants producing taller plants with more number of branches (Shashidhar et *al*., 1987 and Verma and Bajpai, 2002).

With respect to days to 50 per cent flowering there was no influence of interaction effects of variety and seed size which may be due to the fact that flowering behaviour is under genetic control.

The various seed yield attributes were not found to differ due to interactions of varieties and seed size. However, numerically more number of pods per plant (70.33) pod weight per plant (33.28 kg) and finally yield per hectare (35.09 q) were recorded in big seeds of BGD-103 (V_5G_3) and these values were closely followed by bulk seeds of BGD-103(V_5G_4) and were less with small seeds of ICCV-2 (V_2G_1). The variation in seed yield and yield attributes noticed in the present study may be related to the genetic ability of the varieties. Tuba Bicer (2009) also observed that large seeded varieties of chickpea produced higher yield and yield components and produced more large seeds than plants produced from medium and small seeds of same variety. Further, the big and medium size seeds also contribute for seed yield through production of vigourous growing plants with higher yields. Similar beneficial effect of seed size on yield have been reported by Shashidhar *et al.* (1987) in cowpea Verma and Bajpai (2002) in pigeonpea and Kurdikeri (1991) in maize.

In the present study, the interaction effect of variety and seed size did not show any significant influence on all the seed quality parameters except seedling dry weight and vigour index. The big seed of BGD-103 (V_5G_3) recorded more seedling dry weight (221.15 mg) and vigour index (2720) followed by V_5G_2 (213.07 mg and 2686) while, was less (176 mg and 1941) respectively with small seeds of A-1 variety (V_1G_1). The seed obtained from the plants produced from big seeds found to be well developed with more food reserves will always produce healthy and vigorous seedling with higher seedling dry weight and vigour index. The present results are in accordance with findings of Shashidhar *et al.* (1987) in cowpea.

5.3 Experiment – III : Influence of Seed Size on Storage Potential of Chickpea Varieties

In any seed production programme, storage of seeds from harvest to next planting season assumes greater importance. Chickpea is predominately a *rabi* pulse crop and after the harvest of seed crop, the seeds are to be stored for nearly 8-10 months until next *rabi* season without affecting the sowing quality of seed. Therefore, one has to store the seeds in good conditions as the “Seed saved is seed produced” an adage still holds good even today’s modern agriculture. Seed storage potential depends on various factors *viz*., genetic, environmental factors, pest and disease, kind of crops, varieties, seed physical and biochemical factors *etc*. It is believed that well developed big seeds with initial high vigour always store for longer period than small and immature seeds. However the storability in most crops in relation with seed size is still under enigma and is of controversial issue. Both Desi and Kabuli types of chickpea varieties differ greatly in seed size but the influence of seed size on storage potential is yet to be elucidated.

Keeping this in view, storage experiment was conducted to ascertain the influence of seed size on the storability of different chickpea varieties. The storage study was carriedout under ambient storage conditions of Dharwad, Karnataka State for 12 months, involving 5 chickpea varieties (A-1, ICCV-2, KAK-2, Bheema and BGD-103) and four seed size grades (small, medium, big and bulk) stored in cloth bag.

The monthly observations were recorded on various seed quality parameters and the results obtained are discussed in this chapter.

Influence of variety

The present study revealed that, irrespective of seed size the germination percentage in all the varieties of chickpea decreased with the advancement of storage period (Table 17 and Fig 14 and 15). However, significantly higher germination (71.50 and 71.33%) was recorded in A-1 and BGD-103 respectively compared to other chickpea varieties and lower (67.20%) germination was observed in KAK-2 at the end of storage period. Retention of higher germination in A-1and BGD-103 varieties may be due to the fact that storability is under genetic control and varieties differ in deterioration level. Further, the per cent infestation was less in these varieties during entire period of storage. Such varietal variation with respect to germination was reported by Kumbar (1999) and Merwade (2000) in chickpea, Vanangamudi (1988) in soybean and Kumar *et al*. (1997) in peas.

Satisfactory germination above the minimum seed certification standards (85.00%) was maintained in A-1, BGD-103, Bheema, ICCV-2 and KAK-2 for 9, 9, 8, 7 and 7 months, respectively.

The field emergence also decreased in all the varieties irrespective of seed sizes with increase in the period of storage. However, significantly higher field emergence was observed in A-1vareity followed by BGD-103 and Bheema and was lower (56.00%) in KAK-2 at the end of 12^{th} months of storage. Higher field emergence in A-1 and BGD-103 may be attributed to varietal influence. These results are conformed with the earlier reports of Kumbar (1999) and Patil (2000) in chickpea.

In general, among Kabuli and Desi types, the per cent germination and field emergence were relatively higher in Desi chickpea varieties compared to Kabuli varieties during the entire period of storage. This may be due thicker seed coat nature in Desi type varieties (Upadhayay, 1994).

The mean speed of germination, seedling vigour parameters such as seedling length, seedling dry weight, vigour index (Table 18, 19 and 20) decreased with the increase storage period in all the varieties of chickpea. Among the different varieties BGD-103 maintained higher seedling vigour parameters followed by Bheema and KAK-2 while A-1recorded significantly lower vigour parameters in all the months of storage. Differential decrease in all these vigour parameters in chickpea varieties during storage may be ascribed to their genetic difference and age induced deterioration at various degrees with the increase in storage period (Delouche, 1973). Similar decrease in seedling vigour parameters with increase in storage period were reported by Kumbar (1999), Merwade (2000) and Patil (2000) in chickpea, Mohanrao (1993) in soybean.

Generally the electrical conductivity of seed leachate is inversely related to seed quality; higher the electrical conductivity lower is the seed quality and vice-versa. In aged and detoriated seeds, the electrical conductivity will be higher owing to decrease in membrane integrity caused by detrimental physico-biochemical and ultrastructural changes occurring in seeds during storage (Koostra and Harington, 1969 and Roberts, 1972).

In the present study the mean electrical conductivity of seed leachate values were found to increase from (0.393 to 1.078 dSm^{-1}) in initial month to the end of 12^{th} month of storage irrespective of varieties. Electrical conductivity was higher (0.473 and 1.247 dSm^{-1}) in KAK-2 followed by ICCV-2 (0.405 to 1.127 dSm^{-1}) and lower (0.353 to 0.943 dSm^{-1}) with A-1at initial and 12^{th} month of storage respectively.

The different electrical conductivity values recorded among varieties indicates that though membrane permeability is lost during seed ageing, the nature and extent of membrane damage may not be similar for all the varieties and thus differences in electrical conductivity values are bound to occur (Kurdikeri, 1991).

The 100 seed weight of different varieties of chickpea differed significantly during storage period. It decreased gradually in all the chickpoea varieties with the increase in period of storage. However, the mean 100 seed weight at initial month was 32.07 gm and was reduced to 23.94 gm at 12^{th} months of storage. The decrease in 100 seed weight during storage may be attributed to the higher per cent disease infection and pest infestations resulting in decrease of the storage food reserves of the seed. The 100 seed weight was maximum in Desi type BGD-103 in all months of storage period followed by Bheema, while minimum in A-1Desi variety. The decrease in test weight may be attributed to the changes in phsico-chemical properties of seeds and pest and disease attack.

Pulses are mainly attacked by bruchids during storage. The level of bruchid infestation depends on several factors like storage environment, kind and varieties, moisture content of seeds physio-chemical properties of seeds, such as texture, structure, hardiness, size and shape of seed, amount of food reserves, initial pest infestation *etc*. The storage pests cause much qualitative and quantitative damage to seeds in storage and make seeds unfit for sowing and even for consumption.

The data on per cent pest infestation indicated that the mean percentage of pest infestation increased with the advancement of storage (Table 25) period from 0.00 per cent in initial month to 28.47 per cent at the end of 12^{th} months of storage. The bruchid infestation was seen from second month of storage onwards upto 12^{th} months after storage irrespective of varieties. Among the different varieties the bruchid infestation was higher (31.17%) in KAK-2 followed by ICCV-2 (29.42%) of Kabuli types. While, was low (25.92%) in A-1. The differences in level of pest infestation among varieties noticed in the present study may be related to their genetic differences (Kumbar, 1999) thickness of seed coat (Upadhayay, 2002) and storage food reserves. Further, pest activity has been related to physico-chemical properties of seed (Tyagi and Girish, 1997), colour of seeds (Kurdikeri, 1991).

Seeds are hygroscopic in nature and as such loose or gain moisture content in concomitant with the changes in prevailing atmospheric relatively humidity and temperature. In the present study, also moisture fluctuation has been noticed in all the varieties during storage from initial month to the end of 12^{th} month of storage period. The mean moisture content was found to vary from 8.99 to 10.42 per cent from initial month to end of storage period irrespective of varieties.

The moisture content of KAK-2, BGD-103 and Bheema was higher in all the months of storage period while, it was less in A-1and ICCV-2. This difference in moisture content may be related to seed coat factor and chemical composition of seeds. Similar variation in seed moisture content during storage was reported in chickpea by Kumbar (1999), Patil (2000) and Merwade (2000) in chickpea.

Influence of seed size

The seed size is one of the important parameter of seed quality which plays an important role on field performance and storage. Generally big seeds with high food reserves store for longer period but may be more prone to disease and pest infestation. However, the storage potential of seeds with respect to seed size is of controversial issue which needs detail investigation. Gupta (1976) in soybean. On the contrary, Black (1975) reported that more normal seedlings developed from small seeds than from large ones; large seeds produced more abnormal and broken seedlings. In this opinion small seeds may be an advantage in prolonged storage.

In the present study, germination and field emergence did not differ significantly among the different seed size groups. However, germination and field emergence percentage was relatively higher in small and bulk seeds followed by medium seeds and lower with big seeds in all the months of storage irrespective of varieties.

The higher germination and field emergence percentage noticed in small, medium and bulk seed may be attributed to more and rapid absorption of water (UL'rikh, 1961) on account of high protein content (Dhillon and Kler, 1976). Further, small seeds found to detoriate slowly than large size seeds (Vanangamudi, 1988). It has been indicated that big seeds require more water for imbibition germination and the larger cotyledons of big seeds may impede germination and speed of germination (Knittle and Burris 1976).

The speed of germination also followed the same trend as that of germination and field emergence among the seed grades. It was higher in small, medium and bulk but was less in big seeds which might be due to faster imbibition of moisture by the seeds during germination stage.

On the contrary to germination, field emergence and speed of germination, seedling vigour parameters were more in big size seeds followed by medium and was less with small seeds in the entire storage period. The higher seedling vigour parameters noticed with bigger seeds may be due to higher amount of food reserves available during germination of seeds (Polock and Roos, 1972). More seedling length, dry weight and vigour index noticed in big seeds may be due to availability of more food resources to the young seedlings compared to lesser food reserves in small seeds (Vanangamudi, 1988). The similar results were observed by Srimathi and Vanangamudi (1993), Sinha *et al* (1988) in cowpea, Merwade (2000) in chickpea and Joginakatti (2004) in radish.

As pointed out earlier, seed quality is inversely related to leachate values. The electrical conductivity of seeds were found to differ among the seed sizes. However, in big seeds leachates were more (0.410 to 1.164 dSm^{-1}) at initial and last months of storage followed by medium and less in small seeds (0.379 and to 0.987 dSm^{-1}) respectively. The higher electrical conductivity values noticed in big seeds may be due to age induced seed deterioration besides more bruchid pest infestation and disease infection leading to damage of seeds (Kumbar, 1999 and Merwade, 2000).

The fluctuation of seed moisture content was noticed among seed size groups in all the months of storage. However, fluctuation of seed moisture content was more in big seeds in all the months of storage and the moisture content increased gradually with the advancement of storage period. Higher moisture content seen in big seeds may be due to the more surface area and more pest infestation which leads to higher absorption of moisture from the surrounding environment (Mohanrao, 1993).

The mean 100 seed weight also decreased with the increase of storage period irrespective of seed grades. The 100 seed weight at initial month was 32.06 g and it decreased to 23.94 g at the end of 12th month of storage. Among seed size per cent decrease in 100 seed weight was more in (26.00%) in big seeds followed by bulk (25.00%) and medium (24.5%) and was less (23.00%) in small seeds.

The decrease in seed weight observed may be on account of higher pest infestation (28.47%) at the end of storage. Further, big seeds are more proven to pest infestation as they contain more food reserves which are consumed by the bruchids leading to more decrease in the 100 seed weight (Kumbar, 1999).

Influence of interaction between varieties and seed sizes

The interaction effect due to chickpea varieties and seed sizes showed no significant difference on seed germination, speed of germination, field emergence, seedling length, dry weight, vigour index, moisture content, pest infestation and electrical conductivity. However, decrease in these parameters except pest infestation and electrical conductivity values with increase in storage period have been noticed in all the chickpea varieties and seed sizes.

However, small seeds of all the varieties were relatively more in germination and field emergence. While, other seed quality parameters were observed to be higher in big medium and bulk seeds of all varieties.

Higher seed germination and field emergence observed with small seeds may be due to rapid imbibitions resulting in early initiation of germination process (Barbosa and Glovar, 1978). Further, it has been opined by Knittle and Burris (1976) that big seeds because of heavy cotyledons may impade germination and seedling emergence in soil and require more pull-up force for the cotyledons to come above soil surface. Further, big and medium seeds give low germination because seeds coat are ruptured and encourage microbes. On the contrary, the seedling vigour parameters will be always more in resulting seedling on account of higher initial food reserves which will be utilized efficiently and as such will be more vigourous (Merwade, 2000).

5.4 Experiment - IV : Effect of Seed Treatments on Plant Growth, Seed Yield and Quality in Chickpea Varieties

The field experiment consisted of totally 18 treatment combinations involving two varieties A-1and ICCV-2 and nine seed treatments *viz*., $CaCl_2$ (1 g), Boron (1 g), $ZnSO_4$ (1 g), $FeSO_4$ (1 g), $MgSO_4$ (1 g), Rhizobium (20 g), phosphorus solubilizing bacteria (PSB) (20 g) per kg seeds and seed soaked in panchagavya (3%) and control. The experiment was laid out in RCBD with factorial concept in three replications. Results obtained in the present investigations have been discussed in this chapter.

5.4.1 Influence of varieties

The plant height, number of branches, days to 50 per cent flowering, seed yield and quality parameters are influenced by mainly by biotic and abiotic factors besides genetic makeup of a variety.

In the present investigation marked varietal differences on field performance have been noticed in chickpea. Plant height at 30, 60 DAS and at harvest found to differ significantly in chickpea varieties irrespective of seed treatments (Table 27). ICCV-2 recorded maximum plant height (20.65, 41.69 and 49.65 cm) at 30, 60 DAS and at harvest respectively compared to A-1, which might be attributed genetic makeup of varieties and to efficient accumulation of photosynthates in vegetative plant parts. Varietal differences with respect to plant height were also observed by Poma *et al*. (1990) and Aziz and Rehman (1996) in chickpea.

The number of pod bearing branches (Fig. 16) differed significantly at 30, 60 DAS and at harvest. The highest (3.85, 21.2 and 23.73) number of branches were recorded at 30, 60 DAS and at harvest respectively in A-1variety. Compared to ICCV-2 due to genetic character (Poma *et al*., 1990).

The number of days to 50 per cent flowering depends on varietal and environmental factors, ICCV-2 was earlier by 6 days to 50 per cent flowering than the A-1. Similar differences in days to 50 per cent flowering were observed in chickpea varieties by Merwade (2000).

In many field crops it is evident that yield is a function of number of flowers per plant, pods per plant, number of seeds per pod and test weight. The highest number of pods per plant and seeds per pod (44.03 and 1.38) was recorded in A-1compared to ICCV-2 (35.75 and 1.36) respectively. But, the 100 seed weight was maximum (25.11 g) in case of ICCV-2 because of bigger seeds. The higher seed yield per plant, per plot and per ha (13.35 g, 1.09 kg and 30.12 q/ha) were recorded in A-1 variety compared to ICCV-2 (11.77 g, 0.99 kg and 26.49 q) respectively (Table 30 and 31). This significant difference in seed yield between varieties is mainly due to the variations in the number of productive branches, number of pods per plant, seeds per pod, test weight of seeds *etc*. which are governed by the genetic character of a variety. Similar varietal differences on seed yield and yield attribute were reported by Siag and Verma (1995), Merwade (2000) in chickpea, Macha (2004) in cluster bean.

Observations of the present investigation on seed quality parameters showed no significant differences between the varieties. However relatively more germination was seen in A-1 (94.49%) compared to ICCV-2 (94.21%) while, seedling length, seedling dry weight and vigour index and speed of germination was highest in ICCV-2 (28.89 cm, 196.33 mg, 2703 and 48.92) respectively. The difference in the seed quality attributes noticed is mainly due to the genetic factor. Further higher seedling vigour parameters noticed in ICCV-2 may be related to their bigger sized seeds with higher test weight and it is well documented that bigger seeds with higher test weight shall have more initial capital (food reserves) which are available to the germinating seed and developing seeding (Styer *et al.,* 1980).

5.4.2 Influence of seed treatment

Most of the earlier studies with micronutrients and bio-fertilizer indicated that though they are required in small quantities but show beneficial influences on plant growth, flowering, seed development, yield and yield traits besides seed quality parameters. In the present study, irrespective of varieties, the plant height at 30, 60 DAS and at harvest was significantly more (20.86, 42.94 and 50.36 cm) in Rhizobium inoculation (20 g/kg of seeds) followed by PSB compared to control (19.72, 39.74 and 46.86 cm) respectively.

The number of branches also followed the same trend and highest (3.90, 21.50 and 23.94) number of branches were recorded at 30, 60 DAS and at harvest in Rhizobium treatment. The increased plant growth and branches noticed might be due to increased supply of nutrients in Rhizobium inoculation there by enhanced growth (Jain *et al*., 1999) in chickpea and Patel (1991) in pea. The Rhizobium helps more fixation of atmospheric nitrogen in nodules as aspergine and glutathiamin which increase the production of protein, carbohydrates and starch resulting in greater dry matter accumulation and branches per plant (Reddy and Reddi, 1992) in greengram.

Besides beneficial influence of micronutrients and bio-fertilizer on plant height, they are also involved in flowering behavior in most of leguminous crops. In the present study, the days to 50 per cent flowering were found to be significantly influenced by bio-fertilizer inoculation and less number of days were taken (47.58) in Rhizobium followed by PSB (47.75 days) inoculated plants compared to control (50.50 days).

Marked differences were noticed among different micronutrients and biofertilizer seed treatments for seed yield and yield parameters. Higher seed yield per plant (14.15 gm), per plot (1.10 kg) and per hectare (30.07 q) were obtained in rhizobium seed treatment fallowed by PSB compared to other treatments and control (Fig. 18). The increase in seed yield in these two treatments may be due to more nitrogen availability through increased nitrogen fixation. Higher number of pods per plant, seeds per pod and greater yield attributes via higher photosynthetic rate and their translocation to sink contribute for higher seed yield (Chatrabhuj *et al.*, 2001; Jat and Ahlawat, 2004 and Kushwaha, 2007) in chickpea. Further, inoculation of Rhizobium and PSB are known to produce the endogenous growth regulators and release ammonia from Rhizobium and supply ‘P’ nutrients by solubilizing insoluble phosphate by PSB resulting in higher yield (Srinivas and Shaik, 2002) in greengram.

Besides higher seed yield, the better quality seeds need to be produced for successful seed programmes. In the present investigation, seed quality attributes such as 100 seed weight (25.66 g), germination (96.66%), seedling length (90.24 cm), seedling vigour index (2922), speed of germination (51.60) were found to be maximum with Rhizobium (20 g/kg seed) seed treatment followed by PSB (20 g/kg seed) compared to other treatments (Fig. 19 and 20). Generally, the seed quality is associated with higher seed size, weight and food reserves. Germination and seedling growth depend on initial quantity supply of food reserves. Similar higher seed quality attributes were noticed with Rhizobium (20 g/kg) seed treatment by Upadhayay *et al*. (1999) in green gram.

Seed leachate values indicate overall seed development, maturity and membrane integrity and thus the seed quality. The amount of seed leachates (EC values) is inversely related to seed quality; lower the seed leachate values better is the seed quality and vice versa. In the present study also, lower electrical conductivity (0.422 dSm^{-1}) values were recorded with Rhizobium (20 g/kg) followed by PSB (0.425 dSm^{-1}) compared to other treatments.

5.4.3 Influence of interaction between varieties and seed treatments

Generally, seeds treated with very small quantity of micronutrients, bio-fertilizers *etc*. shall have initial advantage of their availability for germination and growth of young seedlings which intrun influence yielding ability. In the present investigation the interaction between varieties and seed treatment with micronutrients and bio-fertilizers was non significant in most of the growth parameters except plant height at 60 DAS, number of branches, days to 50 per cent flowering. In case of ICCV-2 variety seeds treated with Rhizobium (20 g/kg) (V_2T6) recorded significantly highest plant height (42.94 cm) at 60 DAS and number of branches. This relative increase in growth of plant with Rhizobium treatment may be due to its role in nitrogen fixation and continuous supply of nutrients and greater availability of food reserves to the plants.

In the present study, the various seed yield parameter were not influenced by the seed treatments in both the chickpea varieties except number of pods per plant (Fig. 17) which were significantly maximum (48.7 g) in V_1T_6 followed by V_1T_7 (47.58) and V_1T1 (46.37) and were on par with each other and were minimum (35.14) in control. The number of seeds per pod did not differ due to interactions of VxT. Likewise, seed yield per plant, per plot and per hectare also were not influenced by the interaction effects (VxT). However, relatively higher yield parameters were observed in A-1 with Rhizobium, PSB, $MgSO_4$ and $ZnSO_4$ treatments compared to ICCV-2. The differential response with seed treatments in chickpea varieties is as expected due to their differential genetic makeup.

With respect to seed quality parameters there was no significant influence of seed treatments on both the chickpea varieties. However, in ICCV-2 variety seeds treated with Rhizobium, PSB, $MgSO_4$ and $ZnSO_4$ showed higher germination, seedling length, seedling dry weight and vigour index compared to A-1 variety while, EC was higher in ICCV-2 compared to A-1 with the seed treatments. Perhaps, owing to bigger seed size with papery seed coat in ICCV-2 more leaching of food reserves have been noticed through EC values. Similar results were noticed by Kumbar (1999), Patil (2000) and Merwade (2000) in chickpea.

5.5 Experiment - V : Influence of Stages of Harvest on Seed Quality in Chickpea Varieties

Harvesting of seed crop at right stage of physiological maturity is most important to obtain higher seed yield and quality. The seeds harvested at physiological maturity shall have maximum viability and vigour, perform well in field and store for longer period. Physiological maturity refers to morphological, physiological and functional changes from the time of fertilization until the matured ovuls are ready for harvest (Delouche, 1973). Seed development is the period between fertilization and maximum fresh weight accumulation and maturity begins at the end of seed development and continues up to harvest (Abdul-Baki and Baker, 1973). Physiological maturity in most of crops is normally understood to occur when seed reaches its maximum dry weight (Harington, 1972) with low moisture content at which accumulation of nutrients in seeds stops, formation of abscission layer occurs (Eastin *et al*., 1973) and viability and vigour are at maximum. Stage of physiological maturity varies with crop and also with variety in relation with the environmental factors.

Generally, seed crop is harvested based on certain morphological and physiological changes in plants and seed. However, such maturity studies in chickpea varieties are lacking and there is a need to ascertain the right stage of harvest to obtain high quantity of quality seeds. The results of the present study on influence of stages of harvest on seed quality in chickpea varieties are discussed here.

Varietal influence

It has been well documented in most of the field crops that seed maturation proceeds with loss of water at various degrees upon atmospheric conditions and loss of moisture content at maturity stage is an initial phase of seed development (Manohar and Sachan, 1974).

The present study revealed that, irrespective of harvesting stages the varieties found to differ significantly in all the seed quality parameters except EC of seed leachate (Table 37, 38 and 39).

Irrespective of harvesting stages the moisture content of seeds was found to decrease significantly with the advance in maturity in all the five varieties. In ICCV-2 variety the average moisture content of seed was more (37.77%) and was on par with A-1 (37.53%) and it was less (36.37%) in Bheema over harvesting stages. Similar variations in moisture content during maturations of varieties were reported by Bharud and Patil (1990) in chickpea, Arulnandhy and Senanayak (1990) in soybean, Kharab *et al*. (1993) and Rama Rao (2001) in pIgeonpea, Shridhar (1994) and Seth *et al*. (1999) in cowpea. The decrease in moisture content with advancement in maturation stages noticed in the present study could be due to dehydration (Sabir Ahmed, 1989) which could be due to replacement of osmotic material by protein, starch and macromolecules with low hydration capacity.

The varieties were also found to differ significantly with respect to germination percentage, seedling length, seedling vigour index while, electrical conductivity of seed leachate did not differ significantly (Fig. 21).

With the decrease in seed moisture content on account of dehydration, concomitantly the increase in seed dry weight was observed whereas, fresh weight of seed decreased in all the chickpea varieties.

Maximum dry weight of seed occurred at yellow pod stage (H_3) in all the varieties while minimum fresh weight of seed occurred at brown pod stage (H_4). Similar decrease in fresh weight of seed and increase in dry weight of seed were reported by Kharb *et al*. (1993) in redgram. Harington (1972) also expressed that fluid and gaseous forms of nutrients and volatile substances present in seed lots by oxidation and volatilization along with higher rate of moisture elimination.

Germination percentage was found to increase gradually with the increase in maturity stages in all the varieties and attained maximum at yellow pod stage (H_4) and then found to decline. Similarly, the seedling length and vigour index followed same trend as that of germination parameter. Among varieties, BGD-103 (V_3) recorded higher values for all these seed quality parameters compared to other varieties and was least in KAK-2 (V_3). The differences in seed quality parameters noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination and seedling growth.

The seed quality is negatively related to EC of seed leachate. Higher the EC lower is the seed quality. In the present study, BGD-103 (V_5) recorded lower EC (1.514 dSm^{-1}) while was higher (1.826 dSm^{-1}) with KAK-2. The similar varietal difference with respect to seed quality parameters and EC was recorded by Bharud and Patil (1990) in chickpea. Kharb *et al*., (1993) in pegeonpea and Seth *et al*. (1999) in cowpea.

Influence of harvesting stages

The seed quality parameters depend on the stage at which the seed crop is harvested. Harvesting at early stage may result in more number of underdeveloped and immature seeds with high seed moisture content and delayed harvesting results in yield and quality losses due to field weathering. Hence, harvesting at appropriate stage of physiological maturity is most important for obtaining increased seed yield and quality.

The moisture content of seeds was found to decrease with increase in harvest period irrespective of varieties. The moisture content of seed was highest (60.05%) at H_1 stage (full green pod colour) compared to other stages of harvest and was minimum (12.42%) at H_4 stage (copper brown pod colour). Similar decrease in moisture content with advance in maturity stages have been reported by Macha (2004) in cluster bean and was ascribed to rapid loss of moisture content due to dehydration (Sabir Ahmed, 1989).

Fresh weight of seed found to decrease with increase in maturity stages upto H_3 stage. While, 100 dry seed weight increased from full green pod colour (H_1) to full yellow pod colour (H_3) stage and then afterwards both declined in copper brown pod colour (H_4) stage. Decrease in fresh weight of seed and increase in dry weight of seed noticed with advance in maturity stages is mainly due to loss of moisture on account of dehydration (Sabir Ahmed, 1989).

Irrespective of varieties, the percentage of germination, seedling length and vigour index found to increase gradually from from full green pod colour (H_1) to full yellow pod colour

(H_3) stage and declined then after at copper brown pod colour (H_4) stage (Table 35). The seeds collected from H_3 stage recorded significantly higher seed quality parameters *viz*., germination (96.40%), seedling length (31.90 cm) and vigour index (3075) with low electrical conductivity (0.993 dSm^{-1}) compared to other stages of harvest. While in seed collected at (H_4) stage the germination, seedling length, vigour index decreased concomitantly with drastic reduction in fresh and dry weight. Reduction in pod and seed weight may be related to inbuilt mechanism, cessation and disorganization of cell organelles within few days from full yellow pod colour stage of harvest (Mathews, 1973).

The lower seed quality parameters observed in the early stage of harvest (H_1) might be due to presence of more number of undeveloped physiologically immature seeds. Similarly poor seed quality with early harvests were reported by Bharud and Patil (1990) in chickpea, Arulandy and Senanayake (1990), Gore *et al*. (1997) and Shivankar (2001) in soybean, Suryavanshi and Patil (1995) in mungbean and Macha (2004) in cluster bean.

The seed quality parameters were also relatively lesser in seeds harvested at complete copper brown pod stage (H_4) compared to H_3 stage of pod harvest.

Influence of interaction of variety and stage of harvest

In all the five chickpea varieties, the moisture content of seeds decreased gradually with advancement in maturity. The decrease in moisture content of seeds with increase harvest stages may be due to rapid loss of moisture from the seed during seed development. Similar loss of moisture content of seed with advancement in maturity was also observed by Bharud and Patil (1990) in chickpea, Seth *et al*. (1999) in cowpea and Macha (2004) in cluster bean.

The physiological seed quality parameters such as germination (more than 95%), seedling length and vigour index were found to increase gradually and attained maximum at yellow pod stage (H_3) stage of maturity in all the chickpea varieties .

In all the five chickpea varieties, maximum physical and physiological seed quality coincided with duration taken for attainment of maximum dry weight of seed, low moisture content with decrease in fresh weight of seed at H_3 stage. Heydecker (1972) also opined that physical and physiological seed quality parameters which represent totality of seed quality attains maximum values with duration taken for maximization of dry weight, germination, vigour index *etc*. which were claimed to the physical and physiological indices of seed maturation. In the present study, maximum germination, seedling length and seedling vigour index increased with advance in maturation stages which coincided with maximum dry weight of seed and minimum fresh weight of seed. Coepland and Mc.Donald (1995) claimed that maximum germination, seedling length and vigour index to be physical and physiological indices of seed maturation.

5.6 Experiment - VI : Characterization of Chickpea Varieties

Chickpea one of the most important *rabi* pulse crops of India. In recent years, several high yielding chickpea varieties have been released by breeders. For maintenance of genetic purity of varieties during seed production and certification programme there is an urgent need for documentation of diagnostic features of varieties with their accurate identification of morphological key characters. In the present study, five chickpea varieties were characterized based on morphology of seed, seedling, plant, flowering and yield attributing parameters (Table 40 and 41). The results of these studies are discussed as follows.

5.6.1 Seed morphology

Seed coat colour of five chickpea varieties differed distinctly. Among varieties, A-1, BGD-103 and Bheema were brown in colour while ICCV-2 and KAK-2 were with creamy white in seed coat colour (Plate 6).

Marked variation on seed shape and seed surface in chickpea varieties were evident wherein A-1, BGD-103 and Bheema were angular shape with rough seed coat whereas ICCV-2 and KAK-2 were owls shape with smooth seed coat (Plate 6). The variation in seed shape, coat colour and surface noticed in the present study may be accounted for genetic factor (Pundier *et al*., 1985 and Upadhayay et *al*., 2002) in chickpea.

A-1

Bheema

BGD-103

ICCV-2

KAK-2

Plate 7: Seeds of Chickpea varieties

Based on 100 seed weight, the varieties of chickpea were categorized into higher (KAK-2, BGD-103 and Bheema) and medium weight (A-1 and ICCV-2)groups. Similar variations in seed weight were noticed by Pundier *et al*. (1985), Upadhayay (2002) in chickpea, Prashnath (2003) and Chnadrashekhar (2005 and 2008) in frenchbean varieties.

Chickpea varieties showed significant variations in seed coat thickness and mottles on testa. Variety A-1, BGD-103 and Bheema found to have thick seed coat and small black dots on testa. Whereas, ICCV-2 and KAK-2 varieties were without any spots on testa and their seed coat found to be thin. Such variations in seed coat thickness and mottles on testa were related to genetic factors but modified by the environmental factor (Upadhaya *et al.,* 2002) in chickpea.

Variation in seed size interms of length and girth are under genetic control in most of the crops. In the present study also such variations in seed length and girth were seen. A-1 and ICCV-2 were of medium size while KAK-2, BGD-103 and Bheema were of large sized varieties. The variations observed with respect to seed size may be due to bigger size of endosperm and embryo and were indicated to be specific to varieties (Chandrashekhar, 2005). Similar reports were made in chickpea (Anon., 2000) and in frenchbean (Prashant, 2003 and Chandrashekhar, 2005 and 2008).

5.6.2 Seedling morphology

The seedling morphological characters are widely used as key diagnostic characters for varietal identification in most of the crops. Among chickpea varieties, the hypocotyl colour of A-1 was pale green, ICCV-2 and KAK-2 were creamy, while BGD-103 and Bheema were light yellow in colour.

The pubescence on hypocotyl were present in all the varieties. The pigmentation on seedling was observed in A-1, BGD-103 and Bheema while, ICCV-2 and KAK-2 were without pigmentation on their seedling. The similar, varietal characterization based on seedling morphology were made by Prashnat (2003) and Chandrashekhar (2008) in french bean and Agarwal and Pawar (1990) in soybean and Chakrabarthy and Agarwal (1989) in blackgram.

5.6.3 Plant morphology

In field conditions, varietal variations on plant morphological seed characters such as plant height, number of branches, stem colour, hairiness on stem, foliage colour, leaf size, days to flower initiation, days to 50 per cent flowering, pod numbers per plant, pod characteristics, seed yield per plant *etc* are widely taken as basis of varietal identification by breeders. In the present study, varieties showed marked variations in plant height. BGD-103 recorded highest plant height (52.7 cm) followed by Bheema (51.6 cm) and was lowest in A-1 (49.1 cm), while the number of branches were higher in A-1(26.2) followed by BGD-103 (23.4) and were lower in ICCV-2 (20.6). Similarly, variations in the other characteristics like stem colour and pigmentation were evident among chickpea varieties (Plate 6). Varieties A-1, BGD-103 and Bheema were having pink colour stem with anthocynin pigment and ICCV-2 and KAK-2 were pale yellow colour stem and without pigmentation.

All the five chickpea varieties were having dense hair on their stem. Desi and Kabuli types showed many variations with respect to foliage colour and leaf size. Among Desi types A-1, BGD-103 and Bheema) were having dark green colour with small leaves and Kabuli types were light green colour with big leaflets.

In the present study, the days to flower initiation, days to 50 per cent flowering, days to pod initiation and pod maturity differed significantly. Both Kabuli varieties (ICCV-2 and KAK-2) were early in flower initiation (39.2 and 39.4 days), days to 50 per cent flowering (41.0 and 41.4 days), days to pod initiation (55.4 and 56.40 days) and pod maturity (92.8 and 97.0 days) respectively. While, Desi types were took relatively more days in to all these parameters and were categorized in medium group. Similarly, varietal identification based on plant height, pigmentation, flowering and pod maturation and pod characters were made in several agricultural and field crops (Anon., 1999).

Various pod characters such as number of pods per plant, pod length, breadth, pigmentation on pod, seeds per pod in chickpea varieties differed distinctly between Kabuli and Desi types. The numbers of pods per plant were more in varieties BGD-103 (52-78) followed by Bheema (52-67) while less in KAK-2 (36-43). Seeds per pod also differed among the varieties, A-1 and ICCV-2 recorded 1-2 seeds per pod while all other varieties contained only one seed per pod. Though pod length and breadth did not differ much, but were relatively more in KAK-2 (2.3-2.6) and (3.6-3.9 cm) respectively compared to other varieties.

All the varieties found to have dense hairiness on their pod. Based on seed yield per plant, varieties BGD-103 and Bheema were grouped under high yielding varieties, KAK-2 and A-1 under medium and ICCV-2 under low yielding variety. The similar varietal characterization based on plant growth parameters, flowering, pod characteristics and seed yield per plant were made by Chandrashekhar (2008) in French bean.

Practical application of the results

Based on the results of the present study following practical applications are proposed for obtaining higher seed yield and quality in chickpea.

1) Nipping at 30 days after sowing (DAS) in A-1 and ICCV-2 chickpea varieties may be practiced to obtain higher seed yield and quality.
2) Application of NAA @ 50 ppm or triacontanol @ 1 ml per litre through foliar spray may be followed to obtain higher plant growth, seed yield and quality parameters in chickpea.
3) Big, medium and bulk seeds performed better in field condition and produced higher quantity of quality seeds in all the five chickpea varieties.
4) Under ambient storage condition even bulk and small seeds of chickpea varieties were found better in storage potential as that of big and medium seeds and hence size grading may not be necessary.
5) Seed treatment with Rhizobium, PSB and $ZnSO_4$ found beneficial on plant growth, seed yield and quality parameters compared to all other treatments in chickpea varieties.
6) The seeds may be harvested at full yellow pod colour stage for better seed quality parameters compared to harvesting at early (full green pod colour) or later stages (copper brown colour).
7) The morphological characters *viz*., stem colour, pubescence pigmentation foliage colour, pod colour, seed coat colours were found more reliable for varietal characterization in chickpea.

Future line of work

Based on the results obtained in the present study following future line of work are proposed.

1) The nipping effect at different stages of growth in other chickpea varieties need to be studied.
2) The influence of other growth regulators at various concentrations, methods of application at different stages on crop growth seed yield and quality may be carriedout.
3) There is a need to establish the relationship between seed size and field performance and storage potential in other chickpea varieties.
4) The botanicals, organics plant products and different chemicals may be tested in different storage containers with or without desiccatants under varied level of moisture content for their efficiency against bruchids, fungal invasion and storage potential in different chickpea varieties need to be studied.
5) The effect of other micronutrients and organics with different concentration, seed treatment and spray at different stages on crop growth, seed yield and quality of chickpea needs detailed investigations.
6) There is a need to study the physiological maturity of seeds in other existing varieties of chickpea.
7) The characterization based on distinct and stable seed, seedling and plant morphological, chemical and molecular markers are to be standardized for different varieties of chickpea.

6. SUMMARY AND CONCLUSIONS

The field experiments were conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *rabi* 2007-08 and 2008-09 to ascertain the effect of nipping, growth regulators spray, seed size and seed treatment with micronutrients on plant growth, seed yield and quality in chickpea varieties and effect of stages of harvest on seed quality in chickpea varieties. Further, the laboratory experiments were conducted in Department of Seed Science and Technology to ascertain the effect of seed size on storage potential in different chickpea varieties. The characterization of chickpea varieties based on morphological characters was also made during 2008-09 season. The results of field and laboratory experiments are summerised in this chapter.

6.1 Experiment – I: Effect of Nipping and Growth Regulators Spray on Plant Growth, Seed Yield and Quality of Chickpea Varieties

1) Between the varieties, A-1 recorded lower plant height, higher number of branches, number of pods (47.75) per plant, seed yield per plant and per ha (28.75 q) compared to ICCV-2 (25.52 q/ha).
2) The seed quality parameters *viz*., 100 seed weight, seedling length (27.54 cm), dry weight (180.37 mg), vigour index (2301) were more in ICCV-2 compared to A-1.
3) The nipping of plants at 30 DAS lead to decreased the plant height, increased the number of productive branches (25.12), number of pods per plant (46.04), seed yield per ha (28.50 q) irrespective of varieties.
4) The seed quality parameters such as 100 seed weight, seed germination (93.68%), speed of germination, seedling length, seedling dry weight and vigour index (2531) were higher with low electrical conductivity in nipped plants compared to non nipped plants.
5) Among foliar sprays of growth regulators, the plants sprayed with NAA 50 ppm resulted in increase of plant height, number of productive branches (26.13), number of pods per pant (46.76), seed yield per ha (29.91 q) and was followed by triacontanol(1 ml/lit).
6) The higher seed quality parameters like 100 seed weight (24.48 g), germination (95.37%), seedling length (28.37 cm), seedling dry weight (182.18 mg), vigour index (2419) and with lower electrical conductivity (0.420 dSm^{-1}) were obtained by spraying NAA 50 ppm compared to other growth regulators.
7) The interaction effect due to varieties and nipping (VxN) was non significant for plant height, number of pod bearing branches, days to 50 per cent flowering, number of pods per plant, pod weight per plant, seed yield per hectare.
8) The interaction between varieties and nipping treatments was non significant for all the seed quality parameters except seedling length (28.18 cm), seedling dry weight (180.90 mg) in nipped plants of ICCV-2 (V_2N_1).
9) The interaction effect of varieties and growth regulators (VxS) indicated that, A-1 variety sprayed with 50 ppm NAA (V_1S_1)recorded relatively higher number of branches, pods per plant, pod weight per pant and seed yield per ha (32.29).
10) The seed quality parameters *viz*., 100 seed weight, seedling length, seedling dry weight, vigour index were higher in ICCV-2 variety sprayed with 50 ppm NAA (V_2S_1).

6.2 Experiment – II : Effect of Seed Size on Plant Growth, Seed Yield and Quality in Chickpea Varieties

1) The plant height (53.93 cm), number of branches, number of pods pr plant (68.98) and seed yield per ha (34.72 q) were maximum in BGD-103 variety followed by Bheema and KAK-2 whereas, lower yield and yield parameters were recorded in ICCV-2.
2) The seed quality parameters like 100 seed weight (38.65 g), germination (96.08%), seedling length, dry weight and vigour index (2760) were higher in variety BGD-103 followed by Bheema.
3) Among different seed sizes, bigger seeds performed better and recorded significantly higher plant height (52.43 cm), number of branches (23.51), number of pods per plant

and seed yield (33.11 q) per ha, followed by medium and bulk compared to small seeds.

4) The seed quality parameters like germination (96.07%), seedling length (32.02 cm), dry weight (221.15 mg) and vigour index (3076) were higher in bigger seeds followed by medium and bulk over small seeds.
5) The interaction effect of varieties and seed sizes were not significant in all the plant growth, seed yield and quality parameters except seedling dry weight, vigour index and electrical conductivity.

6.3 Experiment – III : Effect of Seed Size on Storage Potential of Chickpea Varieties

1) The germination percentage decreased gradually in all the chickpea varieties during 12 months of ambient storage in cloth bags. The satisfactory germination (85%) as per the minimum seed certification standard was maintained in A-1 and BGD-103 for nine months, Bheema for eight month, in ICCV-2 and KAK-2 for seven months in seeds stored in cloth bags.
2) The speed of germination, seedling length, vigour index, field emergence decreased significantly with increase in the storage period, while electrical conductivity and pest infestation percentage increased in all the varieties of chickpea during storage.
3) Among seed size, the germination, field emergence were relatively higher in small seeds followed by bulk and was lower in big seeds. While, seedling vigour parameters were more in big followed by medium seeds and were less in small seeds.
4) The satisfactory germination percentage (85%) as per the minimum seed certification standards was maintained for nine months in small and bulk seeds and for eight months in big and medium seeds stored in cloth bag.
5) The small seeds maintained satisfactory germination (85%) upto 9 months in A-1 and BGD-103 8 months in Bheema and ICCV-2 and 7 months in KAK-2.
6) The medium seeds maintained for 9 months in A-1 and BGD-103, for 8 months in ICCV-2 and Bheema and for 7 months in KAK-2.
7) The viability of big seeds was maintained for 9 months in A-1, 8 months in Bheema and BGD-103 while only 7 months in ICCV-2 and KAK-2 of big seeds.
8) The bulk seeds of A-1 and BGD-103 maintained satisfactory germination for 9 months, Bheema for 8 months while, KAK-2 and ICCV-2 for only 7 months of storage period.

6.4 Experiment - IV : Effect of Seed Treatment on Plant Growth, Seed Yield and Quality in Chickpea Varieties

1. Between the varieties, significantly lower plant height and higher number of branches (23.73), number of pods per plant (44.03), seed yield per ha (30.12 q) were observed in A-1 variety compared to ICCV-2.
2. The higher seed quality parameters *viz*., 100 seed weight (25.11 g), seedling length (28.89 cm), seedling dry weight (196.33 mg), vigour index (2703) were recorded by ICCV-2 compared to A-1.
3. Among different seed treatments, the seed treated with Rhizobium resulted in higher plant height, number of branches (23.94), number of pods per plant (44.03), seed yield per ha (30.07 q) with early in days to 50 per cent flowering followed by PSB, $ZnSO_4$ and $MgSO_4$ compared to control.
4. Rhizobium seed treatment resulted in higher germination (97.16%), speed of germination, seedling length, dry weight, vigour index (2922) with low electrical conductivity (0.408 dSm^{-1}) followed by PSB, $ZnSO_4$ and $MgSO_4$ seed treatments.

6.5 Experiment - V : Influence of Stages of Harvest on Seed Quality in Chickpea Varieties

1) In all the chickpea varieties, fresh weight of pod and seed, 100 seed weight, moisture content decreased significantly with advance in maturity while, dry weight of pod,

fresh and dry weight of seeds, seed germination, seedling length and vigour index increased.

2) Among varieties, BGD-103 recorded maximum fresh and dry weight of pods , fresh and dry weight of seeds, germination, seedling length, seedling vigour index with lower EC values
3) Among harvesting stages, seeds harvested at yellow pod colour stage (H_3) recorded higher dry seed weight, germination (96.40%), seedling vigour with low electrical conductivity (0.993 dSm^{-1}). The fresh and dry weight of pods and moisture content decreased with advance in harvesting stages.
4) In all the chickpea varieties, the seeds harvested at yellow pod stage (H_3), recorded higher pod dry weight, germination, seedling vigour index and lower electrical conductivity. While, seeds harvested at early or later stages than yellow pod stage recorded less germination and seedling vigour index.

6.6 Experiment - VI : Characterization of Chickpea Varieties

1) The five chickpea varieties were categorized based on seed shape, colour and texture. A-1, BGD-103 and Bheema found angular in shaped with brown rough seed coat. While, ICCV-2 and KAK-2 were Owl's shaped, creamy white smooth surface.
2) Hundred seed weight differed among varieties ; BGD-103, Bheema and KAK-2 were heavy while, ICCV-2 and A-1 were medium in seed weight.
3) The hypocotyl colour differed among varieties as pale green with pigment (BGD-103, Bheema and A-1) as creamy without pigmentation (ICCV-2 and KAK-2).
4) Days to flower initiation, 50 per cent flowering, days to pod initiation and pod maturity were early in ICCV-2 and KAK-2 and late in A-1, BGD-103 and Bheema varieties.
5) Pigmentation and pod colour at maturity differed among varieties ; ICCV-2 and KAK-2 were without pigmentation and yellowish brown pod colour. Whereas, rest of varieties were having pigmentation on their pods and were brown in pod colour.
6) The number of pods and seed yield per plant were maximum in BGD-103 (52.68 and 13.88 g) respectively followed by Bheema and A-1 and minimum in ICCV-2 (36.46 and 11.74 g, respectively).

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Appendix I. Physical and chemical properties of soil of the experimental site

Sl. No.	Particulars	Values
I.	Physical properties	
1.	Coarse sand (International Pippette Method) (Piper, 1966)	6.10%
2.	Fine sand (International Pippette Method) (Piper, 1966)	13.14%
3.	Silt (International Pippette Method) (Piper, 1966)	28.00%
4.	Clay (International Pippette Method) (Piper, 1966)	62.76%
II.	Chemical properties	
	Available nitrogen (Alkaline permanganate method) Subbaiah and Asija, 1956)	0.0068%
	Available P_2O_5 (Olsen's method) (Jackson, 1967)	0.007%
	Available K_2O (Flame photometry method) (Jackson, 1967)	0.016%
III.	pH	7.5
IV.	Electrical conductivity (dSm^{-1})	0.31

Appendix 2. Effect of nipping and growth regulators spray on plant height at 30 DAS in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	19.77	19.87	19.30	19.70	19.66	18.33	18.10	18.20	18.33	18.24
	N_2	20.23	20.23	19.83	19.80	20.02	18.30	18.30	18.33	18.60	18.38
V_2	N_1	21.10	21.37	21.40	21.20	21.27	18.33	18.37	18.53	18.47	18.43
	N_2	21.22	21.10	21.63	21.39	21.34	18.07	18.30	18.80	18.80	18.49
V x S	V_1	20.00	20.05	19.57	19.75	19.84	18.32	18.20	18.27	18.47	18.31
	V_2	21.16	21.24	21.52	21.30	21.30	18.20	18.34	18.67	18.64	18.46
N x S	N_1	20.44	20.62	20.35	20.45	20.46	18.33	18.24	18.37	18.40	18.33
	N_2	20.73	20.67	20.73	20.60	20.68	18.19	18.30	18.57	18.70	18.44
	Mean	20.58	20.64	20.54	20.52	20.57	18.26	18.27	18.47	18.55	18.39
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.36	1.02				0.08	0.23		
Nipping(N)			0.36	1.02				0.08	0.23		
Sprays (S)			0.51	1.44				0.11	0.31		
V x N			0.51	1.44				0.11	0.31		
V x S			0.72	2.03				0.15	NS		
N x S			0.72	2.03				0.15	NS		
V x N x S			1.02	2.88				0.22	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 3. Effect of nipping and growth regulators spray on plant height at 60 DAS in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	38.87	36.90	34.60	32.70	35.77	35.83	35.00	34.23	31.40	34.12
	N_2	41.80	39.73	36.60	33.93	38.02	37.47	35.90	34.40	32.17	34.99
V_2	N_1	42.80	41.10	37.37	35.47	39.19	38.60	37.77	36.80	35.70	37.22
	N_2	42.90	41.50	39.17	35.50	39.77	42.00	40.00	37.87	33.50	38.34
V x S	V_1	40.34	38.32	35.60	33.32	36.89	36.65	35.45	34.32	31.79	34.55
	V_2	42.85	41.30	38.27	35.49	39.48	40.30	38.89	37.34	34.60	37.78
N x S	N_1	40.84	39.00	35.99	34.09	37.48	37.22	36.39	35.52	33.55	35.67
	N_2	42.35	40.62	37.89	34.72	38.89	39.74	37.95	36.14	32.84	36.66
	Mean	41.59	39.81	36.94	34.40	38.18	38.48	37.17	35.83	33.19	36.17
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.22	0.62				0.35	0.99		
Nipping(N)			0.22	0.62				0.35	0.99		
Sprays (S)			0.31	0.87				0.49	1.38		
V x N			0.31	0.87				0.49	NS		
V x S			0.44	NS				0.70	NS		
N x S			0.44	NS				0.70	NS		
V x N x S			0.62	NS				0.99	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 4. Effect of nipping and growth regulators spray on plant height at harvest in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	47.23	45.70	39.17	36.33	42.11	42.13	40.80	39.50	36.00	39.61
	N_2	50.50	47.10	42.30	39.20	44.78	44.83	43.27	40.87	39.90	42.22
V_2	N_1	49.37	48.43	43.77	40.27	45.46	45.13	43.30	41.43	37.43	41.82
	N_2	52.97	49.97	43.13	39.00	46.27	47.57	45.10	42.13	39.87	43.67
V x S	V_1	48.87	46.40	40.74	37.77	43.44	43.48	42.04	40.19	37.95	40.91
	V_2	51.17	49.20	43.45	39.64	45.86	46.35	44.20	41.78	38.65	42.75
N x S	N_1	48.30	47.07	41.47	38.30	43.78	43.63	42.05	40.47	36.72	40.72
	N_2	51.74	48.54	42.72	39.10	45.52	46.20	44.19	41.50	39.89	42.94
	Mean	50.02	47.80	42.09	38.70	44.65	44.92	43.12	40.98	38.30	41.83
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.33	NS				0.18	0.51		
Nipping(N)			0.33	0.93				0.18	0.51		
Sprays (S)			0.46	NS				0.25	0.71		
V x N			0.46	NS				0.25	NS		
V x S			0.65	NS				0.36	1.02		
N x S			0.65	NS				0.36	1.02		
V x N x S			0.92	NS				0.50	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 5. Effect of nipping and growth regulators spray on number of branches at 30 DAS in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	3.33	3.53	3.47	3.53	3.47	3.80	3.73	3.80	3.80	3.78
	N_2	3.47	3.47	3.33	3.33	3.40	3.67	3.87	3.80	4.00	3.84
V_2	N_1	3.47	3.60	3.53	3.40	3.50	3.93	4.20	3.93	3.80	3.97
	N_2	3.27	3.33	3.53	3.26	3.35	3.93	3.93	3.93	4.13	3.98
V x S	V_1	3.40	3.50	3.40	3.43	3.43	3.74	3.80	3.80	3.90	3.81
	V_2	3.37	3.47	3.53	3.33	3.42	3.93	4.07	3.93	3.97	3.97
N x S	N_1	3.40	3.57	3.50	3.47	3.48	3.87	3.97	3.87	3.80	3.87
	N_2	3.37	3.40	3.43	3.30	3.37	3.80	3.90	3.87	4.07	3.91
	Mean	3.39	3.48	3.47	3.38	3.43	3.83	3.93	3.87	3.93	3.89
For comparision means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Vareities (V)			0.03	NS				0.03	0.08		
Nipping(N)			0.03	0.08				0.03	NS		
Sprays (S)			0.05	NS				0.04	NS		
V x N			0.05	NS				0.04	NS		
V x S			0.06	NS				0.06	NS		
N x S			0.06	NS				0.06	0.17		
V x N x S			0.09	NS				0.09	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 6. Effect of nipping and growth regulators spray on number of branches at 60 DAS in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	25.90	25.07	24.13	22.40	24.38	26.13	26.00	24.40	22.40	24.73
	N_2	23.83	23.07	22.03	20.47	22.35	24.80	22.87	21.47	19.40	22.14
V_2	N_1	23.40	21.40	19.97	18.22	20.75	21.93	20.33	19.53	18.00	19.95
	N_2	20.67	18.13	17.00	15.73	17.88	18.13	16.87	16.13	16.27	16.85
V x S	V_1	24.87	24.07	23.08	21.44	23.36	25.47	24.44	22.94	20.90	23.43
	V_2	22.04	19.77	18.49	16.98	19.32	20.03	18.60	17.83	17.14	18.40
N x S	N_1	24.65	23.24	22.05	20.31	22.56	24.03	23.17	21.97	20.20	22.34
	N_2	22.25	20.60	19.52	18.10	20.12	21.47	19.87	18.80	17.84	19.49
	Mean	23.45	21.92	20.78	19.21	21.34	22.75	21.52	20.38	19.02	20.92
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.25	0.71				0.23	0.65		
Nipping(N)			0.25	0.71				0.23	0.65		
Sprays (S)			0.36	1.02				0.33	0.93		
V x N			0.36	NS				0.33	NS		
V x S			0.51	NS				0.46	NS		
N x S			0.51	NS				0.46	NS		
V x N x S			0.72	NS				0.65	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 7. Effect of nipping and growth regulator s spray on number of branches at harvest in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	28.53	27.67	26.33	24.10	26.66	29.23	27.60	26.27	25.23	27.08
	N_2	25.60	23.70	23.53	21.67	23.63	27.87	25.33	23.80	22.77	24.94
V_2	N_1	25.93	23.53	22.20	19.53	22.80	26.00	25.17	23.20	21.33	23.93
	N_2	21.60	20.13	18.53	17.40	19.42	24.27	23.67	19.87	18.80	21.65
V x S	V_1	27.07	25.69	24.93	22.89	25.14	28.55	26.47	25.04	24.00	26.01
	V_2	23.77	21.83	20.37	18.47	21.11	25.14	24.42	21.54	20.07	22.79
N x S	N_1	27.23	25.60	24.27	21.82	24.73	27.62	26.39	24.74	23.28	25.50
	N_2	23.60	21.92	21.03	19.54	21.52	26.07	24.50	21.84	20.79	23.30
	Mean	25.42	23.76	22.65	20.68	23.12	26.84	25.44	23.29	22.03	24.40
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.30	0.85				0.29	0.82		
Nipping(N)			0.30	0.85				0.29	0.82		
Sprays (S)			0.42	1.18				0.41	1.16		
V x N			0.42	NS				0.41	NS		
V x S			0.60	NS				0.58	NS		
N x S			0.60	NS				0.58	NS		
V x N x S			0.85	NS				0.82	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 8. Effect of nipping and growth regulators spray on days to 50% flowering in chickpea varieties

Treatments		2007-08 V x N x S S_1	S_2	S_3	S_4	2007-08 V x N	2008-09 V x N x S S_1	S_2	S_3	S_4	2008-09 V x N
V_1	N_1	54.00	54.33	55.67	56.00	55.00	51.33	52.00	52.33	53.00	52.17
	N_2	51.33	51.67	52.67	53.33	52.25	50.67	51.33	51.67	52.67	51.59
V_2	N_1	44.67	45.33	46.00	46.33	45.58	47.67	48.67	49.00	49.67	48.75
	N_2	43.33	44.33	45.50	46.00	44.79	46.67	46.67	46.67	48.00	47.00
V x S	V_1	52.67	53.00	54.17	54.67	53.63	51.00	51.67	52.00	52.84	51.88
	V_2	44.00	44.83	45.75	46.17	45.19	47.17	47.67	47.84	48.84	47.88
N x S	N_1	49.34	49.83	50.84	51.17	50.29	49.50	50.34	50.67	51.34	50.46
	N_2	47.33	48.00	49.09	49.67	48.52	48.67	49.00	49.17	50.34	49.29
	Mean	48.33	48.92	49.96	50.42	49.41	49.09	49.67	49.92	50.84	49.88
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.18	0.51				0.30	0.85		
Nipping(N)			0.48	1.35				0.30	0.85		
Sprays (S)			0.68	NS				0.43	1.21		
V x N			0.68	NS				0.43	NS		
V x S			0.96	NS				0.61	NS		
N x S			0.96	NS				0.61	NS		
V x N x S			1.35	NS				0.86	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 9. Effect of nipping and growth regulators spray on number of pods per plant in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	57.44	55.30	52.27	44.80	52.45	58.93	55.03	52.40	44.60	52.74
	N_2	48.33	45.53	43.03	38.20	43.77	48.67	45.00	40.87	33.47	42.00
V_2	N_1	44.43	40.30	38.03	35.03	39.45	44.60	41.40	39.60	32.40	39.50
	N_2	35.47	31.20	27.37	27.33	30.34	36.00	32.93	28.73	26.20	30.97
V x S	V_1	52.89	50.42	47.65	41.50	48.11	53.80	50.02	46.64	39.04	47.37
	V_2	39.95	35.75	32.70	31.18	34.90	40.30	37.17	34.17	29.30	35.23
N x S	N_1	50.94	47.80	45.15	39.92	45.95	51.77	48.22	46.00	38.50	46.12
	N_2	41.90	38.37	35.20	32.77	37.06	42.34	38.97	34.80	29.84	36.48
	Mean	46.42	43.08	40.18	36.34	41.50	47.05	43.59	40.40	34.17	41.30
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.44	1.24				0.27	0.76		
Nipping(N)			0.44	1.24				0.27	0.76		
Sprays (S)			0.62	1.75				0.38	1.07		
V x N			0.62	1.75				0.38	1.07		
V x S			0.87	NS				0.53	1.49		
N x S			0.87	NS				0.53	NS		
V x N x S			1.24	NS				0.75	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 10. Effect of nipping and growth regulators spray on pod weight per plant in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	21.92	19.70	18.20	16.03	18.96	21.74	20.27	18.50	18.12	19.66
	N_2	19.97	19.03	17.80	17.07	18.47	18.16	16.67	16.40	15.93	16.79
V_2	N_1	19.21	18.18	17.22	16.39	17.75	18.43	17.47	16.17	15.47	16.89
	N_2	17.52	17.19	15.80	13.81	16.08	16.16	15.80	14.70	13.90	15.14
V x S	V_1	20.95	19.37	18.00	16.55	18.72	19.95	18.47	17.45	17.03	18.22
	V_2	18.37	17.69	16.51	15.10	16.92	17.30	16.64	15.44	14.69	16.01
N x S	N_1	20.57	18.94	17.71	16.21	18.36	20.09	18.87	17.34	16.80	18.27
	N_2	18.75	18.11	16.80	15.44	17.27	17.16	16.24	15.55	14.92	15.97
	Mean	19.66	18.53	17.26	15.83	17.82	18.62	17.55	16.44	15.86	17.12
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.19	0.54				0.16	0.45		
Nipping(N)			0.19	0.54				0.16	0.45		
Sprays (S)			0.27	0.76				0.23	0.65		
V x N			0.27	0.76				0.23	0.65		
V x S			0.38	NS				0.33	NS		
N x S			0.38	NS				0.33	NS		
V x N x S			0.54	NS				0.47	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 11. Effect of nipping and growth regulators spray on number of seeds per pod in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	1.60	1.60	1.47	1.40	1.52	1.87	1.60	1.60	1.47	1.64
	N_2	1.67	1.53	1.47	1.47	1.54	1.67	1.67	1.60	1.53	1.62
V_2	N_1	1.33	1.27	1.27	1.20	1.27	1.53	1.53	1.53	1.33	1.48
	N_2	1.33	1.60	1.33	1.20	1.37	1.47	1.53	1.40	1.40	1.45
V x S	V_1	1.64	1.57	1.47	1.44	1.53	1.77	1.64	1.60	1.50	1.63
	V_2	1.33	1.44	1.30	1.20	1.32	1.50	1.53	1.47	1.37	1.47
N x S	N_1	1.47	1.44	1.37	1.30	1.39	1.70	1.57	1.57	1.40	1.56
	N_2	1.50	1.57	1.40	1.34	1.45	1.57	1.60	1.50	1.47	1.53
	Mean	1.48	1.50	1.39	1.32	1.42	1.64	1.58	1.53	1.43	1.55
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.05	0.14				0.02	0.06		
Nipping(N)			0.05	NS				0.02	NS		
Sprays (S)			0.07	NS				0.03	0.08		
V x N			0.07	NS				0.03	NS		
V x S			0.10	NS				0.04	NS		
N x S			0.10	NS				0.04	NS		
V x N x S			0.14	NS				0.05	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 12. Effect of nipping and growth regulators spray on seed yield per plant in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	18.39	17.40	15.25	13.81	16.21	15.45	14.67	13.66	12.89	14.17
	N_2	17.73	17.10	14.17	13.05	15.51	13.36	13.43	12.60	11.53	12.73
V_2	N_1	18.57	16.65	14.08	12.69	15.50	13.44	12.98	12.23	11.21	12.47
	N_2	16.89	16.12	13.40	11.10	14.38	11.50	11.33	10.96	10.07	10.97
V x S	V_1	18.06	17.25	14.71	13.43	15.86	14.41	14.05	13.13	12.21	13.45
	V_2	17.73	16.39	13.74	11.90	14.94	12.47	12.16	11.60	10.64	11.72
N x S	N_1	18.48	17.03	14.67	13.25	15.86	14.45	13.83	12.95	12.05	13.32
	N_2	17.31	16.61	13.79	12.08	14.95	12.43	12.38	11.78	10.80	11.85
	Mean	17.90	16.82	14.23	12.66	15.40	13.44	13.10	12.36	11.43	12.58
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.29	0.82				0.11	0.31		
Nipping(N)			0.29	0.82				0.11	0.31		
Sprays (S)			0.41	1.16				0.15	0.42		
V x N			0.41	NS				0.15	NS		
V x S			0.58	NS				0.22	NS		
N x S			0.58	NS				0.22	NS		
V x N x S			0.83	NS				0.30	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 13. Effect of nipping and growth regulators spray on seed yield per plot (kg) in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	1.24	1.10	0.98	1.04	1.09	1.05	1.18	1.02	0.99	1.06
	N_2	1.13	1.01	0.97	0.93	1.01	1.06	0.98	0.93	0.84	0.95
V_2	N_1	1.05	1.01	0.96	0.88	0.98	1.02	0.98	0.94	0.87	0.95
	N_2	0.95	0.92	0.87	0.77	0.88	0.94	0.89	0.86	0.78	0.87
V x S	V_1	1.19	1.06	0.98	0.99	1.05	1.06	1.08	0.98	0.92	1.01
	V_2	1.00	0.97	0.92	0.83	0.93	0.98	0.94	0.90	0.83	0.91
N x S	N_1	1.15	1.06	0.97	0.96	1.03	1.04	1.08	0.98	0.93	1.01
	N_2	1.04	0.97	0.92	0.85	0.94	1.00	0.94	0.90	0.81	0.91
	Mean	1.09	1.01	0.95	0.91	0.99	1.02	1.01	0.94	0.87	0.96
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.01	0.03				0.01	0.03		
Nipping(N)			0.01	0.03				0.01	0.03		
Sprays (S)			0.02	0.06				0.02	0.06		
V x N			0.02	NS				0.02	NS		
V x S			0.02	NS				0.03	NS		
N x S			0.02	NS				0.03	NS		
V x N x S			0.03	NS				0.04	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 14. Effect of nipping and growth regulators spray on number of seed yield per hectare (qt) in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	34.54	30.60	27.30	28.98	30.36	33.61	30.83	28.43	27.50	30.09
	N_2	31.50	28.02	26.85	25.95	28.08	29.54	27.13	25.83	23.39	26.47
V_2	N_1	29.26	28.05	26.57	24.41	27.07	28.43	27.13	26.11	24.09	26.44
	N_2	26.30	25.65	24.26	21.48	24.42	26.11	24.81	23.80	21.67	24.10
V x S	V_1	33.02	29.31	27.08	27.47	29.22	31.58	28.98	27.13	25.45	28.28
	V_2	27.78	26.85	25.42	22.95	25.75	27.27	25.97	24.96	22.88	25.27
N x S	N_1	31.90	29.33	26.94	26.70	28.71	31.02	28.98	27.27	25.80	28.27
	N_2	28.90	26.84	25.56	23.72	26.25	27.83	25.97	24.82	22.53	25.29
	Mean	30.40	28.08	26.25	25.21	27.48	29.42	27.48	26.04	24.16	26.78
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.32	0.90				0.19	0.54		
Nipping(N)			0.32	0.90				0.19	0.54		
Sprays (S)			0.45	1.27				0.27	0.76		
V x N			0.45	NS				0.27	0.76		
V x S			0.64	1.80				0.38	1.07		
N x S			0.64	NS				0.38	NS		
V x N x S			0.90	NS				0.54	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 15. Effect of nipping and growth regulators spray on 100 seed weight (g) in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	23.70	22.88	20.84	19.80	21.81	24.14	23.53	22.76	22.50	23.23
	N_2	22.90	21.78	20.51	19.54	21.18	23.70	23.33	22.77	22.07	22.97
V_2	N_1	25.64	23.44	21.06	20.25	22.60	26.36	25.66	24.52	23.90	25.11
	N_2	23.41	22.93	20.34	18.88	21.39	26.00	26.00	24.33	23.60	24.98
V x S	V_1	23.30	22.33	20.68	19.67	21.49	23.92	23.43	22.77	22.29	23.10
	V_2	24.53	23.19	20.70	19.57	21.99	26.18	25.83	24.43	23.75	25.05
N x S	N_1	24.67	23.16	20.95	20.03	22.20	25.25	24.60	23.64	23.20	24.17
	N_2	23.16	22.36	20.43	19.21	21.29	24.85	24.67	23.55	22.84	23.98
	Mean	23.91	22.76	20.69	19.62	21.74	25.05	24.63	23.60	23.02	24.07
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.42	NS				0.19	0.54		
Nipping(N)			0.42	NS				0.19	NS		
Sprays (S)			0.59	1.66				0.28	0.79		
V x N			0.59	NS				0.28	NS		
V x S			0.84	NS				0.40	NS		
N x S			0.84	NS				0.40	NS		
V x N x S			1.18	NS				0.56	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 16. Effect of nipping and growth regulators spray on germination in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	97.77 (81.38)	96.55 (79.26)	94.77 (76.75)	92.00 (73.54)	95.27 (77.41)	97.33 (80.56)	95.36 (77.53)	94.33 (76.19)	92.22 (73.77)	94.81 (76.80)
	N_2	95.96 (78.37)	94.08 (75.89)	93.56 (75.27)	90.57 (72.09)	93.54 (75.25)	96.22 (78.76)	94.50 (76.41)	93.78 (75.53)	91.11 (72.62)	93.90 (75.67)
V_2	N_1	97.00 (79.99)	95.44 (77.64)	94.11 (75.92)	91.56 (73.08)	93.11 (74.75)	96.11 (78.59)	94.62 (76.56)	93.69 (75.42)	92.06 (73.60)	94.12 (75.94)
	N_2	95.55 (77.79)	93.56 (75.27)	92.89 (74.51)	89.99 (71.53)	93.00 (74.63)	95.00 (77.05)	94.00 (75.79)	92.89 (74.51)	90.78 (72.29)	93.17 (74.82)
V x S	V_1	96.87 (79.77)	95.32 (77.47)	94.17 (75.99)	91.29 (72.80)	94.41 (76.29)	96.78 (79.62)	94.93 (76.96)	94.06 (75.86)	91.67 (73.19)	94.36 (76.23)
	V_2	96.28 (78.84)	94.50 (76.41)	93.50 (75.20)	90.78 (72.29)	93.76 (75.51)	95.56 (77.80)	94.31 (76.17)	93.29 (74.96)	91.42 (72.94)	93.64 (75.37)
N x S	N_1	97.39 (80.66)	96.00 (78.42)	94.44 (76.33)	91.78 (73.31)	94.90 (76.92)	96.72 (79.53)	94.99 (77.03)	94.01 (75.80)	92.14 (73.69)	94.47 (76.36)
	N_2	95.76 (78.08)	93.82 (75.58)	93.23 (74.88)	90.28 (71.81)	93.27 (74.93)	95.61 (77.87)	94.25 (76.10)	93.34 (75.01)	90.95 (72.46)	93.54 (75.24)
	Mean	96.57 (79.30)	94.91 (76.93)	93.83 (75.59)	91.03 (72.54)	93.91 (75.68)	96.17 (78.68)	94.62 (76.56)	93.67 (75.40)	91.54 (73.06)	94.00 (75.79)
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.37	1.04				0.37	1.04		
Nipping(N)			0.37	1.04				0.37	1.04		
Sprays (S)			0.52	1.47				0.53	1.49		
V x N			0.52	NS				0.53	NS		
V x S			0.74	NS				0.75	NS		
N x S			0.74	NS				0.75	NS		
V x N x S			1.04	NS				1.06	NS		

NS- Non Significant The figures in the parenthesis are transferred values

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 17. Effect of nipping and growth regulators spray on speed of germination in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	50.70	48.97	45.83	47.40	48.23	49.90	48.57	45.70	47.40	47.89
	N_2	49.50	47.50	46.43	43.53	46.74	49.73	47.17	46.30	46.07	47.32
V_2	N_1	52.70	48.87	47.17	48.60	49.34	52.07	49.67	47.83	48.67	49.56
	N_2	51.73	48.63	47.87	47.10	48.83	51.60	49.00	48.03	46.37	48.75
V x S	V_1	50.10	48.24	46.13	45.47	47.48	49.82	47.87	46.00	46.74	47.61
	V_2	52.22	48.75	47.52	47.85	49.08	51.84	49.34	47.93	47.52	49.16
N x S	N_1	51.70	48.92	46.50	48.00	48.78	50.99	49.12	46.77	48.04	48.73
	N_2	50.62	48.07	47.15	45.32	47.79	50.67	48.09	47.17	46.22	48.03
	Mean	51.16	48.49	46.83	46.66	48.28	50.83	48.60	46.97	47.13	48.38
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.32	0.90				0.38	1.07		
Nipping(N)			0.32	0.90				0.38	1.07		
Sprays (S)			0.46	1.30				0.53	1.49		
V x N			0.46	NS				0.53	NS		
V x S			0.65	NS				0.75	NS		
N x S			0.65	NS				0.75	NS		
V x N x S			0.92	NS				1.06	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 18. Effect of nipping and growth regulators spray on seedling length (cm) 60 DAS in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	26.76	25.96	25.33	24.60	25.66	28.33	26.71	25.33	24.44	26.20
	N_2	26.93	25.90	25.19	24.33	25.59	27.02	26.26	25.45	24.14	25.72
V_2	N_1	30.20	28.47	27.08	25.73	27.87	31.52	28.55	27.55	26.34	28.49
	N_2	27.83	27.13	26.07	24.95	26.50	28.32	27.82	26.78	26.25	27.29
V x S	V_1	26.85	25.93	25.26	24.47	25.63	27.68	26.49	25.39	24.29	25.96
	V_2	29.02	27.80	26.58	25.34	27.18	29.92	28.19	27.17	26.30	27.89
N x S	N_1	28.48	27.22	26.21	25.17	26.77	29.93	27.63	26.44	25.39	27.35
	N_2	27.38	26.52	25.63	24.64	26.04	27.67	27.04	26.12	25.20	26.51
	Mean	27.93	26.87	25.92	24.90	26.40	28.80	27.34	26.28	25.29	26.93
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.24	0.68				0.22	0.62		
Nipping(N)			0.24	0.68				0.22	0.62		
Sprays (S)			0.34	0.96				0.30	0.85		
V x N			0.34	NS				0.30	NS		
V x S			0.48	NS				0.43	NS		
N x S			0.48	NS				0.43	NS		
V x N x S			0.68	NS				0.61	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 19. Effect of nipping and growth regulators spray on seedling dry weight in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	181.62	173.55	165.90	157.48	169.64	181.00	174.55	169.66	161.22	171.61
	N_2	174.53	161.87	155.20	148.67	160.07	178.51	169.61	162.17	153.20	165.87
V_2	N_1	197.57	188.20	183.99	178.47	187.06	189.11	192.21	188.11	183.32	188.19
	N_2	175.73	174.30	167.33	159.93	169.32	179.34	182.37	176.79	169.14	176.91
V x S	V_1	178.08	167.71	160.55	153.08	164.85	179.76	172.08	165.92	157.21	168.74
	V_2	186.65	181.25	175.66	169.20	178.19	184.23	187.29	182.45	176.23	182.55
N x S	N_1	189.60	180.88	174.95	167.98	178.35	185.06	183.38	178.89	172.27	179.90
	N_2	175.13	168.09	161.27	154.30	164.70	178.93	175.99	169.48	161.17	171.39
	Mean	182.36	174.48	168.11	161.14	171.52	181.99	179.69	174.18	166.72	175.64
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			1.34	3.78				1.34	3.78		
Nipping(N)			1.34	3.78				1.34	3.78		
Sprays (S)			1.61	4.54				1.90	5.36		
V x N			1.61	4.54				1.90	NS		
V x S			2.27	NS				2.68	7.56		
N x S			2.27	NS				2.68	NS		
V x N x S			3.12	NS				3.80	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 20. Effect of nipping and growth regulators spray on seedling vigour index in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	2618	2508	2402	2262	2448	2758	2547	2388	2192	2471
	N_2	2584	2433	2353	2204	2394	2600	2483	2387	2200	2418
V_2	N_1	2869	2661	2494	2304	2582	2967	2643	2524	2371	2626
	N_2	2604	2483	2386	2195	2417	2632	2560	2435	2333	2490
V x S	V_1	2601	2471	2378	2233	2421	2679	2515	2388	2196	2444
	V_2	2737	2572	2440	2250	2500	2800	2602	2480	2352	2558
N x S	N_1	2744	2585	2448	2283	2515	2863	2595	2456	2282	2549
	N_2	2594	2458	2370	2200	2405	2616	2522	2411	2267	2454
	Mean	2669	2521	2409	2241	2460	2739	2558	2434	2274	2501
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			26	73				25	71		
Nipping(N)			26	73				25	71		
Sprays (S)			37	104				36	102		
V x N			37	104				36	102		
V x S			52	NS				51	NS		
N x S			52	NS				51	NS		
V x N x S			75	NS				72	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 21. Effect of nipping and growth regulators spray on electrical conductivity in chickpea varieties

Treatments		2007-08					2008-09				
		V x N x S				V x N	V x N x S				V x N
		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
V_1	N_1	0.367	0.367	0.367	0.383	0.371	0.370	0.377	0.373	0.393	0.378
	N_2	0.400	0.410	0.423	0.433	0.417	0.400	0.410	0.420	0.427	0.414
V_2	N_1	0.453	0.463	0.483	0.503	0.476	0.450	0.467	0.490	0.507	0.479
	N_2	0.467	0.500	0.510	0.527	0.501	0.483	0.510	0.513	0.530	0.509
V x S	V_1	0.384	0.389	0.395	0.408	0.394	0.385	0.394	0.397	0.410	0.396
	V_2	0.460	0.482	0.497	0.515	0.488	0.467	0.489	0.502	0.519	0.494
N x S	N_1	0.410	0.415	0.425	0.443	0.423	0.410	0.422	0.432	0.450	0.428
	N_2	0.434	0.455	0.467	0.480	0.459	0.442	0.460	0.467	0.479	0.462
	Mean	0.422	0.435	0.446	0.462	0.441	0.426	0.441	0.449	0.464	0.445
For comparison means of			S.Em±	CD at 5%				S.Em±	CD at 5%		
Varieties (V)			0.003	0.008				0.003	0.008		
Nipping(N)			0.003	0.008				0.003	0.008		
Sprays (S)			0.004	0.011				0.004	0.011		
V x N			0.004	0.011				0.004	NS		
V x S			0.006	NS				0.005	NS		
N x S			0.006	NS				0.005	NS		
V x N x S			0.008	NS				0.008	NS		

NS- Non Significant

Varieties (v) : V_1- A-1 V_2- ICCV-2 Nipping (N): N_1-Nipping N_2-No nipping

Sprays (S) : S_1- NAA 50 ppm S_2- Triacontanol (1ml/lit) S_3- Panchagavya S_4- Water spray (Control)

Appendix 22. Effect of seed treatments on plant height at 30 DAS in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	20.43	21.73	21.08	19.46	21.16	20.31
T_2	20.26	21.26	20.76	19.86	20.66	20.26
T_3	20.53	21.23	20.88	19.46	19.63	19.55
T_4	20.73	21.86	21.30	19.23	19.96	19.60
T_5	20.97	22.50	21.74	19.23	19.36	19.30
T_6	21.03	22.46	21.75	19.73	20.20	19.97
T_7	20.20	20.83	20.52	19.73	20.23	19.98
T_8	20.56	20.90	20.73	19.20	19.13	19.17
T_9	21.43	20.56	21.00	18.46	18.40	18.43
Mean	20.68	21.48	21.08	19.37	19.86	19.62
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.12	0.34		0.21	NS
T		0.25	0.71		0.44	NS
V x T		0.36	NS		0.63	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 23. Effect of seed treatments on plant height at 60 DAS in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	40.26	41.83	41.05	39.70	44.20	41.95
T_2	39.60	41.16	40.38	39.10	42.76	40.93
T_3	38.23	39.06	38.65	39.46	42.16	40.81
T_4	40.33	41.36	40.85	40.46	41.20	40.83
T_5	40.03	41.60	40.82	40.33	41.86	41.10
T_6	42.66	43.83	43.25	42.53	42.73	42.63
T_7	41.46	43.63	42.55	41.50	42.26	41.88
T_8	37.36	41.06	39.21	39.13	40.96	40.05
T_9	42.53	38.93	40.73	37.73	39.76	38.75
Mean	40.27	41.38	40.83	39.99	41.99	40.99
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.25	0.71		0.30	0.85
T		0.53	1.49		0.64	1.80
V x T		0.76	NS		0.90	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 24. Effect of seed treatments on plant height at harvest in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	48.23	47.93	48.08	46.93	49.40	48.17
T_2	47.86	52.06	49.96	46.03	49.50	47.77
T_3	47.86	49.86	48.86	46.46	49.06	47.76
T_4	49.06	51.40	50.23	46.17	49.20	47.69
T_5	48.60	51.20	49.90	46.90	49.70	48.30
T_6	50.40	51.43	50.92	48.36	51.23	49.80
T_7	50.07	50.56	50.32	47.70	49.90	48.80
T_8	48.40	50.03	49.22	46.40	47.36	46.88
T_9	47.40	47.66	47.53	46.26	46.10	46.18
Mean	48.65	50.24	49.45	46.80	49.05	47.93
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.31	0.87		0.39	1.10
T		0.67	1.89		0.83	2.34
V x T		0.96	NS		1.71	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 25. Effect of seed treatments on number of branches at 30 DAS in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	3.60	3.46	3.53	4.13	4.26	4.20
T_2	3.46	3.40	3.43	3.93	4.20	4.07
T_3	3.53	3.53	3.53	4.00	4.26	4.13
T_4	3.53	3.40	3.47	3.80	4.13	3.97
T_5	3.73	3.60	3.67	3.86	4.40	4.13
T_6	3.66	3.60	3.63	4.13	4.20	4.17
T_7	3.53	3.46	3.50	4.06	4.26	4.16
T_8	3.60	3.46	3.53	3.73	4.06	3.90
T_9	3.53	3.53	3.53	3.76	3.93	3.85
Mean	3.57	3.49	3.53	3.93	4.19	4.06
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.02	0.06		0.04	0.11
T		0.05	NS		0.08	0.23
V x T		0.07	NS		0.11	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 26. Effect of seed treatments on number of branches at 60 DAS in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	22.20	19.46	20.83	21.80	18.73	20.27
T_2	21.40	18.96	20.18	21.06	18.83	19.95
T_3	20.53	17.30	18.92	20.86	17.83	19.35
T_4	21.93	18.23	20.08	20.46	17.93	19.20
T_5	20.60	18.26	19.43	20.80	18.00	19.40
T_6	23.40	20.37	21.89	22.66	19.56	21.11
T_7	22.33	19.63	20.98	21.93	19.06	20.50
T_8	20.66	16.86	18.76	20.46	16.66	18.56
T_9	19.46	15.86	17.66	19.13	16.13	17.63
Mean	21.39	18.33	19.86	21.02	18.08	19.55
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.24	0.68		0.57	1.61
T		0.51	1.44		1.09	NS
V x T		0.72	NS		1.54	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 27. Effect of seed treatments on number of branches at harvest in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	24.13	22.03	23.08	24.13	22.03	23.08
T_2	23.46	21.53	22.50	23.46	21.53	22.50
T_3	23.06	20.33	21.70	23.06	20.33	21.70
T_4	23.06	20.90	21.98	23.06	20.90	21.98
T_5	24.20	20.53	22.37	24.20	20.53	22.37
T_6	25.40	22.46	23.93	25.40	22.46	23.93
T_7	25.60	21.53	23.57	25.60	21.53	23.57
T_8	23.53	19.36	21.45	23.53	19.36	21.45
T_9	21.06	18.50	19.78	21.06	18.50	19.78
Mean	22.03	20.80	21.41	23.72	20.80	22.26
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.22	0.62		0.30	0.85
T		0.47	1.33		0.64	1.80
V x T		0.68	NS		0.90	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 28. Effect of seed treatments on days to 50% flowering in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	51.66	45.33	48.50	50.66	45.00	47.83
T_2	51.33	46.33	48.83	49.33	46.66	48.00
T_3	53.66	46.00	49.83	50.66	46.66	48.66
T_4	54.00	46.66	50.33	50.66	46.33	48.50
T_5	53.66	46.33	50.00	50.33	45.33	47.83
T_6	52.33	45.00	48.67	48.33	44.66	46.50
T_7	52.66	45.00	48.83	48.33	45.00	46.67
T_8	54.33	46.00	50.17	51.00	46.33	48.67
T_9	55.00	47.33	51.17	52.00	47.66	49.83
Mean	53.18	46.00	49.59	50.14	45.96	48.05
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.37	NS		0.12	0.34
T		0.80	NS		0.26	0.73
V x T		1.13	NS		0.36	1.02

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 29. Effect of seed treatments on number of pods per plant in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	46.73	37.60	42.17	46.00	36.23	41.12
T_2	43.66	35.60	39.63	44.13	34.53	39.33
T_3	43.16	34.73	38.95	44.60	33.66	39.13
T_4	43.70	36.53	40.12	42.03	35.80	38.92
T_5	44.53	35.60	40.07	43.56	35.36	39.46
T_6	49.06	38.73	43.90	48.43	38.10	43.27
T_7	48.00	38.33	43.17	47.16	37.33	42.25
T_8	41.60	35.40	38.50	40.60	34.46	37.53
T_9	37.86	33.46	35.66	37.53	31.70	34.62
Mean	44.26	36.22	40.24	43.78	35.24	39.51
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.45	1.27		0.54	1.52
T		0.95	2.68		1.14	3.21
V x T		1.35	NS		1.61	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 30. Effect of seed treatments on pod weight per plant in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	19.63	16.53	18.08	18.36	15.96	17.16
T_2	18.43	16.20	17.32	17.83	15.90	16.87
T_3	18.36	15.83	17.10	18.03	15.50	16.77
T_4	18.96	16.33	17.65	18.06	15.93	17.00
T_5	18.80	16.33	17.57	18.13	16.26	17.20
T_6	19.73	17.13	18.43	19.20	16.93	18.07
T_7	19.10	17.36	18.23	18.96	17.03	18.00
T_8	18.16	15.76	16.96	17.83	15.46	16.65
T_9	17.43	46.76	32.10	17.10	14.76	15.93
Mean	18.73	19.80	19.27	18.17	15.97	17.07
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.21	0.59		0.23	0.65
T		0.44	1.24		0.46	1.30
V x T		0.63	NS		0.67	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 31. Effect of seed treatments on number of seeds per pod in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	1.78	1.32	1.55	1.73	1.53	1.63
T_2	1.44	1.32	1.38	1.60	1.53	1.57
T_3	1.67	1.22	1.45	1.60	1.46	1.53
T_4	1.67	1.33	1.50	1.53	1.60	1.57
T_5	1.55	1.44	1.50	1.53	1.53	1.53
T_6	1.66	1.44	1.55	1.73	1.53	1.63
T_7	1.55	1.33	1.44	1.53	1.66	1.60
T_8	1.55	1.33	1.44	1.46	1.66	1.56
T_9	1.33	1.22	1.28	1.40	1.53	1.47
Mean	1.58	1.33	1.45	1.57	1.56	1.56
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.03	0.08		0.02	0.06
T		0.06	NS		0.04	NS
V x T		0.09	NS		0.60	1.69

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 32. Effect of seed treatments on seed yield per plant (g) in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	14.06	11.90	12.98	13.19	11.75	12.47
T_2	13.73	11.56	12.65	12.91	11.78	12.35
T_3	13.33	11.43	12.38	12.76	11.19	11.98
T_4	13.66	11.40	12.53	12.40	11.76	12.08
T_5	14.16	11.60	12.88	12.85	11.12	11.99
T_6	15.33	13.46	14.40	14.86	12.94	13.90
T_7	15.16	12.80	13.98	14.31	12.63	13.47
T_8	12.46	11.56	12.01	12.08	11.50	11.79
T_9	11.86	10.83	11.35	11.07	10.60	10.84
Mean	13.75	11.84	12.79	12.94	11.70	12.32
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.19	0.54		0.21	0.59
T		0.40	1.13		0.48	1.35
V x T		0.57	NS		0.63	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 33. Effect of seed treatments on seed yield per plot (kg) in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	1.13	1.01	1.07	1.12	0.98	1.05
T_2	1.12	0.95	1.04	1.09	0.93	1.01
T_3	1.04	0.90	0.97	1.04	0.92	0.98
T_4	1.10	0.97	1.04	1.12	0.96	1.04
T_5	1.10	0.94	1.02	1.10	0.95	1.03
T_6	1.17	1.04	1.11	1.13	1.05	1.09
T_7	1.15	0.98	1.07	1.14	0.97	1.06
T_8	1.03	0.91	0.97	1.02	0.90	0.96
T_9	1.01	0.84	0.93	0.98	0.84	0.91
Mean	1.09	0.95	1.02	1.08	0.94	1.01
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.01	0.03		0.02	0.06
T		0.02	0.06		0.06	0.17
V x T		0.04	NS		0.08	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 34. Effect of seed treatments on seed yield per hectare (q) in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	31.38	28.05	29.72	31.11	27.31	29.21
T_2	31.47	26.48	28.98	30.27	25.92	28.10
T_3	29.07	26.29	27.68	28.98	25.74	27.36
T_4	31.48	27.03	29.26	31.29	26.66	28.98
T_5	30.83	26.29	28.56	30.70	26.48	28.59
T_6	30.74	28.98	29.86	31.39	29.16	30.28
T_7	29.63	27.40	28.52	31.76	26.94	29.35
T_8	27.96	25.37	26.67	28.33	25.06	26.70
T_9	28.24	23.42	25.83	27.40	24.19	25.80
Mean	30.09	26.59	28.34	30.14	26.38	28.26
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.40	1.13		0.39	1.10
T		0.86	2.43		0.84	2.37
V x T		1.22	NS		1.18	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 35. Effect of seed treatments on 100 seed weight (g) in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	24.30	25.80	25.05	24.10	25.56	24.83
T_2	23.79	25.30	24.55	23.53	25.30	24.42
T_3	23.40	24.50	23.95	23.03	24.53	23.78
T_4	23.50	24.79	24.15	23.10	24.76	23.93
T_5	24.18	25.20	24.69	24.11	25.00	24.56
T_6	24.90	26.43	25.67	24.96	26.32	25.64
T_7	24.62	25.94	25.28	24.46	25.03	24.75
T_8	22.93	24.69	23.81	22.56	24.56	23.56
T_9	22.15	24.23	23.19	22.00	23.93	22.97
Mean	23.75	25.21	24.48	23.54	25.00	24.27
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.84	NS		0.83	NS
T		1.79	NS		1.67	NS
V x T		2.53	NS		2.29	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 36. Effect of seed treatments on germination percentage in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	96.66 (79.44)	94.33 (76.19)	95.50 (77.71)	95.00 (77.05)	94.66 (76.61)	94.83 (76.83)
T_2	96.21 (78.74)	93.89 (75.66)	95.05 (77.11)	94.74 (76.71)	93.13 (74.77)	93.94 (75.71)
T_3	94.89 (76.90)	93.66 (75.39)	94.28 (76.13)	94.43 (76.32)	93.36 (75.04)	93.90 (75.66)
T_4	96.42 (79.06)	94.55 (76.47)	95.49 (77.70)	95.33 (77.49)	94.66 (76.61)	95.00 (77.04)
T_5	96.11 (78.59)	94.77 (76.75)	95.44 (77.64)	94.77 (76.75)	94.46 (76.36)	94.62 (76.55)
T_6	97.75 (81.34)	96.05 (78.50)	96.90 (79.83)	96.86 (79.76)	95.96 (78.37)	96.41 (79.05)
T_7	96.89 (79.81)	95.27 (77.41)	96.08 (78.55)	96.40 (79.08)	95.90 (78.29)	96.15 (78.65)
T_8	95.11 (77.19)	94.44 (76.33)	94.78 (76.76)	94.43 (76.32)	94.06 (75.86)	94.25 (76.09)
T_9	93.21 (74.87)	91.44 (72.96)	92.33 (73.89)	92.88 (74.49)	91.16 (72.67)	92.02 (73.56)
Mean	95.92 (78.31)	94.27 (76.12)	95.09 (77.17)	94.98 (77.02)	94.15 (75.97)	94.57 (76.49)
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.20	0.56		0.21	0.59
T		0.43	1.21		0.45	1.27
V x T		0.61	NS		0.63	NS

NS – Non Significant The figures in the parenthesis are transferred values

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 37. Effect of seed treatments on speed of germination in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	48.86	54.58	54.58	48.40	51.53	48.40
T_2	47.86	49.47	49.47	47.86	41.27	47.86
T_3	44.23	45.91	45.91	44.23	45.55	44.23
T_4	47.91	49.79	49.79	47.91	49.79	47.91
T_5	49.96	51.44	51.44	49.96	51.44	49.96
T_6	46.86	48.34	48.34	46.86	48.34	46.86
T_7	44.56	46.08	46.08	44.56	46.08	44.56
T_8	47.73	49.14	49.14	47.73	49.14	47.73
T_9	45.60	47.03	47.03	44.63	44.70	44.63
Mean	47.06	49.09	49.09	46.90	47.54	46.90
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.38	1.07		0.40	1.13
T		0.80	2.26		0.82	2.31
V x T		1.34	NS		1.36	3.84

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 38. Effect of seed treatments on seedling length in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	28.33	29.87	29.10	28.93	30.40	29.67
T_2	27.94	28.98	28.46	27.60	29.27	28.44
T_3	27.16	28.24	27.70	27.53	28.60	28.07
T_4	28.61	28.94	28.78	28.94	29.16	29.05
T_5	27.89	28.49	28.19	27.35	28.71	28.03
T_6	29.61	30.88	30.25	29.90	30.53	30.22
T_7	29.60	29.77	29.69	29.16	29.30	29.23
T_8	27.22	27.57	27.40	27.79	27.43	27.61
T_9	26.26	26.92	26.59	26.66	26.96	26.81
Mean	28.07	28.85	28.46	28.21	28.93	28.57
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.12	0.34		0.14	0.39
T		0.27	0.76		0.28	0.79
V x T		0.38	1.07		0.41	1.16

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 39. Effect of seed treatments on seedling dry weight in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	195.33	206.66	201.00	196.00	203.00	199.50
T_2	193.00	198.66	195.83	193.66	195.66	194.66
T_3	189.00	192.33	190.67	188.66	195.00	191.83
T_4	189.66	192.66	191.16	189.66	191.66	190.66
T_5	187.66	196.66	192.16	190.00	185.33	187.67
T_6	196.66	208.33	202.50	199.33	205.66	202.50
T_7	193.00	206.33	199.67	194.33	205.00	199.67
T_8	181.66	190.66	186.16	174.66	186.00	180.33
T_9	178.66	182.33	180.50	176.33	182.00	179.17
Mean	189.40	197.18	193.29	189.18	194.37	191.77
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		1.05	2.96		1.20	3.38
T		2.23	6.29		2.10	5.92
V x T		3.15	NS		3.18	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 40. Effect of seed treatments on vigour index in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	2739	2818	2779	2749	2877	2813
T_2	2689	2720	2705	2613	2394	2504
T_3	2578	2646	2612	2600	2669	2635
T_4	2759	2735	2747	2760	2761	2761
T_5	2680	2685	2683	2593	2713	2653
T_6	2894	2966	2930	2897	2933	2915
T_7	2590	2837	2714	2813	2813	2813
T_8	2440	2605	2523	2624	2582	2603
T_9	2818	2462	2640	2479	2458	2469
Mean	2687	2719	2703	2681	2689	2685
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		13	NS		18	51
T		27	76		31	87
V x T		39	110		43	NS

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/ kg) T_7 : PSB (20 gm/ kg) T_8 : Panchagavya (3%) T_9: Control

Appendix 41. Effect of seed treatments on electrical conductivity in chickpea varieties

Treatments	2007-08			2008-09		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1	0.387	0.430	0.409	0.387	0.433	0.410
T_2	0.400	0.440	0.420	0.403	0.440	0.422
T_3	0.407	0.473	0.440	0.417	0.473	0.445
T_4	0.417	0.467	0.442	0.417	0.467	0.442
T_5	0.403	0.450	0.427	0.407	0.457	0.432
T_6	0.393	0.420	0.407	0.939	0.423	0.681
T_7	0.407	0.423	0.415	0.407	0.427	0.417
T_8	0.423	0.483	0.453	0.427	0.483	0.455
T_9	0.430	0.487	0.459	0.430	0.490	0.460
Mean	0.407	0.453	0.430	0.470	0.455	0.463
Comparison for means of		S.Em±	CD (5%)		S.Em±	CD (5%)
V		0.004	0.011		0.003	0.008
T		0.008	0.023		0.006	0.017
V x T		0.012	NS		0.010	0.028

NS – Non Significant

Varieties : V_1: A-1 V_2ICCV-2

Seed treatments: T_1 : $ZnSO_4$ (1 gm/kg) T_2 : $CaCl_2$ (1 gm/kg) T_3 : $FeSO_4$(1 gm/kg) T_4 : B (1 gm/kg) T_5 : Mg SO_4 (1 gm/kg)

T_6 : Rhizobium (20 gm/kg) T_7 : PSB (20 gm/kg) T_8 : Panchagavya (3%) T_9: Control

SEED TECHNOLOGICAL STUDIES IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

Field and laboratory experiments were conducted at the Main Agricultural Research Station, Dharwad and in the laboratory of Department of Seed Science and Technology, University of Agricultural Sciences, Dharwad during rabi 2007-08 and 2008-09.

Nipping at 30 DAS and growth regulator foliar spray in A-1 and ICCV-2 chickpea varieties revealed that over of nipping and growth regulators, A-1 recorded more number of branches and pods per plant with higher seed yield and better seed quality parameters compared to ICCV-2. Nipping showed beneficial influence on number of branches and pods per plant with higher seed yield (28.50 q/ha) and better seed quality. Among growth regulators, NAA (50 ppm) followed by Tricontanol (0.1%) resulted in more number of branches and pods per plant with higher seed yield (29.91 and 27.80, respectively) with better seed quality parameters. The interaction effect of varieties, nipping and growth regulators also showed similar beneficial influence on seed yield and quality.

The field study on seed size grades on seed yield and quality in five chickpea varieties revealed that big and medium seeds produced more seed yield (33.11 and 32.05 kg/ha, respectively) with better seed quality parameters compared to small seeds. Seed yield and quality were more in Desi over Kabuli chickpea varieties. The interaction effect showed that big seeds of Desi and Kabuli types were better in seed yield and quality compared to small seeds.

The storage study indicated that Desi varieties maintained satisfactory germination upto 8-9 months while Kabuli types upto 7-8 months. Among seed size, small and medium seeds were relatively more in storage potential that other seed grades.

In all the chickpea varieties, 100 seed weight and moisture content decreased significantly with advance in maturity, while, germination and vigour index increased. Seeds harvested at full yellow pod colour stage (H_3) recorded higher germination (96.40%) and seed vigour.

The morphological characters viz., stem colour, pigmentation, foliage colour, pod colour, seed coat colour, test weight *etc*. were found more reliable parameters for varietal characterization in chickpea varieties.