RESPONSE OF GROUNDNUT (*Arachis hypogaea* (L.) TO PHOSPHORUS AND POTASSIUM UNDER DIFFERENT WATER MANAGEMENT PRACTICES

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Response of groundnut (*Arachis hypogaea* (L.) to phosphorus and potassium under different water management practices" is a bona fide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title at any other University or Society.

JOSE MATHEW

Vellayani,
2nd April, 1981.

CERTIFICATE

Certified that this thesis, entitled "Response of groundnut (Arachis hypogaea (L.) to phosphorus and potassium under different water management practices" is a record of research work done independently by Sri. JOSE MATHEW under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

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The need for increasing oilseed production in the country has assumed very great importance due to the shortage of edible and fatty oils and the near famine proportion of the situation. Our daily availability of 13.7 g of oil is far below the minimum nutritional level of 18 g due to an acute shortage of about one million tonnes of oil a year (Modha and Singh, 1980). The consumption has been limited by the inability to meet the demand, due to stagnation in domestic output. Hence there is an urgent need for increasing the production of oilseeds in India.

Groundnut is the most important oilseed crop of India which sharesthe largest oilseed area and production and is grown in almost all the states. Groundnut kernels have about 50 per cent oil content. In addition to this it is a highly concentrated form of food rich in proteins, B-vitamins and minerals. The deficiency of cereal protein can be made good by supplementation of groundnut in the food since it contains a sufficiently high concentration of arginine, lysine and leusine (Raheja et al., 1979). Further being a legume, it has also got the capacity to harness the inexhaustible stock of nitrogen in the atmosphere in association with the nitrogen fixing bacteria.

In Kerala, groundnut occupies 12,655 hectares of land and produces 13,288 tonnes of pod with an average of 1050 kg per hectare (Anon., 1978). The production can further be enhanced by bringing more area under its cultivation and improving the yield per unit area by adopting improved management practices.

The area under groundnut cultivation can be increased by extending its cultivation to summer rice fallows which comes to about 2.73 lakh hectares during the third crop season. It is the most remunerative crop during this season, which also helps to increase the fertility of the paddy fields.

Marked increase in groundnut yield was obtained by adopting improved water management practices (Krishnaswamy et al., 1964 and Ali et al., 1974). But scarcity of water is the major yield constraint for attaining potential productivity in groundnut during summer season. It has, therefore, become imperative to work out the efficient and economical method of irrigation, which can maximise the yield of the crop, lead to larger coverage of area by using the available supply of water judiciously. No precise water management techniques have been developed for groundnut in Kerala which are essential for judicious and economic use of water for producing optimum crop yield per unit of irrigated land or per unit of water used in irrigation.

The importance of phosphorus and potassium nutrition on the growth and yield of groundnut has been studied by many workers (Patil, 1968;Gopalaswamy et al., 1976; Pande et al., 1971). Phosphorus and potassium requirement of groundnut in the red loam soils of Kerala was also determined (Muraleedharan 1971; Jayadevan and Sreedharan, 1975a and Nair, 1978). But the responce of groundnut to phosphorus and potassium application in the sandy loam soils of Kerala and under different soil moisture regimes were not studied. This is important since fertilizer use efficiency can be increased by the proper water management practices.

With the objects envisaged in the previous pages, the present investigation was undertaken in the rice fallows during the summer season of 1979-80, at Agronomic Research Station, Chalakudy.

In nutshell the major objectives of the investigation were:

1. To study the growth and yield response of groundnut to different irrigation schedules,

2. To find out the optimum levels of phosphorus and potassium required by the crop under irrigated conditions,

3. To study the effect of the combination of irrigation and nutrients on the growth and yield of crops,

4. To assess the quality of groundnut as affected by different levels of phosphorus and potassium and irrigation schedules,

5. To study the economics of irrigation and nutrient application to groundnut.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Groundnut is an important oil seed crop which is found to respond well to irrigation and phosphorus and potash fertilization. Some of the major works conducted in India and abroad on the influence of these factors on growth, yield, quality and nutrient uptake of this crop are reviewed hereunder.

A. Irrigation

(1) Effect of irrigation on growth characters

Ochs and Wormer (1959) observed a reduction in the total number of leaves produced per plant due to drought. Under drought all plants were shorter, had poor root distribution, less branches and leaves and had smaller leaves containing less water than did irrigated plants (Lin et al., 1963). Krishnaswamy et al. (1964) reported that frequent irrigations helped to produce more vegetative growth, this being indicated by height measurement and yield of hauln. Lenka and Misra (1973) also observed a decrease in plant growth with decreasing frequency of irrigation.

Irrigating groundnut once in 12 to 14 days resulted in increased hauln yield over rainfed crop (Gopalaswamy et al., 1974). Subba Rao et al. (1974) also reported significantly higher bhusa yield by irrigating the crop at 25% Depletion of Available Soil Moisture (DASM) from sowing to pegging and 50% DASM from pegging to harvest. It was observed that there was significant difference in shoot height (at 60th day and harvest) and haulm yield due to the effect of various moisture levels during *rabi* season (Anon., 1975a). A moisture level of 50% appeared to be optimum for maximum shoot and root dry weight (Varma and Subba Rao, 1975). Vivekanandan and Gunasena (1976) reported that increased soil moisture tension decreased the total dry matter production in groundnut. A difference in moisture regimes could produce significant difference in the number of branches produced per plant (Anon., 1978b).

Irrigating the crop at an IW/CPE ratio of 1.0 had produced significantly higher straw yield over 0.4 and 0.6 ratios and was on par with 0.8 ratio (Anon., 1980a). The haulm yield was not influenced by different frequencies of irrigation whereas the plant height, at 50th day and harvest, was significantly affected and an IW/CPE ratio of 0.9 was found to be superior (Anon., 1980b). Khan and Morey (1980) reported that shoot, root and total dry matter production were significantly influenced by soil moisture regimes and the maximum dry matter production was obtained under no stress situations. Reddy (1980) observed an increase in plant height and spread with increase in irrigation frequency.

(2) Effect of irrigation on nodulation and N fixation

Lenka and Misra (1973) observed a decrease in nodulation with decreasing frequencies of irrigation and the maximum number of nodules were with irrigations at 25% DASM. According to Varma and Subba Rao (1975), a moisture level of 50% appeared to be optimum for maximum number and weight of root nodules and an increase in moisture content to 100% reduces the dry weight of nodules in green gram. Mante (1976) reported increased nodule size and persistence with irrigation. Reddy and Tanner (1978) observed increased nitrogen fixation with irrigation compared to no irrigation. While an increase in nodule number was observed with irrigations and irrigations at 120 mm CPE had adversely and significantly affected nodule number, as observed by Shelke and Khupse, 1980.

(3) Effect of irrigation on yield and yield attributes

(a) Depth interval yield approach

Bhavanisankar Rao (1955) reported that irrigating groundnut crop once in every 10 days recorded more out turn than irrigating at 15 days, 20 days or 25 days intervals. Krishnaswamy et al. (1964) observed increase in yield of pods and kernal by irrigating groundnut once in ten days. The same treatment registered significantly higher shelling per cent and was superior in giving bolder kernals. Mantell and Goldin (1964) observed a positive effect on shelling per cent and 1000 seed weight due to irrigation. Boote et al. (1976) reported that drought reduced shelling per cent. Varnell et al. (1976) found that drought reduced kernal yield, percentage of sound and mature kernals and shelling percentage.

(b) Soil moisture deficit approach

Mohan (1970) observed higher yields when irrigated at 60% of field capacity than those at 40 or 80% of field capacity. Yadav (1972) reported that maximum pod yield was recorded by irrigations at 40% DASM. Irrigation at 25% Available Soil Moisture (ASM) was sufficient for optimum yields during rabi season. In an experiment conducted at Bhavanisagar, higher yields were obtained by irrigations at 60% ASM throughout crop growth and it was on par with irrigations at 0 per cent ASM during first stage (0-25 days) and at 60% from 25 days upto harvest (Anon., 1973). Lenka and Misra (1973) observed that during rabi, in a sandy soil highest pod yield was obtained with irrigation at 25% DASM. Number of pods per plant and their weight reduced with decrease in frequency of irrigation.

Saini et al. (1973) reported that irrigation at 50% DASM gave maximum yield of groundnut pods which was attributed to its good effect on the number of mature pods and pod bearing needles. Ali et al. (1974) reported increased yields with a moisture regime of field capacity to 60% moisture availability measured at 30 cm depth. Ono et al. (1974) reported that optimum soil moisture content was 40% for groundnut plant which resulted in better podding per cent. Subba Rao et al. (1974) reported that highest pod yield was obtained by irrigating groundnut crop at 25% DASM from pod formation to harvest stage and at 50% DASM from sowing to pod formation. They also observed more number of pods per plant and better shelling per cent, whenever ample irrigations were provided from sowing to pod formation stage. But severe moisture stress during pegging to pod formation seemed to have depressed the shelling percentage.

Irrigating groundnut crop at 25% DASM significantly increased pod yield over the crop irrigated at 0 per cent ASM and was on par with the crop irrigated at 50% ASM during rabi season (Anon., 1975b). A trend of increase in pod yield and number of mature pods per plant was noted with higher moisture levels (Anon., 1975a).

Gorbet and Rhoades (1975) reported that irrigating groundnut crop to maintain soil moisture tension below one bar increased pod production, shelling percentage and 100 seed weight. Rao et al. (1976) observed yield reduction to the tune of 56% with increase in moisture stress from 40% ASMD to 80% ASMD.

Cheema et al. (1977) observed that irrigation increased pod yield from 1.61 t/ha with no irrigation to 2.36 t/ha with irrigations at 10% ASM, with no further increase with irrigations at higher ASM during wet seasons. They also reported increased number of mature pods per plant, 100 pod weight and shelling per cent due to irrigation. Shelling percentage was not influenced by moisture regimes (Narasimhan et al., 1977). Reddy and Reddy (1977) observed highest pod yields when irrigated at 25% DASM through out the growing period.

According to Narasimhan et al. (1978) the requirement of moisture for groundnut ranges from 20 to 30% of the available soil moisture in sandy loam soils.

Reddy et al. (1978) reported that two to three protective irrigations given when the ASM in top 30 cm layer was depleted to nearly 50%, increased pod yield significantly over rainfed crop. The number and weight of mature pods per plant was also increased with protective irrigation. Shanmugasundaram et al. (1979) observed that maximum groundnut yield was obtained by irrigating the crop at 100% depletion of available moisture content during early growth-cum-flowering stage (upto 35 days after sowing) and 50% depletion during pod formation and pod formation-cum-maturity stage (36 to 10 days before harvest).

(c) Critical phytophase approach

Su and Lu (1963) reported that the most critical period of moisture deficiency in groundnut on sandy loam soil was at the stage of peak flowering to early fruiting (30-60 days after sowing) while moisture deficiency at maturity (90 to 120 days after sowing) had the least effect on plants. According to Reddy and Rao (1968), water stress at the time of flowering (40 days after sowing) produced considerable reduction in yield of pods and kernals.

Singh et al. (1971) reported that application of two irrigations, one each at flowering and peg formation stages increased average yield of unshelled nuts to 1.36 t/ha compared to 1.03 t/ha by plots given one irrigation at flowering stage and 0.99 t/ha by unirrigated plots. Sandhu et al. (1972) observed that two irrigations, one at flowering and other at fruiting, in addition to the normal two irrigations given in the first and third month after sowing, gave 50.6% and 33.16% higher yields of unshelled nuts than no irrigation and one irrigation at flowering respectively in sandy loam soils.

Saini and Sandhu (1973) also reported significantly higher pod yield than no-irrigation and one irrigation, by giving two irrigations to groundnut crop, first at flowering and second at fruiting. Shelling per cent was also improved with irrigations. Mante (1976) found that irrigations at flowering to pod development stage increases seed number per pod and 1000 seed weight and through these components, the yield. As compared with no irrigation, one irrigation at pegging and two irrigations one each at pegging and podding gave significant yield increase of 13.6% and 26.3% respectively (Anon., 1978c).

(d) Climatological approach

Goldberg et al. (1967) reported that optimum irrigation for groundnut was that in which water was applied every seven days in amounts equal to 90% of evaporation from a free water surface, as measured in screened pan.

Subramoniam et al. (1974) reported that groundnut irrigated at IW/CPE ratio of 0.9 and or 0.6 at sowing to flowering (upto 30 days) effective pegging (30-45 days) and pod formation stages gave the highest yield. Irrigation at a ratio of 0.6 during sowing to flowering and effective pegging stages and 0.9 during pod formation stages was the best. Irrespective of irrigation at flowering and effective pegging, irrigation at IW/CPE ratio of 0.9 during pod formation gave significantly higher yields than did irrigation at IW/CPE ratio of 0.6.

Work done with groundnut variety TMV-2 at Bhavanisagar during rabi seasons with IW/CPE ratio of 0.6, 0.75, 0.9 and 1.05 at two depths (4 cm and 6 cm) indicated that irrigation at IW/CPE ratio of 0.6 with 4 cm depth gave maximum yield (Anon., 1977).

Dahatonde (1978) reported that irrigation had significantly affected pod yield and the highest pod yield and shelling percentage were obtained with irrigations scheduled after 75 mm CPE amounting to 18 irrigations which was on par with 100 mm CPE and was significantly superior to irrigations scheduled at 125 and 150 mm CPEs.

From an experiment at Bhavanisagar using POL-2 variety, it was found that there was significant difference in pod yield due to irrigations, and 4 cm irrigation at 0.9 ratio had given significantly higher pod yields than irrigations at 0.6 and 0.75 ratios (Anon., 1979a).

Another experiment conducted in the sandy clay loams of Hyderabad produced significant differences among irrigation levels and the maximum yield of 23.2 q/ha was recorded by 0.95 ratio which was on par with 0.8 ratio and was significantly superior to 0.5 and 0.65 ratios. The depth of irrigation was 5 cm (Anon., 1979b).

Birajdar and Ingle (1979) reported that scheduling irrigation to groundnut at 100 mm CPE (equivalent to 8 irrigations) was optimum for groundnut during summer season in medium black soils.

An experiment conducted at sandy loam to loamy soils of Dapoli revealed that irrigations scheduled at 0.8 IW/CPE ratio produced significantly higher pod yields, which was followed by IW/CPE ratios of 1.0, 0.6 and 0.4 (Anon., 1980a).

Irrigating groundnut at 0.6 IW/CPE ratio recorded significantly higher yield than 0.9 but it was on par with 0.75 (Anon., 1980b). The higher yield at 0.60 was due to higher production of pods per plant than other treatments.

Reddy (1980) reported that highest pod yield was obtained with the highest irrigation frequency tried (irrigation when pan evaporation from USWB class A pan was 2 cm) and highest depth of water (100% of pan evaporation) tried. It required irrigation once in three days. He also reported that number of flowers and number of pegs per plant decreased with decrease in irrigation frequency. Number of filled pods, shelling per cent and 100 pod weight were increased with increase in irrigation frequency.

Shelke and Khupse (1980) reported increased yields in groundnut with irrigation scheduled at 40 and 80 mm CPE over 120 mm CPE. They also reported that irrigation at these frequencies favourably affected number of developed pods per plant.

4. Effect of irrigation on quality of kernal

(a) Protein content

Matlock et al. (1961) reported that protein content of the kernel was slightly depressed by irrigation (29.7% with and 32.5% without irrigation). Narasimhan et al. (1978) also observed depression in protein content with more frequent irrigations.

(b) Oil content

Singh et al. (1971) and Tongire (1971) observed no significant effect of irrigation on the oil content of kernal. Sandhu et al. (1972) reported that oil yield was increased by 292 kg and 91 kg per ha with 2 irrigations (one at flowering and other at fruiting) and with one irrigation (at flowering) respectively. Saini and Sandhu (1973) also observed increased oil yield with irrigation. Increased oil content with irrigations at 50% DASM was reported by Saini et al. (1973). Subba Rao et al. (1974) found that variation in per cent oil in seeds were not marked, except for slightly higher values when ample irrigations were provided in the stage from pod formation to harvest. Narasimhan et al. (1977) observed that oil yield was decreased markedly with an increase in moisture stress, being lowest under severe stress with irrigation at 75% DASM.

According to Shanmugasundaram et al. (1979), the maximum oil content (52.0%) was recorded in the treatments receiving irrigations at 50% DASM in the early growth-cum-flowering and pod formation stages and irrigation at 25% DASM in the pod formation-cum-maturity stage.

5. Effect of irrigation on chemical composition and uptake of nutrients.

According to Varma and Subba Rao (1975) a moisture level of 50% appears to be optimum for maximum nitrogen content and the nitrogen content of plants were reduced at 100% moisture level than in other treatments.

Narasimhan et al. (1978) reported that, the availability of nitrogen and phosphorus at lower soil moisture level were generally more. Potassium uptake was also found more in the lower moisture levels. In general, they observed the maximum nutrient uptake under optimum moisture levels (20-30%). According to Dudde et al. (1979) 25% moisture depletion resulted in highest concentration of nitrogen and phosphorus at all physiological stages of plant growth.

B. Phosphorus

(1) Effect of phosphorus on growth characters

Goldin and Har-tzook (1966) reported that nitrogen and phosphorus increased total plant weight and the number of leaflets per plant, compared with unfertilised groundnuts. Significant increase in number of branches at higher levels of phosphorus was reported by Puntankar and Bathkal (1967).

Jayadevan (1970) and Muraleedharan (1971) at Vellayani recorded increased height of plants by the application of higher levels of phosphorus. Application of higher doses of phosphorus increased the number of branches in groundnut (Dholaria and Joshi, 1972). Numerical increase at 30th day and 60th day and significant increase at harvest in shoot height was observed by the application of higher levels of phosphorus during _kharif_ season (Anon., 1975a). But the number of branches, dry weight of shoot and root per plant and haulm yield were not significantly influenced by phosphorus application.

Khan (1977) reported that application of nitrogen and phosphorus singly and in combination, yielded higher amount of dry matter by the different plant parts over the unfertilized control. Of the 4 levels of phosphorus (0, 50, 100 and 150 kg P_2O_5/ha) tried, 100 kg P_2O_5/ha had produced the highest number of branches per plant (Anon., 1978b). Nair (1978) reported that phosphorus application at the rate of 100 kg P_2O_5/ha increased the height of plants, number of leaves per plant and haulm yield. But he could not observe any significant difference in the number of branches per plant due to phosphorus application. Yayock (1979) observed significant increase in haulm yield by the application of phosphorus.

Shelke and Khupse (1980) observed significant increase in total dry matter per plant with 17.46 kg P/ha over the control.

(2) Effect of phosphorus on nodulation

Verma and Bajpai (1964), in a review on mineral nutrition, concluded that nodulation was completely checked by absence of phosphorus. Khare and Rai (1968) reported that phosphorus plays a remarkable role in symbiotic fixation of nitrogen because in all cases phosphorus treated soil had shown a significant difference in the nitrogen per cent. According to Puri (1969) phosphorus increases the activity of nodular bacteria which fix nitrogen in the soil. Nair et al. (1971) observed that soils showing better crop growth and nodulation contained significantly higher per cent of available phosphorus. Muthuswamy (1973) reported that among the three levels of phosphorus tried 30 kg P_2O_5/ha was superior in producing maximum number of nodules per plant. Deshpande (1974) reported that phosphate fertilization improved nodulation. Punnoose and George (1975) also observed that applied phosphorus increased the mean number and dry weight of nodules at 2,4 and 6 weeks after sowing. Jayadevan and Sreedharan (1975b) observed that number and weight of root nodules were significantly increased by phosphorus at all levels tried and at all stages of growth of crop. Nair (1978) also observed significant increases in the weight of root nodules per plant by higher levels of phosphorus on 30th, 60th and 90th day after sowing. Shelke and Khupse (1980) observed a significant increase in nodule number due to phosphorus application.

(3) Effect of phosphorus on yield and yield attributes

Phosphorus increased the number of flowers and pods per plant besides increasing the yield of pods per hectare and the shelling percentage (Sathyanarayana and Rao, 1962). Favourable effects of phosphate application in increasing the yield of pods were also reported by Pathak and Verma (1964). Katarki and Bahahatti (1965) reported that superphosphate at 50 and 100 lb P_2O_5/acre produced significant increases in pod yield over control. Reddy and Rao (1965) reported that phosphorus at 20 lb P_2O_5/acre only produced yield increases. An experiment with 0, 33.6 and 67.2 kg P_2O_5/ha under lateritic soil conditions in West Bengal showed that high yield was associated with higher doses of phosphorus (Banerjee et al., 1967). According to Dalal et al. (1967) application of 11.5 kg P_2O_5/acre increased the average pod yield by 33% in sandy loam soils. Phosphorus at this rate also increased the weight and number of pods per plant. Significant response of groundnut to phosphorus application at the rate of 80 kg P_2O_5/ha was reported from Andhra Pradesh (Kulkarni et al., 1967). Similar increases in yield of groundnut by phosphate fertilization was also reported by Puntamkar and Bathkal (1967).

Naidu (1968) reported increased yields by the application of 30 kg P_2O_5/acre in the black soils of Andhra Pradesh and higher rates of phosphorus did not show further increase in yield.

Application of 44.8 kg P_2O_5/ha gave significantly higher yield than no P_2O_5 and 22.4 kg P_2O_5 in the sandy loam soils of Maharashtra (Patil, 1968).

Phaniahai et al. (1969) reported that groundnut showed response in pod yield to 33.6 P_2O_5/ha in red loam soils under rainfed conditions. Puri (1969) observed phosphorus as the limiting factor in groundnut yield, the deficiency of which reduces flower production and affect the size of pods.

Singh and Pathak (1969) studied the effect of phosphorus application in light to medium black soils mixed with red and reported significantly higher yield by the application of phosphorus at 22.5 kg P_2O_5/ha over no phosphorus. Bhan and Misra (1970) recommended 30 kg P_2O_5/ha as the optimum fertilizer rate for groundnut.

Kumar and Venkatachari (1971) reported highest pod yield and improvement in shelling per cent by the application of 90 kg P_2O_5/ha. Muraleedharan (1971), in red loam soils of Vellayani, found that phosphorus at the rate of 75 kg P_2O_5/ha significantly increased the number of pods per plant, weight of mature pods per plant, yield of pods per hectare and shelling per cent. The percentage of pegs developed into mature pods significantly decreased with higher levels of phosphorus. Pande et al. (1971), in sandy loam soil, concluded that higher levels of phosphorus (40 kg P_2O_5/ha) tended to increase pod yield. Singh et al. (1971) could not observe any significant difference in pod yield or on shelling per cent due to the application of 15 to 60 kg P_2O_5/ha. Tripathi and Moolani (1971) reported linear increase in pod yield with increase in the rate of applied P_2O_5 from 0 to 50 kg/ha and further increases in the rate of applied phosphorus did not increase yield.

Simple fertiliser trials on farmers' field in India showed significant influence of phosphorus on the yield of groundnut at levels upto 80 kg P_2O_5/ha (Mahapatra et al., 1973).

Muhammed et al. (1973) reported that TMV-2 variety of groundnut responded best to 22.46 kg P_2O_5/ha as rainfed crop and 33.69 kg P_2O_5/ha as irrigated crop whereas TMV 7 variety of groundnut responded to 44.92 kg P_2O_5/ha as rainfed crop and even beyond 56.15 kg P_2O_5/ha as irrigated crop, when these crops were supplied with optimum levels of nitrogen and potassium.

Reddy et al. (1973) observed increased yield of groundnut pods by the application of 60 kg P_2O_5/ha as soil application. Shelling per cent, 100-kernel weight and weight of pods per unit volume were higher in fertilised plots.

Dahatonde and Rohate (1974) observed that soil application of 20 kg P_2O_5/ha to groundnut significantly increased number and weight of pods per plant and yield of unshelled nuts.

Punnoose and George (1974) observed that increasing phosphorus from nil to 75 kg P_2O_5/ha increased groundnut yields.

Jayadevan and Sreedharan (1975a) reported significant increase in 100-seed weight, test weight and shelling percentage with phosphorus application upto 100 kg P_2O_5/ha and the highest pod yield was obtained with 20 kg nitrogen and 75 kg P_2O_5/ha. Patil et al. (1976) observed highest yield of pods by the application of 80 kg P_2O_5/ha when applied in combination with 40 kg nitrogen.

Cheema et al. (1977) reported that phosphorus application upto 80 kg P_2O_5/ha when applied along with 40 kg N/ha on a loamy sand, could not increase pod yield and yield attributes. But Choudhary (1977) observed increased yield in TMV-2 by the application of 60 kg P_2O_5/ha than with 30 kg P_2O_5/ha. According to Gopalaswamy et al. (1977), application of 0 to 90 kg P_2O_5/ha in a sandy loam soil could not produce significant effect on pod yield which was possibly due to the medium status of P_2O_5 in the soil. Kulkarni et al. (1977) recommended optimum dose of phosphorus as 40 kg P_2O_5/ha for Bijapur district which increased yield by 49.54% when applied in combination with 40 kg N.

Mishra (1977) observed that application of 90 kg P_2O_5/ha gave the highest pod yield and increased the shelling percentage. Of the three levels of phosphorus (0, 21.8 and 43.6 kg P_2O_5/ha) tried by Narasimhan et al. (1977) application of 21.8 kg P_2O_5/ha recorded the highest pod yield, but shelling percentage was little affected. According to Raju (1977) application of 40 kg P_2O_5/ha gave the highest pod yield in TMV-2 when 0 to 80 kg P_2O_5/ha were tried. In a trial conducted using phosphorus levels ranging from 0 to 80 kg P_2O_5/ha, the highest pod yield and net profit were obtained with the application of 40 kg P_2O_5/ha in combination with 20 kg N (Rao, 1977).

Reddy et al. (1977) recommended 40 kg P_2O_5/ha in combination with 30 kg each of N and K_2O/ha for optimum yield.

Significantly higher pod yield was obtained in Dharwad by the application of 100 kg P_2O_5/ha when compared to 50 kg and no phosphorus but a further increase to 150 kg P_2O_5/ha reduced the yield (Anon., 1978b). It was also observed that the highest pod weight per plant and number of developed pods per plant were obtained at this level.

Nair (1978) reported that higher levels of phosphorus increased the number of pegs formed per plant, number of mature pods per plant, weight of mature pods per plant, yield of pods, 100 pod weight and 100 kernel weight. The maximum yield was obtained by 100 kg P_2O_5/ha but it was on par with the yield of 75 kg P_2O_5/ha. He further observed a decrease in the number of days taken for flowering and the percentage of pegs developed to mature pods at this level. The optimum and economic levels of phosphorus observed by him were 94 and 90 kg P_2O_5/ha respectively. Pawar and Khupse (1978) predicted the maximum yield of pods to be 19.16 q/ha at the level of 126 kg P_2O_5/ha in combination with 23 kg N and fixed the economic optimum dose at 57 kg P_2O_5/ha in combination with 25 kg N/ha.

From an experiment conducted at Bhavanisagar, it was observed that application of phosphorus (0 to 40 kg P_2O_5/ha) had no significant effect on the mean number of mature pods per plant and pod yield (Anon., 1979a). Out of the 4 levels of phosphorus tried from 0 to 90 kg P_2O_5/ha at Hyderabad, 60 kg P_2O_5/ha produced the maximum yield though it was not statistically significant (Anon., 1979b). The economic optimum dose of phosphorus for irrigated groundnut in medium black soil was 54 kg P_2O_5/ha (Birajdar and Ingle, 1979).

Patil et al. (1979) reported that increased pod yields were obtained in black clay soil with the application of 40 kg P_2O_5/ha over no phosphorus application and with further increase in phosphorus level to 80 kg P_2O_5/ha the yield was reduced. This increased yield was mainly due to the increased number of flowers and pods per plant, pod weight per plant and 100-kernel weight. Phosphorus levels had no significant effects on shelling percentage. Roy and

Kanwar (1979) reported that there was significant responce to phosphorus which was evidenced by the results of 435 trials conducted on cultivators' fields. Singh and Rana (1979) have concluded that the critical value for available phosphorus was 16.6 kg/ha.

In sandy loam to loamy soils of Dapoli, 60 kg P_2O_5/ha produced significantly higher pod yields than that obtained with 0 to 40 kg P_2O_5/ha (Anon., 1980a). An experiment conducted at Bhavanisagar indicated that application of 40 kg P_2O_5/ha yielded significantly higher than no phosphorus control and was on par with 20 and 30 kg P_2O_5/ha (Anon., 1980b). Experiments conducted under AICARP scheme revealed the response of groundnut to fertilizer application and a phosphorus dose of 60 kg P_2O_5/ha for deep black, mixed red and black soils, medium black and red and lateritic soils and 40 kg P_2O_5/ha for red sandy soils were recommended as remunerative (Kulkarni, 1980).

According to Shelke and Khupse (1980) highest dry pod yield was observed by the application of phosphorus at the rate of 17.46 kg P/ha. Number of developed pods per plant and 1000 kernel weight also showed the same trend.

4. Effect of phosphorus on quality of kernel

(a) Protein

Nijhawan (1962) reported that the effect of application of phosphorus alone or in combination with nitrogen on the protein content of seed was not consistent. He also observed that the composition of seed with respect to protein content, as affected by fertilizers, is related with nutrient status of the soil and the yield response obtained by application of fertilizers. Kumar and Venkatachari (1971) reported increase in protein content by the application of 90 kg P_2O_5/ha (30.81%) as against 30 kg P_2O_5/ha (28.93%). An increase in protein content of kernel by the application of 67.2 kg P_2O_5/ha was also reported by Bhuiya and Chowdhury (1974). Punnoose and George (1974) also observed increased seed protein content with increasing rates of nitrogen and phosphorus. Chesney (1975) did not observe any increase in protein content by the application of increasing rates of phosphorus. Jayadevan and Sreedharan (1975b) reported that protein content was significantly increased by the application of phosphorus and nitrogen and the maximum protein content of 30.7% was recorded by 10 kg nitrogen and 100 kg P_2O_5/ha. According to Dimitrov and Georgiev (1976), phosphorus alone had no effect on protein content but when applied in combination with nitrogen it increased seed protein content. Nair (1978) reported an increase in protein content by increasing phosphorus application to 100 kg P_2O_5/ha. Patil et al. (1979) observed linear increases in crude protein content of the seeds with increasing phosphorus rates.

(b) <u>Oil</u>

Nijhawan (1962) reported that application of phosphatic fertiliser alone or in combination with nitrogen had no effect on oil percentage of the seeds and hence the amount of oil produced per acre is directly related to yield only. But Satyanarayana and Rao (1962) observed increased oil content by phosphorus application. Oil content was improved from 46.62% to 49.93% when phosphorus dose was increased from 30 to 90 kg P_2O_5/ha (Kumar and Venkatachari, 1971). Higher levels of phosphorus was found to increase oil content in combination with higher levels of nitrogen and potassium (Pande et al., 1971). According to Singh et al. (1971) and Chesney (1975) application of phosphorus had little effect on seed oil content. But Reddy et al. (1973) and Jayadevan and Sreedharan (1975b) observed increased oil content with increased application of phosphorus. Saini and Sandhu (1973) reported that phosphorus at higher levels helped to increase oil yields but in combination with nitrogen it reduced oil yield. Bhuiya and Chowdhury (1974) observed that oil content of kernal increased with application of 67.2 kg P_2O_5/ha. Increasing applied P_2O_5 from zero to 75 kg P_2O_5/ha increased oil content (Punnoose and George, 1974). According to Saini and Tripathi (1975), oil content improved with increase in phosphorus levels upto 15 kg P_2O_5/ha and beyond that oil content did not improve. Dimitrov and Georgiev (1976) observed that phosphorus alone had no effect on oil content. Mishra (1977) and Perumal et al. (1978) also reported increased seed oil content by the application of phosphorus. Phosphorus application had slight effect on oil content and it increased oil content upto the level of 21.8 kg P/ha but decreased the same at the higher level of 43.6 kg P/ha (Narasimhan et al., 1977). According to Nair (1978) phosphorus had no significant influence on oil content of kernels. Oil content was increased by 4% by the application of 40 kg P_2O_5/ha over no phosphorus (Patil et al., 1979).

5. Effect of phosphorus on nutrient uptake

Puntumkar and Bathkal (1967) reported that application of phosphorus, nitrogen and potassium gave the maximum increase in plant uptake and higher content of nitrogen, phosphorus and potassium. According to Omuoti and Oyenugav (1970), applied phosphorus had increased the seed content of protein, P, K, Ca, Zn, Cl, Co and Mn and decreased those of Fe, Na and Cu in groundnuts and cowpea. Yadav and Singh (1970) observed increased N content of plant and kernel by the application of nitrogen, phosphorus and potassium. P, K, Ca and Mg content in plant and kernel were also increased with the application of 112 kg S, 112 kg P_2O_5 and 28 kg/ha each of nitrogen and potash respectively showed the highest per cent content of minerals in plants.

According to Walker (1975) percentage of nitrogen contents of leaves, stems, roots, hulls and seeds of spanish and runner groundnut, were unaffected by rates of phosphorus.

Potassium content and leaf Ca content were also unaffected by applied phosphorus.

Deshpande (1974) reported that percentage of N, P_2O_5 and K_2O in various plant parts at harvest were not influenced by phosphorus fertilization. Khan (1977) observed a significant increase in content and uptake of phosphorus by the application of increasing rates of phosphorus. According to Georgiev (1977) applied phosphorus slightly increased the rate of P accumulation but promoted more intensive accumulation of N and K in the above ground parts and of K in pods. Rathee and Chahal (1977) observed an increased plant N content by the application of phosphorus.

Nair (1978) reported that the nitrogen and phosphorus contents in haulm, shell and kernel and their total uptake were significantly increased by higher levels of phosphorus. The potassium content of haulm was not significantly influenced by phosphorus levels. He further observed that potassium content in shell and the total uptake by the crops were significantly increased by higher levels of phosphorus. Vali et al. (1978) also observed increased uptake of nitrogen and phosphorus with increase in nitrogen and phosphorus fertilization. They also observed that the uptake of P at pod formation stage was lower than at peg formation. Dudde et al. (1979) reported highest concentration of nitrogen and phosphorus at all physiological stages of plant growth by the application of 60 kg P/ha.

C. Potassium

1. Effect of potassium on growth characters

Brady and Colwell (1945) reported that on soils of extremely low potash content, the use of potash brought about a marked vegetative response in peanuts. Middleton et al. (1945) observed that addition of potassium resulted in increased yields through its effect on plant size. Gopalakrishnan and Nagarajan (1958) observed stunted growth due to potassium deficiency. Reid and York (1958) also reported great reduction in plant growth and dry weight of above ground portion due to the deficiency of potassium. According to Comber (1959), 200 lb/acre of potassium chloride can enhance hay yield by 30%.

Nabeebullah (1973) observed no significant increase in haulm yield by the application of potassium. Nair (1978) reported a significant increase in the height of plants due to the application of 50 kg K_2O/ha. But the number of branches and number of leaves were not significantly influenced. He further observed a significant increase in haulm yield due to potassium application upto 75 kg K_2O/ha. Rao (1979) observed no increase in the number of branches per plant due to increasing levels of potassium but the dry matter production was increased, with increase in levels of potassium.

2. Effect of potassium on nodulation and nitrogen fixation

Sreedharan and George (1969) reported a significant increase in the number of nodules produced per plant with increasing rates of potash. The total potassium content in soil had not significantly influenced nodulation in groundnut (Nair et al., 1971). According to Muthuswamy (1973), the number of nodules produced per plant was higher in treatments receiving 45 kg K/ha compared to that of 0 kg and 90 kg K/ha. But Deshpande (1974) found that potash fertilization was not effective for nodulation. According to Nair (1978) potassium application had not significantly influenced the nodule weight at various growth stages. Levels of potassium did not influence the number of nodules in rabi but increased it in kharif (Rao, 1979).

3. Effect of potassium on yield and yield attributes

After reviewing several experiments, Panikkar (1961) concluded that the highest net income obtained with application of 25 lb K_2O/acre was most economical. According to Sathyanarayana and Rao (1962) application of 20 lb K/acre in combination with 20 lb each of nitrogen and P_2O_5 had increased the number of flowers, number of pods and shelling percent.

Potassium application had no effect on true shelling percentage and the relative yield of first quality seeds but in two soils of coastal region potassium significantly increased 1000-pod weight and 1000-seed weight (Lachover and Arnon., 1964). After reviewing works on mineral nutrition of groundnut Verma and Bajpai (1964) concluded that soils deficient in potassium seldom failed to respond to potassium fertilization. An experiment conducted in the red loam soils of Kerala showed that the weight of pods per plant and the yield of pods per ha were significantly increased with higher levels of potassium (Veeraraghavan, 1964). Banerjee et al. (1967) obtained significant increase in yield by the application of 44.8 kg K_2O/ha, compared to no potash control. Sreedharan and George (1968) reported an yield increase of 38% by the application of 50 kg K_2O/ha over no potash control. Shelling per cent was also significantly increased by potassium application. There was no difference in yield between the treatments receiving 100 and 143 kg K_2O/ha but the application of 177 kg K_2O/ha had considerably increased the yield of groundnut pods (Chesney and Diyaljee, 1969). Phanishai et al. (1969) reported that groundnut showed response in pod yield to 16.8 kg K_2O/ha but a further increase to 33.6 kg K_2O/ha decreased the yield. According to Singh and Pathak (1969) application of 22.5 kg K_2O/ha yielded much more than no fertilizer.

The results of trials conducted in cultivators' fields under All India Co-ordinated Agronomic Experiment Scheme revealed that groundnut responded to potassium application at 30 kg K_2O/ha in deep black soil, mixed red and black soils and red and yellow soil and 60 kg K_2O/ha in red soil and coastal alluvial soil (Prasad and Mahapatra, 1970). According to Raheja et al. (1970) significant responses of various oil seeds including groundnut to potash application were observed in a number of regions but they were generally low to moderate. Higher levels of potassium (40 kg K_2O/ha) tended to increase pod yields (Pando et al., 1971). In a two year experiment, Roy and Chatterjee (1972) observed significant increase in groundnut yield during the first year only.

Mahapatra et al. (1973) reported a significant but low order of response to potash fertilization in groundnut which was quite distinct in soils where the available potassium status was medium. According to Muhammad et al. (1973), best response to groundnut variety TMV-2 was obtained by the application of 33.69 kg K_2O/ha in combination with 11.23 kg N and 22.46 kg P_2O_5 under rainfed conditions and 50.54 kg K_2O/ha in combination with 16.85 kg N and 33.69 kg P_2O_5/ha under irrigated conditions. But rainfed crop of TMV-7 responded best to 67.38 kg K_2O/ha in combination with 22.46 kg N and 44.92 kg P_2O_5/ha whereas under irrigation, the general response seemed to be linear indicating scope for further increase beyond the highest dose of 84.23 kg K_2O/ha in combination with 28.08 kg N and 56.15 kg P_2O_5/ha.

According to Deshpande (1974), shelling per cent and 1000-kernal weight were improved by potash fertilization but not yield. A consistently significant increase in pod yield was noted by Jayachandran et al. (1975) due to potash application and the optimum dose was found to be 46 kg K_2O/ha. According to Gopalaswamy et al. (1976), there was significant difference in pod yield when the levels of potassium was increased from 0 to 90 kg K_2O/ha and maximum physical production was obtained at the potassium level of 89 kg K_2O/ha. But the most profitable level of production was at 74.6 kg K_2O/ha.

Choudhary (1977) reported that groundnut crop showed no response to the application of 20 to 40 kg K_2O/ha. Gopalaswamy et al. (1977) computed the economic optimum dose of potassium to be 45.2 kg K_2O/ha while the cost of input and outprice was at 1:1 ratio. Reddy et al. (1977) observed significant increases in pod yield by the application of potash upto 80 kg K_2O/ha in sandy loam soils. The yield maximisation level was found to be 100.2 kg K_2O/ha and the profit maximisation level was 70.7 kg K_2O/ha.

Gopalaswamy et al. (1978) reported that significantly higher pod yield was recorded by irrigated groundnut receiving 60 kg K_2O/ha compared to 0 and 30 kg K_2O/ha and was on par with 90 kg K_2O/ha. The reason for lower yield by 90 kg K_2O/ha was attributed to the reduction in 100-kernel weight. The maximum physical production was obtained at the potash level of 80.5 kg K_2O/ha and most profitable level of production was 77.2 kg K_2O/ha. Gustein (1978) observed an improvement in pod yield, harvest index and seed quality by potash application. Nair (1978) reported an increase in pod yield by the application of potassium upto 75 kg K_2O/ha. He further observed a significant increase in the number of pegs per plant, number of mature pods per plant, weight of mature pods per plant, 100 pod weight and 100 kernal weight due to potassium application. Shelling percentage was not affected by levels of potassium but a significant decrease in the percentage of pegs developed to mature pods was observed.

The results of 435 trials conducted in the groundnut growing states in India revealed that an addition of 20 kg K/ha with 30 kg N and 40 kg P/ha improved the response considerably (Roy and Kanwar, 1979). Rao (1979) reported a significant increase in pod yield over control with the application of 40 and 80 kg K_2O/ha. Number of filled pods and shelling per cent were also increased with higher levels of potassium. The results of experiments conducted in 15 districts indicated that 30 kg K_2O/ha for red sandy and red and laterite soils and 40 kg K_2O/ha for medium black soils were remunerative in groundnut cultivation (Kulkarni, 1980).

4. Effect of potassium on quality of kernel

(a) Protein

Cheeney (1975) reported that protein content of kernal was not influenced by levels of potassium. Nair (1978) reported the highest protein content of 26.99 per cent was obtained by the application of 25 kg K_2O/ha.

(b) Oil

Satyanarayana and Rao (1962) observed an increase in oil content with increase in potash levels. According to Lachover and Arnon (1964) potassium application had no effect on the oil content of first quality seeds. After reviewing works on mineral nutrition of groundnut, Verma and Bajpai (1964) observed that potassium in general appears to increase oil content of kernels.

Pande et al. (1971) also reported increased oil content in kernels with higher levels of nitrogen, phosphorus and potassium than their respective lower levels. Potash manuring increased oil content of kernels in groundnut and safflower (Roy and Chatterjee, 1972). Habeebullah (1973) observed only a little increase in oil content by potassium manuring.

Chesney (1975) reported that seed oil content was unaffected by potassium application. Nair (1978) reported a significant effect on oil content of kernel due to potassium application. Narasimhan and Surendran (1978) also made a similar observation.

5. Effect of potassium on chemical composition and nutrient uptake.

Lachover and Arnon (1964) reported, on 4 different soils, that potassium application significantly increased the K content of leaves, stems and roots but did not significantly increase the K content of pods. Nakagawa et al. (1966) found that the application of potassium increased the contents of P, K and Ca in the leaves; it increased the content of N in the absence of Ca, but reduced it in its presence. Puntamkar and Bathkal (1967) observed maximum increase in plant uptake and higher content of N, P and K by the application of nitrogen, phosphorus and potassium.

According to Walker (1973) percentage of N contents of leaves, stems, roots, hulls and seeds of spanish and runner groundnut were unaffected by rates of potassium. He also observed that increasing rates of potassium increased K levels in leaves, stems and roots but not in seeds and hulls. Deshpande (1974) reported that the percentage of N, P_2O_5 and K_2O in various plant parts at harvest were not influenced by potassium fertilization.

According to Habeebullah et al. (1977) potassium application did not significantly influence N content of both haulm and kernels but an indication of maximum level of potassium increasing N content of haulm in the absence of application of calcium to soil was observed. Potassium application in general recorded higher P content in haulm. They also observed that levels of potassium influenced K content in haulm and kernal when compared to no potassium.

Nair (1978) reported a significant difference in nitrogen content of haulm, shell and kernal due to different levels of potash application. N content of shell and kernal was significantly decreased by higher levels of potassium. He also observed a significant increase in the phosphorus and potassium content of shell and kernal due to the increasing levels of potassium. Higher levels of potassium had no effect on P content of haulm but had significantly increased K content of haulm. He further observed a significant increase in the nitrogen, phosphorus and potassium uptake by the application of higher levels of potassium.

The favourable influence of the application of higher dose of potash, as basal dose, in increasing the uptake of nitrogen and potassium was clearly noted by Narasimhan and Surendran (1978). Rao (1979) also reported increased uptake of potassium by potassium application.

Effect of irrigation, phosphorus and potash on soil fertility status

Baine (1967) observed from field and glass house experiments on field bean that under glass house condition soil test values for available P_2O_5 and available K_2O were affected by the application of respective fertilizer element particularly at higher levels of applied phosphate and potash which indicated build up of available nutrient in the soil.

In a field trial, Sahu and Behera (1972) reported that phosphate manuring of cowpea, groundnut and green gram at 22.4 kg P_2O_5/ha resulted in 58, 29 and 26 per cent increase in soil nitrogen content respectively.

According to Sharma and Yadav (1976), the available phosphorus content of the soil, in general, increased with the addition of phosphorus and increase in the level of irrigation.

Shanmugasundaram et al. (1979) revealed that, in general, available potassium content was low when irrigations were given frequently whereas the same was markedly high in respect of irrigations given at longer intervals.

A study conducted at Bhavanisagar indicated that different levels of irrigation did not influence the available phosphorus status of the soil whereas the graded doses of phosphorus resulted in gradual and significant increase in the available phosphorus status of the soil (Anon, 1980b).

MATERIALS AND METHODS

MATERIALS AND METHODS

An investigation to study the response of groundnut to phosphorus and potassium under different water management practices was undertaken in the summer rice fallow, in a statistically laid out field experiment.

The materials used and methods adopted are detailed below.

Materials

Experimental site

The experiment was carried out in the farm of the Agronomic Research Station, Chalakudy, Trichur District, under the Kerala Agricultural University. The station is situated at 10° 20' North and 76° 20' East, at an altitude of 3.25 m above mean sea level.

Soil

The soil of the experimental area is sandy loam in nature. The chemical and physical characteristics of the soil before starting the experiment is presented in Table 1.

Season

The experiment was conducted during the summer season (January-April) of 1979-80.

Climatic conditions

The weekly averages of temperature, evaporation, relative humidity and the weekly total of rainfall during the cropping period and during the previous four years, collected from the meteorological observatory attached to the farm are presented in Figure 1 and Appendix I.

The weather conditions during the crop period was normal when compared to that during the previous four years. The variation in maximum temperature during the crop period, from the average, had ranged between -0.54°C to +1.03°C and that of minimum temperature from -2.56°C to +1.08°C. The variation in rainfall was within -17.92 mm and +15.43 mm, which occurred mostly during the later stages of crop growth. The variation in relative humidity ranged between -2.80% to +5.30% except during the 3rd and 9th meteorological week when the variation was +12.54% and +11.37% respectively. Mean evaporation varied between -0.30 mm and +0.92 mm from the average data. From this, it can be inferred that the variation in meteorological parameters during the crop period, with that during the previous four years, was negligible and hence the crop period was normal when considering weather conditions.

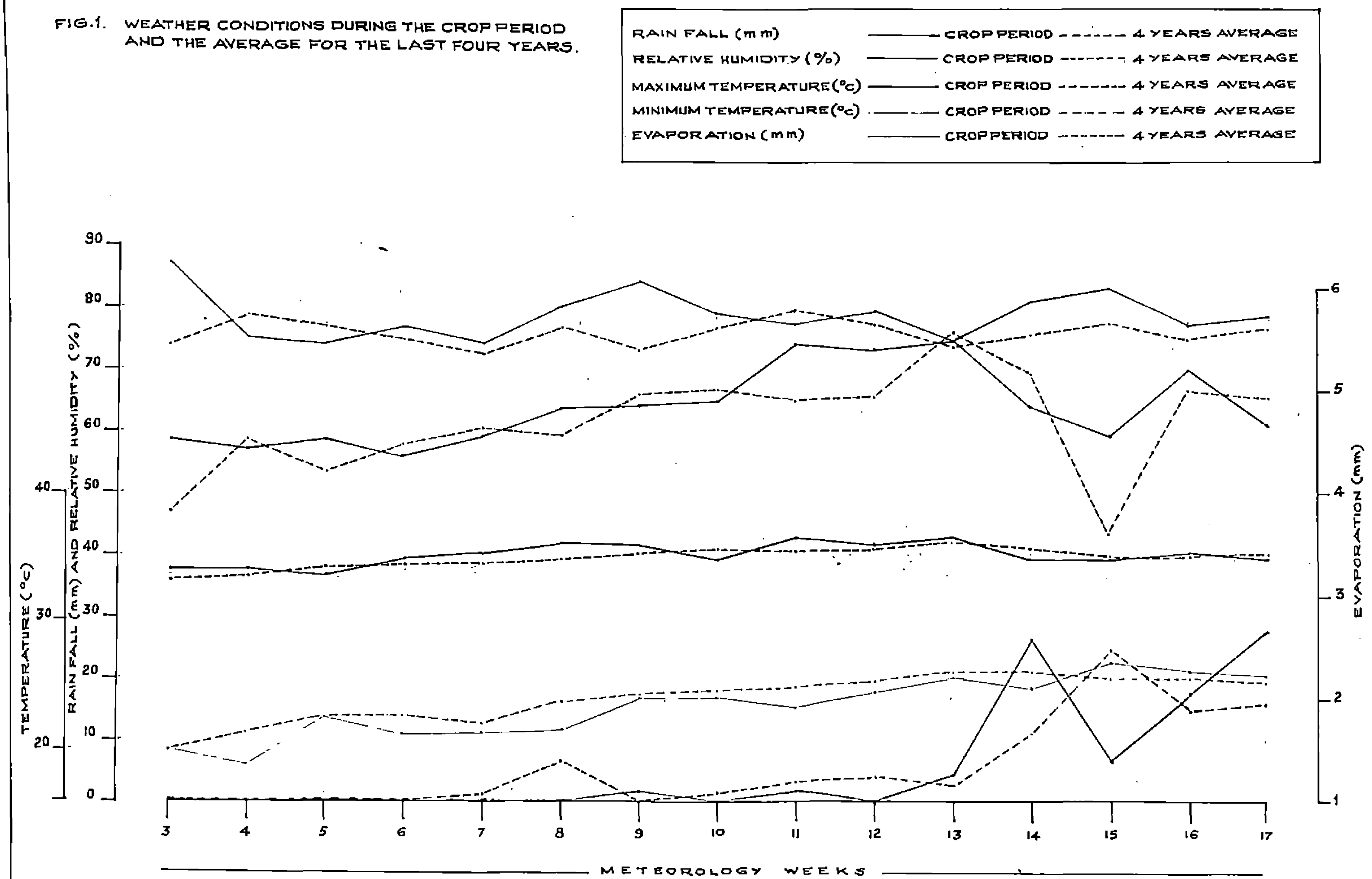
Cropping history of the field

The experimental site was under bulk crop of paddy during the first and second crop season of 1979-80.

Variety

The variety TMV-2 was selected for the trial. This is a bunch variety with no seed dormancy and maturesin about 105 days. The pods are small and one to two seeded. It is

FIG.1. WEATHER CONDITIONS DURING THE CROP PERIOD AND THE AVERAGE FOR THE LAST FOUR YEARS.



grown as both rainfed and irrigated crop.

Seed materials

The seed materials for the experiment was obtained from Integrated Seed Development Farm, Eruthempathy, Kerala State.

Manures and fertilizers

Cattle manure analysing 41 per cent moisture, 0.56 per cent total N, 0.32 per cent total P and 0.43 per cent total K was used. Urea (46 per cent N), superphosphate (16 per cent P_2O_5) and Muriate of potash (60 per cent K_2O) were used as the sources of nitrogen, phosphorus and potassium respectively.

Methods

Treatments

1. Irrigation schedules

I_0	-	Irrigation at 0.3 IW/CPE ratio
I_1	-	Irrigation at 0.6 IW/CPE ratio
I_2	-	Irrigation at 0.9 IW/CPE ratio

The irrigation schedules were based on IW/CPE ratio where IW = Irrigation water in mm and CPE = cumulative pan evaporation in mm. IW was fixed at 50 mm.

2. Phosphorus levels

P_0	-	25 kg P_2O_5/ha
P_1	-	50 "
P_2	-	75 "

3. Potassium levels

K_0 - 25 kg K_2O/ha

K_1 - 50 "

K_2 - 75 "

Treatment combinations

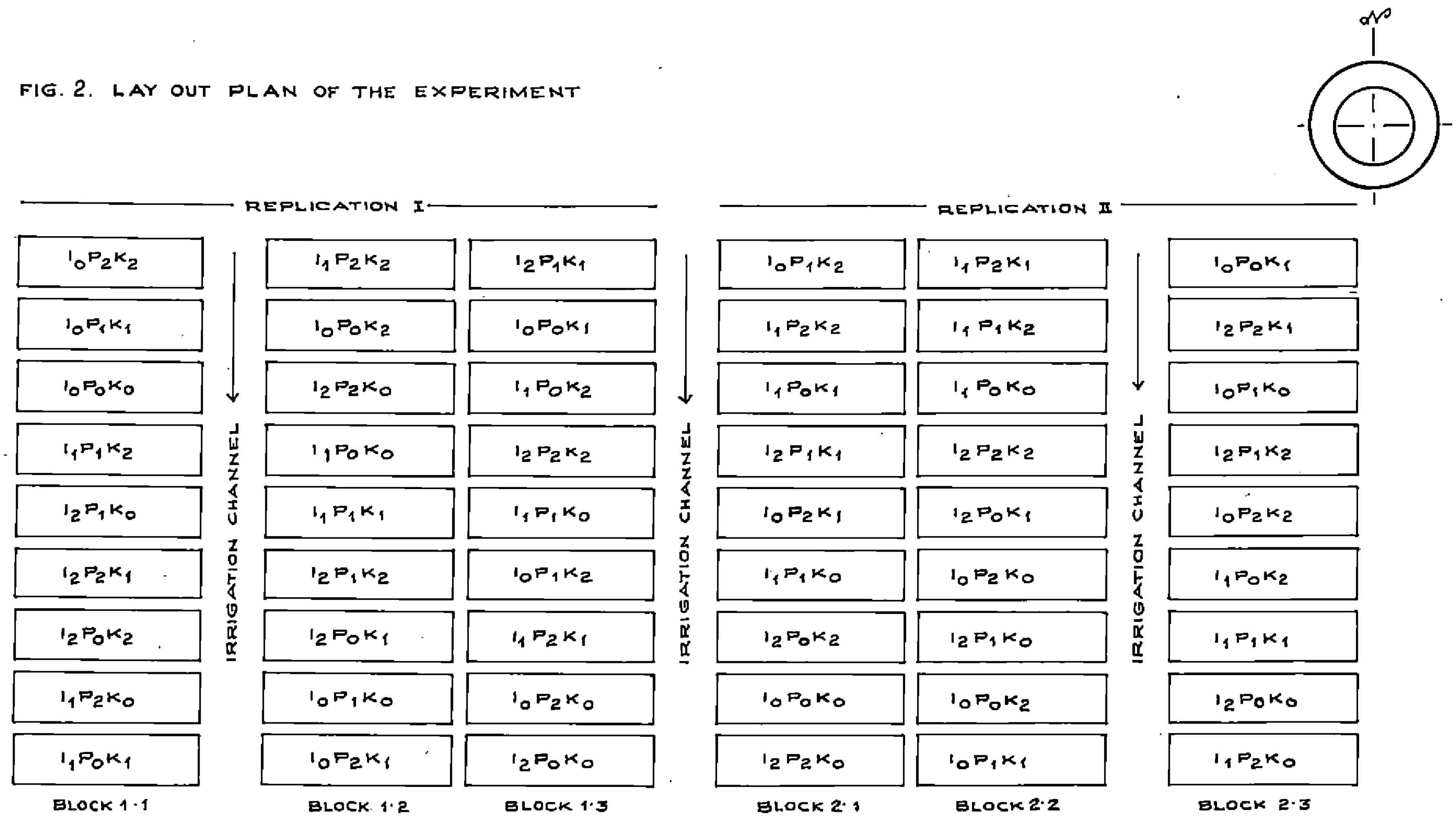
1.	$I_0P_0K_0$	10.	$I_1P_0K_0$	19.	$I_2P_0K_0$
2.	$I_0P_0K_1$	11.	$I_1P_0K_1$	20.	$I_2P_0K_1$
3.	$I_0P_0K_2$	12.	$I_1P_0K_2$	21.	$I_2P_0K_2$
4.	$I_0P_1K_0$	13.	$I_1P_1K_0$	22.	$I_2P_1K_0$
5.	$I_0P_1K_1$	14.	$I_1P_1K_1$	23.	$I_2P_1K_1$
6.	$I_0P_1K_2$	15.	$I_1P_1K_2$	24.	$I_2P_1K_2$
7.	$I_0P_2K_0$	16.	$I_1P_2K_0$	25.	$I_2P_2K_0$
8.	$I_0P_2K_1$	17.	$I_1P_2K_1$	26.	$I_2P_2K_1$
9.	$I_0P_2K_2$	18.	$I_1P_2K_2$	27.	$I_2P_2K_2$

Layout and design

This experiment was laid out in partially confounded factorial experiment in R.B.D. confounding IPK^2 in replication I and IP^2K^2 in replication II. The layout of the experiment is presented in Fig.II.

Number of replications:	2
Number of treatment combinations:	27
Total number of plots:	54

FIG. 2. LAY OUT PLAN OF THE EXPERIMENT



3^3 CONFOUNDED FACTORIAL EXPERIMENT GROSS PLOT SIZE 6m. x 2·75m.

TREATMENTS.

LEVELS OF IRRIGATION	LEVELS OF PHOSPHORUS	LEVELS OF POTASSIUM
I_0 - 0·3 IW/CPE RATIO	P_0 - 25 kg P_2O_5/ha.	K_0 - 25 kg K_2O/ha.
I_1 - 0·6 IW/CPE RATIO	P_1 - 50 kg P_2O_5/ha.	K_1 - 50 kg K_2O/ha.
I_2 - 0·9 IW/CPE RATIO	P_2 - 75 kg P_2O_5/ha.	K_2 - 75 kg K_2O/ha.

Spacing: 25cm x 15cm ~~15cm x 25 cm~~

Gross plot size: 6 m x 2.75 m

Net plot size: 4.80 m x 1.75 m

Border rows:

Two rows of plants were left as border rows all around the plot. Two additional rows were left as destructive rows along the width of the plot to facilitate periodical removal of sample plants from the field. Two more border rows were also left after the destructive rows.

1. Field culture

The experimental area was thoroughly ploughed once with power tiller. Then the field was laid out into six blocks each with nine plots. The allotment of treatments to various plots was done as per the design. Buffer area with 50 cm width was left all around the experimental plots to prevent the seepage of moisture to one plot, from the neighbouring plots and/or from the irrigation channels, to the maximum extent possible.

2. Fertilizer application

Cattle manure at the rate of 2 t/ha was given uniformly to all plots as basal dressing. A uniform dose of nitrogen at the rate of 10 kg/ha was given in all plots as basal dressing in addition to cattle manure. Differential doses of phosphorus and potassium were applied fully as basal in accordance with the various treatments. Lime at the rate of

1000 kg per hectare was applied at the time of flowering and mixed with soil by light hoeing and earthing up as per recommendations of Package of Practices, Kerala Agricultural University (Anon., 1978).

3. Seeds and sowing

The seeds were inoculated with rhizobium and were dibbled at the rate of two seeds per hole at a depth of 4 to 5 cm on 17-1-1980. Thinning and gap filling were done on the seventh day after sowing to secure a uniform stand of the crop.

4. After cultivation

The first intercultivation was done fifteen days after sowing by hand weeding. The second intercultivation which includes light hoeing and earthing up was done along with liming fifteen days after the first interculture.

5. Irrigation

Canal water with good quality was used for irrigation. The quality of the irrigation water is presented in Table 2.

One pre-sowing irrigation (50 mm) was given uniformly to all plots one the day before sowing.

The evaporation readings were recorded daily using USWB Class A pan evaporimeter and whenever cumulative pan evaporation minus rainfall reached 166.67 mm, 83.33 mm or 55.56 mm, differential irrigations were administered at a depth of 50 mm (825 litres) to I_0, I_1 and I_2 treatments respectively. The water was measured by using a circular

Table 1. Physical properties and chemical characteristics of the soil of the experimental area.

A. Physical properties	
1. Mechanical composition	
Coarse sand (%)	60.5
Fine sand (%)	16.1
Silt (%)	8.9
Clay (%)	12.7
2. Bulk density (g/cc)	1.46
3. Field capacity (%)	16.7
B. Chemical characteristics	
Total nitrogen (%)	0.0336
Available P_2O_5 (kg/ha)	12.47
Available K_2O (kg/ha)	41.53
Organic carbon (%)	0.4
pH	5.4

Table 2. Quality of irrigation water

1. pH	6.4
2. EC (micromhos/cm)	40.2
3. Bicarbonate (meq./litre)	1.0
4. Chloride (meq./litre)	0.36
5. Carbonate (meq./litre)	Traces

orifice plate.

The details of irrigations given are presented in Table 3.

6. Plant protection

Insecticides and fungicides were sprayed as and when required.

7. Harvesting

Harvesting was done on 25-4-80. After removing the observation plants and border rows the plants were hand pulled plotwise and removed to threshing yard. The pods were hand picked and the weight of the pods and haulm were recorded after sundrying.

Observations recorded

The characters studied and the observations recorded are detailed below.

A. Biometric observations

(1) Height of plants

Eight plants from each plot were selected at random and tagged. The height of the plants from the ground level to the tip of the top most leaf was measured in cm at three stages viz., 30th and 60th day after sowing and at harvest. The mean height per plant was worked out and recorded.

(2) Number of primary branches per plant

The number of primary branches on each of the eight observation plants were recorded and the average number per plant was worked out.

Table 3. Details of irrigations given.

Serial number of irrigation	Irrigation schedules (IW/CPE) 0.3	0.6	0.9
1*	16-1-80	16-1-80	16-1-80
2	22-2-80	3-2-80	28-1-80
3	26-3-80	22-2-80	9-2-80
4	-	10-3-80	21-2-80
5	-	26-3-80	4-3-80
6	-	-	15-3-80
7	-	-	26-3-80
8	-	-	15-4-80
Total number of irrigations	3	5	8
Quantity of irrigation water applied (mm)	150	250	400
Irrigation water plus rainfall during the crop period (mm)	206.6	306.6	456.6
Irrigation interval (days) excluding rainy period	35	17.5	11.7

*Presowing irrigation

(3) Number of compound leaves per plant

The number of compound leaves of the observation plants were counted at three stages viz., 30th and 60th day after sowing and at harvest and the average number of leaves per plant at each stage was worked out and recorded.

(4) Leaf area index

This observation was recorded at three stages i.e. 30th and 60th day after sowing and at harvest. The leaf area was worked out by using the formula formulated by Saxena et al. (1972). Leaf area measurements were taken in the terminal leaflets of 4th compound leaf of the central shoot.

$$\text{Leaf area per plant} = \text{Length} \times \text{width} \times 0.7659 \times \text{Number of leaflets per plant}$$

$$\text{Leaf area index} = \frac{\text{Leaf area per plant}}{\text{Land area occupied per plant}}$$

(5) Number and weight of root nodules per plant

This was recorded once, at the time of 50% flowering. Three plants were dug out at a uniform depth of approximately 40 cm from the rows especially left for this observation. Roots of the plants were washed free of soil particles. The nodules were removed from the roots and counted and the average number of nodules per plant was recorded. The nodules were then oven dried to a constant weight and the weight of nodules per plant was recorded.

(6) Dry matter production per plant

This observation was recorded at three stages viz., 30th and 60th day after sowing and at harvest. Three plants were removed from the rows left for this purpose and were oven dried at 80°C to a constant weight and the dry matter production in g per plant was then averaged.

(7) Number of pegs per plant

The total number of pegs formed in the observation plants were counted and the average number of pegs formed per plant was calculated.

(8) Number of mature pods per plant

Number of mature pods from the observation plants were taken and the average number was worked out.

(9) Weight of mature pods per plant

The total dry weight of mature pods produced in the observation plants were recorded and the average weight of mature pods per plant was calculated.

(10) Yield of pods per hectare

Pods per plot was collected by plucking. These were labelled and dried in sun for five days. Drying was continued till constant weight was attained. The dry weight of the pods per plot was recorded and the yields of pod per hectare was worked out.

(11) Yield of haulm per hectare

The haulm obtained from each plot after the separation of pods was sundried and the weight was recorded and from which the yield of haulm per hectare was calculated.

(12) Weight of 100-pods

Samples of 100 pods were drawn from each plot and their weight recorded.

(13) Weight of 100 kernels

This was obtained by weighing 100 randomly collected kernels from each plot.

(14) Shelling percentage

Hundred grams of pods were drawn randomly from each plot, decorticated and weight of kernels were recorded and expressed as per cent.

B. Chemical analysis

1. Analysis of plant samples

(1) Nitrogen content of plant parts

The content of nitrogen in the plant samples at 30th and 60th day after sowing and in haulm, kernel and shell at harvest were determined by using microkjeldahl method (Jackson, 1967).

(2) Phosphorus content of plant parts

The phosphorus content in the plant samples ... at 30th and 60th day after sowing and in haulm, kernel and shell at harvest were determined by using triple acid extraction method (Jackson, 1967). The perkin-Elmer UV-Vis micro computer controlled spectrophotometer was used for reading colour intensity developed by Vanadomolybdo phosphoric acid.

(3) Potassium content of plant parts

The content of potassium in the plant samples were determined at 30th and 60th day after sowing and in haulm, kernel and shell at harvest by using triple acid extraction method (Jackson, 1967) and by reading the triple acid extract in an EEL Flame Photometer.

(4) Nitrogen, phosphorus and potassium uptake

The total nitrogen uptake by the crop in kg per hectare at 30th and 60th day after sowing was obtained based on the nitrogen content in the plant samples and the dry matter produced per hectare at the respective stages.

The nitrogen content was multiplied by the respective dry matter yield per hectare of each plant part viz., haulm, kernel and shell at harvest and by adding them the total uptake by the crop at harvest was found out.

Similar procedure, as used for nitrogen uptake, was adopted to work out the phosphorus and potassium uptake at the three stages.

(5) Protein content of kernel

The protein content of kernel was worked out by multiplying nitrogen content with the constant 6.25 (Simpson et al., 1965).

(6) Kernel protein yield

The kernel protein yield was calculated from the protein content and the total dry weight of the kernels and expressed in kg/ha.

(7) Oil content of kernel

The oil content of kernel was estimated by using Soxlet extraction apperatus (Chopra and Kanwar, 1976).

(8) Oil yield

The oil yield was calculated from the oil content and the total dry weight of the kernels and expressed in kg/ha.

(ii) Analysis of irrigation water and soil

The quality of irrigation water and the physical and chemical characteristics of the soil of the experimental area, before the start of the experiment, was carried out using standard analytical procedures.

After the harvest of groundnut, soil samples were removed from the plots under each treatment, from one replication, and analysed for total nitrogen, available phosphorus and available potassium.

(a) Total nitrogen

The total nitrogen content of the soil was determined by using Microkjeldahl method (Jackson, 1967).

(b) Available phosphorus

The available phosphorus was determined by employing the Bray II chlorostannious reduced phospho molybdic acid method using photo electric colorimeter.

(c) Available potassium

The soil was extracted by using neutral ammonium acetate solution and the potassium content was read by EEL flame photometer.

C. Statistical analysis

The data obtained were analysed statistically by employing the methods described by Snedecor and Cochran (1967). The analysis was conducted with the help of a micro 2200 Hindustan computer. Important correlations were also worked out.

RESULTS

RESULTS

RESULTS

The observations recorded were statistically analysed and the abstract of analysis of variance table given in Appendices II to XIII. The mean values are presented in Tables 4 to 20(b).

A. Growth characters

1. Height of plant

The mean height of plants recorded at 30th day and 60th day after sowing and at harvest are presented in Table 4 and their analysis of variance in Appendix II.

The data revealed the significant influence of irrigation on the height of plants at all the three stages of crop growth. I_2 (IW/CPE = 0.9) had recorded the maximum plant height (14.42 cm, 41.98 cm and 47.06 cm at 30th and 60th day after sowing and at harvest respectively) which was significantly superior to I_1 (0.6 ratio) and I_0 (0.3 ratio). I_1 was significantly superior to I_0 at 30th day after sowing and were on par at 60th day after sowing and at harvest.

Levels of phosphorus did not significantly influence plant height at any of the stages. An increasing trend in plant height was noted in the later stages of growth with increasing levels of phosphorus, though the effect was not significant.

Table 4. Mean height of plants (cm) at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	12.05	32.66	38.21
0.6	13.22	34.02	40.23
0.9	14.42	41.98	47.06
F test	Sig.	Sig.	Sig.
P_2O_5 (kg/ha)			
25	13.26	34.82	40.45
50	12.90	36.51	41.98
75	13.53	37.32	43.49
F test	NS	NS	NS
K_2O (kg/ha)			
25	13.26	32.07	37.14
50	13.16	36.48	42.71
75	13.28	40.11	45.60
F test	NS	Sig.	Sig.
C.D. (0.05)	0.964	3.375	3.956

Sig. = Significant

NS = Not significant

Application of incremental doses of potash had significantly increased plant height at 60th day after sowing and at harvest. K_2 (75 kg K_2O/ha) (40.11 cm and 45.68 cm at 60th day after sowing and at harvest respectively) was significantly superior to K_1 (50 kg K_2O/ha) and K_0 (25 kg K_2O/ha) at 60th day after sowing and was superior to K_0 only at harvest. K_1 was significantly superior over K_0 at 60th day after sowing and at harvest.

None of the interactions were found significant.

2. Number of branches

The mean number of branches produced per plant, recorded at 30th and 60th day after sowing and at harvest, are given in Table 5 and their analysis of variance in Appendix II.

Irrigation schedules did not significantly influence the number of branches produced per plant at 30th day after sowing and at harvest. But I_2 had significantly increased the number of branches per plant at 60th day (6.1) over I_1 and I_0 which in turn were on par. Similar trend was also observed at early and late stages.

Phosphorus and potash levels did not significantly influence the number of branches.

None of the interactions were found significant.

3. Number of leaves

The mean number of leaves produced per plant at 30th and 60th day after sowing and at harvest are presented in

Table 5. Mean number of branches per plant at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	3.4	5.7	5.6
0.6	3.5	5.8	5.7
0.9	4.0	6.1	5.9
F test	NS	Sig.	NS
P_2O_5 (kg/ha)			
25	3.8	5.9	5.8
50	3.3	5.8	5.7
75	3.8	5.9	5.8
F test	NS	NS	NS
K_2O (kg/ha)			
25	3.6	5.8	5.7
50	3.6	5.9	5.8
75	3.6	5.8	5.7
F test	NS	NS	NS
C.D.(0.05)	-	0.27	-

Table 6 and their analysis of variance in Appendix III.

Irrigation did not significantly influence leaf production at 30th day after sowing and at harvest, but higher frequencies of irrigation had produced comparatively higher number of leaves. At 60th day after sowing, I_2 had produced significantly higher number of leaves (46.1) over I_1 and I_0 which in turn were on par.

Levels of phosphorus did not significantly influence leaf production at any of the stages. But the highest number of leaves were produced by P_2 (75 kg P_2O_5/ha) at 30th day (21.7) and at harvest (59.3) and by P_1 (50 kg P_2O_5/ha) at 60th day (43.4).

Levels of potash had significantly influenced leaf production at harvest only. At this stage K_2 (64.4) had significantly increased leaf production over K_0 but was on par with K_1. K_1 and K_0 were on par. Some trend of increase in the number of leaves produced per plant with increasing doses of potash was noted during the early stages, though the effects were not significant.

None of the interactions were found significant.

4. Leaf Area Index

The leaf area index recorded at 30th and 60th day after sowing and at harvest are presented in Table 7 and their analysis of variance in Appendix III.

Irrigation had significantly influenced LAI. I_2 had

Table 6. Mean number of leaves per plant at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	20.2	39.5	54.8
0.6	20.4	38.5	55.2
0.9	22.0	46.1	58.9
F test	NS	Sig.	NS
P_2O_5 (kg/ha)			
25	21.4	39.7	53.1
50	19.5	43.4	56.5
75	21.7	41.0	59.3
F test	NS	NS	NS
K_2O (kg/ha)			
25	19.7	39.4	49.2
50	20.7	40.7	57.3
75	22.2	43.9	62.4
F test	NS	NS	Sig.
C.D. (0.05)	—	4.09	9.69

Table 7. Leaf Area Index at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	1.15	4.91	4.71
0.6	1.18	4.81	4.94
0.9	1.85	6.72	5.67
F test	Sig.	Sig.	NS
P_2O_5 (kg/ha)			
25	1.41	5.07	5.14
50	1.16	5.96	5.18
75	1.57	5.41	5.01
F test	NS	NS	NS
K_2O (kg/ha)			
25	1.25	4.49	4.31
50	1.37	5.48	5.40
75	1.52	6.47	5.62
F test	NS	Sig.	NS
C.D. (0.05)	0.558	0.862	-

recorded the highest LAI which was superior to I_1 and I_0 which in turn were on par. This was true only at 30th day and 60th day after sowing. A similar trend was maintained at harvest also.

Phosphorus application did not influence LAI at any of the stages.

Higher potash levels tended to increase LAI at all stages, but it reached the level of statistical significance only at 60th day. At 60th day K_2 had significantly increased LAI over the lower doses. K_1 was superior to K_0. K_2 had recorded the highest LAI at 30th day after sowing and at harvest also.

None of the interactions were found significant.

5. Dry matter production

The dry matter production per plant at 30th and 60th day after sowing and at harvest are presented in Tables 8(a) and 8(b) and their analysis of variance in Appendix IV.

Irrigation schedules influenced dry matter accumulation at all the stages, even though they have reached the level of statistical significance only at 60th day and at harvest. I_2 was superior over I_1 and I_0 which in turn were on par, at 60th day and at harvest. Maximum dry matter was produced by I_2 at 30th day also.

Phosphorus levels did not significantly influence dry matter accumulation at 30th day and 60th day after sowing. At harvest, P_2 had significantly increased dry

Table 8(a). Dry matter production (g/plant) at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	1.13	6.92	20.74
0.6	1.13	7.19	22.36
0.9	1.41	9.93	27.46
F test	NS	Sig.	Sig.
P_2O_5 (kg/ha)			
25	1.20	8.03	21.22
50	1.17	8.37	22.78
75	1.30	7.64	26.57
F test	NS	NS	Sig.
K_2O (kg/ha)			
25	1.15	6.50	19.01
50	1.21	8.32	23.59
75	1.31	9.22	27.97
F test	NS	Sig.	Sig.
C.D. (0.05)	-	0.776	3.062

Table 8(b). Combined effect of phosphorus and potash on dry matter production (g/plant) at 60th day after sowing.

		P_2O_5 (kg/ha)			
		25	50	75	Mean
K_2O (kg/ha)	25	5.41	7.16	6.93	6.50
	50	8.58	8.41	7.96	8.32
	75	10.10	9.55	8.03	9.22
Mean		8.03	8.37	7.64	

C.D.(0.05) Marginal means = 0.776
Means of combinations = 1.344

matter accumulation (26.57 g per plant) over lower doses, which in turn were on par.

Potash application had increased dry matter accumulation significantly except during 30th day, where only a trend was observed. K_2 was superior to K_1 and K_0 at 60th day and at harvest. K_1 was superior to K_0 at 60th day after sowing and at harvest.

The P x K interaction at 60th day alone was significant. P_0K_2 had recorded the highest dry matter production per plant (10.1 g). The lowest dry matter was produced by P_0K_0 (5.41 g).

6. Number of nodules

The mean number of nodules produced per plant at the time of 50 per cent flowering is presented in Table 9 and the analysis of variance in Appendix IV.

A significant increase in the number of nodules per plant with a decrease in moisture stress was observed. I_2 had recorded the maximum number of nodules (96.6) which was superior to I_0 and I_1 which in turn were on par.

Even though higher levels of phosphorus produced more number of nodules, the effect was not statistically significant.

Potash levels and interactions did not significantly influence nodule number.

7. Dry weight of nodules per plant

The data on the mean dry weight of nodules produced per plant is presented in Table 9 and the analysis of variance in Appendix IV.

Significant increase in the dry weight of nodules per plant was observed due to irrigation. I_2 had recorded the maximum dry weight of nodules (64.96 mg/plant) which was significantly superior to I_1 and I_0, which were on par.

The effect of levels of phosphorus was not significant on the dry weight of nodules per plant. However, a comparative increase in the dry weight of nodules per plant could be observed due to the application of phosphorus up to 50 kg P_2O_5/ha. Application of 75 kg P_2O_5/ha failed to increase the nodule weight further.

A significant increase in nodule dry weight was observed at higher doses of potash. K_2 was superior (63.65 mg) to K_0 and was on par with K_1. K_1 and K_0 were on par.

None of the interaction were found significant.

B. Yield and yield attributes

(1) Total number of pegs per plant

The mean number of total pegs produced per plant is presented in Tables 10(a) and 10(b) and its analysis of variance in Appendix V.

Levels of irrigation, phosphorus and potash had failed to produce any significant effect on the total number of pegs.

P x K interaction was found significant. The highest

Table 9. Mean number of nodules and dry weight of nodules (mg) per plant at 50 per cent flowering.

	Number of nodules	Dry weight of nodules
IW/CPE ratio		
0.3	80.8	52.00
0.6	75.2	52.11
0.9	96.6	64.96
F test	Sig.	Sig.
P_2O_5 (kg/ha)		
25	81.7	52.11
50	86.8	58.41
75	84.1	58.56
F test	NS	NS
K_2O (kg/ha)		
25	82.9	50.43
50	80.2	55.00
75	89.4	63.65
F test	NS	Sig.
C.D.(0.05)	12.19	9.613

number of pegs was observed in P_2K_2 (40.4) and the lowest in P_0K_1 (26.1).

(2) Number of pods per plant

The data on the mean number of pods per plant is presented in Table 10(a) and its analysis of variance in Appendix V.

The data revealed the significant influence of irrigation on the mean number of pods produced per plant. The number of pods produced by I_2 (15.6) was significantly superior to I_1 and I_0 which in turn were on par. Thus as the moisture stress decreased, an increase in the number of pods per plant was observed.

Higher phosphorus levels had also increased the number of pods per plant but not to a significant level. Application of phosphorus up to 50 kg P_2O_5/ha had showed an increasing trend in the number of pods per plant.

Increasing potash application from 25 kg K_2O/ha to 75 kg K_2O/ha, had increased the number of pods per plant, but the differences were not significant. The number of pods produced by 25 kg K_2O/ha and 50 kg K_2O/ha was nearly the same.

None of the interactions were found significant.

(3) Percentage of pegs developed to pods

The data on the percentage of pegs developed to pods was analysed after angular transformation and the mean data is presented in Tables 10(a) and 10(c) and its analysis of variance in Appendix V.

The data indicate the significant influence of irrigation on the percentage of pegs developed to pods. I_2 had recorded the highest percentage of pegs developed to pods (49.0 per cent) which was superior to I_1 and I_0 which among them were on par. Thus an increase in moisture stress reflected on the development of pegs to pods.

Phosphorus application had also favourably influenced the percentage of pegs developed to pods. P_1 was significantly superior (47.7 per cent) over P_0 and was on par with P_2. Addition of phosphorus over 50 kg P_2O_5 per hectare had not helped to increase the percentage of pegs developed to pods further.

The percentage of pegs developed to pods was not significantly influenced by higher levels of potash.

I x P interaction was found significant in influencing the percentage of pegs developed to pods. The maximum percentage was recorded by I_1P_2 (50 per cent) and the minimum by I_1P_0 (39.4 per cent).

(4) <u>Weight of mature pods per plant</u>

The mean weight of mature pods in grams per plant, is presented in Table 10(a) and its analysis of variance in Appendix V.

I_2 had recorded the maximum per plant pod yield (9.65 g) which was significantly superior to I_0 (8.14 g) and

Table 10(a). Mean number of pegs and pods per plant, pod to peg per cent and weight of mature pods (g/plant).

	Number of pegs	Number of pods	Pod to peg per cent*	Weight of mature pods
IW/CPE ratio				
0.3	31.3	13.1	44.1 (41.6)	8.14
0.6	28.8	13.1	45.6 (42.5)	8.85
0.9	32.0	15.6	49.0 (44.4)	9.65
F test	NS	Sig.	Sig.	Sig.
P_2O_5 (kg/ha)				
25	28.9	12.5	43.8 (41.4)	7.88
50	30.8	14.7	47.7 (43.7)	9.32
75	32.4	14.6	47.2 (43.4)	9.44
F test	NS	NS	Sig.	Sig.
K_2O (kg/ha)				
25	29.5	13.5	46.0 (42.7)	7.84
50	29.2	13.3	45.8 (42.6)	8.55
75	33.4	15.0	47.0 (43.2)	10.24
F test	NS	NS	NS	Sig.
C.D. (0.05)	-	2.06	(1.78)	1.207

*Figures in parenthesis are values after angular transformation.

Table 10(b). Combined effect of phosphorus and potash on number of total pegs per plant.

		P_2O_5 (kg/ha)			
		25	50	75	Mean
K_2O (kg/ha)	25	30.9	29.8	27.7	29.5
	50	26.1	32.4	29.1	29.2
	75	29.9	30.0	40.4	33.4
Mean		28.9	30.8	32.4	

C.D.(0.05) Means of combinations = 7.26

Table 10(c). Combined effect of irrigation and phosphorus on pod to peg per cent*.

		IW/CPE ratios			
		0.3	0.6	0.9	Mean
P_2O_5 (kg/ha)	25	43.2(41.1)	39.4(38.9)	48.9(44.4)	43.8(41.4)
	50	46.2(42.8)	47.5(43.6)	48.8(44.6)	47.7(43.7)
	75	43.0(41.0)	50.0(45.0)	49.4(44.3)	47.2(43.4)
Mean		44.1(41.6)	45.6(42.5)	49.0(44.4)	

C.D.(0.05) Marginal means = 1.78
Means of combinations = 3.09

*Figures in parenthesis are values after angular transformation.

was on par with I_1(8.85 g). I_1 and I_0 were on par.

Higher doses of phosphorus had significantly increased per plant pod yield. P_2 had recorded the highest per plant pod yield (9.44 g) which was superior to P_0 (7.88 g) and was on par with P_1 (9.32 g). P_1 was superior over P_0.

A significant increase in pod yield per plant could be observed with additional doses of potash. K_2 had recorded the maximum pod yield per plant (10.24 g) and was superior to K_1 and K_0 which in turn were on par.

None of the interactions were found significant.

(5) Weight of 100 pods

The data on the mean weight of 100 pods in grams, is presented in Table 11 and its analysis of variance in Appendix VI.

Irrigation had significantly influenced the weight of 100 pods. I_2 had recorded the maximum 100 pod weight (76.63 g) which was superior to I_0 (65.59 g) and was on par with I_1 (72.0 g). I_1 was found superior to I_0.

Higher levels of phosphorus had significantly enhanced 100 pod weight. P_2 had recorded the maximum weight of 100 pods (74.66 g) which was superior to P_0 (64.95 g) and was on par with P_1 (74.61 g). P_1 was superior to P_0.

A significant increase in 100 pod weight could be observed by the application of higher levels of potash. K_1 had recorded the maximum 100 pod weight (74.78 g) which was on par with K_2 (74.31 g) and both were superior to K_0 (65.13 g).

None of the interactions were found significant.

(6) Weight of 100 kernels

The data on the mean weight of 100 kernels in grams is presented in Table 11 and its analysis of variance in Appendix VI.

Irrigation schedules had significantly influenced the weight of 100 kernels. The maximum 100 kernel weight was recorded by I_2 (31.99 g) which was superior to I_0 and was on par with I_1. I_1 and I_0 were on par.

The effect of phosphorus application on 100 kernel weight was significant. P_1 had recorded the maximum weight of 100 kernels (31.4 g) which was superior to P_0 (28.07 g) and was on par with P_2 (31.24 g). P_2 was superior to P_0.

Higher levels of potash had significantly enhanced 100 kernel weight. K_2 had recorded the maximum weight of 100 kernels (31.64 g) which was superior to K_0 (28.46 g) and was on par with K_1 (30.62 g). K_1 and K_0 were on par.

None of interactions were found significant.

(7) Shelling percentage

The data on shelling percentage is presented in Table 11 and its analysis of variance in Appendix VI.

Higher frequencies of irrigation had increased shelling percentage significantly. I_2 had recorded the highest shelling percentage (72.7) which was on par with

Table 11. 100 pod weight (g), 100 kernel weight (g) and shelling percentage.

	100 pod weight	100 kernel weight	Shelling percentage
IW/CPE ratios			
0.3	65.59	28.43	65.9
0.6	72.00	30.29	70.2
0.9	76.63	31.99	72.7
F test	Sig.	Sig.	Sig.
P_2O_5 (kg/ha)			
25	64.95	28.07	68.6
50	74.61	31.40	70.0
75	74.66	31.24	70.2
F test	Sig.	Sig.	NS
K_2O (kg/ha)			
25	65.15	28.46	68.8
50	74.70	30.62	69.6
75	74.31	31.64	70.4
F test	Sig.	Sig.	NS
C.D. (0.05)	5.276	2.168	2.59

I_1 (70.2) and both in turn were superior to I_0 (65.9).

The effect of higher levels of phosphorus was not significant in increasing shelling percentage. However a comparative increase in shelling percentage could be observed upto 50 kg P_2O_5 per hectare.

Potash levels did not significantly increase shelling percentage. But a marginal increase in shelling percentage was observed with every incremental dose of potash.

None of the interactions were found significant.

(8) Yield of pods per hectare

The data on the yield of pods in kg per ha is presented in Table 12(a) and its analysis of variance in Appendix VI.

Irrigation schedules had significantly influenced pod yield. The highest yield was recorded by I_2 (2533 kg) which was superior to I_1 (2054 kg) and I_0 (1848 kg) which in turn were on par.

Higher doses of phosphorus had also increased pod yield significantly. The maximum pod yield was recorded by P_2 (2399 kg) which was superior to P_0 (1910 kg) and was on par with P_1 (2125 kg). P_1 and P_0 were on par.

Effect of higher levels of potash on pod yield was significant. Highest pod yield was observed in K_2 (2480 kg) which was superior to K_1 (2016 kg) and K_0 (1940 kg), which in turn were on par.

None of the interactions were found significant.

(9) Yield of haulm

The data on the yield of haulm in kg per ha is presented in Tables 12(a) and 12(b) and its analysis of variance in Appendix VI.

Irrigations at shorter intervals had significantly increased haulm yield. I_2 had produced the maximum haulm yield (5261 kg) which was superior to I_1 and I_0. I_1 was superior to I_0.

Higher doses of phosphorus increased haulm yield significantly. P_2 had recorded the maximum haulm yield (4878 kg) which was superior to P_1 (4548 kg) and P_0 (4509 kg), which in turn were on par.

Higher doses of potash enhanced haulm yield significantly. K_2 had produced the highest haulm yield (4885 kg) which was superior to K_0 and was on par with K_1. K_1 and K_0 were on par.

I x K interaction was found to be significant. I_2K_1 had recorded the highest yield (5528 kg) and I_0K_0 (4007 kg) the lowest.

C. Quality factors

1. Protein content

The data on the protein content of kernals is given in Table 13 and its analysis of variance in Appendix VII.

Different irrigation schedules and phosphorus levels had failed to enhance the protein content of kernals. Even

Table 12(a). Pod yield and haulm yield (kg/ha).

	Pod yield	Haulm yield
IW/CPE ratio		
0.3	1848	4082
0.6	2054	4590
0.9	2533	5261
F test	Sig.	Sig.
P_2O_5 (kg/ha)		
25	1910	4509
50	2125	4548
75	2399	4878
F test	Sig.	Sig.
K_2O (kg/ha)		
25	1940	4412
50	2016	4638
75	2480	4885
F test	Sig.	Sig.
C.D.(0.05)	358.7	294.6

Table 12(b). Combined effect of irrigation and potash on haulm yield (kg/ha).

		IW/CPE ratio			
		0.3	0.6	0.9	Mean
K_2O(kg/ha)	25	4007	4133	5095	4412
	50	4030	4356	5528	4638
	75	4210	5281	5162	4885
Mean		4082	4590	5261	

C.D.(0.05) Marginal Means = 294.6
Means of combinations = 510.5

though protein content was not significantly enhanced by potash application, the highest level (75 kg K_2O/ha) showed an increase of 0.88 per cent over 25 kg K_2O/ha. Such variations were not noted among other treatments.

None of the interactions were significant.

2. Kernal protein yield per hectare

The kernal protein yield in kg per hectare is presented in Table 13 and the analysis of variance in Appendix VII.

Irrigation had significantly enhanced kernal protein yield. I_2 had recorded the highest kernal protein yield of 509.9 kg/ha which was superior to I_1 and I_0 which in turn were on par.

Application of higher levels of phosphorus had increased kernal protein yield significantly. P_2 had recorded the highest yield of 473.7 kg/ha which was superior to P_0 (366.0 kg/ha) and was on par with P_1 (414.9 kg/ha). P_1 and P_0 were on par.

The effect due to potash application on kernal protein yield was also significant. The highest yield was observed in K_2 (495.9 kg/ha) which was superior to K_1 and K_0 which in turn were on par.

None of the interactions were found to be significant.

3. Oil content

The data on the oil content of kernels is presented in Table 13 and its analysis of variance in Appendix VII.

A significant enhancement in oil content of kernel can be observed by scheduling irrigation at shorter intervals. I_2 (45.76%) and I_1 (45.36%) were on par and were superior to I_0 (42.79%).

The effect of phosphorus on the oil content of kernel was significant. P_1 (46.06%) was superior over P_2 (43.24%) and was on par with P_0 (44.61%). P_0 and P_2 were on par.

Significant enhancement in oil content can be observed by the application of higher levels of potash. K_2 (46.16%) and K_1 (45.03%) were on par and both were superior to K_0 (42.7%).

None of the interactions were significant.

4. Oil yield per hectare

The mean oil yield in kg per hectare is presented in Table 13 and the analysis of variance in Appendix VII.

Higher levels of irrigation, phosphorus and potash had significantly enhanced per hectare oil yield.

Among irrigation schedules, I_2 had recorded the highest oil yield of 843.6 kg/ha which was superior to I_1 and I_0. I_1 was superior over I_0.

Among phosphorus levels, highest oil yield was observed in P_2 (746.0 kg/ha) which was on par with P_1 and both were superior to P_0.

With regard to potash, highest oil yield was observed

Table 13. Protein and oil content (per cent) of kernels and kernal protein yield and oil yield (kg/ha).

	Protein content	Kernal protein yield	Oil content	Oil yield
IW/CPE ratio				
0.3	27.27	342.5	42.79	529.6
0.6	27.37	402.5	45.36	662.3
0.9	27.56	509.9	45.76	843.6
F test	NS	Sig.	Sig.	Sig.
P_2O_5 (kg/ha)				
25	27.63	366.0	44.61	590.6
50	27.23	414.9	46.06	698.9
75	27.53	473.7	43.24	746.0
F test	NS	Sig.	Sig.	Sig.
K_2O (kg/ha)				
25	26.98	368.6	42.70	585.3
50	27.58	390.2	45.03	640.2
75	27.86	495.9	46.18	810.1
F test	NS	Sig.	Sig.	Sig.
C.D.(0.05)	-	78.58	1.789	105.11

in K_2 (810.1 kg/ha) which was superior to K_1 and K_0. K_1 was also superior over K_0.

None of the interactions were found significant.

D. Chemical composition and nutrient uptake

(1) Nitrogen content in dry matter

The nitrogen content in dry matter at 30th and 60th day after sowing and in haulm at harvest are presented in Tables 14(a) to 14(c) and its analysis of variance in Appendix VIII.

Irrigation schedules and levels of phosphorus and potash had failed to produce any significant effect in the nitrogen content of dry matter at 30th day and 60th day after sowing and in haulm at harvest.

I x P and I x K interactions at 30th day after sowing and I x P and P x K interactions at 60th day after sowing were significant.

Among I x P combinations at 30th day after sowing, I_0P_1 (3.672%) had recorded the maximum and I_2P_1 (2.828%) had recorded the minimum nitrogen content.

Among I x K combinations, I_2K_0 (3.495%) had recorded the maximum and I_2K_2 (2.948%) had recorded the minimum nitrogen content.

Among I x P combinations at 60th day after sowing, the maximum nitrogen content was noted in I_2P_0 (3.02%) and the minimum in I_2P_2 (2.565%).

P_0K_1 (2.9%) had recorded the maximum and P_1K_2 (2.542%) had recorded the minimum nitrogen content among P x K combinations.

(2) <u>Nitrogen content in shell</u>

The data on the nitrogen content in shell is presented in Table 14(a) and its analysis of variance in Appendix VIII.

Levels of irrigation, phosphorus, potash and their interactions did not significantly influence nitrogen content in shell.

(3) <u>Nitrogen content in kernal</u>

The data on the nitrogen content in kernal is presented in Table 14(a) and its analysis of variance in Appendix VIII.

Nitrogen content in kernal was not significantly influenced by irrigation schedules, levels of phosphorus or potash or any of their interactions.

(4) <u>Uptake of nitrogen</u>

The data on the nitrogen uptake at 30th and 60th day after sowing and at harvest are presented in Tables 15(a) to 15(c) and its analysis of variance in Appendix XI.

Irrigation schedules had significantly influenced nitrogen uptake except at 30th day after sowing. I_2 (72.62 kg N/ha) was superior to I_1 (53.29 kg N/ha) and I_0 (49.76 kg N/ha) which in turn were on par, at 60th day after sowing. At harvest also, I_2 had recorded the maximum nitrogen uptake which was superior to I_1 and I_0 which were on par. I_2 had recorded the maximum nitrogen uptake at

Table 14(a). Nitrogen content (per cent) in plant parts at different stages.

	Plants at 30th day after sowing	Plants at 60th day after sowing	Haulm	Shell	Kernel
IW/CPE ratio					
0.3	3.337	2.680	1.864	1.392	4.363
0.6	3.246	2.709	1.738	1.354	4.412
0.9	3.181	2.746	1.779	1.382	4.410
F test	NS	NS	NS	NS	NS
P_2O_5 (kg/ha)					
25	3.299	2.761	1.783	1.361	4.424
50	3.152	2.692	1.772	1.338	4.357
75	3.314	2.763	1.826	1.428	4.404
F test	NS	NS	NS	NS	NS
K_2O (kg/ha)					
25	3.292	2.704	1.851	1.373	4.316
50	3.246	2.799	1.782	1.403	4.412
75	3.226	2.712	1.748	1.352	4.457
F test	NS	NS	NS	NS	NS
C.D. (0.05)	-	-	-	-	-

Table 14(b). Combined effect of irrigation and phosphorus and irrigation and potash on nitrogen content (per cent) in plants at 30th day after sowing.

		IW/CPE ratio			
		0.3	0.6	0.9	Mean
P_2O_5 (kg/ha)	25	2.955	3.603	3.338	3.299
	50	3.672	2.955	2.828	3.152
	75	3.385	3.180	3.377	3.314
	Mean	3.337	3.246	3.181	
K_2O (kg/ha)	25	3.260	3.122	3.495	3.292
	50	3.378	3.260	3.100	3.246
	75	3.373	3.357	2.948	3.226
	Mean	3.337	3.246	3.181	

C.D.(0.05) Marginal means = 0.1821

Means of combinations = 0.3154

Table 14(c). Combined effect of irrigation and phosphorus and phosphorus and potash on nitrogen content (per cent) in plants at 60th day after sowing.

		IW/CPE ratio			
		0.3	0.6	0.9	Mean
P_2O_5 (kg/ha)	25	2.652	2.610	3.020	2.761
	50	2.618	2.805	2.653	2.692
	75	2.770	2.953	2.565	2.763
Mean		2.680	2.789	2.746	

		P_2O_5 (kg/ha)			
		25	50	75	Mean
K_2O (kg/ha)	25	2.562	2.823	2.727	2.704
	50	2.900	2.710	2.787	2.799
	75	2.820	2.542	2.775	2.712
Mean		2.761	2.692	2.763	

C.D.(0.05) Means of combinations = 0.2505

Table 15(a). Nitrogen uptake (kg/ha) at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	10.22	49.76	139.50
0.6	9.88	53.29	152.44
0.9	11.83	72.62	184.76
F test	NS	Sig.	Sig.
P_2O_5 (kg/ha)			
25	10.56	60.26	146.76
50	9.78	59.69	155.18
75	11.59	55.73	174.76
F test	NS	NS	Sig.
K_2O (kg/ha)			
25	10.12	46.95	149.28
50	10.49	62.03	153.13
75	11.32	66.68	174.30
F test	NS	Sig.	Sig.
C.D. (0.05)	-	5.783	13.986

Table 15(b). Combined effect of phosphorus and potash on nitrogen uptake at 60th day after sowing.

	P_2O_5 (kg/ha)			
	25	50	75	Mean
K_2O (kg/ha)				
25	37.69	53.49	49.68	46.95
50	66.57	61.06	58.47	62.03
75	76.52	64.51	59.03	66.68
Mean	60.26	59.69	55.73	

C.D.(0.05) Marginal means = 5.783
Means of combinations = 10.016

Table 15(c). Combined effect of irrigation and potash on nitrogen uptake (kg/ha) at harvest.

	IW/CPE ratio			
	0.3	0.6	0.9	Mean
K_2O (kg/ha)				
25	125.72	135.91	186.19	149.28
50	133.31	140.22	185.86	153.13
75	159.47	181.19	182.24	174.30
Mean	139.50	152.44	184.76	

C.D.(0.05) Marginal means = 13.986
Means of combinations = 24.224

30th day also, though it was not significantly superior to lower doses. Thus, shorter the interval between irrigations, higher nitrogen uptake was noted.

The effect due to higher levels of phosphorus was significant only at harvest. At this stage, P_2 had recorded the maximum nitrogen uptake which was superior to P_1 and P_0 which in turn were on par.

The effect of higher levels of potash on nitrogen uptake was significant except at 30th day. At 60th day, K_2 (66.68 kg N/ha) and K_1 (62.03 kg N/ha) were on par and both of them were superior to K_0 (46.95 kg N/ha). At harvest, K_2 was superior over K_1 and K_0 which were on par. A trend of increase in nitrogen uptake at higher potash levels was noted at 30th day after sowing, though not statistically significant.

P x K interaction at 60th day after sowing and I x K interaction at harvest were significant.

Among P x K interaction at 60th day after sowing, highest nitrogen uptake was noted in P_0K_2 (76.52 kg N/ha) and the lowest in P_0K_0 (37.69 kg N/ha).

Among I x K interactions at harvest, I_2K_0 had recorded the maximum and I_0K_0 had recorded the minimum nitrogen uptake.

(5) Phosphorus content in dry matter

The data on the phosphorus content in dry matter at 30th and 60th day after sowing and in haulm at harvest are presented in Tables 16(a) and 16(b) and the analysis of variance in Appendix IX.

The effect due to irrigation schedules on phosphorus content in dry matter was significant only at 30th day after sowing and in haulm at harvest. Moreover a general decrease in phosphorus content with higher frequencies of irrigation was observed at all stages. At 30th day after sowing and at harvest, I_0 had recorded the maximum phosphorus content (0.299% and 0.170% respectively) which was superior to the higher frequencies of irrigation. I_2 and I_1 were on par at both stages. At 60th day after sowing also the maximum phosphorus content was observed in I_0 (0.217%), thus following the same trend noted at 30th day after sowing and at harvest.

Levels of phosphorus had not affected phosphorus content at any of the stages.

Potash application had significantly influenced phosphorus content at all stages except at 30th day after sowing. At 60th day after sowing, K_0 had recorded the highest phosphorus content (0.220%) which was superior to K_2 and K_1 which in turn were on par. At harvest, the highest phosphorus content was observed in K_0 (0.169%) which was superior to K_1 (0.155%) and was on par with K_2 (0.161%). K_2 and K_1 were on par. A similar trend was also noted at 30th day after sowing where K_0 had recorded the maximum phosphorus content (0.288%).

Only the I x K and P x K interactions at harvest were significant. Among I x K combinations, I_2K_0 (0.177%) had recorded the maximum and I_2K_1 (0.143%) had recorded the minimum phosphorus content. Highest phosphorus content was noted in P_1K_0 (0.177%) and the lowest in P_1K_1 and P_1K_2 (0.146% each), among P x K combinations.

(6) Phosphorus content in shell

The data on phosphorus content in shell is presented in Table 16(a) and analysis of variance in Appendix IX.

The levels of irrigation, phosphorus and potash had failed to influence phosphorus content in shell. But a general decrease in phosphorus content with increasing irrigation frequencies and an increase in phosphorus content with increasing phosphorus levels were noted.

None of the interactions were significant.

(7) Phosphorus content in kernal

The mean data on phosphorus content in kernal is presented in Table 16(a) and analysis of variance in Appendix IX.

Levels of irrigation and phosphorus, did not influence phosphorus content in kernal.

The effect of levels of potash on phosphorus content in kernal was found to be significant. K_2 was significantly superior over K_1 and K_0 which were on par.

None of the interactions were found significant.

Table 16(a). Phosphorus content (per cent) in plant parts at different stages.

	Plants at 30th day after sowing	Plants at 60th day after sowing	Haulm	Shell	Kernel
IW/CPE ratio					
0.3	0.299	0.217	0.170	0.072	0.390
0.6	0.268	0.207	0.156	0.065	0.382
0.9	0.271	0.208	0.158	0.059	0.388
F test	Sig.	NS	Sig.	NS	NS
P_2O_5 (kg/ha)					
25	0.282	0.207	0.165	0.062	0.388
50	0.275	0.209	0.156	0.064	0.386
75	0.282	0.216	0.163	0.070	0.386
F test	NS	NS	NS	NS	NS
K_2O (kg/ha)					
25	0.288	0.220	0.169	0.068	0.397
50	0.280	0.200	0.155	0.063	0.384
75	0.270	0.204	0.161	0.065	0.378
F test	NS	Sig.	Sig.	NS	Sig.
C.D.(0.05)	0.0211	0.0150	0.0105	--	0.0111

Table 16(b). Combined effect of irrigation and potash and phosphorus and potash on phosphorus content (per cent) in haulm.

	IW/CPE ratio			
	0.3	0.6	0.9	Mean
K_2O (kg/ha)				
25	0.168	0.161	0.177	0.169
50	0.176	0.145	0.143	0.155
75	0.167	0.161	0.154	0.161
Mean	0.170	0.156	0.158	

	P_2O_5 (kg/ha)			
	25	50	75	Mean
K_2O (kg/ha)				
25	0.159	0.177	0.169	0.169
50	0.166	0.146	0.154	0.155
75	0.170	0.146	0.166	0.161
Mean	0.165	0.156	0.163	

C.D.(0.05) Marginal means = 0.0105

Means of combinations = 0.0181

(8) Uptake of phosphorus

The mean data on phosphorus uptake at 30th and 60th day after sowing and at harvest are presented in Tables 17(a) and 17(b) and analysis of variance in Appendix XI.

The effect of irrigation schedules on phosphorus uptake was significant at all stages except at 30th day after sowing. I_2 had recorded the maximum uptake at 60th day and at harvest (5.46 and 15.90 kg/ha respectively) which was superior to I_1 and I_0 which in turn were on par. A similar trend was observed at 30th day also and the highest phosphorus uptake was recorded by I_2 (1.03 kg/ha).

Phosphorus levels had significantly influenced its uptake only at harvest. Highest phosphorus uptake at this stage was observed in P_2 (15.05 kg/ha) which was superior to P_1 and P_0 which in turn were on par. At 30th day highest phosphorus uptake was observed in P_2 (0.99 kg/ha) and at 60th day in P_1 (4.6 kg/ha).

Levels of potash had significantly enhanced phosphorus uptake at all stages except at 30th day after sowing. At 60th day and at harvest K_2 had recorded the highest phosphorus uptake (5.00 and 15.00 kg/ha respectively) which was superior to K_1 and K_0. K_1 was superior to K_0 at 60th day and were on par at harvest. A similar trend was observed at 30th day also, where K_2 had recorded the maximum phosphorus uptake (0.94 kg/ha).

Table 17(a). Phosphorus uptake (kg/ha) at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	0.90	3.95	12.21
0.6	0.82	3.97	13.07
0.9	1.03	5.46	15.90
F test	NS	Sig.	Sig.
P_2O_5 (kg/ha)			
25	0.90	4.39	12.89
50	0.85	4.60	13.25
75	0.99	4.39	15.05
F test	NS	NS	Sig.
K_2O (kg/ha)			
25	0.88	3.91	13.26
50	0.92	4.47	12.92
75	0.94	5.00	15.00
F test	NS	Sig.	Sig.
C.D.(0.05)	-	0.431	1.429

Table 17(b). Combined effect of irrigation and potash and phosphorus and potash on phosphorus uptake (kg/ha) at 60th day after sowing.

	IW/CPE ratio			
	0.5	0.6	0.9	Mean
K_2O (kg/ha)				
25	3.22	3.52	5.00	3.91
50	4.50	3.59	5.33	4.47
75	4.13	4.81	6.05	5.00
Mean	3.95	3.97	5.46	

	P_2O_5 (kg/ha)			
	25	50	75	Mean
K_2O (kg/ha)				
25	3.20	4.31	4.22	3.91
50	4.76	4.26	4.39	4.47
75	5.20	5.23	4.57	5.00
Mean	4.39	4.60	4.39	

C.D.(0.05) Marginal means = 0.431
Means of combinations = 0.747

I x K and P x K interactions at 60th day alone were significant. Among I x K combinations, highest uptake was noted in I_2K_2 (6.05 kg/ha) and lowest in I_0K_0 (3.22 kg/ha). Among P x K combinations, the highest uptake was observed in P_1K_2 (5.23 kg/ha) and the lowest in P_0K_0 (3.20 kg/ha).

(9) Potassium content in dry matter

The mean data on potassium content in dry matter at 30th and 60th day after sowing and in haulm at harvest are presented in Tables 18(a) and 18(b) and analysis of variance in Appendix X.

Irrigation schedules had significantly influenced potassium content at 30th day after sowing only. At this stage, I_2 had recorded the maximum potassium content (1.797%) which was superior to I_0 (0.939%) and was on par with I_1 (1.767%). I_1 was superior to I_0. Maximum potassium content was observed in I_2 at 60th day (0.779%) and I_1 at harvest (0.527%).

Levels of phosphorus did not significantly influence potassium content at none of the stages.

Higher levels of potash had significantly enhanced potassium content at all stages. K_2 had recorded the highest potassium content at 30th day and 60th day after sowing and at harvest (1.845, 0.824 and 0.591% respectively), which was superior to K_1 and K_0 at 30th day and at harvest and was on par with K_1 at 60th day. K_1 was superior to K_0 at 30th and 60th day and were on par at harvest.

I x K and P x K interactions at 30th day alone were significant. Among I x K combinations, I_1K_2 (2.371%) had recorded the highest potassium content and I_0K_0 (0.838%) the minimum. Among P x K combinations, P_1K_2 (2.146%) had recorded the highest potassium content and P_2K_0 (0.992%) the minimum.

(10) Potassium content in shell

The mean data on potassium content in shell is presented in Table 18(a) and analysis of variance in Appendix X.

Irrigation schedules and phosphorus levels did not significantly influence potassium content. But a marginal decrease in potassium content with increasing irrigation frequencies was observed. Among the phosphorus levels maximum potassium content was recorded by P_2 (0.613%).

Potash levels had significantly influenced potassium content in shell. K_2 had enhanced potassium content in shell to 0.659% which was superior to K_0 (0.507%) and was on par with K_1 (0.585%). K_1 and K_0 were on par.

(11) Potassium content in kernal

The mean data on potassium content in kernal is given in Table 18(a) and analysis of variance in Appendix X.

The potassium content was not influenced by irrigation, phosphorus or potash levels or any of their interactions. But an increasing trend in potassium content could be observed at higher doses of potash.

Table 10(a). Potassium content (per cent) in plant parts at different stages.

	Plants at 30th day after sowing	Plants at 60th day after sowing	Haulm	Shell	Kernel
IW/CPE ratio					
0.3	0.939	0.605	0.492	0.636	1.258
0.6	1.767	0.755	0.527	0.563	1.249
0.9	1.797	0.779	0.512	0.550	1.251
F test	Sig.	NS	NS	NS	NS
P_2O_5 (kg/ha)					
25	1.514	0.736	0.540	0.583	1.269
50	1.560	0.720	0.458	0.555	1.249
75	1.428	0.682	0.534	0.613	1.240
F test	NS	NS	NS	NS	NS
K_2O (kg/ha)					
25	1.108	0.555	0.460	0.507	1.213
50	1.549	0.759	0.481	0.565	1.271
75	1.845	0.824	0.591	0.659	1.275
F test	Sig.	Sig.	Sig.	Sig.	NS
C.D. (0.05)	0.2120	0.1663	0.0958	0.0815	-

Table 18(b). Combined effect of irrigation and potash and phosphorus and potash on potassium content (per cent) in plants at 30th day after sowing.

	IW/CPE ratio			
	0.3	0.6	0.9	Mean
K_2O (kg/ha)				
25	0.838	1.094	1.394	1.108
50	0.986	1.836	1.825	1.549
75	0.994	2.371	2.171	1.845
Mean	0.939	1.767	1.797	

	P_2O_5 (kg/ha)			
	25	50	75	Mean
K_2O (kg/ha)				
25	1.215	1.119	0.992	1.108
50	1.533	1.417	1.696	1.549
75	1.794	2.146	1.596	1.845
Mean	1.514	1.560	1.428	

C.D.(0.05) Marginal means = 0.2120
Means of combinations = 0.3671

(12) Uptake of potassium

The mean data on potassium uptake at 30th and 60th day after sowing and at harvest is presented in Table 19 and analysis of variance in XII.

Irrigation schedules significantly influenced potassium uptake at all stages. I_2 had recorded the maximum potassium uptake at 30th and 60th day after sowing and at harvest (7.03, 21.32, 53.43 kg/ha respectively) and it was superior to I_1 and I_0 at 60th day and harvest and over I_0 only at 30th day. I_1 was superior to I_0 at 30th day and at harvest and were on par at 60th day.

Phosphorus levels significantly influenced potassium uptake only at harvest. At this stage P_2 had recorded the maximum potassium uptake (51.69 kg/ha) which was superior to P_0 and P_1 which in turn were on par.

Higher doses of potash had significantly increased potassium uptake at all stages. K_2 had recorded the maximum potassium uptake at 30th and 60th day after sowing and at harvest (6.48, 20.82, 56.36 kg/ha respectively) which was superior to K_1 and K_0 at 60th day and at harvest and over K_0 only at 30th day. K_1 was superior to K_0 at 60th day and were on par at 30th day and at harvest.

None of the interactions were significant.

E. Soil analysis

(a) Total nitrogen content in the soil after the experiment

The mean values are presented in Tables 20(a) and

Table 19. Potassium uptake (kg/ha) at different stages.

	30th day after sowing	60th day after sowing	Harvest
IW/CPE ratio			
0.3	2.89	11.23	39.14
0.6	5.36	14.77	46.46
0.9	7.03	21.32	53.43
F test	Sig.	Sig.	Sig.
P_2O_5 (kg/ha)			
25	5.11	16.33	44.48
50	5.06	16.80	42.87
75	5.11	14.20	51.69
F test	NS	NS	Sig.
K_2O (kg/ha)			
25	3.56	9.87	39.21
50	5.24	16.64	43.47
75	6.48	20.82	56.36
F test	Sig.	Sig.	Sig.
C.D.(0.05)	2.003	3.964	4.883

20(b) and the analysis of variance in Appendix XIII.

The individual effect of irrigation, phosphorus and potash was not significant in influencing the total nitrogen content in the soil after the experiment.

The I x K interaction was found to be significant in influencing the total nitrogen content in the soil. The highest and lowest nitrogen contents were recorded by I_2K_2 and I_0K_2 respectively.

(b) Available phosphorus content in the soil after the experiment

The mean values are presented in Table 20(a) and analysis of variance in Appendix XIII.

There was no significant effect, for the different levels of irrigation, phosphorus, potash or their interactions, on the available phosphorus content in the soil. But an increasing trend can be observed, as the treatment levels were increased, which was more pronounced in the case of phosphorus application.

(c) Available potassium content in the soil after the experiment

The mean data are presented in Table 20(a) and the analysis of variance in Appendix XIII.

Levels of irrigation and phosphorus did not significantly influence the available potassium content in soil.

Application of higher levels of potash had significantly increased the available potassium content of the

Table 20(a). Total nitrogen, available phosphorus and available potassium content in the soil after the experiment (kg/ha).

	Total nitrogen	Available phosphorus	Available potassium
IW/CPE ratio			
0.3	781.56	16.04	78.38
0.6	786.11	16.96	68.49
0.9	794.11	17.95	67.29
F test	NS	NS	NS
P_2O_5 (kg/ha)			
25	774.56	15.47	69.22
50	791.78	16.63	70.89
75	795.44	18.85	74.04
F test	NS	NS	NS
K_2O (kg/ha)			
25	783.00	16.47	55.31
50	785.00	17.00	65.11
75	793.78	17.48	93.73
F test	NS	NS	Sig.
C.D. (0.05)	-	-	23.793

Table 20(b). Combined effect of irrigation and potash on the total nitrogen content of the soil after the experiment (kg/ha).

	IW/CPE ratio			
	0.3	0.6	0.9	Mean
K_2O (kg/ha)				
25	828.33	746.00	774.67	783.00
50	785.00	817.67	752.33	785.00
75	731.33	794.67	855.33	793.78
Mean	781.56	786.11	794.11	

C.D.(0.05) Means of combinations = 81.210

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F test	NS	NS	NS
K_2O (kg/ha)			
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75	793.78	17.48	93.73
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C.D. (0.05)	-	-	23.793

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75	731.33	794.67	855.33	793.78
Mean	781.56	786.11	794.11	

C.D.(0.05) Means of combinations = 81.210

soil. K_2 had recorded the highest potassium content which was significantly superior over K_1 and K_0 which were on par.

None of the interactions were found significant.

F. Correlation studies

The values of simple correlation coefficients are presented in Table 21.

Pod yield was significantly and positively correlated with the haulm yield, number of pods per plant, 100 pod weight, 100 kernal weight, nitrogen uptake, phosphorus uptake, potassium uptake and dry weight of nodules per plant and the correlation coefficients were 0.3169, 0.3112, 0.5059, 0.4814, 0.8893, 0.8658, 0.5905 and 0.3187 respectively.

Oil content of kernal was positively and significantly correlated with potassium uptake and the 'r' value was 0.2831.

Table 21. Values of simple correlation coefficients.

Sl. No.	Characters correlated	Correlation coefficients
1.	Pod yield x Haulm yield	0.3169*
2.	Pod yield x Number of pods per plant	0.3112*
3.	Pod yield x 100 pod weight	0.5059*
4.	Pod yield x 100 kernel weight	0.4814*
5.	Pod yield x Nitrogen uptake	0.8093*
6.	Pod yield x Phosphorus uptake	0.8658*
7.	Pod yield x Potassium uptake	0.5905*
8.	Pod yield x Dry weight of nodules per plant	0.3187*
9.	Oil content of kernel x Potassium uptake	0.2831*

*Significant at 0.05 level

DISCUSSION

DISCUSSION

An experiment was conducted at Agronomic Research Station, Chalakudy, Kerala Agricultural University, during the summer season of 1979-80 to study the response of groundnut to phosphorus and potassium under different water management practices. The field experiment laid out in a 3^3 partially confounded factorial in RBD with two replications, had three levels each of irrigation, phosphorus and potash. The results obtained from the study are discussed below.

A. Growth characters

(1) Height of plants

(Table 4, Appendix II)

It can be seen from the results that plant height at all stages was significantly increased by irrigation at shorter intervals. Plant height occurs as a result of cell division and cell enlargement and water stress adversely affect these processes (Begg and Turner, 1976). This might have caused the stunting of growth in plants under stress. Similar results were also reported by Lin et al. (1963), Krishnaswamy et al. (1964) and Reddy (1980).

Eventhough the effect was not significant, higher levels of phosphorus tended to increase plant height, especially at later stages. The favourable influence of phosphorus on plant height was also reported by Jayadevan (1970) and Muraleedharan (1971).

It can be seen from the results that increase in the levels of potash significantly increased plant height except at the early stage. Since the active vegetative growth starts only after 30th day, the effect of higher levels of potash was not manifested in the early stage. The role of potassium is important as an essential element for the promotion of growth of meristematic tissue (Tisdale and Nelson, 1975). Higher doses of potash increased its availability to the crop which might have resulted in increased plant height. Similar findings were also reported by Gopalakrishnan and Nagarajan (1958) and Nair (1978).

(2) <u>Number of branches per plant</u>

(Table 5, Appendix II)

The results show that irrigation had significantly increased number of branches produced per plant at 60th day only whereas a similar, though not significant, trend was observed at both the early and late stages as well. The favourable influence of frequent irrigations on the normal physiological activities might have helped such plants to produce more branches. Similar results were also reported from Dharwad (Anon., 1978b). Lin et al. (1963) also observed lesser number of branches under drought.

The lack of response to phosphorus and potash in terms of the number of branches produced, has been observed at Bhavanisagar (Anon., 1975a) and also by Nair (1978) and Rao (1979).

(3) Number of leaves per plant

(Table 6, Appendix III)

The results indicate that irrigation schedules had significantly influenced leaf production only at 60th day. The effect was more pronounced at this stage since the active vegetative growth of groundnut falls during the second month of the crop. But an increasing trend in leaf production was maintained with more irrigations at the early and late stages also. The adverse effect of moisture stress on the rate of leaf initiation and cell division might have caused the production of lesser number of leaves in plants under stress. Ochs and Wormer (1959) and Lin et al. (1963) also made similar observations.

The effect of different levels of phosphorus was not significant, in influencing the number of leaves per plant, at any of the growth stages studied. But there was an increasing trend upto 50 kg P_2O_5/ha at 60th day and upto 75 kg P_2O_5/ha at harvest. The beneficial effect of phosphorus on increasing leaf production has been reported by Goldin and Har-tzook (1966) and Nair (1978).

A significant increase in the number of leaves per plant at the final stages of crop growth and marginal increases observed in earlier stages, due to the application of higher levels of potash corroborates earlier observations of Bhan and Misra (1970) and Nair (1978). Potassium, an essential element for the promotion of growth of meristematic tissue (Tisdale and Nelson, 1975) might have helped in increasing leaf number. It may further be noted that the increase in plant height due to higher doses of potash might also have helped in producing more number of leaves due to the enhanced number of nodes.

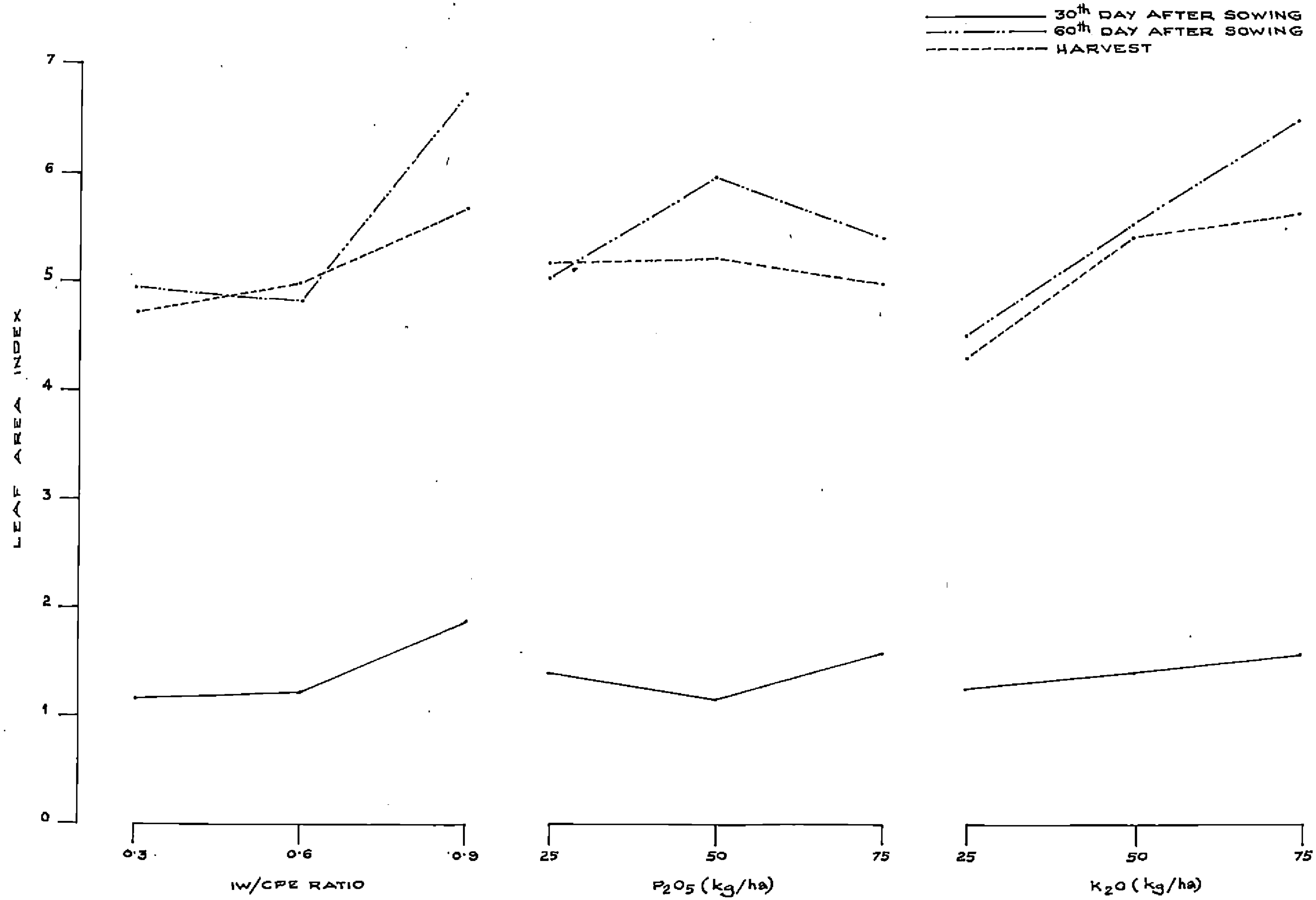
(4) Leaf area index

(Table 7, Fig. 3, Appendix III)

As observed from the results, frequent irrigations had enhanced LAI significantly at the early stages. A similar trend was maintained at harvest also. The decrease in LAI due to water deficits might be due to the marked reduction in leaf area through its effect on cell enlargement. Decrease in the number of leaves produced at low soil moisture levels also might have lowered the LAI at these levels. Lin et al. (1965) observed production of smaller leaves under drought.

Eventhough the effect was not significant, an increase in LAI could be observed due to the application of higher doses of phosphorus upto 50 kg P_2O_5/ha at 60th day after sowing. The favourable influence of phosphorus on the production of leaves and leaf area might have resulted in increased LAI.

FIG. 3. LEAF AREA INDEX AS AFFECTED BY LEVELS OF IRRIGATION, PHOSPHORUS AND POTASH



The result shows that potash levels had significantly influenced leaf number only at the harvest stage. While in the case of LAI, potash levels were significant only at 60th day after sowing which indicated that in the early stages of growth neither the number nor the area of leaves were affected by the potash levels. During the active stage of growth eventhough the number was not significantly increased, the total leaf area might have been significantly increased with the increase in the levels of potash which has influenced the LAI. At harvest, though the number were more at higher levels of potash the area of leaves might have been reduced which did not influence the LAI and hence LAI remained uniform.

(5) Dry matter production per plant

(Tables 8(a) and 8(b), Appendix IV)

It is observed from the results that higher frequencies of irrigation enhanced dry matter production per plant significantly except at the early stage. A similar trend was noted at the early stage also. Since the active vegetative growth starts only after the early stage, the effect of irrigation might not have been exhibited to a significant level in the early stage. The reduction in dry matter production due to moisture stress may be due to its adverse effect on photosynthesis, as evidenced by Begg and Turner (1976). The size of the photosynthetic apparatus was also reduced due to reduction in LAI, by moisture stress.

An increase in growth characters like height of plants and number of leaves per plant had also contributed to the increased dry matter production at higher levels of irrigation. Vivekanandan and Gunasena (1976) and Khan and Morey (1980) also reported increased dry matter production due to irrigation.

Phosphorus levels had significantly increased dry matter production at harvest stage whereas an increasing trend was maintained upto 50 kg P_2O_5/ha at 60th day after sowing. An increasing trend noted in the case of height of plants and number of leaves per plant might have contributed to the increased dry matter production at harvest. Further an increase in the weight of pods produced per plant had also contributed to the above result. Increased dry matter production at higher levels of phosphorus was also reported by Khan (1977) and Shelke and Khupse (1980).

It can be seen from the results that application of potash had significantly enhanced dry matter production except at the early stage, where it showed an increasing trend. Potassium promotes the growth of meristematic tissue whereas an insufficient potash supply decreases photosynthesis and increases respiration (Tisdale and Nelson, 1975). Increased height and more number of leaves produced per plant at higher levels of potash had also contributed to the increased dry matter production. Nair (1978) and Rao (1979) also reported similar findings.

The combined effect of phosphorus and potassium at 60th day was found significant. The highest dry matter production was recorded by P_0K_2 (25 kg P_2O_5 and 75 kg K_2O/ha) and the lowest by P_0K_0 (25 kg P_2O_5 and 25 kg K_2O/ha).

(6) Number and dry weight of nodules per plant

(Table 9, Appendix IV)

It can be seen from the results that higher soil moisture levels had produced the maximum number and dry weight of nodules per plant. Doku (1970) stated that the effective nodulation not only acts upon plant vigour but is also to some extend dependent upon it. The vigorous plant growth observed under wetter moisture regimes helped to produce higher number and maximum dry weight of nodules. Further, it was also reported that the first effect of the onset of drought is for the crop to shed its nodules (Russel, 1973). Increased nodule number and weight due to increased soil moisture levels were also reported by Lenka and Misra (1973), Varma and Subba Rao (1975) and Shelke and Khupse (1980).

Eventhough the effect was not significant, levels of phosphorus upto 50 kg P_2O_5/ha, tended to increase the nodule number and dry weight. This may be due to the increased activity of rhizobia at this level of phosphorus. The beneficial effect of phosphorus on nodulation and nodular bacteria was also reported by Puri (1969), Muthuswamy (1973) and Deshpande (1974).

The non significant effect of levels of potash on nodule number, as observed from this study, was in agreement with the findings of Deshpande (1974), Nair (1978) and Rao (1979). But a marginal increase in nodule number can be observed at the highest level of potash (75 kg K_2O/ha) and this in combination with bigger sized nodules might have helped in increasing the nodule weight significantly. Better plant growth under highest rates of potash fertilization might have helped in the production of bigger sized nodules.

B. Yield and yield attributes

(1) Total number of pegs per plant

(Tables 10(a) and 10(b), Appendix V)

The total number of pegs produced per plant was not significantly influenced by levels of irrigation. It can be observed from the Table 3 that the first, second and third irrigation after sowing was respectively given to I_0, I_1 and I_2 treatments, around 37 days after sowing which coincides with the flowering to peg formation stage of the crop. This irrigation might have uniformly helped all the treatments in pegging, and as such the effect of irrigation schedules on the production of pegs become nonsignificant.

Eventhough phosphorus and potash application did not significantly influence the number of pegs produced per plant an increasing trend can be observed at higher levels of these nutrients. This shows the importance of phosphorus and potassium in the production of pegs.

Though the individual effects of phosphorus and potash were not significant in increasing the total number of pegs per plant, their interaction was found to be significant. There was an increasing trend in the number of pegs, with increase in levels of phosphorus and potash and as such the cumulative effect of this nutrients might have increased the number of pegs significantly.

(2) Number of pods per plant

(Table 10(a), Fig. 4, Appendix V)

As the soil wetness increased, the number of pods produced per plant was significantly increased. Eventhough the number of pegs produced per plant remained uniform, more number of pegs would have developed into pods. The adverse effect of moisture stress on pod formation resulted in lesser number of pods in stressed plants. Lenka and Misra (1973), Subba Rao et al. (1974), Cheema et al. (1977) and Reddy (1980) also reported similar results.

Eventhough the effect due to phosphorus levels on the number of pods per plant was not significant, an increasing trend can be observed at higher levels. This increase was to the tune of 17.5 per cent when the level of phosphorus was increased from 25 to 50 kg P_2O_5/ha. Further increase in phosphorus levels did not increase the number of pods. The increasing trend reveals the important role of phosphorus in fruiting and seed production. The nonsignificant effect of phosphorus on the number of pods per plant was in agreement with the findings of Cheema et al. (1977).

It can be observed from the results that the effect of levels of potash was not significant. But increasing potash level from 25 kg K_2O/ha to 75 kg K_2O/ha had recorded an increase of 11.4 per cent in the number of pods produced per plant.

(3) <u>Percentage of pegs developed to pods</u>

(Table 10(a) and 10(c), Fig. 4, Appendix V)

As the interval between irrigation became closer, the percentage of pegs developed into pods was significantly increased. Eventhough the total number of pegs produced per plant remained uniform under various irrigation levels, the number of pods produced per plant was more in well irrigated plots which resulted in an increase in the percentage of pegs developed to pods.

Results also indicated that application of phosphorus upto 50 kg P_2O_5/ha had significantly enhanced the percentage of pegs developed in to pods. Though the number of pegs and number of pods produced per plant was not significantly increased by higher levels of phosphorus, it could be observed that more number of pegs were converted into pods at higher levels of phosphorus. Thus the significant role of phosphorus in converting more number of pegs into pods was revealed.

The number of pegs and number of pods produced per plant were tended to increase with higher levels of potash but the development of pegs into pods was not found to be significantly influenced by levels of potash since the percentage of pegs developed to pods remained uniform.

The interaction effect of irrigation and phosphorus was significant in influencing the percentage of pegs developed into pods. The highest per cent was observed in I_1P_2 (Irrigation at 0.6 IW/CPE ratio and 75 kg P_2O_5/ha)and the lowest in I_1P_0 (Irrigation at 0.6 IW/CPE ratio and 25 kg P_2O_5/ha).

(4) Weight of mature pods per plant

(Table 10(a), Appendix V)

The results show that higher frequencies of irrigation had significantly enhanced the weight of mature pods per plant. Frequent irrigations had produced more number of pods per plant (Table 10(a), increased the weight of 100 pods (Table 11) and produced bolder kernals. The cumulative affect of irrigation on these characters had contributed to the observed increase in the yield of pods per plant.

From the results it is clear that phosphorus application upto 50 kg P_2O_5/ha had increased the weight of mature pods per plant. A further increase to 75 kg P_2O_5/ha had resulted in no further increase in the pod weight per plant. Phosphorus at this enhanced level had produced a marginal increase in the number of pods produced per plant (Table 10(a))and significantly increased the weight of 100 pods and 100 kernals (Table 11) as compared to 25 kg P_2O_5/ha. The increase in the weight of mature pods per plant was due to the cumulative effect of phosphorus on these characters. Similar results were also reported by Dalal et al. (1967), Dahatonde and Rahate (1974), Nair (1978), Patil et al. (1979).

Additional doses of potash had significantly enhanced the per plant pod yield. The cumulative effect of higher number of mature pods per plant (Table 10(a)) and increased 100 pod weight and 100 kernal weight (Table 11) at higher levels of potash had contributed to the increased per plant pod yield. The result is in conformity with the earlier findings of Veeraraghavan (1964) and Nair (1978) under Kerala conditions.

(5) <u>Weight of 100 pods and 100 kernals</u>

(Table 11, Fig. 4, Appendix VI)

It can be observed from the results that irrigation had significantly improved 100 pod weight and 100 kernal weight. The adverse effect of water deficit on the various physiological activities such as translocation of assimilates to the reproductive parts might have contributed to the reduced 100 pod weight and 100 kernal weight in plants under stress. This occurs mainly due to the adverse effects of water stress on the rate of assimilation, rate of utilization, loading and unloading of sieve elements and the

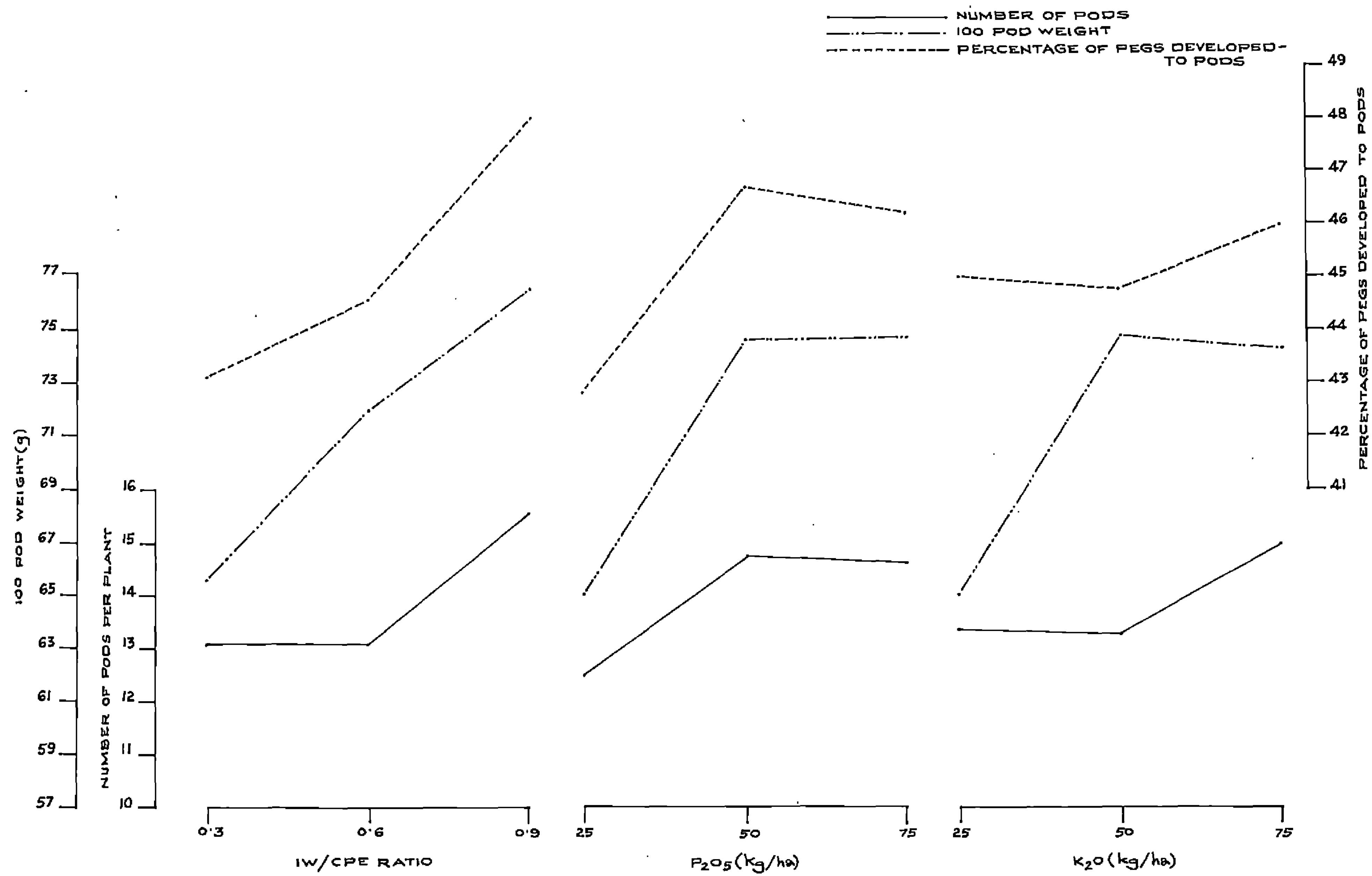


FIG. 4. NUMBER OF PODS PER PLANT, 100 POD WEIGHT AND PERCENTAGE OF PEGS DEVELOPED TO PODS AS AFFECTED BY LEVELS OF IRRIGATION, PHOSPHORUS AND POTASH

velocity of assimilate movement in the sieve tube (Begg and Turner, 1976). The results are in agreement with the findings of Mantell and Goldin (1964), Gorbet and Rhoades (1975), Mante (1976), Cheema et al. (1977) and Reddy (1980).

Increasing the levels of phosphorus had increased 100 pod weight and 100 kernal weight significantly. Phosphorus is considered as essential to seed formation and is found in large quantities in seed and fruit (Tisdale and Nelson, 1975). Similar results were also reported by Reddy et al. (1975), Nair (1978), Patil et al. (1979) and Shelke and Khupse (1980).

The result shows that application of higher levels of potash had increased both 100 pod weight and 100 kernal weight significantly. Potassium plays an important role in the carbohydrate and nitrogen metabolism and synthesis of proteins and in the formation of oils. This effect of potassium might have helped in increasing 100 pod weight and 100 kernal weight. This is in agreement with the findings of Lechover and Arnon (1964), Muraleedharan (1971), Deshpande (1974) and Nair (1978).

(6) <u>Shelling percentage</u>

(Table 11, Appendix VI)

As observed from the results, irrigation levels had significantly increased shelling percentage. This might be due to the production of bolder kernals at higher frequencies of irrigation. Similar results were also reported by

Krishnaswamy et al. (1964), Boote et al. (1976) and Varnell et al. (1976).

The nonsignificant effect of phosphorus on shelling percentage was reported by Cheema et al. (1977), Narasimhan et al. (1977) and Patil et al. (1979) and this is in corroboration with the findings of the present study. The effect of potash on shelling percentage was not significant and this is in agreement with the findings of Nair (1978). But an improvement in shelling percentage was noted in this study, at higher levels of potash, which was also reported by Deshpande (1974).

(7) Yield of pod per hectare

(Table 12(a), Fig.5, Appendix VI)

It can be observed from the results that an increase in irrigation frequency enhanced pod yield significantly. Irrigating at an IW/CPE ratio of 0.9 had recorded an yield increase of 23.3 per cent over 0.3 ratio. These ratios received eight and three irrigations respectively. Thus by giving five additional irrigations the yield can be increased by about 685 kg/ha. Irrigation had markedly improved the weight of mature pods per plant, number of pods per plant (Table 10(a)) and 100 pod weight and 100 kernel weight and the cumulative effect of all these characters ultimately contributed to the higher per hectare yield. The results are in corroboration with the findings of Bhavanisankar Rao (1955), Krishnaswamy et al.

(1964), Mohan (1970), Lenka and Misra (1973), Ali et al. (1974), Subramonian et al. (1974), Cheema et al. (1977), Dahatonde (1978), Birajdar and Ingle (1979) and Reddy (1980) who recommended optimum moisture conditions for maximum yield in groundnut.

Higher doses of phosphorus had significantly increased groundnut pod yield. Increasing the application of phosphorus from 25 kg P_2O_5 to 75 kg P_2O_5/ha had significantly increased pod yield but the yield at 50 kg and 75 kg P_2O_5 were on par. Phosphorus application had improved the number of pods per plant (Table 10(a)) and significantly increased the weight of pods per plant (Table 10(a)), 100 pod weight and 100 kernal weight (Table 11). The cumulative effect of all these characters were responsible for the increased per hectare pod yield due to the application of higher doses of phosphorus. Similar results were also reported by Sathyanarayana and Rao (1962), Pathak and Varma (1964), Katarakki and Bahabatti (1965), Kulkarni et al. (1967), Puntamkar and Bathkal (1967), Naidu (1968), Kumar and Venkatachari (1971), Tripathi and Moolani (1971), Mahapatra et al. (1973), Muraleedharan (1971), Punnoose and George (1974), Jayadevan and Sreedharan (1975a) and Nair (1978).

Application of higher doses of potash had increased pod yield significantly. Higher doses of potash significantly increased weight of mature pods per plant (Table 10(a)), weight of 100 pods and 100 kernals (Table 11) and marginally improved the number of pods per plant. The cumulative effect of these characters had contributed to the maximum per hectare yield of pods at higher doses of potash. This is in agreement with the findings of Sreedharan and George (1968), Mohapatra et al. (1973), Muhammed et al. (1973), Jayachandran et al. (1975), Gopalaswamy et al. (1976), Reddy et al. (1977) and Nair (1978).

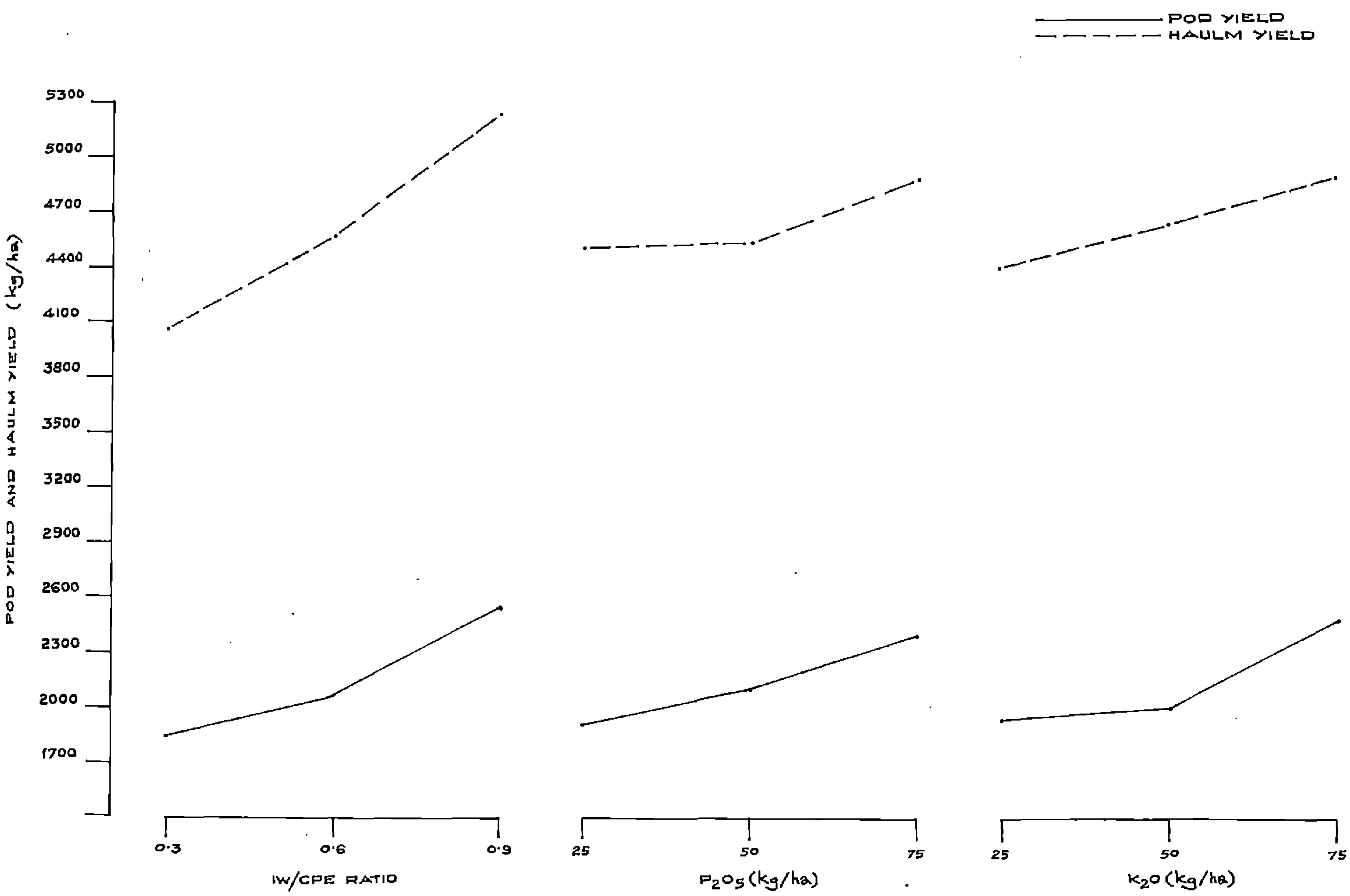
It can be seen from Table 21 that pod yield shows positive and significant correlations with number of pods per plant, 100 pod weight and 100 kernel weight and also with nitrogen, phosphorus and potassium uptake.

(8) <u>Haulm yield per hectare</u>

(Table 12(a) and 12(b), Fig. 5, Appendix VI)

It can be seen from the results that frequent irrigations had significantly enhanced haulm yield. The growth characters like height of plants, number of leaves per plant and dry matter production per plant were markedly increased by frequent irrigations which might have contributed to the increased haulm yield. Further increased LAI at higher levels of irrigation might also have helped in increasing haulm production by increasing the rate of assimilation by photosynthesis. The result is in agreement with the findings of Krishnaswamy et al. (1964), Lenka and Misra (1973), Gopalaswamy et al. (1974) and Subba Rao et al. (1974).

FIG. 5. POD YIELD AND HAULM YIELD AS AFFECTED BY LEVELS OF IRRIGATION, PHOSPHORUS AND POTASH.



The results show that higher levels of phosphorus significantly enhanced haulm yield. An increase in the growth characters like height of plants, number of leaves produced per plant and dry matter production at higher doses of phosphorus might have caused an increase in haulm yield. Similar results were also reported by Bhan (1977), Nair (1978) and Yayock (1979).

Higher doses of potash increased haulm yield significantly. The significant influence of potash in increasing the height of plants, number of leaves per plant and dry matter production per plant had ultimately resulted in increased haulm yield. This finding is in corroboration with the findings of Brady and Colwell (1945), Comber (1959), Nair (1978) and Rao (1979).

The I x K interaction was found to be significant. The highest yield was observed in I_2K_1 (Irrigation at 0.9 IW/CPE ratio and 50 kg K_2O/ha) and the lowest in I_0K_0 (Irrigation at 0.3 IW/CPE ratio and 25 kg K_2O/ha). The beneficial effect of irrigation in combination with potash fertilization was thus brought out.

C. Quality factors

1. Protein content of kernel and kernel protein yield per hectare

(Table 13, Appendix VII)

It can be seen from the results that the protein content of kernel was not influenced by irrigation whereas the kernel protein yield per hectare was significantly increased by irrigation. The significant effect of irrigation on kernal protein yield was due to its significant effect on yield of kernals.

Eventhough the protein content of kernal was not significantly influenced by levels of phosphorus, it increased kernal protein yield significantly. The significant effect of phosphorus on kernal protein yield was due to the significant effect of this nutrient on the yield of kernals. The non significant effect of phosphorus levels on protein content of kernal was also reported by Nijhawan (1962), Chesney (1975) and Dimitrov and Georgiev (1976).

As observed from the results, the kernal protein yield was significantly increased by levels of potash whereas the protein content remain unaffected. Increased kernal yield at higher levels of potash increased the kernal protein yield. The nonsignificant effect of potash on protein content was reported by Chesney (1975) and Nair (1978) which agrees with the present study.

2. Oil content of kernals and oil yield per hectare

(Table 13, Appendix VII)

It can be noted from the results that oil content of kernals and oil yield per hectare were improved with higher levels of irrigation. The formation of oil from the photosynthetic products of the plant will largely depend upon the quantity of mineral nutrient available to the plant and an optimum moisture condition will improve the nutrient availability. It can be seen that oil content of kernal is positively correlated with potassium uptake. Increased oil content and kernal yield at higher levels of irrigation increased the per hectare oil yield. The findings observed in this study are in corroboration with that of Saini et al. (1973), Narasimhan et al. (1977) and Shanmugasundaram et al. (1979).

Application of phosphorus upto 50 kg P_2O_5/ha had increased the oil content but a further increase to 75 kg P_2O_5/ha had decreased the same. The favourable influence of Phosphorus on oil content was reported by Sathyanarayana and Rao (1962), Reddy et al. (1973) and Jayadevan and Sreedharan (1975b). Narasimhan et al. (1977) observed a reduction in oil content beyond an optimum level of phosphorus which is in agreement with the present study. Oil yield was significantly improved at higher levels of phosphorus and 75 kg P_2O_5/ha had recorded the maximum oil yield. Eventhough the oil content was decreased at 75 kg P_2O_5/ha, the loss was compensated by the higher oil yield due to the higher kernal yield.

It can be observed from the results that oil content of kernals and oil yield were significantly increased by higher levels of potash. The increased oil content due to higher levels of potash may be due to its influence on the activation of fat producing enzymes. Increased oil content and kernal yield at higher potash levels increased per hectare oil yield. Similar results were also reported by Sathyanarayana and Rao (1962), Verma and Bajpai (1964), Pande et al. (1971), Roy and Chatterjee (1972) and Nair (1978).

D. Chemical composition and nutrient uptake

(1) Nitrogen content in plant parts

(Table 14(a) to 14(c), Appendix VIII)

It can be observed from the results that nitrogen content in plant parts were not significantly influenced by irrigation at any of the stages. But a general decrease in nitrogen content can be observed in plant parts under high irrigation treatments. Since the plant becomes more succulant under high soil moisture regimes, the decrease in the concentration of nitrogen occurs as a dilution effect. Verma and Subba Rao (1975) also made similar observations.

Nitrogen content in plant parts were not influenced by phosphorus or potash levels at any of the stages. Even if the nitrogen uptake was increased at higher levels of phosphorus and potash, the nitrogen concentration in the plant remained uniform, due to its dilution by increased growth. The nonsignificant effect of phosphorus and potash levels on nitrogen content was also reported by Walker (1975), Deshpande (1974) and Habeebullah et al. (1977).

The I x P interaction was significant in influencing nitrogen content in plant parts at 30th and 60th day after sowing. I_0P_1 (Irrigation at 0.3 ratio and 50 kg P_2O_5/ha) and I_2P_0 (Irrigation at 0.9 ratio and 25 kg P_2O_5/ha) had recorded the maximum and I_2P_1 (Irrigation at 0.9 ratio and 50 kg P_2O_5/ha) and I_2P_2 (Irrigation at 0.9 ratio and 75 kg P_2O_5/ha) had recorded the minimum nitrogen contents at 30th and 60th day after sowing respectively. The I x K interaction was significant at 30th day after sowing. I_2K_0 (Irrigation at 0.9 ratio and 25 kg K_2O/ha) had recorded the maximum and I_2K_2 (Irrigation at 0.9 ratio and 75 kg K_2O/ha) had recorded the minimum nitrogen contents.

The P x K interaction was significant at 60th day after sowing. The maximum nitrogen content was recorded by P_0K_1 (25 kg P_2O_5 and 50 kg K_2O/ha) and the minimum by P_1K_2 (50 kg P_2O_5 and 75 kg K_2O/ha).

(2) <u>Phosphorus content in plant parts</u>

(Table 16(a) and 16(b), Appendix IX)

It can be seen from the results that phosphorus content in plant parts were significantly decreased at higher levels of irrigation at 30th day after sowing and at harvest. But plant growth was found to be more at higher levels of irrigation. Since the nutrient concentration was dropped as plant growth was increased, it can be inferred that nutrient availability has not kept pace with growth. Similar trend was also noted in plant material at 60th day after sowing and in kernel and shell at harvest.

The result shows that phosphorus content in plant parts were not significantly influenced by levels of phosphorus at any of the stages. Increased growth of the plant parts at higher levels of phosphorus especially at later stages of the crop might have reduced the concentration of phosphorus, eventhough the total phosphorus uptake was high at these doses. The results are in corroboration with the findings of Deshpande (1974) and Georgiev (1977).

Phosphorus content in plant parts at all the stages were decreased by higher levels of potash eventhough this effect was not significant at 30th day after sowing and in shell at harvest. Increased growth stimulated by higher levels of potash might have resulted in a decreased concentration of phosphorus. Similar findings were reported by Deshpande (1974) and Nair (1978).

The I x K and P x K interactions were significant. Among combinations, between irrigation and potash, I_2K_0 (Irrigation at 0.9 ratio and 25 kg K_2O/ha) and I_2K_1 (Irrigation at 0.9 ratio and 50 kg K_2O/ha) had recorded the maximum and minimum phosphorus contents respectively. Among P x K interaction maximum phosphorus content was recorded by P_1K_0 (50 kg P_2O_5 and 25 kg K_2O/ha). The minimum contents were recorded by P_1K_1 (50 kg each of P_2O_5 and K_2O/ha) and P_1K_2 (50 kg P_2O_5 and 75 kg K_2O/ha).

(3) <u>Potassium content in plant parts</u>

(Table 18(a) and 18(b), Appendix X)

It can be seen from the results that potassium content in plant was significantly increased by irrigation at 30th day after sowing only. It may be due to the increased availability of potassium to plants at higher levels of irrigation. This trend was maintained in shoots at later stages also. The nonsignificant effect of irrigation on potassium content in plants at later stages may be due to the increased dry matter production at these stages. Hence the nutrient availability could not keep pace with the high growth as a consequence of which resulted in a decrease in the nutrient concentration in plant parts.

As observed from the results, phosphorus application did not significantly influence potassium content in plants at any of the stages. It might be due to increased growth at higher levels of phosphorus which reduced the concentration of potassium, even though the total potassium uptake was significantly increased. Similar results have been reported by Walker (1973) and Deshpande (1974).

The potassium content in the plant parts, except in kernel, were found to be significantly increased by the application of higher levels of potash. The increase in potassium concentration at higher levels of potassium might be due to its increased availability to plant at these doses. It could be observed that successive levels of potash had helped the continued absorption of this nutrient upto the highest dose applied. Similar results have been reported by Lachover and Arnon (1964), Nakagawa et al. (1966), Puntamkar and Bathkal (1967), Walker (1973), Habeebullah et al.(1977) and Nair (1978).

The I x K interaction was found to be significant at 30th day after sowing. The maximum potassium content was recorded by I_1K_2 (Irrigation at 0.6 IW/CPE ratio and 75 kg K_2O/ha) and the minimum by I_0K_0 (Irrigation at 0.3 IW/CPE ratio and 25 kg K_2O/ha).

The interaction between phosphorus and potassium was found to be significant at 30th day after sowing. The highest potassium content was recorded by P_1K_2 (50 kg P_2O_5 and 75 kg K_2O/ha) and the lowest by P_1K_0 (50 kg P_2O_5 and 25 kg K_2O/ha).

(4) <u>Uptake of nitrogen</u>

(Table 15(a), 15(b) & Appendix XI)

The results show that though there was no significant effect due to irrigation on nitrogen uptake at the early stage, the effect was significant at later stages. The effect of irrigation was not significant in influencing the nitrogen content and dry matter production at 30th day after sowing. This causes the nonsignificant effect of irrigation on nitrogen uptake at 30th day. Eventhough the nitrogen content of plant parts did not vary significantly due to irrigation levels, increased nitrogen uptake at later stages was due to the significant effect of irrigation on vegetative growth and pod yield. Thus it could be inferred that sufficient soil moisture in soil helped the availability of nitrogen in soil which resulted in its increased absorption by plant.

The nonsignificant effect of phosphorus on nitrogen uptake at the early two stages and that of potash at the early stage was due to the nonsignificant effect of these nutrients on nitrogen content and dry matter production at these stages. Increased dry matter production at higher doses of phosphorus and potash had resulted in the significant increase in nitrogen uptake by the plant at later stages. The results are in agreement with the findings of Puntamkar and Bathkal (1967), Bhan (1977) and Vali et al. (1978) who observed increased nitrogen uptake at higher levels of phosphorus and with that of Narasimhan and Surendran (1978) and Nair (1978) who reported increased nitrogen uptake at higher levels of potash.

P x K interaction was found to be significant at 60th day after sowing. P_0K_2 (25 kg P_2O_5 and 75 kg K_2O/ha) and P_0K_0 (25 kg P_2O_5 and 25 kg K_2O/ha) had recorded the maximum and minimum nitrogen uptake respectively.

The effect due to interaction between irrigation and potash was found to be significant at harvest. I_2K_0 (Irrigation at 0.9 ratio and 25 kg K_2O/ha) and I_0K_0 (Irrigation at 0.3 ratio and 25 kg K_2O/ha) had recorded the maximum and minimum nitrogen uptake at this stage respectively.

(5) Uptake of phosphorus

(Table 17(a) and 17(b), Appendix XI)

The effect of irrigation schedules on phosphorus uptake was found to be significant at all stages except at 30th day after sowing where only a trend was observed. In general, eventhough the phosphorus content was found to be significantly more at lower moisture levels, the phosphorus uptake was higher at higher levels of irrigation, which might be due to the increased dry matter production at these stages.

The nonsignificant effect of phosphorus on phosphorus content and dry matter production at 30th and 60th day after sowing resulted in the nonsignificant effect of this nutrient on its uptake at these stages. At harvest stage phosphorus uptake was more at higher levels of phosphorus. The increased dry matter production at higher levels of phosphorus resulted in a proportionate increase in phosphorus uptake. Puntamkar and Bathkal (1967), Bhan (1977), Vali et al. (1978) and Nair (1978) also observed increased phosphorus uptake due to phosphorus fertilization in groundnut.

It can be seen from the results that phosphorus uptake was significantly improved at higher levels of potash at 60th day after sowing and at harvest. Since the dry matter production was also improved at higher levels of potash at these stages, it might have resulted in a proportionate increase in phosphorus uptake. Similar result was also reported by Nair (1978).

I x K and P x K interactions were found to be significant at 60th day after sowing. The highest phosphorus uptake was recorded by I_2K_2 (Irrigation at 0.9 ratio and 75 kg K_2O/ha) and the lowest by I_0K_0 (Irrigation at 0.3 ratio and 25 kg K_2O/ha). Among the combinations of phosphorus with potash P_1K_2 (50 kg P_2O_5 and 75 kg K_2O/ha) and P_0K_0 (25 kg P_2O_5 and K_2O each/ha) had recorded the maximum and minimum nutrient uptakes respectively.

(6) <u>Uptake of potassium</u>

(Table 19, Appendix XII)

It can be seen from the results that irrigation had significantly influenced potassium uptake at all stages. The cumulative effect of increased potassium content and dry matter production might have resulted in the increased potash uptake at higher moisture levels. This might further be due to increased potassium availability at higher moisture levels.

The results show that higher levels of phosphorus increased potash uptake only at the later stage. The nonsignificant effect of phosphorus levels on potassium content and dry matter production might have resulted in the nonsignificant effect of this nutrient on potassium uptake at early stages. Eventhough the potassium content did not very significantly the production of larger amount of dry matter might have contributed to the increased potassium uptake at later stage under higher levels of phosphorus. Increased potassium uptake at higher levels of phosphorus was also reported by Puntamkar and Bathkal (1967) and Nair (1978).

It can be observed from the results that higher levels of potash increased its uptake at all stages of crop growth. Since higher levels of potash increased its availability in soil, continued absorption of this nutrient upto the highest dose applied was observed. This resulted in increased nutrient content in plant parts and higher dry matter production. The cumulative effect of these led to an increased potassium uptake. Puntamkar and Bathkal (1967), Narasimhan and Surendran (1978) and Nair (1978) also observed similar findings.

E. Soil analysis

(a) Total nitrogen content of the soil after the experiment (Table 20(a) and 20(b), Appendix XIII)

As seen from the results, the total nitrogen content in the soil after the experiment was not significantly influenced by levels of irrigation, phosphorus or potash.

From Table 9, it can be observed that higher levels of irrigation and potash had significantly increased the number and dry weight of nodules per plant which would have increased nitrogen fixation in soil. Since an increase in total nitrogen content did not occur, it can be assumed that plants receiving higher levels of these inputs might have utilised this nutrient better in larger quantities, which was evidenced by the increased nitrogen uptake at higher levels of irrigation, phosphorus and potash (Table 15(a)).

The combined effect of irrigation and potash in increasing the nodulation might have led to the significant interaction effect of irrigation and potash in increasing the total nitrogen content of soil.

(b) Available phosphorus content of the soil after the experiment

(Table 20(a), Appendix XIII)

Levels of irrigation and potash did not significantly influence the available phosphorus content in soil. Even if the phosphorus availability was increased at higher levels of irrigation and potash, as reported by Sharma and Yadav (1976), the increased uptake at these levels might be the reason for the phosphorus content to remain uniform at different levels of irrigation and potash. In the case of applied phosphorus an increase in the available phosphorus content to the tune of 21.8 per cent was observed when the phosphorus application was increased from 25 kg P_2O_5/ha to 75 kg P_2O_5/ha. The favourable influence of phosphorus application in increasing the phosphorus content in soil was also reported by Bains (1967), Sharma and Yadav (1976).

(c) Available potassium content of the soil after the experiment

(Table 20(a), Appendix XIII)

An increased potassium uptake might have led to a decreasing trend in available potassium content in soil at higher levels of irrigation. The effect of phosphorus application was not significant in influencing the available potassium content in soil.

Potassium content of the soil was found to be significantly increased by the application of higher doses of potash. This shows the need for potash manuring to increase the content of available potassium in soil to meet the crop needs. Bains(1967) also observed build up of available potassium content in the soil by the application of potash fertilisers.

Response curve for phosphorus and potash levels and economics of irrigation scheduling and phosphorus and potash application.

The response of groundnut to phosphorus application was found to be significant and it was linear viz.,

$$\hat{Y} = 9.78a + 1655.666$$

Similarly, the response to potassium application was also found to be linear viz., $\hat{Y}$ = 10.8x + 1605.333.

The economics of irrigation schedules and phosphorus and potash application is presented in Table 22 . Since there was linear increase in pod yield with higher levels of irrigation, phosphorus and potash, the maximum net profits were obtained at the highest levels of irrigation, phosphorus and potash. The maximum net profits of Rs.3096.00, Rs.2222.90 and Rs.3102.90 were obtained by scheduling irrigations at 0.9 IW/CPE ratio and by the application of 75 kg P_2O_5/ha and 75 K_2O/ha respectively.

Table 22. Economics of Irrigation schedules and fertilizer application

Treatments	Cost of production excluding the treatment	Additional cost of treatments	Total cost of production	Yield of pods (kg/ha)	Value of pods	Additional profit from the treatment over the lowest level	Net profit
	Rs. Ps	Rs. Ps	Rs. Ps		Rs. Ps	Rs. Ps	Rs. Ps
IW/CPE ratio							
0.3	2676.50	210.00	2886.50	1848.00	4620.00	-	1733.50
0.6	2676.50	350.00	3026.50	2054.00	5135.00	375.00	2108.50
0.9	2676.50	560.00	3236.50	2533.00	6332.50	1362.50	3096.00
P_2O_5 (kg/ha)							
25	2799.60	125.00	2924.60	1910.00	4775.00	-	1850.40
50	2799.60	250.00	3049.60	2125.00	5312.50	412.50	2262.90
75	2799.60	375.00	3174.60	2399.00	5997.50	972.50	2822.80
K_2O (kg/ha)							
25	2954.60	47.50	3002.10	1940.00	4850.00	-	1847.90
50	2954.60	95.00	3049.60	2016.00	5040.00	142.50	1990.40
75	2954.60	142.50	3097.10	2480.00	6200.00	1255.00	3102.90

Cost of one irrigation = Rs.70.00
Price of 1 kg P_2O_5 = Rs. 5.00
Price of 1 kg K_2O = Rs.1.90
Price of 1 kg pod = Rs.2.50

SUMMARY

SUMMARY

An investigation was undertaken at the Agronomic Research Station, Chalakudy, attached to the Kerala Agricultural University, during the period from 17th January 1980 to 25th April 1980 to study the response of groundnut to graded doses of phosphorus (25, 50 and 75 kg P_2O_5/ha) and potassium (25, 50 and 75 kg K_2O/ha) under different schedules of irrigation (0.3, 0.6 and 0.9 IW/CPE ratios). The experiment was laid out in a 3^3 factorial experiment with two replications. The higher order interactions IPK^2 and IP^2K^2 were partially confounded in replication I and II respectively. The results of the experiment are summarised below.

1. Higher levels of irrigation had significantly increased plant height at all the stages of crop growth. Plant height was not significantly affected by levels of phosphorus whereas it was increased with higher levels of potash at 60th day after sowing and at harvest.

2. The number of branches per plant was significantly increased by irrigation schedules only at 60th day after sowing while phosphorus and potash had no effect on this character.

3. Irrigation schedules and levels of potash had significantly affected number of leaves per plant at 60th day after sowing and at harvest, respectively, whereas the

effect of phosphorus was not found to be significant.

4. LAI was significantly increased by irrigation schedules at 30th and 60th day after sowing and by levels of potash at 60th day after sowing. Phosphorus had no effect on this character.

5. Irrigation schedules and levels of potash had significantly increased dry matter production per plant at 60th day after sowing and at harvest whereas the effect of phosphorus was significant only at harvest. P x K interaction was found to be significant in influencing dry matter production at 60th day after sowing.

6. An increase in the number of nodules was observed at higher levels of irrigation and the dry weight of nodules were superior at higher levels of irrigation and potash. Phosphorus had no significant effect on number and dry weight of nodules/plant.

7. Only P x K interaction had significantly influenced the number of total pegs per plant.

8. Irrigation schedules alone had significantly increased the number of pods per plant.

9. The percentage of pegs developed to pods was significantly influenced by levels of irrigation and phosphorus and by I x P interaction. Potash had no significant effect on this character.

10. Weight of mature pods per plant was significantly increased by levels of irrigation, phosphorus and potash.

11. A significant increase in the weight of 100 pods and 100 kernels was observed with higher levels of irrigation, phosphorus and potash.

12. Shelling per cent was favourably influenced by irrigation schedules. Phosphorus and potash levels had no effect on this character.

13. Pod yield and haulm yield per hectare were significantly increased with higher levels of irrigation, phosphorus and potash. The highest pod yield of 2533 kg/ha, 2399 kg/ha and 2480 kg/ha were obtained by scheduling irrigation at 0.9 ratio and by the application of 75 kg P_2O_5/ha and 75 kg K_2O/ha, respectively. I x K interaction was found to significantly influence haulm yield.

14. Protein content of kernel was not significantly influenced by levels of irrigation, phosphorus or potassium or by any of their interactions.

15. Levels of irrigation, phosphorus and potassium had significantly influenced the oil content of kernel.

16. Kernal protein yield and oil yield per hectare were increased with higher levels of irrigation, phosphorus and potassium.

17. Nitrogen content in plants at 30th and 60th day after sowing and in haulm, shell and kernal at harvest were not significantly affected by irrigation schedules or by phosphorus or potassium application. Nitrogen content in plants at 30th day after sowing was affected by I x P and

I x K interactions and that in plants at 60th day after sowing was affected by I x P and P x K interactions.

18. Phosphorus content in plants at 30th day after sowing and in haulm at harvest were only significantly influenced by irrigation and it showed a decrease with higher levels of irrigation. Phosphorus content in none of the plant parts were significantly influenced by phosphorus application while potash application had significantly decreased phosphorus content in plants at 60th day after sowing and in haulm and kernel at harvest. The I x K and P x K interactionshad significantly influenced phosphorus content in haulm.

19. Potassium content was significantly increased by levels of irrigation only in plants at 30th day after sowing. Phosphorus application did not significantly affect potassium content in plant parts at none of the stages while potash application had significantly increased potassium content in plants at 30th and 60th day after sowing and in haulm and shell at harvest. I x K and P x K interactions were found to be significant in influencing potassium content in plants at 30th day after sowing.

20. Nitrogen uptake by the crop at 60th day after sowing and at harvest were significantly increased by higher levels of irrigation and potassium. Phosphorus influenced nitrogen uptake only at harvest. P x K interaction at 60th day after sowing and I x K interaction at harvest were

significant in influencing nitrogen uptake.

21. Phosphorus uptake by the crop at 60th day after sowing and at harvest were significantly increased by higher levels of irrigation and potash. Phosphorus application had increased phosphorus uptake only at harvest. I x K and P x K interactions were significant in influencing phosphorus uptake at 60th day after sowing.

22. Potassium uptake by the crop at all the stages of crop growth were significantly increased by higher levels of irrigation and potash while higher levels of phosphorus increased phosphorus uptake only at harvest.

23. The total nitrogen content of the soil after the experiment was found to be significantly influenced by the I x K interaction.

24. There was no significant effect on the available phosphorus content of the soil after the experiment with different levels of irrigation, phosphorus and potash and their interactions.

25. Available potassium content in the soil after the experiment was found to be significantly increased by the application of higher levels of potash.

26. Pod yield was significantly and positively correlated with hauln yield, yield attributes and nitrogen, phosphorus and potassium uptake.

Oil content was significantly correlated with potash uptake.

27. The maximum net profit of Rs.3096.00, Rs.2822.90 and Rs. 3102.90 were obtained by irrigations at IW/CPE ratio of 0.9, 75 kg P_2O_5/ha and 75 kg K_2O/ha, respectively.

The present investigation indicates that scheduling irrigation to groundnut is to be done in Kerala at an IW/CPE ratio of 0.9 and this requires eight irrigations at an approximate interval of 12 days. Groundnut requires 50 kg P_2O_5/ha and 75 kg K_2O/ha for better yields under irrigated conditions.

Future line of work

Critical periods for irrigation to groundnut during summer season under different soil conditions of Kerala needs detailed investigations.

REFERENCES

REFERENCES

Ali, A.M., Chandramohan, J. and Shantha, R. (1974). Response of groundnut to different moisture regimes and farm yard manure. Madras Agric. J. 61(8): 472-476.

Anonymous (1973). Annual Progress Report, The All India Coordinated scheme for water management and soil salinity, Coimbatore Centre, pp. 20-24.

Anonymous (1975a). Annual Progress Report, Integrated project for Research on water management and soil salinity, Coimbatore Centre, pp. 72-82.

Anonymous (1975b). Annual Progress Report, All India Coordinated Research Project on water management and soil salinity, Mahatma Phule Krishi Vidyapeeth, Rahuri, pp. 18-22.

Anonymous (1977). Annual Progress Report, Integrated Project for Research on water management and soil salinity, Bhavanisagar, pp. 19-23.

Anonymous (1978a). Farm Guide. Farm Information Bureau, Trivandrum, pp. 160.

Anonymous (1978b). Annual Progress Report, Integrated Project for Research on water management and soil salinity, Regional Research Station, Dharwad, pp. 20-23.

Anonymous (1978c). Annual Progress Report, Integrated Project for Research on water management and soil salinity, Punjab Agricultural University, Ludhiana, pp. 30-32.

Anonymous (1978d). Package of Practices recommendations. Kerala Agricultural University, Mannuthy, pp.41-42.

Anonymous (1979a). Annual Progress Report, Integrated Project for Research on water management and soil salinity, Bhavanisagar, pp. 20-22.

Anonymous (1979b). Annual Progress Report, Integrated Project for Research on water management and soil salinity, Andhra Pradesh Agricultural University, Hyderabad, pp. 4-7.

Anonymous (1980a). Annual Progress Report, Coordinated Project for Research on water management, Konkan Krishi Vidyapeeth, Dapoli, pp. 26-30.

Anonymous (1980b). Annual Progress Report, Coordinated Project for Research on water management, Tamil Nadu Agricultural University, Coimbatore, pp. 37-43 and 79-82.

Baino, K.S. (1967). Effect of applied nutrients on soil fertility, chemical composition and yield of field beans. Indian J. Agron. 12(2): 200-206.

Banerjee, H.D., Das, M. and Bhattacharjee, T.K. (1967). Nutrition of lateritic zone groundnut in West Bengal. Fert. News. 12(9): 41-42.

Begg, E.J. and Turner, N.C. (1976). Crop water deficits. Adv. Agron. 28: 161-207.

Bhan, S. (1977). Nutrient uptake by groundnut (Arachis hypogaea L.) as influenced by variety, spacing and soil fertility on desert soil. Indian J. Agric. Res. 11(2): 65-74.

Bhan, S. and Misra, D.K. (1970). Effect of variety, spacing and soil fertility on root development in groundnut under arid conditions. Indian J. Agric. Sci. 40(12): 1050-1055.

Bhavanisankar Rao, M. (1955). Groundnut irrigation experiment. Madras Agric. J. 38(9): 388-391.

Bhuiya, Z.H. and Chowdhury, S.U. (1974). Effect of N, P, K and S on the protein and oil content of groundnut grown in Brahmaputra flood plain soil. Indian J. Agric. Sci. 44(11): 751-754.

Birajdar, J.M. and Ingle, V.N. (1979). Studies on the watering and N and P fertilization requirements of summer groundnut crop. Indian J. Agron. 24(1): 7-9.

*Boote, K.J., Varnell, R.J. and Duncan, W.G. (1976). Relationships of size, osmotic concentration and sugar concentration of peanut pods to soil water. Proceedings soil and crop Sci. Soc. of Florida. 35: 47-50.

Brady, N.C. and Colwell, W.E. (1945). Yield and quality of large seeded type peanuts as affected by potassium and certain combinations of potassium, magnesium and calcium. J. American Soc. Agron. 37(6): 429-441.

Cheema, S.S., Minhas, K.S., T ripathi, H.P. and Kundra, H.C. (1977). The effect of applying phosphorus and nitrogen to groundnut under different regimes of soil moisture. J. Res. Punjab Agric. Univ. 14(1): 9-14.

Chesney, H.A.D. (1975). Fertiliser studies with groundnut on the brown sands of Guyana. II Effect of nitrogen, phosphorus, potassium and gypsum and timing of phosphorus application. Agron. J. 67: 7-10.

*Chesnoy, H.A.D. and Diyaljee, R.B. (1969). Yield response of peanuts to fertilizer nitrogen, phosphorus and potassium on the brown sands of Guyana. Agric. Res. Guyana. 3: 111-115.

Chopra, S.L. and Kanwar, J.S. (1976). Analytical Agricultural Chemistry. Kalyani Publishers, Ludhiana. pp..339.

Choudhary, C.H. V.V.S.K. (1977). Studies on the effect of different levels of nitrogen, phosphorus and potassium on growth, yield and quality of irrigated groundnut (TMV 2). Thesis Abstracts 3(4): 30-31.

Comber, R. (1959). Effect on the groundnut of variation in supply of potassium, calcium and magnesium. Nature. 184(4691): 1003.

Dahatonde, B.N. (1978). Response of varying levels of irrigation and NP fertilization on summer groundnut. J. Maharashtra Agric. Univ. 3(2): 137-138.

Dahatonde, B.N. and Rahate, V.T. (1974). Effects of levels and methods of phosphate fertilization on the yield and yield contributory characters of summer groundnut. Punjabrao Krishi Vidyapeeth Res. J. 3(1): 1-4.

Dalal, J.L., Gill, G.S. and Saini, J.S. (1967). Effects of hoeing-weeding-cum-manuring on the yield of rainfed groundnut in Punjab. Indian J. Agron. 12(3): 309-313.

Deshpande, P.C. (1974). Growth, uptake of nutrients and yield of groundnut (Arachis hypogaea) as influenced by graded levels of NPK. Postgraduate Inst. J. 1: 24.

Dholaria, S.J. and Joshi, S.N. (1972). Effect of high and low fertilization on variability in groundnut. Indian J. Agric. Sci. 42(6): 467-470.

*Dimitrov, I. and Georgiev, S. (1976). Effect of nitrogen and phosphorus on oil and protein contents in seeds of groundnut. Rasteniev dul Naukl. 13(10): 108-112.

Doku, E.V. (1970). Effect of day length and water on nodulation of cowpea (Vigna unguiculata) in Ghana. Exp. Agric. 6(1): 13-18.

Dudde, K.B., Malewar, G.V. and Gaffar, S.A. (1979). Studies on the effect of nitrogen, phosphorus and moisture and alkali levels on dry matter production and concentration of nutrients in groundnut. J. Maharashtra Agric. Univ. 4(2): 161-164.

*Georgiev, S. (1977). Effect of nitrogen and phosphorus application on the intensity of nitrogen, phosphorus and potassium accumulation in groundnut. Pochvozenie i Agrokhimiya. 12(1): 81-92.

Goldberg, S.D., Gornat, B. and Sadan, D. (1967). Relation between water consumption of peanuts and Class A Pan evaporation during the growing season. Soil Sci. 104(4): 289-296.

*Goldin, E. and Har-tzook, A. (1966). The effect of fertilization on the vegetative and reproductive development of Virginia bunch improved groundnuts. Oleagineux 21(1): 17-20.

Gopalakrishnan, S. and Nagarajan, S.S. (1958). Macronutrient deficiency studies on groundnut. Indian Oilseeds J. 2(1): 5-9.

Gopalaswamy, N., Elangovan, R. and Morachan, Y.B. (1976). Potash needs of irrigated groundnut. Indian Potash J. 1(4): 10-12.

Gopalaswamy, N., Elangovan, R. and Nagarajan, . (1977). Effect of NPK on the yield of rainfed bunch groundnut. Indian Potash J. 2(3): 7-12.

Gopalaswamy, N., Elangovan, R. and Rajah, C. (1978). Potash and production of pods in irrigated bunch groundnut (Arachis hypogaea L.). Indian Potash J. 3(2): 8-13.

Gopalaswamy, N., Loganathan, N.S., Sivasankaran, D., Shanmugasundaram, S. and Morachan, Y.B. (1974). Impact of canal irrigation on the yield of groundnut in the Parambikulam Aliyar Project area. Madras Agric. J. 61(9): 807-808.

Gorbet, D.W. and Rhoades, F.M. (1975). Response of two peanut cultivars to irrigation and kylar. Agron. J. 67(3): 373.

*Gutstein, Y. (1978). Response of groundnuts to potassium fertilization and its absorption pattern from the soil profiles. Hassadeh. 58(10): 1967-72.

Habeebullah, B. (1973). Studies on the influence of potassium and calcium on the nutrient availability, yield and chemical composition of groundnut (POL.1) in the alluvial and red soils of Tamil Nadu. M.Sc.(Ag.) Thesis submitted to Tamil Nadu Agricultural University.

Habeebullah, B., Ramanathan, G., Loganathan, S. and Krishnamoorthy, K.K. (1977). Effect of calcium and potassium application on the composition of nutrient elements in groundnut. Madras Agric. J. 64(3): 158-161.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, pp. 1-498.

Jayachandran, V., Natarajan, A., Krishnamurthy, V.S. and Thandavarayan, K. (1975). Potash Newsletter. 9(4): 4-10.

Jayadevan, R. (1970). Studies on the performance of groundnut var. Asiriya Mwitunde under graded doses of nitrogen and phosphorus at Vellayani. M.Sc.(Ag.) Thesis submitted to University of Kerala.

Jayadevan, R. and Sreedharan, C. (1975a). Effect of nitrogen and phosphorus on Asiriya Mwitunde groundnut in Kerala. Agric. Res. J. Kerala. 13(1): 74-79.

Jayadevan, R. and Sreedharan, C. (1975b). Effect of nitrogen and phosphorus on Asiriya Mwitunde groundnut in Kerala. Agric. Res. J. Kerala. 13(2): 123-127.

Katarakki, B.H. and Banahatti, A.L. (1965). Effect of nitrogen, phosphorus and potassium on yields of groundnut in black soils of Mysore State. Indian Oilseeds J. 9(1): 50-57.

Khan, G.Z. and Morey, D.K. (1980). Influence of kaolin spray on transpiration and water use efficiency of groundnut (Arachis hypogaea L.) under different soil moisture regimes. J. Maharashtra Agric. Univ. 5(2): 131-134.

Khare, N.K. and Rai, M.M. (1968). Effect of phosphorus on symbiotic fixation of nitrogen by leguminous crops. J. Indian Soc. Soil Sci. 16(2): 111-114.

Krishnaswamy, P., Viswanathan, P.S., Pearan, S.N. and Govindadas, G. (1964). Effect of irrigation frequencies on certain economic characters of groundnut. Madras Agric. J. 51(2): 62.

Kulkarni, K.R. (1980). Scope for increasing production of important oil seed crops under rainfed conditions through use of fertilizers and its economics. Fert. News. 25(10): 21-27.

Kulkarni, K.R., Kulkarni, M.V., Koraddi, V.R., Sadashivaiah, T., Onkaraiah, K.M. and Raju, S. (1977). Response of groundnut to fertilizer and moisture conservation under dry farming conditions in Bijapur district. Mysore J. Agric. Sci. 11(2): 248-253.

Kulkarni, L.G., Yusuf Sharif and Sarma, V.S. (1967). Asiriya Mwitunde groundnut gives good results at Hyderabad. Ind. Fmg. 27(2): 9-12.

Kumar, M.A. and Venkatachari, A. (1971). Studies on the effect of intra row spacings and fertility levels on the yield and quality of two varieties of groundnut (Arachis hypogaea L.). Indian J. Agric. Res. 5(2): 67-73.

*Lachover, D. and Arnon, I. (1964). Influence on groundnut of potassium deficiency in certain soils. Effect on quality and foliar diagnosis at the end of cultivation. Oleagineux. 19(6): 391-395.

Lenka, D. and Misra, P.K. (1973). Response of groundnuts (Arachis hypogaea L.) to irrigation. Indian J. Agron. 18(4): 492-498.

*Lin, H., Chen, C. and Lin, C.Y. (1963). Study of drought resistance in the virginia and spanish types of peanuts. J. Agric. Assoc. China. 43: 40-51.

Mahapatra, I.C., Rajendra Prasad, Krishnan, K.S., Goswami, N.N. and Bapat, S.R. (1973). Response of rice, jowar, maize, bajra, groundnut and castor to fertilizers under rainfed conditions on farmers' fields. Fert. News. 18(8): 18-20.

*Monte, E.F.G. (1976). Suitable soils for grain legume production. In proceedings of the Joint University of Ghana Council for scientific and Industrial Research Symposium on grain legumes in Ghana. pp. 7-23.

*Mantell, A. and Goldin, E. (1964). The influence of irrigation frequency and intensity on the yield and quality of peanuts (Arachis hypogaea). Israel J. Agric. Res. 14(4): 203-210.

*Matlock, R.S., Garton, J.E. and Stone, J.F. (1961). Peanut irrigation studies in Oklahoma, 1956-1959. Bull. B. 580 Oklahoma agric. Exp. Station. pp. 19.

Middleton, G.K., Colwell, W.E., Brady, N.C. and Schultz, E.F. (1945). The behaviour of four varieties of peanuts as affected by calcium and potassium variables. J. American Soc. Agron. 37(6): 443-457.

Mishra, C.M. (1977). Response of groundnut (Arachis hypogaea Linn.) to various levels of phosphorus. Thesis Abstracts. 3(4): 38.

Modha, V.V. and Singh, B.C. (1980). Constraints of groundnut production in India and suggestive remedial measures. Seeds and Farm. 6(11): 3-6.

Mohan, J.C. (1970). Bhavanisagar experiments shows the way: Efficient water management for groundnut. Indian Fmg. 19(10): 9-11.

Muhammad, S.V., Ramachandran, M. and Ramanathan, Y. (1973). Fertiliser response and yield potential of TMV-7 groundnut. Indian J. Agric. Sci. 43(1): 67-69.

Muraleedharan, A. (1971). Effect of phosphorus and molybdenum on the yield and other plant characters of groundnut variety. POL.1. M.Sc.(Ag.) Thesis submitted to University of Kerala.

Muthuswamy, S. (1973). Effect of application of nitrogen, phosphorus and potassium on nodulation of groundnut plants. Fert. News. 18(2): 45-47.

Naidu, N.A. (1968). Studies on groundnut on black soils in the Nagarjunasagar project, Andhra Pradesh. Madras Agric. J. 55(8): 344-350.

Nair, N.P. (1978). Studies on the performance of two groundnut varieties, TMV-2 and TMV-9, under graded doses of phosphorus and potassium. M.Sc.(Ag.) Thesis submitted to Kerala Agricultural University.

Nair, K.S., Ramaswamy, P.P. and Perumal, R. (1971). Studies on the case of poor nodulation in groundnut in soils of Tamil nadu. Madras Agric. J. 58(1): 5-8.

*Nakagawa, J., Scoton, L.C., Almeida, T.D.E.C. and Neptune, A.M.L. (1966). NPK manuring, liming and foliar diagnosis of groundnut. Anais Esc. Sup. Agric. Luiz Queiroz. 23: 36-77.

Narasimhan, C.R.L., Nagarajan, C., Elangovan, R. and Surendran, R. (1978). The effect of moisture regimes on the nutrient contents in groundnut (Arachis hypogaea). Oils and Oilseeds J. 31(2): 25-26.

Narasimhan, R.L., Subba Rao, I.V. and Singa Rao, M. (1977). Effect of moisture stress on response of groundnut to phosphate fertilization. Indian J. Agric. Sci. 47(11): 573-576.

Narasimhan, C.R.L. and Surendran, R. (1978). Influence of split application of potash on a groundnut variety for table purposes. Indian Potash J. 3(1): 15-18.

Nijhawan, M.L. (1962). Effect of application of manures on the composition of groundnut crop I. Change in the important constituents of groundnut seed affecting its quality in trade. Indian Oilseeds J. 6(2): 123-129.

*Ochs, R. and Wormer, T.M. (1959). Influence of water supply on the growth of groundnuts. Oleagineaux. 14(5): 281-291.

*Omueti, J.O. and Oyenuga, A. (1970). Effect of phosphorus fertilizer on the protein and the essential components of the ash of groundnuts and cowpeas. W. Afr. J. biol. appl. chem. 13(1): 14-19.

*Ono, Y., Nakayama, K. and Kubota, M. (1974). Effects of soil temperature and the soil moisture in the podding zone on pod development of groundnut plants. Proceedings of the crop Sci. Soc. of Japan. 43(2): 247-251.

Pande, D., Misra, S.N. and Padhi, S.C. (1971). Response of groundnut varieties to varying levels of fertility. Indian J. Agron. 16(2): 249-250.

Panikkar, M.R. (1961). Balanced fertilizer application gives record groundnut yields. Fert. News. 6(6): 22-25.

Pathak, G.N. and Verma, G. (1964). Studies on the cultural and manurial requirement of groundnut in Uttar Pradesh. Indian Oilseeds J. 8(2): 164-167.

Patil, V.J. (1968). Effect of nitrogen and phosphorus on yield of groundnut in Gujarath. Fert. News. 13(5): 24-27.

Patil, S.B., Patil, G.D. and Salunkhe, R.K. (1976). Economics of fertilizer application in groundnut cultivation. Oilseeds J. 6(1 and 2): 55-56.

Patil, V.C., Radder, G.D. and Kudasomannavar, B.T. (1979). Effect of zinc, iron and calcium under varying levels of phosphorus on groundnut. Mysore J. Agric. Sci. 13: 395-399.

Pawar, K.R. and Khupse, V.S. (1978). Response of groundnut to nitrogen and phosphorus and economics of resultant yield surfaces. Indian J. Agron. 23(1): 27-30.

Perumal, R., Venkataraman, C.R., Krishnamoorthy, K.K. and Ramaswami, P.P. (1978). Rhizobia and phosphorus incorporation influence the oil content of groundnut (Arachis hypogaea L.). Oils and Oilseeds J. 30(4): 19-20.

Phanishai, G., Rajashekaran B.G. and Sanjeevaiah, B.S. (1969). Response of groundnut to fertilizers under rainfed conditions in red loam soils. Mysore J. Agric. Sci. 3(4): 410-415.

Prasad, R. and Mahapatra, I.C. (1970). Crop response to potassium on different Indian soils. Fert. News. 15(2): 48-56.

Punnoose, K.I. and George, C.M. (1974). Studies on the effect of nitrogen and phosphorus on the yield and quality of groundnut in the red loam soils of Kerala. Agric. Res. J. Kerala. 12(2): 151-157.

Punnoose, K.I. and George, C.M. (1975). Effect of applied nitrogen and phosphorus on the nodulation of groundnut. Agric. Res. J. Kerala. 13(2): 169-174.

Puntamkar, S.S. and Bathkal, B.G. (1967). Influence of nitrogen, phosphorus and potassium fertilizers on composition, growth and yield of groundnut. Ind. J. Agron. 12(4): 344-350.

Puri, D.N. (1969). Groundnut responds well to superphosphate. Fert. News. 14(7): 46-47.

Raheja, R.K., Labana, K.S. and Jaswal, S.V. (1979). Role of groundnut in nutrition. Farmer and Parliament. 14(1): 19-20.

Raheja, S.K., Selhand, G.R. and Bapat, S.R. (1970). Crop response to potassic fertilizers under different agro-climatic and soil conditions. Fert. News. 15(2): 15-33.

Raju, M.S. (1977). Studies on the effect of different levels of irrigation, plant population and phosphorus on groundnut (TMV 2). Thesis Abstracts. 3(3): 140.

Rao, P.N. (1977). Effect of fertility levels, inter and intra row spacing on the yield of AH.1192 groundnut (Arachis hypogaea L.). Thesis Abstracts. 3(1): 18-19.

Rao, S.R. (1979). Studies on the effect of potassium, calcium and magnesium on growth and yield of irrigated groundnut (TMV-2). Thesis Abstracts. 6(4): 259-260.

Rao, P.V., Venkatachari, A. and Ananda Reddy, K. (1976). Consumptive use of oil seed crops in winter. Oilseeds J. 6(2): 28-33.

Rathee, O.P. and Chahal, R.S. (1977). Effect of phosphorus and sulphur application on the yield and chemical composition of groundnut (Arachis hypogaea L.) in Ambala soils. Haryana Agric. Univ. J. Res. 7(4): 173-177.

Reddy, G.B. (1980). Studies on frequency and depth of irrigation water for groundnut. Thesis Abstracts. 6(2): 87-89.

Reddy, N.M., Havanagi, G.V. and Hegde, B.R. (1978). Effect of soil moisture level and geometry of planting on the yield and water use of groundnut. Mysore J. Agric. Sci. 12(1): 50-55.

Reddy, A.S., Nageswara Reddy, M. and Sankara Reddy, G.H. (1977). Potash needs of rainfed groundnut. Indian Potash J. 2(2): 17-21.

Reddy, G.P. and Rao, C.S. (1965). Fertilizer response in groundnut. Indian Oilseeds. J. 9(4): 274-279.

Reddy, A.J. and Rao, I.M. (1968). Preliminary studies on the effect of progressive water stress on growth and yield of groundnut (Arachis hypogaea L.). Andhra Agric. J. 15(5): 123-127.

Reddy, G.H.S. and Reddy, M.N. (1977). Efficient use of irrigation water for wheat and groundnut. Mysore J. Agric. Sci. 11(1): 22-27.

*Reddy, V.M. and Tanner, J.W. (1978). The effect of irrigation, innoculant type and nitrogen fertilizer on nitrogen fixation and yield of spanish groundnuts. Proceedings of American Peanut Research and Education Association. 10(1): 74.

Reddy, G.B.S., Yanda Goudar, B.A. and Sindagi, S.S. (1973). Soil and foliar application of phosphate fertilizer to rain fed groundnut (Arachis hypogaea L.). Indian J. Agron. 18(3): 260-263.

Reid, P.H. and York, E.T. Jr. (1958). Effect of nutrient deficiencies on growth and fruiting characteristics of peanuts in sand cultures. Agron. J. 50(1): 63-67.

Roy, B. and Chatterjee, B.N. (1972). Effect of soil conditions with and without NPK fertilizers on the utilization of soil potassium. J. Indian Soc. Soil Sci. 20(3): 271-280.

Roy, R.N. and Kanwar, I.S. (1979). Importance of phosphorus in balanced fertilization in India. Fert. News. 24(6): 12-25.

Russel, E.W. (1973). Soil conditions and plant growth. Longman Group Ltd., London, 10th Edition, pp. 1-810.

Sahu, S.K. and Behera, B. (1972). Note on the effect of rhizobium inoculation on cowpea, groundnut and green gram. Indian J. Agron. 17(4): 359-360.

Saini, J.S. and Sandhu, R.S. (1973). Yield and quality of groundnut as affected by irrigation and fertilizer levels. J. Res. Punjab Agric. Univ. 10(2): 179-183.

Saini, J.S. and Tripathi, H.P. (1975). Effect of nitrogen and phosphorus levels on the yield and quality of groundnut (Arachis hypogaea L.). Oilseeds J. 5(3): 3-6.

Saini, J.S., Tripathi, H.P. and Cheema, S.S. (1973). Effect of soil moisture and fertilizer levels on groundnut. Ind. J. Agron. 28(3): 362-365.

Sandhu, R.S., Saini, J.S. and Tirath Singh (1972). The effect of irrigation and fertilizer levels on the yield and quality of groundnut C-501. J. Res. Punjab Agric. Univ. 9(4): 535-540.

Sathyanarayana, P. and Rao, D.V.K. (1962). Investigation on the mineral nutrition of groundnut by the method of foliar diagnosis. Andhra Agric. J. 9(6): 329-43.

Saxena, D.K., Dixit, P.K. and Chandola, R.P. (1972). Estimates of leaf area in bunch type of groundnut (*Arachis hypogaea* L.). Sci. Cult. 38(8): 368-369.

Shanmugasundaram, V., Jayapal, P., Govindan, T.S. and Madhava Rao, S. (1979). Irrigation study on TMV-7 groundnut (*Arachis hypogaea* L.). Farm Sci. 6(5): 10-14.

Sharma, B.M. and Yadav, J.S.P. (1976). Availability of Phosphorus to gram as influenced by phosphate fertilization and irrigation regime. Indian J. Agric. Sci. 46(5): 205-210.

Shelke, D.K. and Khupse, V.S. (1980). Response of groundnut (*Arachis hypogaea* L.) to varying levels of irrigation. Phosphorus and antitranspirants in summer. J. Maharashtra Agric. Univ. 5(2): 149-153.

*Simpson, J.E., Adair, C.R., Kohler, G.O., Dawson, E.H., Dobald, H.A., Kester, E.B. and Klick, J.T. (1965). Quality evaluation studies of foreign and domestic rices. Tech. Bull. No. 1331. Service, U.S.D.A. 1-186.

Singh, B.P., Kanwar Singh and Yadava, T.P. (1971). Effect of irrigation and fertilizer levels on the yield and quality of groundnut. Haryana Agric. Univ. J. Res. 1(2): 11-14.

Singh, C. and Pathak, S.S. (1969). Groundnut responds to nitrogen, phosphorus and potassium. Fert. News. 14(2): 26-27.

Singh, B. and Rana, D.S. (1979). The critical limit of available phosphorus for predicting response of groundnut to applied fertilizer phosphorus. J. Indian Soc. Soil Sci. 27(2): 146-149.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical methods. Oxford and IBH Publishing Co., Calcutta 16. 6th Ed. pp. 593.

Sreedharan, C. and George, C.M. (1968). Effect of calcium, potassium and magnesium on growth, yield and shelling percentage of groundnut in red loam soils of Kerala. Agric. Res. J. Kerala. 6(2): 74-78.

*Su, K.C. and Lu, P.C. (1963). The effect of time of irrigation and amount of water irrigated on peanut yield. J. Agric. Assoc. China. 41: 43-51.

Subba Rao, I.V., Narasimhan, R.L. and Uma Malleswara Rao, C. (1974). Effect of moisture stress at different growth stages on yield and oil content of groundnut. Andhra Agric. J. 21(5 and 6): 111-116.

Subramonian, S., Sunder Singh, S.D., Ramaswamy, Packiaraj, S.P. and Rajagopalan, K. (1974). Effect of moisture stress at different growth stages of groundnut. Madras Agric. J. J. 61(9): 813-814.

*Tengire, H.J. (1971). Influence of levels of supplemental irrigations applied at different critical growth phases on quality of groundnut (Arachis hypogaea L.). Poona Agric. College Magazine. 61(½): 22-26.

Tisdale, S.L. and Nelson, W.L. (1975). Soil Fertility and Fertilizers. Macmillan Publishing Co., Inc., N. Y., 3rd Edition. pp. 694.

Tripathi, H.P. and Moolani, M.K. (1971). Response of groundnut to phosphatic and nitrogenous fertilization. Haryana Agric. Univ. J. Res. 1(2): 27-31.

Vali, P.M., Nageswara Reddy, M. and Sankara Reddy, G.H. (1978). Effect of different levels and methods of fertilizer application on rainfed groundnut. Mysore J. Agric. Sci. 12(3): 408-412.

Verma, A.K. and Subba Rao, N.S. (1975). Effect of different levels of soil moisture on growth, yield and some physiological aspects of nodulation in greengram. Indian J. Agric. Sci. 45(1): 11-16.

*Varnell, R.J., Mwandemere, H., Robertson, W.K. and Boote, K.J. (1976). Peanut yields affected by soil water, no till and gypsum. Proceedings Soil and Crop Science Society of Florida. 35: 56-59.

Veeraraghavan, P.G. (1964). Effect of lime and potassium on the yield and quality of groundnut in the red loam soils of Kerala State. M.Sc. (Ag.) Thesis submitted to the University of Kerala.

Verma, J.K. and Bajpai, M.R. (1964). A brief review of mineral nutrition of groundnut in relation to growth, yield and quality. Indian Oilseeds J. 8(3): 222-229.

*Vivekanandan, A.S. and Gunasena, H.P.M. (1976). Lysimetric studies on the effect of soil moisture tension on the growth and yield of maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.) Beitrage Zur Tropischen Landwirtschaft und veterinarmedizin. 14(4): 269-378.

*Walker, M.E. (1973). The effect of rate and method of application of N, P and K on yield, quality and chemical composition of spanish and runner peanuts. Dissertation Abstracts International B 33(7): 2896-2897.

Yadav, J.S. P. (1972). The impact of water management and salinity research in agriculture. Indian Eng. 22(6): 52-58.

Yadav, R. and Singh, D. (1970). Effect of Gypsum on the chemical composition, nutrient uptake and yield of groundnut. J. Indian Soc. Soil Sci. 13(2): 183-186.

Yoyock, J.Y. (1979). Effect of population density and fertilizer level on the economic yield of five varieties of groundnut at three locations in Nigeria. Indian J. Agric. Sci. 49(11): 867-74.

*Original not seen.

APPENDICES

APPENDIX I

Weather data during the crop period and its variation from the last four years (weekly averages).

Meteorology week	Temperature °C				Rainfall (mm)*		Relative humidity (%)		Evaporation (mm)	
	Maximum		Minimum							
	1980	Variation	1980	Variation	1980	Variation	1980	Variation	1980	Variation
3	34.14	+0.98	19.93	-0.18	-	-	86.86	+12.54	4.52	+0.72
4	34.07	+0.41	18.64	-2.56	-	-	75.14	-2.80	4.39	-0.06
5	33.50	-0.47	22.36	+0.07	-	-	74.50	-1.77	4.49	+0.30
6	35.21	+0.64	21.29	-1.01	-	-	76.43	+1.61	4.33	-0.14
7	35.14	+0.84	21.07	-1.02	-	-0.13	74.50	+1.80	4.56	-0.03
8	35.71	+1.03	21.79	-1.62	-	-5.65	79.64	+2.60	4.80	+0.26
9	35.69	+0.22	24.00	-0.17	0.6	+0.60	84.56	+11.37	4.86	-0.08
10	35.21	-0.47	24.14	-0.32	-	-0.10	79.36	+2.84	4.90	-0.11
11	36.29	+0.63	23.36	-1.45	0.6	-1.88	77.43	-1.52	5.43	+0.54
12	36.21	+0.42	24.43	-0.71	-	-3.59	79.21	+1.85	5.39	+0.43
13	36.36	+0.17	25.00	-0.48	4.2	+2.29	75.14	+1.18	5.51	-0.05
14	35.43	-0.28	24.93	-1.16	26.6	+15.45	81.29	+5.30	4.86	-0.30
15	35.29	+0.04	26.79	+1.08	6.4	-17.92	82.93	+5.11	4.54	+0.92
16	35.36	+0.29	25.86	+0.36	17.8	+2.68	77.14	+1.83	5.18	+0.17
17	34.64	-0.54	25.43	+0.36	27.2	+11.79	78.50	+1.98	4.68	-0.27

* Weekly total

Positive sign (+) shows increase over the average data
Negative sign (-) shows decrease over the average data

APPENDIX II

Abstract of analysis of variance table for height of plants and number of branches per plant at different stages.

Source	df	Mean square					
		Height (cm) 30th day after sowing	Height (cm) 60th day after sowing	Height (cm) at harvest	Number of branches at 30th day after sowing	Number of branches at 60th day after sowing	Number of branches at harvest
Block	5	4.081	95.936**	92.928*	1.3128	0.1536	0.2510
I	2	25.443**	455.869**	387.164**	2.2106	0.6450*	0.4237
P	2	1.785	29.264	42.451	1.1199	0.0717	0.0864
I x P	4	1.693	43.427	57.003	0.5185	0.0923	0.2924
K	2	0.069	291.862**	338.653**	0.0046	0.0057	0.0023
I x K	4	0.144	39.959	59.191	0.4217	0.2220	0.2908
P x K	4	0.157	38.255	25.642	0.3695	0.2895	0.2361
I P K	4	3.542	72.819	63.034	0.0738	0.1497	0.3390
I P^2 K	2	4.922	7.846	2.518	0.1404	0.0224	0.0096
I P K^2 ⊙	2	0.328	7.328	6.493	0.4425	0.1145	0.1998
I P^2 K^2 ⊙	2	1.127	24.544	7.138	0.2002	0.2506	0.0973
Error	22	1.946	23.851	32.749	0.6657	0.1501	0.1779

⊙ Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX III

Abstract of analysis of variance table for number of leaves per plant and LAI at different stages

Source	df	Mean square					
		Number of leaves per plant at 30th day after sowing	Number of leaves per plant at 60th day after sowing	Number of leaves per plant at harvest	LAI at 30th day after sowing	LAI at 60th day after sowing	LAI at harvest
Block	5	21.555	218.344**	76.478	1.1821	9.3700**	0.5561
I	2	17.792	306.966**	92.985	2.6957*	20.8271**	4.5566
P	2	24.383	65.454	42.466	0.7549	3.6391	0.1588
I x P	4	10.013	42.664	245.250	0.4465	3.5262	3.6208
K	2	26.801	97.196	795.425*	0.3222	17.7898**	8.8926
I x K	4	15.427	56.068	81.284	0.1962	3.5127	1.6375
P x K	4	19.903	28.096	40.289	0.3426	2.7612	1.8246
I P K	2	8.171	79.650	127.544	0.5175	5.9305*	1.6829
I P^2 K	2	7.539	3.280	861.582*	0.6170	0.2604	5.3160
I P K^2O	2	2.300	40.232	1.340	0.0470	1.9178	0.6231
I P^2 K^2O	2	10.861	7.791	52.952	1.1519	1.3352	0.3715
Error	22	20.577	34.922	204.741	6.5232	1.5530	2.6802

O Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX IV

Abstract of analysis of variance table for dry matter production at different stages and number and weight of nodules per plant at 50 per cent flowering.

Source	df	Mean square: Dry matter production (g/plant) at 30th day after sowing	Dry matter production (g/plant) at 60th day after sowing	Dry matter production (g/plant) at harvest	Number of nodules per plant at flowering	Weight of nodules (mg/plant) at flowering
Block	5	0.3658	3.117	26.865	754.510	507.269
I	2	0.4537	49.907**	221.016**	2214.474**	999.643*
P	2	0.0821	2.423	136.222**	121.284	243.596
I x P	4	0.1362	0.794	26.597	506.973	25.192
K	2	0.1212	34.745**	361.249**	405.021	811.620*
I x K	4	0.0572	2.773	21.773	386.163	79.980
P x K	4	0.1306	5.257*	5.584	314.869	38.820
I P K	2	0.0170	2.333	5.127	542.240	99.297
I P^2 K	2	0.0002	5.601*	28.640	316.146	26.988
I P K^2 O	2	0.0090	8.140**	0.039	549.145	5.140
I P^2 K^2 O	2	0.2595	4.925*	10.010	99.925	150.120
Error	22	0.2707	1.259	19.617	310.756	193.359

O Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX V

Abstract of analysis of variance table for number of pegs, number of pods and weight of mature pods per plant and pod to peg percentage.

Source	df	Mean square			
		Number of pegs per plant	Number of pods per plant	Weight of mature pods (g/plant)	Pod to peg percentage (After angular transformation)
Block	5	164.180**	20.146	13.449**	21.894*
I	2	49.282	38.289*	10.739*	37.578*
P	2	57.403	28.055	13.646*	26.934*
I x P	4	61.724	19.349	2.627	20.846*
K	2	101.335	16.039	27.347**	2.253
I x K	4	69.729	8.797	4.474	11.096
P x K	4	119.481*	21.212	4.687	8.532
I P K	2	133.107*	21.005	0.685	17.862
I P^2 K	2	42.144	4.094	0.973	2.211
I P K^2 ○	2	0.958	1.826	0.331	6.804
I P^2 K^2 ○	2	138.994*	20.756	3.825	11.019
Error	22	36.813	8.837	3.045	6.647

○ Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX VI

Abstract of analysis of variance table for pod yield and haulm yield per ha and 100 pod weight, 100 kernal weight and shelling percentage.

Source	df	Mean square				
		Pod yield (kg/ha)	Haulm yield (kg/ha)	100 pod weight (g)	100 kernal weight (g)	Shelling percentage
Block	5	1577170.9**	741595.0**	131.318	38.799*	68.439**
I	2	2226493.8**	6298431.4**	553.068*	56.934**	207.642**
P	2	1081635.1*	743303.8*	562.805*	63.391**	14.332
I x P	4	394719.9	530565.1	45.595	6.640	3.752
K	2	1532743.6*	1006450.3*	532.845*	47.353*	10.699
I x K	4	208466.8	809944.8**	61.250	4.519	9.845
P x K	4	228971.7	406681.1	70.595	15.370	13.790
I P K	2	95689.7	71767.3	184.106	9.267	5.086
I P^2 K	2	218719.3	334913.9	2.459	3.124	32.593
I P K^2○	2	893673.3	213593.0	4.974	8.853	3.529
I P^2 K^2○	2	18796.2	393011.2	168.557	23.027	12.525
Error	22	268272.9	181126.9	58.236	9.655	14.078

○ Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX VII

Abstract of analysis of variance table for protein and oil content of kernels and kernal protein yield and oil yield per ha.

Source	df	Mean square			
		Protein content (per cent) of kernels	Oil content (per cent) of kernal	Kernal protein yield (kg/ha)	Oil yield (kg/ha)
Block	5	5.165**	8.000	95926.336**	226724.821**
I	2	0.530	46.650**	129781.959**	447097.436**
P	2	0.825	35.600*	52382.764*	114276.865*
I x P	4	1.074	3.015	14160.654	49629.083
K	2	3.625	56.845**	85477.556**	247383.519**
I x K	4	2.253	2.318	6889.047	16912.215
P x K	4	1.340	0.787	9312.932	28002.309
I P K	2	0.713	3.515	4549.216	23585.863
$I\ P^2\ K$	2	1.060	8.822	14419.175	15873.218
$I\ P\ K^2$ ○	2	0.201	1.923	37486.660	100223.727
$I\ P^2K^2$ ○	2	1.596	9.542	1397.872	8046.766
Error	22	1.173	6.696	12919.718	25116.126

○ Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX VIII

Abstract of analysis of variance table for nitrogen content in plant parts at different stages.

Source	df	Mean square				
		Nitrogen content (per cent) in plant at 30th day after sowing	Nitrogen content (per cent) in plant in 60th day after sowing	Nitrogen content (per cent) in haulm	Nitrogen content (per cent) in shell	Nitrogen content (per cent) in kernel
Block	5	0.1111	0.0086	0.0764	0.0511*	0.132**
I	2	0.1107	0.0542	0.0740	0.0067	0.013
P	2	0.1447	0.0294	0.0150	0.0390	0.021
I x P	4	0.9242**	0.2679**	0.0350	0.0240	0.028
K	2	0.0207	0.0498	0.0488	0.0120	0.093
I x K	4	0.2839*	0.0236	0.0558	0.0280	0.058
P x K	4	0.1461	0.1322*	0.0310	0.0380	0.034
I P K	2	0.1248	0.0445	0.0390	0.0090	0.018
I P^2 K	2	0.2153	0.0338	0.0250	0.0020	0.027
I P K^2○	2	0.1518	0.0159	0.0036	0.0130	0.005
I P^2 K^2○	2	0.0958	0.0324	0.0370	0.0380	0.041
Error	22	0.0694	0.0438	0.0320	2.0590	3.006

○ Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX IX

Abstract of analysis of variance table for phosphorus content in plant parts at different stages.

Source	df	Mean square				
		Phosphorus content (per cent) in plant at 30th day after sowing	Phosphorus content (per cent) in plant at 60th day after sowing	Phosphorus content (per cent) in haulm	Phosphorus content (per cent) in shell	Phosphorus content (per cent) in kernel
Block	5	0.0032*	0.0034**	0.0007*	0.0003	0.00060
I	2	0.0053*	0.0005	0.0010*	0.0007	0.00030
P	2	0.0003	0.0004	0.0004	0.0003	0.00002
I x P	4	0.0004	0.0007	0.0004	0.0001	0.00067
K	2	0.0014	0.0045**	0.0009*	0.0001	0.00180**
I x K	4	0.0009	0.0004	0.0008*	0.0002	0.00012
P x K	4	0.0003	0.0006	0.0009*	0.0002	0.00002
I P K	2	0.0002	0.0003	0.0012*	0.0003	0.00007
I P^2 K	2	0.0007	0.0005	0.0003	0.0001	0.00012
I P K^2O	2	0.0005	0.0006	0.0005	0.0005	0.00046
I P^2 K^2O	2	0.0014	0.0001	0.0001	0.0000003	0.00001
Error	22	0.0009	0.0005	0.0002	0.0003	0.00026

O Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX X

Abstract of analysis of variance table for potassium content in plant parts at different stages.

Source	df	Mean square				
		Potassium content (per cent) in plants at 30th day after sowing	Potassium content (per cent) in plants at 60th day after sowing	Potassium content (per cent) in haulm	Potassium content (per cent) in shell	Potassium content (per cent) in kernal
Block	5	0.1977	0.1306	0.0253	0.0284	0.03090*
I	2	4.2645**	0.1596	0.0055	0.0402	0.00045
P	2	0.0813	0.0140	0.0370	0.0153	0.00406
I x P	4	0.1078	0.0194	0.0218	0.0141	0.00608
K	2	2.4735**	0.3556**	0.0896**	0.1042**	0.02198
I x K	4	0.4748**	0.0706	0.0202	0.0067	0.00300
P x K	4	0.2887*	0.0186	0.0495	0.0036	0.00719
I P K	2	0.1273	0.0553	0.0530	0.0039	0.00170
I P^2 K	2	0.0230	0.0318	0.0451	0.0020	0.01680
I P K^2O	2	0.0956	0.0680	0.0110	0.0090	0.01021
I P^2 K^2O	2	0.2483	0.0313	0.0593	0.0161	0.01860
Error	22	0.0940	0.0579	0.0192	0.0139	0.00930

O Partially estimatable

** Significant at 0.01 level

* Significant at 0.05 level

APPENDIX XI

Abstract of analysis of variance table for nitrogen and phosphorus uptake at different stages.

		Mean square					
Source	df	Nitrogen uptake (kg/ha) at 30th day after sowing	Nitrogen uptake (kg/ha) at 60th day after sowing	Nitrogen uptake (kg/ha) at harvest	Phosphorus uptake (kg/ha) at 30th day after sowing	Phosphorus uptake (kg/ha) at 60th day after sowing	Phosphorus uptake (kg/ha) at harvest
Block	5	35.868	204.636*	2139.098**	0.312	3.243**	16.714*
I	2	19.520	2726.297**	9782.450**	0.204	13.437**	67.286**
P	2	14.871	109.662	3714.035**	0.086	0.263	24.186*
I x P	4	27.575	160.842	473.380	0.061	0.741	2.842
K	2	6.791	1915.114**	3268.092**	0.015	5.307**	22.448*
I x K	4	5.898	116.799	1194.220*	0.066	1.100*	10.465
P x K	4	13.491	440.562**	964.273	0.083	1.614*	7.718
I P K	2	0.441	199.109	260.546	0.008	1.008	2.963
I P^2K	2	1.218	179.821	1355.764	0.016	0.858	4.595
I PK^2 O	2	0.278	522.209**	914.096	0.002	4.097**	7.125
IP^2K^2 O	2	14.870	115.279	150.929	0.097	1.612	1.054
Error	22	21.215	69.960	409.263	0.192	0.389	4.269

O Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX XII

Abstract of analysis of variance table for potassium uptake at different stages.

Source	df	Mean square		
		Potassium uptake (kg/ha) at 30th day after sowing	Potassium uptake (kg/ha) at 60th day after sowing	Potassium uptake (kg/ha) at harvest
Block	5	5.667	64.427	28.698
I	2	77.959**	472.045**	919.435**
P	2	0.012	34.613	396.900**
I x P	4	5.019	12.924	109.365
K	2	38.702*	549.852**	1434.661**
I x K	4	5.274	58.356	126.472
P x K	4	10.124	51.526	37.411
I P K	2	3.064	94.754	27.102
I P^2 K	2	1.147	12.389	280.693*
I P K^2 O	2	0.186	121.912*	6.948
I P^2 K^2 O	2	16.857	18.215	38.449
Error	22	8.396	32.870	49.888

O Partially estimable
** Significant at 0.01 level
* Significant at 0.05 level

APPENDIX XIII

Abstract of analysis of variance table for total nitrogen, available phosphorus and available potassium content in soil after the experiment.

Source	df	Total nitrogen content (kg/ha)	Available phosphorus content (kg/ha)	Available potassium content (kg/ha)
I	2	363.593	8.279	343.290
P	2	1119.593	26.583	53.983
I x P	4	806.204	25.363	484.628
K	2	295.815	2.282	3587.308*
I x K	4	9805.926*	6.998	253.566
P x K	4	1469.426	2.192	575.006
Error	8	1660.358	7.649	479.058

*Significant at 0.05 level

RESPONSE OF GROUNDNUT (*Arachis hypogaea* (L.) TO PHOSPHORUS AND POTASSIUM UNDER DIFFERENT WATER MANAGEMENT PRACTICES

By

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ABSTRACT OF A THESIS
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ABSTRACT

An experiment was conducted at Agronomic Research Station, Chalakudy during the summer season of 1979-80 to study the response of groundnut (Arachis hypogaea(L.) to graded doses of phosphorus (25, 50 and 75 kg P_2O_5/ha) and potash (25, 50 and 75 kg K_2O/ha) under different schedules of irrigation (Irrigations at 0.3, 0.6 and 0.9 IW/CPE ratios). The experiment was laid out as 3^3 partially confounded factorial experiment with two replications, confounding IPK^2 in replication I and IP^2K^2 in replication II.

The study revealed the favourable influence of frequent irrigations on growth characters like plant height, number of branches and leaves per plant, LAI, dry matter production per plant and number and dry weight of nodules per plant and through these characters, haulm yield. The yield and yield attributes also showed a significant increase at higher levels of irrigation. The highest yield of 2533 kg/ha was obtained by scheduling irrigation at 0.9 IW/CPE ratio. In general a decrease in phosphorus content could be observed at higher levels of irrigation. Frequent irrigations helped to increase oil content, oil yield and kernel protein yield per hectare. In general, the nitrogen and potassium content in the plant parts were less affected by irrigation. More frequent irrigations had

increased nitrogen, phosphorus and potassium uptake by the crop.

Higher levels of phosphorus had significantly increased dry matter production per plant and haulm yield per hectare at harvest. The yield and yield attributes like 100 pod weight, 100 kernel weight and weight of mature pods per plant were also increased with higher levels of phosphorus. The maximum pod yield of 2599 kg/ha was recorded by 75 kg P_2O_5/ha which was on par with 50 kg P_2O_5/ha (2125 kg/ha). The oil content, kernel protein and oil yield per hectare and the uptake of nitrogen, phosphorus and potassium by the crop were increased at higher levels of phosphorus.

Application of potash at higher doses had increased growth attributes like plant height, number of leaves per plant, LAI, dry matter production and dry weight of nodules per plant, and through these components haulm yield. The yield and yield attributes like 100 pod weight, 100 kernel weight and weight of mature pods per plant were also increased at higher levels of potash. The maximum pod yield of 2480 kg/ha was obtained by the application of 75 kg K_2O/ha. As the potash levels were increased a general decrease in phosphorus content and an increase in potassium content in plant parts were observed. The nitrogen, phosphorus and potassium uptake by the crop were also increased at higher levels of potash. The available potassium content in the soil after the experiment was increased by the application of higher doses of potash.

Positive and significant correlations between pod yield and other characters such as haulm yield, number of pods per plant, 100 pod weight and 100 kernel weight were obtained. The oil content was significantly correlated with potassium uptake.