

**STUDIES ON INTEGRATED NUTRIENT MANAGEMENT AND
PLANTING METHODS ON SEED YIELD AND QUALITY
OF GROUNDNUT (*Arachis hypogaea* Gaertn.)**

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PLANTING METHODS ON SEED YIELD AND QUALITY
OF GROUNDNUT (*Arachis hypogaea* Gaertn.)**

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By

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CERTIFICATE

*This is to certify that the thesis entitled "STUDIES ON INTEGRATED NUTRIENT MANAGEMENT AND PLANTING METHODS ON SEED YIELD AND QUALITY OF GROUNDNUT (*Arachis hypogaea* Gaertn.)" submitted by A.S. CHANNAVEERSWAMI for the degree of DOCTOR OF PHILOSOPHY in SEED SCIENCE AND TECHNOLOGY, to the University of Agricultural Sciences, Dharwad, is a record of bonafide research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.*

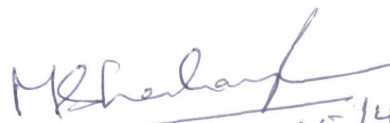
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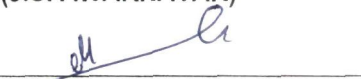
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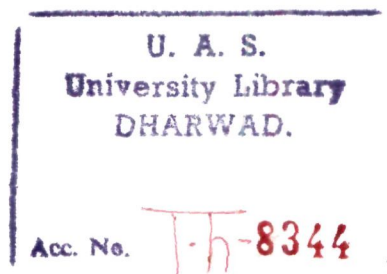
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Introduction

I. INTRODUCTION

Groundnut (*Arachis hypogaea* Gaertn.) is the most important oilseed crop of tropical and subtropical regions of the world. It is believed to be native of Brazil (South America). It was introduced in India during first half of the sixteenth century. It belongs to the family Leguminosae and sub family Papilionaceae. The cultivated form of groundnut has been classified into two major groups viz., Valencia or Spanish type (*Arachis hypogaea* sub spp. *fistigiata*) and Virginia type (*Arachis hypogaea* sub spp. *hypogaea*). It is a unique crop, combining the attributes of both oil seed and legume crop in the farming system of Indian Agriculture. Cultivation of this crop is mostly confined to the geographical area between 40° N and 45° S latitudes. It is a valuable cash crop planted in the dry areas of Asia, Africa, Central and South America, Australia and Caribbean in view of its economic, food and nutritional value. It is a primary source of edible oil and has a high oil content (44-50%) and protein content (25%) and is also a valuable source of vitamins E, K and B. It is the richest plant source of thiamine and is also rich in niacin, which is low in cereals. The plants, kernels, shells, oil and cakes are economically used in one or the other way.

Being regarded as the king of vegetable oilseeds it is grown on an area of 25.10 m ha and producing 34.07 m t of pod with average production of 1370 kg per ha. In India, it is cultivated on an area of 6.87 m ha and producing 5.31 m t pod while, the average productivity is 774 kg per ha which is very low compared to world productivity. In Karnataka, it is cultivated in both *kharif* and *rabi*/summer seasons and

accounts for an acreage of 1.11 m ha with a production of 0.79 m t while, the productivity of the state is 715 kg per ha (Anon., 2002). The low yields are mainly due to poor nutrient management and being raised on rainfed conditions.

Integrated nutrient management is an efficient way of fertility management of the soils and nutrient to the crops. The imperative now is to formulate economically viable, technically feasible and socially acceptable INM package for the crops and cropping systems of the varied agroclimatic situations of the country. INM aims at achieving harmony in the conjoint use of all resources – chemical fertilizers, organic manures, green manures, biofertilizers, crop residues and other non-conventional sources of plant nutrients. Behind such harmonious use lies the target of achieving maximization of nutrient use efficiency of the crops and minimization of the avoidable losses and leakage of nutrients from all the sources.

India, one of the most populous country in the world needs vertical growth as the horizontal growth is no more possible. Man began to cultivate land in an organized way for food grains around 8000 BC. Later he learned that the same land cannot support the growth of the plants forever and this led him to think about different ways and means of improving the fertility of the soil. However, due to shortage of food in many pockets of the world, he started adopting Hi-Tech modern agriculture, largely depending on chemical fertilizers. But once he came to know about environmental hazards on the eco-system due to their excessive use, he for the first time felt the need for integrated nutrient management. In a

country like India, where nearly 75 per cent of the farmers operate small and marginal holdings and are resource poor coupled with poor soils only fertilizers occupy a key place in agricultural planning and programming. Fertilizer nutrient wastage arising from inefficient use will prove prohibitively expensive and thus can be ill afforded. Further, any inefficient use of fertilizer nutrients can produce adverse effects on environment casting additional doubt on the long term sustainability of oilseeds production. In spite of such abundant use of costly inputs, it is not certain whether we would meet the challenge of feeding the people to the desired extent with the right quality of safe food. Fertilizer use efficiency holds key to productivity, since its price has risen faster than the price of agricultural crops. Though the use of fertilizers is the quickest and surest way of boosting oilseeds production, hardly 30 to 40 per cent of nutrients applied through fertilizers are utilized by the crops and the remaining are lost through various pathways such as leaching, volatilization, surface runoff, soil erosion and fixation. Less than 15 per cent of nutrients absorbed by oilseed crops is contributed by fertilizers while, the rest is contributed from soil reserves, organic manures, biological sources and residues and wastes. The declining efficiency of fertilizers is of great concern at this point of time. Hence, conjunctive application of inorganic, organic and bio fertilizer sources of nutrients will reduce the dependence on chemical inputs.

Balanced and full diet plays an important role in the well being and proper growth of any living organism and plants are no exception to that. Certain nutrients are required in larger quantity and others in traces but

the availability of both are essential for the overall growth of the plant. As the adage goes “A bulk of a material will not fetch half a price if handful of it is of low quality”. Of all the macro and micro nutrients, importance of N, P, K, Fe, Zn, Cu, S and Ca have always been most prominently stressed because of the role they play in significantly influencing the yield and quality when compared to others.

Nitrogen improves the photosynthetic efficiency as it enhances the vegetative growth and is also essential in synthesis of protein and to realize better seed yield and quality (Reddy *et al.*, 1981). Phosphorus is essential component of ATP and NADPH⁺ which are rich energy source and they in turn play an important role in synthesis of DNA, RNA and nuclear divisions which adds new cells to growing hypocotyls and leaf (Durrant and Tyson, 1960). Phosphorous containing enzymes are essential for fatty acid synthesis and is a constituent in lecithin, a phospholipid due to which oil and fat content increases. It is chiefly concerned with fruiting and seed development. Potassium plays an important role in flowering and is necessary for the seed development. It influences physiological processes which are directly related to symbiotic nitrogen fixation, photosynthesis and carbohydrate transportation in leguminous oilseeds. Apart from increase in yield low N and high K nutrition also increases phenol content in plants which plays a beneficial role in plant resistance (Perrenoud, 1990).

Iron is necessary for groundnut nodulation and its deficiency at nodulation stage limits further division of root cortical cells and proliferation of N fixing bacteria in roots. Zinc is essential for catalysing

the activity of dehydrogenase enzyme in the oxidation process. It also stimulates IAA synthesis and decrease ribonuclease activity leading to more RNA content and higher protein synthesis. Its deficiency is known to reduce the size and viability of pollen grains. Calcium influences pod-hull thickness, specific weight and time taken for pods to mature and seed dry weight. Sulphur is a constituent of essential amino acids and vitamins and it influences the protein and oil composition of seeds by increasing the activity of acetic thiokinase. It provides disulfide group for cross linkage of two polypeptide chains in protein formation. Deficiency of copper may cause pod abortion resulting in to less number of pods per plant. The beneficial effects of the nutrients may be either direct or indirect. They provide the nutrient directly to the plant thus avoids many deficiency disorders or indirectly act as cofactors for many enzymes and their by improves the overall metabolic efficiency.

Organic manures have been time tested materials for improving the fertility and productivity of soils. We have ignored the exploitation of the potential of organic manures and their synergistic effect with chemical fertilizers for increasing productivity, sustainability of agriculture and improving soil health and environmental security. These bulky organic manures have the significant ability to neutralize the rapid yield fall with the continuous use of chemical fertilizers and to sustain productivity (Abrol and Katyal, 1990). Organic manures besides supplying nutrients to the current crop, very often leave substantial residual effect on the succeeding crops in the system and this residual effect lasts often for several seasons. They are not just sources of nutrients, they have

profound, even sometimes dominant effect on soil physical properties resulting in better structure, greater water retention, more favourable environment for root and pod growth and better infiltration of water. The beneficial effects of such properties on crop yields has rarely been given due economic importance.

Farm yard manure seems to act directly in increasing the crop yields either by acceleration of respiratory process with increasing cell permeability and hormonal growth action or by combination of all these processes. It supplies nitrogen, phosphorus and sulphur in available forms to the plants through biological decomposition and improves physical properties of soil such as aggregation, aeration permeability and water holding capacity. Vermicompost is an aerobically degraded organic matter which has undergone chemical disintegration by the enzymatic activity in the gut of worms and also enzymes of the associated microbial population. Vermicompost has been considered as bio-manure because of its richness in humus forming and nitrogen fixing microorganisms. Vermicompost contains considerable amount of plant nutrients and encourage the plant growth by providing nutrients in the available form.

Bio fertilizers have an important role to play in improving the nutrient supply and their availability in crop production. They help in increasing the biologically fixed atmospheric nitrogen and enhancing native phosphorus availability to crops. Among the bio fertilizers for increasing nitrogen supply to oilseed crops, nitrogen - fixing bacteria *Rhizobium* is most important. Groundnut being a legume, it requires

small quantity of nitrogen at initial stages to fulfill the nitrogen demand of seedlings till *Rhizobia* are established on roots. To improve the effectiveness of *Rhizobia*, seed inoculation with *rhizobium* responds favorably in the formation of nodules on the roots as well as fixation of atmospheric nitrogen. Only a fraction of total agricultural need for nitrogen, comes from synthetic and natural fertilizers, the remaining portion must be satisfied from soil reserve nitrogen and through the biological fixation from atmospheric nitrogen. The presence of nodules on groundnut roots does not necessarily indicate sufficient nitrogen fixation for maximum growth of the host plant. Poor N₂ fixation is one of the reasons for low productivity in groundnut. *Rhizobium* inoculation combined with judicious use of organic manures may prove a cheaper, effective and eco friendly management practice for ensuring adequate nutrition of legumes including groundnut (Singh and Ahuja, 1985). The availability of P is improved by 'P' solubilising microorganisms (PSM). Here the 'P' solubilising fungi plays a vital role to make the non available form of P in to available form of P to the crops (Balasubramanian and Palaniappan, 1994). Use of biofertilizers also saves land and water from being polluted.

To achieve high crop productivity, there has to be proper balance between source and sink besides higher dry matter production. The time of application and method followed for application of the nutrients play a vital role to over come the nutrient stress by the plants otherwise it may lower the yield of crops. Remobilization of nutrients from various plant parts to the pods during the reproductive phase has also been observed.

Hence, the method of application of these nutrients particularly micronutrients is of great importance in harnessing their full dividends.

Plant geometry and method of planting is another factor which is responsible for low productivity. Skipped row planting method of cultivation is known to reduce the competition between plants above ground as well as below ground. This method of planting reduces the seed rate and plant population but helps to achieve increased number of branches, flower number ultimately resulting in more pod set and better seed filling and seed weight (Radder *et al.*, 1989). The work on this aspect in groundnut is meagre.

Keeping all these backdrops in focus, the studies were made on integrated nutrient management and planting methods on seed yield and quality in groundnut with following objectives.

1. To find out the individual and combined effect of inorganic, organic and biofertilizers on crop growth, seed yield and quality of groundnut.
2. To find out the influence of iron, zinc and method of their application on crop growth, seed yield and quality of groundnut.
3. To find out the influence of row skipping on seed yield and quality of groundnut varieties.
4. To find out the profitable method of groundnut seed production.

Review of Literature

II. REVIEW OF LITERATURE

Studies made with regard to integrated nutrient management and planting methods on seed yield and quality in groundnut and other oilseed crops are reviewed in this chapter.

2.1 MACRONUTRIENTS

The average yield of groundnut under rainfed conditions is very low. Efficient use of fertilizers, particularly of N, P and K plays an important role in enhancing the production and productivity of the crop by increasing cell division and multiplication. Nitrogen is a fundamental structural unit of protein, which is required for the formation of amides, amino acids and subsequently the proteins as reported by Singh and Singh (1978) and Nyital and Singh (1984). N nutrition is required for improvement of growth parameters through efficient metabolic activity and increased rate of photosynthesis. Nitrogen and phosphorus are the most common elements limiting growth and yield. Adequate supply of these nutrients to crop helps in synthesis of carbohydrates and proteins in plants, which in turn are required for the formation of protoplasm resulting in to higher cell division and cell enlargement and favourable improvement in the growth characters ultimately leading to higher dry matter accumulation. P is a constituent of nucleoprotein and is known to help for increased cell division and expansion of cells ultimately resulting into higher dry matter production and its accumulation in reproductive parts. Single super phosphate is the best source of supplying P_2O_5 as it contains besides phosphorus (16%), calcium (19.5%) and sulphur

(12.5%) which are needed for groundnut crop. Potassium plays a significant role in increasing the crop yield and also exerts a balancing effect on both nitrogen and phosphorus. K nutrition also helps in increasing the oil percentage due to its beneficial role in the formation of fatty acids (Swami and Yadav, 1985).

2.1.1 Macronutrients on growth parameters

Girase *et al.* (1975) conducted an experiment to find out the optimum level of N nutrition to sunflower and recorded maximum benefit of nitrogen manuring resulting in to increase in plant height with the application of 25 kg N per ha.

Tripathi and Kalra (1980) reported that in sunflower application of 40 kg N per ha significantly reduced the number of days taken to floral bud opening and induced early maturity followed by 80 kg N per ha while, 120 kg N per ha prolonged vegetative phase and delayed reproductive phase whereas, no nitrogen pushed the plant to reproductive phase earlier because of poor vegetative growth. Phosphorus and potassium application significantly reduced the days taken to various developmental stages.

Ibrahim *et al.* (1982) could not obtain any consistent effect on dry matter production in groundnut due to N and P application.

Zohra Ahmed *et al.* (1985) in a field trial to know the response of safflower to nitrogen and phosphorus applied 0, 20, 40 and 60 kg N per ha and 0 and 40 kg P₂O₅ per ha with a uniform dose of 60 kg K₂O per ha. They could notice significant increase in plant height and number of branches per plant with every increment in nitrogen up to 60 kg N per

ha. Addition of 40 kg P_2O_5 per ha at each level of nitrogen indicated perceptible response over control.

Increase in plant growth characters in groundnut were noticed due to successive increase in P_2O_5 and K_2O levels from 0, 20, 40 and 60 kg per ha (Dubey *et al.*, 1986).

Dwivedi and Patel (1987) recorded an increase in linseed plant height from 44.0 cm with no nitrogen to 54.7 cm with 60 kg N per ha. Further increase in N levels could not produce any significant effect. Number of branches were also more with this level of nitrogen.

With every 20 kg per ha increase in K levels to mustard crop significant increase in total dry matter at flowering and 30 days after flowering and also number of branches were obtained up to 60 kg K_2O per ha. Further increase in K level was not beneficial (Mondal *et al.*, 1990)

Significant increase in sunflower plant height, leaf area index at 60 days after sowing and dry matter per plant were reported with application of nitrogen and phosphorus. As against a plant height of 105 cm, leaf area index of 1.49 and dry matter per plant of 31.0 g recorded by control plot the crop which received 60 kg N per ha recorded 134 cm plant height, 2.04 leaf area index and 50.3 g dry matter per plant while, the crop which received 60 kg P per ha recorded 130 cm plant height, 2.02 leaf area index and 48.8 g dry matter per plant (Mishra *et al.*, 1994).

Barik and Mukherjee (1995) in groundnut noticed that compared to no nitrogen and increasing rates of nitrogen supply (80 and 120 kg N/ha)

application of 40 kg N per ha recorded significantly highest husk yield and nodule number per plant at 30, 45 and 60 days after sowing. Higher levels of N had no beneficial effect.

Significant positive effects on nitrogen utilization efficiency and total dry matter production due to nitrogen application to groundnut genotypes were reported by Chetti *et al.* (1995).

In mustard, significant increase in number of primary branches per plant from 4.27 to 9.07 and secondary branches per plant from 6.05 to 12.66 were noticed due to no nitrogen and 75 kg N per ha respectively. Further increase in N level was not beneficial. Similar response was noticed for dry matter per plant and stover yield (Kakati and Kalita, 1996).

Madhavi *et al.* (1997) noticed significant increase in soybean plant height at 75 days after sowing and total dry matter production at 75 and 90 days after sowing with fertilizer level of 90 N + 120 P₂O₅ + 60 K₂O kg per ha over control and lower fertility levels

The pollen parent (RHA-271) and seed parent (CMS 7-1A) of APSH-11 sunflower hybrid responded to grow significantly tall, attain more stem girth and larger head size at 150 kg N per ha over recommended rate of 100 kg N per ha. However, it delayed the days needed to initiate and 50 per cent flowering in both the parents (Mary Kamala *et al.*, 1997).

Nagavani *et al.* (1997) in case of sunflower as against 109.76 cm plant height, 9.64 number of green leaves, 368.86 g per m² total dry matter and 11.05 cm head diameter recorded with no nitrogen,

significantly higher corresponding values of 130.68 cm, 11.43, 626.29 g per m² and 14.11 cm were recorded with 100 kg N per ha.

Sarawgi *et al.* (1997) reported significant increase in nodule number and their dry weight at 35 and 75 days after sowing in case of soybean with increasing levels of phosphorus, but the difference between 60 and 90 kg P₂O₅ per ha was not significant.

In case of groundnut progressive and significant increase in plant height by the successive increment of N and P was observed and maximum plant height was recorded with 90 kg N and 75 kg P per ha (Mahalanobis and Maiti, 1998).

Naik and Rao (2004) recorded higher plant height and number of branches in *rabi* soybean due to 40 kg per ha N application compared to no nutrition.

2.1.2 Macronutrients on yield parameters

Vikram Singh *et al.* (1973) recorded a higher sunflower seed yield per head of 18.90, 36.20 and 51.14 per cent over control (91.37 g/plant) with application of 20, 40 and 60 kg N per ha respectively. They also noticed significantly higher seed yield over control with application of 26.4 kg P per ha but it was on par with P application @ 13.2 kg per ha level. Significant increase in number of seeds per head were also noticed with every increment in N and P levels.

Girase *et al.* (1975) in a two year study conducted during 1973 and 1974 observed that nitrogen application improved the sunflower head diameter, number and weight of seeds per head. The maximum benefit

was associated with 25 kg N per ha application and further increase in N level did not show any improvement in yield and yield contributing characters.

Krishnanda *et al.* (1977) recorded higher number of total and filled pods per plant in TMV-2 groundnut variety with nitrogen level of 20 kg per ha and phosphorus level of 60 kg per ha and potassium level of 40 kg per ha.

The yield and yield contributing characters such as head diameter and number of seed per head were significantly maximum with lower level of 40 kg nitrogen in conjunction with 60 kg P_2O_5 and 60 kg K_2O per ha to sunflower as reported by Tripathi and Kalra (1980).

Purushothaman *et al.* (1981) found out the optimum and economic levels of P_2O_5 and K_2O for groundnut. The optimum and economic levels were 94 and 90 kg P_2O_5 per ha and 124 and 116 kg K_2O per ha respectively.

Ibrahim *et al.* (1982) could not get any consistent effect due to N and P application in seed yield of groundnut. The oil and protein content were negatively correlated with yield.

Hadad *et al.* (1983) noticed varied responses by groundnut cultivars for nitrogen nutrition. Application of 40 kg N per ha increased the yield by 38 per cent in Cv. Barberton while, 120 kg N per ha increased the yield of Cv. Barberton by 52 per cent and Cv. Ashford by 23 per cent.

Zohra Ahmed *et al.* (1985) obtained significantly highest safflower flower heads per plant, protein per cent and yield with the application of 60 kg N and 40 kg P_2O_5 per ha.

In linseed 60 kg N per ha recorded significantly maximum number of capsules per plant, seeds per capsule and seed yield while, further increase in N level noticed reduction in yield and yield attributes (Dwivedi and Patel, 1987).

Roshan Lal and Ganga Saran (1988) recorded significantly maximum groundnut pod yield with 20 kg N per ha while, phosphorus application up to 40 kg per ha recorded significantly higher yield.

Uppar and Kulkarni (1989) obtained significantly highest sunflower processed seed yield with 120 kg N per ha nitrogen level along with other yield attributes.

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The favourable response to potassium up to 60 kg K₂O per ha by mustard crop with a higher number of silique per plant, seeds per silique, seed yield and oil content were reported by Mondal *et al.* (1990).

The increase in groundnut yield from 7.65 q to 15.77 q per ha was reported with the balanced use of N, P₂O₅ and K₂O @ 20, 60 and 40 kg per ha respectively (Yadav, 1990).

Gnanamurthy and Balasubramanian (1992) recorded increased pod number, sound mature kernel and shelling percentages, pod and haulm yield with the application of recommended dose of P₂O₅ and K₂O @ 10 and 45 kg per ha respectively along with N @ 10 kg per ha as basal dose to groundnut cultivar CO-1.

Saraswathy and Dharmalingam (1992) opined that 50:20:30 kg NPK per ha is the best combination for augmenting the yield and yield attributes in mustard crop. Similarly in linseed, application of 60:45:30 kg

NPK per ha recorded 818.6 kg seed yield per ha as against 271.1 kg per ha with no fertilization. The increase in yield was 202 per cent with an additional profit of Rs. 2080 per ha (Uttaray *et al.*, 1992).

Application of 30, 60 and 60 kg NPK per ha was beneficial in getting higher filled pods per plant, shelling, protein and oil content as well as pod yield in TMV-2 groundnut cultivar (Yakadri *et al.*, 1992).

In a field trial application of 25 kg N + 72 kg P₂O₅ + 37.5 kg K₂O per ha (recommended dose) to groundnut Cv. TMV-2 gave highest seed (3669 kg/ha), protein (786 kg/ha) and oil (1606 kg/ha) yields. Reducing fertilizer application to half the recommended dose, decreased the seed, protein and oil yields by 16, 15 and 12 per cent respectively and 25, 33 and 27 per cent when no fertilizer was applied (Thimmegowda, 1993a).

A pod yield of 4.49 t per ha by TMV-2 groundnut variety was recorded with application of 25:75:37.5 kg NPK per ha. The pod yield was 4.10 t per ha when this NPK dose was reduced to half and it was 3.55 t per ha when no fertilizer was applied (Thimmegowda, 1993b).

In sunflower total dry matter accumulation per plant, seed fertility per cent, seed and stalk yield were maximum with 60 kg N per ha which offered an yield advantage of 24 and 8.5 per cent over 20 and 40 kg N per ha respectively. Seed yield of 8.66 q per ha was recorded at 60 kg P₂O₅ per ha which was 8.5 and 3 per cent more than that of 20 and 40 kg P₂O₅ per ha respectively (Mishra *et al.*, 1994).

Sharma (1994) stated that application of 62 and 46 kg N and P per ha respectively to sunflower increased the size of the head and seed index

and also recorded significantly higher seed yield of 15.14 q per ha than the lower level of half of their doses.

Barik and Mukherjee (1995) recorded higher groundnut pod and kernel yield and oil content with 40 kg N per ha and decline in yield and yield attributes were noticed with higher doses of nitrogen application (80 and 120 kg N/ha).

Patra *et al.* (1995) found that application of 40 kg N per ha to summer groundnut increased pod yield by 14.9 per cent and oil yield by 20.1 per cent over control (no nitrogen) and 45 kg K₂O per ha increased pod yield by 25.9 per cent and oil yield by 36.3 per cent over control (no potassium). Whereas, highest mean pod yield of 3.22 t per ha and highest net returns were obtained with the application of 25:50:25 kg NPK per ha at Dharwad to groundnut Cv. Dh-3-30 (Agasimani, 1996).

Mahalanobis and Maiti (1998) recorded 36.37, 58.89 and 53.58 per cent increase in groundnut pod yield and 36.66, 67.36 and 65.56 per cent increase in oil yield over control with application of 30 N + 25 P, 60 N + 50 P and 90 N + 75 P kg per ha respectively.

Application of 40 kg per ha N to rabi soybean recorded higher number of pods per plant, seeds per pod and seed yield over lower levels of N application (Naik and Rao, 2004).

2.1.3 Macronutrients on seed quality parameters

Ashwani Srivastava (1978) concluded that nitrogen fertilization with an optimum dose of phosphorus is a determining factor for the development of healthy seeds on the sunflower capitulum, with higher

protein and lipid content and high germinability. Poor nutrient supply resulted in abortion of embryos in sunflower seeds.

Ravikumar and Basavaraju (1984) concluded that application of higher doses of nitrogen and phosphorus (120 kg N and 90 kg P/ha) recorded an increase in seed recovery, seed germination and seedling vigour in sunflower. Similar beneficial effects of nitrogen application (120 kg /ha) on seed quality characters like germination, vigour index and protein content in sunflower were also reported by Uppar and Kulkarni, (1989).

Gnanamurthy and Balasubramanian (1992) recorded highest 100-kernel weight of CO-1 groundnut variety when the crop was provided with 10:10:45 kg NPK per ha. Whereas, for TMV-2 groundnut cultivar application of 30:60:60 kg NPK per ha was beneficial for getting higher 100 kernel weight (Yakadri *et al.*, 1992). While, for JL-24 groundnut cultivar application of 40 kg N and 45 kg K₂O per ha gave higher 100-kernel weight (Patra *et al.*, 1995).

2.2 MICRONUTRIENTS

For leguminous oilseeds like groundnut and soybean, the main nutrients from fertilizer management point of view are P, K, S, Ca, Fe and Zn. Being legumes, these crops can meet a large part of their nitrogen needs through biological N fixation. Sulphur influences the protein and oil composition of seeds by increasing the activity of acetic thiokinase, an important enzyme necessary for conversion of acetyl Co A in to malonyl Co A. It provides disulfide group for cross linkage of two polypeptide chains in

protein formation. Zinc is essential for the activity of dehydrogenase enzyme for catalysing the oxidation process. It is also known to stimulate IAA synthesis and decrease ribonuclease activity leading to more RNA content and higher protein synthesis. Pod filling in groundnut is known to be strongly depressed by inadequate Ca in the soil. Calcium also influences pod-hull thickness, specific weight and time taken for pods to mature and seed dry weight. In groundnut nodule initiation stage is sensitive stage to Fe deficiency. Deficiency of Fe at this stage limits further division of root cortical cells and proliferation of N fixing bacteria in roots is inhibited.

2.2.1 Micronutrients on growth parameters

Foliar application of 20 kg Fe, 2 kg Zn and 2 kg Cu per ha to groundnut in three equal doses sprayed at 20, 40 and 60 days after emergence increased the plant height, chlorophyll content in leaves and fodder yields. Increase in fodder yields were to the tune of 41, 35 and 25 per cent over control with Fe, Zn and Cu application respectively (Singh *et al.*, 1990).

Patel *et al.* (1993) observed two fold increase in groundnut haulm yield and three to four fold increase in leaf chlorophyll and active iron content with foliar spray of ferrous sulphate (1 %) + citric acid (0.1 %) or ferric citrate (2 %).

Rao and Rao (1994) observed three to four fold reduction in photosynthetic rate and chlorophyll content in groundnut, black gram and green gram due to Fe deficiency.

Hugar and Kurdikeri (2000a) in soybean reported that combined application method of seed treatment and foliar spray of Zn and Mo recorded higher plant height, number of leaves, plant diameter, number of pods per plant and number of seed per pod over either seed treatment or foliar spray alone.

2.2.2 Micronutrients on yield parameters

Hartzook (1982) recorded greater groundnut pod and seed yield, number of pods per plant with soil application of 10-15 kg Fe per ha.

Groundnut Cv. Deccan -1 recorded maximum pod yield with the application of 15 kg S + 10 kg Zn per ha. (Talukder and Islam, 1982).

Chatterjee *et al.* (1985) found that application of ZnSO₄ equivalent to 20 kg S per ha to mustard recorded 26 per cent increase in yield over control.

Singh *et al.* (1990) reported 43, 40 and 11 per cent increase in groundnut pod yield over control with the foliar spray of 20 kg Fe, 2 kg Zn and 2 kg Cu per ha respectively.

Krishnappa *et al.* (1992) reported that application of Fe and Zn to groundnut increased protein concentration by 31 and 34 per cent respectively over control.

Ramamoorthy and Sudarsan (1992) stated that application of Zn to groundnut increased pod yield, shelling percentage, seed protein and oil percentages.

Krishnappa (1993) stated that application of NPK + 5 ppm iron to groundnut gave higher pod yield over other treatments.

Foliar sprays of 1 per cent ferrous sulphate + 0.1 per cent citric acid or 2 per cent ferric citrate to groundnut resulted in two fold increase in pod yield (Patel *et al.*, 1993).

Gopalagowda *et al.* (1995) inferred that, zinc application significantly enhanced the pod yield from 3990 kg with control to 4880 kg per ha with Zn 11.2 kg per ha soil application. The pattern of improvement of kernel yield was similar to that of pod yield. Maximum kernel yield (3710 kg/ha) was recorded at Zn 11.2 kg per ha level as compared to control (2930 kg/ha). This accounted for extra yield of 780 kg per ha. In case of seed dressing, the kernel yield of 3450 kg per ha was obtained with seed dressing of Zn @ 2 g per kg compared to that of control (2930 kg/ha) resulting in extra yield of 550 kg per ha.

Foliar spray of 0.4 per cent ZnSO_4 + MnSO_4 at 50 days after sowing to groundnut has increased shelling percentage with reduction in the percentage of rotten, empty or immature pods (El Din and Ali, 1996).

Geetha *et al.* (1996) found that, seed dressing with 8 g of Zn + Mo per kg of groundnut, recorded 3548 kg per ha pod yield as against 2312 kg per ha recorded with control.

Moussa *et al.* (1996) recorded highest groundnut seed yield of 805 kg per feddan with the application of Zn + Fe (1 feddan = 0.42 ha).

Singh and Vidya Chaudhari (1996) reported that use of zincated super phosphate in groundnut resulted in increased nodule weight, pod number and pod yield over use of ordinary super phosphate.

Hugar and Kurdikeri (2000b) reported highest soybean seed yield (24.34 q/ha) and oil content (20.2 %) due to application of zinc and molybdenum by seed treatment + foliar spray application method. While, Halepyati (2001b) reported that application of zinc (12 kg/ha) recorded 13.1 q per ha groundnut pod yield over no application (11.3 q/ha).

2.2.3 Micronutrients on seed quality parameters

Significant increase in test weight of mustard seeds was obtained with application of zinc sulphate equivalent to 20 kg S per ha (Chatterjee *et al.*, 1985).

Ramamoorthy and Sudarsan (1992) observed that application of Zn to groundnut increased the 100 seed weight when these seeds were stored, the loss of viability was lower compared to the plants which had not received Zn treatment.

Geetha *et al.* (1996) stated that seed dressing of 4 g per kg Zn + Mo to groundnut though it did not influence the germination, the main root length, number of rootlets per seedling and shoot length were highest.

Application of Fe + Zn + Cu to groundnut recorded highest shoot dry matter yield (Moussa *et al.*, 1996). Whereas, combined application of Zinc and molybdenum to soybean by seed treatment + foliar spray method recorded highest test weight (14.41 g) and less electrical conductivity of seed leachate (0.76 dSm⁻¹).

2.3 ORGANIC MANURES AND ALLIED NUTRIENTS

In fluctuating rainfall situations organic manures help to bring the stability in crop yields by alleviating drought effects. These also alter

physio-chemical properties of soil, increase soil fertility status by increasing the amount of organic carbon, available N, P, K and S in the subsequent seasons. Groundnut needs good aeration in the rooting and pegging zones. The inadequate aeration results in abnormal respiration, which in turn inhibits root growth and retards metabolic functions. Further, the plant becomes chlorotic due to deficiency of nitrogen caused by inability of roots to take up nitrogen and ineffectiveness of nitrogen fixing bacteria in oxygen deficient environment. Use of organic manures reduces soil crusting, increases water holding capacity, hydraulic conductivity and infiltration rate besides reducing environmental pollution.

2.3.1 Organic manures and allied nutrients on growth parameters

Jain and Tiwari (1995) noticed increase in nodulation in soybean crop with application of FYM and sugar press mud. In another study, with soybean Jain *et al.* (1995) noticed that application of FYM and sugar press mud each at 4 t per ha significantly enhanced the plant height (76.23 cm), which was 43 per cent more over control. Application of FYM @ 5 t per ha and sugar press mud @ 3 t per ha significantly enhanced the number of leaves per plant (24) which was 75 per cent higher over control.

Application of FYM 12.5 t per ha to groundnut increased number of nodules per plant and nodule dry weight compared to application of NPK fertilizer alone (Balasubramaniyan and Palaniappan, 1996).

Devidayal and Agarwal (1998) recorded an average of 9 per cent increase in dry weight per plant with application of FYM 10 t per ha and

10.5 per cent increase with application of vermicompost 10 t per ha over no organic manure to sunflower crop.

In a field experiment application of 1000 kg per ha copper ore tailing significantly increased the concentration and uptake of Cu, Zn, Fe and Mn in haulm of groundnut. The highest uptake of Cu (56.12 g/ha), Zn (93.38 g/ha), Fe (1767 g/ha) and Mn (197.67 g/ha) in haulm of groundnut was obtained with 1000 kg per ha copper ore tailing application (Gundlur and Manjunathaiah, 2000).

2.3.2 Organic manures and allied nutrients on yield parameters

Ramachandran and Natarajan (1986) in a measure to maximize the yields of *rabi* groundnut recorded 33 per cent increase in pod yield with application of 6.25 t per ha FYM over no FYM treatment. They also observed 34 per cent increase in yield of bunch groundnut over control with application of 200 kg per ha gypsum as basal dose and again 200 kg per ha gypsum at 2nd weeding and hoeing stage.

Maximum number of filled pods per plant, shelling percentage and pod yield were recorded when groundnut crop was fertilized with 80 N + 35 P + 250 kg gypsum as basal + 250 kg gypsum per ha at 30 DAS (Chitkala Devi *et al.*, 1987).

Narasareddy *et al.* (1987) concluded that, application of 30 N + 10 P + 25 K + 500 kg gypsum per ha at 30 DAS recorded significantly higher pod yield and other yield attributes. The supply of calcium and sulphur in the form of gypsum along with NPK on an average increased pod yield by 10.6 per cent over NPK application alone.

Sharma (1992) in field studies to find out nutrient requirements for soybean and safflower revealed that the conjunctive use of 6 t per ha of FYM along with half of the recommended level of N fertilizer enhanced the crop yields by 20.5 and 49.5 per cent respectively under rainfed conditions, as compared with the equivalent level of nutrients applied through fertilizer source alone.

Chittapur *et al.* (1993) reported that application of gypsum + FYM to groundnut resulted in higher kernel oil (44.38 %) and this was on par with application of gypsum + sand + FYM (43.55 %) which recorded significantly highest pod (33.62 q/ha) and oil yields (11.34 q/ha) owing to higher shelling (77.17 %) and pod weight (16.35 g/plant).

Sanyal *et al.* (1993) recorded maximum yield of groundnut pod in the treatment receiving 75 per cent RDF (RDF level is 20 : 60 : 40 : kg NPK/ha) along with 10 t FYM per ha. The yield recorded by this treatment was significantly more than the yield recorded by treatment which received 100 per cent RDF and also with the treatment which received 150 per cent RDF. This clearly indicated that for sustenance of productivity it is important to use 75 per cent RDF + 10 t FYM per ha.

Jain *et al.* (1995) recorded 59 per cent increase in soybean seed yield over control with the application of FYM @ 5 t per ha and sugar press mud @ 5 t per ha.

Significant increase in soybean seed yield, oil and protein content were recorded with application of 10 t per ha organic matter (1:1 ratio of FYM + paddy straw). The seed yield recorded with 10 t per ha organic

matter application was 2690 kg per ha while, with 5 t per ha and control it was 2300 and 2070 kg per ha respectively (Ramamurthy and Shivashankar, 1995).

Organic amendments with arecanut waste to groundnut recorded highest protein content (17.81 %), pod yield (19.00 g/pot) and oil yield (4.9 g/pot). Biogas slurry applied treatment recorded the highest oil content (48.4 %) (Subbaraj and Ramaswami, 1995).

Application of vermicompost @ 10 t per ha to sunflower produced significantly more number of seeds per head which was on an average 18.95 per cent higher than no organic manure (Devidayal and Agarwal, 1998).

Mallikarjuna *et al.* (1998) found that application of 50 per cent recommended dose of phosphorus through single super phosphate and 50 per cent through enriched FYM to sunflower gave significantly higher seed yield (2286 kg/ha) than the recommended practice of single super phosphate alone (1646 kg/ha). The higher seed yield was due to significantly higher test weight (4.69 g), number of filled seeds (860), per cent seed filling (88.68) and threshing per cent (71.45).

Gundlur and Manjunathaiah (2000) recorded significantly highest (24.03 q/ha) groundnut pod yield with 1000 kg per ha copper ore tailing application.

Malligawad *et.al.* (2000) in a field experiment on groundnut revealed that application of RDF (25 kg N, 75 kg P₂O₅ and 25 kg K₂O/ha) + vermicompost (1 t/ha) recorded significantly higher dry pod yield

(3389 kg/ha) compared to FYM (4 t/ha) + 50 per cent RDF (12.5 kg N, 30 kg P₂O₅ and 12.5 kg K₂O/ ha) application (3232 kg/ha), RDF alone (3148 kg/ha) and no application (2742 kg/ha).

Halepyati (2001a) recorded highest (20.80 q/ha) groundnut pod yield and net returns (Rs. 16,038/ha) by application FYM (6 t/ha) + RDF. While, Nagaraj *et.al.* (2001) in a fertilizer management practice involving the application of recommended dose of fertilizer (RDF) (25 kg N, 32.7 kg P and 20.72 kg K/ha) + FYM (7.5 t/ha) + vermicompost (1 t/ha) + micronutrients (4.5 kg/ha Fe)+ 5 kg/ha Zn) + 0.25 kg/ha Mo) produced significantly higher dry pod yield of groundnut (1796 kg/ha) compared to fertilizer management practice involving RDF only (1475 kg/ha).

2.3.3 Organic manures and allied nutrients on seed quality parameters

Chitkala Devi *et al.* (1987) recorded the higher groundnut 100 kernel weight with application of 80 N + 35 P + 250 kg gypsum as basal + 250 kg gypsum per ha at 30 DAS.

Narasareddy *et al.* (1987) in groundnut with the application of 30 N + 10 P + 25 K + 500 gypsum kg per ha at 30 DAS recorded maximum 100 pod weight and 100 kernel weight.

Jain *et al.* (1995) recorded 83 per cent increase in soybean 100 seed weight due to application of FYM @ 5 t per ha and sugar press mud @ 5 t per ha over control.

2.4 BIO-FERTILIZERS

Poor N₂ fixation is one of the reasons for low productivity in groundnut. The prime objective of inoculation of legumes is to ensure sufficient number of *rhizobia* in the root zone for effective nodulation. Groundnut and soybean, leguminous oilseeds too need starter doses of N through fertilizers to be effective as N fixers. Most of the soil phosphorus is in unavailable form while, the requirement of oilseed crops is high. 'P' solubilizing bacteria help to convert non-available P in to available P. Bio-fertilizers can be also called as soil energizers, because of their immense use.

2.4.1 Bio-fertilizers on growth parameters

Raverkar and Knode (1988) noticed favourable influence on number of nodules, nodule dry weight, amount of dry matter production and N content of peanut plants due to rhizobium inoculation.

Katiyar and Pant (1993) noticed that seed treatment of soybean with *rhizobium* inoculation with 10 per cent gum arabic gave highest nodule mass (25.5 mg/plant), plant dry weight (4.2 mg/plant) and plant nitrogen (2.2 %) whereas, number of nodules (5.8) per plant were highest when inoculant granules were applied in soil.

Shasidhara *et al.* (1994) recorded highest nodule number and dry weight per plant of groundnut due to inoculation with *rhizobium* + *G macrocarpum* and with application of 50 per cent recommended NPK rates.

Manjaiah *et al.* (1996) in a field trial, gave 50 kg P_2O_5 per ha as single super phosphate or the same rate as mussoorie rock phosphate with or without seed treatment with phosphate solubilizing bacteria (*Pseudomonas striata*) and fungus (*Aspergillus awamori*) and/or 10 t organic amendments per ha to groundnut Cv. Dh-3-30. They found that nodule number and weight per plant, N and dry matter accumulation were higher with a combination of organic amendments, 'P'-solubilizing bacteria and fungi and mussoorie rock phosphate.

Sarkar and Tripathi (1996) noticed that application of 30 kg N + 60 kg P + *Rhizobium* as basal dose to soybean recorded highest total N uptake, available soil N at harvest, N supplied + native soil N, N balance and N fixed compared to other treatments.

2.4.2 Bio-fertilizers on yield parameters

Graham and Donawa (1982) obtained a air dried groundnut pod yields of 527 to 929 kg per ha by inoculation with different *rhizobium* strains while uninoculated plot recorded 511 kg per ha pod yield.

Joshi *et al.* (1989) recorded a seed yield of 1.27 t per ha in groundnut and 0.97 t per ha in soybean with *rhizobium* seed inoculation compared to 1.11 and 0.88 t per ha respective yield recorded without seed inoculation.

Khune *et al.* (1989) recorded 36.5 per cent increase in groundnut yields due to seed inoculation with *rhizobium*.

Thorge *et al.* (1989) recorded an average groundnut seed yield of 1.24 t per ha with seed inoculation of *rhizobium* compared to 1.14 t per

ha without inoculation. While, seed inoculation with rhizobium gave an average soybean yield of 0.97 t per ha compared to 0.88 t per ha without inoculation.

Tripathi *et al.* (1994) in an experiment to find out the efficacy of combined effect of *rhizobium* and nitrogen on legume crops noticed that in soybean inoculation recorded 22.5 per cent more yield and Rs. 1370 per ha more net profit over 20 kg N per ha. In other crops including groundnut the effect of inoculants was at par with that of 20 kg N per ha hence, this 20 kg nitrogen fertilizer can be saved.

Sarkar and Tripathi (1996) recorded a highest soybean seed yield of 2295 kg per ha with 30 kg N + 60 kg P + *Rhizobium* basal application as against 2170 kg per ha yield recorded with 30 kg N + 60 kg P only.

Awatiger *et al.* (1997) found from the data collected with 240 farmers in Belgaum and Dharwad districts on use of *rhizobium* bio-fertilizer to groundnut and soybean that, net incomes of farmers utilizing *rhizobium* bio-fertilizers were Rs. 6144 and Rs. 4420 in irrigated groundnuts and soybeans and Rs. 2246 and Rs. 1904 in rainfed groundnuts and soybeans respectively. Compared with no biofertilizer use, incomes with *rhizobium* utilization were 45 and 44 per cent higher in irrigated groundnuts and soybeans and 31 and 29 per cent higher in rainfed groundnuts and soybeans respectively.

Bhuiyan *et al.* (1997) recorded a groundnut yield of 1.26 t per ha with seed inoculation of *rhizobium* as against 1.10 t per ha yield recorded by control treatment.

Patel and Thakur (1997) in groundnut recorded 8.23 per cent yield increase with *rhizobium* inoculation over un inoculated control.

Irrespective of forms and levels of phosphorus supplied to sunflower, biophos and *P strita* inoculated plots recorded significantly maximum (13.62 and 12.70 q/ha respectively) seed yield over uninoculated control (10.73 q/ha) (Gadagi and Alagawadi, 1998).

Marimuthu and Wahab (1998) found that application of 100 per cent recommended dose of inorganic P_2O_5 as enriched FYM (80 kg/ha) to soybean along with seed and soil inoculation of phosphobacteria significantly influenced the nutrient uptake and recorded higher protein and oil content.

2.4.3 Bio-fertilizers on seed quality parameters

Joshi *et al.* (1989) noticed increase in 100 seed weight of groundnut and soybean due to seed inoculation with *rhizobium*

Gadagi and Alagawadi (1998) in sunflower recorded a mean head weight of 79.41 and 73.85 g per plant with biophos and *P strita* inoculation as against 59.83 g per plant recorded with un inoculated control irrespective of super phosphate levels. The 1000 seed weight recorded by un inoculated control was 33.21 g whereas, biophos and *P strita* inoculation recorded 33.95 and 33.53 g 1000 seed weight respectively. Irrespective of P levels when rock phosphate was used as P source un inoculated control recorded 53.68 g per plant head weight and 30.79 g 1000 seed weight. While biophos and *P strita* inoculations

recorded 69.16 and 63.55 g per plant head weights and 32.70 and 32.34 g 1000 seed weights respectively.

2.5 PLANTING METHODS

Agronomic management practices is one of the factor which decides the productivity of groundnut. Pod number per plant is determined primarily by plant density and is directly proportional to area per plant. At a constant density and sowing patterns the pod number is determined by partitioning factor and pod growth rate (Duncan, 1981).

2.5.1 Planting methods on growth parameters

Rasve *et al.* (1983) recorded significantly more effective gynophores per plant (15.62), haulm yield (27.55 q/ha) by groundnut grown on ridges and furrows when compared to flat bed method of sowing which recorded 6.91 effective gynophores per plant and 25.51 q per ha haulm yield.

Nikam *et al.* (1984a and 1984b) found in safflower that, the growth parameters like number of primary and secondary branches were more in paired and skip row planting than in normal planting. The same trend was observed for plant height and spread.

Khan and Agarwal (1985) recorded significantly more mustard plant height, number of branches and dry matter production when ridge and furrow method of planting was adopted compared to flat bed method of cultivation.

Hadvani *et al.* (1993) recorded maximum groundnut plant height, leaf area index, dry matter per plant, root nodules per plant, haulm yield

under ridge- furrow method of planting, followed by broad bed-furrow and flat bed sowing with significant differences among them.

Rathore and Pal (1995) noticed that the phenology of soybean and peanut were altered due to water logging in the root zone. The date of flowering, pod and seed development were delayed in wide bed (4.8 m) as compared to medium (2.4 m) and narrow (1.6 m) beds because of higher water tables in wide beds which restricted the growth of the plants. Plant height, number of leaves, nodes, dry weight of stem, leaves and pods were highest in narrow bed (1.6 m) sowing practice.

Patra *et al.* (1996b and 1996c) found that planting groundnut in broad bed furrow (BBF) method significantly increased plant height, leaf area index, dry matter over planting in flat bed (FB) with or without earthing up. The net assimilation rate was similar for BBF and FB with earthing up method.

Jayaramaiah and Thimmegowda (1997) in groundnut noticed significant differences in growth parameters due to sowing methods. Higher plant height (48.81 cm) was obtained with ridges and furrow method followed by dibbling (46.75 cm) and furrow method (45.73 cm) at harvest. The number of branches were also significantly higher with ridges and furrow method (6.66). This method also recorded higher haulm yield (3950 kg/ha) and dry matter accumulation per plant (38.07 g).

2.5.2 Planting methods on yield parameters

Yadav and Amar Singh (1973) concluded that for castor skip row planting is not beneficial on yield or in terms of economic returns. They

found that sowing castor in rows 60 cm apart (normal planting) produced 22.5 per cent more yield than two lines of castor sown at 30 cm apart with a skip of 60 cm. Even the other row skipping methods followed were not beneficial to normal planting.

Wright and Porter (1982) concluded that for virginia types of groundnut under row ripping method had no advantage on yield or it had an adverse effect on yield.

Rasve *et al.* (1983) found that ridges and furrows method of groundnut sowing recorded significantly highest (70.28 %) shelling, (23.59 %) protein and (49.63 %) oil content as against (69.71, 23.44 and 49.55 %) shelling, protein and oil content respectively recorded by flat bed method of cultivation.

Paired and skip row planting methods in safflower resulted in higher number of capitula per plant and yield over normal planting method (Nikam *et al.*, 1984a and 1984b).

Khan and Agarwal (1985) recorded significantly more mustard yield with ridge and furrow method of planting over flat bed method of planting.

Thorate and Patil (1987) reported that under lateritic soil conditions of Konkan the groundnut crop could be sown either at a spacing of 30 x 15 cm² or 45 x 15 cm². However from economic point of view 45 x 15 cm² spacing would be the best as it will save seed as well as labour cost.

Radder *et al.* (1989) evaluated the effect of skipping one row after every two or three rows using 100 or 75 per cent of the recommended seed

rate and fertilizer dose on the performance of rainfed *rabi* crops. In sorghum, skipping one row after three or two rows produced seed yield on par with solid planting in all the three years of experimentation. On an average 18.9 per cent increase in seed yield was recorded with planting three rows and skipping one row compared to solid planting. In safflower, skipping one row after every two rows has increased the seed yield significantly in one year out of three years, with an increase in yield of 21.6 per cent compared to solid planting. In chickpea, skipping one row after every three rows has increased the seed yield significantly in one year out of three years with an increase of 27.8 per cent compared to solid planting. During these other two years border method of planting produced seed yield on par with solid planting in safflower and chickpea. They further summarised that though the rainfall received varied from 28 to 202 mm after sowing of *rabi* crops in these three years, the border/skip row method of planting gave the seed yield on par in two years and significantly more in one year than solid planting. With this method of planting it is possible to reduce the seed rate and fertilizer use to the extent of 25 per cent without reducing the yield.

Jindal *et al.* (1990) conducted an experiment at two locations to determine the best combination of rows sown for spring groundnut to obtain maximum breeder seed production. Sowing in paired rows leaving one blank row in between was found to be the best at both the locations as well as for pooled data.

Sankarareddy *et al.* (1991) recorded 28.1 and 24.6 per cent increase in groundnut pod yield with broad bed and furrow (BBF) and bed and

furrow (BF) method of planting respectively over conventional flat bed (FB) method. An additional net profit of Rs. 1916 per ha and Rs. 1636 per ha were obtained with BBF and BF methods over FB method.

Desai and Kenjale (1992) noticed in groundnut that, though the number of developed pods per plant were more with broad bed and furrow method of planting, the pod yield was significantly more with ridges and furrows (27.53 q/ha) method, than borders (23.08 q/ha) method and broad bed furrow (21.68 q/ha) method.

Jadhao *et al.* (1992) on the basis of three years pooled data found that, spacing of 45 x 10, 30 x 10 and 30 x 15 cm were optimum for groundnut varieties UF-70103 and SB-XI to get higher yield during summer season.

Highest number of pods per plant, shelling percentage and ultimately pod yield were recorded under ridge-furrow sowing method due to more soil porosity resulting in greater peg penetration and better development of pods (Hadvani *et al.*, 1993.).

Chouhan and Ishwar Singh (1994) found that seed yield of castor increased significantly by 10.7 and 12.7 per cent under irrigated conditions and 9.7 and 9.1 per cent under rainfed conditions when grown in rows at 90 and 60/120 cm pairing respectively, compared to skipped planting method. Under skipped planting method, three continuous rows were planted at lesser spacing (60 cm) due to which more below ground as well as above ground competition was exerted on the middle rows compared to the outer rows which resulted in overall reduction in yield.

Rathore and Pal (1995) found that seed yield of soybean and pod yield of peanut were significantly high in 1.6 m wide bed whereas, other two width of beds (2.4 and 4.8 m) gave statistically similar yields.

Sidhu *et al.* (1995) emphasized the superiority of ridge sowing of sunflower over flat sowing with regard to yield and yield attributes. Similarly higher seed and oil yields were recorded in ridge planted sunflower than those planted in furrow or flat patterns, the order being ridge > flat > furrow. However, the magnitude of yield difference between ridge planted and flat planted sunflower was not sufficiently high to compensate for the additional labour and materials required for making ridges and based on these planting in flat is recommended by Esechie *et al.* (1996)

Out of the different land configuration methods like broad bed and furrow (BBF), ridge and furrow (RF) and check basin (CB) methods followed for soybean, BBF method produced higher seed yield (1350 kg/ha) in summer and (1284 kg/ha) in *kharif*. The protein and oil contents were also maximum with this method of planting (Jayapaul *et al.*, 1996).

Patra *et al.* (1996a) found that planting groundnut in flat bed with earthing up (FBE) at 25 days after sowing gave better response than planting in flat bed without earthing up (FB) and broad bed and furrow method (BBF). Increase in pod and oil yield by 7.6 and 7.1 per cent respectively were recorded by planting in FBE over planting in the FB method.

Patra *et al.* (1996b) recorded higher number of pods per plant, pod, kernel, oil and haulm yields of groundnut with broad bed furrow (BBF) method of planting. Planting in BBF method increased pod, kernel, oil and haulm yields by 14.1, 13.8, 13.9 and 8.1 per cent respectively over flat bed without earthing up method while, the corresponding figures for flat bed with earthing up were 7.6, 7.5, 7.0 and 3.9 per cent respectively.

Patra *et al.* (1996c) in groundnut noticed that planting in broad bed furrow (BBF) method increased 14.1 and 13.9 per cent pod and oil yields respectively, and planting in flat bed with earthing up increased 7.6 and 7.0 per cent pod and oil yields respectively over planting in flat bed without earthing up.

Jayaramaiah and Thimmegowda (1997) recorded significantly higher groundnut pod yield with ridges and furrow method of planting (3748 kg/ha) and it was lowest with furrow method (3338 kg/ha). There was an increase of 12.28 per cent pod yield with ridges and furrow method over furrow method. Pod to gynophores ratio was 0.73 in ridges and furrow method and 0.60 in furrow method and 0.58 in dibbling. Compared to other methods ridges and furrow method recoded higher number of filled pods per plant (27.80), oil yield (1332 kg/ha) and kernel yield (2698 kg/ha).

No significant difference in yield and yield attributes of sugarcane were noticed between normal method of planting and paired row method of planting (Roodgi *et.al.*, 2001).

2.5.3 Planting methods on seed quality parameters

Ridges and furrows method of groundnut cultivation recorded significantly higher 100 kernel weight (26.78 g) compared to 25.79 g with flat bed method of cultivation (Rasve *et al.*, 1983).

Nikam *et al.* (1984a and 1984b) recorded significantly more 1000 seed weight of safflower when it was raised by following paired or skip row planting method compared to normal planting.

Sankarareddy *et al.* (1991) recorded significantly higher 100 pod weight in groundnut with broad bed furrow and bed furrow methods of planting over flat bed method.

In groundnut maximum 100 kernel weight (39.1 g) was recorded with ridge and furrow sowing method compared to broad bed-furrow and flat bed sowing methods and these recorded 37.2 and 35.9 g kernel weights respectively (Hadvani *et al.*, 1993).

Patra *et al.* (1996b and 1996c) recorded higher 100 kernel weight of groundnut when raised in broad bed furrow method of planting compared to flat bed with or without earthing up methods.

Material and Methods

III. MATERIAL AND METHODS

The field experiments were conducted at the Main Agricultural Research Station, Dharwad during *kharif* 1999 and *kharif* 2000 seasons to study the integrated nutrient management and planting methods on seed yield and quality in groundnut (*Arachis hypogaea* Gaertn.). Further, after the crop harvest the laboratory studies were made during both the years in the laboratory of Seed Science and Technology Department, College of Agriculture, Dharwad. The details of the materials used and methodology followed during the course of these investigations are described in this chapter.

3.1 GENERAL DESCRIPTION

3.1.1 Experimental site

The field experiments were conducted in plot number 148 of 'F' block of the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* season of 1999 and 2000.

3.1.2 Location

Geographically, the station is situated in the transitional tract (Zone 8) of Karnataka State at 15° 26' North latitude and 75° 07' East longitude with an altitude of 678 meters above mean sea level.

3.1.3 Soil type of experimental site

The soil of the experimental plot was deep black clayey loam, porous and well drained in nature. In general, experimental site was of moderate fertility status with neutral pH. The physical and chemical properties of

the soil were analyzed before and after the experimentation by following standard procedures and presented in Table 3.01.

3.1.4 Weather data during the crop period

The meteorological data from 29th standard week (16th July to 22nd July) to 47th standard week (19th November to 25th November) for the year 1999 and from 27th standard week (2nd July to 8th July) to 45th standard week (5th November to 11th November) for the year 2000 recorded at meteorological observatory of the Main Agricultural Research Station, Dharwad are presented in Table 3.02.

During crop growth period in 1999, a total of 301.4 mm rain fall was received with 21 rainy days. Just before sowing and up to 30 days of crop period a total of 121.2 mm rainfall was received with eight rainy days. Their after one week dry spell was observed. This was followed by two rainy days with 9.4 mm rainfall. From 45th to 65th day of crop period three weeks dry spell was noticed. Then up to the crop harvest 170.8 mm rains were received with nine rainy days. During 2000, a total of 394.8 mm rainfall was received with 26 rainy days. Just before sowing and up to 12 days of crop period a rainfall of 124.0 mm was received in six rainy days. Their after two weeks dry spell was recorded. Then up to 54 days crop period 59.3 mm rains were received with six rainy days. This was followed by a week dry spell with hardly 0.7 mm rainfall. From 62nd day of crop period up to the harvest 210.8 mm rains were received in 12 rainy days.

The mean maximum temperature ranged between 24.2^oC (28th and 29th standard week) to 30.6^oC (39th standard week) during 1999, while,

Table 3.01. Physical and chemical properties of the soils of the experimental site

Particulars	Before experimentation	After experimentation
	Values	Values
A. Physical properties		
Clay (%)	32.70	32.70
Silt (%)	9.50	9.50
Fine sand (%)	31.24	31.24
Coarse sand (%)	26.56	26.56
B. Chemical properties		
Total N (kg/ha)	265.0	303.0
Available P ₂ O ₅ (kg/ha)	10.8	12.4
Available K ₂ O (kg/ha)	245.0	286.0
pH	6.7	6.8
Available Fe (ppm)	6.0	6.8
Available Zn (ppm)	0.6	0.7
Available Cu (ppm)	1.2	1.4
Available S (ppm)	25	28
Available Ca (m eq/100 g) (Exchangeable)	25	29

Table 3.02. Meteorological data during the crop growth period during *kharif* 1999 and 2000

Standard week	Dates	Rain fall (mm)		Number of Rainy Days		Mean Temperature (°C)				Mean Relative Humidity (%)	
						Maximum		Minimum			
		1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
27	2 nd July to 8 th July	--	1.6	--	0	--	26.9	--	20.7	--	86
28	9 th July to 15 th July	--	118.5	--	6	--	23.1	--	20.7	--	92
29	16 th July to 22 nd July	95.4	3.9	6	0	24.2	24.7	20.7	20.7	97	85
30	23 rd July to 29 th July	12.5	0.0	2	0	24.2	31.0	20.7	20.0	93	67
31	30 th July to 5 ^h August	7.2	0.0	0	0	25.4	30.9	20.7	20.1	90	69
32	6 th August to 12 ^h August	4.5	35.3	0	3	25.2	27.0	20.8	19.5	91	85
33	13 th August to 19 th August	1.6	1.8	0	0	28.4	27.7	20.4	20.3	82	74
34	20 th to August 26 th August	0.0	10.3	0	1	28.4	26.2	20.1	20.9	84	85
35	27 th August to 2 nd September	9.4	11.9	2	2	27.3	25.2	20.2	20.3	83	85
36	3 rd September to 9 th September	0.0	0.7	0	0	26.0	27.9	20.0	19.6	90	78
37	10 th September to 16 th September	0.0	32.0	0	2	27.1	29.9	20.1	19.9	87	72
38	17 th September to 23 rd September	0.0	45.3	0	3	29.3	29.3	18.9	21.0	77	77
39	24 th September to 30 th September	8.8	45.2	1	2	30.6	30.2	20.9	21.2	76	74
40	1 st October to 7 th October	31.0	10.4	5	1	28.3	29.7	20.6	20.5	83	75
41	8 th October to 14 th October	39.0	36.9	2	3	28.8	28.2	21.1	20.6	84	79
42	15 th October to 21 st October	62.2	22.0	2	2	29.1	29.4	18.8	20.5	80	80
43	22 nd October to 28 th October	28.9	19.0	1	1	29.7	29.8	19.2	20.0	73	78
44	29 th October to 4 th November	0.9	0.0	0	0	28.3	30.9	17.8	18.3	70	69
45	5 th November to 11 th November	0.0	0.0	0	0	30.4	30.3	18.4	18.6	67	69
46	12 th November to 18 th November	0.0	--	0	--	29.3	--	13.6	--	47	--
47	19 th November to 25 th November	0.0	--	0	--	28.6	--	15.0	--	58	--
Total		301.4	394.8	21	26						

mean minimum temperature ranged between 15.0°C (47th standard week) to 21.1°C (41st standard week). During 2000, mean maximum temperature ranged from 23.1°C (28th standard week) to 31.0°C (30th standard week) whereas, mean minimum temperature ranged from 18.3°C (44th standard week) to 21.2°C (39th standard week).

The mean relative humidity ranged between 47 per cent (46th standard week) to 97 per cent (29th standard week) during 1999 while, it ranged from 67 per cent (30th standard week) to 92 per cent (28th standard week) during 2000.

3.1.5 Previous crop in the experimental site

The sorghum crop was raised on the experiment site during *rabi* 1998 and *rabi* 1999 seasons.

3.1.6 Seed source

The required truthful labeled seed material of JL-24, TAG-24 and R-8808 varieties were procured from the Main Agricultural Research Station, Dharwad which were produced during 1998 *kharif* season. The seed material was having 100 per cent physical purity, 95 per cent germination with 9 per cent moisture content.

3.2 EXPERIMENTAL DETAILS

3.2.1 EXPERIMENT - I : EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SEED YIELD AND QUALITY OF GROUNDNUT

The experiment consisted of 16 treatments comprising of various organic, inorganic and bio-fertilizers. The details of the treatments are as under.

T₁ - 25:50:25 NPK kg per ha (RDF)

T₂ - T₁ + FYM (5 t/ha)

T₃ - T₁ + Vermicompost (2.5 t/ha)

T₄ - T₁ + Copper ore tailing (12.5 q/ha)

T₅ - T₁ + Gypsum (5 q/ha)

T₆ - T₁ + Bio-fertilizer (*Rhizobium* + 'P' solubilizer each @ 1 kg/ha)

T₇ - T₂ + Vermicompost (2.5 t/ha)

T₈ - T₂ + Copper ore tailing (12.5 q/ha)

T₉ - T₂ + Gypsum (5 q/ha)

T₁₀ - T₂ + Bio-fertilizer (*Rhizobium* + 'P' solubilizer each @ 1kg/ha)

T₁₁ - T₃ + Copper ore tailing (12.5 q/ha)

T₁₂ - T₃ + Gypsum (5 q/ha)

T₁₃ - T₃ + Bio-fertilizer (*Rhizobium* + 'P' solubilizer each @ 1kg/ha)

T₁₄ - T₄ + Gypsum (5 q/ha)

T₁₅ - T₄ + Bio-fertilizer (*Rhizobium* + 'P' solubilizer each @ 1kg/ha)

T₁₆ - T₅ + Bio-fertilizer (*Rhizobium* + 'P' solubilizer each @ 1kg/ha)

3.2.1 Other details of the experiment

The experiment consisted of 16 treatments and was replicated thrice. Total number of plots were 48. The gross plot and net plot sizes of the plots were 2.4 x 5.0 m and 1.8 x 4.8 m respectively. The spacing

provided was 30 x 10 cm. Groundnut Cv. JL-24 was used in this experiment.

3.2.2 Design and layout

The experiment was laid out in randomized block design with three replications. The plan and layout of this experiment is depicted in Figure 3.01.

3.2.2 EXPERIMENT - II : EFFECT OF MICRONUTRIENTS AND METHODS OF APPLICATIONS ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of 28 treatment combinations involving four micronutrients and seven methods of applications. Groundnut Cv. JL-24 was used in this experiment. The details of the treatments are as under.

Factor - I - Micronutrients (C)

C₀ - No micronutrient

C₁ – FeSO₄

C₂ - ZnSO₄

C₃ – FeSO₄ + ZnSO₄

Factor - II - Methods of applications (A)

A₁ – Seed treatment

A₂ – Soil application

A₃ – Foliar spray (at 40 DAS)

A₄ – Seed treatment + soil application

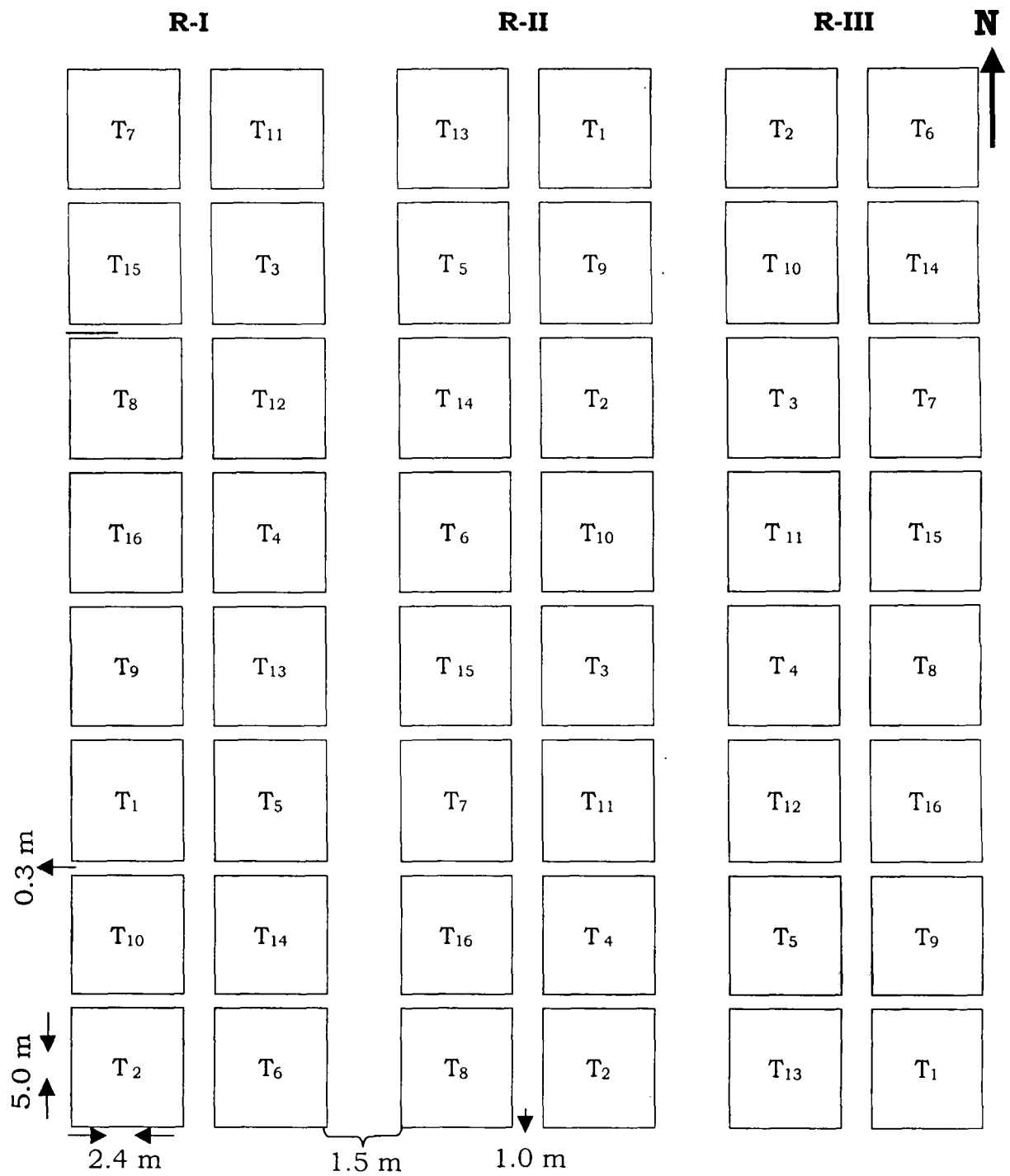


Fig. 3.01 : Plan and Lay out of experiment - I

A₅ – Seed treatment + foliar spray (at 40 DAS)

A₆ – Soil application + foliar spray (at 40 DAS)

A₇ – Seed treatment + soil application + foliar spray (at 40 DAS)

3.2.2.1 Other details of the experiment

The experiment consisted of 28 treatment combinations and was replicated thrice. Total number of plots were 84. The gross plot and net plot sizes of the plots were 2.4 x 5.0 m and 1.8 x 4.8 m respectively. The spacing provided was 30 x 10 cm. Groundnut Cv. JL-24 was used in this experiment. The dosage for seed treatment of iron was 2 g per kg and zinc was 2 g per kg. The dosage for soil application of iron was 25 kg per ha and zinc was 25 kg per ha. While, the dosage for foliar spray of iron was 0.4 per cent and zinc was 0.5 per cent.

3.2.2.2 Design and layout

This experiment was laid out in randomized block design by adopting factorial concept. The plan and layout design of this experiment is depicted in Figure 3.02.

3.2.3 EXPERIMENT - III : EFFECT OF METHODS OF ROW SKIPPING ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of nine treatment combinations involving three methods of row skipping and three groundnut varieties. The treatment details are as under.

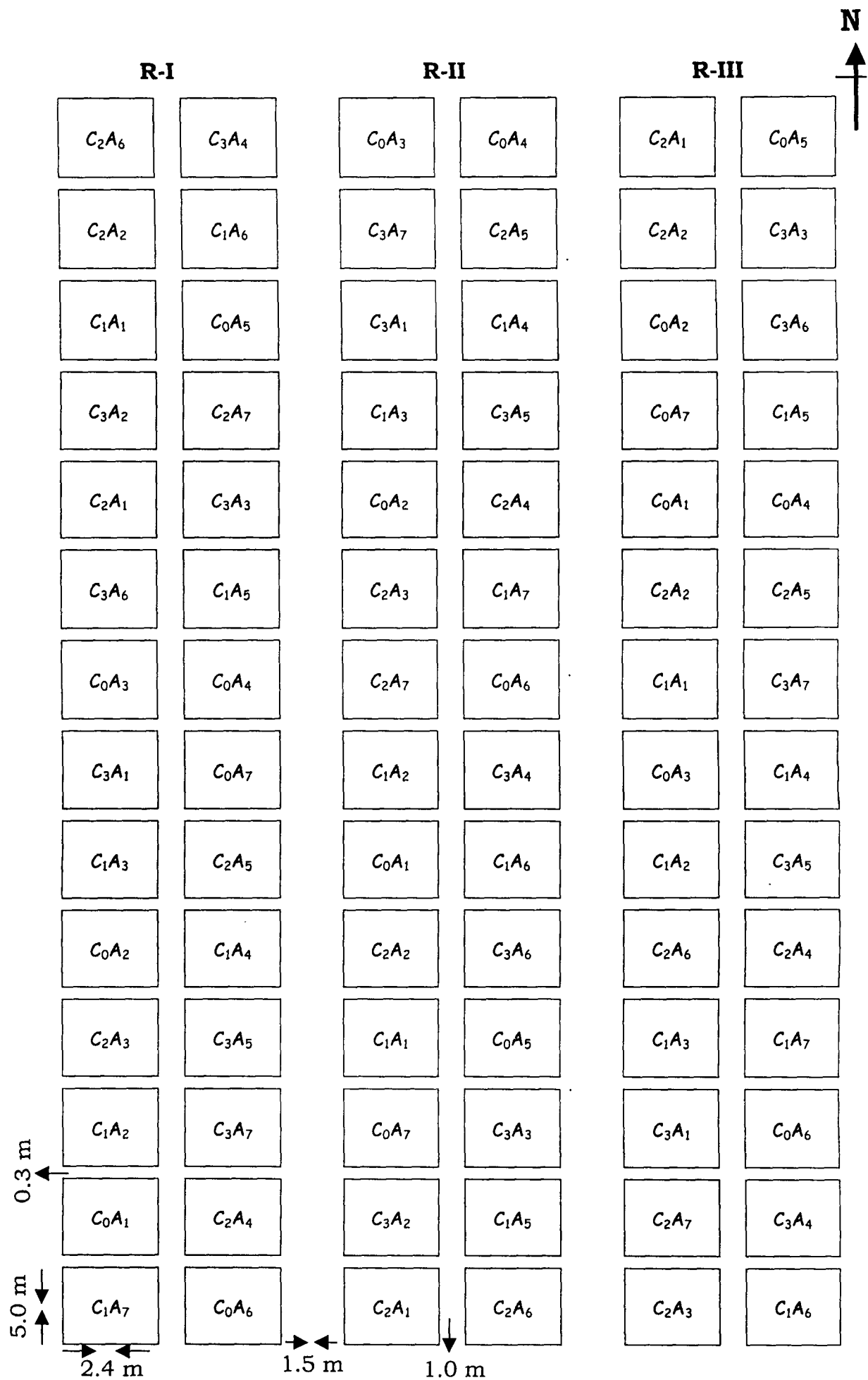


Fig. 3.02 : Plan and Lay out of experiment - II

Factor – I – Methods of row skipping (S)

S₀ - No row skipping

S₁ - One row skipping after every three rows

S₂ - One row skipping after every four rows

Factor - II - Varieties (V)

V₁ - JL-24

V₂ - TAG-24

V₃ - R-8808

3.2.3.1 Other details of the experiment

The experiment consisted of nine treatment combinations and was replicated thrice. Total number of plots were 27. The gross plot and net plot sizes of the plots were 6.0 x 2.0 m and 5.4 x 1.8 m respectively. The spacing provided was 30 x 10 cm.

3.2.3.3 Design and layout

The experiment was laid out in randomized block design by adopting factorial concept. The plan and layout design of this experiment is depicted in Figure 3.03. The sketch of row skipping method followed in this experiment is depicted in Figure 3.04.

3.3 CULTURAL OPERATIONS**3.3.1 Land preparation**

The land was brought to fine tilth after one deep ploughing and three harrowings. The plots were leveled and laid out well before sowing.

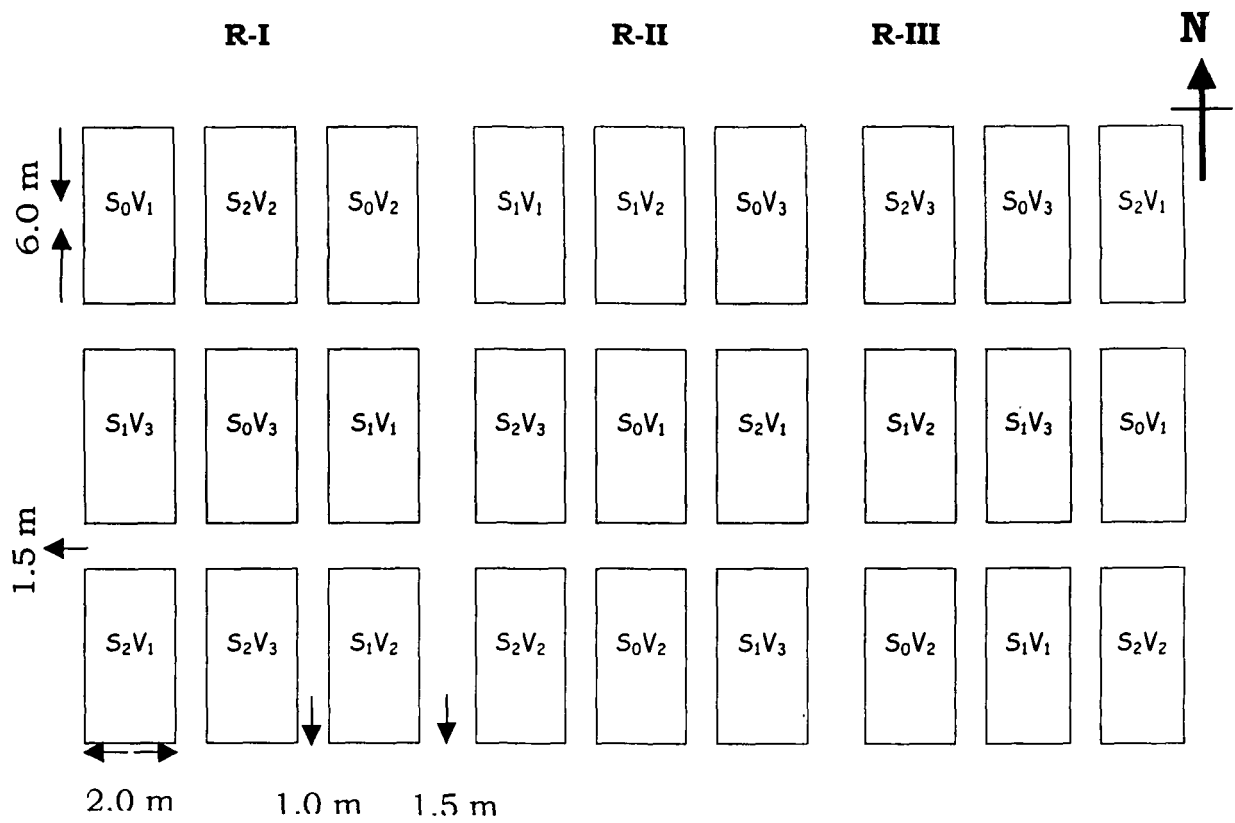
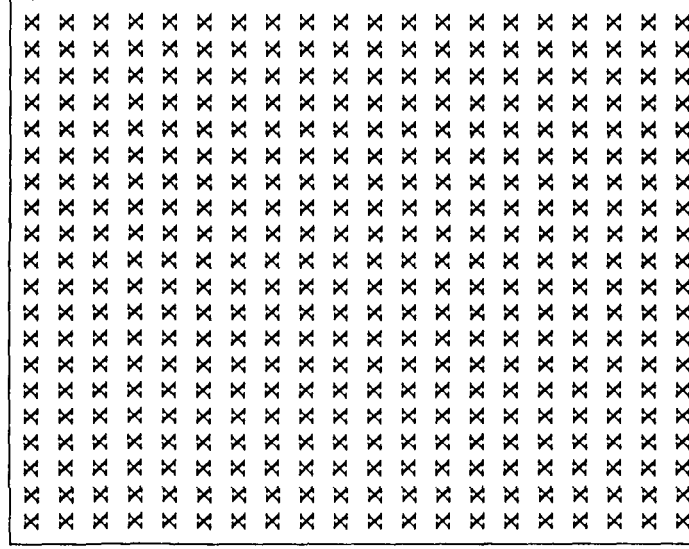


Fig. 3.03 : Plan and Lay out of experiment - III

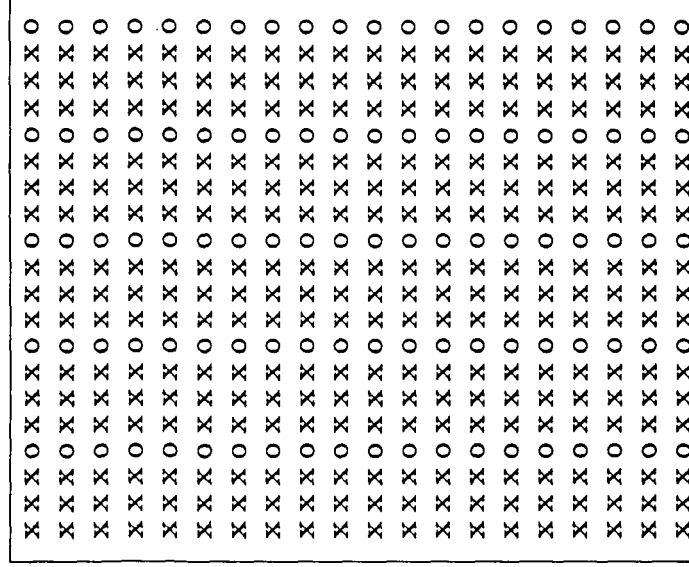
LEGEND :

x – Entire row

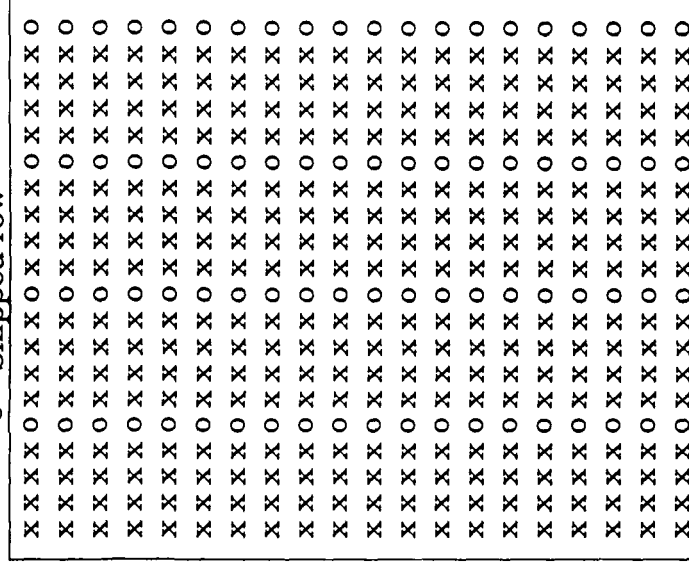
o – Skipped row



S₀ - No row skipping



S₁ -One row skipping after every
three rows



S₂ -One row skipping after every
four rows

Figure 3.04. Methods of row skipping followed in experiment III

3.3.2 Fertilizer and micronutrients application

Urea, single super phosphate and muriate of potash were used for application as a source of nitrogen, phosphorus and potash respectively. A day prior to sowing the calculated quantity of fertilizers were applied to the experimental plots in a continuous band opened at 5 cm away from seed line. For Experiment-I the various organic, inorganic and bio-fertilizers were applied as per treatment schedule described under 3.2.1. For experiment II and III the recommended fertilizer dose of 25:50:25 kg NPK per ha was applied to all the plots. The micronutrient iron was applied in the form of FeSO_4 while zinc was applied as ZnSO_4 . For Experiment-II micronutrients were applied as per treatment schedule described under 3.2.2.

3.3.3 Seeds and sowing

The pods were shelled by hand just before sowing. Two seeds per hill were hand dibbled at about 2 to 3 cm deep from the soil surface and 5 cm away from fertilizer band. Sowing was done on 21st July during 1999 and 11th July during 2000.

3.3.4 After care

Gap filling and thinning was attended 12 days after sowing so as to maintain single healthy plant per spot. Intercultivation was done on 20th and 30th day after sowing. Hand weeding was attended thrice during crop growth period. Earthing up was done on 40th day after sowing to facilitate easy penetration of pegs in the soil and for better development of pods. Recommended plant protection measures were attended from time to time

in order to raise a healthy crop. For experiment-II foliar sprays of required micronutrients were given on 40th day after sowing as per the treatment schedule detailed in 3.2.2.

3.3.5 Harvesting

Harvesting of the crop was done when the pods attained their physiological maturity depending on visual observations of leaf senescence and black colour appearance in the inside of the shell. The plants from the net plot area were manually uprooted separately and spread in the field for drying. The pods were hand separated and washed to remove soil adhering to it. The pods were dried in shade for one week to bring the seed moisture content below nine per cent.

3.4 RECORDING OF OBSERVATIONS

The following observations were recorded for all the above three experiments as per the procedures described below. Ten healthy and normal plants were selected randomly in each net plot area and were tagged with a label for recording various observations on growth and yield parameters.

3.4.1 Growth parameters

3.4.1.1 Plant height (cm)

The plant height was measured from ground level to the tip of the main shoot from ten randomly tagged plants at 60 days after sowing (DAS) and at harvest for each treatment and replications. The average of ten plants was computed and expressed as plant height in centimetres (cm) for respective stage of crop growth.

3.4.1.2 Number of branches per plant

At harvest, number of branches per plant were counted for the earlier tagged ten plants, then the average was computed and expressed as number of branches per plant at harvest.

3.4.1.3 Days to 50 per cent flowering

Flower initiation was regularly recorded in each plot starting from 25 days after sowing in the earlier ten randomly tagged plants. The 50 per cent flowering was noted when the flower initiation in the fifth plant had started and number of days taken from the date of sowing was worked out as days to 50 per cent flowering.

3.4.1.4 Days to peg initiation

In the earlier randomly tagged ten plants peg initiation was observed starting from 40 days after sowing in each plot. The day on which each plant induced peg initiation was recorded. Then the number of days taken to peg initiation in each plant was worked out from date of sowing. The average was computed and expressed as days to peg initiation.

3.4.1.5 Days to pod maturity

Based on the visual observations of leaf senescence and black layer formation in the inside of the shell in earlier tagged ten plants in each plot days to pod maturity was decided. This was observed from 95 days after sowing onwards. Then the number of days taken to pod maturity in each plant was worked out from date of sowing. The average was computed and expressed as days to pod maturity.

3.4.1.6 Number of nodules per plant

Number of nodules were counted in earlier tagged ten plants at harvest, then the average was computed and expressed as nodule number per plant.

3.4.1.7 Nodule dry weight (mg/plant)

After recording the nodule number in each plant the nodules were manually separated from earlier tagged ten plants and were dried at room temperature for five hours before drying in hot air oven maintained at $85 \pm 1^\circ\text{C}$ temperature for 24 hours and cooled in desiccators for 30 minutes. The weight was recorded in electronic balance in milligrams (mg) and average was computed and expressed as nodule dry weight in milligrams per plant.

3.4.2 Yield parameters

3.4.2.1 Number of mature pods per plant

The pods of ten randomly tagged plants in each plot were harvested and cleaned separately. Based on visual observation of pod maturity and seed filling, mature and immature pods were separated. The mature pods per plant were counted, average was worked out and expressed as number of mature pods per plant.

3.4.2.2 Number of immature pods per plant

The immature pods separated in each plot from ten tagged plants were counted, average of these ten plants was worked out and expressed as number of immature pods per plant.

3.4.2.3 Pod yield (g/plant)

The pods obtained in each of the ten earlier tagged plants in each plot were dried in shade until kernel moisture content was around nine per cent. The total pod weight obtained from each plant was recorded in grams. The average was worked out and expressed as pod yield in grams per plant.

3.4.2.4 Pod yield (kg/ha)

Pod yield in kilograms per hectare was computed utilizing the pod yield from net plot area for each treatment and replications. Care was taken to add the pod yield obtained from ten randomly tagged plants. The pod yield was expressed in kg per ha.

3.4.2.5 Shelling percentage

Two hundred grams of dried and cleaned pods from each plot were shelled manually. The weight of the kernels was recorded and shelling percentage was expressed employing the formula give below.

$$\text{Shelling percentage} = \frac{\text{Weight of kernels (g)}}{\text{Weight of pods (g)}} \times 100$$

3.4.2.6 Kernel yield (kg/ha)

Kernel yield in kilograms per hectare was computed using pod yield per hectare and shelling percentage data for each treatment and replications.

3.4.2.7 Benefit cost ratio

To know the rate of returns per rupee invested, benefit cost ratio was worked out by using following formula.

$$\text{Benefit cost ratio} = \frac{\text{Net returns (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

The price of various inputs and outputs used in calculating the cost of cultivation and net returns of groundnut are presented in Appendix - I. The gross and net returns obtained by experiments I, II and III are presented in Appendix II, III and IV respectively.

3.4.2.8 Sound mature kernel percentage

Kernel sample obtained from 200 grams shelled pods used to determine shelling percentage was taken, then well developed kernels were sorted and sound mature kernel percentage was worked out as follows.

$$\text{Sound mature kernel percentage} = \frac{\text{Number of well developed kernels}}{\text{Total number of kernels}} \times 100$$

3.4.2.9 Oil content percentage

Oil content of 15 gram kernels from each treatment with three replications was estimated by using Nuclear Magnetic Resonance (NMR) spectrophotometer at the Regional Agricultural Research Station, Raichur and was expressed as percentage by weight basis.

3.4.2.10 Oil yield (kg/ha)

Oil yield in kilograms per hectare was computed using seed kernel yield per hectare and oil content percentage data for each treatment and replications.

3.4.3 Seed quality parameters

3.4.3.1 100 Seed weight (g)

The weight of the 100 seeds drawn randomly from each treatments was recorded in eight replications as per the procedure given by ISTA Rules (Anon., 1999) and the average was expressed in grams.

3.4.3.2 Germination percentage

The standard germination test was carried out by following the between paper method. Eight replications of 50 randomly selected seeds were used for germination test in each treatment. The germinator was maintained at 25°C temperature with 95±1 per cent relative humidity. On tenth day of the test the number of normal seedlings were separated as per the procedure stated in ISTA Rules (Anon., 1999) and were counted then average of eight replications was worked out and expressed as germination percentage.

3.4.3.3 Seedling length (cm)

On tenth day of germination test, ten randomly selected normal seedlings were taken out carefully from each treatments and replications and were measured from the tip of primary root to the point of junction of

the cotyledons. The average of ten seedling was calculated and expressed as mean seedling length in centimetres.

3.4.3.4 Seedling dry weight (g)

Ten randomly selected seedlings which were used for recording seedling length were also used for determining seedling dry weight. Seedlings were enveloped in butter paper bags and dried in pre heated oven at 85°C temperature for 24 hours. After this, the paper bags were removed and cooled in desiccators for 30 minutes. Then the dry weight was recorded in grams and average was worked out and expressed as seedling dry weight in grams (Evans and Bhatt, 1977).

3.4.3.5 Seedling vigour index

Seedling vigour index was calculated as per the formula given by Abdul-Baki and Anderson (1973) and expressed in whole number.

$$\text{Seedling vigour index} = \text{Germination (\%)} \times \text{seedling length (cm)}$$

3.4.3.6 Electrical conductivity of seed leachate (dSm⁻¹)

Four replications of five grams seeds in each treatment were weighed up to two decimal places. The seeds were surface sterilized with acetone for 30 seconds and were thoroughly washed in distilled water. The seeds were soaked in 25 ml distilled water and were kept in an incubator at 25±1°C temperature for 24 hours. Electrical conductivity of the seed leachate was measured in the digital conductivity meter (model - sensitive conductivity cell-CCS-811). After subtracting the electrical conductivity value of distilled water (blank) from the value obtained from the seed

leachate, the actual electrical conductivity due to the leached electrolytes was measured and expressed in dS m⁻¹ (Presley, 1958).

3.5 STATISTICAL ANALYSIS

The mean data were statistically analyzed and subjected to the analysis of variance by adopting the appropriate methods as outlined by Panse and Sukhatme (1978) and Sundararaj *et. al.* (1972). The critical differences were calculated at five per cent level of probability wherever 'F' test was significant. The percentage data were transformed in to arc sine root transformation before analysis.

Experimental Results

IV. EXPERIMENTAL RESULTS

The results obtained on the field experiments conducted at the Main Agricultural Research Station, Dharwad during *kharif* 1999 and *kharif* 2000 and year-wise pooled regarding studies on integrated nutrient management and planting methods on seed yield and quality in groundnut are presented in this chapter.

4.1 EXPERIMENT - I: EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SEED YIELD AND QUALITY OF GROUNDNUT

The experiment consisted of 16 treatments involving various combinations of organic, inorganic and bio-fertilizer nutrients. The experiment was laid out in randomized block design with three replications. The results obtained in this experiment are presented here under.

4.1.1 Growth parameters

4.1.1.1 Plant height (cm) at 60 DAS

The results obtained on plant height at 60 days after sowing (DAS) during 1999, 2000 year-wise and pooled are presented in Table 4.01.

Effect of organic and inorganic nutrients on plant height at 60 DAS in groundnut exhibited non-significant differences during both the year of experimentation as well as in pooled data. In the pooled data T₉ was numerically higher in plant height (31.12 cm) while, T₁ was lower (26.25 cm). The mean plant height recorded was 29.02 cm.

Table 4.01. Effect of organic, inorganic nutrients and bio-fertilizers on plant height (cm) at 60 DAS in groundnut

Treatments	Plant height (cm) at 60 DAS		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	25.00	27.50	26.25
T ₂ - T ₁ + FYM (5 t/ha)	26.68	29.02	27.85
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	27.98	30.74	29.36
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	27.11	29.46	28.29
T ₅ - T ₁ + Gypsum (5 q/ha)	26.89	29.58	28.23
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	25.12	27.91	26.52
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	27.95	30.83	29.39
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	29.48	31.75	30.62
T ₉ - T ₂ + Gypsum (5 q/ha)	30.16	32.07	31.12
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	29.42	31.59	30.51
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	29.06	31.90	30.48
T ₁₂ - T ₃ + Gypsum (5 q/ha)	25.04	27.52	26.28
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	28.86	31.64	30.25
T ₁₄ - T ₄ + Gypsum (5 q/ha)	29.63	31.36	30.50
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	28.51	30.68	29.60
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	27.77	30.30	29.04
Mean	27.79	30.24	29.02
S.Em±	2.01	1.73	1.33
C.D. at 5 %	NS	NS	NS

NS – Non significant

4.1.1.2 Plant height (cm) at harvest

The plant height recorded at harvest due to effect of organic and inorganic nutrients in groundnut showed non-significant differences in both the years as well as in pooled data are presented in Table 4.02.

In the pooled data the plant height at harvest ranged between 37.33 cm (T_1) to 43.94 cm (T_{11}) with a mean of 41.45 cm.

4.1.1.3 Number of branches per plant at harvest

The data which showed non-significant differences in pooled as well as during 1999 and 2000 year of production on number of branches per plant at harvest due to various nutrients are presented in Table 4.03.

The mean number of branches were 6.92 in the pooled data and it ranged between 6.20 (T_1) to 8.25 (T_{11}).

4.1.1.4 Days to 50 per cent flowering

Days to 50 per cent flowering observations due to nutrition effect are presented in Table 4.04.

Days taken to 50 per cent flowering differed significantly due to nutrient levels in both the years as well in pooled data. The average days to 50 per cent flowering were 37.43, 37.74 and 37.58 in 1999, 2000 and pooled data respectively. In the pooled data significantly less (35.15) days were taken to 50 per cent flowering by treatment T_{11} . This treatment was on par with treatment T_8 , T_9 , T_{10} and T_{12} . The treatment T_1 took significantly more (39.65) days to 50 per cent flowering and was on par with treatments T_2 , T_3 , T_4 , T_5 and T_6 .

Table 4.02. Effect of organic, inorganic nutrients and bio-fertilizers on plant height (cm) at harvest in groundnut

Treatments	Plant height (cm) at harvest		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	35.94	38.71	37.33
T ₂ - T ₁ + FYM (5 t/ha)	39.59	41.45	40.52
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	40.16	42.05	41.11
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	37.24	40.87	39.06
T ₅ - T ₁ + Gypsum (5 q/ha)	37.52	40.49	39.01
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	37.50	39.90	38.70
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	42.05	44.02	43.04
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	41.85	44.74	43.30
T ₉ - T ₂ + Gypsum (5 q/ha)	42.13	44.56	43.35
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	40.21	43.78	41.10
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	42.36	45.51	43.94
T ₁₂ - T ₃ + Gypsum (5 q/ha)	42.73	45.13	43.93
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	40.56	43.85	42.21
T ₁₄ - T ₄ + Gypsum (5 q/ha)	41.54	43.47	42.51
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	40.16	43.19	41.68
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	40.42	42.60	41.51
Mean	40.12	42.77	41.45
S.Em _±	3.08	2.08	1.86
C.D. at 5 %	NS	NS	NS

NS – Non significant

Table 4.03. Effect of organic, inorganic nutrients and bio-fertilizers on number of branches per plant at harvest in groundnut

Treatments	Number of branches/plant at harvest		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	6.00	6.40	6.20
T ₂ - T ₁ + FYM (5 t/ha)	6.30	6.70	6.50
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	6.10	6.70	6.40
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	6.20	6.60	6.40
T ₅ - T ₁ + Gypsum (5 q/ha)	6.30	6.60	6.45
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.20	6.60	6.40
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	7.00	7.50	7.25
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	7.50	7.90	7.70
T ₉ - T ₂ + Gypsum (5 q/ha)	7.00	7.60	7.30
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.80	7.10	6.95
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	8.10	8.40	8.25
T ₁₂ - T ₃ + Gypsum (5 q/ha)	7.70	8.10	7.90
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.90	7.20	7.05
T ₁₄ - T ₄ + Gypsum (5 q/ha)	6.60	7.00	6.80
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.20	6.80	6.50
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.40	6.80	6.60
Mean	6.71	7.13	6.92
S.Em±	0.76	0.74	0.53
C.D. at 5 %	NS	NS	NS

NS – Non significant

Table 4.04. Effect of organic, inorganic nutrients and bio-fertilizers on days to 50 per cent flowering in groundnut

Treatments	Days to 50 % flowering		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	39.50	39.80	39.65
T ₂ - T ₁ + FYM (5 t/ha)	38.30	38.50	38.40
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	38.00	38.40	38.20
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	38.60	38.90	38.75
T ₅ - T ₁ + Gypsum (5 q/ha)	39.00	39.40	39.20
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	39.30	39.50	39.40
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	36.90	37.30	37.10
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	35.70	35.90	35.80
T ₉ - T ₂ + Gypsum (5 q/ha)	35.60	36.00	35.80
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	37.40	37.60	37.50
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	35.00	35.30	35.15
T ₁₂ - T ₃ + Gypsum (5 q/ha)	35.50	35.70	35.60
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	37.00	37.47	37.23
T ₁₄ - T ₄ + Gypsum (5 q/ha)	37.60	37.90	37.75
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	37.70	38.00	37.85
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	37.70	38.10	37.90
Mean	37.43	37.74	37.58
S.Em _±	0.77	0.87	0.58
C.D. at 5 %	2.22	2.51	1.67

4.1.1.5 Days to peg initiation

The data on days to peg initiation as influenced by organic and inorganic nutrients are presented in Table 4.05

Significant differences on days taken to peg initiation were noticed with the treatment effects in both the years as well as pooled data. Average days to peg initiation were 51.79, 52.50 and 52.14 during 1999, 2000 and pooled data respectively. In the pooled data it was significantly less (50.00) days in treatment T₁₁ which was at par with treatments T₇, T₈, T₉, T₁₂ and T₁₄. Significantly more (54.40) days to peg initiation were taken by treatment T₁ and was at par with treatments T₂, T₃, T₄, T₅, T₆, T₁₀ and T₁₃.

4.1.1.6 Days to pod maturity

The observations recorded on days to pod maturity are presented in Table 4.06.

Days to pod maturity was found to record significant differences in both the years as well as in pooled data. The treatment T₁₁ recorded significantly less (97.9, 98.2 and 98.1) days to pod maturity in 1999, 2000 and pooled data respectively. This treatment was at par with treatments T₈, and T₁₂ during 1999 and 2000 and with T₁₂ in pooled record. Significantly more (107.7, 108.1 and 107.9) days to pod maturity were recorded by treatment T₁ in 1999, 2000 and pooled data respectively. This was at par with T₂, T₃, T₄, T₅ and T₆ treatments.

An overall average of 104.1 days to pod maturity was recorded.

Table 4.05. Effect of organic, inorganic nutrients and bio-fertilizers on days to peg initiation in groundnut

Treatments	Days to peg initiation		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	54.20	54.60	54.40
T ₂ - T ₁ + FYM (5 t/ha)	52.60	52.90	52.75
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	52.50	52.70	52.60
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	53.00	53.30	53.15
T ₅ - T ₁ + Gypsum (5 q/ha)	53.40	53.90	53.65
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	53.70	54.00	53.85
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	51.00	51.20	51.10
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	50.60	50.80	50.70
T ₉ - T ₂ + Gypsum (5 q/ha)	49.80	51.10	50.45
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	51.30	51.50	51.40
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	49.90	50.10	50.00
T ₁₂ - T ₃ + Gypsum (5 q/ha)	50.10	50.50	50.30
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	51.00	57.20	54.10
T ₁₄ - T ₄ + Gypsum (5 q/ha)	51.70	51.90	51.80
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	51.80	52.10	51.95
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	52.00	52.20	52.10
Mean	51.79	52.50	52.14
S.Em _±	0.96	0.80	0.62
C.D. at 5 %	2.77	2.31	1.80

Table 4.06. Effect of organic, inorganic nutrients and bio-fertilizers on days to pod maturity in groundnut

Treatments	Days to pod maturity		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	107.7	108.1	107.9
T ₂ - T ₁ + FYM (5 t/ha)	105.9	106.2	106.1
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	104.8	105.3	106.1
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	106.0	106.4	106.2
T ₅ - T ₁ + Gypsum (5 q/ha)	107.8	107.5	107.6
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	107.1	107.6	107.4
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	102.3	102.7	102.5
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	100.6	100.8	100.7
T ₉ - T ₂ + Gypsum (5 q/ha)	102.4	102.9	102.7
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	103.6	104.0	103.8
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	97.9	98.2	98.1
T ₁₂ - T ₃ + Gypsum (5 q/ha)	99.9	100.4	100.2
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	103.1	103.5	103.3
T ₁₄ - T ₄ + Gypsum (5 q/ha)	104.0	104.6	104.3
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	104.7	105.0	104.9
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	104.8	105.3	105.1
Mean	103.9	104.3	104.1
S.Em _±	1.2	1.1	0.8
C.D. at 5 %	3.5	3.2	2.3

4.1.1.7 Number of nodules per plant

The number of nodules recorded due to the effect of organic and inorganic nutrition in groundnut during 1999, 2000 and year-wise pooled are presented in Table 4.07.

Nodules number per plant was found to be non-significant in both the years of experimentation while, it exhibited significant differences when pooled analysis was carried out. The treatment T₁₁ recorded significantly maximum (74.55) nodules number per plant. This treatment was on par with T₃, T₇, T₈, T₉, T₁₀, T₁₂, T₁₃, T₁₄, T₁₅ and T₁₆ treatments. Significantly minimum (63.70) nodules number was recorded by T₁ treatment which was again on par with treatments T₂, T₃, T₄, T₅, T₆, T₁₄, T₁₅, and T₁₆. The average nodules number recorded was 69.17.

4.1.1.8 Nodule dry weight (mg/plant)

Nodule dry weight data as influenced by nutrient levels are presented in Table 4.08.

The organic and inorganic nutrients were able to produce significant differences on nodule dry weight in both the years as well in pooled data. The treatment T₁₁ recorded significantly maximum (144.2, 148.3 and 146.3 mg/plant) nodule dry weight in 1999, 2000 and pooled data respectively. This was followed by treatment T₁₂.

The treatments T₁, T₂, T₃, T₄, T₅, T₆ and T₁₆ were on par with each other and recorded significantly lesser nodule dry weight in both the years and pooled data.

Table 4.07. Effect of organic, inorganic nutrients and bio-fertilizers on number of nodules per plant in groundnut

Treatments	Number of nodules/plant		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	62.30	65.10	63.70
T ₂ - T ₁ + FYM (5 t/ha)	65.10	69.30	67.20
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	66.10	70.50	68.30
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	63.00	67.70	65.35
T ₅ - T ₁ + Gypsum (5 q/ha)	62.70	66.90	64.80
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	62.70	66.80	64.75
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	69.20	73.00	71.10
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	70.00	74.60	72.30
T ₉ - T ₂ + Gypsum (5 q/ha)	70.10	74.40	72.25
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	69.70	73.20	71.45
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	72.10	77.00	74.55
T ₁₂ - T ₃ + Gypsum (5 q/ha)	71.50	75.20	73.35
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	69.10	73.40	71.25
T ₁₄ - T ₄ + Gypsum (5 q/ha)	67.40	71.60	69.50
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	66.30	70.80	68.55
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	65.80	70.70	68.25
Mean	67.07	71.26	69.17
S.Em _±	2.73	3.85	2.36
C.D. at 5 %	NS	NS	6.81

NS – Non significant

Table 4.08. Effect of organic, inorganic nutrients and bio-fertilizers on nodule dry weight (mg/plant) in groundnut

Treatments	Nodule dry weight (mg/plant)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	90.1	94.7	92.4
T ₂ - T ₁ + FYM (5 t/ha)	91.9	97.7	94.8
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	94.7	99.3	97.0
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	91.6	96.8	94.2
T ₅ - T ₁ + Gypsum (5 q/ha)	91.4	96.1	93.8
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	89.8	95.5	92.7
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	120.1	125.8	123.0
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	127.4	132.9	130.2
T ₉ - T ₂ + Gypsum (5 q/ha)	125.1	129.5	127.3
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	101.9	108.6	105.3
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	144.2	148.3	146.3
T ₁₂ - T ₃ + Gypsum (5 q/ha)	131.2	135.6	133.4
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	115.6	121.0	118.3
T ₁₄ - T ₄ + Gypsum (5 q/ha)	99.8	104.4	102.1
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	98.1	103.7	100.9
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	94.9	100.6	97.8
Mean	106.7	111.9	109.3
S.Em _±	3.7	3.4	2.5
C.D. at 5 %	10.7	9.8	7.2

4.1.2 Yield parameters

4.1.2.1 Number of mature pods per plant

The data recorded on number of mature pods per plant are presented in Table 4.09.

During both years of experimentation and when pooled analysis was done, the number of mature pods per plant recorded significant differences. The treatment T₁₁ was significantly superior by recording maximum mature pods (16.88, 17.24 and 17.06) in 1999, 2000 and pooled values respectively. Whereas, the treatment T₁ recorded minimum (10.64, 11.0 and 10.86) mature pods during 1999, 2000 and pooled values respectively. In the pooled data treatments T₇, T₈, T₉ and T₁₂ were on par with T₁₁ treatment while T₅ and T₆ were at par with T₁ treatment. An average of 14.45 mature pods were recorded.

4.1.2.2 Number of immature pods per plant

The values recorded on number of immature pods per plant during 1999, 2000 and pooled data are presented in Table 4.10.

Significant differences were noticed in number of immature pods in both the years as well as pooled data. An average of 5.98, 6.51 and 6.24 immature pods were recorded in 1999, 2000 and pooled values. The treatment T₁₁ was superior by recording 3.69 immature pods and was at par with treatments T₇, T₈, T₉ and T₁₂ in the pooled values. The treatment T₁ recorded significantly more (8.04) number of immature pods and was at par with T₂, T₃, T₄, T₅, T₆ and T₁₆ treatments in pooled values.

Table 4.09. Effect of organic, inorganic nutrients and bio-fertilizers on number of mature pods per plant in groundnut

Treatments	Number of matured pods/plant		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	10.64	11.70	10.86
T ₂ - T ₁ + FYM (5 t/ha)	13.34	13.72	13.53
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	13.66	14.10	13.88
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	12.88	13.31	13.10
T ₅ - T ₁ + Gypsum (5 q/ha)	12.18	12.63	12.41
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	11.27	11.88	11.57
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	15.54	15.81	15.68
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	16.06	16.67	16.37
T ₉ - T ₂ + Gypsum (5 q/ha)	15.79	16.19	15.99
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	15.05	15.43	15.24
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	16.88	17.24	17.06
T ₁₂ - T ₃ + Gypsum (5 q/ha)	16.26	16.88	16.57
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	15.08	15.64	15.36
T ₁₄ - T ₄ + Gypsum (5 q/ha)	14.48	15.06	14.77
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	14.24	14.77	14.51
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	13.97	14.54	14.26
Mean	14.21	14.68	14.45
S.Em±	0.88	0.76	0.58
C.D. at 5 %	2.54	2.19	1.67

Table 4.10. Effect of organic, inorganic nutrients and bio-fertilizers on number of immature pods per plant in groundnut

Treatments	Number of immature pods/plant		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	7.77	8.31	8.04
T ₂ - T ₁ + FYM (5 t/ha)	7.28	7.69	7.49
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	6.85	7.30	7.08
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	7.26	7.74	7.50
T ₅ - T ₁ + Gypsum (5 q/ha)	7.57	8.02	7.80
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	7.64	8.17	7.91
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	4.86	5.39	5.13
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	4.38	4.94	4.66
T ₉ - T ₂ + Gypsum (5 q/ha)	4.61	5.15	4.88
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	5.61	6.16	5.89
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	3.12	4.26	3.69
T ₁₂ - T ₃ + Gypsum (5 q/ha)	4.34	4.71	4.53
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	5.41	5.87	5.64
T ₁₄ - T ₄ + Gypsum (5 q/ha)	6.03	6.41	6.22
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.27	6.84	6.56
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	6.66	7.17	6.92
Mean	5.98	6.51	6.24
S.Em _±	0.69	0.71	0.50
C.D. at 5 %	1.99	2.05	1.44

4.1.2.3 Pod yield (g/plant)

The pooled, 1999 and 2000 year per plant pod yield recorded are presented in Table 4.11.

In the pooled values and during 1999 the per plant pod yield exhibited significant differences while, it was non-significant during 2000 year. In the pooled values the treatment T_{11} recorded significantly maximum (11.99 g) pod yield per plant. This was followed by T_{12} (11.53 g), T_8 (11.35 g), T_9 (11.26 g), T_7 (11.08 g), T_{13} (10.90 g), T_{14} (10.74 g), T_{10} (10.62 g) and T_{15} (10.09 g) and all these were at par with each other. The treatment T_1 recorded significantly minimum (7.74 g) pod yield per plant and the treatments T_2 , T_3 , T_4 , T_5 , T_6 and T_{16} were on par with T_1 .

4.1.2.4 Pod yield (kg/ha)

The data on pod yield per hectare of 1999, 2000 and pooled as influenced by nutrition levels are presented in Table 4.12.

The per hectare pod yield was non significant during 2000 while it was significant during 1999 and also in pooled values. On an average (2658 and 2778 kg/ha) yields were recorded in 1999 and pooled data respectively. The treatment T_{11} recorded significantly higher (3337 kg/ha) pod yield in pooled values which was on par with treatments T_7 , T_8 , T_9 , T_{10} , T_{12} , T_{13} , T_{14} and T_{15} . The remaining treatments were on par with each other and among them T_1 recorded significantly lowest (2153 kg/ha) pod yield.

Table 4.11. Effect of organic, inorganic nutrients and bio-fertilizers on pod yield (g/plant) in groundnut

Treatments	Pod yield (g/plant)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	7.42	8.05	7.74
T ₂ - T ₁ + FYM (5 t/ha)	8.48	9.22	8.85
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	8.91	9.53	9.22
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	8.39	8.94	8.67
T ₅ - T ₁ + Gypsum (5 q/ha)	7.77	8.37	8.07
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	7.64	8.26	7.95
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	10.79	11.36	11.08
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	11.03	11.67	11.35
T ₉ - T ₂ + Gypsum (5 q/ha)	10.96	11.55	11.26
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	10.31	10.92	10.62
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	11.77	12.21	11.99
T ₁₂ - T ₃ + Gypsum (5 q/ha)	11.18	11.88	11.53
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	10.64	11.21	10.93
T ₁₄ - T ₄ + Gypsum (5 q/ha)	10.74	10.74	10.74
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	9.88	10.30	10.09
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	9.45	9.91	9.68
Mean	9.71	10.26	9.98
S.Em _±	0.97	1.01	0.70
C.D. at 5 %	2.80	NS	2.02

NS – Non significant

Table 4.12. Effect of organic, inorganic nutrients and bio-fertilizers on pod yield (kg/ha) in groundnut

Treatments	Pod yield (kg/ha)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	2026	2280	2153
T ₂ - T ₁ + FYM (5 t/ha)	2315	2612	2464
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	2434	2701	2568
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	2292	2539	2415
T ₅ - T ₁ + Gypsum (5 q/ha)	2126	2373	2249
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	2168	2342	2255
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	2948	3225	3087
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	3013	3152	3083
T ₉ - T ₂ + Gypsum (5 q/ha)	2990	3275	3133
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	2816	3098	2957
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	3214	3461	3337
T ₁₂ - T ₃ + Gypsum (5 q/ha)	3056	3372	3214
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	2909	3179	3044
T ₁₄ - T ₄ + Gypsum (5 q/ha)	2936	3048	2992
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	2697	2924	2811
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	2581	2808	2695
Mean	2658	2899	2778
S.Em±	262	297	198
C.D. at 5 %	756	NS	572

NS – Non significant

4.1.2.5 Shelling percentage

The values of shelling percentage are presented in Table 4.13 which exhibited significant differences only in the pooled data.

An average of 68.01 per cent shelling was recorded. Per cent shelling was significantly higher (70.71 %) and lower (65.59 %) with treatment T₁₁ and T₁ respectively. The treatments T₇, T₈, T₉, T₁₀, T₁₁, T₁₂, T₁₃, T₁₄ and T₁₅ did not differ significantly with each other. Similarly, the treatment T₁, T₂, T₃, T₄, T₅, T₆, T₁₅ and T₁₆ showed non significant difference among themselves.

4.1.2.6 Kernel yield (kg/ha)

The computed data on kernel yield per hectare of 1999, 2000 and pooled are presented in Table 4.14.

The kernel yield showed significant difference during both years as well as pooled values. The average per hectare kernel yield of 1807, 1979 and 1893 kg were recorded during 1999, 2000 and pooled values respectively. Though T₁₁ treatment recorded significantly highest kernel yield during 1999 (2267 kg/ha), 2000 (2458 kg/ha) and pooled (2362 kg/ha) values this treatment was at par with T₇, T₈, T₉, T₁₀, T₁₂, T₁₃ and T₁₄ treatments. Significantly lowest (1414 kg/ha) kernel yield was recorded in pooled data with T₁ treatment and this was on par with T₂, T₃, T₄, T₅ and T₆ treatments.

4.1.2.7 Benefit cost ratio

The data on benefit cost ratio as influenced by nutrition levels are presented in Table 4.15.

Table 4.13. Effect of organic, inorganic nutrients and bio-fertilizers on shelling percentage in groundnut

Treatments	Shelling percentage		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	65.47 (54.02)*	65.71 (54.17)	65.59 (54.09)
T ₂ - T ₁ + FYM (5 t/ha)	66.61 (54.71)	67.08 (55.01)	66.85 (54.86)
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	66.85 (54.85)	67.40 (55.23)	67.13 (55.04)
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	66.23 (54.48)	66.89 (54.88)	66.56 (54.68)
T ₅ - T ₁ + Gypsum (5 q/ha)	65.89 (54.27)	66.27 (54.50)	66.08 (54.39)
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	65.56 (54.07)	66.04 (54.36)	65.80 (54.22)
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	68.74 (56.01)	69.24 (56.33)	68.99 (56.17)
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	69.55 (56.51)	69.88 (56.75)	69.72 (56.63)
T ₉ - T ₂ + Gypsum (5 q/ha)	69.03 (56.21)	69.56 (56.54)	69.30 (56.38)
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	68.48 (55.85)	68.92 (56.13)	68.70 (55.99)
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	70.44 (57.07)	70.97 (57.40)	70.71 (57.24)
T ₁₂ - T ₃ + Gypsum (5 q/ha)	69.49 (56.48)	70.17 (56.90)	69.83 (56.69)
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	68.37 (55.79)	69.11 (56.24)	68.74 (56.02)
T ₁₄ - T ₄ + Gypsum (5 q/ha)	68.21 (55.69)	68.74 (56.01)	68.48 (55.85)
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	67.88 (55.48)	68.33 (55.75)	68.11 (55.62)
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	67.44 (55.21)	67.91 (55.50)	67.68 (55.36)
Mean	67.77 (55.42)	68.26 (55.73)	68.01 (55.58)
S.Em _±	0.67	1.00	0.60
C.D. at 5 %	NS	NS	1.73

NS – Non significant

* Figures in the parentheses indicate arc sine transformed values

Table 4.14. Effect of organic, inorganic nutrients and bio-fertilizers on kernel yield (kg/ha) in groundnut

Treatments	Kernel yield (kg/ha)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	1326	1502	1414
T ₂ - T ₁ + FYM (5 t/ha)	1536	1740	1638
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	1633	1827	1730
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	1527	1697	1612
T ₅ - T ₁ + Gypsum (5 q/ha)	1401	1568	1484
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1421	1543	1482
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	2023	2242	2133
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	2093	2224	2158
T ₉ - T ₂ + Gypsum (5 q/ha)	2057	2271	2164
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1934	2127	2030
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	2267	2458	2362
T ₁₂ - T ₃ + Gypsum (5 q/ha)	2125	2364	2244
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1987	2197	2092
T ₁₄ - T ₄ + Gypsum (5 q/ha)	2006	2003	2005
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1834	1998	1916
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1741	1901	1821
Mean	1807	1979	1893
S.Em±	182	212	140
C.D. at 5 %	525	612	404

Table 4.15. Effect of organic, inorganic nutrients and bio-fertilizers on benefit cost ratio in groundnut

Treatments	Benefit cost ratio		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	3.62	4.20	3.91
T ₂ - T ₁ + FYM (5 t/ha)	3.70	4.31	4.01
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	2.94	3.73	3.16
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	3.97	4.51	4.24
T ₅ - T ₁ + Gypsum (5 q/ha)	3.46	4.00	3.73
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	3.92	4.31	4.12
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	3.39	3.81	3.60
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	4.86	5.13	4.99
T ₉ - T ₂ + Gypsum (5 q/ha)	4.66	5.21	4.93
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.70	5.27	4.98
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	3.99	4.41	4.20
T ₁₂ - T ₃ + Gypsum (5 q/ha)	3.68	4.16	3.92
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	3.70	4.13	3.92
T ₁₄ - T ₄ + Gypsum (5 q/ha)	4.91	5.14	5.03
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.82	5.31	5.07
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.41	4.89	4.65
Mean	4.05	4.51	4.28
S.Em _±	0.50	0.57	0.38
C.D. at 5 %	NS	NS	1.10

NS – Non significant

The various nutrient levels did not produce significant difference in benefit cost ratio during both the years of experimentation. While, significant differences were noticed in year-wise pooled data. It was significantly high (5.07) in T₁₅ treatment and was followed by T₁₄ (5.03), T₈ (4.99), T₁₀ (4.98), T₉ (4.93), T₁₆ (4.65), T₄ (4.24), T₁₁ (4.20), T₆ (4.12) and T₂ (4.01) and all these were at par with each other. An average of 4.28 benefit cost ratio was obtained in the pooled data. The treatments T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₁₁, T₁₂, T₁₃ and T₁₆ recorded less benefit cost ratio.

4.1.2.8 Sound mature kernel percentage

The data on sound mature kernel percentage due to nutrition levels are presented in Table 4.16.

The sound mature kernel percentage did not record any significant difference during 1999, 2000 and in pooled values. It was numerically high (84.82 %) and low (77.03 %) in T₁₁ and T₁ treatments respectively in the pooled data. An average of 80.38, 81.02 and 80.70 per cent sound mature kernels were recorded during 1999, 2000 and pooled data respectively.

4.1.2.9 Oil content percentage

The per cent oil content values as influenced by nutrition levels are presented in Table 4.17.

The various treatments were unable to record any significant differences among themselves in both the years of experimentation and also in pooled data. An average of 44.65, 45.08 and 44.87 per cent oil content was recorded in 1999, 2000 and pooled data respectively. In the

Table 4.16. Effect of organic, inorganic nutrients and bio-fertilizers on sound mature kernel percentage in groundnut

Treatments	Sound mature kernel (%)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	76.67 (61.17)*	77.38 (61.65)	77.03 (61.41)
T ₂ - T ₁ + FYM (5 t/ha)	78.34 (62.32)	79.19 (63.02)	78.77 (62.67)
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	79.08 (62.91)	79.74 (63.50)	79.41 (63.21)
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	78.15 (62.31)	78.90 (62.74)	78.53 (62.52)
T ₅ - T ₁ + Gypsum (5 q/ha)	77.89 (62.05)	78.34 (62.32)	78.12 (62.18)
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	77.03 (61.41)	77.83 (62.05)	77.43 (61.73)
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	82.35 (65.25)	83.06 (65.76)	82.71 (65.50)
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	83.16 (65.85)	83.50 (66.18)	83.33 (66.02)
T ₉ - T ₂ + Gypsum (5 q/ha)	82.82 (65.69)	83.31 (65.91)	83.07 (65.80)
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	81.27 (64.49)	81.84 (64.89)	81.56 (64.69)
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	84.46 (67.25)	85.17 (67.67)	84.82 (67.46)
T ₁₂ - T ₃ + Gypsum (5 q/ha)	83.88 (66.54)	84.51 (67.12)	84.20 (66.83)
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	81.78 (64.86)	82.27 (65.14)	82.03 (65.00)
T ₁₄ - T ₄ + Gypsum (5 q/ha)	80.46 (63.85)	81.05 (64.30)	80.76 (64.07)
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	79.93 (63.42)	80.58 (64.62)	80.26 (64.02)
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	78.84 (62.64)	79.66 (63.28)	79.25 (62.96)
Mean	80.38 (63.88)	81.02 (64.38)	80.70 (64.13)
S.Em±	2.11	2.19	1.52
C.D. at 5 %	NS	NS	NS

NS – Non significant

* Figures in the parentheses indicate arc sine transformed values

Table 4.17. Effect of organic, inorganic nutrients and bio-fertilizers on oil content percentage in groundnut

Treatments	Oil content percentage		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	42.64 (40.77)*	43.15 (41.06)	42.90 (40.91)
T ₂ - T ₁ + FYM (5 t/ha)	43.29 (40.81)	43.86 (41.47)	43.58 (41.14)
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	44.39 (41.78)	45.04 (42.15)	44.72 (41.97)
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	43.02 (40.98)	43.58 (41.31)	43.30 (41.15)
T ₅ - T ₁ + Gypsum (5 q/ha)	43.88 (41.48)	43.37 (41.19)	43.63 (41.34)
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	42.67 (40.78)	43.21 (41.09)	42.94 (40.94)
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	45.48 (42.41)	45.95 (42.67)	45.72 (42.54)
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	45.84 (42.61)	46.23 (42.83)	46.04 (42.72)
T ₉ - T ₂ + Gypsum (5 q/ha)	45.61 (42.48)	46.06 (42.74)	45.84 (42.61)
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	45.14 (42.21)	45.69 (42.53)	45.42 (42.37)
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	46.55 (43.02)	47.13 (43.35)	46.84 (43.19)
T ₁₂ - T ₃ + Gypsum (5 q/ha)	46.07 (42.74)	46.61 (43.05)	46.34 (42.90)
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	45.48 (42.40)	45.82 (42.60)	45.65 (42.50)
T ₁₄ - T ₄ + Gypsum (5 q/ha)	45.06 (42.16)	44.96 (42.10)	45.01 (42.13)
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	44.86 (42.05)	45.36 (42.34)	45.11 (42.19)
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	44.44 (41.81)	45.24 (42.22)	44.84 (42.02)
Mean	44.65 (41.91)	45.08 (42.17)	44.87 (42.04)
S.Em±	0.91	0.90	0.64
C.D. at 5 %	NS	NS	NS

NS – Non significant

* Figures in the parentheses indicate arc sine transformed values

pooled data, it was numerically high (46.84 %) and low (42.90 %) with T₁₁ and T₁ treatments respectively.

4.1.2.10 Oil yield (kg/ha)

The data on computed oil yield per hectare of 1999, 2000 and pooled which shown significant differences due to nutrient levels are presented in Table 4.18.

The oil yield was significantly highest (1103 kg/ha) and lowest (608 kg/ha) in pooled data with T₁₁ and T₁ treatments respectively. The treatments T₇, T₈, T₉, T₁₂ and T₁₃ were at par with T₁₁ and treatments T₂, T₃, T₄, T₅ and T₆ were at par with T₁ treatment. Similar trend was noticed during both the years.

4.1.3 Seed quality parameters

4.1.3.1 100-Seed weight (g)

The year-wise as well as pooled data on 100 seed weight are presented in Table 4.19.

The nutrient level treatments did not record any significant difference on 100 seed weight in both the years of experimentation as well as pooled values. However, in the pooled values numerically high (35.26 g) and low (30.12 g) 100 seed weights were recorded by T₁₁ and T₁ treatments respectively.

4.1.3.2 Germination percentage

The data on germination percentage are presented in Table 4.20.

Table 4.18. Effect of organic, inorganic nutrients and bio-fertilizers on oil yield (kg/ha) in groundnut

Treatments	Oil yield (kg/ha)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	568	648	608
T ₂ - T ₁ + FYM (5 t/ha)	665	767	716
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	720	816	768
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	658	740	699
T ₅ - T ₁ + Gypsum (5 q/ha)	615	681	648
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	606	667	637
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	922	1020	971
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	964	1019	992
T ₉ - T ₂ + Gypsum (5 q/ha)	941	1045	993
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	866	968	917
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	1052	1154	1103
T ₁₂ - T ₃ + Gypsum (5 q/ha)	979	1098	1038
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	902	1004	953
T ₁₄ - T ₄ + Gypsum (5 q/ha)	905	892	898
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	819	902	861
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	772	853	812
Mean	810	892	851
S.Em±	086	084	060
C.D. at 5 %	248	243	173

Table 4.19. Effect of organic, inorganic nutrients and bio-fertilizers on 100 seed weight (g) in groundnut

Treatments	100 seed weight (g)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	29.87	30.36	30.12
T ₂ - T ₁ + FYM (5 t/ha)	31.61	32.17	31.89
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	31.85	32.41	32.13
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	31.11	31.77	31.44
T ₅ - T ₁ + Gypsum (5 q/ha)	30.87	31.31	31.09
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	30.16	30.88	30.52
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	33.61	34.02	33.82
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	33.86	34.44	34.15
T ₉ - T ₂ + Gypsum (5 q/ha)	33.58	34.19	33.89
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	33.09	33.63	33.36
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	34.92	35.59	35.26
T ₁₂ - T ₃ + Gypsum (5 q/ha)	34.12	34.85	34.49
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	33.16	33.74	33.45
T ₁₄ - T ₄ + Gypsum (5 q/ha)	32.74	33.31	33.03
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	32.44	33.08	32.76
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	32.18	31.18	31.68
Mean	32.45	32.93	32.69
S.Em _±	1.51	1.73	1.15
C.D. at 5 %	NS	NS	NS

NS – Non significant

Table 4.20. Effect of organic, inorganic nutrients and bio-fertilizers on germination percentage in groundnut

Treatments	Germination percentage		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	86.75 (68.93)*	88.16 (69.90)	87.46 (69.30)
T ₂ - T ₁ + FYM (5 t/ha)	88.50 (70.21)	90.19 (71.79)	89.35 (71.00)
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	89.11 (70.77)	90.32 (71.89)	89.72 (71.33)
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	88.12 (69.85)	89.86 (71.45)	88.99 (70.65)
T ₅ - T ₁ + Gypsum (5 q/ha)	88.10 (70.26)	89.61 (71.21)	88.86 (70.73)
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	87.86 (69.64)	89.34 (70.97)	88.60 (70.31)
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	90.09 (71.65)	91.87 (73.48)	90.98 (72.57)
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	91.88 (73.45)	93.51 (75.30)	92.70 (74.38)
T ₉ - T ₂ + Gypsum (5 q/ha)	91.60 (73.19)	92.30 (73.90)	91.95 (73.54)
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	90.04 (71.67)	91.22 (72.83)	90.63 (72.25)
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	93.44 (75.24)	95.17 (77.35)	94.31 (76.30)
T ₁₂ - T ₃ + Gypsum (5 q/ha)	92.34 (74.20)	94.08 (76.31)	93.21 (75.25)
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	90.02 (71.61)	91.55 (73.15)	90.79 (72.38)
T ₁₄ - T ₄ + Gypsum (5 q/ha)	88.86 (70.55)	90.94 (72.51)	89.90 (71.53)
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	89.69 (70.82)	90.63 (72.21)	90.16 (71.52)
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	88.91 (72.69)	90.45 (72.05)	89.68 (71.37)
Mean	89.71 (71.41)	91.20 (72.89)	90.45 (72.15)
S.Em±	1.44	1.03	0.88
C.D. at 5 %	NS	2.97	2.54

NS – Non significant

* Figures in the parentheses indicate arc sine transformed values

The per cent germination due to nutrition treatments differed only in 2000 and pooled data. The treatments T₁₁, T₁₂ and T₈ recorded significantly higher germination of 95.17, 94.08 and 93.51 per cent during 2000 and 94.13, 93.21 and 92.70 per cent with pooled values respectively. The average germination of 91.20 and 90.45 per cent were recorded with 2000 and pooled data respectively. During 1999 average germination was 89.71 per cent.

4.1.3.3 Seedling length (cm)

The data on seedling length recorded during 1999, 2000 and pooled values are presented on Table 4.21.

Only in the year-wise pooled data seedling length exhibited significant differences due to organic and inorganic nutrition treatments. In the pooled values an average seedling length of 21.66 cm was recorded. The treatment T₁₁ recorded significantly maximum (23.85 cm) seedling length and this treatment was followed by T₁₂ and T₈ treatments and both these were at par with T₁₁ by recording a seedling length of 22.75 cm. The treatments T₇, T₉, T₁₀, T₁₃ and T₁₅ were also at par with T₁₁ treatment. Significantly minimum (19.65 cm) seedling length was recorded by T₁ treatment which was at par with T₂, T₃, T₄, T₅, T₆, T₁₃, T₁₄, T₁₅ and T₁₆ treatments.

4.1.3.4 Seedling dry weight (g)

The seedling dry weight observations which exhibited non significant differences in both years as well as pooled values are presented in Table 4.22.

Table 4.21. Effect of organic, inorganic nutrients and bio-fertilizers on seedling length (cm) in groundnut

Treatments	Seedling length (cm)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	19.00	20.30	19.65
T ₂ - T ₁ + FYM (5 t/ha)	20.40	21.80	21.10
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	20.70	22.00	21.35
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	20.20	21.50	20.85
T ₅ - T ₁ + Gypsum (5 q/ha)	20.20	21.10	20.65
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	19.10	20.70	19.90
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	21.80	23.00	22.40
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	22.00	23.50	22.75
T ₉ - T ₂ + Gypsum (5 q/ha)	22.00	23.40	22.70
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	21.50	22.60	22.05
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	23.20	24.50	23.85
T ₁₂ - T ₃ + Gypsum (5 q/ha)	21.60	23.90	22.75
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	20.90	22.60	21.75
T ₁₄ - T ₄ + Gypsum (5 q/ha)	20.50	22.80	21.65
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	21.10	22.30	21.70
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	20.50	22.30	21.40
Mean	20.92	22.39	21.66
S.Em _±	1.10	1.01	0.75
C.D. at 5 %	NS	NS	2.17

NS – Non significant

Table 4.22. Effect of organic, inorganic nutrients and bio-fertilizers on seedling dry weight (g) in groundnut

Treatments	Seedling dry weight (g)		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	3.60	4.10	3.85
T ₂ - T ₁ + FYM (5 t/ha)	3.70	4.30	4.00
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	4.00	4.40	4.20
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	3.90	4.30	4.10
T ₅ - T ₁ + Gypsum (5 q/ha)	3.60	4.20	3.90
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	3.50	4.10	3.80
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	4.20	4.60	4.40
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	4.40	4.70	4.55
T ₉ - T ₂ + Gypsum (5 q/ha)	4.20	4.70	4.45
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.00	4.60	4.30
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	4.30	4.90	4.60
T ₁₂ - T ₃ + Gypsum (5 q/ha)	4.10	4.70	4.40
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.20	4.60	4.40
T ₁₄ - T ₄ + Gypsum (5 q/ha)	3.90	4.50	4.20
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.00	4.50	4.25
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	4.10	4.50	4.30
Mean	3.98	4.48	4.23
S.Em _±	0.38	0.34	0.25
C.D. at 5 %	NS	NS	NS

NS – Non significant

Irrespective of nutrition levels an average of 3.98 g, 4.48 g and 4.23 g seedling dry weights were recorded by 1999, 2000 and pooled values respectively. In the pooled values numerically high (4.60 g) and low (3.80 g) seedling dry weights were recorded by T₁₁ and T₆ treatments respectively.

4.1.3.5 Seedling vigour index

The data on seedling vigour index of 1999, 2000 and pooled are presented in Table 4.23.

The seedling vigour showed significant difference in both the years of experimentation as well as pooled values. An average of 1877, 2044 and 1961 indices values were recorded in 1999, 2000 and pooled data respectively. In the year-wise pooled data vigour indices value was significantly higher (2219) with treatment T₁₁. This was followed by treatments T₁₂ (2119), T₈ (2109) and T₉ (2087) which were at par with each other and also with treatment T₁₁. The treatments T₁, T₂, T₄, T₅ and T₆ recorded significantly less indices values and were on par with each other.

4.1.3.6 Electrical conductivity of seed leachate (dSm⁻¹)

The seed leachate values of 1999, 2000 and year-wise pooled are presented in Table 4.24.

In both years of experimentation as well as pooled values seed leachate electrical conductivity values recorded significant differences.

The treatment T₁₁ recorded significantly lowest (0.193, 0.179 and 0.186 dSm⁻¹) and T₁₂ recorded (0.193, 0.181 and 0.187 dSm⁻¹) seed leachate values during 1999, 2000 and pooled data respectively and both

Table 4.23. Effect of organic, inorganic nutrients and bio-fertilizers on seedling vigour index in groundnut

Treatments	Seedling vigour index		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	1647	1791	1719
T ₂ - T ₁ + FYM (5 t/ha)	1805	1966	1886
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	1844	1987	1916
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	1780	1933	1857
T ₅ - T ₁ + Gypsum (5 q/ha)	1768	1891	1830
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1677	1848	1763
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	1963	2114	2039
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	2021	2197	2109
T ₉ - T ₂ + Gypsum (5 q/ha)	2014	2160	2087
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1933	2061	1997
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	2167	2331	2249
T ₁₂ - T ₃ + Gypsum (5 q/ha)	1991	2247	2119
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1880	2067	1974
T ₁₄ - T ₄ + Gypsum (5 q/ha)	1820	2075	1947
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1897	2021	1959
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	1827	2020	1924
Mean	1877	2044	1961
S.Em±	92	95	66
C.D. at 5 %	266	274	191

Table 4.24. Effect of organic, inorganic nutrients and bio-fertilizers on electrical conductivity of seed leachate (dSm^{-1}) in groundnut

Treatments	Electrical conductivity of seed leachate (dSm^{-1})		
	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	0.250	0.238	0.244
T ₂ - T ₁ + FYM (5 t/ha)	0.233	0.220	0.226
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	0.230	0.217	0.224
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	0.239	0.226	0.233
T ₅ - T ₁ + Gypsum (5 q/ha)	0.241	0.229	0.235
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	0.245	0.233	0.239
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	0.202	0.189	0.196
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	0.195	0.184	0.189
T ₉ - T ₂ + Gypsum (5 q/ha)	0.200	0.187	0.193
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	0.210	0.198	0.204
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	0.193	0.179	0.186
T ₁₂ - T ₃ + Gypsum (5 q/ha)	0.193	0.181	0.187
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	0.207	0.193	0.200
T ₁₄ - T ₄ + Gypsum (5 q/ha)	0.215	0.203	0.209
T ₁₅ - T ₄ +Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	0.220	0.208	0.214
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	0.223	0.212	0.217
Mean	0.218	0.206	0.212
S.Em _±	0.007	0.005	0.004
C.D. at 5 %	0.020	0.014	0.012

these treatments were at par with each other along with treatments T₇, T₈ and T₉ for both the years as well in pooled observations. T₁ treatment recorded significantly highest (0.250, 0.238 and 0.244 dSm⁻¹) seed leachate values during 1999, 2000 and pooled values respectively which were at par with T₄, T₅ and T₆ treatments in pooled data.

4.2 EXPERIMENT - II : EFFECT OF MICRONUTRIENTS AND METHODS OF APPLICATIONS ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of in all 28 treatment combinations involving four micronutrients and seven methods of applications. The experiment was conducted in randomized block design with factorial concept and was replicated thrice. The results of this experiment are presented hereunder.

4.2.1 Growth parameters

4.2.1.1 Plant height (cm) at 60 DAS

The data on influence of micronutrients and methods of applications on plant height at 60 days after sowing (DAS) of 1999, 2000 and pooled values are presented in Table 4.25.

Irrespective of the methods of application, micronutrients recorded significant difference on plant height at 60 DAS during 2000 and also in pooled values. The C₀ micronutrient significantly recorded minimum (27.29 and 26.98 cm) plant height with 2000 and pooled values respectively over other micronutrients. In the 2000 and pooled data

Table 4.25. Influence of micronutrients and methods of applications on plant height (cm) at 60 DAS in groundnut

Treatments	Plant height (cm) at 60 DAS														
	1999					2000					Pooled				
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	
A ₁	26.64	27.68	27.26	27.94	27.38	27.19	28.37	27.95	28.53	28.01	26.92	28.03	27.61	28.24	27.70
A ₂	27.05	29.02	29.56	29.61	28.81	27.61	29.60	30.02	30.34	29.39	27.33	29.31	29.79	29.98	29.10
A ₃	26.48	28.06	28.87	28.44	27.96	27.06	28.78	29.40	29.22	28.62	26.77	28.42	29.14	28.83	28.29
A ₄	26.75	31.18	32.86	31.48	30.57	27.34	31.96	32.58	22.11	28.50	27.05	31.57	32.72	26.80	29.53
A ₅	26.55	31.14	31.07	30.96	29.93	27.03	31.75	31.87	31.69	30.59	26.79	31.45	31.47	31.33	30.26
A ₆	26.11	31.47	31.74	31.88	30.30	26.81	32.13	32.55	32.77	31.07	26.46	31.80	32.15	32.33	30.68
A ₇	27.15	29.95	30.08	30.86	29.51	27.99	30.60	30.72	31.54	30.21	27.57	30.28	30.40	31.20	29.86
Mean	26.68	29.79	30.21	30.17	29.21	27.29	30.46	30.73	29.46	29.48	26.98	30.12	30.47	29.81	29.35
For comparing the means of	S.Em±				C.D. at 5%	S.Em±				C.D. at 5%	S.Em±				C.D. at 5%
C	1.04				NS	0.67				1.91	0.62				1.76
A	1.37				NS	0.89				NS	0.82				NS
C x A	2.74				NS	1.78				NS	1.64				NS

NS - Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g /kg

Zn SO₄ - 2 g/kg

Soil application : Fe SO₄- 25 kg /ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

micronutrients C₁, C₂ and C₃ were significantly higher than C₀ micronutrient but were at par with each other.

Plant height at 60 DAS did not show any significant differences due to methods of micronutrient application in both the years of experimentation and also in pooled data. In the pooled data, it was numerically high (30.68 cm) and low (27.70 cm) with A₆ and A₁ methods of application respectively.

Interaction effect between micronutrients and methods of application (C x A) on plant height at 60 DAS was non-significant in both the years and in pooled data. In the pooled data, it was numerically high (32.33 cm) in C₃A₆ and low (26.46 cm) in C₀A₆ treatment combinations. An over all average 29.35 cm plant height was recorded.

4.2.1.2 Plant height (cm) at harvest

The data on plant height at harvest due to micronutrients and methods of application are presented in Table 4.26.

Plant height at harvest differed significantly due to micronutrients irrespective of methods of application in both the years and pooled data. The micronutrients C₁, C₂ and C₃ were at par with each other in both years and also in pooled values of plant height but were significantly higher than C₀ micronutrient.

Methods of application recorded significant differences in plant height at harvest only during 2000 and in pooled values irrespective of micronutrients. In the pooled values, it was significantly high (43.48 cm) in A₆ method of application and was on par with A₂, A₄, A₅ and A₇

Table 4.26. Influence of micronutrients and methods of applications on plant height (cm) at harvest in groundnut

Treatments	Plant height (cm) at harvest															
	1999						2000									
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean	
	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		
Methods of application (A)																
A ₁	37.73	38.74	39.15	39.68	38.83	38.20	39.32	39.84	40.16	39.38	37.97	39.03	39.50	39.92	39.10	
A ₂	38.24	41.13	41.88	42.04	40.82	38.88	41.79	42.27	42.65	41.40	38.56	41.46	42.08	42.35	41.11	
A ₃	37.90	39.89	40.15	40.66	39.65	38.53	40.41	40.80	41.12	40.22	38.22	40.15	40.48	40.89	39.93	
A ₄	37.95	44.21	44.38	44.62	42.79	38.44	44.96	45.18	45.29	43.47	38.20	44.59	44.78	44.96	43.13	
A ₅	38.04	43.51	43.68	43.89	42.28	38.67	44.05	44.23	44.51	42.87	38.36	43.78	43.96	44.20	42.57	
A ₆	37.64	44.68	44.88	45.11	43.08	38.31	45.23	45.45	45.77	43.69	37.98	44.96	45.17	45.44	43.38	
A ₇	38.15	42.57	42.75	43.11	41.65	38.79	43.10	36.65	43.74	40.57	38.47	42.84	39.70	43.43	41.11	
Mean	37.95	42.10	42.41	42.73	41.30	38.55	42.69	42.06	43.32	41.66	38.25	42.40	42.24	43.03	41.48	
For comparing the means of	S.Em _±				C.D. at 5%				S.Em _±				C.D. at 5%			
C	1.04				2.96				0.80				0.66			
A	1.38				NS				1.05				0.87			
C x A	2.76				NS				2.11				1.74			
					NS								NS			

NS – Non significant

Methods of application (A)

A₁ – Seed treatment

A₂ – Soil application

A₃ – Foliar spray (at 40 DAS)

A₄ – Seed treatment + Soil application

A₅ – Seed treatment + Foliar spray (at 40 DAS)

A₆ – Soil application + Foliar spray (at 40 DAS)

A₇ – Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

C₀ – No micronutrient

C₁ – Fe SO₄

C₂ – Zn SO₄

C₃ – Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

methods of applications. Significantly less (39.10 cm) plant height was recorded by A₁ method of application and was at par with A₂, A₃ and A₇ methods of applications.

Interaction effect between C x A was non-significant in both the years and pooled data. In the pooled data an average plant height of 41.48 cm was recorded at harvest.

4.2.1.3 Number of branches per plant at harvest

The observations on number of branches per plant at harvest due to micronutrients and methods of application of 1999, 2000 and pooled values are presented in Table 4.27.

Micronutrients irrespective of methods of application recorded significant difference on number of branches in 2000 and pooled data. C₀ micronutrient recorded significantly minimum (6.50 and 6.16) branches in 2000 and pooled data respectively over the other micronutrients and C₁, C₂ and C₃ micronutrients were on par with each other.

Methods of application irrespective of micronutrients recorded significant difference on number of branches during 2000 and in pooled data. A₆ method of application recorded significantly maximum (7.88 and 7.41) branches in 2000 and pooled values respectively but was on par with A₄, A₅ and A₇ methods of applications. Significantly minimum (6.60 and 6.28) branches were recorded by A₁ method of application in 2000 and pooled values respectively and again this method of application was at par with A₂ and A₃ methods of applications.

Table 4.27. Influence of micronutrients and methods of applications on number of branches per plant at harvest in groundnut

Treatments	Number of branches per plant at harvest																	
	1999						2000											
	Micronutrients (C)				Mean	Micronutrients (C)				Mean								
	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃									
Methods of application (A)																		
A ₁	5.70	5.90	6.20	6.00	5.95	6.40	4.60	6.70	6.70	6.60	6.05	6.25	6.45	6.35	6.28			
A ₂	5.80	6.30	6.60	6.40	6.28	6.50	7.00	7.10	7.10	6.93	6.15	6.65	6.85	6.75	6.60			
A ₃	5.70	6.30	6.10	6.40	6.13	6.40	6.80	6.80	6.90	6.73	6.05	6.55	6.45	6.65	6.43			
A ₄	6.00	7.30	7.50	7.40	7.05	6.60	8.10	8.20	8.20	7.78	6.30	7.70	7.85	7.80	7.41			
A ₅	5.80	7.20	7.30	7.50	6.95	6.50	7.90	8.00	8.10	7.63	6.15	7.55	7.65	7.80	7.29			
A ₆	5.80	7.60	7.60	6.80	6.95	6.50	8.30	8.30	8.40	7.88	6.15	7.95	7.95	7.60	7.41			
A ₇	6.00	6.80	7.10	7.50	6.85	6.60	7.40	7.70	7.90	7.40	6.30	7.10	7.40	7.70	7.13			
Mean	5.83	6.77	6.91	6.86	6.59	6.50	7.44	7.54	7.61	7.28	6.16	7.11	7.23	7.24	6.93			
For comparing the means of	S.Em _±				C.D. at 5%				S.Em _±				C.D. at 5%					
C	0.38				NS				0.20				0.58				0.61	
A	0.50				NS				0.27				0.77				0.80	
C x A	1.00				NS				0.54				NS				NS	

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
A₂ - Soil application
A₃ - Foliar spray (at 40 DAS)
A₄ - Seed treatment + Soil application
A₅ - Seed treatment + Foliar spray (at 40 DAS)
A₆ - Soil application + Foliar spray (at 40 DAS)
A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
C₁ - Fe SO₄
C₂ - Zn SO₄
C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

In both the years of experimentation and in pooled data the interaction between C x A on number of branches was non significant. In the pooled data an overall 6.93 branches were recorded.

4.2.1.4 Days to 50 per cent flowering

The data on days to 50 per cent flowering of both the years and pooled are presented in Table 4.28.

Irrespective of the methods of application micronutrients recorded significant difference on days to 50 per cent flowering in both years and pooled values. In both years and pooled values C₀ micronutrient took significantly more days to 50 per cent flowering over other micronutrients and all other micronutrients were at par with each other.

Irrespective of the micronutrients, methods of application produced significant differences on days taken to 50 per cent flowering in both the years and pooled values. The method of application A₆ took significantly less (36.69) days to 50 per cent flowering in the pooled data and was on par with A₄ (37.06 days) and A₅ (37.38 days) methods of applications. Whereas, A₁ method of application took significantly more (39.81) days to 50 per cent flowering which was at par with A₃ (39.19 days) method of application.

Only in the pooled values the interaction effect produced significant difference on days to 50 per cent flowering. An average 38.11 days were taken to 50 per cent flowering. Days taken to 50 per cent flowering ranged between 35.15 to 40.70 days.

Table 4.28. Influence of micronutrients and methods of applications on days to 50 per cent flowering in groundnut

Treatments	Days to 50 per cent flowering											
	1999				2000				Pooled			
	Micronutrients (C)			Mean	Micronutrients (C)			Mean	Micronutrients (C)			Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃
A ₁	40.80	39.80	39.80	39.40	39.95	40.50	39.60	39.50	39.10	39.68	39.65	39.25
A ₂	40.40	38.50	38.10	38.00	38.75	40.00	38.00	37.70	37.70	38.35	37.90	37.85
A ₃	40.20	39.30	39.00	38.80	39.33	40.00	38.90	38.70	38.60	39.05	38.85	38.70
A ₄	40.60	36.30	36.00	35.80	37.18	40.40	36.00	35.80	35.60	36.95	35.90	35.70
A ₅	40.50	36.80	36.50	36.60	37.60	40.30	36.50	35.60	36.20	37.15	36.05	36.40
A ₆	40.90	35.70	35.50	35.30	36.85	40.50	35.30	35.30	35.00	36.53	35.40	35.15
A ₇	40.7	37.60	37.50	37.20	38.25	40.40	37.30	37.30	36.80	37.95	37.40	37.00
Mean	40.59	37.71	37.49	37.30	38.27	40.30	37.37	37.13	37.00	37.95	37.31	37.15
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
C	0.27			0.76	0.26			0.74	0.19			0.53
A	0.36			1.01	0.34			0.98	0.25			0.70
C x A	0.71			NS	0.69			NS	0.49			1.40

NS - Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g / kg

Zn SO₄ - 2 g/kg

Soil application : Fe SO₄- 25 kg /ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

4.2.1.5 Days to peg initiation

The data on days to peg initiation as influenced by micronutrients and methods of application are presented in Table 4.29.

In both the years and pooled values micronutrients recorded significant differences in days to peg initiation. The micronutrients C₁, C₂ and C₃ were at par with each other and took significantly less days to peg initiation than C₀ micronutrient in both years and pooled values.

Methods of application produced significant differences on days to peg initiation in 1999 and pooled values. In the pooled data significantly less (52.15, 51.63 and 52.66) days were taken by A₄, A₆ and A₇ methods of application respectively and were on par with each other. The other methods of application were at par with each other and these took significantly more days to peg initiation.

The interaction effect was non significant in 1999, 2000 and pooled data. In the pooled data an average of 52.94 days were recorded for peg initiation.

4.2.1.6 Days to pod maturity

The data on days taken to pod maturity of 1999, 2000 and pooled are presented in Table 4.30.

Over the methods of application C₀ micronutrient registered significantly more (108.3, 108.4 and 108.4) days to pod maturity in 1999, 2000 and pooled data respectively. The other micronutrients were at par with each other and registered significantly less days to pod maturity.

Table 4.29. Influence of micronutrients and methods of applications on days to peg initiation in groundnut

Treatments	Days to peg initiation															
	1999						2000									
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Pooled					
	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	Mean	
Methods of application (A)																
A ₁	54.60	54.00	53.90	53.90	54.10	54.30	53.80	53.80	53.70	53.60	53.85	54.45	53.90	53.80	53.75	53.98
A ₂	54.00	53.40	53.10	52.90	53.35	53.80	53.00	53.00	52.60	52.60	53.00	53.90	53.20	52.85	52.75	53.18
A ₃	54.50	53.90	53.80	53.60	53.95	54.00	53.70	53.70	53.50	53.40	53.65	54.25	53.80	53.65	53.50	53.80
A ₄	54.20	51.30	51.30	51.20	52.00	54.00	49.90	51.00	51.00	54.33	52.31	54.10	50.60	51.15	52.77	52.15
A ₅	54.80	52.00	51.90	51.70	52.60	54.50	51.60	51.60	51.60	57.40	53.78	54.65	51.80	51.75	54.55	53.19
A ₆	54.70	51.00	50.90	50.50	51.78	54.50	50.70	50.70	50.50	50.20	51.48	54.60	50.85	50.70	50.35	51.63
A ₇	54.40	52.50	52.50	52.40	52.95	54.00	51.20	51.20	52.30	52.00	52.38	54.20	51.85	52.40	52.20	52.66
Mean	54.46	52.59	52.49	52.31	52.96	54.16	51.99	51.99	52.17	53.36	52.92	54.31	52.29	52.33	52.84	52.94
For comparing the means of	S.Em _±				C.D. at 5%				S.Em _±				C.D. at 5%			
C	0.29				0.81				0.52				1.49			
A	0.38				1.08				0.69				NS			
C x A	0.76				NS				1.39				NS			
									S.Em _±				C.D. at 5%			
									0.30				0.85			
									0.40				1.14			
									0.79				NS			

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg / ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

Table 4.30. Influence of micronutrients and methods of applications on days to pod maturity in groundnut

Treatments	Days to pod maturity											
	1999				2000				Pooled			
	Micronutrients (C)			Mean	Micronutrients (C)			Mean	Micronutrients (C)			Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃
A ₁	107.9	107.1	107.1	107.2	108.2	107.7	107.5	107.6	108.1	107.4	107.3	107.4
A ₂	108.0	105.2	104.7	104.8	108.4	105.5	105.3	105.0	108.2	105.4	105.0	104.9
A ₃	108.5	105.9	106.0	106.1	108.6	106.9	106.6	106.3	108.6	106.4	106.3	106.2
A ₄	108.1	99.9	100.5	100.0	108.8	100.4	100.3	100.0	108.5	100.2	100.4	100.0
A ₅	107.7	102.2	102.0	102.3	108.0	102.9	102.5	102.0	107.9	102.6	102.3	102.2
A ₆	109.1	97.9	98.3	97.9	108.5	98.6	98.5	97.3	108.8	98.3	98.4	97.6
A ₇	109.1	102.8	102.6	102.8	108.3	104.8	104.6	104.5	108.7	103.8	103.6	103.6
Mean	108.3	103.0	103.0	103.0	108.4	103.8	103.6	103.2	108.4	103.4	103.3	103.1
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
C	0.6			1.6	0.3			1.0	0.3			0.9
A	0.7			2.1	0.5			1.3	0.4			1.2
C x A	1.5			NS	0.9			2.6	0.9			2.4

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

In both the years and pooled values days to pod maturity differed significantly due to methods of application over micronutrients. A₆ method of application registered significantly less (100.8, 100.7 and 100.8) days to pod maturity over other methods of application in 1999, 2000 and pooled data respectively. Significantly more days were taken by A₁ and A₃ methods of application.

The interaction between C x A was significant during 2000 and in pooled data. The days to pod maturity ranged from 97.6 days (C₃A₆) to 108.8 days (C₀A₆) in the pooled data. An over all average 104.6 days were taken to pod maturity.

4.2.1.7 Number of nodules per plant

The data of 1999, 2000 and pooled on number of nodules per plant are presented in Table 4.31.

Micronutrients also showed significant differences on number of nodules irrespective of methods of application in 1999, 2000 and pooled values. In both the years and pooled data C₀ micronutrient recorded significantly less number of nodules over other micronutrients and other micronutrients were at par with each other.

Number of nodules per plant irrespective of micronutrients recorded significant differences due to methods of application in 1999, 2000 and pooled data. In the pooled data it was significantly maximum (71.56) with A₆ method of application which was at par with A₄ (69.97) and A₅ (69.05) methods of applications. While, it was significantly minimum (64.64) with

Table 4.31. Influence of micronutrients and methods of applications on number of nodules per plant in groundnut

Treatments	Number of nodules per plant															
	1999					2000					Pooled					
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)		Mean			
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		
A ₁	60.10	62.40	62.60	65.60	62.68	64.90	66.70	67.50	67.30	66.60	62.50	64.55	65.05	66.45	64.64	
A ₂	60.20	64.90	67.50	66.30	64.73	64.10	70.00	71.20	71.40	69.18	62.15	67.45	69.35	68.85	66.95	
A ₃	60.20	65.70	65.00	66.30	64.30	64.60	69.80	69.00	70.10	68.38	62.40	67.75	67.00	68.20	66.34	
A ₄	58.70	70.00	71.20	70.50	67.60	63.30	74.50	75.70	75.90	72.35	61.00	72.25	73.45	73.20	69.97	
A ₅	60.10	68.70	69.90	69.80	67.13	64.00	73.10	73.30	73.50	70.98	62.05	70.90	71.60	71.65	69.05	
A ₆	60.10	72.30	72.10	72.80	69.33	64.70	76.90	76.20	77.40	73.80	62.40	74.60	74.15	75.10	71.56	
A ₇	59.90	68.20	67.50	68.50	66.05	64.60	72.80	72.00	72.20	70.40	62.25	70.50	69.75	70.40	68.23	
Mean	59.90	67.46	67.97	68.56	65.97	64.31	71.97	72.13	72.54	70.24	62.11	69.71	70.05	70.55	68.11	
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%				S.Em _±		C.D. at 5%
C	0.89				2.54	1.21				3.42				0.76		2.13
A	1.18				3.35	1.60				4.53				0.99		2.82
C x A	2.37				NS	3.19				NS				1.99		NS

NS - Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g /kg

Zn SO₄ - 2 g /kg

Soil application : Fe SO₄- 25 kg /ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

A₁ method of application and this was on par with A₃ (66.34) and A₂ (66.95) methods of applications.

The interaction effect was non significant in both the years and also in pooled data. Overall 68.11 number of nodules were recorded in the pooled data.

4.2.1.8 Nodule dry weight (mg/plant)

The data on nodule dry weight of both the years and pooled values are presented in Table 4.32.

Micronutrients also exhibited significant differences in nodule dry weight over methods of application in both the years and pooled values. C₂ and C₃ micronutrients were at par with each other and were significantly higher than other micronutrients. C₀ micronutrient recorded significantly lesser (89.9, 94.6 and 92.2 mg/plant) nodule dry weights in 1999, 2000 and pooled data respectively over other micronutrients.

During both the years and also in pooled values nodule dry weight differed significantly due to methods of application over micronutrients. A₆ method of application recorded significantly maximum (126.0, 131.0 and 128.5 mg/plant) nodule dry weights in 1999, 2000 and pooled values respectively over other methods of applications. A₁ and A₃ methods of applications were on par with each other and recorded significantly minimum nodule dry weights.

Interaction effect between C x A was also significant in both years and in pooled values. Irrespective of the micronutrients and methods of applications in the pooled data it was significantly maximum

Table 4.32. Influence of micronutrients and methods of applications on nodule dry weight (mg/plant) in groundnut

Treatments	Nodule dry weight (mg/plant)															
	1999					2000					Pooled					
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)		Mean			
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	Mean	
A ₁	90.7	90.2	91.5	92.5	91.2	94.5	96.6	97.0	97.3	96.4	92.6	93.4	94.3	94.9	93.8	
A ₂	89.8	100.1	100.1	100.9	97.7	94.3	104.8	106.6	107.4	103.3	92.1	102.5	103.3	104.2	100.5	
A ₃	90.0	93.5	95.8	98.9	94.6	94.7	99.6	100.3	100.7	99.6	92.4	96.6	98.1	101.3	97.1	
A ₄	88.8	122.4	128.4	130.8	117.6	94.1	128.0	132.7	136.3	122.8	91.5	125.2	130.6	133.6	120.2	
A ₅	89.8	115.3	115.4	120.1	110.2	94.9	119.0	121.5	124.8	115.1	92.4	117.2	118.5	122.5	112.6	
A ₆	90.1	135.2	138.0	140.8	126.0	94.6	139.6	142.1	147.5	131.0	92.4	137.4	140.1	144.2	128.5	
A ₇	90.1	105.1	110.1	111.0	104.1	94.8	111.1	114.4	116.3	109.2	92.5	108.3	112.3	113.6	106.7	
Mean	89.9	108.9	111.3	113.4	105.9	94.6	114.1	116.4	119.0	111.0	92.2	111.5	113.9	116.3	108.5	
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%				S.Em _±		C.D. at 5%
C	1.4				3.9	1.9				5.4				1.2		3.3
A	1.8				5.1	2.5				7.1				1.5		4.4
C x A	3.6				10.2	5.0				14.2				3.1		8.7

Methods of application (A)

- | | Seed treatment | Soil application | Foliar spray (at 40 DAS) | Seed treatment + Soil application | Seed treatment + Foliar spray (at 40 DAS) | Soil application + Foliar spray (at 40 DAS) | Seed treatment + Soil application + Foliar spray (at 40 DAS) |
|----------------|----------------|------------------|--------------------------|-----------------------------------|---|---|--|
| A ₁ | - | - | - | - | - | - | - |
| A ₂ | - | - | - | - | - | - | - |
| A ₃ | - | - | - | - | - | - | - |
| A ₄ | - | - | - | - | - | - | - |
| A ₅ | - | - | - | - | - | - | - |
| A ₆ | - | - | - | - | - | - | - |
| A ₇ | - | - | - | - | - | - | - |

Micronutrients (C)

- | | |
|----------------|---|
| C ₀ | - No micronutrient |
| C ₁ | - Fe SO ₄ |
| C ₂ | - Zn SO ₄ |
| C ₃ | - Fe SO ₄ + Zn SO ₄ |

Seed treatment: $\text{Fe SO}_4 - 2 \text{ g/kg}$

- Soil application :** Fe SO₄– 25 kg /ha
Zn SO₄– 2 g/kg
- Foliar spray :** Fe SO₄ – 0.4%
Zn SO₄ – 0.5%

(144.2 mg/plant) in C₃A₆ treatment combination which was on with C₂A₆ (140.1 mg/plant) and C₁A₆ (137.4 mg/plant) treatment combinations. Over all 108.5 mg nodule dry weight per plant was recorded in the pooled values.

4.2.2 Yield Parameters

4.2.2.1 Number of mature pods per plant

The data of 1999, 2000 and pooled on number of mature pods per plant are presented in Table 4.33.

Micronutrients also showed significant differences on number of mature pods per plant. Irrespective of methods of application C₁, C₂ and C₃ micronutrients were on par with each other in both the years and also in pooled data but were significantly higher than C₀ micronutrient. The number of mature pods in the pooled data were 13.98, 14.11 and 14.57 with C₁, C₂ and C₃ micronutrients.

Number of mature pods per plant differed significantly due to methods of application in both the years and also in pooled data. Irrespective of micronutrients A₆ method of application in the pooled data registered significantly maximum (15.28) mature pods per plant and this method was followed by A₄ method of application with 14.68 number of mature pods. Both these methods of application were on par with each other. Significantly minimum (10.94 and 11.80) number of mature pods were recorded by A₁ and A₃ methods of application. Similar trend was recorded in both the years of experimentation.

Table 4.33. Influence of micronutrients and methods of applications on number of mature pods per plant in groundnut

Treatments	Number of mature pods per plant														
	1999					2000					Pooled				
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)		Mean		
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	
A ₁	9.86	11.18	11.44	11.63	11.03	10.22	11.63	9.35	12.17	10.84	10.04	11.41	10.40	11.90	10.94
A ₂	10.01	12.90	13.27	13.22	12.35	10.41	13.31	13.66	13.94	12.83	10.21	13.11	13.47	13.58	12.59
A ₃	9.84	11.85	12.13	12.37	11.55	10.38	12.34	12.61	12.90	12.06	10.11	12.10	12.37	12.64	11.80
A ₄	10.02	15.58	15.91	16.29	14.45	10.54	16.07	16.38	16.64	14.91	10.28	15.83	16.15	16.47	14.68
A ₅	9.87	14.40	14.82	15.34	13.61	10.27	15.05	15.43	15.88	14.16	10.07	14.73	15.13	15.61	13.88
A ₆	9.85	16.46	16.84	17.06	15.05	10.35	16.93	17.21	17.52	15.50	10.10	16.70	17.03	17.29	15.28
A ₇	9.88	13.75	13.94	14.16	12.93	10.46	14.24	14.51	14.79	13.50	10.17	14.00	14.23	14.48	13.22
Mean	9.90	13.73	14.05	14.30	13.00	10.38	14.22	14.17	14.83	13.40	10.14	13.98	14.11	14.57	13.20
For comparing the means of	S.Em _±	C.D. at 5%				S.Em _±	C.D. at 5%				S.Em _±	C.D. at 5%			
C	0.23	0.64				0.64	1.81				0.34	0.96			
A	0.30	0.85				0.85	2.40				0.45	1.27			
C x A	0.60	1.69				1.69	NS				0.90	NS			

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
A₂ - Soil application
A₃ - Foliar spray (at 40 DAS)
A₄ - Seed treatment + Soil application
A₅ - Seed treatment + Foliar spray (at 40 DAS)
A₆ - Soil application + Foliar spray (at 40 DAS)
A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
C₁ - Fe SO₄
C₂ - Zn SO₄
C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g / kg
Zn SO₄ – 2 g / kg

Soil application : Fe SO₄– 25 kg / ha
Zn SO₄ – 25 kg / ha

Foliar spray : Fe SO₄ – 0.4%
Zn SO₄ – 0.5%

The interaction effect between C x A was significant only in 1999. Mature pods were significantly maximum (17.06) in C₃A₆ treatment combination and this treatment was on par with C₂A₆, C₁A₆, C₃A₄, C₂A₄ and C₁A₄ treatment combinations.

4.2.2.2 Number of immature pods per plant

The values of immature pods per plant as influenced by micronutrients and methods of application are presented in Table 4.34.

Irrespective methods of application, C₀ micronutrient recorded significantly more (7.80, 8.33 and 8.06) immature pods in 1999, 2000 and pooled values respectively. The other micronutrients were at par with each other.

Irrespective of micronutrients, methods of application exhibited significant difference on number of immature pods per plant in pooled and both the years data. A₆ and A₄ methods of application registered significantly less 4.72 and 5.32 number of immature pods per plant respectively in the pooled data while A₁, A₂ and A₃ methods of application recorded significantly more (7.72, 6.74 and 7.21) immature pods respectively. similar trend was noticed in both the years of experimentation.

Interaction effect between C x A was non-significant. An average of 6.03, 6.53 and 6.28 number of immature pods were recorded in 1999, 2000 and pooled values respectively.

Table 4.34. Influence of micronutrients and methods of applications on number of immature pods per plant in groundnut

Treatments	Number of immature pods per plant																	
	1999					2000					Pooled							
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)		Mean					
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃				
A ₁	7.83	7.35	7.27	7.18	7.41	8.36	8.05	7.96	7.74	8.03	8.10	7.70	7.62	7.46	7.72			
A ₂	7.77	6.29	5.94	5.87	6.47	8.31	6.83	6.59	6.31	7.01	8.04	6.56	6.27	6.09	6.74			
A ₃	7.86	6.81	6.66	6.43	6.94	8.29	7.40	7.19	7.04	7.48	8.08	7.11	6.93	6.74	7.21			
A ₄	7.79	4.41	4.21	3.74	5.04	8.34	4.95	4.73	4.38	5.60	8.07	4.68	4.47	4.06	5.32			
A ₅	7.77	5.04	4.86	5.75	5.86	8.38	5.49	5.26	5.12	6.06	8.08	5.27	5.06	5.44	5.86			
A ₆	7.78	3.58	3.35	3.12	4.46	8.35	4.04	3.96	3.61	4.99	8.07	3.81	3.66	3.36	4.72			
A ₇	7.77	5.59	5.46	5.37	6.05	8.30	6.06	5.98	5.81	6.54	8.04	5.83	5.72	5.59	6.29			
Mean	7.80	5.58	5.39	5.35	6.03	8.33	6.12	5.95	5.72	6.53	8.06	5.85	5.67	5.53	6.28			
For comparing the means of	S.Em _±				C.D. at 5%		S.Em _±				C.D. at 5%		S.Em _±		C.D. at 5%			
C	0.42				1.18		0.44				1.24		0.30				0.86	
A	0.55				1.56		0.58				1.65		0.40				1.13	
C x A	1.10				NS		1.16				NS		0.80				NS	

4.2.2.3 Pod yield (g/plant)

The per plant pod yield was significant only due to main treatment effect while, the interaction effect was non-significant in both the years and also in pooled values and these are presented in Table 4.35.

The micronutrients C_1 , C_2 and C_3 recorded significantly more (10.19, 10.35 and 10.62 g/plant) pod yield respectively in the pooled data over C_0 (7.67 g/plant) micronutrient. Similar trend was recorded in both the years of experimentation.

The methods of application A_6 , A_4 and A_5 were on par with each other in both the years and in pooled data. These methods recorded significantly more (10.94, 10.59 and 10.26 g/plant) pod yield respectively in pooled data over other methods of application. Significantly less (8.18 and 8.81 g/plant) pod yields were recorded by A_1 and A_3 methods of application respectively.

An average 9.46, 9.96 and 9.71 g pod yield per plant was recorded with 1999, 2000 and pooled values.

4.2.2.4 Pod yield (kg/ha)

The influence of micronutrients and methods of application on per hectare pod yield data are presented in Table 4.36.

Micronutrients also exhibited significant differences on pod yield in pooled and year-wise data. Significantly higher pod yields were recorded by C_1 , C_2 and C_3 micronutrients in pooled and year-wise data over C_0 micronutrient.

Table 4.35. Influence of micronutrients and methods of applications on pod yield (g/plant) in groundnut

Treatments	Pod yield (g/plant)											
	1999						2000					
	Micronutrients (C)			Mean			Micronutrients (C)			Mean		
	C ₀	C ₁	C ₂	C ₃			C ₀	C ₁	C ₂	C ₃		
A ₁	7.43	7.94	8.02	8.33	7.93		7.92	8.35	8.55	8.91	8.43	
A ₂	7.41	9.42	7.75	9.98	9.14		7.88	9.92	10.13	10.40	9.58	
A ₃	7.51	8.65	8.80	9.25	8.55		7.96	9.11	9.39	9.77	9.06	
A ₄	7.32	11.34	11.22	11.37	10.31		7.90	11.74	11.88	11.93	10.86	
A ₅	7.46	10.66	10.81	11.10	10.01		7.94	11.13	11.31	11.63	10.50	
A ₆	7.47	11.55	11.67	12.02	10.68		7.98	12.08	12.21	12.54	11.20	
A ₇	7.49	10.13	10.34	10.44	9.60		7.95	10.66	10.81	10.95	10.09	
Mean	7.44	9.96	10.09	10.36	9.46		7.93	10.43	10.61	10.88	9.96	
For comparing the means of	S.Em _±			C.D. at 5%			S.Em _±			C.D. at 5%		
C	0.24			0.69			0.36			1.02		
A	0.32			0.91			0.48			1.37		
C x A	0.64			NS			0.96			NS		
							S.Em _±			C.D. at 5%		
							0.22			0.62		
							0.29			0.82		
							0.58			NS		

NS - Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g / kg

Zn SO₄ - 2 g / kg

Soil application : Fe SO₄- 25 kg / ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

Table 4.36. Influence of micronutrients and methods of applications on pod yield (kg/ha) in groundnut

Treatments	Pod yield (kg/ha)															
	1999					2000					Pooled					
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean	
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		
A ₁	2033	2172	2192	2276	2168	2249	2370	2427	2527	2393	2141	2271	2309	2402	2281	
A ₂	2026	2570	2662	2727	2496	2234	2816	2874	2951	2719	2130	2693	2768	2839	2608	
A ₃	2053	2365	2404	2527	2337	2261	2585	2666	2770	2571	2157	2475	2535	2649	2454	
A ₄	2002	3098	3067	3106	2819	2238	3329	3368	3384	3080	2120	3214	3218	3245	2949	
A ₅	2037	2909	2952	3029	2732	2253	3156	3210	3299	2980	2145	3032	3081	3164	2856	
A ₆	2037	3156	3187	3283	2916	2265	3426	3465	3557	3178	2151	3291	3326	3420	3047	
A ₇	2045	2766	2828	2851	2622	2257	3021	3063	3106	2862	2151	2893	2946	2979	2742	
Mean	2033	2719	2756	2829	2584	2251	2958	3010	3085	2826	2142	2839	2883	2957	2705	
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%				S.Em _±		C.D. at 5%
C	66				187	103				293				61		174
A	87				248	137				388				81		230
C x A	175				NS	273				NS				162		NS

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

Significant differences on per hectare pod yield were noticed due to methods of application in both the years and pooled data. A₆ method of application recorded significantly maximum (3047 kg/ha) pod yield in pooled data and this method could not exhibit any significant difference with A₄ and A₅ methods of application. Similar trend was noticed in both the years of experimentation.

Interaction effect was non-significant. An average (2705 kg/ha) pod yield was recorded in the pooled data.

4.2.2.5 Shelling percentage

The data on shelling percentage are presented in Table 4.37.

In both the years of experimentation and pooled values, shelling recorded significant differences due to micronutrients. Significantly least shelling percentage was recorded by C₀ micronutrient in both the years and pooled values while, other micronutrients were at par with each other by recording higher shelling percentage.

Shelling percentage recorded significant differences due to methods of application in pooled and 2000 year values. In the pooled data A₄ and A₆ methods recorded significantly maximum (67.26 and 68.06 %) shelling respectively. While, A₁, A₂, A₃ and A₇ methods recorded significantly minimum shelling percentage.

Interaction between C x A was non-significant in the pooled data and an average 66.35 per cent shelling was recorded.

Table 4.37. Influence of micronutrients and methods of applications on shelling percentage in groundnut

Treatments	Shelling percentage												
	1999						2000						
	Micronutrients (C)			Mean	Micronutrients (C)			Mean	Micronutrients (C)			Mean	
C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂		C ₃	C ₀	C ₁		C ₂
Methods of application (A))													
A ₁	64.29 (53.31)*	64.86 (53.65)	65.02 (53.75)	65.15 (53.82)	64.83 (53.63)		64.82 (53.62)	65.37 (53.97)	65.49 (54.05)	65.66 (54.13)	65.34 (53.94)	65.41 (53.98)	65.08 (53.79)
A ₂	64.58 (53.48)	65.89 (54.28)	66.06 (54.37)	66.11 (54.40)	65.66 (54.13)		64.91 (53.68)	66.21 (54.46)	66.38 (54.56)	66.53 (54.65)	66.01 (54.34)	66.32 (54.53)	65.83 (54.24)
A ₃	64.38 (53.37)	65.39 (54.00)	65.47 (54.01)	65.61 (54.10)	65.12 (53.87)		64.87 (53.65)	65.30 (53.91)	65.91 (54.28)	66.04 (54.36)	65.53 (54.05)	65.69 (54.15)	65.37 (53.96)
A ₄	64.48 (53.42)	67.64 (55.33)	67.92 (55.50)	68.14 (54.31)	67.05 (54.64)		64.94 (53.70)	68.08 (55.60)	68.31 (55.74)	68.59 (55.92)	67.48 (55.24)	68.12 (55.62)	67.26 (54.94)
A ₅	64.33 (53.34)	66.88 (54.92)	67.11 (55.03)	67.52 (55.26)	66.46 (54.64)		64.89 (53.67)	67.29 (55.12)	67.51 (55.25)	67.76 (55.40)	66.86 (54.86)	67.31 (55.14)	66.66 (54.75)
A ₆	64.34 (53.34)	68.26 (55.72)	69.04 (56.20)	69.58 (56.53)	67.81 (55.45)		64.85 (53.64)	68.86 (56.08)	67.47 (56.46)	70.07 (56.83)	68.31 (55.75)	69.26 (56.33)	68.06 (55.60)
A ₇	64.51 (53.44)	66.29 (54.51)	66.38 (54.56)	66.59 (54.69)	65.92 (54.30)		64.90 (53.67)	66.77 (54.80)	66.82 (54.83)	67.01 (54.94)	66.38 (54.56)	66.60 (54.70)	66.16 (54.43)
Mean	34.42 (53.39)	66.50 (54.63)	66.71 (54.77)	66.96 (54.73)	66.14 (54.38)		64.88 (53.66)	66.84 (54.85)	67.13 (55.03)	67.38 (55.18)	66.56 (54.68)	66.92 (54.90)	66.35 (54.53)
For comparing the means of	S.Em _±			C.D. at 5%			S.Em _±			C.D. at 5%			
C	0.30			0.86			0.19			0.54			0.51
A	0.40			NS			0.25			0.72			0.67
C x A	0.80			NS			0.51			NS			NS

4.2.2.6 Kernel yield (kg/ha)

The computed kernel yield of both the years and pooled data are presented in Table 4.38.

Irrespective of methods of application, micronutrients recorded significant differences on kernel yield. Significantly maximum (1990, 1939 and 1836 kg/ha) but on par kernel yields were recorded in the pooled data by C₃, C₂ and C₁ micronutrients respectively.

Methods of application exhibited significant difference on kernel yield irrespective of micronutrients. In the pooled data, significantly maximum (2085 and 1991 kg/ha) seed kernel yields were recorded by A₆ and A₄ methods of application respectively. Whereas, significantly minimum (1484 and 1613 kg/ha) kernel yields were recorded by A₁ and A₃ methods respectively.

Only in the year-wise pooled data interaction effect showed significant differences. The per hectare kernel yield ranged between 1372 kg to 2387 kg with an average of 1803 kg.

4.2.2.7 Benefit cost ratio

The data on benefit cost ratio are presented in Table 4.39.

Micronutrients irrespective of methods of application recorded significant difference on benefit cost ratio in pooled and 1999 data. While, non-significant effect was noticed in 2000 values. C₁ micronutrient recorded significantly maximum (4.63) followed by C₂ (4.29) ratio in pooled values and were at par. Significantly minimum (3.88 and 3.97) ratio were recorded by C₀ and C₃ micronutrients.

Table 4.38. Influence of micronutrients and methods of applications on kernel yield (kg/ha) in groundnut

Treatments	Kernel yield (kg/ha)															
	1999					2000					Pooled					
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean	
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		
A ₁	1307	1408	1428	1481	1406	1470	1553	1573	1656	1563	1388	1481	1501	1569	1484	
A ₂	1307	1692	1759	1801	1640	1450	1865	1909	1966	1797	1378	1779	1834	1884	1719	
A ₃	1321	1536	1572	1656	1521	1466	1691	1829	1831	1704	1394	1613	1701	1743	1613	
A ₄	1290	2096	2083	2116	1896	1454	2268	2301	2320	2086	1372	2182	2192	2218	1991	
A ₅	1307	1944	1989	2047	1822	1461	2124	2167	2235	1997	1384	2034	2078	2141	1909	
A ₆	1311	2156	2198	2283	1987	1468	2360	2410	2492	2182	1390	2258	2304	2387	2085	
A ₇	1319	1833	1878	1902	1733	1462	2016	2048	2081	1920	1390	1924	1963	1992	1817	
Mean	1390	1809	1844	1898	1715	1462	1982	2034	2083	1890	1385	1896	1939	1990	1803	
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%				S.Em _±		C.D. at 5%
C	45				128	69				196				41		117
A	60				169	91				259				55		155
C x A	119				NS	183				NS				109		309

Table 4.39. Influence of micronutrients and methods of applications on benefit cost ratio in groundnut

Treatments	Benefit cost ratio														
	1999					2000					Pooled				
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	
A ₁	3.64	3.93	3.98	4.16	3.93	4.13	4.37	4.47	4.72	4.42	3.88	4.15	4.23	4.44	4.18
A ₂	3.62	3.71	3.31	2.77	3.35	4.09	4.16	3.66	3.07	3.75	3.86	3.94	3.49	2.92	3.55
A ₃	3.68	4.29	4.26	4.43	4.17	4.15	4.78	4.84	4.95	4.68	3.92	4.53	4.55	4.69	4.42
A ₄	3.57	4.66	3.96	3.27	3.87	4.10	5.09	4.44	3.65	4.32	3.84	4.88	4.20	3.46	4.09
A ₅	3.64	5.49	5.44	5.47	5.01	4.14	6.04	6.01	6.05	5.56	3.89	5.76	5.73	5.76	5.29
A ₆	3.64	4.69	4.02	3.42	3.94	4.16	5.18	4.46	3.74	4.38	3.90	4.94	4.24	3.58	4.16
A ₇	3.66	3.98	3.44	2.78	3.47	4.14	4.44	3.81	3.12	3.88	3.90	4.21	3.63	2.95	3.67
Mean	3.64	4.39	4.06	3.76	3.96	4.13	4.87	4.53	4.19	4.43	3.88	4.63	4.29	3.97	4.20
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%
C	0.13				0.36	0.22				NS	0.13				0.36
A	0.17				0.48	0.28				0.79	0.17				0.47
C x A	0.34				0.96	0.57				NS	0.33				0.94

NS – Non significant

Methods of application (A)

A₁ – Seed treatment

A₂ – Soil application

A₃ – Foliar spray (at 40 DAS)

A₄ – Seed treatment + Soil application

A₅ – Seed treatment + Foliar spray (at 40 DAS)

A₆ – Soil application + Foliar spray (at 40 DAS)

A₇ – Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

C₀ – No micronutrient

C₁ – Fe SO₄

C₂ – Zn SO₄

C₃ – Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

Irrespective of micronutrients, benefit cost ratio differed significantly due to methods of application in pooled and year-wise data. In the pooled values, significantly higher (5.29) benefit cost ratio was recorded by A₅ method of application over other methods of application. Significantly lesser (3.55 and 3.67) ratio were recorded by A₂ and A₇ methods of application respectively.

In the 1999 year of production and pooled data interaction effect between C x A recorded significant differences on benefit cost ratio. The ratio ranged between 3.88 in C₀A₁ to 5.76 in C₁A₅ and C₃A₅. The average benefit cost ratio was 4.20.

4.2.2.8 Sound mature kernel percentage

The data on sound mature kernel percentage influenced by micronutrients and methods of application are presented in Table 4.40.

Micronutrients irrespective of methods of application recorded significant difference on sound mature kernel percentage in both years and pooled values. It was significantly less with C₀ micronutrient while, other micronutrients recorded higher per cent of sound mature kernels and were at par with each other.

Only in the pooled values methods of application recorded significant differences in sound mature kernel percentage. A₄, A₅, A₆ and A₇ methods of application recorded significantly more (82.41, 81.55, 83.01 and 81.12 %) sound mature kernels respectively.

Table 4.40. Influence of micronutrients and methods of applications on sound mature kernel percentage in groundnut

Treatments	Sound mature kernel percentage															
	1999					2000										
	Micronutrients (C)				Mean	Micronutrients (C)				Mean						
	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃							
Methods of application (A)	C ₀	C ₁	C ₂	C ₃	Mean	C ₀	C ₁	C ₂	C ₃	Mean	Pooled			Mean		
											C ₀	C ₁	C ₂		C ₃	
A ₁	76.68 (61.29)*	77.17 (61.57)	77.86 (61.99)	76.68 (62.24)	78.31 (61.77)	77.26 (61.63)	77.83 (62.03)	78.34 (62.39)	78.92 (62.69)	78.09 (62.19)	76.97 (61.46)	77.50 (61.80)	78.10 (62.19)	80.22 (62.47)	78.20 (61.98)	
A ₂	76.68 (61.21)	79.76 (63.32)	80.18 (63.67)	80.80 (64.16)	79.36 (63.09)	77.31 (61.69)	80.41 (63.82)	80.97 (64.42)	81.22 (64.52)	79.98 (63.61)	77.00 (61.45)	80.09 (63.57)	80.58 (64.05)	81.01 (64.34)	79.67 (63.35)	
A ₃	76.82 (61.39)	78.81 (62.67)	78.92 (62.81)	79.64 (63.19)	78.55 (62.52)	77.38 (61.65)	79.27 (62.95)	79.64 (63.24)	80.08 (63.53)	79.09 (62.84)	77.10 (61.52)	79.04 (62.81)	79.28 (63.02)	79.86 (63.36)	78.82 (62.68)	
A ₄	76.56 (61.11)	83.65 (66.26)	84.02 (66.52)	84.21 (66.73)	82.11 (65.16)	77.35 (61.61)	84.14 (66.81)	84.51 (66.88)	84.86 (67.22)	82.72 (65.63)	76.96 (61.36)	83.90 (66.53)	84.27 (66.70)	84.54 (66.98)	82.41 (65.39)	
A ₅	76.84 (61.29)	82.18 (65.23)	82.82 (65.64)	83.17 (66.02)	81.25 (64.54)	77.29 (61.56)	82.85 (66.03)	83.36 (65.99)	83.89 (66.44)	81.85 (65.01)	77.07 (61.43)	82.52 (65.63)	83.09 (65.82)	83.53 (66.23)	81.55 (64.78)	
A ₆	76.87 (61.34)	84.44 (66.80)	84.55 (66.95)	85.04 (67.39)	82.73 (65.62)	77.42 (61.69)	85.02 (67.26)	85.13 (67.47)	85.61 (67.98)	83.30 (60.10)	77.15 (61.51)	84.73 (67.03)	84.84 (67.21)	85.33 (67.68)	83.01 (65.86)	
A ₇	76.76 (61.23)	81.03 (64.25)	84.61 (64.45)	81.61 (64.67)	81.00 (63.65)	77.34 (61.63)	81.59 (64.83)	85.28 (65.13)	80.70 (65.37)	81.23 (64.24)	77.05 (61.43)	81.31 (64.54)	84.95 (64.79)	81.16 (65.02)	81.12 (63.95)	
Mean	76.74 (61.27)	81.01 (64.30)	81.85 (64.58)	82.29 (64.91)	80.47 (63.76)	77.34 (61.64)	81.59 (64.82)	82.46 (65.08)	82.18 (65.39)	80.89 (64.23)	77.04 (61.45)	81.30 (64.56)	82.16 (64.83)	82.23 (65.15)	80.68 (64.00)	
For comparing the means of	S.Em±				C.D. at 5%	S.Em±				C.D. at 5%	S.Em±				C.D. at 5%	
C	0.72				2.05	0.84				2.39	0.55				1.57	
A	0.95				NS	1.11				NS	0.73				2.08	
C x A	1.91				NS	2.23				NS	1.47				NS	

The interaction between C x A was non-significant. An average of 80.47, 80.89 and 80.68 per cent sound mature kernels were recorded in 1999, 2000 and pooled values respectively.

4.2.2.9 Oil content percentage

The data on oil content percentage influenced by micronutrients and methods of application are presented in Table 4.41.

Per cent oil content differed significantly due to micronutrients in both the years and pooled values. It is observed that C₁, C₂ and C₃ micronutrients recorded significantly higher (44.67, 44.87 and 45.09%) oil values in pooled data and similar trend was noticed in both the years of experimentation.

The per cent oil content differed only in pooled data due to methods of application. A₄, A₅, A₆ and A₇ methods recorded significantly higher but on par (45.10, 44.68, 45.79 and 44.35 %) oil content values while, A₁ method recorded significantly lesser (43.23 %) oil content. A₁ method was at par with A₂, A₃ and A₇ methods also.

Interaction effect was non-significant. In the year-wise pooled data, an average of 44.39 per cent oil content was recorded.

4.2.2.10 Oil yield (kg/ha)

The computed data on oil yield as influenced by micronutrients and methods of application of 1999, 2000 and pooled are presented in Table 4.42.

Table 4.4.1. Influence of micronutrients and methods of applications on oil content percentage in groundnut

Treatments		Oil content percentage													
		1999					2000					Pooled			
		Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)			
Methods of application (A)	C ₀	C ₁	C ₂	C ₃	Mean	C ₀	C ₁	C ₂	C ₃	Mean	C ₀	C ₁	C ₂	C ₃	Mean
A ₁	42.56 (40.72)*	42.77 (40.85)	43.83 (41.45)	43.11 (41.04)	43.07 (41.01)	43.17 (41.07)	43.36 (41.18)	43.42 (41.22)	43.65 (41.35)	43.40 (41.21)	42.87 (40.89)	43.07 (41.02)	43.63 (41.34)	43.38 (41.19)	43.23 (41.11)
A ₂	42.68 (40.79)	43.88 (41.48)	44.10 (41.61)	44.29 (41.72)	43.74 (41.40)	43.21 (41.09)	44.51 (41.84)	44.63 (41.91)	44.84 (42.03)	44.30 (41.72)	42.95 (40.94)	44.20 (41.66)	44.37 (41.76)	44.57 (41.88)	44.02 (41.56)
A ₃	42.68 (40.79)	43.28 (41.14)	43.43 (41.22)	43.83 (41.45)	43.31 (41.15)	43.26 (41.12)	43.88 (41.48)	44.06 (41.60)	44.30 (41.72)	43.88 (41.48)	42.97 (40.96)	43.58 (41.31)	43.75 (41.41)	44.07 (41.59)	43.59 (41.32)
A ₄	42.66 (40.77)	45.47 (42.40)	45.45 (42.39)	45.83 (42.63)	44.85 (42.05)	43.11 (41.04)	45.93 (42.67)	46.05 (42.73)	46.33 (42.89)	45.36 (42.33)	42.89 (40.90)	45.70 (42.53)	45.75 (42.56)	46.08 (42.76)	45.10 (42.19)
A ₅	42.70 (40.80)	44.86 (42.05)	44.91 (42.08)	45.13 (42.20)	44.40 (41.78)	43.15 (41.06)	45.41 (42.36)	45.57 (42.46)	45.72 (42.54)	44.96 (42.11)	42.93 (40.93)	45.14 (42.20)	45.24 (42.27)	45.43 (42.37)	44.68 (41.94)
A ₆	42.86 (40.89)	46.13 (42.78)	46.38 (42.92)	46.83 (43.18)	45.55 (42.44)	43.29 (41.14)	46.60 (43.05)	46.85 (43.19)	47.38 (43.50)	46.03 (42.72)	43.08 (41.01)	46.36 (42.92)	46.62 (43.06)	47.11 (43.34)	45.79 (42.58)
A ₇	42.81 (40.87)	44.39 (41.78)	44.38 (41.77)	44.66 (41.93)	44.06 (41.59)	43.20 (41.09)	44.96 (42.11)	45.07 (42.17)	45.29 (42.29)	44.63 (41.91)	43.01 (40.98)	44.68 (41.94)	44.73 (41.97)	44.98 (42.11)	44.35 (41.75)
Mean	42.71 (40.80)	44.40 (41.78)	44.64 (41.92)	44.81 (42.02)	44.14 (41.63)	43.20 (41.09)	44.96 (42.10)	45.09 (42.18)	45.36 (42.33)	44.65 (41.93)	42.95 (40.95)	44.67 (41.94)	44.87 (42.05)	45.09 (42.18)	44.39 (41.78)
For comparing the means of	S.Em _±		C.D. at 5%.			S.Em _±		C.D. at 5%			S.Em _±		C.D. at 5%		
C	0.33		0.93			0.33		0.95			0.23		0.65		
A	0.43		NS			0.44		NS			0.31		0.88		
C x A	0.87		NS			0.89		NS			0.62		NS		

* Figures in the parentheses indicate arc sine transformed values

Seed treatment : Fe SO₄ - 2 g /kg

Zn SO₄ - 2 g/kg

Soil application : Fe SO₄- 25 kg /ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

Methods of application (A) : A₁ - Seed treatment

A₂ - Soil application

A₃ - Foliar spray (at 40 DAS)

A₄ - Seed treatment + Soil application

A₅ - Seed treatment + Foliar spray (at 40 DAS)

A₆ - Soil application + Foliar spray (at 40 DAS)

A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Table 4.42. Influence of micronutrients and methods of applications on oil yield (kg/ha) in groundnut

Treatments	Oil yield (kg/ha)														
	1999					2000					Pooled				
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	
A ₁	553	600	624	638	604	624	669	688	725	676	589	635	656	681	640
A ₂	556	740	776	797	717	628	829	859	882	800	592	785	818	839	758
A ₃	564	666	677	723	658	626	751	807	807	748	595	709	742	765	703
A ₄	549	952	946	970	854	627	1039	1057	1073	949	588	996	1002	1022	902
A ₅	554	875	892	921	811	630	966	988	1022	901	592	920	940	971	856
A ₆	564	996	1020	1074	913	632	1101	1130	1180	1011	598	1049	1075	1127	962
A ₇	566	814	832	845	764	636	908	920	937	850	601	861	876	891	807
Mean	558	806	824	853	760	629	895	921	946	848	594	850	873	900	804
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%
C	20				57	32				91	19				54
A	27				77	42				120	25				71
C x A	54				153	84				NS	50				141

NS - Non significant

Methods of application (A)

- A₁ - Seed treatment
A₂ - Soil application
A₃ - Foliar spray (at 40 DAS)
A₄ - Seed treatment + Soil application
A₅ - Seed treatment + Foliar spray (at 40 DAS)
A₆ - Soil application + Foliar spray (at 40 DAS)
A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
C₁ - Fe SO₄
C₂ - Zn SO₄
C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g / kg

Zn SO₄ - 2 g / kg

Soil application : Fe SO₄ - 25 kg / ha

Zn SO₄ - 25 kg / ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

Micronutrients irrespective of methods of application recorded significant differences in oil yields in pooled and year-wise data. C₀ micronutrient recorded significantly least (594 kg/ha) oil yield in the pooled data. The C₁, C₂ and C₃ micronutrients recorded 850, 873 and 900 kg oil yields per hectare respectively and were at par.

Methods of application could register significant differences in oil yield in both the years and pooled data. In the pooled data, significantly maximum (962 and 902 kg/ha) by A₆ and A₄ methods and minimum (640 and 703 kg/ha) by A₁ and A₃ methods oil yields were recorded respectively.

During 1999 and pooled values oil yield could record significant differences due to interaction effect. In the pooled data per hectare oil yield ranged between 588 kg with C₀A₄ to 1127 kg with C₃A₆ treatment combinations. Average per hectare oil yield recorded was 804 kg.

4.2.3 Seed quality parameters

4.2.3.1 100 seed weight (g)

The 100 seed weight data as influenced by micronutrients and methods of application of both the years of experimentation and pooled are presented in Table 4.43.

In both the years and pooled values, micronutrients recorded significant differences on 100 seed weight. In the pooled data, C₀ micronutrient recorded significantly minimum (29.80 g) seed weight. While C₁, C₂ and C₃ recorded on par but significantly maximum (32.20, 32.18 and 32.70 g) 100 seed weights respectively.

Table 4.43. Influence of micronutrients and methods of applications on 100 seed weight (g) in groundnut

Treatments	100 seed weight (g)														
	1999					2000					Pooled				
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean
	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃	
Methods of application (A)															
A ₁	29.42	29.88	26.71	30.41	29.10	30.12	30.46	30.69	30.93	30.55	29.77	30.17	28.70	30.67	29.83
A ₂	29.75	31.18	31.19	31.69	30.95	30.28	31.73	31.97	32.14	31.53	30.02	31.46	31.58	31.92	31.24
A ₃	29.61	30.51	30.83	30.88	30.46	28.51	31.06	31.31	31.47	30.59	29.06	30.79	31.07	31.18	30.52
A ₄	29.65	33.15	33.51	33.85	32.54	30.21	33.87	34.09	34.41	33.15	29.93	33.51	33.80	34.13	32.84
A ₅	29.86	32.41	32.77	32.92	31.99	30.25	33.06	33.33	33.55	32.55	30.06	32.74	33.05	33.24	32.27
A ₆	29.48	34.37	34.48	35.05	33.34	30.14	34.89	35.20	35.62	33.96	29.81	34.63	34.84	35.33	33.65
A ₇	29.45	31.84	31.87	32.13	31.32	30.52	32.35	32.58	32.82	32.07	29.99	32.10	32.23	32.48	31.70
Mean	29.60	31.91	31.62	32.42	31.39	30.00	32.49	32.74	32.99	32.06	29.80	32.20	32.18	32.70	31.72
For comparing the means of	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%	S.Em _±				C.D. at 5%
C	0.68				1.93	0.68				1.92	0.48				1.36
A	0.90				2.55	0.90				NS	0.64				1.82
C x A	1.80				NS	1.79				NS	1.27				NS

NS - Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g / kg

Zn SO₄ - 2 g/kg

Soil application : Fe SO₄- 25 kg /ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

Seed weight differed significantly in 1999 and pooled data due to methods of application. In the pooled data significantly maximum (33.65 g) 100 seed weight was recorded by A₆ method of application and this did not differ with A₄ (32.84 g) and A₅ (32.27 g) methods. Significantly minimum (29.83 g) seed weight was recorded by A₁ method of application and again this was on par with A₂ (31.24 g) and A₃ (30.52 g) methods.

Interaction between C x A was non-significant in pooled and year-wise data. The average 100 seed weight of 31.39, 32.06 and 31.72 g were recorded by 1999, 2000 and pooled data respectively.

4.2.3.2 Germination percentage

The data on per cent germination of both the years and pooled are presented in Table 4.44.

In both years of experimentation and pooled values, micronutrients showed significant differences on per cent germination. Significantly maximum but on par (90.03, 90.18 and 90.55 %) germination were recorded in the pooled data by C₁, C₂ and C₃ micronutrients respectively while, C₀ recorded 87.16 per cent germination.

Methods of application exhibited significant differences on per cent germination in pooled and year-wise data. In the pooled values significantly maximum (91.92 and 91.16 %) germination were recorded by A₆ and A₄ methods respectively over other methods.

Interaction effect on per cent germination was non-significant in pooled and year-wise data. In the pooled data, average 89.48 per cent germination was recorded.

Table 4.44. Influence of micronutrients and methods of applications on germination percentage in groundnut

Treatments	Germination percentage											
	1999						2000					
	Micronutrients (C)			Mean			Micronutrients (C)			Mean		
Methods of application (A)	C ₀	C ₁	C ₂	C ₃			C ₀	C ₁	C ₂	C ₃		
A ₁	86.21 (68.23)*	86.18 (67.80)	86.57 (68.53)	86.17 (68.20)	86.28 (68.19)		88.64 (70.40)	88.92 (70.66)	89.09 (70.81)	89.16 (70.78)	88.95 (70.66)	87.43 (69.32)
A ₂	86.27 (68.33)	88.34 (70.06)	87.58 (69.43)	87.45 (69.40)	87.41 (69.31)		88.59 (70.36)	90.15 (71.75)	90.38 (71.95)	90.47 (72.06)	89.90 (71.53)	87.43 (69.35)
A ₃	85.50 (67.67)	87.31 (69.14)	86.30 (68.31)	86.27 (68.30)	86.35 (68.36)		88.35 (70.14)	89.34 (71.12)	89.57 (71.25)	89.89 (71.50)	89.29 (71.00)	86.93 (68.91)
A ₄	85.67 (67.80)	91.22 (72.88)	90.89 (72.47)	92.20 (73.95)	90.00 (71.77)		88.42 (70.17)	93.03 (75.32)	93.66 (75.67)	94.15 (76.09)	92.32 (74.31)	87.05 (68.98)
A ₅	85.86 (67.96)	89.12 (70.97)	89.84 (71.44)	90.05 (71.67)	88.72 (70.51)		88.51 (70.26)	91.83 (73.72)	92.30 (74.40)	92.74 (74.61)	91.35 (73.25)	87.19 (69.11)
A ₆	85.53 (67.68)	92.15 (73.77)	91.86 (73.84)	93.04 (74.95)	90.65 (72.56)		88.48 (70.32)	94.38 (76.67)	94.71 (76.97)	95.18 (77.47)	93.19 (75.36)	87.01 (69.00)
A ₇	85.59 (67.86)	87.64 (69.52)	88.76 (72.47)	89.61 (71.91)	87.90 (69.94)		88.55 (70.37)	90.79 (72.44)	90.96 (73.02)	91.28 (73.12)	90.40 (72.24)	87.07 (69.12)
Mean	85.80 (67.94)	88.85 (70.59)	88.83 (70.64)	89.26 (71.20)	88.19 (70.09)		88.51 (70.29)	91.21 (73.10)	91.52 (73.44)	91.84 (73.66)	90.77 (72.62)	87.16 (69.11)
For comparing the means of	S.Em±			C.D. at 5%			S.Em±			C.D. at 5%		
C	0.60			1.70			0.70			1.99		
A	0.79			2.25			0.93			2.64		
C x A	1.59			NS			1.86			NS		
	S.Em±			C.D. at 5%			S.Em±			C.D. at 5%		
	0.46			1.31			0.61			1.73		
	1.22			NS			1.22			NS		

* Figures in the parentheses indicate arc sine transformed values

NS - Non significant

Micronutrients (C)

C₀ - No micronutrient

C₁ - Fe SO₄

C₂ - Zn SO₄

C₃ - Fe SO₄ + Zn SO₄

Methods of application (A) : A₁ - Seed treatment

A₂ - Soil application

A₃ - Foliar spray (at 40 DAS)

A₄ - Seed treatment + Soil application

A₅ - Seed treatment + Foliar spray (at 40 DAS)

A₆ - Soil application + Foliar spray (at 40 DAS)

A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Seed treatment : Fe SO₄ - 2 g /kg

Zn SO₄ - 2 g/kg

Soil application : Fe SO₄ - 25 kg /ha

Zn SO₄ - 25 kg/ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

4.2.3.3 Seedling length (cm)

The data on seedling length are presented in Table 4.45.

Irrespective of the methods of application, micronutrients showed significant differences in seedling length in pooled and year-wise data. C₀ micronutrient recorded significantly less length of the seedling in pooled and also year-wise data over other micronutrients which were on par with each others.

Except in 1999, seedling length showed significant difference due to methods of application in pooled and 2000 year values. In the pooled data, the methods of application A₄, A₅ and A₆ recorded significantly higher (22.13, 21.75 and 22.73 cm) but on par seedling lengths respectively. The other methods were on par with each other and recorded statistically lesser seedling lengths.

Interaction effect between C x A was non-significant. In the pooled data, over all average 21.29 cm seedling length was recorded.

4.2.3.4 Seedling dry weight (g)

The data on dry weight of seedling are presented in Table 4.46 which showed non-significant differences due to methods of application, micronutrients and their interactions in pooled and year-wise values except for micronutrient effect in the pooled data.

C₁, C₂ and C₃ micronutrients recorded significantly higher (4.36, 4.38 and 4.46 g) but on par seedling dry weights respectively over C₀ (3.79 g) micronutrient.

Table 4.45. Influence of micronutrients and methods of applications on seedling length (cm) in groundnut

Treatments	Seedling length (cm)											
	1999				2000				Pooled			
	Micronutrients (C)			Mean	Micronutrients (C)			Mean	Micronutrients (C)			Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃
A ₁	19.10	19.70	19.60	20.00	19.60	20.30	20.80	21.00	19.70	20.25	20.30	20.50
A ₂	19.50	20.00	20.10	20.30	19.98	20.70	21.40	21.50	20.10	20.70	20.80	21.00
A ₃	19.50	19.80	19.90	20.00	19.80	20.50	21.10	21.20	20.00	20.45	20.55	20.60
A ₄	18.80	21.90	21.60	22.60	21.23	20.40	23.60	23.90	19.60	22.75	22.75	23.40
A ₅	18.90	21.50	21.80	22.00	21.05	20.50	22.80	23.10	19.70	22.15	22.45	22.70
A ₆	18.80	22.70	22.90	23.50	21.98	20.70	24.20	24.30	19.75	23.45	23.60	24.10
A ₇	19.50	20.80	21.40	20.80	20.63	20.60	22.00	22.30	20.05	21.40	21.85	21.55
Mean	19.16	20.91	21.04	21.31	20.61	20.53	22.27	22.47	19.84	21.59	21.76	21.98
For comparing the means of	S.Em±			C.D. at 5%		S.Em±			C.D. at 5%		C.D. at 5%	
C	0.47			1.33		0.35			0.99		0.81	
A	0.61			NS		0.44			1.25		1.07	
C x A	1.22			NS		0.89			NS		NS	

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

Table 4.46. Influence of micronutrients and methods of applications on seedling dry weight (g) in groundnut

Treatments	Seedling dry weight (g)											
	1999				2000				Pooled			
	Micronutrients (C)			Mean	Micronutrients (C)			Mean	Micronutrients (C)			Mean
Methods of application (A)	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃	C ₀	C ₁	C ₂	C ₃
A ₁	3.70	3.90	3.80	3.90	3.83	4.10	4.20	4.20	4.20	4.05	4.00	4.10
A ₂	3.50	4.00	4.40	4.30	4.05	4.00	4.60	4.60	3.75	4.20	4.50	4.23
A ₃	3.30	3.80	3.70	4.00	3.70	3.90	4.30	4.40	3.60	4.05	4.00	3.96
A ₄	3.50	4.50	4.30	4.50	4.20	3.90	4.80	4.80	3.70	4.65	4.55	4.39
A ₅	3.50	4.50	4.40	4.10	4.13	4.10	4.70	4.70	3.80	4.60	4.55	4.34
A ₆	3.60	4.40	4.40	4.80	4.30	4.00	4.90	5.10	3.80	4.60	4.66	4.50
A ₇	3.80	4.20	4.10	4.20	4.08	4.20	4.70	4.70	4.00	4.40	4.40	4.31
Mean	3.56	4.19	4.16	4.26	4.04	4.03	4.54	4.66	3.79	4.36	4.38	4.25
For comparing the means of	S.Em±			C.D. at 5%		S.Em±			C.D. at 5%		C.D. at 5%	
C	0.25			NS		0.21			NS		0.16	
A	0.33			NS		0.27			NS		0.21	
C x A	0.66			NS		0.55			NS		0.43	

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
- A₂ - Soil application
- A₃ - Foliar spray (at 40 DAS)
- A₄ - Seed treatment + Soil application
- A₅ - Seed treatment + Foliar spray (at 40 DAS)
- A₆ - Soil application + Foliar spray (at 40 DAS)
- A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
- C₁ - Fe SO₄
- C₂ - Zn SO₄
- C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

In the pooled data numerically maximum (4.50 g) and minimum (3.96 g) seedling dry weights were recorded by A₆ and A₃ methods respectively.

Average seedling dry weight was 4.25 g in pooled data.

4.2.3.5 Seedling vigour index

The seed quality assessed through seedling vigour exhibited significant difference only due to main treatments while, their interaction was non-significant in both years and pooled data and these are presented in Table 4.47.

In both the years and pooled data C₀ micronutrient recorded significantly less indices value over other micronutrients and the other micronutrients were on par with each other.

In the pooled data, significantly maximum indices of 2095 and 2021 were recorded by A₆ and A₄ methods respectively. Whereas A₁, A₂ and A₃ methods recorded significantly minimum indices of 1769, 1830 and 1791 respectively. Similar trend was noticed in both the years.

In the pooled data an overall average 1909 vigour index was recorded.

4.2.3.6 Electrical conductivity of seed leachate (dSm⁻¹)

The seed leachate values measured as electrical conductivity are presented in Table 4.48.

Micronutrients also exhibited significant differences on seed leachate values in pooled and year-wise data. In both the years and pooled

Table 4.47. Influence of micronutrients and methods of applications on seedling vigour index in groundnut

Treatments	Seedling vigour index											
	1999						2000					
	Micronutrients (C)			Mean			Micronutrients (C)			Mean		
Methods of application (A)	C ₀	C ₁	C ₂	C ₃			C ₀	C ₁	C ₂	C ₃		
A ₁	1648	1698	1699	1722	1692	1798	1848	1870	1873	1847	1723	1773
A ₂	1679	1767	1760	1769	1744	1831	1928	1943	1962	1916	1755	1848
A ₃	1665	1728	1718	1722	1708	1809	1883	1897	1904	1873	1737	1806
A ₄	1610	1998	1963	2084	1914	1805	2195	2238	2277	2129	1707	2096
A ₅	1624	1911	1958	1979	1868	1813	2094	2135	2175	2054	1719	2002
A ₆	1609	2090	2103	2186	1997	1830	2287	2304	2351	2193	1719	2188
A ₇	1564	1825	1902	1877	1817	1822	1998	2032	2042	1974	1743	1912
Mean	1643	1860	1872	1906	1820	1816	2033	2060	2083	1998	1729	1947
For comparing the means of	S.E.m _±			C.D. at 5%			S.E.m _±			C.D. at 5%		
C	42			119			34			97		
A	56			158			45			129		
C x A	111			NS			91			NS		

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
A₂ - Soil application
A₃ - Foliar spray (at 40 DAS)
A₄ - Seed treatment + Soil application
A₅ - Seed treatment + Foliar spray (at 40 DAS)
A₆ - Soil application + Foliar spray (at 40 DAS)
A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
C₁ - Fe SO₄
C₂ - Zn SO₄
C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ – 2 g /kg

Zn SO₄ – 2 g/kg

Soil application : Fe SO₄– 25 kg /ha

Zn SO₄ – 25 kg/ha

Foliar spray : Fe SO₄ – 0.4%

Zn SO₄ – 0.5%

Table 4.48. Influence of micronutrients and methods of applications on electrical conductivity of seed leachate (dSm⁻¹) in groundnut

Treatments	Electrical conductivity of seed leachate (dSm ⁻¹)															
	1999					2000					Pooled					
	Micronutrients (C)				Mean	Micronutrients (C)				Mean	Micronutrients (C)				Mean	
Methods of application (A)	C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		C ₀	C ₁	C ₂	C ₃		
A ₁	0.247	0.244	0.241	0.240	0.243	0.235	0.232	0.229	0.227	0.231	0.241	0.238	0.235	0.234	0.237	
A ₂	0.252	0.231	0.229	0.225	0.234	0.238	0.218	0.215	0.211	0.220	2.245	0.225	0.222	0.218	0.227	
A ₃	0.251	0.240	0.234	0.233	0.239	0.239	0.225	0.221	0.220	0.226	0.245	0.232	0.228	0.226	0.233	
A ₄	0.246	0.202	0.198	0.199	0.211	0.235	0.187	0.186	0.184	0.198	0.240	0.195	0.192	0.192	0.205	
A ₅	0.248	0.210	0.205	0.201	0.216	0.236	0.197	0.194	0.190	0.204	0.242	0.204	0.199	0.196	0.210	
A ₆	0.251	0.196	0.194	0.191	0.208	0.237	0.182	0.181	0.178	0.195	0.244	0.189	0.188	0.184	0.201	
A ₇	0.250	0.221	0.216	0.214	0.225	0.238	0.208	0.204	0.199	0.212	0.244	0.215	0.210	0.206	0.219	
Mean	0.249	0.221	0.217	0.215	0.225	0.237	0.207	0.204	0.201	0.212	0.243	0.214	0.211	0.208	0.219	
For comparing the means of	S.Em±					C.D. at 5%					S.Em±					C.D. at 5%
C	0.003					0.009					0.003					0.006
A	0.004					0.012					0.004					0.008
C x A	0.008					NS					0.008					0.017

NS – Non significant

Methods of application (A)

- A₁ - Seed treatment
A₂ - Soil application
A₃ - Foliar spray (at 40 DAS)
A₄ - Seed treatment + Soil application
A₅ - Seed treatment + Foliar spray (at 40 DAS)
A₆ - Soil application + Foliar spray (at 40 DAS)
A₇ - Seed treatment + Soil application + Foliar spray (at 40 DAS)

Micronutrients (C)

- C₀ - No micronutrient
C₁ - Fe SO₄
C₂ - Zn SO₄
C₃ - Fe SO₄ + Zn SO₄

Seed treatment : Fe SO₄ - 2 g / kg

Zn SO₄ - 2 g / kg

Soil application : Fe SO₄- 25 kg / ha

Zn SO₄ - 25 kg / ha

Foliar spray : Fe SO₄ - 0.4%

Zn SO₄ - 0.5%

data significantly maximum leachate values were recorded by C₀ micronutrient while other micronutrients recorded significantly lesser but on par leachate values.

Methods of application noticed significant differences in seed leachate value in pooled and year-wise data. In the pooled data A₄ and A₁ methods of application recorded significantly minimum (0.205 and 0.201 dSm⁻¹) leachate values respectively while, A₁ and A₃ methods recorded significantly maximum (0.237 and 0.233 dSm⁻¹) leachate values respectively.

Only in the pooled data interaction between C x A on leachate value was significant. Significant but minimum leachate value ranged from 0.184 to 0.199 dSm⁻¹ while, significant but maximum leachate value ranged between 0.228 to 0.245 dSm⁻¹. An average of 0.219 dSm⁻¹ leachate value was recorded.

4.3 EXPERIMENT - III : EFFECT OF METHODS OF ROW SKIPPING ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of in all nine treatment combinations involving three methods of row skipping and three varieties. The experiment was conducted in three replications by adopting randomized block design with factorial concept. The results of this experiment are presented here under.

4.3.1 Growth Parameters

4.3.1.1 Plant height (cm) at 60 DAS

The data on plant height at 60 days after sowing (DAS) of 1999, 2000 and pooled as influenced by methods of row skipping in different groundnut varieties are presented in Table 4.49.

Methods of row skipping recorded significant differences on plant height at 60 DAS during both the years of experimentation and also in pooled data. It was significantly maximum (23.71, 25.54 and 24.62 cm) and minimum (19.97, 21.84 and 20.91 cm) with S_1 and S_0 methods of row skipping in 1999, 2000 and pooled values respectively. In 1999 and pooled values S_2 method of row skipping with a plant height of 22.67 and 23.04 cm respectively was on par with both S_0 and S_1 methods of row skipping.

Varieties also recorded significant differences on plant height at 60 DAS. JL-24 (V_1) variety recorded significantly maximum (27.94, 28.84 and 28.39 cm) height in 1999, 2000 and pooled values respectively. While the corresponding height recorded by TAG-24 (V_2) variety were significantly minimum (16.49, 18.27 and 17.30 cm). In the pooled data the variety R-8808 (V_3) recorded a plant height of 22.88 cm.

Interaction effects between methods of row skipping and varieties ($S \times V$) on plant height were also significant in both the years and pooled data. In pooled data it was significantly maximum (30.43 cm) with S_1V_1 treatment combination which was on par with S_2V_1 and S_0V_1 treatment

Table 4.49. Effect of methods of row skipping on plant height (cm) at 60 DAS in groundnut varieties

Treatments	Plant height (cm) at 60 DAS											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	25.52	14.76	19.63	19.97	27.82	16.44	21.26	21.84	26.67	15.60	20.45	20.91
S ₁ - One row skipping after every three rows	29.67	17.84	23.61	23.71	31.18	19.61	25.83	25.54	30.43	18.73	24.72	24.62
S ₂ - One row skipping after every four rows	28.64	16.86	22.56	22.67	27.52	18.27	24.39	23.39	28.08	17.57	23.48	23.04
Mean	27.94	16.49	21.93	22.12	28.84	18.11	23.83	23.60	28.39	17.30	22.88	22.86
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	0.99			2.97	1.06			3.16	0.72			2.17
V	0.99			2.97	1.06			3.16	0.72			2.17
S x V	1.72			5.73	1.83			6.10	1.25			4.17

combinations. Significantly minimum (15.60 cm) height was recorded by S_0V_2 treatment and this was on par with S_2V_2 and S_1V_2 treatment combinations.

4.3.1.2 Plant height (cm) at harvest

The data on plant height at harvest as influenced by methods of row skipping in different groundnut varieties are presented in Table 4.50.

Methods of row skipping influenced the plant height significantly in pooled and year-wise values. It was significantly maximum (35.49 cm) and minimum (29.71 cm) in pooled data with S_1 and S_0 methods of row skipping respectively. While, S_2 method of row skipping recorded in between plant height of 32.78 cm and was on par with both S_1 and S_0 methods of skippings. Similar trend was noticed in year-wise data also.

Varieties also recorded significant differences in plant height in pooled and year-wise data. In the pooled data it was significantly maximum (41.56 cm) and minimum (24.14 cm) with JL-24 and TAG-24 varieties respectively. Similar observations were noticed in both the years.

Interaction between $S \times V$ also recorded significant differences in plant height in pooled and year-wise data. In the pooled data significantly higher (44.43, 41.49 and 38.77 cm) plant height were recorded by S_1V_1 , S_2V_1 and S_0V_1 treatments respectively while, lesser (21.72, 26.44 and 24.27 cm) plant height were recorded by S_0V_2 , S_1V_2 and S_2V_2 treatments respectively.

Table 4.50. Effect of methods of row skipping on plant height (cm) at harvest in groundnut varieties

Treatments	Plant height (cm) at harvest											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	37.83	30.61	27.44	28.63	39.71	22.83	29.85	30.78	38.77	21.72	28.65	29.71
S ₁ - One row skipping after every three rows	43.68	25.58	34.82	34.69	45.17	27.29	36.40	36.29	44.43	26.44	35.61	35.49
S ₂ - One row skipping after every four rows	40.65	22.89	31.42	31.65	42.32	25.64	33.76	33.91	41.49	24.27	32.59	32.78
Mean	40.72	23.03	31.23	31.66	42.40	25.25	33.34	33.66	41.56	24.14	32.28	32.66
For comparing the means of	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%
S	1.52		4.55		1.42		4.25		1.04		3.11	
V	1.52		4.55		1.42		4.25		1.04		3.11	
S x V	2.63		8.77		2.45		8.17		1.80		6.00	

4.3.1.3 Number of branches per plant at harvest

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Number of branches per plant at harvest differed significantly in pooled and year-wise values due to main treatments and also interaction effects except for methods of row skipping during 2000 and these are presented in Table 4.51.

In the pooled data S_0 , S_1 and S_2 methods of skippings recorded 5.85, 7.17 and 6.47 branches at harvest respectively. S_2 method of skipping was on par with S_0 and S_1 methods of skippings while, S_1 method of skipping recorded significantly higher number of branches over S_0 method of skipping.

JL-24 and R-8808 varieties recorded significantly higher (7.27 and 6.53) but on par number of branches respectively over TAG-24 (5.68) in the year-wise pooled data.

In the pooled data the number of branches ranged between 5.05 (S_0V_2) to 8.00 (S_1V_1) with an average branches of 6.49.

4.3.1.4 Days to 50 per cent flowering

The data of 1999, 2000 and pooled on days taken to 50 per cent flowering are presented in Table 4.52.

S_1 method of row skipping recorded significantly less (38.71, 39.17 and 38.26) days to 50 per cent flowering over other methods of row skippings in pooled, 1999 and 2000 data respectively. The other two methods of row skippings were at par with each other.

Table 4.51. Effect of methods of row skipping on number of branches per plant at harvest in groundnut varieties

Number of branches per plant at harvest												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	6.30	4.90	5.60	5.60	6.90	5.20	6.20	6.10	6.60	5.05	5.90	5.85
S ₁ - One row skipping after every three rows	7.80	6.30	6.80	6.97	8.20	6.60	7.30	7.37	8.00	6.45	7.05	7.17
S ₂ - One row skipping after every four rows	7.00	5.40	6.50	6.30	7.40	5.70	6.80	6.63	7.20	5.55	6.654	6.47
Mean	7.03	5.53	6.30	6.29	7.50	5.83	6.77	6.70	7.27	5.68	6.53	6.49
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	0.35			1.06	0.39			NS	0.26			0.79
V	0.35			1.06	0.39			1.17	0.26			0.79
S x V	0.61			2.03	0.68			2.27	0.46			1.53

NS – Non significant

Table 4.52. Effect of methods of row skipping on days to 50 per cent flowering in groundnut varieties

Days to 50 per cent flowering												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	39.70	43.00	45.80	42.83	40.10	43.30	46.20	43.20	39.90	43.15	46.00	40.02
S ₁ - One row skipping after every three rows	35.60	39.50	42.40	39.17	32.47	39.70	42.60	38.26	34.03	39.60	42.50	38.71
S ₂ - One row skipping after every four rows	37.00	41.30	43.90	40.73	37.40	41.50	44.30	41.07	37.20	41.40	44.10	40.90
Mean	37.43	41.27	44.03	40.91	36.66	41.50	44.37	40.84	37.04	41.38	44.20	40.88
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	0.39			1.17	0.76			2.28	0.43			1.28
V	0.39			1.17	0.76			2.28	0.43			1.28
S x V	0.68			2.27	1.32			4.40	0.74			2.47

In the pooled, 1999 and 2000 data significantly less (37.04, 37.43 and 36.66) and more (44.20, 44.03 and 44.37) days were taken respectively by JL-24 and R-8808 varieties for 50 per cent flowering.

Interaction between S x V was also significant for days to 50 per cent flowering. In the pooled values the treatment S₁V₁ recorded significantly minimum (34.03) days to 50 per cent flowering. On an average 40.88 days were taken to 50 per cent flowering.

4.3.1.5 Days to peg initiation

The individual and interactions between S x V recorded significant differences on days taken to peg initiation in both the years and pooled data which are presented in Table 4.53.

In the pooled data S₁ and S₀ methods of row skipplings recorded significantly less (52.87) and more (59.48) days to peg initiation respectively. The same trend was noticed in both the years.

In the pooled data JL-24 variety took significantly less (54.47) days to peg initiation while, R-8808 variety took more (59.22) days. Same trend was recorded in both the years.

Interaction treatments S₁V₁ and S₀V₃ recorded significantly less (50.80) and more (63.20) days to peg initiation respectively over other treatment combinations in the pooled values.

4.3.1.6 Days to pod maturity

Days taken to pod maturity values of 1999, 2000 and pooled are presented in Table 4.54 which recorded significant differences due to individual and interaction effects in both the years and pooled data.

Table 4.53. Effect of methods of row skipping on days to peg initiation in groundnut varieties

Treatments	Days to peg initiation											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	55.00	60.00	63.00	59.33	55.30	60.20	63.40	59.63	55.15	60.10	63.20	59.48
S ₁ - One row skipping after every three rows	50.70	53.50	54.00	52.73	50.90	53.80	54.30	53.00	50.80	53.65	54.15	52.87
S ₂ - One row skipping after every four rows	57.30	56.60	60.00	57.97	57.60	57.00	60.60	58.40	57.45	56.80	60.30	58.18
Mean	54.33	56.70	59.00	56.68	54.60	57.00	59.43	57.01	54.47	56.85	59.22	56.84
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	0.62			1.86	0.40			1.18	0.37			1.10
V	0.62			1.86	0.40			1.18	0.37			1.10
S x V	1.07			3.57	0.68			2.28	0.64			2.12

Table 4.54. Effect of methods of row skipping on days to pod maturity in groundnut varieties

Treatments	Days to pod maturity											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	105.5	110.5	114.8	110.3	107.0	112.2	116.4	111.9	106.3	111.4	115.6	111.1
S ₁ - One row skipping after every three rows	99.3	101.7	106.8	102.6	100.8	103.1	108.3	104.1	100.1	102.4	107.6	103.3
S ₂ - One row skipping after every four rows	103.7	106.4	112.5	107.5	104.5	107.7	113.9	108.7	104.1	107.1	113.2	108.1
Mean	102.8	106.2	111.4	106.8	104.1	107.7	112.9	108.2	103.5	106.9	112.1	107.5
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
S	0.5			1.6	0.6			1.7	0.4			1.1
V	0.5			1.6	0.6			1.7	0.4			1.1
S x V	0.9			3.03	1.0			3.33	0.7			2.33

In the pooled data S_1 and S_0 methods of row skipplings recorded significantly less (103.3) and more (111.1) days to pod maturity respectively over S_2 method of row skipping.

In the pooled data JL-24 and R-8808 varieties took significantly less (103.5) and more (112.1) days to pod maturity respectively while, TAG-24 took 106.9 days to maturity.

In the pooled data interaction effect between $S \times V$ recorded an average of 107.5 days to pod maturity while, it was significantly less (100.1) and more (115.6) days with S_1V_1 and S_0V_3 treatments respectively over other treatment combinations.

4.3.1.7 Number of nodules per plant

The data on number of nodules per plant due to methods of row skipping and varieties are presented in Table 4.55.

Significantly maximum (71.00, 72.47 and 71.73) and minimum (58.83, 59.73 and 59.28) number of nodules were recorded by S_1 and S_0 methods of row skipplings in 1999, 2000 and pooled values respectively.

In the pooled and year-wise data number of nodules differed significantly among varieties. In the pooled data it was significantly maximum (70.98) and minimum (59.32) with JL-24 and TAG-24 varieties respectively.

Interaction between $S \times V$ also recorded significant differences on number of nodules in 1999, 2000 and pooled values. In the pooled data significantly higher (77.15 and 72.00) number of nodules were recorded by S_1V_1 and S_1V_3 treatments respectively while, lesser (52.95, 58.95 and

Table 4.55. Effect of methods of row skipping on number of nodules per plant in groundnut varieties

Number of nodules per plant												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	64.60	52.50	59.40	58.83	65.20	53.40	60.60	59.73	64.90	52.95	60.00	59.28
S ₁ - One row skipping after every three rows	76.50	65.20	71.30	71.00	77.80	66.90	72.70	72.47	77.15	66.05	72.00	71.73
S ₂ - One row skipping after every four rows	70.30	58.60	63.30	64.07	71.50	59.30	64.10	64.97	70.90	58.95	63.70	64.52
Mean	70.47	58.77	64.67	64.63	71.50	59.87	65.80	65.72	70.98	59.32	65.23	65.18
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
S	1.63		4.87		1.10		5.98		1.29		3.86	
V	1.63		4.87		1.10		5.98		1.29		3.86	
S x V	2.82		9.40		3.46		11.53		2.23		7.43	

60.00) number of nodules were recorded by S_0V_2 , S_2V_2 and S_0V_3 treatments respectively.

4.3.1.8 Nodule dry weight (mg/plant)

Nodule dry weight exhibited significant differences due to methods of row skipping, varieties and their interactions in both years and pooled data which are presented in Table 4.56.

In the pooled data significantly maximum (135.2 mg/plant) and minimum (77.4 mg/plant) nodule dry weights were recorded by S_1 and S_0 methods of row skippings respectively. Similar trend was recorded in both the years.

Significantly maximum (121.1 mg/plant) and minimum (95.2 mg/plant), nodule dry weights were recorded by JL-24 and TAG-24 varieties respectively in the pooled data. Similar trend was noticed in both the years.

In the pooled data S_1V_1 and S_0V_2 interaction combinations recorded significantly maximum (146.0 mg/plant) and minimum (63.2 mg/plant), nodule dry weights respectively over other treatment combinations.

4.3.2 Yield parameters

4.3.2.1 Number of mature pods per plant

The data on number of mature pods per plant of both the years and pooled are presented in Table 4.57.

Significant differences on mature pods number due to methods of row skipping were noticed in both the years and pooled data irrespective of varieties. The mature pods recorded by methods of row skippings S_1

Table 4.56. Effect of methods of row skipping on nodule dry weight (mg/plant) in groundnut varieties

Treatments	Nodule dry weight (mg/ plant)											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	91.5	60.9	72.3	74.9	96.8	65.6	77.4	79.9	94.2	63.2	74.9	77.4
S ₁ - One row skipping after every three rows	143.7	123.6	130.4	132.6	148.2	129.5	136.0	137.9	146.0	126.6	133.2	135.2
S ₂ - One row skipping after every four rows	120.8	93.1	103.5	105.8	125.3	98.6	109.9	111.3	123.1	95.9	106.7	108.5
Mean	118.7	92.5	102.1	104.4	123.4	97.9	107.8	109.7	121.1	95.2	104.9	107.1
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	2.2		6.7		2.3		6.9		1.6		4.8	
V	2.2		6.7		2.3		6.9		1.6		4.8	
S x V	3.9		13.0		4.0		13.3		2.8		9.3	

Table 4.57. Effect of methods of row skipping on number of mature pods per plant in groundnut varieties

Treatments	Number of mature pods per plant											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	11.44	10.21	10.83	10.83	12.21	10.89	11.47	11.52	11.83	10.55	11.15	11.18
S ₁ - One row skipping after every three rows	17.65	14.11	16.27	16.01	18.11	14.82	16.95	16.63	17.88	14.47	16.61	16.32
S ₂ - One row skipping after every four rows	16.29	12.24	14.36	14.30	16.94	12.78	15.14	14.95	16.62	12.51	14.75	14.63
Mean	15.13	12.19	13.82	13.71	15.75	12.83	14.52	14.37	15.44	12.51	14.17	14.04
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	0.97		2.89		0.96		2.86		0.68		2.04	
V	0.97		2.89		0.96		2.86		0.68		2.04	
S x V	1.67		5.57		1.66		5.53		1.18		3.93	

and S₂ were significantly maximum (16.01 and 14.30) during 1999, (16.63 and 14.95) during 2000 and (16.32 and 14.63) in pooled values respectively but were at par between each other.

Varieties also recorded significant differences on mature pods number in pooled and year-wise values. R-8808 variety recorded in between maximum and minimum number of mature pods in pooled and year-wise data and was on par with JL-24 and TAG-24 varieties. While, JL-24 recorded significantly maximum (15.13, 15.75 and 15.44) and TAG-24 recorded minimum (12.19, 12.83 and 12.51) mature pods in 1999, 2000 and pooled values respectively irrespective of methods of row skipping.

Interaction between S x V was also significant in pooled and year-wise data. The mature pods number ranged between 10.55 (S₀V₂) to 17.88 (S₁V₁) in pooled values with an over all average of 14.04.

4.3.2.2 Number of immature pods per plant

The data on immature pods per plant are presented in Table 4.58.

Significant variations were noticed due to methods of row skipping in pooled and both year values. Immature pods were significantly less (4.58, 5.25 and 4.92) in 1999, 2000 and pooled values respectively with S₁ method of row skipping. S₀ method of row skipping recorded significantly high (7.12, 7.78 and 7.45) immature pods in 1999, 2000 and pooled values respectively irrespective of varieties. S₂ method of row skipping with a immature pods of 5.91, 6.63 and 6.27 in 1999, 2000 and pooled values respectively was on par with either S₁ and S₀ methods of row skipplings.

Table 4.58. Effect of methods of row skipping on number of immature pods per plant in groundnut varieties

Number of immature pods per plant												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	6.69	7.44	7.22	7.12	7.38	8.14	7.83	7.78	7.04	7.79	7.53	7.45
S ₁ - One row skipping after every three rows	4.09	5.19	4.47	4.58	4.62	5.93	5.19	5.25	4.36	5.56	4.83	4.92
S ₂ - One row skipping after every four rows	5.76	6.56	5.41	5.91	6.54	7.08	6.27	6.63	6.15	6.82	5.84	6.27
Mean	5.51	6.40	5.70	5.87	6.18	7.05	6.43	6.55	5.85	6.72	6.07	6.21
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
S	0.62			1.86	0.76			2.28	0.49			1.47
V	0.62			NS	0.76			NS	0.49			NS
S x V	1.07			NS	1.32			NS	0.85			2.83

NS - Non significant

No Significant differences among varieties were noticed in both the years and pooled data on immature pods number irrespective of methods of row skipping.

Interaction between methods of row skipping and varieties showed significant difference on immature pods number only in the pooled data. It ranged between 4.36 (S_1V_1) to 7.79 (S_0V_2) with an average of 6.21.

4.3.2.3 Pod yield (g/plant)

The data on pod yield per plant showed significant differences due to methods of row skipping, varieties and their interaction in both years and pooled values and these are presented in Table 4.59.

Irrespective of varieties in the pooled data S_1 and S_0 methods of row skipplings recorded significantly maximum (11.85 g/plant) and minimum (8.26 g/plant) pod yields respectively.

In the pooled data irrespective of methods of row skipping, JL-24 and TAG-24 varieties recorded significantly maximum (11.83 g/plant) and minimum (8.57 g/plant) pod yields respectively.

In the pooled values interaction treatments S_1V_1 and S_1V_2 recorded significantly higher (13.78 and 12.40 g/plant) pod yields respectively over other treatments. Whereas, S_0V_2 , S_2V_2 and S_0V_3 recorded significantly lesser (7.18, 8.57 and 8.28 g/plant) pod yields respectively.

4.3.2.4 Pod yield (kg/ha)

The data on pod yield per hectare are presented in Table 4.60.

Table 4.60. Effect of methods of row skipping on pod yield (kg/ha) in groundnut varieties

Treatments	Pod yield (kg/ha)											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	2476	1903	2195	2191	2716	2094	2411	2407	2596	1999	2303	2299
S ₁ - One row skipping after every three rows	2877	2085	2449	2470	3080	2219	2651	2650	2979	2152	2550	2560
S ₂ - One row skipping after every four rows	2757	1879	2373	2337	2987	2089	2555	2544	2872	1984	2464	2440
Mean	2704	1956	2339	2333	2928	2134	2539	2533	2816	2045	2439	2433
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	101		NS		140		NS		87		259	
V	101		304		140		420		87		259	
S x V	176		587		243		810		150		500	

NS – Non significant

The per hectare pod yield due to methods of row skipping irrespective of varieties was significant only in pooled data. S_0 , S_1 and S_2 methods of row skipplings recorded 2299, 2560 and 2440 kg per hectare pod yield respectively wherein, S_1 and S_0 methods of row skipplings were significantly high and low respectively while, S_2 method of row skipping was on par at both the yield levels.

Irrespective of methods of row skipping, varieties differed among themselves on per hectare pod yield. In the pooled results it was significantly maximum (2816 kg/ha) with JL-24 variety and minimum (2045 kg/ha) with TAG-24 variety.

The differences in pod yield per hectare was significant in both the years and pooled values due to interaction between $S \times V$. The per hectare pod yield in the pooled data ranged from 1984 kg (S_2V_2) to 2979 kg (S_1V_1) with an overall average yield of 2433 kg irrespective of methods of row skipping and varieties.

4.3.2.5 Shelling percentage

The original and arc sine transformed values on shelling percentage are presented in Table 4.61.

Shelling percentage differed significantly due to methods of row skipping in both years and pooled values. In pooled values it was significantly maximum (69.16 %) with S_1 method of row skipping which was followed by S_2 method of row skipping with a shelling of 68.50 per cent and both were at par between each other. S_0 method of row

Table 4.61 Effect of methods of row skipping on shelling percentage in groundnut varieties

Treatments	Shelling percentage											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	66.69 (54.76)*	66.12 (54.41)	66.38 (54.56)	66.40 (54.58)	67.23 (55.08)	66.54 (54.66)	66.90 (54.88)	66.89 (54.88)	66.96 (54.92)	66.33 (54.54)	66.64 (54.72)	66.64 (54.73)
S ₁ - One row skipping after every three rows	69.54 (56.50)	68.19 (55.71)	69.08 (56.22)	68.94 (56.14)	70.11 (56.86)	68.61 (55.94)	69.45 (56.45)	69.39 (56.42)	69.83 (56.68)	68.40 (55.82)	69.27 (56.34)	69.16 (56.28)
S ₂ - One row skipping after every four rows	69.11 (56.24)	67.29 (55.12)	68.37 (55.78)	68.26 (55.71)	69.58 (56.54)	67.75 (55.40)	68.91 (56.11)	68.75 (56.02)	69.35 (56.39)	67.52 (55.26)	68.64 (55.95)	68.50 (55.86)
Mean	68.45 (55.83)	67.20 (55.08)	67.94 (55.52)	67.86 (55.48)	68.97 (56.16)	67.63 (55.33)	68.42 (55.82)	68.34 (55.77)	68.71 (56.00)	67.42 (55.21)	68.18 (55.67)	68.10 (55.62)
For comparing the means of	S.Em _±	C.D. at 5%			S.Em _±	C.D. at 5%			S.Em _±	C.D. at 5%		
S	0.36	1.09			0.36	1.09			0.26	0.77		
V	0.36	NS			0.36	NS			0.26	0.77		
S x V	0.63	NS			0.63	2.10			0.45	1.50		

NS – Non significant

* Figures in the parentheses indicate arc sine transformed values

skipping recorded significantly minimum (66.64 %) shelling. Similar trend was noticed in both the years of experimentation.

Irrespective of methods of row skipping, varieties could exert significant difference on shelling percentage only in pooled data. It was 68.71, 68.18 and 67.42 per cent with JL-24, R-8808 and TAG-24 varieties respectively. R-8808 was at par with either JL-24 and TAG-24 varieties.

Irrespective of methods of row skipping and varieties interaction between these recorded significant differences on shelling percentage in 2000 and pooled values. The shelling ranged between 66.33 per cent (S_0V_2) to 69.83 per cent (S_1V_1) with an average value of 68.10 per cent.

4.3.2.6 Kernel yield (kg/ha)

The computed data on kernel yield per hectare of both the years and pooled are presented in Table 4.62.

Methods of row skipping could not exhibit any significant differences on kernel yield during 2000 while, it was significant in 1999 and pooled results. In pooled results it was significantly higher (1773 kg/ha) in S_1 method of row skipping which was followed by S_2 method of row skipping (1675 kg/ha) and both were at par with each other. S_0 method of row skipping recorded significantly lesser (1535 kg/ha) kernel yield and again S_2 method of row skipping was at par with S_0 method of row skipping.

Irrespective of methods of row skipping, varieties exhibited significant differences in kernel yield in pooled and year-wise results. In the pooled data it was significantly maximum (1939 kg/ha) and minimum

Table 4.62 Effect of methods of row skipping on kernel yield (kg/ha) in groundnut varieties

Kernel yield (kg/ha)												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
Methods of row skipping (S)												
S ₀ - No row skipping	1656	1260	1459	1458	1829	1390	1615	1611	1742	1325	1537	1535
S ₁ - One row skipping after every three rows	2001	1423	1692	1706	2161	1524	1838	1841	2081	1474	1765	1773
S ₂ - One row skipping after every four rows	1907	1265	1622	1598	2080	1414	1763	1752	1994	1339	1693	1675
Mean	1855	1316	1591	1587	2023	1443	1739	1735	1939	1379	1665	1661
For comparing the means of	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%
S	75		223		98		NS		62		184	
V	75		223		98		293		62		184	
S x V	129		430		170		567		107		357	

NS -- Non significant

(1379 kg/ha) with JL-24 and TAG-24 varieties respectively over R-8808 (1665 kg/ha).

Interaction between S x V on kernel yield was significant in both years and pooled values. On an average 1587, 1735 and 1661 kg kernel yield per hectare were recorded in 1999, 2000 and pooled results respectively. In the pooled data the treatments S₀V₁, S₁V₁, S₂V₁ and S₁V₃ recorded higher but on par kernel yields while, treatments S₀V₂, S₁V₂, S₂V₂ and S₀V₃ recorded lesser but on par kernel yields.

4.3.2.7 Benefit cost ratio

The benefit cost ratio data as influenced by methods of row skipping and varieties and their interactions are presented in Table 4.63.

Due to methods of row skipping benefit cost ratio was significant in 1999 and pooled values while, it was non-significant in 2000 results. In pooled values it was significantly high (5.14) with S₁ method of row skipping and low (4.24) with S₀ method of row skipping. The S₂ method of row skipping with a ratio of 4.77 was at par with either S₀ and S₁ methods of row skipplings. Similar trend was recorded during 1999 year of production.

Irrespective of methods of row skipping, varieties differed among themselves in benefit cost ratio during both years and also in pooled values. It was significantly maximum (5.62) and minimum (3.80) with JL-24 and TAG-24 varieties respectively in the pooled data. The variety R-8808 recorded 4.73 benefit cost ratio.

Table 4.63. Effect of methods of row skipping on benefit cost ratio in groundnut varieties

Treatments	Benefit cost ratio											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	4.65	3.34	4.00	4.00	5.19	3.78	4.49	4.49	4.92	3.56	4.25	4.24
S ₁ - One row skipping after every three rows	5.91	4.00	4.88	4.93	6.39	4.32	5.36	5.36	6.15	4.16	5.12	5.14
S ₂ - One row skipping after every four rows	5.52	3.44	4.62	4.53	6.07	3.94	5.04	5.02	5.79	3.69	4.83	4.77
Mean	5.36	3.60	4.50	4.48	5.88	4.01	4.97	4.95	5.62	3.80	4.73	4.72
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
S	0.23		0.70		0.32		NS		0.20		0.60	
V	0.23		0.70		0.32		0.97		0.20		0.60	
S x V	0.41		1.37		0.56		1.87		0.35		1.17	

NS – Non significant

Interaction between S x V was also significant in both years and pooled results. In pooled data it ranged between 3.56 (S_0V_2) to 6.15 (S_1V_1) treatments with an average ratio of 4.72.

4.3.2.8 Sound mature kernel percentage

The data on sound mature kernel percentage which exhibited non significant differences due to main and interaction effects during both the years while, in pooled values it was significant for methods of row skipping and interaction effects only and these are presented in Table 4.64.

Sound mature kernel recorded by S_1 method of row skipping was significantly maximum (83.17 %) while, it was minimum (75.35 %) with S_0 method of row skipping. S_2 method of row skipping was at par with S_1 and S_0 method of row skipplings with 79.38 per cent sound mature kernels.

The varieties JL-24, TAG-24 and R-8808 recorded 81.53, 77.01 and 79.37 per cent sound mature kernels respectively.

Interaction treatments S_1V_1 and S_0V_2 recorded higher (85.50 %) and lesser (73.49 %) sound mature kernels respectively. The average sound mature kernels recorded were 79.30 per cent.

4.3.2.9 Oil content percentage

The data on oil content percentage of 1999, 2000 and pooled are presented in Table 4.65.

Table 4.64. Effect of methods of row skipping on sound mature kernel percentage in groundnut varieties

Treatments	Sound mature kernel percentage											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	77.02 (61.42)*	73.18 (58.88)	74.85 (60.40)	75.02 (60.23)	77.71 (62.05)	73.79 (59.24)	75.57 (60.48)	75.69 (60.59)	77.37 (61.74)	73.49 (59.06)	75.21 (64.44)	75.35 (60.41)
S ₁ - One row skipping after every three rows	85.18 (67.51)	80.84 (64.14)	82.64 (65.42)	82.89 (65.69)	85.81 (68.06)	81.30 (64.67)	83.25 (66.12)	83.45 (66.28)	85.50 (67.79)	81.07 (64.41)	82.95 (65.77)	83.17 (65.99)
S ₂ - One row skipping after every four rows	81.38 (64.77)	76.11 (60.91)	79.66 (62.61)	79.05 (62.76)	82.09 (65.13)	76.84 (61.49)	80.22 (63.95)	79.72 (63.52)	81.74 (64.95)	76.48 (61.20)	79.94 (63.28)	79.38 (63.14)
Mean	81.19 (64.56)	76.71 (61.31)	79.05 (62.81)	78.99 (62.89)	81.87 (65.08)	77.31 (61.80)	79.68 (63.52)	79.62 (63.47)	81.53 (64.82)	77.01 (61.55)	79.37 (63.16)	79.30 (63.18)
For comparing the means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
S	1.55		NS		1.67		NS		1.14		3.41	
V	1.55		NS		1.67		NS		1.14		NS	
S x V	2.68		NS		2.89		NS		1.97		6.57	

NS - Non significant

* Figures in the parentheses indicate arc sine transformed values

Table 4.65. Effect of methods of row skipping on oil content percentage in groundnut varieties

Oil content percentage												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
Methods of row skipping (S)											Mean	
S ₀ - No row skipping	42.84 (40.88)*	40.51 (39.53)	41.86 (40.31)	41.74 (40.24)	43.34 (41.17)	41.09 (39.87)	42.28 (40.55)	42.24 (40.53)	43.09 (41.03)	40.80 (39.70)	42.07 (40.43)	41.99 (40.39)
S ₁ - One row skipping after every three rows	46.82 (43.18)	44.86 (42.05)	46.02 (42.72)	45.90 (42.65)	47.35 (43.48)	45.51 (42.42)	46.61 (43.05)	46.49 (42.99)	47.09 (43.33)	45.19 (42.24)	46.32 (42.89)	46.20 (42.82)
S ₂ - One row skipping after every four rows	44.93 (42.09)	43.12 (41.04)	44.08 (41.60)	44.04 (41.58)	45.57 (42.46)	43.68 (41.36)	44.72 (41.97)	44.66 (41.93)	45.25 (42.27)	43.40 (41.20)	44.40 (41.78)	44.35 (41.75)
Mean	44.86 (42.05)	42.83 (40.87)	43.99 (41.54)	43.89 (41.49)	45.42 (42.37)	43.43 (41.22)	44.54 (41.86)	44.46 (41.82)	45.14 (42.21)	43.13 (41.05)	44.26 (41.70)	44.18 (41.65)
For comparing the means of	S.Em _±	S.Em _±	C.D. at 5%	S.Em _±	S.Em _±	S.Em _±	C.D. at 5%	C.D. at 5%	S.Em _±	S.Em _±	C.D. at 5%	C.D. at 5%
S	0.42		1.25		0.52		1.56		0.33		1.00	1.00
V	0.42		NS		0.52		NS		0.33		1.00	1.00
S x V	0.72		2.40		0.90		3.00		0.58		1.93	1.93

NS - Non significant

* Figures in the parentheses indicate arc sine transformed values

Irrespective of varieties oil content differed significantly due to methods of row skipping in pooled and year-wise data. In pooled values it was significantly maximum (46.20 %) and minimum (41.99 %) with S_1 and S_0 methods of row skippings respectively.

Only in the pooled results oil content percentage showed significant differences among varieties. The varieties JL-24 and R-8808 recorded significantly higher (45.14 and 44.26 %) but on par oil content respectively while, TAG-24 recorded significantly lesser (43.13 %) oil content.

Interaction between $S \times V$ was significant in pooled and year-wise results. In pooled values average oil content of 44.18 per cent was recorded irrespective of methods of row skipping and varieties. It ranged from 40.80 per cent (S_0V_2) to 47.09 per cent (S_1V_1). The interaction treatments S_1V_1 , S_2V_1 , S_1V_2 , S_1V_3 and S_2V_3 were at par with each other while, remaining interactions were at par.

4.3.2.10 Oil yield (kg/ha)

The data on computed oil yield per hectare are presented in Table 4.66.

Oil yield differed significantly due to methods of row skipping in pooled and both year results. It was significantly maximum (822 and 746 kg/ha) but on par with S_1 and S_2 methods of row skippings respectively in pooled data. Significantly minimum (648 kg/ha) oil yield was recorded by S_0 method of row skipping.

Varieties also differed in their oil yields in pooled and both year results. In pooled data significantly highest (878 kg/ha) and lowest

Table 4.66. Effect of methods of row skipping on oil yield (kg/ha) in groundnut varieties

Treatments	Oil yield (kg/ha)											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	707	510	610	609	799	572	689	687	753	540	650	648
S ₁ - One row skipping after every three rows	936	641	779	785	1021	692	860	858	979	666	810	822
S ₂ - One row skipping after every four rows	861	547	714	707	946	619	788	784	904	583	751	746
· Mean	835	566	701	701	922	628	779	776	878	597	740	738
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	34		101		48		146		30		89	
V	34		101		48		146		30		89	
S x V	58		197		85		283		51		170	

(597 kg/ha) oil yields were recorded by JL-24 and TAG-24 varieties respectively.

Interaction between S x V on oil yield was significant in both years and pooled values. In pooled values it was significantly maximum (979 kg/ha) with S₁V₁ treatment combination and this was on par with S₂V₁ and S₁V₃ treatments. Average oil yield per hectare recorded was 738 kg.

4.3.3 Seed quality parameters

4.3.3.1 100 seed weight (g)

The data on 100 seed weight influenced by methods of row skipping and varieties are presented in Table 4.67.

Among methods of row skippings significant differences were noticed in seed weight in both years and pooled results. In pooled values it was significantly higher (33.85 g) and lesser (27.99 g) with S₁ and S₀ methods of row skippings respectively.

Varieties irrespective of methods of row skipping also exhibited significant differences among themselves in both years and pooled results. In pooled values it was significantly higher (33.72 g) in JL-24 and lesser (28.37 g) in TAG-24 varieties.

Interaction between S x V was also significant on seed weight in pooled and year-wise results. An average 100 seed weight of 30.84, 31.11 and 30.98 g were recorded in 1999, 2000 and pooled results. In pooled values highest (36.13 g) and lowest (25.58 g) 100 seed weights were recorded by S₁V₁ and S₀V₂ treatments respectively.

Table 4.67. Effect of methods of row skipping on 100 seed weight (g) in groundnut varieties

100 seed weight (g)												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
Methods of row skipping (S)												
S ₀ - No row skipping	30.82	25.19	28.64	28.22	31.26	25.96	26.04	27.75	31.04	25.58	27.34	27.99
S ₁ - One row skipping after every three rows	35.84	31.27	33.55	33.55	36.41	31.83	34.13	34.12	36.13	31.55	33.84	33.84
S ₂ - One row skipping after every four rows	33.74	27.53	31.02	30.77	34.27	28.44	31.66	31.46	34.01	27.98	31.34	31.11
Mean	33.47	28.00	31.07	30.84	33.98	28.74	30.61	31.11	33.72	28.37	30.84	30.98
For comparing the means of	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%	S.Em±			C.D. at 5%
S	1.10			3.32	1.00			3.00	0.75			2.24
V	1.10			3.32	1.00			3.00	0.75			2.24
S x V	1.92			6.40	1.73			5.77	1.29			4.30

The original and arc sine transformed values of germination percentage which resulted in exhibiting significant differences due to main factors and also their interaction effects in 1999, 2000 and pooled values are presented in Table 4.68.

In the pooled results significantly maximum (92.01 %) and minimum (84.95 %) germination were recorded by S_1 and S_0 methods of row skippings respectively.

In the pooled results irrespective of methods of row skipping JL-24 variety recorded significantly maximum (90.81 %) germination over TAG-24 (86.57 %) and R-8808 (88.27 %) varieties.

Interaction between $S \times V$ in pooled results recorded significantly higher (93.53, 92.09, 91.35 and 90.41 %) germination with S_1V_1 , S_1V_3 , S_2V_1 and S_1V_2 treatment combinations respectively. While, significantly lesser (82.84, 84.45 and 86.46 %) germination were recorded by S_0V_2 , S_0V_3 and S_2V_2 treatments respectively.

4.3.3.3 Seedling length (cm)

The data on seedling length influenced by methods of row skipping in groundnut varieties showed significant differences due to main factors and also interaction effect in both years and pooled results and these are presented in Table 4.69.

In pooled data S_1 and S_0 methods of row skippings recorded significantly maximum (22.60 cm) and minimum (18.13 cm) seedling lengths respectively.

Table 4.69. Effect of methods of row skipping on seedling length (cm) in groundnut varieties

Treatments	Seedling length (cm)											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	18.50	15.90	17.00	17.13	20.80	17.70	18.90	19.13	19.65	16.80	17.95	18.13
S ₁ - One row skipping after every three rows	22.70	21.00	21.60	21.78	24.20	22.40	23.70	23.43	23.45	21.70	22.65	22.60
S ₂ - One row skipping after every four rows	20.80	17.50	18.60	18.97	22.60	19.70	20.50	20.93	21.70	19.15	19.55	19.95
Mean	20.67	18.13	19.07	19.29	22.53	19.93	21.03	21.17	21.60	19.03	20.05	20.23
For comparing the means of	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%
S	0.58			1.74	0.53			1.58	0.39			1.17
V	0.58			1.74	0.53			1.58	0.39			1.17
S x V	1.01			3.37	0.91			3.03	0.68			2.37

Irrespective of methods of row skipping, JL-24 variety recorded significantly maximum (21.60 cm) seedling length in pooled results over TAG-24 (19.03 cm) and R-8808 (20.05 cm) which were on par with each other.

Irrespective of methods of row skipping and varieties in the pooled data seedling length ranged from 16.80 cm (S_0V_2) to 23.45 cm (S_1V_1) with an average length of 20.23 cm.

4.3.3.4 Seedling dry weight (g)

The observations on seedling dry weight are presented in Table 4.70 which exhibited non-significant difference due to methods of row skipping, varieties and also their interactions in pooled and year-wise results.

In pooled data numerically high (4.50 g) and low (3.83 g) dry weights of seedling were recorded by S_1 and S_0 methods of row skipping respectively.

The varieties JL-24 and TAG-24 recorded numerically more (4.36 g) and less (3.93 g) dry weights of seedling respectively in pooled data.

In the pooled data average seedling dry weight of 4.15 g was recorded.

4.3.3.5 Seedling vigour index

The data on vigour index of seedling assessed as a seed quality parameter are presented in Table 4.71.

Irrespective of varieties, methods of row skipping recorded significant differences among themselves in both years of experimentation

Table 4.70. Effect of methods of row skipping on seedling dry weight (g) in groundnut varieties

Treatments	Seedling dry weight (g)											
	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	3.80	3.50	3.60	3.63	4.30	3.80	4.00	4.03	4.05	3.65	3.80	3.83
S ₁ - One row skipping after every three rows	4.60	4.00	4.40	4.33	4.90	4.40	4.70	4.67	4.75	4.20	4.55	4.50
S ₂ - One row skipping after every four rows	4.20	3.70	3.90	3.93	4.33	4.20	4.30	4.28	4.27	3.95	4.10	4.11
Mean	4.20	3.73	3.97	3.97	4.51	4.13	4.33	4.33	4.36	3.93	4.15	4.15
For comparing the means of	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%	S.E.m _±			C.D. at 5%
S	0.25			NS	0.31			NS	0.20			NS
V	0.25			NS	0.31			NS	0.20			NS
S x V	0.44			NS	0.54			NS	0.35			NS

NS - Non significant

Table 4.71. Effect of methods of row skipping on seedling vigour index in groundnut varieties

Seedling vigour index												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			Mean
	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	1597	1302	1418	1439	1849	1485	1614	1649	1723	1393	1516	1544
S ₁ - One row skipping after every three rows	2095	1886	1966	1982	2290	2039	2211	2180	2193	1963	2088	2081
S ₂ - One row skipping after every four rows	1886	1495	1622	1668	2083	1730	1840	1884	1985	1612	1731	1776
Mean	1859	1561	1669	1696	2074	1751	1888	1905	1967	1656	1778	1800
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	60		179		57		169		41		123	
V	60		179		57		169		41		123	
S x V	104		347		98		327		71		237	

and pooled results. Indices values were significantly maximum (1982, 2180 and 2081) with S_1 method of row skipping and minimum (1439, 1649 and 1544) with S_0 method of row skipping in 1999, 2000 and pooled values respectively.

Varieties also showed significant differences on vigour index in both the years and pooled results. In pooled results JL-24 variety recorded significantly maximum (1967) index value while, TAG-24 and R-8808 recorded 1656 and 1778 indices values respectively but were at par with each other.

Interaction between $S \times V$ was also significant in pooled and year-wise results. In pooled data indices values ranged from 1393 (S_0V_2) to 2193 (S_1V_1) with an average of 1800 vigour index value.

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

The data on electrical conductivity of seed leachate for the year 1999, 2000 and pooled are presented in Table 4.72.

Electrical conductivity of seed leachate values differed significantly due to methods of row skipping in 1999, 2000 and also in pooled data. It was significantly minimum (0.198, 0.211 and 0.204 dSm^{-1}) in 1999, 2000 and pooled values respectively with S_1 method of row skipping. The S_0 method of row skipping recorded significantly maximum (0.256, 0.269 and 0.262 dSm^{-1}) electrical conductivity of seed leachate values in 1999, 2000 and pooled data respectively.

Electrical conductivity of seed leachate values recorded significant differences among varieties in year-wise and pooled data. JL-24 recorded

Table 4.72. Effect of methods of row skipping on electrical conductivity of seed leachate (dSm⁻¹) in groundnut varieties

Electrical conductivity of seed leachate (dSm ⁻¹)												
Treatments	1999				2000				Pooled			
	Varieties (V)			Mean	Varieties (V)			Mean	Varieties (V)			
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)		JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	Mean
S ₀ - No row skipping	0.227	0.284	0.258	0.256	0.240	0.295	0.271	0.269	0.233	0.290	0.264	0.262
S ₁ - One row skipping after every three rows	0.188	0.210	0.197	0.198	0.200	0.223	0.209	0.211	0.194	0.216	0.203	0.204
S ₂ - One row skipping after every four rows	0.202	0.246	0.231	0.226	0.213	0.261	0.245	0.240	0.208	0.254	0.238	0.233
Mean	0.206	0.247	0.229	0.227	0.218	0.260	0.242	0.240	0.212	0.253	0.235	0.233
For comparing the means of	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%	S.Em _±			C.D. at 5%
S	0.004		0.011		0.003		0.008		0.002		0.007	
V	0.004		0.011		0.003		0.008		0.002		0.007	
S x V	0.007		0.023		0.005		0.016		0.004		0.013	

significantly minimum (0.206, 0.218 and 0.212 dSm⁻¹) and TAG-24 recorded maximum (0.247, 0.260 and 0.253 dSm⁻¹) electrical conductivity of seed leachate values in 1999, 2000 and pooled results respectively.

Interaction effects between S x V was also significant in both the years of experimentation and pooled data on electrical conductivity of seed leachate values. In pooled data it was significantly minimum (0.194 dSm⁻¹) and maximum (0.290 dSm⁻¹) with S₁V₁ and S₀V₂ treatment combinations respectively.

Discussion

V. DISCUSSION

The results of the studies on integrated nutrient management and planting methods on seed yield and quality of groundnut was carried out during 1999 and 2000 *kharif* seasons and the pooled data are discussed in this chapter in line with the findings of the earlier researchers.

5.1 EXPERIMENT - I: EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of in all 16 nutrient treatments involving various inorganic, organic nutrients, bio-fertilizers and their combinations.

5.1.1 Influence on growth parameters

The plant height at 60 days after sowing (Table 4.01) and at harvest (Table 4.02) as well as number of branches per plant at harvest (Table 4.03) were found to be non significant due to nutrient treatments during both years of experimentation as well in pooled data. However, combined application of RDF (25:50:25 NPK kg/ha) + Vermicompost (VC @ 2.5 t/ha) + Copper ore tailing (COT @ 12.5 q/ha) (T₁₁) treatment recorded numerically higher plant height (43.94 cm) with more number of branches (8.25) at harvest.

Days taken to 50 per cent flowering (Table 4.04), peg initiation (Table 4.05) and pod maturity (Table 4.06) also showed statistical differences in both years and pooled results due to nutrient levels. The nutrient level RDF + VC + COT (T₁₁) recorded significantly less (35.15, 50.00 and 98.1) days to 50 per cent flowering, peg initiation and pod

maturity which was followed by and was on par with nutrient treatment of RDF + VC + Gypsum (T₁₂) by taking 35.60, 50.30 and 100.2 days to 50 per cent flowering, peg initiation and pod maturity respectively.

Only in the pooled data, number of nodules per plant (Table 4.07) exerted significant differences due to nutrient levels. Combined application of RDF + VC + COT (T₁₁) recorded significantly maximum (74.55) number of nodules per plant and it was followed by application of RDF + VC + Gypsum (5 q/ha) (T₁₂), RDF + FYM (5 t/ha) + COT (T₈), RDF + FYM + Bio-fertilizer (Rhizobium + 'P' solubilizer each @ 1kg/ha) (T₉), RDF + VC + Bio-fertilizer (T₁₃), RDF + FYM + VC (T₇) and all these treatments were at par with each other. The data on nodule dry weight (Table 4.08) exhibited significant differences due to nutrition levels during both the years of experimentation as well in pooled values. Combined application of RDF + VC + COT (T₁₁) recorded significantly maximum (144.2, 148.3 and 146.3 mg/plant) nodule dry weights in 1999, 2000 and pooled values respectively over all other treatments.

Considering various growth parameters T₁₁ and T₁₂ treatments were found to be superior by recording lesser days to 50 per cent flowering, peg initiation and pod maturity (Fig. 5.01) and higher number of nodules than rest of the treatments. Between these two treatments T₁₁ treatment recorded significantly maximum nodule dry weight compared to T₁₂ treatment and hence it was proved to be superior nutrient treatment for groundnut seed production.

The higher values for growth attributes like plant height, number of branches, nodule number and dry weight and earliness in days to

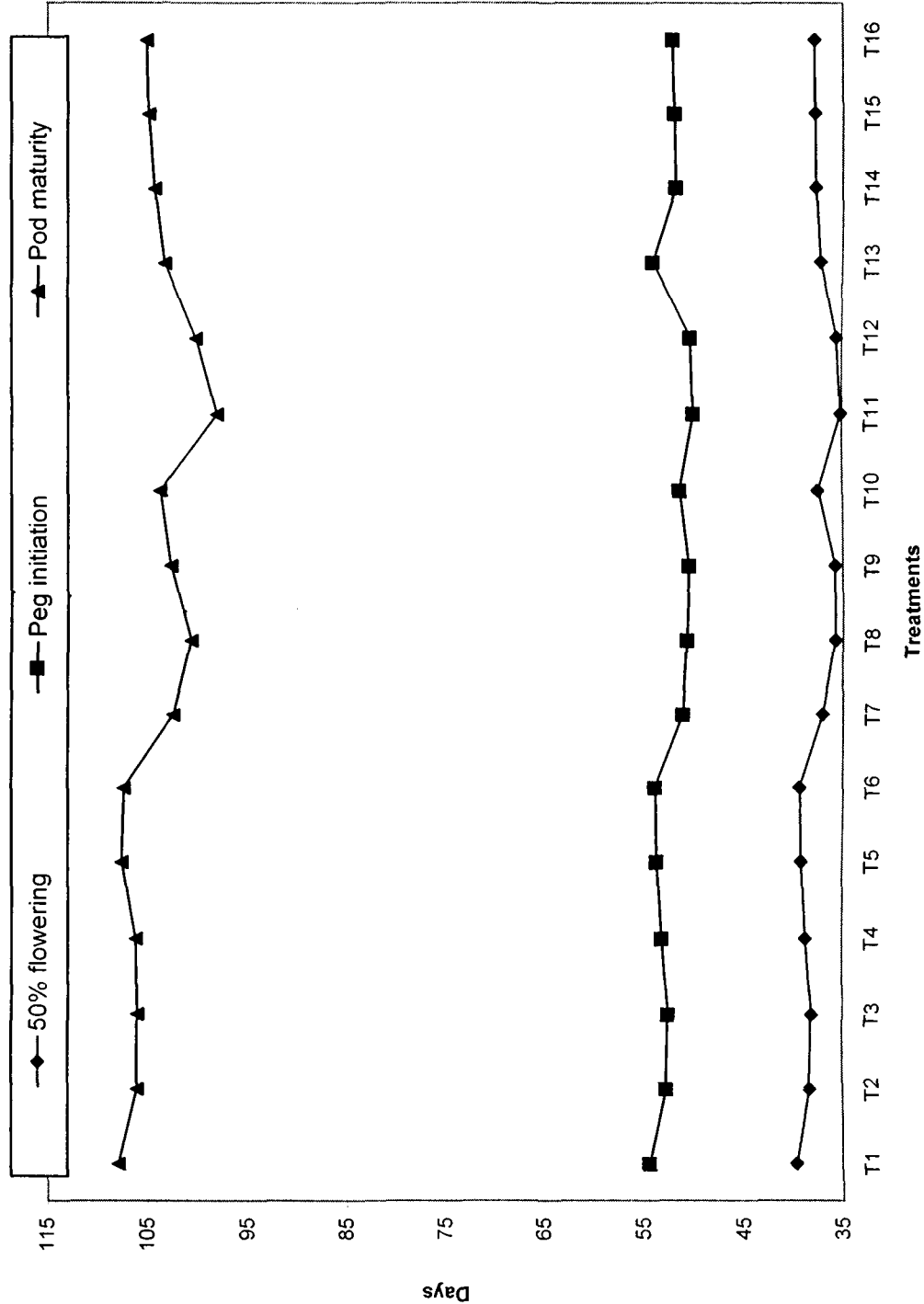


Fig. 5.01: Effect of organic, inorganic nutrients and biofertilizers on days to 50 per cent flowering, peg initiation and pod maturity in groundnut

50 per cent flowering, peg initiation and pod maturity noticed in the nutrient treatment T₁₁ may be attributed to cumulative effect of inorganic nutrients (NPK) + organic manure (VC) + COT (which contains micronutrients like sulphur 34.5 mg/kg, iron 21.1 mg/kg, manganese 7.2 mg/kg, copper 7.1 mg/kg and lead 2.3 mg/kg).

Similar increase in nodule number and dry weight per plant of groundnut due to application of 50 per cent recommended NPK and inoculation with *rhizobium* + *G. macrocarpum* was reported by Shasidhara *et al.* (1994). Jain and Tiwari (1995) also noticed increase in nodulation of soybean with FYM and sugar press mud application. About 43 per cent increase in soybean plant height over control due to application of 4 t per ha FYM and 4 t per ha sugar press mud and 75 per cent increase in number of leaves due to FYM application @ 5 t per ha and sugar press mud @ 3 t per ha was reported by Jain *et al.* (1995). While, Balasubramaniyan and Palaniappan (1996) recorded higher nodule number and dry weight per plant due to application of 12.5 t per ha FYM to groundnut compared to NPK fertilizers. Higher nodule number and weight per plant, N and dry matter accumulation in groundnut were recorded with application of 50 kg P₂O₅ per ha as mussoorie rock phosphate in combination with 10 t per ha organic amendments and 'P' solubilizing bacteria and fungus were also reported by Manjaiah *et al.* (1996). In sunflower, Devidayal and Agarwal (1998) recorded 7 to 9 per cent increase in per plant dry weight with 10 t per ha FYM and 10.5 per cent increase with 10 t per ha vermicompost applications over no organic manure.

Nutrient treatments exhibited significant differences for number of mature pods (Table 4.09) and immature pods (Table 4.10) per plant in both years and pooled values. Application of RDF + VC + COT (T₁₁) recorded significantly maximum (17.06) mature and minimum (3.69) immature pods per plant. This was succeeded by treatments which were applied with RDF +VC + Gypsum (T₁₂), RDF + FYM + COT (T₈) and RDF + FYM + Gypsum (T₉) nutrients. All these were at par with each other.

The data on pod yield per plant (Table 4.11) and pod yield per ha (Table 4.12 and Fig. 5.02) differed significantly due to nutrition levels only in 1999 and pooled results. The treatments T₇ (RDF + FYM +VC), T₈ (RDF + FYM + COT), T₉ (RDF + FYM + Gypsum), T₁₀ (RDF + FYM + Bio-fertilizer), T₁₁ (RDF + VC + COT), T₁₂ (RDF + VC + Gypsum), T₁₃ (RDF + VC + Bio-fertilizer), T₁₄ (RDF + COT + Gypsum) and T₁₅ (RDF + COT + Bio-fertilizer) were on par with each other and recorded significantly higher pod yields. Among these treatments, T₁₁ recorded highest (3337 kg/ha) pod yield. Kernel yield (Table 4.14) differed significantly in both years and pooled data due to nutrient levels. All these treatments which recorded significantly higher pod yield also recorded significantly higher kernel yield except T₁₅ treatment. Furthermore, T₁₁ treatment recorded higher (2362 kg/ha) kernel yield among these.

Shelling percentage (Table 4.13) differed statistically due to nutrient levels in pooled results only. Again all those treatments which recorded higher pod yield also recorded significantly higher shelling percentages. Among themselves, a high of 70.71 per cent shelling was recorded by

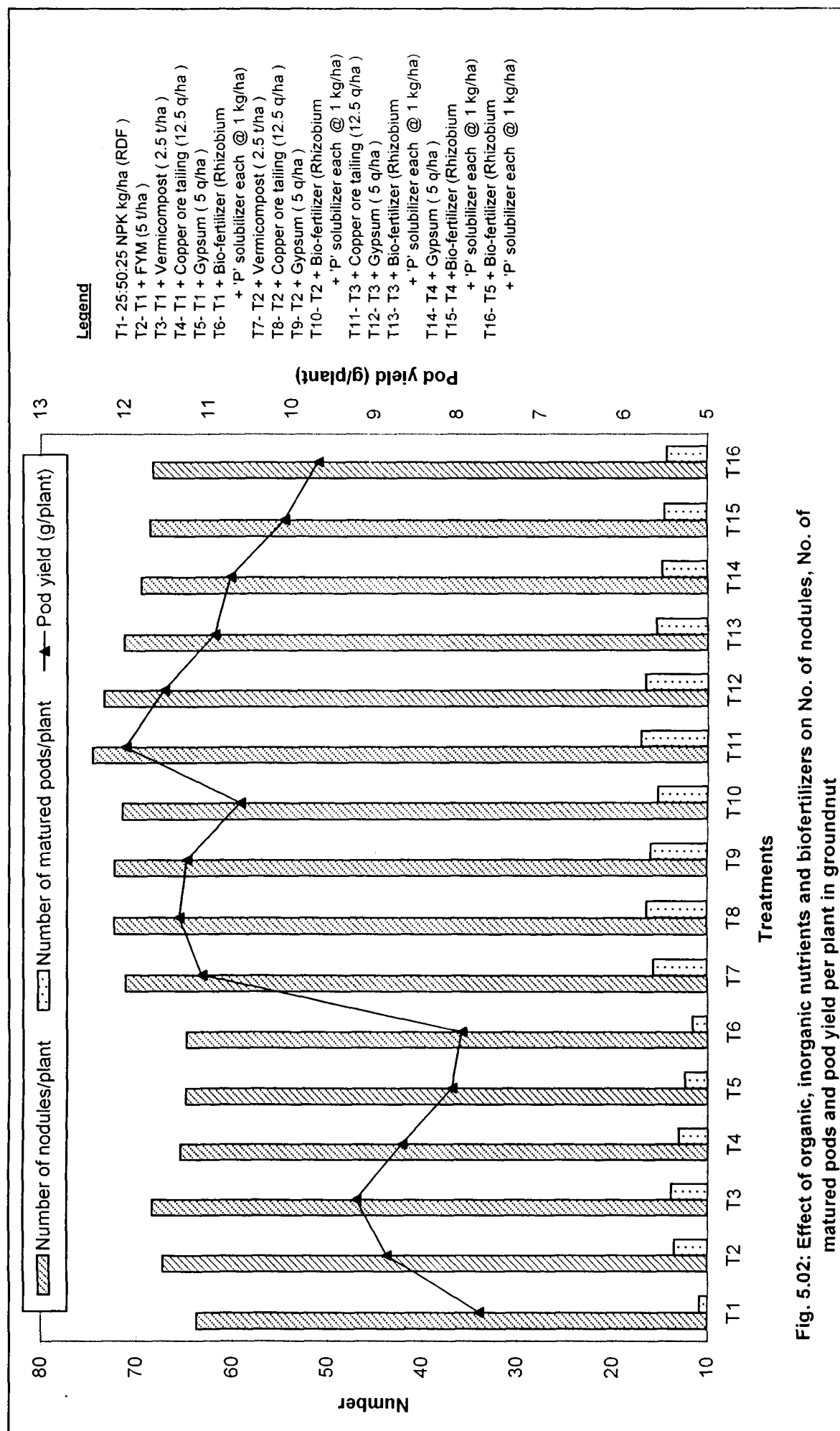


Fig. 5.02: Effect of organic, inorganic nutrients and biofertilizers on No. of nodules, No. of matured pods and pod yield per plant in groundnut

T₁₁ treatment. Sound mature kernel (Table 4.16 and Fig. 5.03) and oil content (Table 4.17) percentage values did not differ due to nutrient levels in both years of experimentation as well in pooled values. However, numerically higher (84.82 and 46.84%) sound mature kernels and oil content were recorded by T₁₁ treatment. The oil yield (Table 4.18 and Fig. 5.04) exhibited significant difference due to nutrient levels in both years and also in pooled values. Except treatments T₁₀ and T₁₄, all other treatments which recorded significantly higher kernel yield also recorded significantly higher oil yields. Among themselves, T₁₁ recorded highest (1103 kg/ha) oil yield.

The benefit cost ratio (Table 4.15) due to nutrient treatments exhibited significant differences only in pooled values. The treatment T₁₅ recorded significantly maximum (5.07) benefit cost ratio and this was on par with T₂ (RDF + FYM), T₄ (RDF + COT), T₆ (RDF + Bio-fertilizer), T₈, T₉, T₁₀, T₁₁, T₁₄ and T₁₆ (RDF + Gypsum + Bio-fertilizer) treatments. The treatment T₁₁ recorded a benefit cost ratio of 4.20.

Though treatments T₂, T₄, T₆ and T₁₆ recorded higher benefit cost ratio but they failed to register higher pod, kernel and oil yields. The treatments T₇, T₁₂ and T₁₃ although these treatments recorded higher pod, kernel and oil yields but they were not economical due to their lesser benefit cost ratio. The treatments T₁₀, T₁₄ and T₁₅ inspite of registering higher benefit cost ratio could not record significantly higher oil yields and T₁₅ treatment also failed to register higher kernel yield. The treatments T₈ and T₉ registered significantly less nodule dry weight and took significantly more days to mature. Looking to various growth and yield

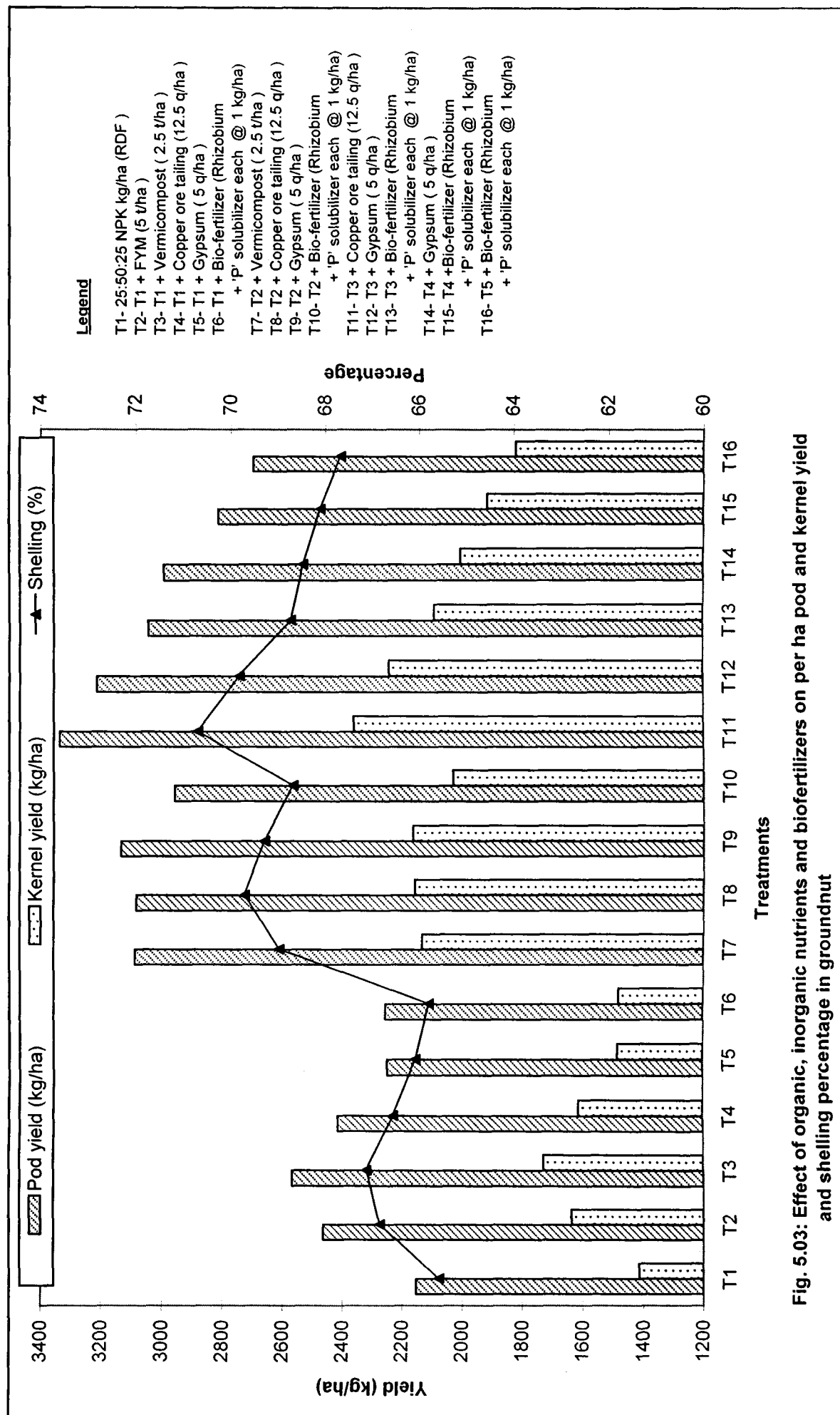
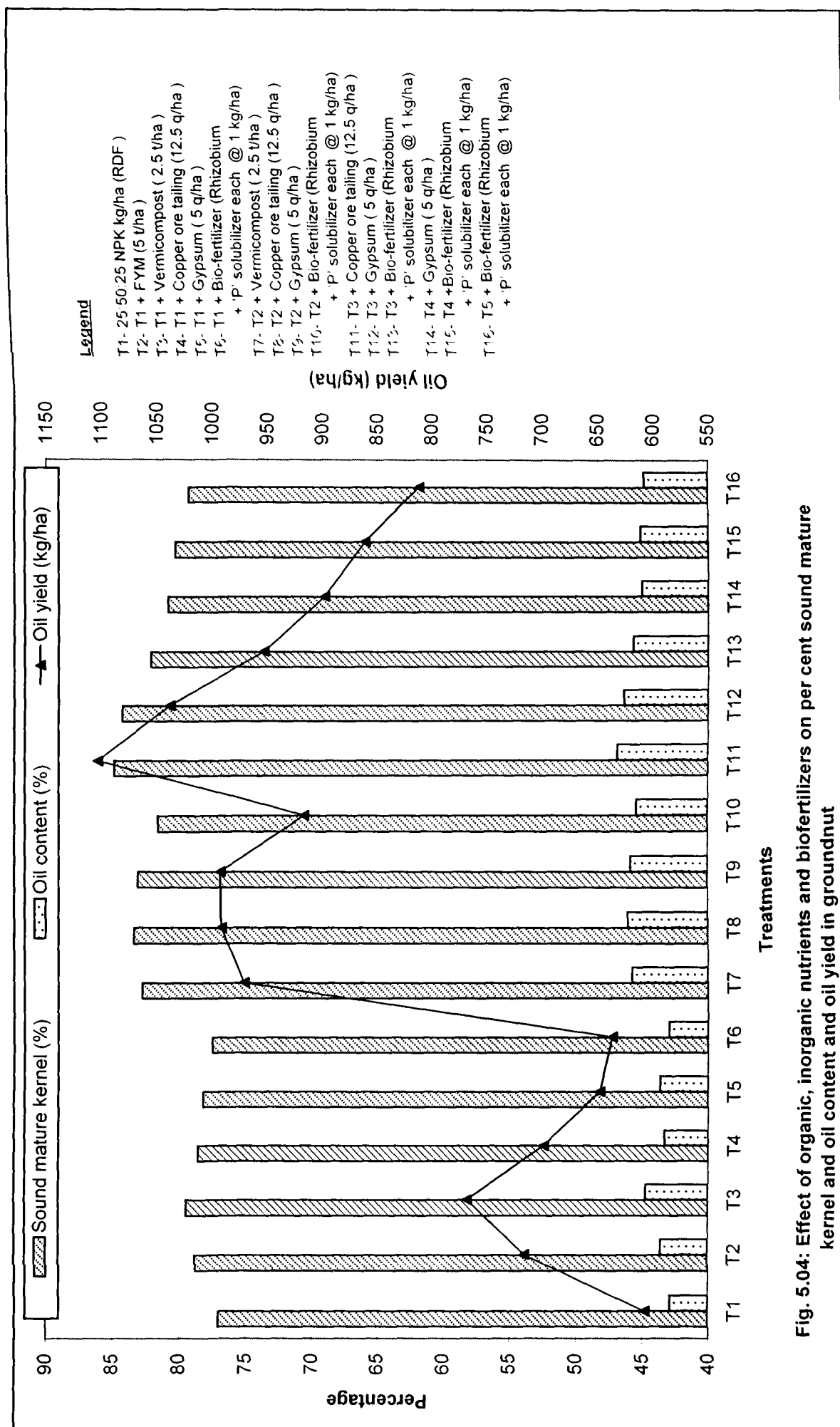


Fig. 5.03: Effect of organic, inorganic nutrients and biofertilizers on per ha pod and kernel yield and shelling percentage in groundnut



parameters and benefit cost ratio, T₁₁ treatment emerges as the best nutrient combination for groundnut seed production. Similar findings were also reported by Ramachandran and Natarajan (1986) they recorded 34 per cent increase in bunch groundnut yield due to application of 200 kg per ha gypsum as basal and again 200 kg gypsum per ha at 2nd weeding and hoeing stage over control. They also recorded 33 per cent increase in pod yield due to application of 6.25 t per ha FYM over no FYM treatment. Application of 80 N + 35 P + 250 kg gypsum as basal + 250 kg gypsum per ha at 30 DAS to groundnut was found effective in recording higher number of filled pods per plant, shelling percentage and pod yield (Chitkala Devi *et al.*, 1987). Whereas, Narasareddy *et al.* (1987) obtained 10.6 per cent increase in groundnut pod yield with application of 30 N + 10 P + 25 K + 500 kg gypsum per ha at 30 DAS. Conjunctive use of 6 t per ha FYM + half of the recommended level of N to rainfed soybean and safflower enhanced the yield by 20.5 and 49.5 per cent respectively compared to equivalent level of nutrients applied through fertilizer source alone (Sharma, 1992). Chittapur *et al.* (1993) reported that although gypsum + FYM application to groundnut resulted in highest oil percentage but application of gypsum + sand + FYM recorded statistically on par oil percentage and significantly higher pod and oil yields, shelling percentage and pod weight per plant. In a study conducted by Sanyal *et al.* (1993) the maximum groundnut pod yield was obtained with application of 75 per cent RDF (20 : 60 : 40 kg NPK/ha) along with FYM (10 t/ha) over application of 100 per cent RDF alone and also over 150 per cent RDF alone. In soybean, Sarkar and Tripathi (1996) recorded highest seed yield (2295 kg/ha) due to 30 kg N + 60 kg P + *Rhizobium* basal application

against 30 kg N + 60 kg P per ha only (2170 kg/ha). In sunflower, 18.95 per cent increase in number of seeds per head was recorded with application of 10 t per ha vermicompost over no organic manure (Devidayal and Agarwal, 1998). Significantly maximum sunflower seed yield due to inoculation with biophos and *P. strita* over un-inoculated control was recorded irrespective of the forms and levels of phosphorus supplied (Gadagi and Alagawadi, 1998). Whereas, Mallikarjuna *et al.* (1998) recorded highest sunflower seed yield due to application of 50 per cent recommended dose of phosphorus through single super phosphate and 50 per cent through enriched FYM compared to recommended practice of single super phosphate alone. The higher yield and yield attributes recorded in the present study due to T₁₁ treatment may be ascribed to the additive effect of combined application of inorganic and organic sources of nutrients. Similarly increase in groundnut haulm yield and uptake of Cu, Zn, Fe and Mn were noticed due to application of 1000 kg per ha copper ore tailing by Gundlur and Manjunathaiah (2000). Increase in dry pod yield of groundnut due to application of RDF + vermicompost (1 t/ha) over RDF alone or no application were also reported by Malligawad *et.al.* (2000).

5.1.3 Influence on seed quality parameters

The data on 100 seed weight (Table 4.19) could not produce any statistical difference due to nutrient treatments. However, numerically higher (35.26 g) 100 seed weight was recorded by treatment which was applied with RDF + VC + COT (T₁₁). Per cent germination data (Table 4.20 and Fig. 5.05) registered significant differences due to nutrient treatments

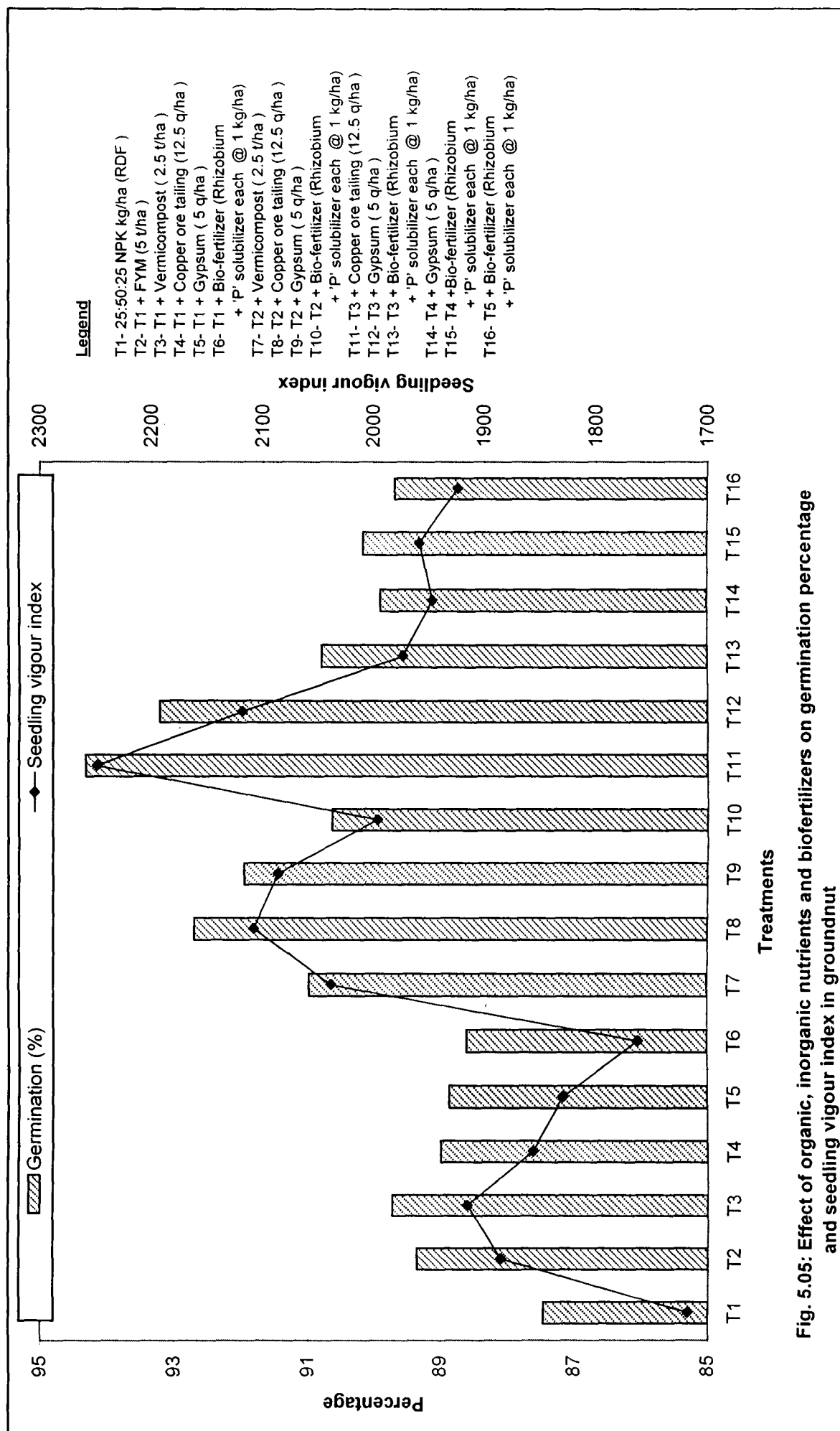


Fig. 5.05: Effect of organic, inorganic nutrients and biofertilizers on germination percentage and seedling vigour index in groundnut

in 2000 and pooled results only. The treatment T₁₁ (94.31 %) followed by T₁₂ (93.21%) and T₈ (92.70 %) recorded significantly maximum germination percentage over rest of the nutrient treatments. Seedling length (Table 4.21 and Fig. 5.06) exerted significant difference among nutrient treatments in pooled results only. The nutrient treatments T₇, T₈, T₉, T₁₀, T₁₁, T₁₂, T₁₃ and T₁₅ recorded on par but significantly higher seedling lengths over rest of the nutrient levels. Among these, T₁₁ registered highest (23.85 cm) seedling length. Other nutrient levels were unable to produce any significant differences on seedling dry weight (Table 4.22). However, it was numerically more (4.60 g) with T₁₁ treatment. Seedling vigour index (Table 4.23) showed significant differences due to nutrient treatments in both the years of experimentation as well in pooled results. The treatments T₈, T₉, T₁₁ and T₁₂ were on par and recorded significantly higher seedling vigour indices over rest of the treatments. Among these, T₁₁ recorded highest (2249) seedling vigour index value. The electrical conductivity of seed leachate (Table 4.24) also exhibited significant differences due to nutrient treatments in both the years of experimentation and also in pooled results. The treatments T₇, T₈, T₉, T₁₁ and T₁₂ were on par with each other and recorded significantly lesser seed leachate values. Among these, T₁₁ treatment recorded least (0.186 dSm⁻¹) electrical conductivity value.

Looking to the various seed quality attributes T₈, T₁₁ and T₁₂ treatments emerged as best nutrient treatments but T₈ treatment as it recorded lesser nodule dry weight and more days to pod maturity and T₁₂ treatment because of its lesser benefit cost ratio, these two treatments

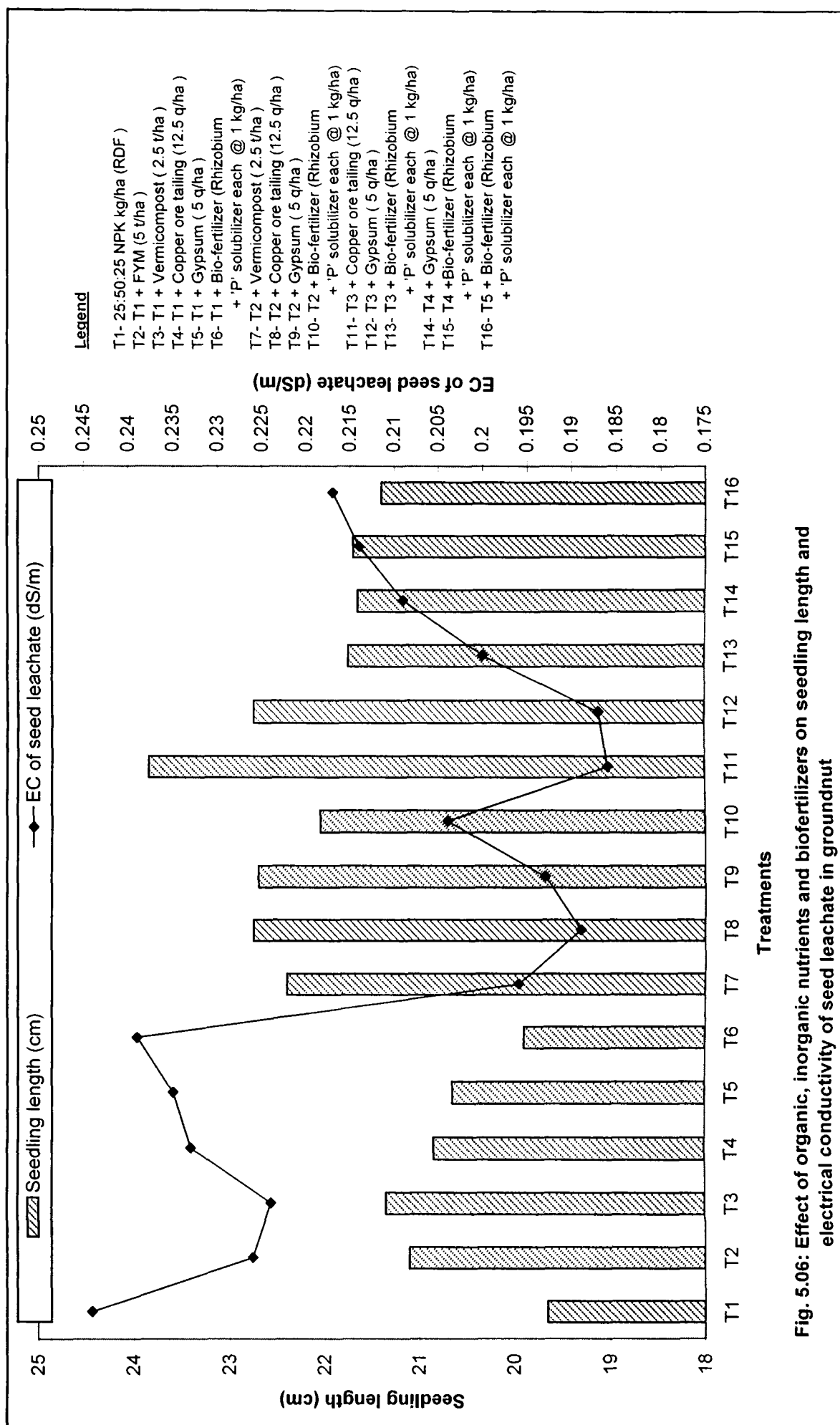


Fig. 5.06: Effect of organic, inorganic nutrients and biofertilizers on seedling length and electrical conductivity of seed leachate in groundnut

were inferior to T₁₁ treatment and hence T₁₁ nutrient treatment is better for groundnut seed production. Similar increase in 100 kernel weight of groundnut due to application of 80 N + 35 P + 250 kg gypsum as basal + 250 kg gypsum per ha at 30 DAS was also reported by Chitkala Devi *et al.* (1987) and increase in pod and kernel weight due to application of 30 N + 10 P + 25 K + 500 kg gypsum per ha at 30 DAS by Narasareddy *et al.* (1987). Whereas, Jain *et al.* (1995) recorded 83 per cent increase in soybean 100 seed weight due to application of FYM (5 t /ha) and sugar press mud (5 t/ha) over control. Increase in 1000 seed weight of sunflower was reported due to inoculation with biophas and also *P. strita* (Gadagi and Alagawadi, 1998).

5.2 EXPERIMENT - II : EFFECT OF MICRONUTRIENTS AND METHODS OF APPLICATIONS ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of four micronutrients and seven methods of applications with 28 treatment combinations.

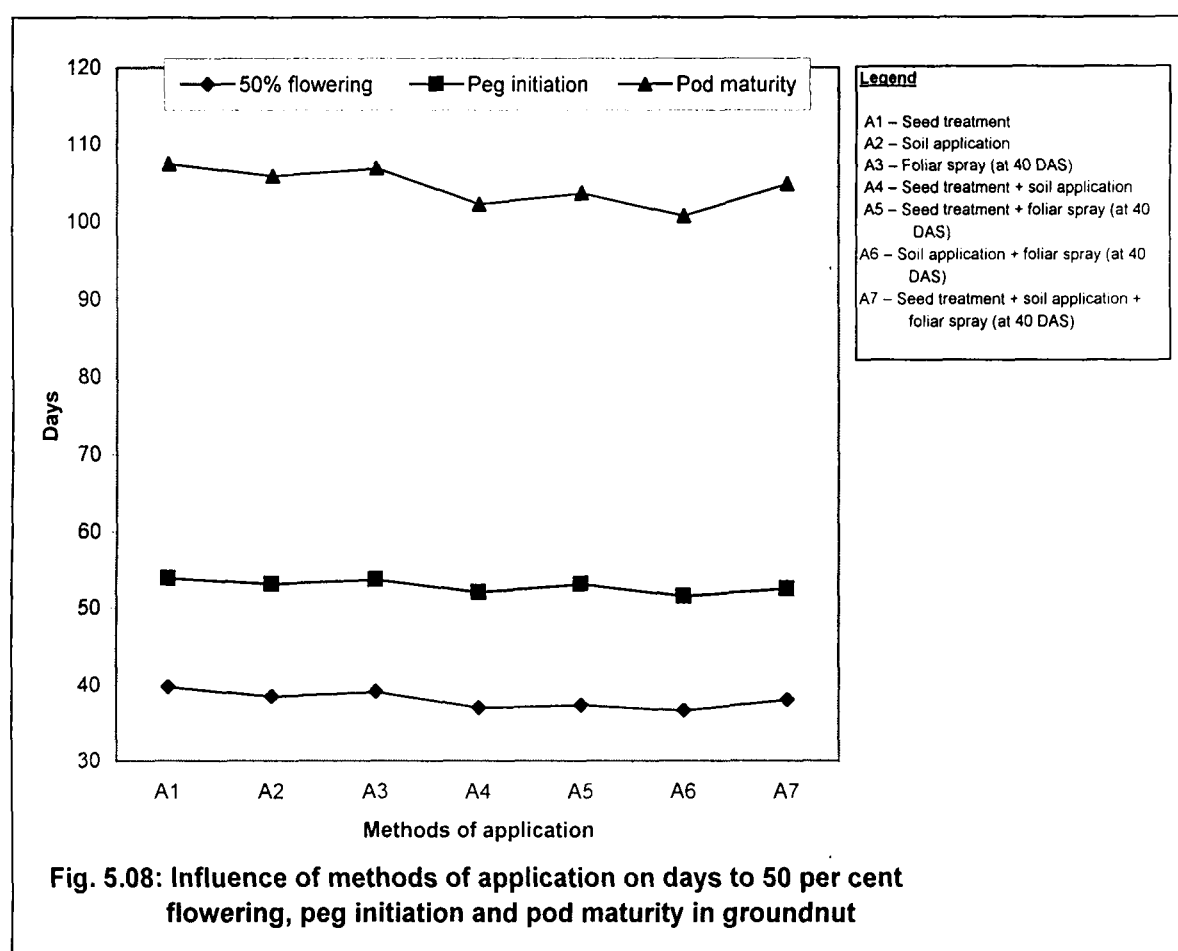
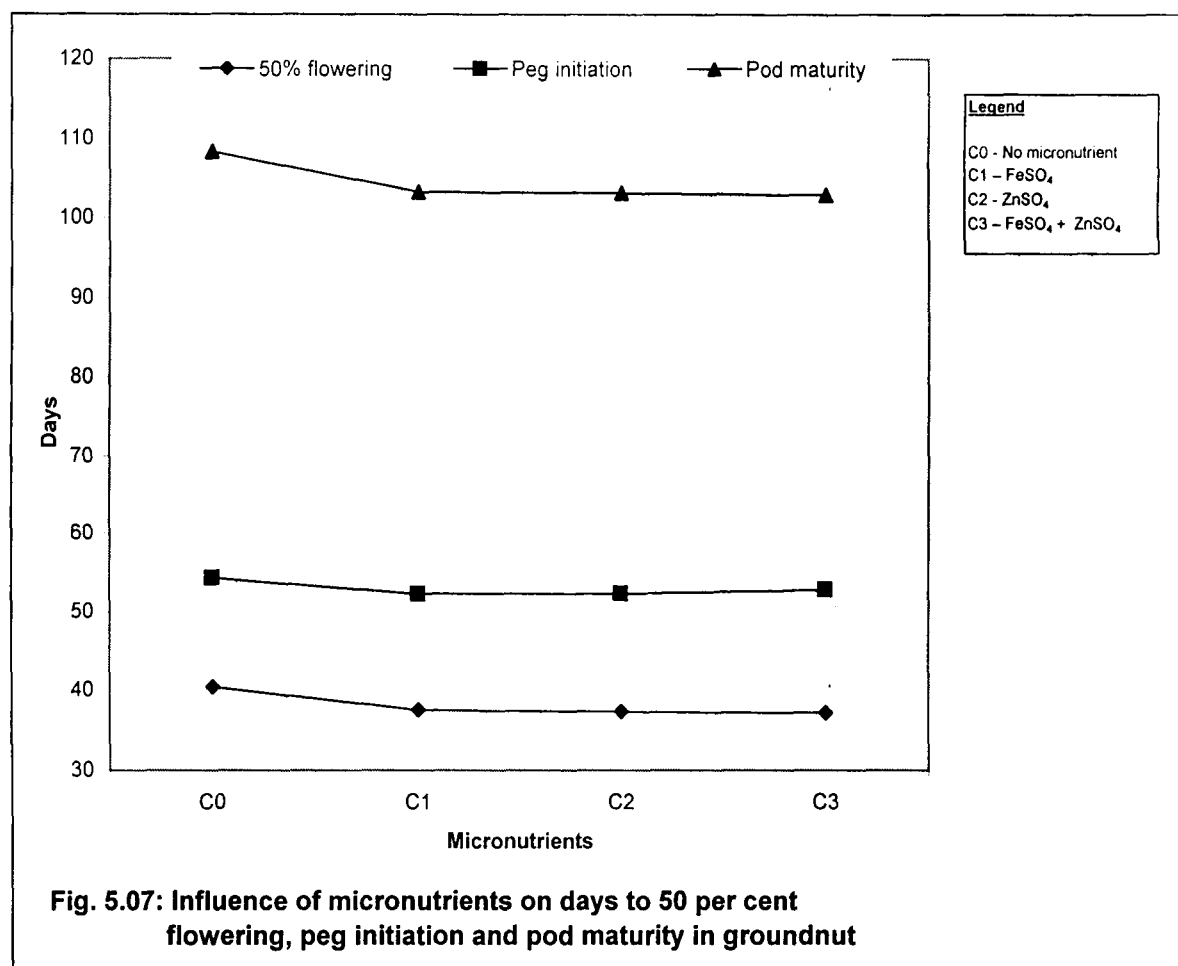
5.2.1 Influence on growth parameters

Plant height at harvest (Table 4.26), days to 50 per cent flowering (Table 4.28), peg initiation (Table 4.29) and pod maturity (Table 4.30), number of nodules (Table 4.31) and nodule dry weight (Table 4.32) recorded significant differences due to micronutrients in both years and also in pooled values. While, the plant height at 60 DAS (Table 4.25) and number of branches (Table 4.27) were non-significant due to micronutrients in the year 1999. The micronutrients FeSO₄ (C₁),

ZnSO₄ (C₂) and FeSO₄ + ZnSO₄ (C₃) were on par with each other and recorded significantly higher growth attributes with earliness (Fig. 5.07). Among these, C₂ and C₃ micronutrients recorded significantly more (113.9 and 116.3 mg/plant) nodule dry weight (Table 4.32) than C₁ micronutrient. These two micronutrients emerge as best to achieve higher growth response by groundnut crop.

Similarly, increase in vegetative growth and flower number by foliar application of Zn to groundnut was reported by Patel *et al.* (1993) they recorded two fold increase in groundnut haulm yield and three to four fold increase in leaf chlorophyll and iron content with the foliar spray of 1 per cent ferrous sulphate + 0.1 per cent citric acid or 2 per cent ferric citrate. Three to four fold reduction in photosynthetic rate and chlorophyll content in three legumes due to Fe deficiency was also reported by Rao and Rao (1994). In the present study, it is evident from the data on number of nodules and nodule dry weight that the supply of iron might have enhanced the activity of N fixing bacteria in the root zone ultimately leading to better vegetative growth.

The plant height at 60 days after sowing did not differ significantly due to methods of applications in both the years and pooled results. Plant height at harvest and number of branches differed significantly due to methods of applications in 2000 and pooled results. Days to peg initiation differed due to methods of applications in 1999 and pooled results. The remaining growth attributes namely days to 50 per cent flowering, days to pod maturity, number of nodules per plant and nodule dry weight differed



significantly due to methods of applications in both years as well as in pooled results.

Among the various methods of applications, soil application (A₂), seed treatment + soil application (A₄), seed treatment + foliar spray (A₅), soil application + foliar spray (A₆) and seed treatment + soil application + foliar spray (A₇) methods of applications recorded on par but significantly higher plant height at harvest. Among these five method of applications A₂ method of application recorded less number of branches, A₂ and A₇ methods of applications recorded less number of nodules and more days to 50 per cent flowering, A₂ and A₅ methods of applications recorded more days to peg initiation and A₂, A₄, A₅ and A₇ methods of applications recorded less nodule dry weight and more days to pod maturity. Hence A₆ method of application emerges as superior method of application by recording significantly higher (43.38 cm) plant height, (7.41) number of branches, (71.56) number of nodules per plant, (128.5 mg/plant) nodule dry weight and significantly less (36.69, 51.63 and 100.8) days to 50 per cent flowering, peg initiation and pod maturity respectively (Fig. 5.08).

The increase in growth parameters due to application of micronutrients by soil application + foliar spray (A₆) method of application may be due to the balanced and timely availability of nutrients for groundnut which helped to over come the deficiency disorders ultimately leading to better vegetative growth. The benefits of foliar application of 20 kg Fe, 2 kg Zn and 2 kg Cu per ha to groundnut in three equal doses at 20, 40 and 60 days after emergence in increasing the growth parameters

and fodder yield to the tune of 41, 35 and 25 per cent respectively over control was reported by Singh *et al.* (1990). Similarly in soybean combined application method of seed treatment and foliar spray of Zn and Mo recorded higher plant height, number of leaves, plant diameter, number of pods per plant and number of seed per pod over either seed treatment or foliar spray alone (Hugar and Kurdikeri, 2000a).

Interaction effects between micronutrients and methods of applications (C x A) were significant for days to 50 per cent flowering in pooled data and for nodule dry weight and days to pod maturity in both the years of experimentation as well as in pooled results. A₆ method of application (soil application + foliar spray) in combination with C₁ (FeSO₄), C₂ (ZnSO₄) and C₃ (FeSO₄ + ZnSO₄) micronutrients recorded significantly more nodule dry weight and less days to pod maturity. With respect to days to 50 per cent flowering these treatment combinations along with A₄ (seed treatment + soil application) method of application with C₁, C₂ and C₃ micronutrients recorded significantly less days to 50 per cent flowering. Among these treatment combinations, C₃A₆ and C₂A₆ treatments recorded higher (144.2 and 140.1 mg/plant) nodule dry weight and less (35.15 and 35.40) days to 50 per cent flowering and (97.6 and 98.4) days to pod maturity respectively. Timely and balanced availability of nutrients with these treatments may be the cause for getting increased response over rest of the treatment combinations.

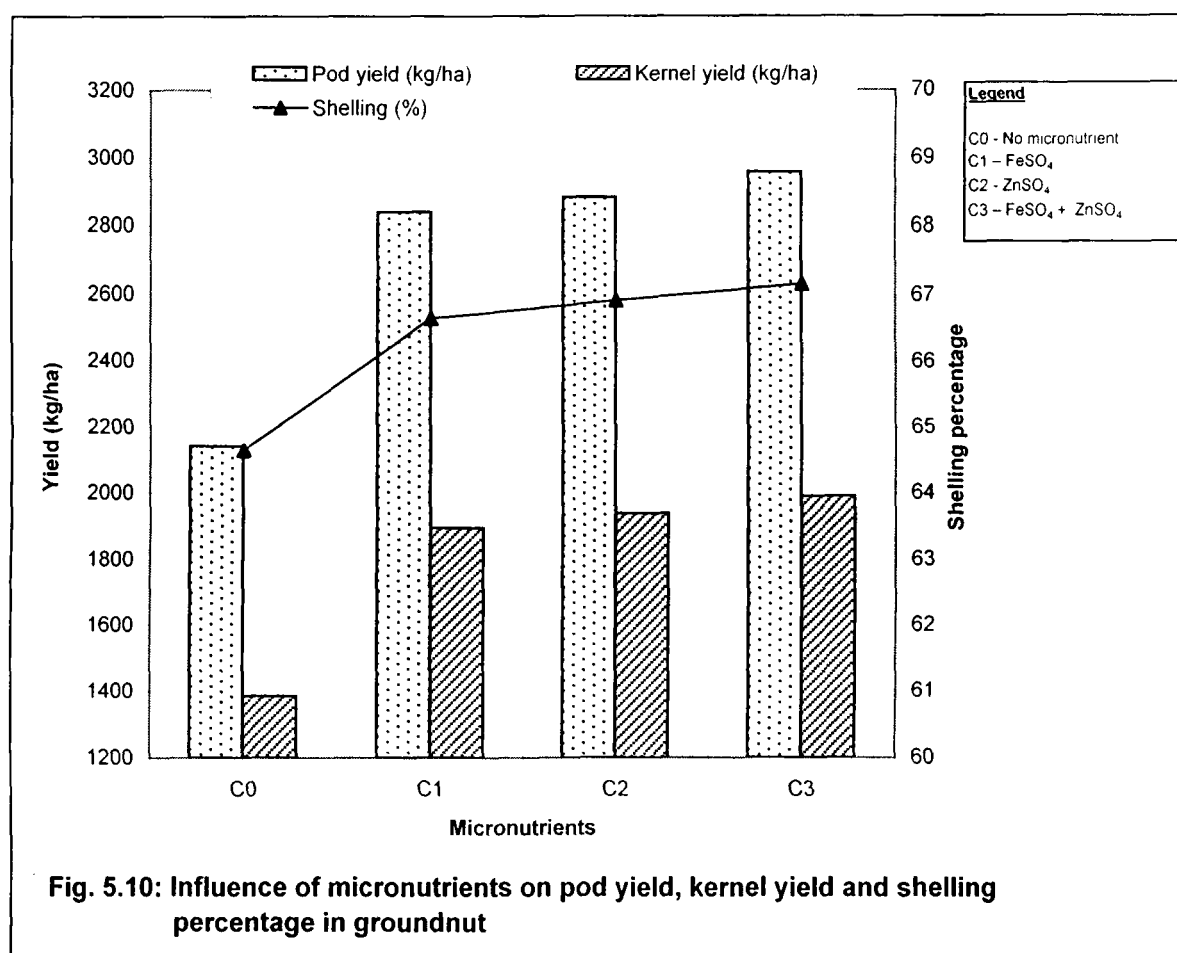
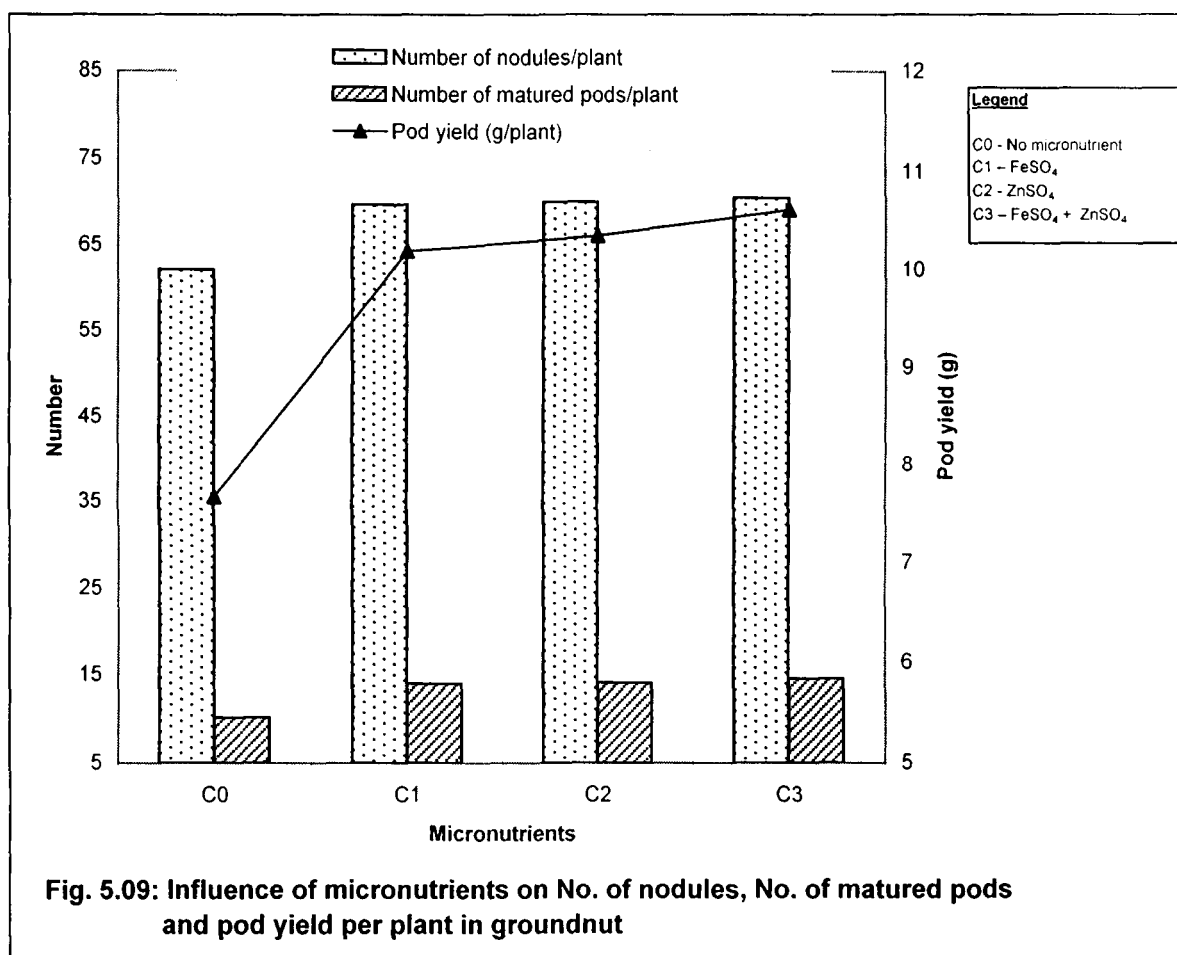
5.2.2 Influence on yield parameters

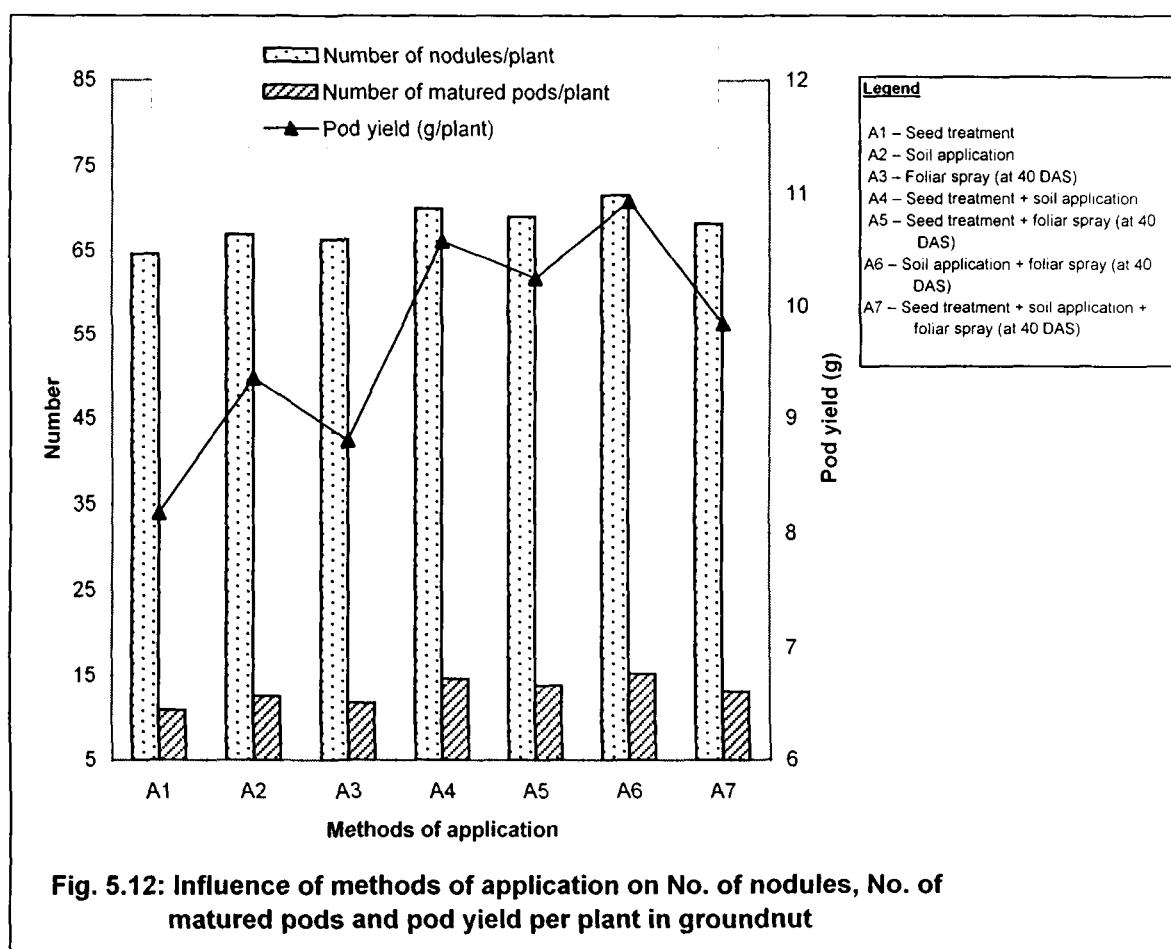
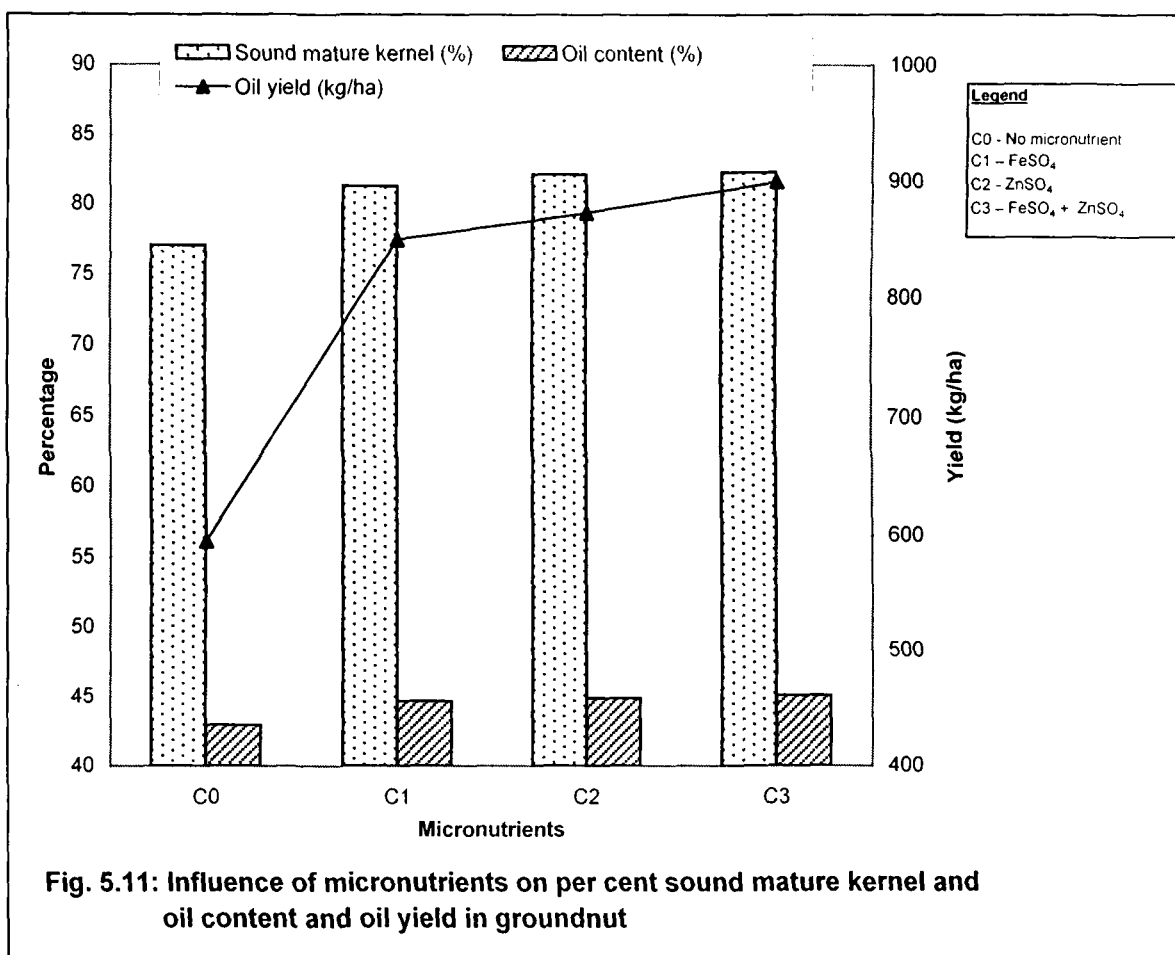
All the yield parameters exhibited significant differences due to micronutrients in both years of experimentation as well in pooled results

(Fig. 5.09, 5.10 and 5.11). Except for benefit cost ratio (Table 4.39) C₁, C₂ and C₃ micronutrients recorded significantly higher but on par values over C₀ micronutrient for all the yield parameters. The micronutrients C₁ and C₂ registered 4.63 and 4.29 benefit cost ratio respectively and were on par with each other and significantly higher than C₃ (3.97) and C₀ (3.88) micronutrients.

Hence, considering various growth and yield parameters among C₁, C₂ and C₃ micronutrients C₁ by recording less nodule dry weight and C₃ by recording lower benefit cost ratio emerged as inferior to C₂ micronutrient and thus C₂ micronutrient is effective for groundnut seed production. About 43, 40 and 11 per cent increase of groundnut pod yield over control was also reported with the foliar spray of 20 kg Fe, 2 kg Zn and 2 kg Cu per ha respectively by Singh *et al.* (1990). Increase in protein concentration from 31 per cent to 34 per cent with foliar application of Fe and Zn to groundnut was also reported by Krishnappa *et al.* (1992). Ramamoorthy and Sudarsan (1992) obtained increased groundnut pod yield, shelling, seed protein and oil percentages with Zn application. Whereas, Krishnappa (1993) recorded higher pod yield with application of NPK + 5 ppm iron to groundnut. Two fold increase in groundnut pod yield with foliar spray of 1 per cent ferrous sulphate + 0.1 per cent citric acid or 2 per cent ferric citrate over control was also reported (Patel *et al.*, 1993).

The data on per plant number of mature pods (Table 4.33 and Fig. 5.12), immature pods (Table 4.34), pod yield per plant (Table 4.35), pod yield per hectare (Table 4.36 and Fig. 5.13), kernel yield per hectare





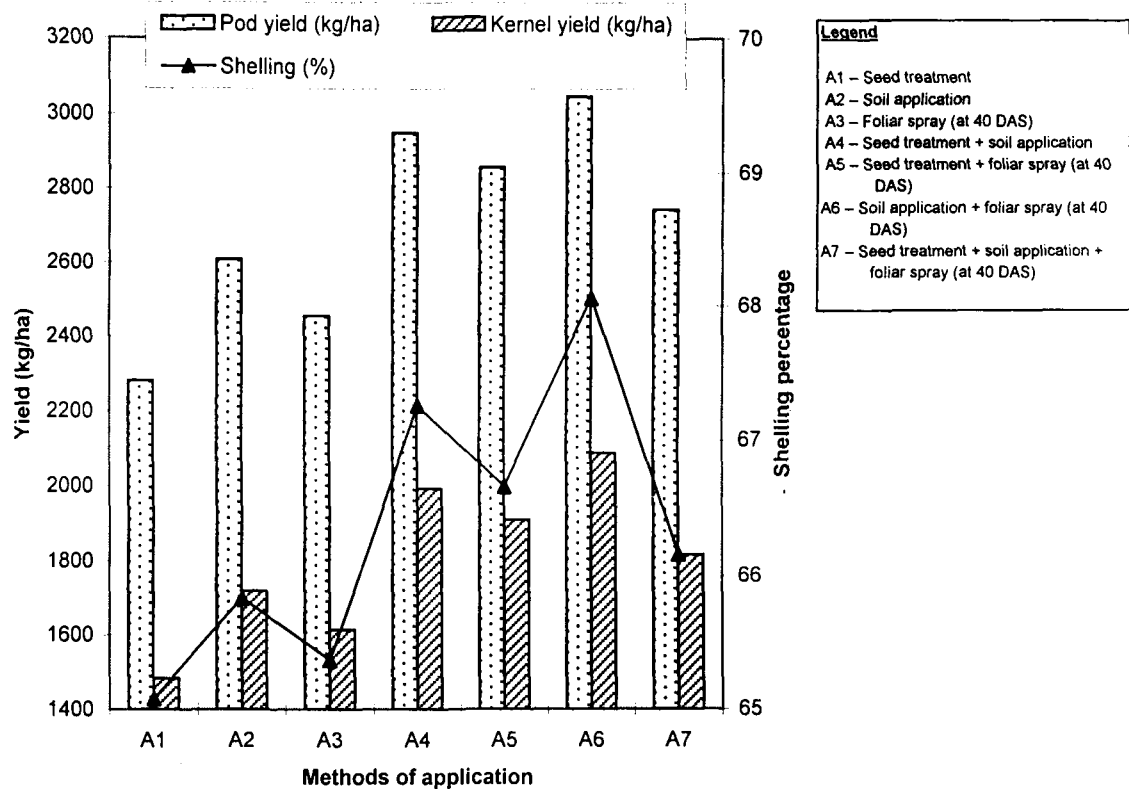


Fig. 5.13: Influence of methods of application on pod yield, kernel yield and shelling percentage in groundnut

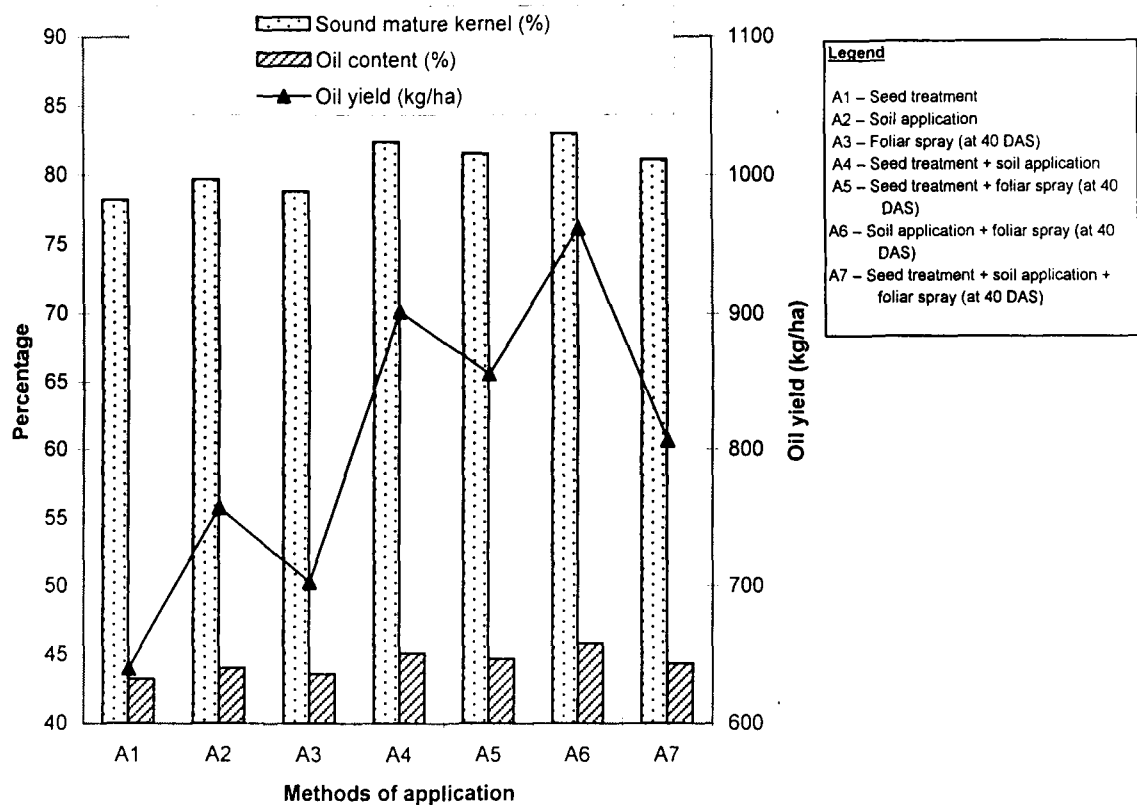


Fig. 5.14: Influence of methods of application on per cent sound mature kernel and oil content and oil yield in groundnut

(Table 4.38), benefit cost ratio and oil yield per hectare (Table 4.42 and Fig. 5.14) differed significantly due to methods of applications in both years as well as in pooled results. Whereas, shelling percentage (Table 4.37) was significant only in 2000 and pooled values while, sound mature kernel (Table 4.40) and oil content percentages (Table 4.41) were significant only in pooled results due to methods of applications.

A₄, A₅, A₆ and A₇ methods of applications recorded significantly higher but on par values for sound mature kernel and oil content percentages. Pod yield per plant and also per hectare were significantly more in A₄, A₅ and A₆ methods of applications. While, significantly more number of mature pods per plant, kernel yield and oil yield per hectare with significantly less immature pods per plant were recorded by A₄ and A₆ methods of applications. Though A₅ method of application recorded significantly highest (5.29) benefit cost ratio because of its lesser kernel and oil yield, shelling and mature pod number this method proved to be inferior to A₄ and A₆ methods of applications. A₄ and A₆ methods of applications recorded 4.09 and 4.16 benefit cost ratio respectively.

Hence, because of its superiority in growth parameters and a little higher benefit cost ratio registered by A₆ method of application over A₄ method of application it emerged as the effective method of micronutrient application for groundnut. Similar benefits of getting increased number of pods per plant, pod and seed yield of groundnut with application of Fe 10-15 kg per ha was reported by Hartzook (1982) and with application of 15 kg S + 10 kg Zn per ha by Talukder and Islam (1982). While, Chatterjee *et al.* (1985) recorded 26 per cent increase in

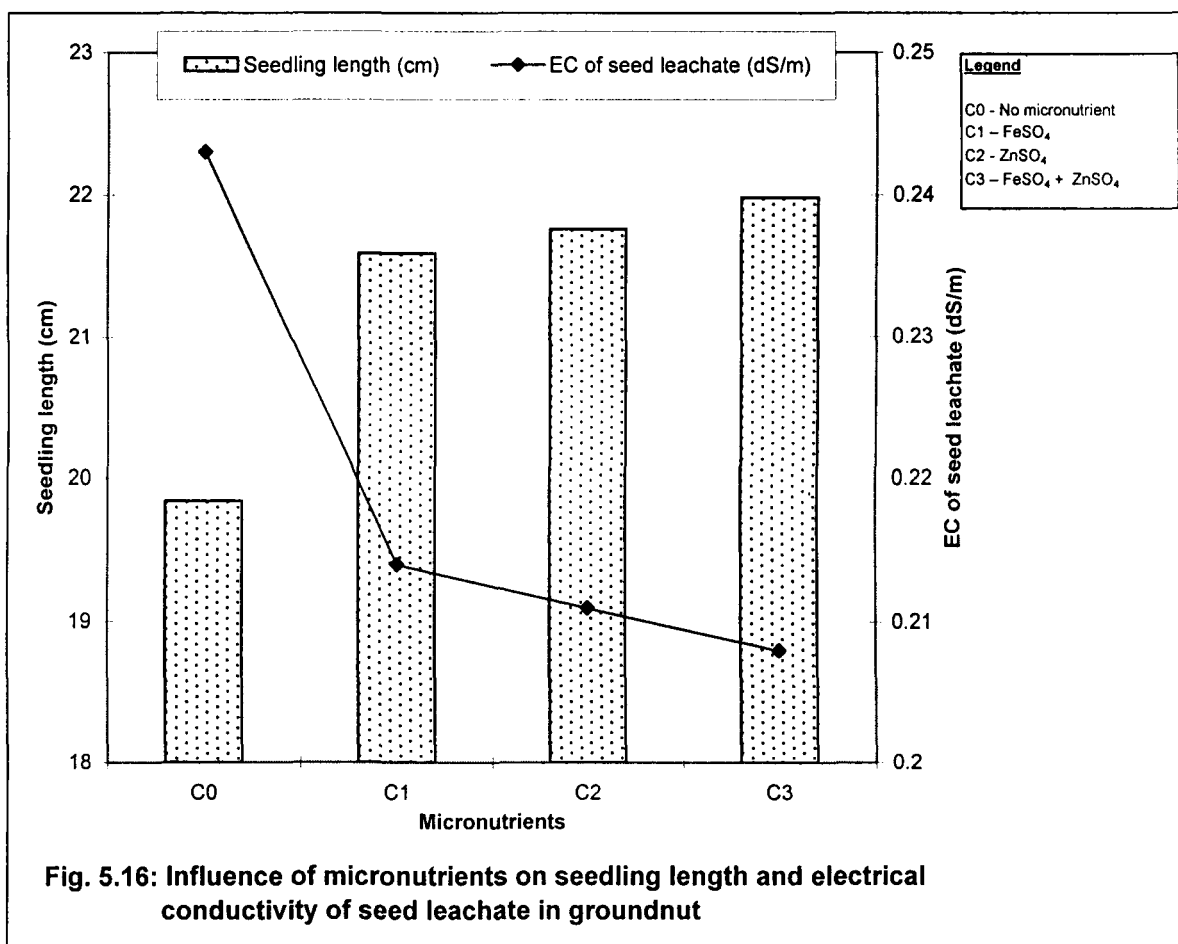
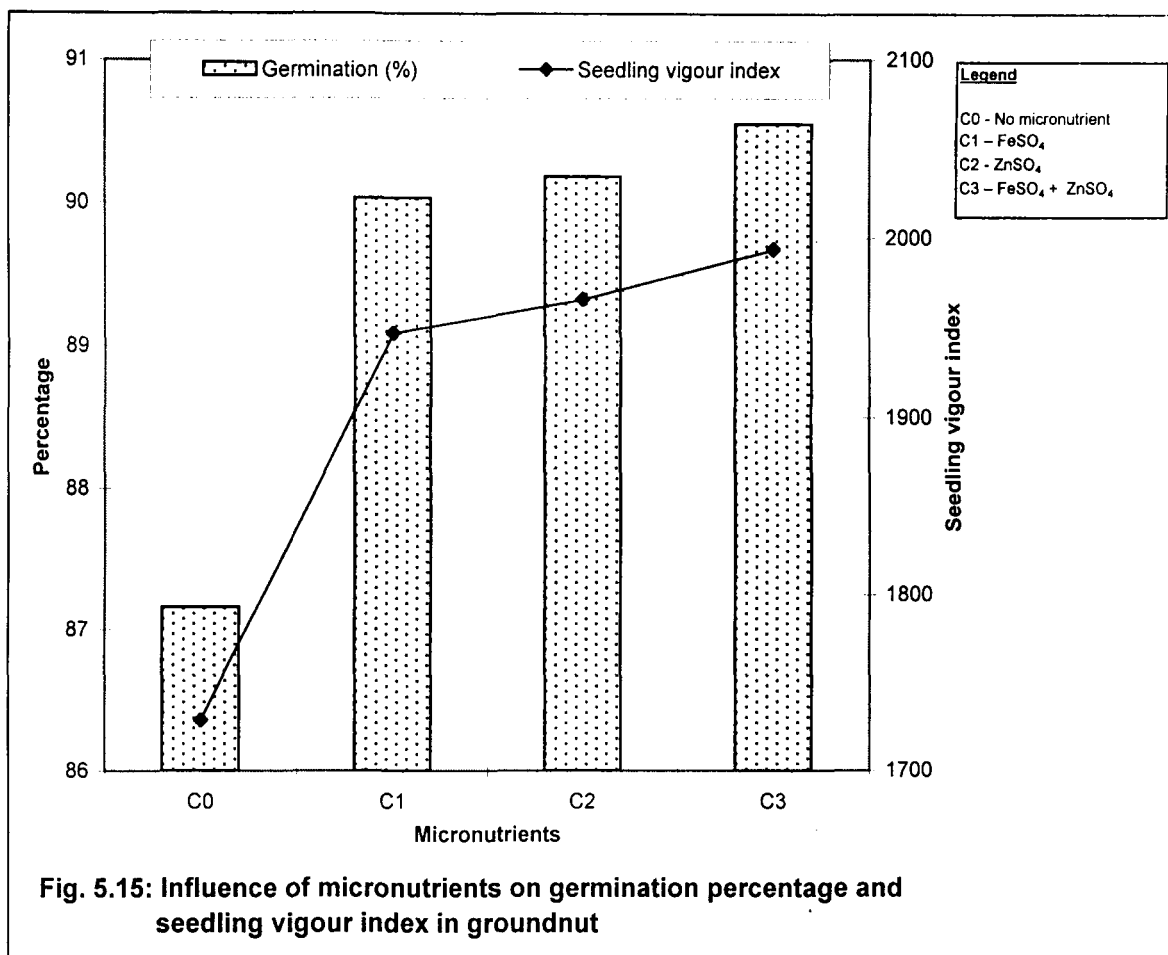
mustard seed yield with the application of ZnSO_4 equivalent to 20 kg S per ha. Soil application of Zn (11.2 kg/ha) to groundnut recorded the pod and seed kernel yield of 4880 and 3710 kg per ha against 3990 and 2930 kg per ha in control, respectively. While, seed dressing of Zn @ 2 g per kg recorded seed kernel yield of 3450 kg per ha against 2930 kg per ha of control (Gopalagowda, *et. al.*, 1995). Singh and Vidya Chaudhari (1996) reported that groundnut nodule weight, pod number and pod yield increased with the use of zincated super phosphate over use of ordinary super phosphate.

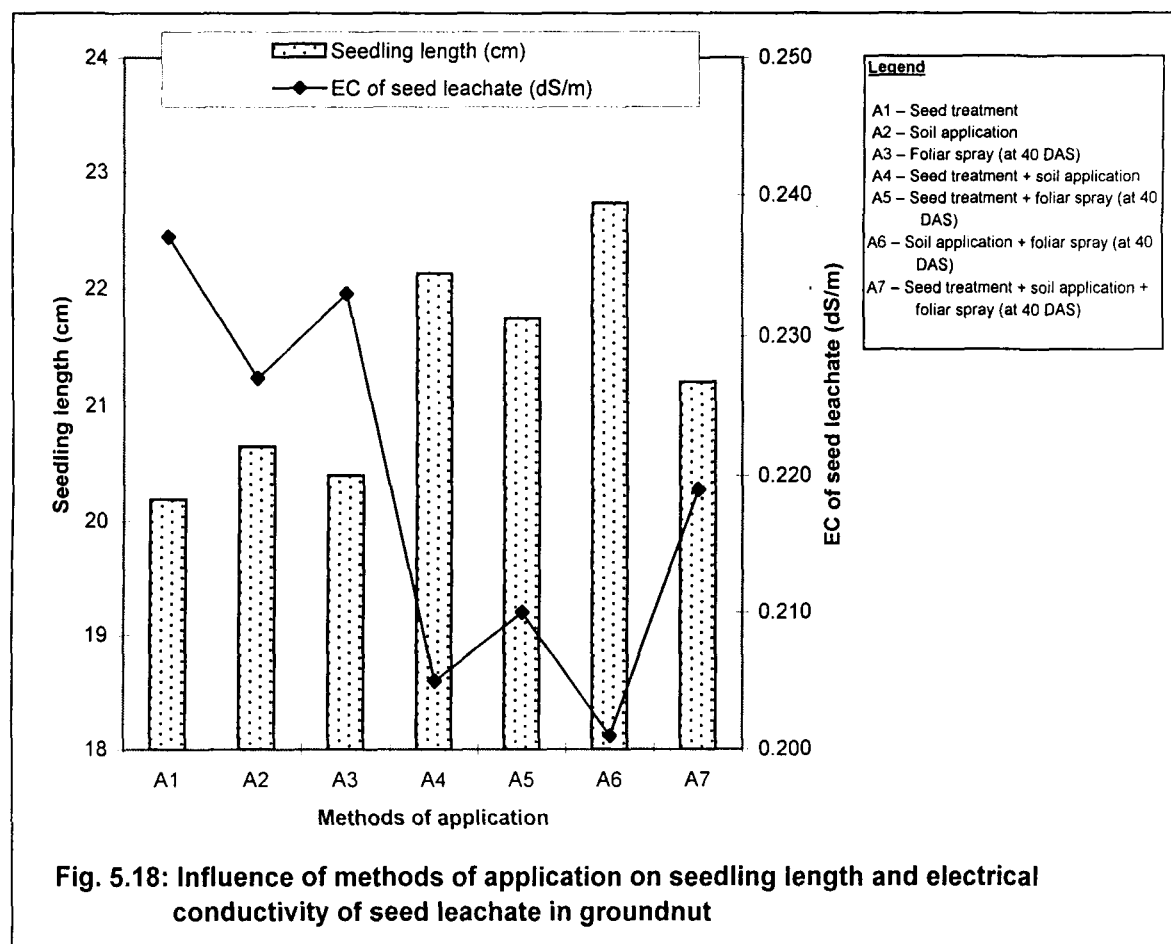
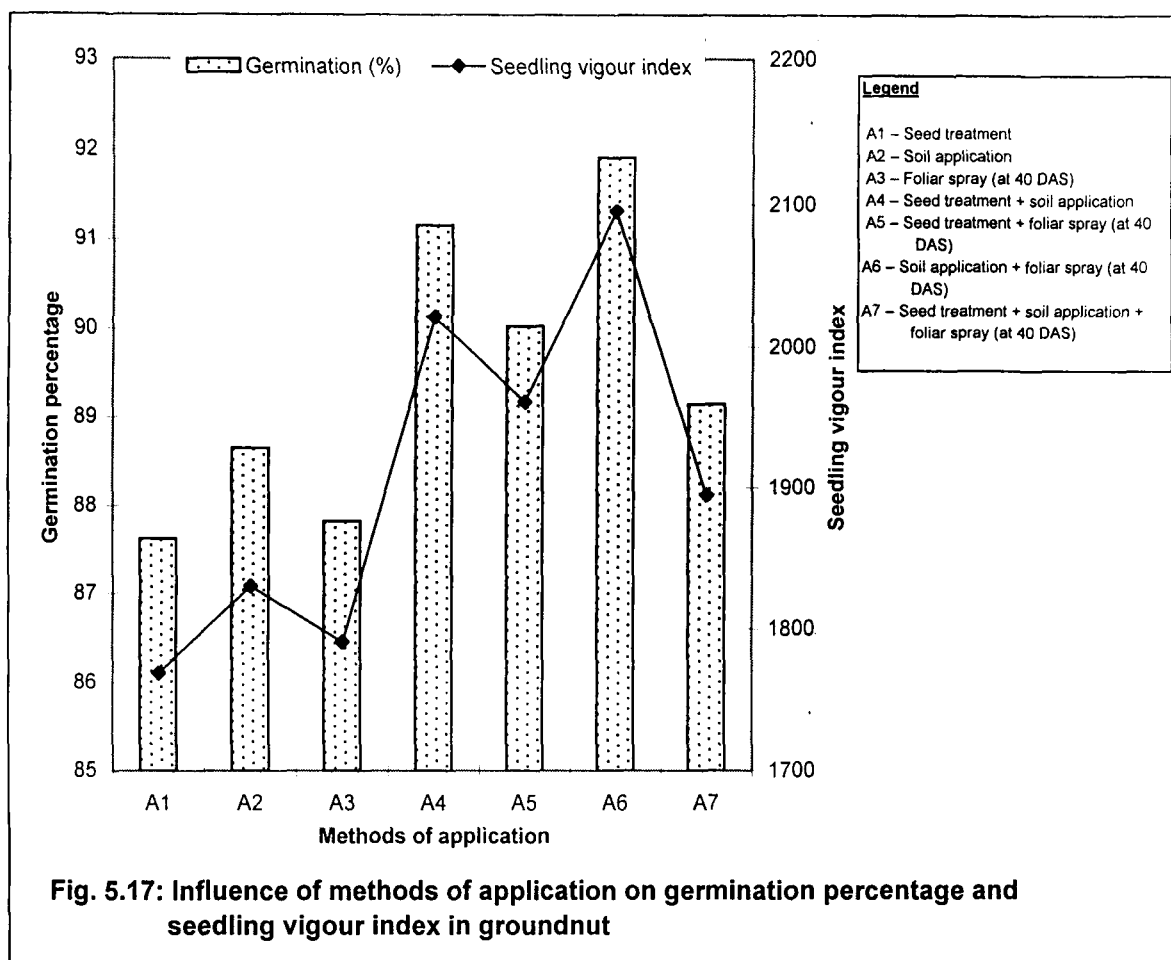
Interaction between micronutrients and methods of applications (C x A) were significant in 1999 and pooled values on oil yield and in pooled values on kernel yield and benefit cost ratio. The rest of the growth parameters were non-significant. C_1A_6 , C_2A_6 , C_3A_6 , C_1A_4 , C_2A_4 and C_3A_4 treatment combinations were on par but among these C_3A_6 followed by C_2A_6 treatment combinations recorded higher values for yield and yield parameters. This may be spelled out to the better vegetative growth leading to increase in yield and yield attributes of groundnut. While, Nagaraj *et.al.* (2001) in a fertilizer management practice involving the application of recommended dose of fertilizer (RDF) (25 kg N, 32.7 kg P and 20.72 kg K/ha) + FYM (7.5 t/ha) + vermicompost (1 t/ha) + micronutrients (4.5 kg/ha Fe) + 5 kg/ha Zn) + 0.25 kg/ha Mo) produced significantly higher dry pod yield of confectionery groundnut (1796 kg/ha) compared to fertilizer management practice involving RDF only (1475 kg/ha).

5.2.3 Influence on seed quality parameters

The seed quality assessed by 100 seed weight (Table 4.43), per cent germination (Table 4.44 and Fig. 5.17), seedling length (Table 4.45 and Fig. 5.18), seed vigour index (Table 4.47) and electrical conductivity of seed leachate (Table 4.48) exerted significant differences due to micronutrients in both the years and also in pooled values while seedling dry weight (Table 4.46) was significant only in pooled values. The micronutrients C₁, C₂ and C₃ recorded significantly higher but on par values for 100 seed weight (32.20, 32.18 and 32.70 g), germination (90.03, 90.18 and 90.55%) (Fig. 5.15), seedling length (21.59, 21.76 and 21.98 cm) (Fig. 5.16), seedling dry weight (4.36, 4.38 and 4.46 g) and seedling vigour index (1946, 1966 and 1994) with significantly lesser (0.214, 0.211 and 0.208 dSm⁻¹) electrical conductivity of seed leachate values respectively.

Considering benefit cost ratio out of these three micronutrient treatments, C₁ and C₂ micronutrient treatments were found better than C₃ micronutrient treatment and looking to its higher nodule dry weight C₂ micronutrient treatment emerged as superior and better micronutrient treatment for groundnut seed production. Ramamoorthy and Sudarsan (1992) have also confirmed that application of Zn to groundnut increased the 100 seed weight and the loss of viability of these seeds were less during storage compared to control. Seed dressing of 4 g per kg Zn + Mo to groundnut recorded increase in main root length, number of rootlets and shoot length as reported by Geetha *et al.* (1996). Increase in shoot dry matter yield due to application of Fe + Zn + Cu to groundnut was also reported by Moussa *et al.* (1996).





The per cent germination, seedling vigour index and electrical conductivity of seed leachate exhibited significant differences due to methods of applications in both years and also pooled results. Whereas, 100 seed weight was not significant in 2000, seedling length was not significant in 1999 and seedling dry weight was not significant in both the years and also in pooled results. A₄, A₅ and A₆ methods of applications recorded significantly higher but on par 100 seed weight and seedling length over other methods of applications. In these three methods of applications only A₄ and A₆ methods of applications recorded significantly higher but again on par values for germination (91.16 and 91.92%), seedling vigour index (2021 and 2095) and lesser electrical conductivity of seed leachate (0.205 and 0.201 dSm⁻¹) values respectively. Again considering the growth and yield parameters together with seed quality parameters A₆ method of application is suitable for groundnut seed production. Similar increase in seed test weight with application of zinc sulphate equivalent to 20 kg S per ha was reported in mustard by Chatterjee *et al.* (1985).

Only the electrical conductivity of seed leachate exerted significant differences due to interaction between micronutrients and methods of applications (C x A) in pooled values and rest of the seed quality attributes were non-significant. The treatment combinations C₁A₆, C₂A₆, C₃A₆, C₂A₅, C₃A₅, C₁A₄, C₂A₄ and C₃A₄ recorded significantly lower but on par electrical conductivity of seed leachate values over rest of the treatment combinations. Among these C₃A₆ followed by C₂A₆ treatment combinations recorded the least values of electrical conductivity of seed leachate and

numerically higher other seed quality attributes. The higher seed quality recorded with these treatment combinations was due to the healthy and better growth, increase in yield attributes, leading to increase in sound mature kernel percentage, 100 seed weight and thus higher germination and seedling vigour.

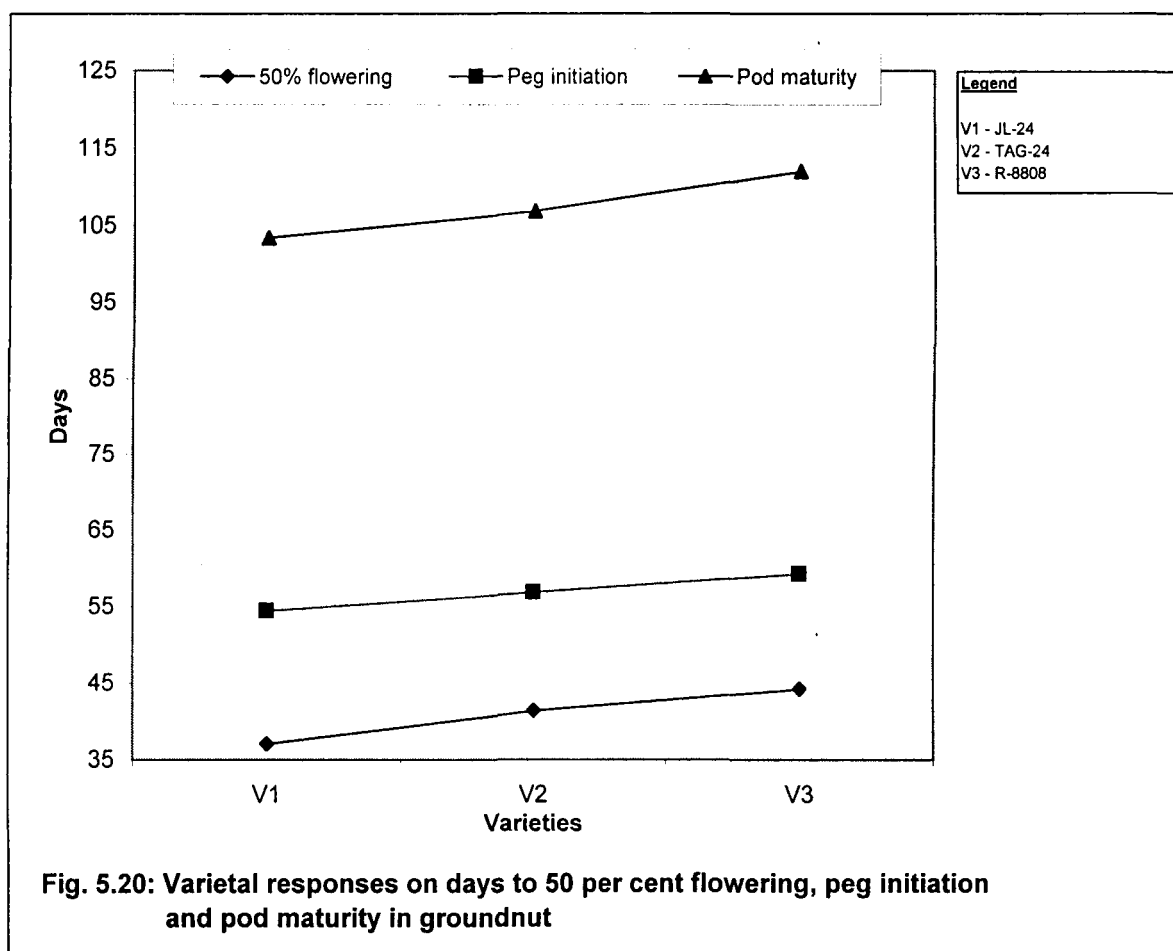
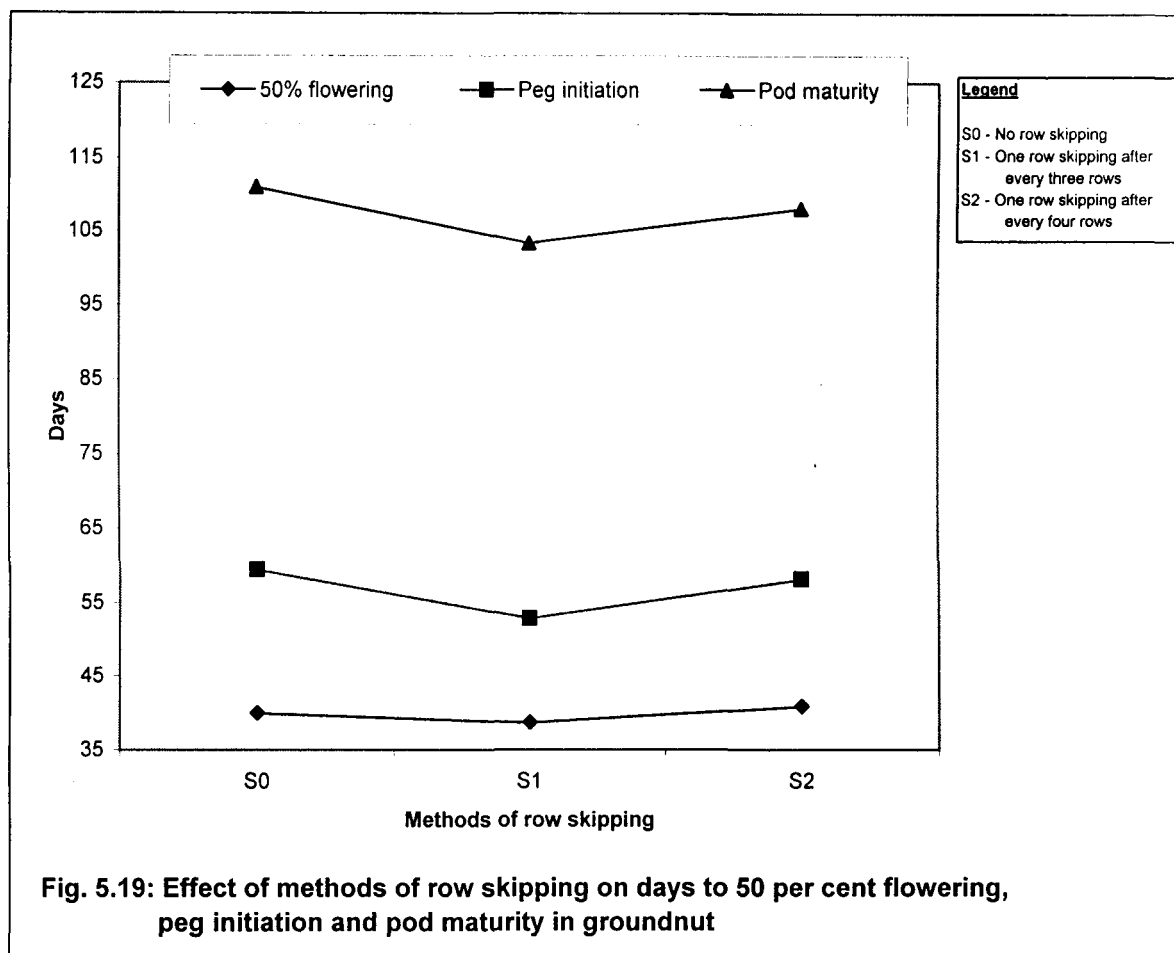
5.3 EXPERIMENT - III: EFFECT OF METHODS OF ROW SKIPPING ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment involved three methods of row skipping and three varieties totaling to nine treatment combinations.

5.3.1 Influence on growth parameters

The data on plant height at 60 DAS (Table 4.49) and at harvest (Table 4.50) exhibited significant differences due to methods of row skipping in both years of experimentation and in pooled values also. While, number of branches per plant (Table 4.51) due to methods of row skipping was significant in 1999 and pooled results only. One row skipping after every three rows (S₁) method of row skipping recorded significantly maximum (24.62 and 35.49 cm) plant height at 60 DAS and at harvest respectively with significantly more (7.17) number of branches. This method of row skipping was followed by one row skipping after every four rows (S₂) method of row skipping and both were at par with each other.

The data on days to 50 per cent flowering (Table 4.52), peg initiation (Table 4.53) and pod maturity (Table 4.54 and Fig. 5.19) also showed significant differences due to methods of row skipping treatments. One



row skipping after every three rows (S_1) took significantly less (38.71, 52.87 and 103.3) days to 50 per cent flowering, peg initiation and pod maturity respectively compared to other methods of row skipping treatments.

Number of nodules per plant (Table 4.55) and nodule dry weight (Table 4.56) also exhibited significant differences due to methods of row skipping. S_1 method of row skipping recorded significantly maximum (71.73) number of nodules per plant and (135.2 mg/plant) nodule dry weight over other two methods of row skipping treatments.

Similar increase in growth parameters like number of primary and secondary branches, plant height and spread in safflower with paired and skip row planting compared to normal planting was also noticed by Nikam *et al.* (1984a and 1984b). The better growth parameters recorded with one row skipping after every three rows (S_1) method of row skipping and one row skipping after every four rows (S_2) method of row skipping compared to no row skipping (S_0) method of row skipping may be attributed to 25 and 20 per cent lesser plant densities respectively in these methods of row skipplings which facilitated the crop for better utilization of soil and solar energy which might have resulted in higher photosynthesis leading to increased vegetative growth and early completion of vegetative life cycle by the crop.

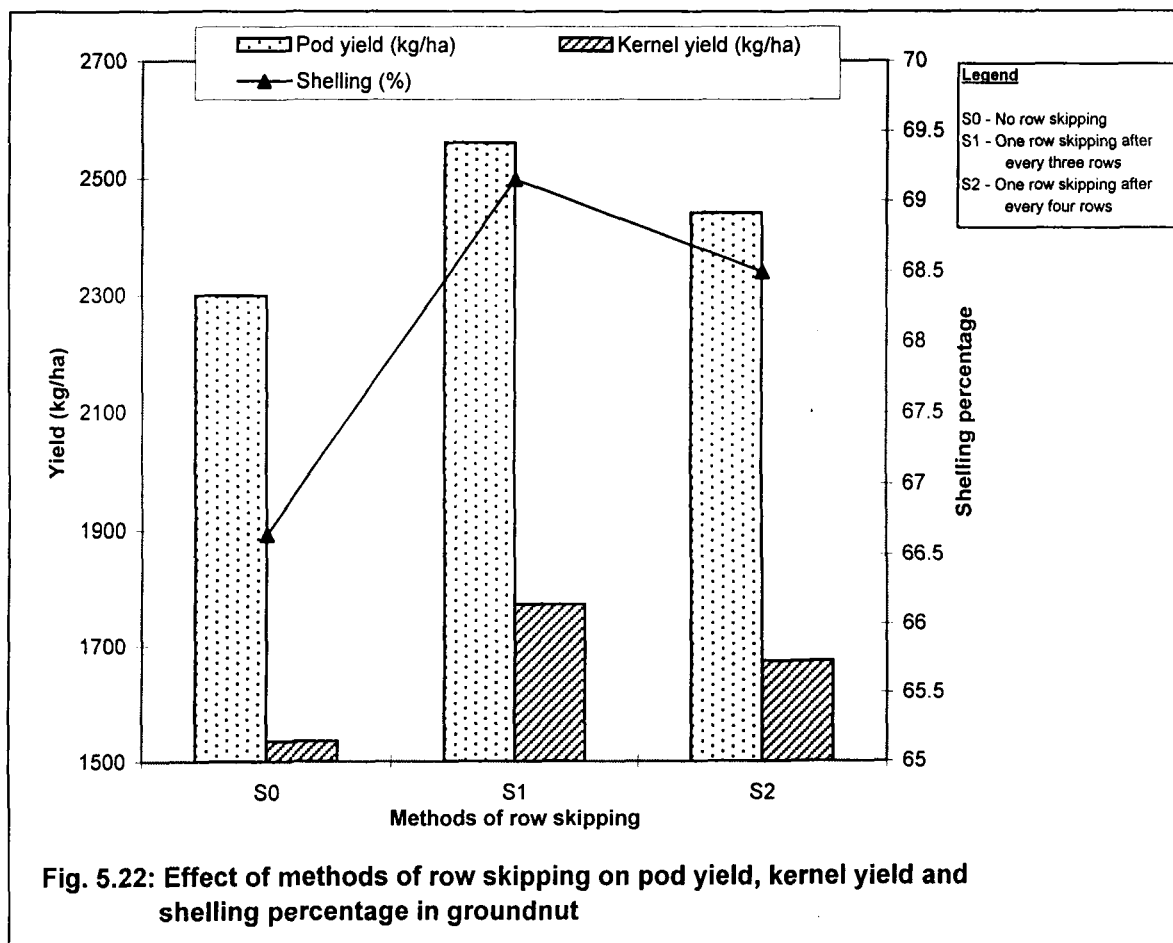
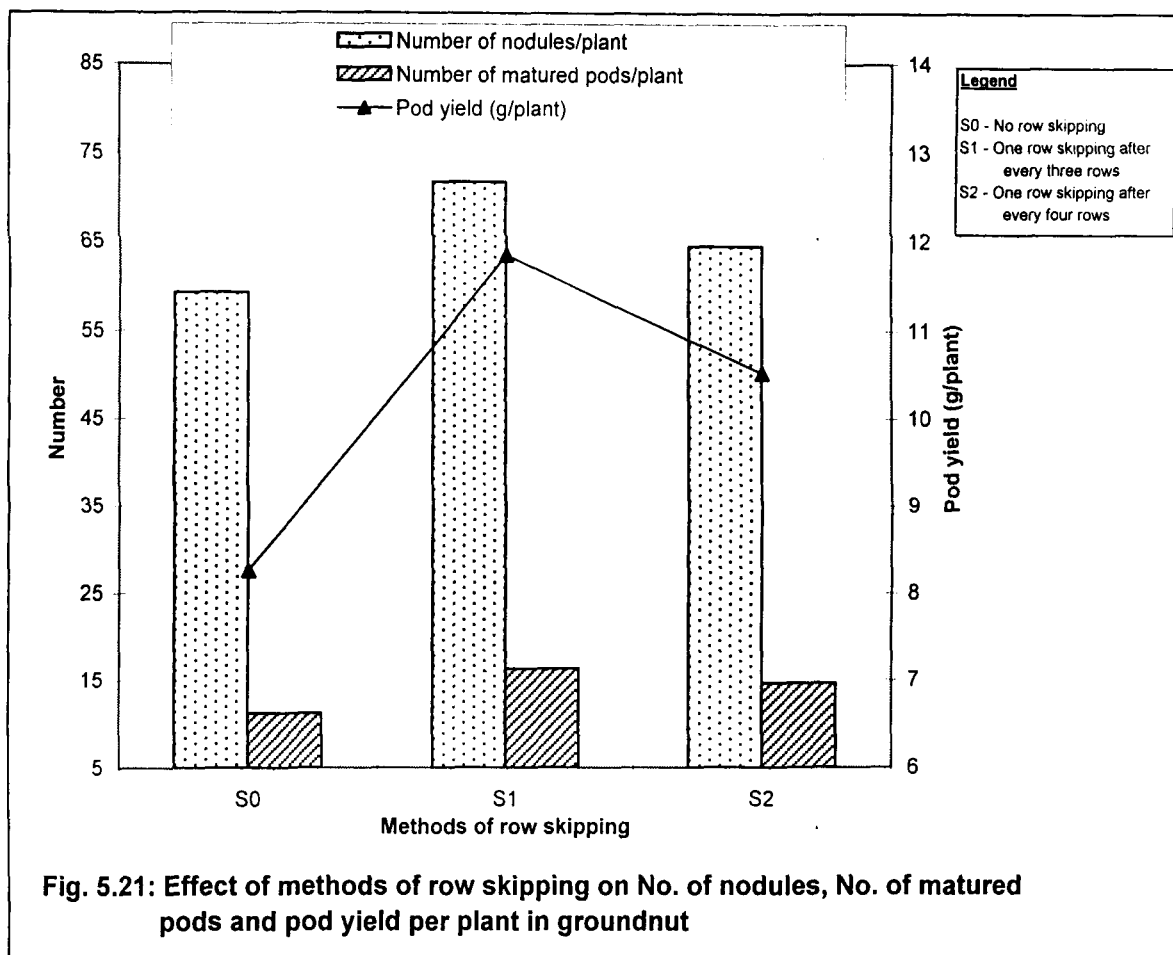
In both the years of experimentation and pooled results, significant differences in all the growth parameters were noticed due to varieties. JL-24 (V_1) variety recorded significantly maximum (28.39 and 41.56 cm) plant height at 60 DAS and at harvest respectively

along with significantly more (7.27) number of branches, (70.98) number of nodules and (121.1 mg/plant) nodule dry weight. The variety R-8808 (V_3) recorded on par number of branches (6.53) with JL-24 (V_1) variety. JL-24 variety also took significantly less (37.04, 54.47 and 103.5) days to 50 per cent flowering, peg initiation and pod maturity respectively (Fig. 5.20). The higher growth attributes recorded by JL-24 groundnut variety compared to R-8808 and TAG-24 varieties may be ascribed to the genotypic differences of the test varieties.

Interaction between methods of row skipplings and varieties ($S \times V$) also showed significant differences in both the years of experimentation and pooled results for all the growth parameters. One row skipping after every three rows with JL-24 variety (S_1V_1) recorded significantly maximum (146.0 mg/plant) nodule dry weight and less (34.03, 50.80 and 100.1) days to 50 per cent flowering, peg initiation and pod maturity respectively over other treatment combinations. The other growth attributes recorded by this treatment were also maximum. The higher growth parameters recorded with S_1 method of row skipping by JL-24 variety (S_1V_1) may be due to effective utilization of below ground and above ground space by JL-24 variety.

5.3.2 Influence on yield parameters

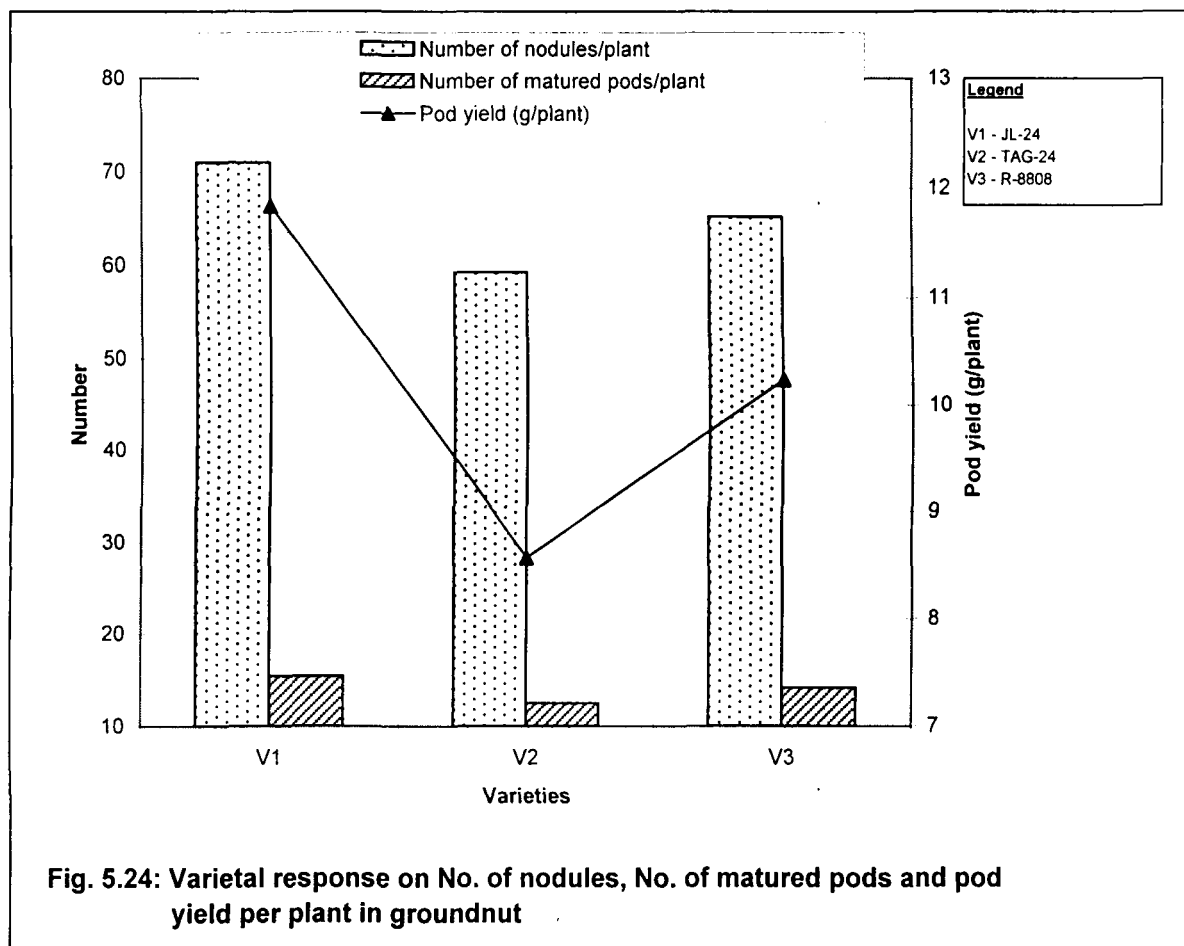
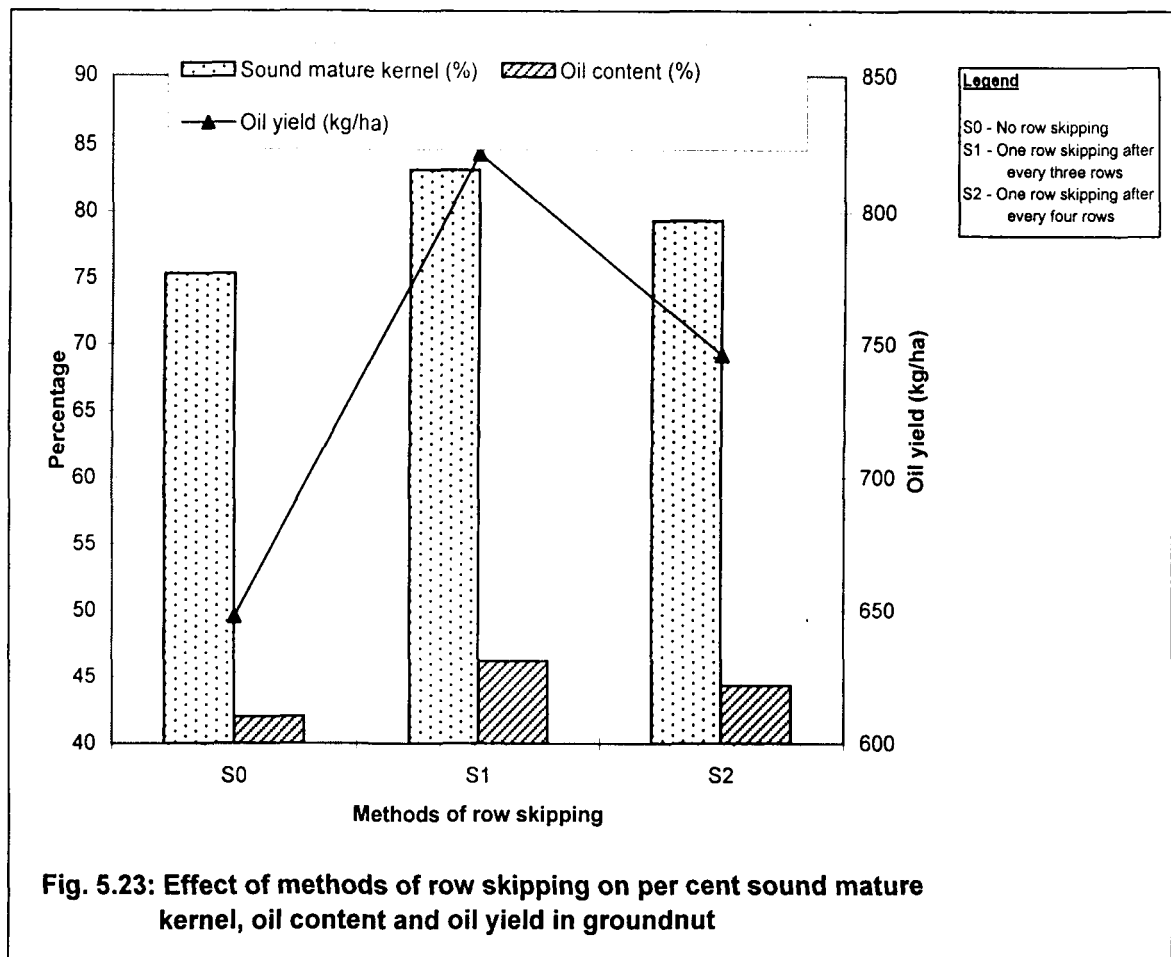
The data on number of mature (Table 4.57 and Fig. 5.21) and immature (Table 4.58) pods per plant exhibited significant differences due to methods of row skipping in 1999, 2000 and pooled values. S_1 method of row skipping recorded significantly maximum (16.32) and minimum (4.92)



mature and immature pods respectively. This method of row skipping was followed by S₂ method of row skipping and both were at par.

Significant differences due methods of row skipping were noticed on pod yield per plant (Table 4.59) in both the years and pooled values, on pod yield per hectare (Table 4.60 and Fig. 5.22) in pooled values only and on kernel yield (Table 4.62) in 1999 and pooled values. S₁ method of row skipping recorded significantly maximum (11.85 g/plant) pod yield over other methods of row skipplings. The pod and kernel yield per hectare recorded by S₁ and S₂ methods of row skipplings were significantly higher than S₀ method of row skipping but were on par with each other.

The benefit cost ratio (Table 4.63) differed significantly due to methods of row skipplings. S₁ method of row skipping recorded significantly maximum (5.14) benefit cost ratio while S₀ method of row skipping recorded significantly minimum (4.24) benefit cost ratio. The S₂ method of row skipping by recording 4.77 benefit cost ratio was on par with both the levels. The shelling (Table 4.61) and oil content (Table 4.65 and Fig. 5.23) percentages and also oil yield per hectare (Table 4.66) differed significantly due to methods of row skipplings in both years and pooled results while, sound mature kernel percentage (Table 4.64) differed only in pooled values. S₁ and S₂ methods of row skipplings recorded significantly maximum but on par shelling, sound mature kernel percentages and also oil yield per hectare. Whereas, oil content percentage recorded by S₁ method of row skipping was significantly maximum (46.20%) over other methods of row skipplings.



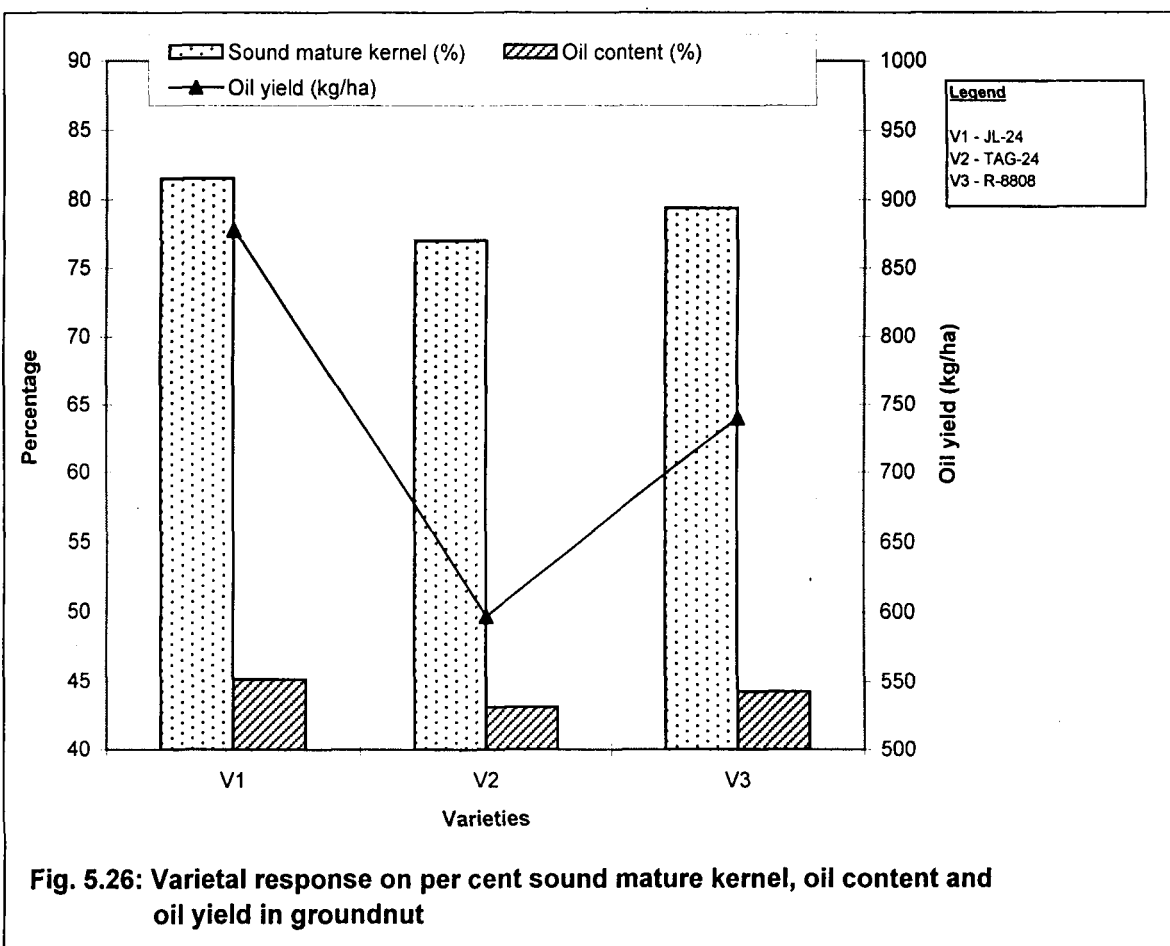
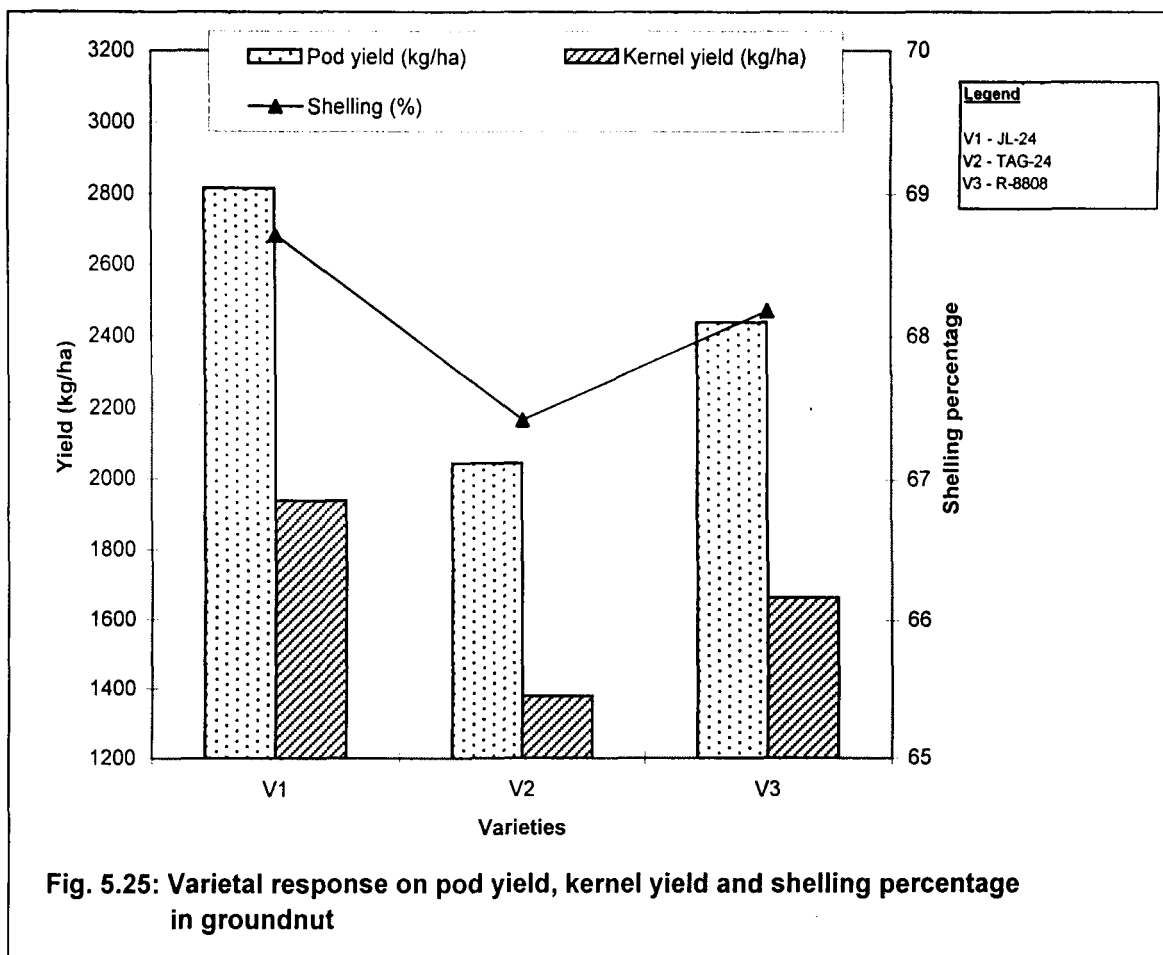
Considering the higher pod yield and oil content percentage recorded by S₁ method of row skipping and also growth parameters, S₁ method of row skipping was found most effective method of row skipping for groundnut seed production.

Contradictory results were noticed with skip row planting in castor which resulted in 22.5 per cent reduction in seed yield over normal planting (Yadav and Amar Singh, 1973). Wright and Porter (1982) also reported that row skipping method has no advantage on yield in virginia types of groundnut and rather it showed adverse effect on yield. Whereas, Nikam *et al.* (1984a and 1984b) reported that paired and skip row planting methods in safflower resulted in production of higher number of capitula per plant and yield over normal planting. Similarly, Radder *et al.* (1989) reported an average of 18.9 per cent increase in sorghum seed yield with one row skipping after every three rows over solid planting. They also reported that the same method of planting recorded 21.6 and 27.8 per cent increase in seed yield over solid planting in case of safflower and chickpea respectively. Further, they concluded that with this method of planting, it was possible to reduce the seed rate and fertilizer use to the extent of 25 per cent without reducing the seed yield. For spring groundnut, sowing in paired rows leaving one blank in between was found to be the best method of planting (Jindal *et al.*, 1990). Likewise, Chouhan and Ishwar Singh (1994) in case of castor by sowing in paired rows at 90 and 60/120 cm respectively compared to skipped planting recorded 10.7 and 12.7 per cent increase in seed yield under irrigated conditions and 9.7 and 9.1 per cent increase under rainfed conditions respectively.

The reduction in seed yield by skipped planting method was because under this method three continuous rows were planted at lesser spacing of 60 cm apart which exerted more competition among the plants. While, in the present study, lesser competition for the energy in S₁ method of row skipping might have resulted in increased yield and yield attributes.

Number of immature pods per plant and sound mature kernel percentage data were unable to produce any significant difference due to varieties. Shelling and oil content percentage values exerted significant differences only in pooled results. Whereas, all other yield parameters exhibited significant difference due to varieties during both the years of experimentation and also in pooled results. JL-24 (V₁) and R-8808 (V₃) varieties recorded on par but significantly higher number of mature pods per plant (Fig. 5.24) and also oil content percentage. The other yield (Fig. 5.25 and 5.26) and yield parameters recorded by JL-24 variety were significantly maximum than other two varieties. This may be related to the genotypic difference among the groundnut varieties resulting in to differential growth response leading to differences in yield and yield attributes.

Interaction effects between methods of row skippings and varieties (S x V) were significant for all the yield and yield parameters in pooled results. Though S₁V₁, S₂V₁, S₁V₂, S₂V₂, S₁V₃ and S₂V₃ interaction treatment combinations were on par and recorded higher values for several yield attributes among these S₁V₁ recorded highest value and also considering the growth parameters this treatment combination is found most effective combination for groundnut. The higher yield attributes and yield recorded by all the three groundnut varieties with S₁ method of row

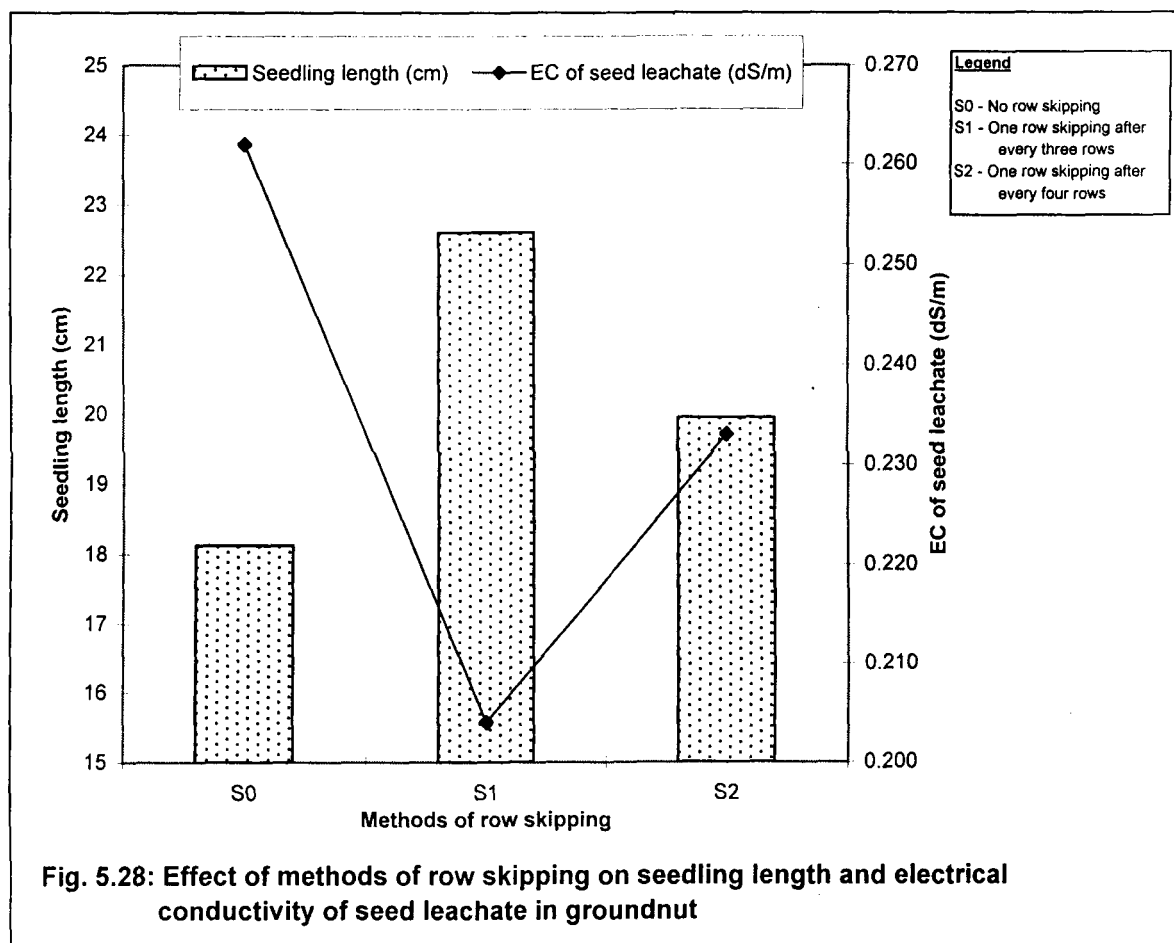
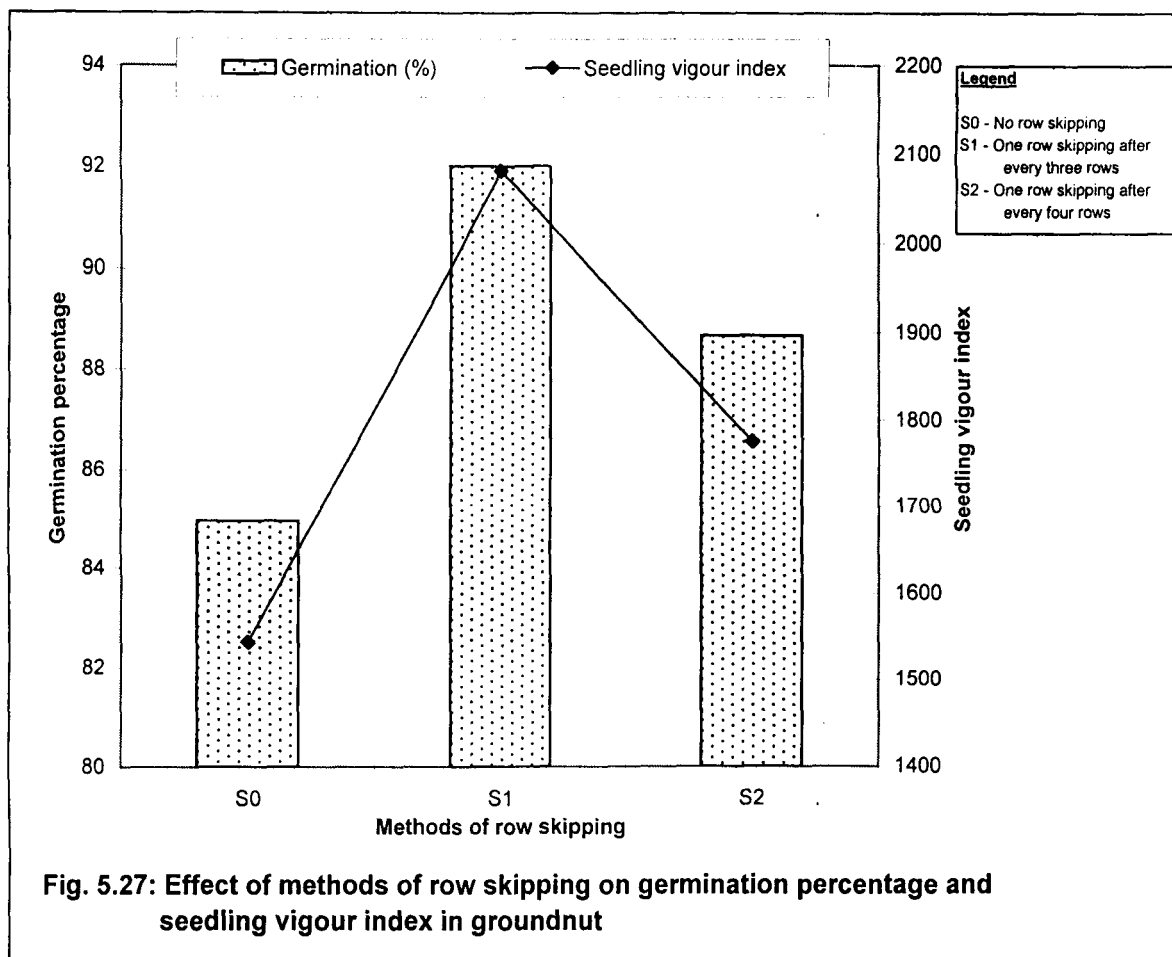


skipping may be due to lesser competition for the energy source. Again the superior performance of S₁V₁ treatment combination may be spelled out to the plant density and also genotypic response.

5.3.3 Influence on seed quality parameters

Methods of row skipplings exhibited significant differences on 100 seed weight (Table 4.67), germination percentage (Table 4.68 and Fig. 5.27), seedling length (Table 4.69 and Fig. 5.28), seedling vigour index (Table 4.71) and electrical conductivity of seed leachate (Table 4.72) values during both the years of experimentation and also in pooled results. Whereas, seedling dry weight (Table 4.70) was non-significant. S₁ method of row skipping recorded significantly maximum (33.84 g) 100 seed weight, (92.01 %) germination, (22.60 cm) seedling length, (2081) seedling vigour index with significantly minimum (0.204 dSm⁻¹) electrical conductivity of seed leachate value. Thus one row skipping after every three rows was found most effective and best row skipping method for groundnut seed production.

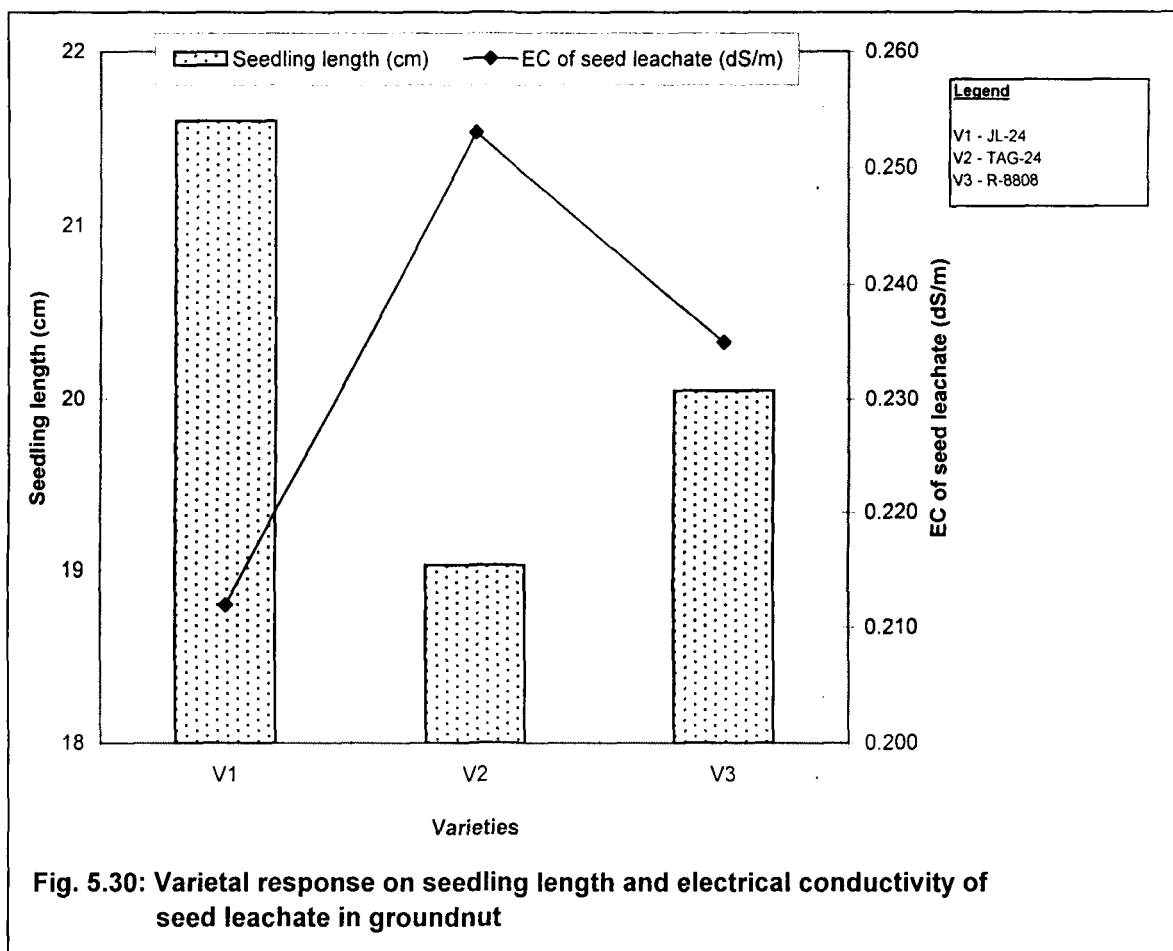
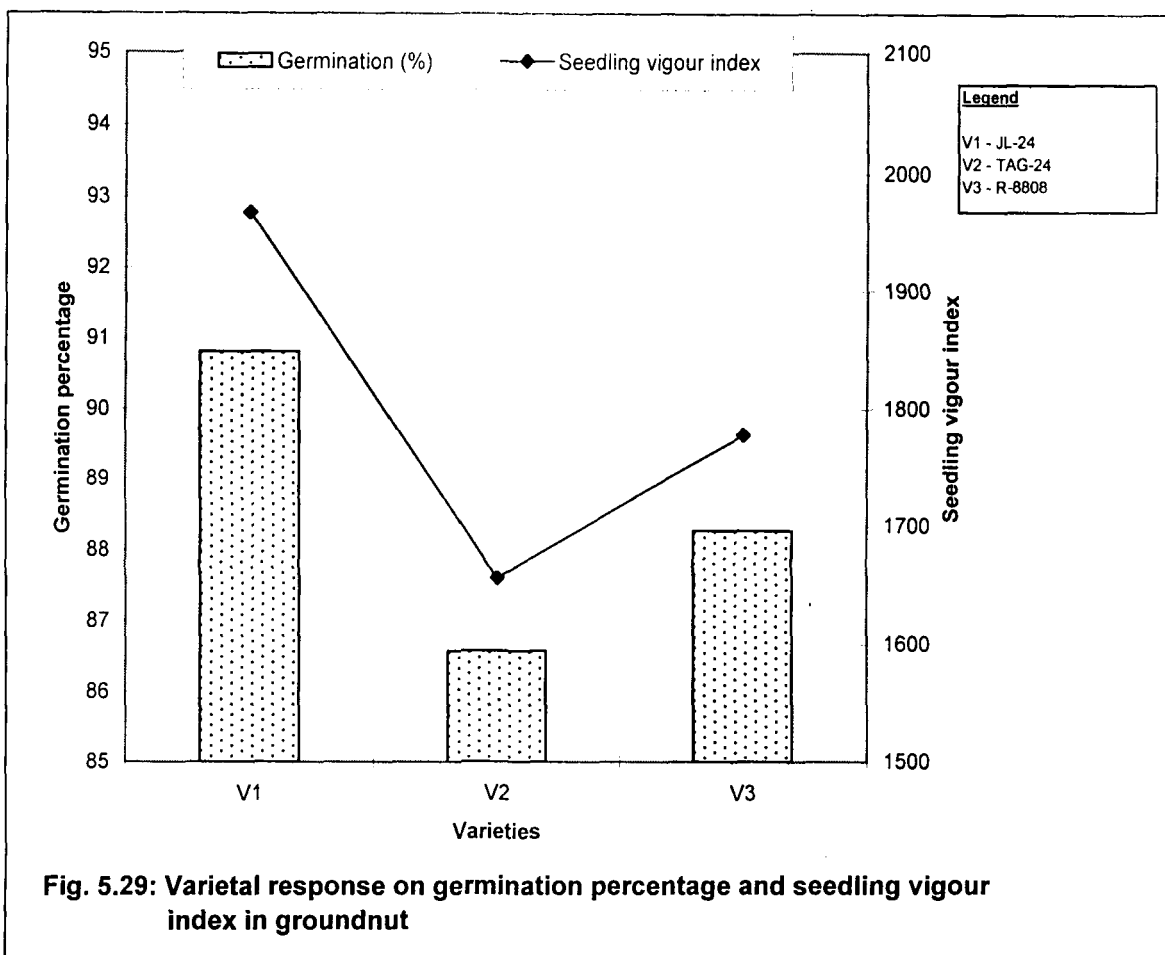
Similar increase in seed quality by recording higher 1000 seed weight of safflower when raised in paired or skip row method compared to normal planting was reported by Nikam *et al.* (1984a and 1984b). The increase in seed quality parameters, noticed in the present study might be due to lesser plant density of S₁ method of row skipping which resulted in higher 100 seed weight and better filling and is evident by increased sound mature kernel percentage ultimately leading to higher germination and seedling vigour with lesser electrical conductivity of seed leachate values.



Except for seedling dry weight the other seed quality attributes recorded significant differences due to varieties. JL-24 variety recorded significantly maximum (33.72 g) 100 seed weight, (90.81 %) germination (Fig. 5.29), (21.60 cm) seedling length (Fig. 5.30), (1967) seedling vigour index with significantly less (0.212 dSm^{-1}) electrical conductivity of seed leachate value. Thus JL-24 variety emerged as suitable for groundnut seed production. The increased percentage of sound mature kernels with JL-24 in the present study resulted in higher test weight leading to higher seed quality.

Interaction between methods of row skipplings and varieties ($S \times V$) were significant for all the seed quality attributes during both the years of experimentation and in pooled results except for seedling dry weight. S_1V_1 treatment combination recorded highest (93.53 %) germination, (2193) seedling vigour index with least (0.194 dSm^{-1}) electrical conductivity of seed leachate value. Thus, looking to the growth, yield and seed quality parameters one row skipping after every three rows with JL-24 variety (S_1V_1) treatment was found most effective for groundnut seed production. The better vegetative growth by S_1V_1 treatment combination resulted in higher yield attributes ultimately leading to increased seed quality parameters.

In general looking into weather data of both the years, in all the three experiments the lesser pod and seed yield recorded during 1999 compared to 2000 year of production was due to the less rainfall (301.4 mm) and lesser (21) number of rainy days compared to that of (394.8 mm) rainfall and (26) rainy days of 2000 year. Further, during 1999 the crop underwent a dry spell of three weeks from 45th to 65th day



of its growth which coincided with peak flowering and peg initiation stage. Before this also from 30th to 37th day of crop period, the crop was subjected to dry spell. This resulted in reduction in pod number and ultimately reducing the yield. Whereas, during 2000 the crop underwent a dry spell of two weeks from 13th to 27th day of crop period and one week dry spell from 55th to 62nd day of crop growth. In this year of production though the vegetative growth was little hampered initially but the crop recovered afterwards due to good and well distributed rainfall resulting in higher seed yield.

PRACTICAL UTILITY OF THE RESULTS

1. Combined application of RDF (25:50:25 kg NPK/ha) + vermicompost (@ 2.5 t/ha) + copper ore tailing (@ 12.5 q/ha) to groundnut is found effective to get higher seed yield and quality.
2. Combined application of RDF (25:50:25 kg NPK/ha) + vermicompost (@ 2.5 t/ha) + gypsum (@ 5.0 q/ha) to groundnut is found next best nutrient combination to get higher seed yield and quality.
3. To groundnut soil application + foliar spray at 40 days after sowing of micronutrients is found to record higher seed yield and quality.
4. Zinc micronutrient application to groundnut recorded higher seed yield and quality.
5. One row skipping after every three rows saves the seed rate by 25 per cent apart from recording higher seed yield and quality.
6. One row skipping after every four rows saves the seed rate by 20 per cent without reduction in seed yield and quality.

1. There is a need to prepare an inventory of promising organic and biological sources under different agro-eco regions involving diverse farming situations for groundnut seed production.
2. Different industrial wastes with potential manurial value need to be studied for groundnut seed crop.
3. More field data on *in situ* decomposition of crop residues including stubbles in relation to soil properties and seed crop productivity are needed.
4. Research on residual effect of various organic sources under different environments and management practices needs to be initiated.
5. The hidden hungers for the micronutrients by groundnut crop need to be taken care under different farming situations.
6. Bio-fertilizer technology needs to be refined to make of more acceptable by seed producers. Microbial strains which can compete with indigenous ones and work efficiently over a wide range of soil-climatic conditions need to be isolated and multiplied.
7. There is a need to standardize the suitable planting method under rainfed farming situations for groundnut seed production.
8. There is a need to come out with inexpensive and economically feasible mulching practice to conserve soil moisture and also to smother the weeds for groundnut seed production.

Summary

VI. SUMMARY

Studies on integrated nutrient management and planting methods on seed yield and quality of groundnut (*Arachis hypogaea* Garten.) were made at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during 1999 and 2000 *kharif* seasons. The results obtained out of the field and laboratory studies during individual years were either non-significant for most of the characters nor they followed the same trend as that of pooled analyzed data, hence only the year-wise pooled results are summarized in this chapter.

6.1 EXPERIMENT - I : EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of 16 treatments involving organic, inorganic and bio-fertilizers and their combinations. The experiment was replicated thrice and was laid out in randomized block design.

In the growth parameters, non-significant differences due to nutrient treatments were noticed on plant height at 60 days after sowing (DAS) and at harvest and on number of branches. The treatment T₁₁ recorded numerically higher (43.94 cm) plant height with 8.25 number of branches at harvest. Significantly less (35.15, 50.00 and 98.1) days were taken for 50 per cent flowering, peg initiation and pod maturity respectively by T₁₁ treatment. This treatment also recorded significantly maximum (146.3 mg) nodule dry weight with 74.55 number of nodules per plant. In all the growth parameters this treatment was followed by T₁₂ treatment. T₁ treatment recorded significantly more days to 50 per cent

flowering, peg initiation and pod maturity and less number of nodules and nodule dry weight.

In the yield parameters studied, nutrient levels exhibited significant differences on per plant mature and immature pods number, per plant and per hectare pod yield, shelling percentage, kernel yield per hectare, benefit cost ratio, and oil yield per hectare while, sound mature kernel percentage and oil content percentage did not exhibit any significant differences. The treatment T₁₁ followed by T₁₂ recorded significantly maximum (17.06 and 16.57) mature pods and minimum (3.69 and 4.53) immature pods number, maximum (11.99 and 11.53 g) pod yield per plant, and per hectare pod yield of 3337 and 3214 kg, kernel yield of 2362 and 2244 kg and oil yield of 1103 and 1038 kg, shelling (70.71 and 69.83%) and numerically higher (84.82 and 84.20 %), sound mature kernels and (46.84 and 46.34 %) oil content respectively. The benefit cost ratio recorded by T₁₅ treatment was significantly maximum (5.07) but treatment T₁₁ was on par with T₁₅ treatment by recording 4.20 benefit cost ratio. The treatment T₁ by recording significantly minimum (10.86) and maximum (8.04) number of mature and immature pods respectively also recorded lesser pod, kernel and oil yields. The shelling, sound mature kernel and oil content percentages recorded by this treatment were also less.

In the seed quality parameters, nutrient treatments exhibited significant differences on per cent germination, seedling length, seedling vigour index and electrical conductivity of seed leachate while, 100 seed weight and seedling dry weight were non significant. Significantly

maximum (94.31%) germination, (23.85 cm) seedling length, (2249) seedling vigour index and minimum (0.186 dSm⁻¹) seed leachate values were recorded by T₁₁ treatment. This treatment recorded numerically higher (35.26 g) 100 seed weight and (4.60 g) seedling dry weight. The treatment T₁₂ followed this treatment for all the seed quality characters and both were on par with each other. T₁ treatment recorded significantly inferior values for the seed quality parameters studied.

6.2 EXPERIMENT - II : EFFECT OF MICRONUTRIENTS AND METHODS OF APPLICATIONS ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of four micronutrients as factor-I and seven methods of application as factor-II with over all 28 treatment combinations. The experiment was conducted in randomized block design by adopting factorial concept and was replicated thrice.

Irrespective of the methods of applications, significant differences in all the growth parameters were noticed due to micronutrients. C₁, C₂ and C₃ micronutrients were at par with each other and these recorded significantly higher plant height at 60 DAS and at harvest, number of branches, number of nodules, nodule dry weight and less days to 50 per cent flowering, peg initiation and pod maturity than C₀ micronutrient.

Methods of application irrespective of micronutrients differed significantly among themselves in plant height and number of branches at harvest, days to 50 per cent flowering, peg initiation and pod maturity,

number of nodules and nodule dry weight. The A₆ and A₄ methods of applications were at par for most of the growth parameters and recorded significantly maximum (43.38 and 43.13 cm) plant height at harvest, (7.41) in both the methods of applications number of branches and significantly less (36.69 and 37.06) days to 50 per cent flowering, (51.63 and 52.15) days to peg initiation and (100.8 and 102.3) days to pod maturity respectively. These methods of applications also recorded significantly maximum (71.56 and 69.97) number of nodules and (128.5 and 120.2 mg/plant) nodule dry weights respectively. While, A₁ and A₃ methods of applications recorded significantly lesser plant height, number of branches, number of nodules, nodule dry weight and took more days to 50 per cent flowering, peg initiation and pod maturity.

Interaction between micronutrients and methods of applications (C x A) was significant on nodule dry weight, days to 50 per cent flowering and pod maturity. The treatment combinations C₃A₆, C₂A₆ and C₁A₆ were at par and recorded significantly higher nodule dry weight and less days to 50 per cent flowering and pod maturity.

Significant differences due to micronutrients and methods of applications were also noticed on number of mature and immature pods per plant, pod, kernel and oil yields, benefit cost ratio, shelling, sound mature kernel and oil content percentages. Whereas, their interaction effects were significant for only kernel yield, benefit cost ratio and oil yield.

Among the micronutrients C₀ micronutrient recorded significantly higher immature pods and lesser values for other yield parameters than C₁, C₂ and C₃ micronutrient treatments and these were at par with each

other. The benefit cost ratio recorded by C₁ and C₂ micronutrients were 4.63 and 4.29 respectively and were significantly higher over C₀ (3.88) and C₃ (3.97) micronutrients.

A₆ method of application recorded significantly maximum (15.28) mature pods, minimum (4.72) immature pods, maximum (10.94 g/plant) pod yield, (3047 kg/ha) pod yield, (2085 kg/ha) kernel yield, (68.06 %) shelling, (83.01 %) sound mature kernels, (45.79 %) oil content and (962 kg/ha) oil yield. This method of application was followed by A₄ method of application and both were at par. The benefit cost ratio recorded by A₅ method of application was significantly maximum (5.29) while, A₂ and A₇ methods of applications recorded significantly minimum (3.55 and 3.67) benefit cost ratio respectively. The ratio recorded by A₆ and A₄ methods of applications were 4.16 and 4.09 respectively.

The interaction treatments C₃A₆, C₂A₆ and C₁A₆ recorded on par but significantly higher kernel and oil yields. Whereas, the benefit cost ratio recorded by treatment combinations C₃A₅, C₂A₅, C₁A₅, C₁A₆ and C₁A₄ were at par and significantly higher than other treatment combinations.

The micronutrients C₁, C₂ and C₃ recorded significantly higher seed quality attributes than C₀ micronutrient but were at par with each other.

Methods of applications A₆ and A₄ recorded significantly maximum (33.65 and 32.84 g) 100 seed weight, (91.92 and 91.16 %) germination, (22.73 and 22.13 cm) seedling length, (2095 and 2021) seedling vigour index and minimum (0.201 and 0.205 dSm⁻¹) seed leachate values respectively but were at par with each other. While A₁, A₂ and A₃ methods of applications recorded lesser seed quality attributes.

Interaction effect between C x A was significant for only electrical conductivity of seed leachate values. The treatment combinations C₃A₆, C₂A₆ and C₁A₆ recorded significantly less electrical conductivity of seed leachate values over other treatment combinations.

6.3 EXPERIMENT - III : EFFECT OF METHODS OF ROW SKIPPING ON SEED YIELD AND QUALITY OF GROUNDNUT

This experiment consisted of nine treatment combinations involving three methods of row skipping and three varieties. The experiment was replicated thrice in randomized block design by adopting factorial concept.

Irrespective of varieties, S₁ method of row skipping recorded significantly maximum (24.62 cm) plant height at 60 DAS, (35.49 cm) plant height at harvest, (7.17) number of branches, (71.73) number of nodules, (135.2 mg) nodule dry weight and significantly less (38.71, 52.87 and 103.3) days to 50 per cent flowering, peg initiation and pod maturity respectively while, S₀ method of row skipping recorded lesser plant height, branches, number of nodules, nodule dry weight and took more days to 50 per cent flowering, peg initiation and pod maturity.

Irrespective of methods of row skippings, the variety JL-24 (V₁) recorded significantly maximum (28.39 and 41.56 cm) plant height at 60 DAS and at harvest respectively, (7.27) number of branches, (70.98) number of nodules, (121.1 mg) nodule dry weight and took less (37.04, 54.47 and 103.5) days to 50 per cent flowering, peg initiation and pod maturity respectively.

In the interaction between methods of row skippings and varieties (S x V), JL-24 variety in all the methods of row skippings recorded higher plant height and number of branches, while TAG-24 (V₂) variety in all the methods of row skippings recorded lesser values for these growth parameters. Among them S₁V₁ recorded higher values and S₀V₂ recorded lesser values. Number of nodules and dry weight recorded by these treatment combinations were significantly maximum and minimum respectively. The S₁V₁ treatment took significantly less (34.03, 50.80 and 100.1) days to 50 per cent flowering, peg initiation and pod maturity respectively while, S₀V₃ treatment took significantly more (46.00, 63.20 and 115.6) days to 50 per cent flowering, peg initiation and pod maturity respectively.

Irrespective of the varieties, S₁ method of row skipping recorded significantly maximum (16.32) mature pods, (11.85 g/plant) pod yield, (2560, 1773 and 822 kg/ha) pod, kernel and oil yields respectively, (5.14) benefit cost ratio and (69.16, 83.17 and 46.20 %) shelling, sound mature kernels and oil content respectively with significantly minimum (4.92) immature pods per plant. The corresponding yield parameter values recorded by S₀ method of row skipping were significantly less except the immature pods number which was higher.

Irrespective of methods of row skippings, JL-24 variety recorded significantly maximum (15.44) mature pods, (2816, 1939 and 878 kg/ha) pod, kernel and oil yields respectively, (68.71, 81.53 and 45.14%) shelling, sound mature kernels and oil content respectively with a benefit cost ratio of 5.62. Whereas, TAG-24 variety recorded significantly lesser yield parameters with a benefit cost ratio of 3.80.

The interaction treatment combination S_1V_1 recorded significantly maximum (6.15) benefit cost ratio with 2979 and 2081 kg per ha pod and seed kernel yields respectively. The treatment S_0V_2 recorded 3.56 benefit cost ratio and also significantly less values for other yield parameters.

S_1 method of row skipping recorded significantly maximum (33.84 g) 100 seed weight, (92.01 %) germination, (22.60 cm) seedling length, (2081) seedling vigour index and minimum (0.204 dSm^{-1}) electrical conductivity of seed leachate value. While, S_0 method of row skipping recorded lesser seed quality parameters with higher electrical conductivity of seed leachate value.

Among varieties, JL-24 variety was superior in seed quality and recorded significantly maximum (33.72 g) 100 seed weight, (90.81 %) germination, (21.60 cm) seedling length, (1967) vigour index and minimum (0.212 dSm^{-1}) electrical conductivity of seed leachate value. TAG-24 variety was inferior in seed quality attributes studied.

Significantly maximum and minimum seed quality attributes were recorded by S_1V_1 and S_0V_2 treatment combinations respectively whereas, the electrical conductivity of seed leachate values recorded by these respective treatments were minimum (0.194 dSm^{-1}) and maximum (0.290 dSm^{-1}).

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Appendices

Appendix I : Price of various inputs and outputs used in calculating the cost of cultivation and net returns of groundnut.

Particulars	Quantity	Rate (Rs.)	Total Price (Rs.)
A. INPUTS			
1. Seeds	100 kg	42/kg	4,200
2. Fertilizers (25:50:25 kg NPK/ha)			
Urea (45 % N)	56 kg	5.10/kg	285
Single super phosphate (16 % P)	313 kg	4.30/kg	1,345
Muriate of potash (60 % K)	42 kg	4.40/kg	185
3. Land preparation			
Bullock pair	2 pairs	150/day	300
Equipment hire charges	1 plough	50/day	50
	2 harrows	50/day	100
Men labour	2 No's	50/day	100
Women labour	3 No's	35/day	105
4. Sowing			
Bullock pair	1 pairs	150/day	150
Equipment hire charges	1 plough	50/day	50
	1 harrow	50/day	50
Men labour	2 No's	50/day	100
Women labour	8 No's	35/day	280
5. Inter culturing and Earthingup			
Bullock pair	2 pairs	150/day	300
Equipment hire charges	2 times	50/day	100
Men labour	4 No's	50/day	200
Women labour	4 No's	35/day	140
6. Plant protection chemicals			
Captan	1 kg	320	320
Pendimethalin	1 ltr.	425	425
Monocrotophos	1.5 ltr.	320	480
Mancozeb	1 kg	205	205
Carbandizem	1 kg	455	455
7. Hand weeding and spraying			
Men labour	4 No's	50/day	200
Women labour	20 No's	35/day	700
8. Harvesting and plucking			
Men labour	2 No's	50/day	100
Women labour	20 No's	35/day	700
9. Cleaning, drying and packing			
Men labour	2 No's	50/day	100
Women labour	16 No's	35/day	560
		Total	12,285
10. Other inputs			
FYM	5 t/ha	300/t	1,500
Vermicompost	2.5 t/ha	2000/t	5,000
Copper Ore Tailing	12.5 q/ha	50/q	625
Gypsum	5 q/ha	200/q	1,000
Rhizobium and 'P' solubilizer (each)	1 kg/ha	30/kg	60
FeSO ₄ - Seed treatment @ 2 g/kg	200 g	120/kg	24
FeSO ₄ - Soil application @ 25 kg/ha	25 kg	120/kg	3,000
FeSO ₄ - Foliar spray @ 0.4 %	2 kg	120/kg	240
ZnSO ₄ - Seed treatment @ 2 g/kg	200 g	200/kg	40
ZnSO ₄ - Soil application @ 25 kg/ha	25 kg	200/kg	5,000
ZnSO ₄ - Foliar spray @ 0.5 %	2.5 kg	200/kg	500
B. OUTPUTS			
Groundnut pods (Truthful Seeds)		2800/q	

Appendix II. Economics of organic, inorganic and bio-fertilizers in groundnut

Treatments	Gross returns (Rs)			Net returns (Rs)		
	1999	2000	Pooled	1999	2000	Pooled
T ₁ - 25:50:25 NPK kg/ha (RDF)	57,717	63,840	60,779	44,434	51,555	47,995
T ₂ - T ₁ + FYM (5 t/ha)	64,820	73,136	68,978	51,035	59,351	55,193
T ₃ - T ₁ + Vermicompost (2.5 t/ha)	68,161	75,619	71,890	50,885	58,334	54,610
T ₄ - T ₁ + Copper ore tailing (12.5 q/ha)	64,167	71,083	67,625	51,257	58,173	54,715
T ₅ - T ₁ + Gypsum (5 q/ha)	59,528	66,435	62,982	45,909	53,150	49,230
T ₆ - T ₁ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	60,713	65,576	63,145	48,368	53,231	50,800
T ₇ - T ₂ + Vermicompost (2.5 t/ha)	82,535	90,309	86,422	63,750	71,524	67,637
T ₈ - T ₂ + Copper ore tailing (12.5 q/ha)	83,364	88,256	85,810	69,956	73,846	71,901
T ₉ - T ₂ + Gypsum (5 q/ha)	83,720	91,709	87,715	68,935	76,924	72,930
T ₁₀ - T ₂ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	78,857	86,744	82,801	65,012	72,899	68,956
T ₁₁ - T ₃ + Copper ore tailing (12.5 q/ha)	89,311	96,899	93,105	71,401	78,989	75,195
T ₁₂ - T ₃ + Gypsum (5 q/ha)	85,559	94,759	90,159	67,274	76,140	71,707
T ₁₃ - T ₃ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	81,452	89,021	85,237	64,107	71,676	67,892
T ₁₄ - T ₄ + Gypsum (5 q/ha)	82,208	85,353	83,781	68,298	71,443	69,871
T ₁₅ - T ₄ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	75,507	81,878	78,693	62,537	68,911	65,724
T ₁₆ - T ₅ + Bio-fertilizer (<i>Rhizobium</i> + 'P' solubilizer each @ 1 kg/ha)	72,268	78,633	75,451	58,923	65,288	62,102

Appendix III. Economics of micronutrients and methods of application in groundnut

Treatments	Gross returns (Rs)											
	1999						2000					
	Micronutrients (C)						Micronutrients (C)					
	C ₀ -No micro nutrient	C ₁ - FeSO ₄	C ₂ - ZnSO ₄	C ₃ - FeSO ₄ +ZnSO ₄	C ₀ -No micro nutrient	C ₁ - FeSO ₄	C ₂ - ZnSO ₄	C ₃ - FeSO ₄ +ZnSO ₄	C ₀ -No micro nutrient	C ₁ - FeSO ₄	C ₂ - ZnSO ₄	C ₃ - FeSO ₄ +ZnSO ₄
A ₁ - Seed treatment	56,933	60,816	61,367	63,737	62,981	66,332	67,443	70,756	59,957	63,574	64,405	67,247
A ₂ - Soil application	56,719	71,951	74,545	76,365	62,552	78,857	80,481	82,637	59,636	75,404	77,513	79,501
A ₃ - Foliar spray	57,475	66,220	67,303	70,765	63,308	72,389	74,639	77,560	60,392	69,305	70,971	74,163
A ₄ - A ₁ + A ₂	56,065	86,753	85,885	86,968	62,664	93,221	94,304	94,743	59,365	89,987	90,095	90,856
A ₅ - A ₁ + A ₃	57,045	81,452	82,647	84,803	63,093	88,359	87,880	92,872	60,069	84,906	85,264	88,589
A ₆ - A ₂ + A ₃	57,036	88,359	89,236	91,933	63,411	95,928	97,011	99,596	60,224	92,144	93,124	95,765
A ₇ - A ₁ + A ₂ + A ₃	57,251	77,448	79,184	79,828	63,196	84,579	85,773	86,968	60,224	81,014	82,479	93,398
Treatments	Net returns (Rs)											
	1999						2000					
	Micronutrients (C)						Micronutrients (C)					
	C ₀ -No micro nutrient	C ₁ - FeSO ₄	C ₂ - ZnSO ₄	C ₃ - FeSO ₄ +ZnSO ₄	C ₀ -No micro nutrient	C ₁ - FeSO ₄	C ₂ - ZnSO ₄	C ₃ - FeSO ₄ +ZnSO ₄	C ₀ -No micro nutrient	C ₁ - FeSO ₄	C ₂ - ZnSO ₄	C ₃ - FeSO ₄ +ZnSO ₄
A ₁ - Seed treatment	44,648	48,466	49,042	51,377	50,696	53,982	55,118	58,396	47,672	51,224	52,080	54,887
A ₂ - Soil application	44,434	56,666	57,260	56,080	50,267	63,572	63,196	62,352	47,351	60,119	60,228	59,216
A ₃ - Foliar spray	45,190	53,695	54,518	57,740	51,023	59,864	61,854	64,535	48,107	55,780	58,186	61,138
A ₄ - A ₁ + A ₂	43,780	71,433	68,560	66,608	50,379	77,901	76,979	74,383	47,080	74,667	72,770	70,496
A ₅ - A ₁ + A ₃	44,760	68,894	69,822	71,703	50,808	75,799	77,055	79,272	44,784	72,347	73,439	75,488
A ₆ - A ₂ + A ₃	44,751	72,834	71,452	71,908	51,126	80,403	79,226	78,571	47,939	76,619	75,339	75,240
A ₇ - A ₁ + A ₂ + A ₃	44,966	61,888	61,359	58,728	50,911	69,019	67,948	65,868	56,993	65,454	64,654	62,298

Appendix IV. Economics of methods of row skipping in groundnut varieties

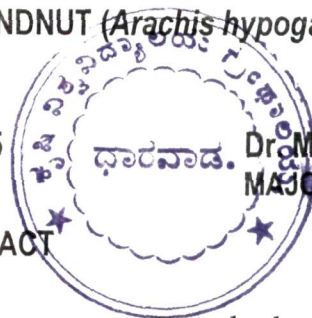
Treatments	Gross returns (Rs)									
	1999			2000			Pooled			
	Varieties (V)			Varieties (V)			Varieties (V)			
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	69,337	53,293	61,451	76,057	58,679	67,499	72,697	55,986	64,475	
S ₁ - One row skipping after every three rows	80,565	58,380	68,563	86,231	62,123	74,228	83,398	60,252	71,396	
S ₂ - One row skipping after every four rows	77,205	52,621	66,453	83,636	58,483	71,531	80,421	55,552	68,992	
Treatments	Net returns (Rs)									
	1999			2000			Pooled			
	Varieties (V)			Varieties (V)			Varieties (V)			
Methods of row skipping (S)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	JL-24 (V ₁)	TAG-24 (V ₂)	R-8808 (V ₃)	
S ₀ - No row skipping	57,052	41,008	49,166	63,772	46,394	55,214	60,412	43,701	52,190	
S ₁ - One row skipping after every three rows	68,896	46,711	56,894	74,562	50,454	62,559	71,729	48,583	59,727	
S ₂ - One row skipping after every four rows	65,368	40,784	54,615	71,799	46,646	59,694	68,584	43,715	57,155	

STUDIES ON INTEGRATED NUTRIENT MANAGEMENT AND PLANTING METHODS ON
SEED YIELD AND QUALITY OF GROUNDNUT (*Arachis hypogaea* Gaertn.)

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ABSTRACT



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Studies on integrated nutrient management and planting methods on seed yield and quality in groundnut were made at Main Agricultural Research Station, Dharwad during 1999 and 2000 *kharif* seasons. The experiment involving 16 treatments with organic, inorganic nutrients and biofertilizers revealed that application of RDF (25:50:25 kg NPK/ha) + vermicompost (@2.5 t/ha) + copper ore tailings (@ 12.5 q/ha) recorded significantly higher nodule number and dry weight per plant, besides significantly reducing days to 50 per cent flowering, peg initiation and pod maturity. It also recorded significantly higher number of matured pods per plant, pod yield (3337 kg/ha), kernel yield (2362 kg/ha) and seed quality parameters *viz.*, germination (94.31 %) and seedling vigour index (2249). Application of RDF (25:50:25 kg NPK/ha) + vermicompost (@ 2.5 t/ha) + gypsum (@ 5.0 q/ha) was next nutrient combination to get higher seed yield and quality.

Results of the experiment involving four micronutrients and seven methods of application indicated that $ZnSO_4$ micronutrient recorded higher pod yield (2883 kg/ha), kernel yield (1939 kg/ha), germination (90.18 %) and seedling vigour index (1966). Among the micronutrient application methods the soil application + foliar spray at 40 DAS recorded higher pod yield (3047 kg/ha), kernel yield (2085 kg/ha), germination (91.92 %) and seedling vigour index (2095).

Results of the experiment involving three methods of row skipping and three varieties revealed that one row skipping after every three rows recorded higher pod yield (2560 kg/ha), kernel yield (1763 kg/ha), germination (92.01 %) and seedling vigour index (2081) it also saves 25 per cent seed rate. One row skipping after every four rows saves the seed rate by 20 per cent without reduction in seed yield and quality. The variety JL-24 recorded higher pod yield (2816 kg/ha), kernel yield 1939 kg/ha, germination (90.81 %) and seedling vigour index (1967).