RESPONSE OF TWO SESAMUM VARIETIES (KAYAMKULAM-1 AND SURYA) TO DIFFERENT PLANT DENSITIES AND NITROGEN LEVELS

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Response of two sesamum varieties (Kayamkulam-1 and Surya) to different plant densities and nitrogen levels" is a bonafide 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 of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
26-12-1988.

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CERTIFICATE

Certified that this thesis entitled "Response of two sesamum varieties (Kayamkulam-1 and Surya) to different plant densities and nitrogen levels" is a record of research work done independently by Sri. Santhosh.P 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

INTRODUCTION

Sesamum is one of the important oil seed crops of India. It also assumes importance as a source of protein and essential aminoacids in human and livestock nutrition. Though India occupies first place in area of this crop with 25 lakh hectares (39.5% of world area), it stands only second in production with 5 lakh tonnes of seeds (24% of world production) as per FAO statistics (Anon, 1983). The reason for low production in India is mainly due to low productivity. The average per hectare yield of sesamum in India is only 283 kg, while the world average is 329 kg/ha. The production potential of this crop is estimated to be around 600-1000 kg/ha under dry land and 1000 - 1200 kg/ha under irrigated conditions.

Research on sesamum appears to have been initiated only from the early twenties in India. Not much work on the agronomy of this crop seems to have been attempted in this country. A review of the research work on this crop revealed that only a fringe of the problems connected with its cultivation has been touched so far.

The research works in most of the states have been confined only to evolving high yielding plant types by selection from the local or acclamatised varieties. As the sesamum crop is grown mostly as a catch crop in a number of states, it had not received adequate attention.

The major constraints in the production of this crop are considered to be low residual moisture level in the soil mainly leading to poor stand of the crop and the low soil fertility. Adequate manuring and maintenance of optimal population are the two most important aspects to be ensured for enhancing the production. A study of the work done on the nitrogen management in this crop revealed that the response to applied nitrogen varied with the variety and the soil condition.

In the case of sesamum there are branching and non-branching genotypes which demand different spacing requirements. (Mazzani and Cobo, 1956). As such, systematic trials on these aspects with different promising

varieties should be undertaken so that results of immediate value to the grower can be generated and the present low level of yields can be stepped up.

The varieties chosen in the present study differ in their branching nature. Kayamkulam-1 is a profusely branching variety whereas Surya is a shy-branching type. Besides, Surya being a new_y evolved high yielding variety not much work on the nutritional requirement of this variety has been done.

With this background, the present investigation was undertaken to achieve the following broad objectives.

(1) To study the comparative performance of the two varieties under different plant densities and nitrogen levels.

(2) To find out the optimum plant population and spacing for the two varieties.

(3) To fix up the optimum dose of nitrogen for the two varieties.

(4) To study the NPK uptake pattern of the two varieties.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In Kerala sesamum is mainly cultivated as a catch crop during the summer season utilising the residual moisture and nutrients and as such the crop gets only little attention. Experimental evidences on the nutrition and spacing of sesamum crop are very meagre in Kerala. A brief review of the work done on the influence of nitrogen and spacing on sesamum and other related crops is presented below.

Influence of applied nitrogen on growth characters

Moursi and Abdel Gawad (1966) reported that increased application of nitrogen resulted in increased dry matter production of leaves, stems and fruits in sesamum. Gopalakrishnan et al (1979) reported that increasing fertilizer levels had a positive effect during early stages of crop growth, but fluctuations were noticed as the crop attained maturity. Pal (1979) observed that the dry matter production was maximum with 80 kg nitrogen per hectare in sunflower. Subramanian et al (1979) found that nitrogen application increased the number of branches per plant in sesamum. The dry matter production was increased upto 60 kg nitrogen per hectare in rainfed mustard (Vir and Verma, 1979). Abdul Rahman et al (1980) concluded that there was increase in plant height with increased nitrogen application in sesamum. Ahmed et al (1985) reported that the plant height and number of branches were increased by increasing rates of applied nitrogen from 0 to 60 kg/ha in safflower.

Maini et al (1965) reported that the dry matter production in mustard under irrigated conditions in a sandy loam soil low in nitrogen and poor in organic matter was not affected by nitrogen application. Bonsu (1977) pointed out that fertilizer nitrogen lowered plant height by 10% below the control in sesamum. Bonsu (1977) concluded that fertilizer nitrogen lowered shoot dry matter production in sesamum.

Influence of applied Nitrogen on yield attributes

Moursi and Abdel Gawad (1966) revealed that nitrogen application increased the number of fruits per plant in sesamum. Rahman et al (1978) observed an increase in the number of heads with increased levels of nitrogen application in safflower and obtained maximum number of heads with the application of 40 kg nitrogen.

According to Singh et al (1978), the number of pods per plant in mustard increased with increased levels of nitrogen application. Subramanian et al (1979) observed an increase in the number of capsules per plant in sesamum with increased levels of nitrogen application. Abdul Rahman et al (1980) correlated the physiological response of sesamum to nitrogen fertilizer and found that the highest number of effective capsules per plant obtained with the application of 45 kg N/ha. Andhule and Kalbhor (1980) reported that 1000 seed weight of sunflower increased with increased application of nitrogen upto 75 kg/ha. Maity et al (1980) observed that increased rate of nitrogen application resulted in an increase in the production of capsules per plant in mustard. Ahmed et al (1985) reported that inflorescences per plant and 1000 seed weight increased by increasing rates of applied nitrogen from 0 to 60 kg/ha in safflower. Singh et al (1985) observed that number of capsules per plant in safflower increased with increase in nitrogen rates from 0 to 60 kg/ha.

Bonsu (1979) studied the effect of fertilizer application on the growth, yield and yield components of sesamum and found that fertilizer application did not significantly increase the number of podding nodes per plant nor the number of mature seeds per pod, though nitrogen tended to increase the seed weight.

Influence of applied nitrogen on seed yield

Rai and Srivastava (1968) conducted manurial trials in sesamum in red loam soils and found that seed yield increased with nitrogen application and optimum level of nitrogen was found to be 22.5 kg/ha. Gaur and Trehan (1973) correlated the studies under Rajasthan condition and found that the highest yield of sesamum was obtained with 30 kg N/ha applied half at sowing and half one month after sowing. Gaur and Trehan (1974) pointed out that in sesamum the seed yield was highest with 50 kg N/ha in Kharif season. Gowda (1974) reported that application of 40 kg N/ha gave the highest seed yield of 1.44 t/ha in sesamum crop. Nair et al (1975) observed that application of 15 kg/ha N in the form of urea half as basal and half through foliage was beneficial for increasing seed yield. Singh and Kaushal (1975) studied the response of rainfed sesamum to fertilizer levels and found that application of 50 kg N/ha increased yields from 431 kg/ha to 617 kg/ha.

Popov et al (1976) reported that application of 100 kg N/ha at the two to three leaf stage of sesamum gave the highest average seed yields. Gowda and Krishnamurthy (1977) observed that application of 60 kg N/ha resulted in the highest seed yield of 772 kg/ha in sesame. Gowda et al (1977) reported that application of 40 kg N/ha gave the highest seed yields in sesamum type K_4.

Reddy (1977) pointed out that seed yields of the sunflower cultivars increased with increase in rates of applied nitrogen from 0 to 120 kg/ha.

Aleshehenko (1978) pointed out that application of 60 kg N/ha along with phosphorus and potassium gave the highest average seed yields of 2.82 t/ha compared to 2.38 t/ha without fertilizer in the case of sunflower. Delgado et al (1978) reported that sesame responds positively to nitrogen. Appropriate rates are of the order of 200 kg urea/ha. Mehrotra et al (1978) studied the response of rainfed sesamum to nitrogen levels and found that average seed yields of sesame increased from 400 to 760 kg/ha with increase in rates of applied nitrogen from 0 to 30 kg/ha and further increase in yield with 45 kg N/ha was not significant. Mukand Singh et al (1978) observed that average seed yields of raya varieties increased with the increased application of nitrogen. Salam et al (1978) reported that the response and productive efficiency of nitrogen decreased with increasing nitrogen rates in sunflower. Satyanarayana (1978) studied the effect of nitrogen on the yield of two gingelly varieties and found that highest seed yield was obtained with the application of 25 kg N/ha. Subramanian et al (1978) studied the effect of applied nitrogen on the nutrient uptake and yield of sesamum and observed response upto 30 kg N/ha.

Arunachalam and Morachan (1979) found that application of 40 kg N/ha gave the highest average seed yield in safflower. Bhan (1979) reported that the yields of two mustard cultivars were greater with the increased application of nitrogen from 0 to 120 kg/ha. Bhosule et al (1979) studied the effect of graded levels of nitrogen on the yield of sunflower variety peredavik and found that average seed yields of sunflower increased from 0.73 to 1.26 t/ha with increase in rate of applied nitrogen from 0 to 50 kg/ha. However, further increase in yield with 78 kg N/ha was not significant. Bishnoi & Kanwar (1979) reported that average seed yields of raya increased from 1 - 1.7 to 1.37 - 2.32 t/ha by increasing the rates of nitrogen application from 30 to 90 kg/ha.

Gangasaran and Kinra (1979) studied the response of rai to nitrogen with and without phosphorus and potassium and found that seed yield increased with increased nitrogen application. Gowda and Gajanan (1979) made studies on the differential response of sunflower to nitrogen levels on red sandy loam soils and found that increasing rates of applied nitrogen from 0-90 kg/ha increased seed yields of sunflower from 1.05 to 1.91 t/ha, further increases in nitrogen rates decreased yields. Gowda et al (1979) indicated that the economical optimum nitrogen rate for sunflower hybrids was 60 kg/ha and further increase was not economical. Kachapur et al (1979) reported that application of 40 kg nitrogen increased seed yields of niger. Kachapur et al (1979) reported an increase in the seed yield of niger from 225 kg to 405 kg/ha with the increased rate of application of nitrogen. Munoz (1979) studied the response of two species of rape to different levels of nitrogenous fertilizers and found that maximum yields were obtained with 200 units of nitrogen. Sadanandan and Sasidhar (1979) studied the response of sesamum variety Kayamkulam-1 to fertilizer application and found that 30 kg nitrogen per ha was optimum for getting higher yield. Saran and De (1979) observed an increase in yield of rape with increased application of nitrogen. Singh and Yusuf (1979) reported an yield increase in brown sarson with the increased application of nitrogen. Subramanian et al (1979) reported that application of 40, 60, 40 kg/ha of nitrogen, phosphoric acid and potash respectively increased seed yield of sunflower compared to no fertilizer application. Thakur and Borulkar (1979) observed that grain yield of sesame was significantly increased with every added level of N over its preceding level. According to Vir and Verma (1979) increasing the rates of nitrogen from 0 to 30 and 60 kg/ha increased the seed yield and yield components in mustard. Studies conducted by Aulakh et al (1980) showed that the grain yield of both yellow mustard and white mustard increased with the increased level of application of nitrogen.

Daulay and Singh (1980) indicated that seed yield of sunflower increased with the increased level of nitrogen. Maity et al (1980) found that application of 50 kg N/ha under rainfed conditions without irrigation significantly increased seed yields in mustard variety Varuna. Patel et al (1980) studied the response of mustard to different levels of nitrogen and found that mustard gave significantly higher seed yields with 50 kg applied N/ha than with 0-25 or 75 kg N/ha. Sheppared and Bates (1980) observed that rape responded to broadcast application of nitrogen with maximum seed yields at 100 kg N/ha independent of sowing date or banded fertilization. Yadav et al (1980) found that the seed yield per plant in 22 sesame cultivars was positively correlated with number of capsules, primary branches per plant and 1000 seed weight. Path coefficient analysis showed that capsules per plant, 1000 seed weight, number of days taken for 50% flowering and primary branches per plant had high direct effects on yield.

Maiti et al (1981) reported that seed yields of six sesame cultivars were increased by increasing nitrogen rates from 0 to 80-120 kg/ha and yields were further increased by adding phosphorus and potassium along with nitrogen. The yields were increased due to an increase in the number of capsules per plant and the capsule size brought about by increased level of nitrogen. Zaidi and Khan (1981) observed that seed yields of sesame were increased by 81 kg/ha by the application of 72 kg urea. Daulay and Singh (1982) observed that seed yield of sesame increased with increasing nitrogen rates from 0 to 60 kg/ha. Ganga Kishan et al (1982) found that application of 50 kg N/ha and 50 kg P/ha was beneficial in getting higher yields in sesamum. Velazquez et al (1983) reported that highest seed yield in sesame was obtained with 100 kg N/ha and the optimum economic dose was 45.4 kg N/ha. Arunachalam and Venkatesan (1984) observed that seed yield of sesamum was highest with 30 kg N/ha as urea. Metwally et al (1984) studied the effect of nitrogen fertilizer on sesame and found that highest seed yield was obtained at the highest rate of nitrogen application (60 kg N/0.42 ha). Sagar and Ray (1984) conducted multiple regression analysis of the indices of yields of oil seed crops such as tori, rai and til and concluded that nitrogen made a significant contribution to yield in oil seed crops. Ahmed et al (1985) reported that seed yields of safflower were increased by increasing rates of applied nitrogen from 0 to 60 kg/ha. Singh et al (1985) reported that safflower showed significant increase in seed yield with increase in nitrogen rates from 0 to 60 kg/ha.

Influence of applied nitrogen on quality attributes

Oil content

Satyanarayana (1978) observed that oil yields of two sesamum cultivars were higher with the application of 25 kg N/ha. Munoz (1979) observed an increase in the seed oil content of rape with the increased application of nitrogen. Metwally *et al* (1984) reported that highest oil production in sesamum was obtained with highest rate of nitrogen application(60 kg/0.42 ha).

Mitchell (1974) observed that increased nitrogen application reduced oil content of mustard. Revenko (1977) reported that different combinations of nitrogen, phosphorus and potassium did not favour an increase in the oil content of sunflower. Bishnoi and Kanwar (1979) studied the oil yield and quality parameters of three raya varieties as influenced by nitrogen levels and found that applied nitrogen decreased the oil content. Singh and Yusuf (1979) studied the effect of nitrogen on oil content of brownsarson and found that oil content was increased by low rates but decreased by higher rates (48-60 kg N/ha) Aulakh *et al* (1980) studied the quality of mustard crops as influenced by nitrogen fertilizer and found that nitrogen had little effect on oil content of grain; but total oil production increased manyfold.

Protein content

Mitchell (1974) found that seed protein content of mustard was increased by increased nitrogen application.

Mitchell *et al* (1974) studied the mineral composition and seed characteristic of sesame as influenced by nitrogen nutrition and found that increased nitrogen application did affect seed quality significantly. Mitchell *et al* (1976) observed an increase in the concentration of individual protein - animoacid with the increased level of nitrogen, in the seeds of sesame.

Skalski (1978) reported that increased levels of nitrogen increased the protein content from 31.15 to 35.9% of the dry matter in white mustard.

Diepenbrock (1979) studied the influence of nitrogen nutrition on qualitative characteristics of seeds of rape (*Brassica napus*) and found that nitrogen application decreased the lipid content during the main growth stages. Nitrogen nutrition significantly changed fatty acid composition only during the early stages of seed growth. At maturity, increased nitrogen application resulted in a trend towards higher contents of palmitic and linoleic acids but a lower oleic acid content. Aulakh *et al* (1980) indicated that protein content of mustard grain improved markedly with applied nitrogen. Ahmed *et al* (1985) observed that the seed protein content of safflower was increased by increasing rates of applied nitrogen from 0 to 60 kg/ha.

Influence of applied nitrogen on the content and uptake of nutrients

Bishnoi and Kanwar (1979) studied the effect of nitrogen levels on the nitrogen, phosphorus and potassium uptake of raya and observed that applied nitrogen increased the nitrogen and phosphorus contents and their uptake. Vir and Verma (1979) found that increasing the rates of nitrogen from 0 to 30 and 60 kg/ha to mustard increased seed nitrogen contents and uptake of total nitrogen. Aulakh et al (1980) observed that nitrogen fertilizer significantly increased the concentration and uptake of nitrogen in mustard crop. Bhati and Rathor (1982) studied the response of Indian mustard to nitrogen fertilization and found that seed yield and uptake with 60 kg N/ha were higher than 20-40 kg/ha.

Reddy and Narayanan (1983) studied the concentration of nitrogen in plant parts of sesame cultivars and observed that nutrient concentration in all vegetative plant parts increased until six weeks after sowing followed by a gradual decline towards maturity. Remobilisation of nitrogen occurred from leaf, stem and root to the pods during the reproductive phase. The nutrient concentration of the leaves was higher than the reported critical concentration through out the growth period, indicating that nutrient status of the crop was more than sufficient.

Influence of spacing on growth and yield attributes

Hoag et al (1968) reported that 53 and 91 cm row spacings resulted in good yield in safflower where as 15 cm row spacing resulted in fewer heads per plant, fewer seeds per head and less weight per 100 seed.

Gaur (1973) reported that for a sesame variety Pratap a row spacing of 40 cm and plant spacing of 15 cm were conducive for better root development. Lazim and ElNadi (1974), studied the effect of population and variety on vegetative growth of sesamum under irrigated conditions and found that nearly two-fold population brings down the leaf area and dry weight of leaves. Plant density however, had no influence on height or production of branches or interaction. Delgado and Yesmanos (1975) studied effect of population densities on yield components of sesame and made the following conclusions. The plant height and height of first fruit were only slightly affected by changes in plant density. More branches were produced at lower densities. Capsule length was smaller and number of seeds was lower only at 2.5 cm plant spacing. Number of capsules and seed yield per plant increased in wider spacings. In the above study the rows were 60 cm apart and spacing between plants on row was 2.5, 7.4, 15.0, 22.5 or 30 cm. Bonsu (1977) reported that close spacing of sesame variety Dulce (7.5 x 60 cm and 15 x 60 cm) increased the leaf area index, crop growth rate and shoot dry matter production but not plant height. The above study also indicated the following. The number of branches per plant, podding nodes per plant, pods per plant and mature seeds per pod decreased with close planting whereas wider spaced plants (22.5 x 60 cm and 30 x 60 cm) produced their first pods at lower height. The 1000 seed weight was not affected by spacing. Thakur and Borulkar (1979) reported that in sesame, all growth attributes except height of plant was negatively influenced by spacing treatments. Kochapur and Radder (1983) reported that niger plants in 60 cm rows tended to produce more number of branches per plant, more capsules per plant, more seeds per capsule and higher seed weight per plant than 30 or 45 cm row spacing. Singh et al (1985) observed that in mustard wider inter and intra-row spacings improved growth and yield attributes.

Mazzani and Cobo (1956) in their studies with different spacings on some characters of branched types of sesamum have experienced very little change due to plant densities in the matter of seed yield, oil per cent, number of branches, plant height and height of the first capsule site. Montilla (1969) studied the effect row spacing (40, 60 and 80 cm) and plant spacing (5, 10 and 15 cm) on the growth and yield of safflower cultivar Gila and found that plant height remained unaffected by any of the treatment combinations.

Influence of spacing on seed yield

Olive and Cano (1954) compared the influence of various spacings and yields of different types of sesamum and found that Columbian types preferred a row width of 60 to 80 cm in contrast to improved varieties requiring 10 to 20 cm for giving similar yields. Narain and Srivastava (1962) observed that a row spacing of 30.5 cm and plant spacing of 15.2 cm is the best for maximising yield from among the treatment combinations of three row spacings and three plant spacings in a sesamum variety M 1-2. Seshadri (1967) reported that a spacing of 22.86 by 22.86 cm is best suited for rainfed sesamum whereas a spacing of 30.48 by 30.48 is the best for irrigated conditions.

Montilla (1969) reported that in safflower highest plant density has been found to give the highest yield.

Whitehead (1969) observed that increase in plant density from 21,780 to 1,74,240 plant per acre resulted in increased yields in sesamum.

Singh and Nema (1972) found that the highest seed rate (6 kg/ha) and the two lower spacings (30 & 37.5 cm) gave the highest yields of sesamum. Gaur and Trehan (1974) observed that in the kharif sesame the yields of sesamum were highest with a spacing of 35 cm between the rows and were lowest with 55 cm between the rows. Gowda (1974) in a trial with three sesame cultivars grown at three spacings observed that cultivar Dharwar local grown at 30 x 10 cm gave the highest seed yield. Singh and Kaushal (1975) reported that sesame grown at intra-row spacings of 15, 20 or 25 cm in rows 25, 35 or 45 cm apart gave the highest seed yield at a spacing of 15 x 45 cm. Gowda and Krishnamurthy (1977) observed that average seed yields with between plant spacings of 10, 20 or 30 cm in rows 30 cm apart were 832.4, 738.8 and 627.7 kg/ha respectively. Bonsu (1977) reported that close spacing of sesame variety Dulce (7.5 x 60 cm and 15.0 x 60 cm) did not increase the final seed yield. Satyanarayana (1978) concluded from a trial that in sesame rows spaced 30 cm apart resulted in highest seed yield as compared to rows spaced 45 cm apart. Daulay and Singh (1982) reported that in the good rainfall year the plant densities (25,000 to 50,000 plants/ha) did not significantly affect the seed yield in rainfed sesame but in the below normal year yield was highest with the lowest plant density. Ganga Kishan et al (1982) observed no significant difference in the yield of sesame for the various row spacings and plant spacings and for their interactions; a spacing of 25 x 20 cm was found to be beneficial in getting higher yields. Velazquez et al (1983) studied the effect of sowing rate of sesame on yield and observed that of all the sowing rates; 2,4 or 8 kg/ha (plant density ranged from 17500 to 71666plants/ha) tried, 6 kg/ha resulted in the highest yield. Rao et al (1985) reported that dibbling seeds at a spacing of 30 x 15 cm gave the highest seed yield as compared to the combinations of 3 row spacings (15, 22.5 or 30 cm) and two plant spacings (10 or 15 cm).

Influence of spacing on seed quality

Gaur (1973) from a trial revealed that for a sesamum variety Pratap a row spacing of 40 cm and a plant spacing of 15 cm were conducive for better seed and oil production. Satyanarayana (1978) reported that the highest oil yield was obtained in irrigated sesamum when grown in rows 30 cm apart as compared to 45 cm row spacing. Thakur and Borulkar (1979) concluded from a study that wider spacing had depressing effect on qualitative aspects while medium spacing (45 x 12 cm) proved beneficial in improving the oil percent and had significant influence on protein percent as compared to closer spacing. Singh et al (1985) reported that narrow row spacing gave higher oil content than wider spacing.

Mazzani and Cobo (1956) in their studies with different spacings on some characters of branched types of sesamum observed very little changes due to plant densities in the oil percent of seeds. Williams (1962) reported that increased spacing in safflower tended to decrease the oil content. Kachapur and Radder (1983) observed that seed protein content was not influenced by row spacing.

MATERIALS AND METHODS

MATERIALS & METHODS

The present investigation was undertaken with the objective of assessing the comparative performance of two sesamum varieties, Kayamkulam-1 and Surya under different plant densities and nitrogen levels and also to study the influence of spacing and nitrogen levels on the growth, yield, oil content, quality, chemical composition and mineral uptake pattern of the above two varieties.

1. MATERIALS

1.1. Experimental site

The experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani. The College is located at 8°N latitude and at an altitude of 29m above mean sea level.

1.2. Soil

The soil of the experimental area is red loam. The data on the physico-chemical properties of the soil of the experimental site are given below.

A. Mechanical composition

Coarse sand	(%) - 13.80
Fine sand	(%) - 33.50
Silt	(%) - 28.00
Clay	(%) - 24.70

B. Chemical composition

pH	- 5.2
Total Nitrogen	- 0.056%
Available Nitrogen	- 160 kg/ha
Available P_2O_5	-38.49 kg/ha
Available K_2O	-53.14 kg/ha

1.3. Cropping history of the field

The experimental area was lying fallow for three months prior to the present investigation and before that it was under a crop of vegetables.

1.4. Season

The experiment was conducted during Rabi Season (from 15th October to 5th January) of the year 1987-88.

1.5. Weather conditions

Data on maximum temperature, minimum temperature, rainfall and relative humidity during the entire crop season were collected from the meteorological observatory of the Instructional Farm and presented as weekly averages in Appendix I and in Fig.1.

In general, the weather conditions were favourable for the satisfactory growth of the crop.

1.6. Varieties

The varieties used for the study were Kayamkulam-1 and Surya (ACV-2).

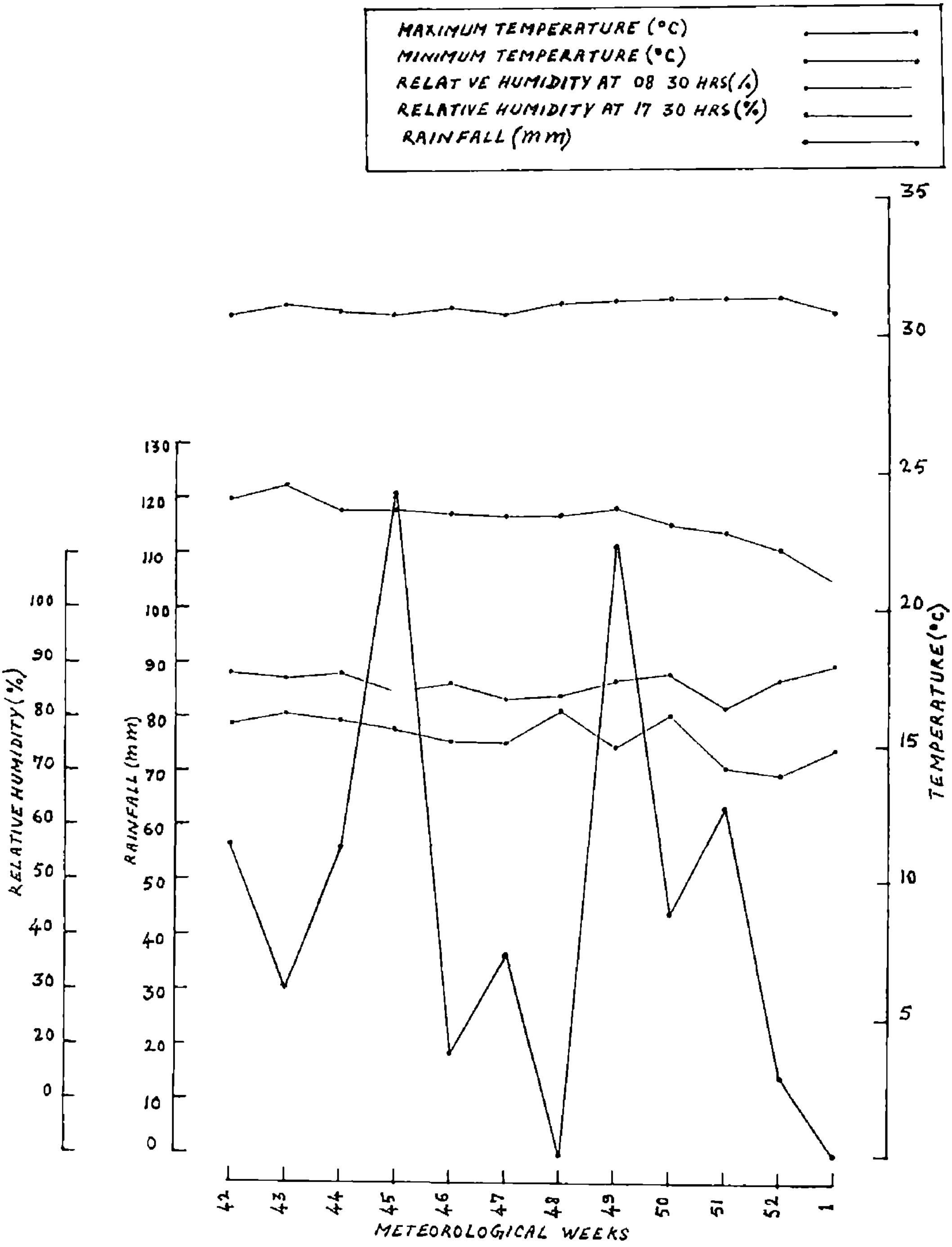
Kayamkulam-1 is a pureline selection from the Onattukara local variety. This is a profusely branching variety and matures in about 75-80 days. The average yield is about 250-300 kg/ha. The seeds were obtained from the Rice Research Station, Kayamkulam.

Surya (ACV-2 or Culture 42-1) is a pureline selection from a West Bengal variety and is a shy-branching variety. It matures in 82 to 87 days and the average yield is about 350 kg/ha. The seeds of this variety were obtained from the Department of Plant Breeding, College of Agriculture, Vellayani.

1.7. Fertilizers

Fertilizers with the following analysis were used for the experiment.

FIG 1 WEATHER DATA DURING CROP PERIOD (OCT 15 1986 TO JAN 6 1988)



Urea - 46 per cent N

Super Phosphate - 16 per cent P_2O_5

Muriate of Potash - 60 per cent K_2O

2. METHODS

2.1. Details of treatments

The treatments consisted of factorial combinations of two varieties and three spacings in the main plots and four levels of nitrogen in the sub plots.

(i) Main plot

Varieties

v_1 - Kayamkulam - 1

v_2 - Surya (ACV-2)

Spacings

s_1 - 30 x 15 cm (2.22 lakh plants/ha)

s_2 - 30 x 10 cm (3.33 lakh plants/ha)

s_3 - 30 x 5 cm (6.66 lakh plants/ha)

Main plot treatment combinations

(i) v_1s_1

(ii) v_1s_2

(iii) v_1s_3

(iv) v_2s_1

(v) v_2s_2

(vi) v_2s_3

(ii) Sub Plot:

Levels of Nitrogen

n_0 - 0 kg N/ha

n_1 -20 kg N/ha

n_2 -40 kg N/ha

n_3 -60 kg N/ha

2.2. Design and Layout

The experiment was laid out in a split-plot design with four replications. Factorial combinations of two varieties and three spacings were allotted to the main-plots and levels of nitrogen to the sub plots. The allocation of various treatments to different plots was done using random numbers. The layout plan is shown in Fig.2.

Gross plot size	- 4.5 x 3 m
Net plot size	- 4.2 x 2.4 m (s_1)
	4.3 x 2.4 m (s_2)
	4.4 x 2.4 m (s_3)
Treatment combinations	- 24 (6 main plots x 4 sub plots)
Replications	- 4
Total number of plots	- 96

2.3. Field culture

FIG 2 LAYOUT PLAN SPLIT PLOT EXPERIMENT

N

$V_2 S n_2$	$V_2 S n_0$	$V_2 S n$	$V_2 S n_3$
$V S_2 n_0$	$V_1 S_2 n$	$V S_2 n_3$	$V_1 S_2 n_2$
$V_2 S_3 n_0$	$V_2 S_3 n_2$	$V_2 S_3 n$	$V_2 S_3 n_3$
$V_2 S_2 n_3$	$V_2 S_2 n_0$	$V_2 S_2 n_1$	$V_2 S_2 n_2$
$V_1 S_3 n_1$	$V S_3 n_2$	$V S_3 n_3$	$V S_3 n_0$
$V S n_2$	$V S n_0$	$V S n_3$	$V S n_1$

REPLICATION 1

$V_2 S_2 n_0$	$V_2 S_2 n_2$	$V_2 S_2 n$	$V_2 S_2 n_3$
$V_2 S_3 n_2$	$V_2 S_3 n_1$	$V_2 S_3 n_0$	$V_2 S_3 n_3$
$V_1 S_2 n_3$	$V_1 S_2 n_0$	$V_1 S_2 n_2$	$V S_2 n_1$
$V_2 S n_1$	$V_2 S n_0$	$V_2 S n_3$	$V_2 S n_2$
$V_1 S_3 n_3$	$V S_3 n_2$	$V_1 S_3 n_0$	$V_1 S_3 n_1$
$V_1 S_1 n_3$	$V S n_2$	$V_1 S n_0$	$V_1 S n_1$

REPL CATION 2

$V_2 S_3 n_0$	$V_2 S_3 n$	$V_2 S_3 n_2$	$V_2 S_3 n_3$
$V_2 S_2 n_3$	$V_2 S_2 n_0$	$V_2 S_2 n_2$	$V_2 S_2 n_1$
$V S_3 n_1$	$V_1 S_3 n_0$	$V S_3 n_2$	$V_1 S_3 n_3$
$V S n_3$	$V_1 S n_2$	$V S n_0$	$V_1 S n_1$
$V_2 S n_0$	$V_2 S n_2$	$V_2 S n_3$	$V_2 S n$
$V_1 S_2 n_0$	$V S_2 n_3$	$V S_2 n_2$	$V S_2 n$

REPLICAT ON 3

$V S_3 n_0$	$V S_3 n_2$	$V S_3 n$	$V S_3 n_3$
$V_2 S n_3$	$V_2 S n_0$	$V_2 S n_2$	$V_2 S_1 n_1$
$V_1 S n_0$	$V S n_3$	$V S n_1$	$V_1 S_1 n_2$
$V_2 S_2 n$	$V_2 S_2 n_2$	$V_2 S_2 n_0$	$V_2 S_2 n_3$
$V_2 S_3 n_2$	$V_2 S_3 n_3$	$V_2 S_3 n_1$	$V_2 S_3 n_0$
$V S_2 n_0$	$V_1 S_2 n_2$	$V_1 S_2 n_3$	$V S_2 n_1$

REPLICATION 4

MAIN PLOT TREATMENTS

VARIETIES V_1 KAYAMKULAM 1
V_2 SURYA

SPACINGS S 30 X 15 cm
S_2 30 X 0 cm
S_3 30 X 5 cm

SUB PLOT TREATMENT

LEVELS OF NITROGEN

n_0 – 0 kg N/ha
n – 20 kg N/ha
n_2 – 40 kg N/ha
n_3 – 60 kg N/ha

2.3.1. Preparation of main field

The experimental plot was dug twice, stubbles removed, clods broken and the field was laid out into blocks and plots.

2.3.2. Fertilizer application

Nitrogen was applied to the sub plots in the form of urea in appropriate quantities according to the treatment schedule. Phosphorus as Superphosphate and potash as Muriate of potash were applied at the rate of 15 kg P_2O_5/ha and 30 kg K_2O/ha respectively. Entire quantity of phosphorus and potash and 75% nitrogen were applied as basal dose one day prior to sowing. The remaining quantity of nitrogen was given as urea spray (3%) 30 days after sowing. In plots where nitrogen was applied at the rate of 20 kg/ha, one spraying was given. The plots applied with 40 kg N/ha received 2 sprayings at 3 days interval and plots applied with 60 kg N/ha received 3 sprayings at 3 days interval.

2.3.3. Seeds and Sowing

The seeds were dibbled in rows spaced 30 cm apart. Within rows the seeds were spaced as per the spacing treatments.

2.3.4. After cultivation

Thinning and intercultural operations were done 15 days after sowing. The second interculture and weeding were done 25 days after sowing.

2.3.5. Plant Protection

Bavistin 0.05% was sprayed to control leaf blight disease during the maturity phase.

2.3.6. Harvesting

The crop was ready for harvest in 83 days after sowing. Harvesting was done by pulling out the plants. Then the root portion was cut and the plants were bundled and stacked for five days. Later the bundles were spread in the sun and beaten with sticks to break the capsules. Drying and threshing were continued for three days more.

3. Observations recorded

The following observations were recorded

3.1. Growth characters

1. Height of plants
2. Number of leaves per plant
3. Number of branches per plant
4. Leaf area index
5. Dry matter production
6. Height to first capsule

3.2. Yield and yield components

1. Number of capsules per plant
2. Length of capsule
3. Number of seeds per capsule
4. 1000 seed weight
5. Seed yield
6. Stover yield
7. Harvest index

3.3. Chemical Analysis

3.3.1. Plant analysis

Plant parts were analysed for nitrogen, phosphorus and potassium on 30th day after sowing, 60th day after sowing and at harvest.

3.3.1.1. Nitrogen content in plant sample

(i) Percentage of nitrogen in plant sample

3.3.1.2. Phosphorus content in plant sample

(i) Percentage of phosphorus in plant sample

3.3.1.3. Potash content in the plant sample

(i) Percentage of phosphorus in plant sample

3.3.1.4. Uptake of nitrogen by plants

3.3.1.5. Uptake of phosphorus by plants

3.3.1.6. Uptake of potash by plants

3.3.1.7. Quality characteristics

(i) Protein content of seeds

(ii) Oil content of seeds

4. Sampling Procedure

Observations on the growth characters like height, number of branches, number of leaves etc. were takenfrom six plants from each plot at 30th day, at 60th day and at harvest. Six rows were selected after eliminating the border rows and one plant from each row was selected at random as observational plant. For chemical analysis studies three plants were uprooted at a stretch from the 3rd row after eliminating the border rows at 30th day and at 60th day after sowing. These plants were used for determining the dry matter production and for chemical analysis at 30th day and at 60th day after sowing. At harvest, three out of the six observational plants were used for dry matter estimation and chemical analysis.

5. Details of observation

5.1. Height of plants

Six plants from each plot were selected at random and tagged. The height of the plants from the ground level to the growing tip was measured in centimetres and the average height per plant was worked out and recorded. Observations were recorded on the same plants at the three growth stages, namely 30th day, 60th day and at harvest.

5.2. Number of leaves

The number of leaves of the observational plants were recorded at 30th day, 60th day and at harvest, and the average number of leaves per plant was then worked out and recorded.

5.3. Number of branches

The number of primary branches seen on each of the six observational plants were counted and the average number per plant was worked out and recorded.

5.4. Leaf area index

Leaf area index was determined by punch method (Winter *et al* 1956) at 30th day, 60th day and at harvest.

5.5. Dry matter production

Three sample plants each uprooted at 30th day and 60th day after sowing were used for the determination of dry weight and at harvest the observational plants were used for the dry weight estimation. The samples were dried in a hot air oven at a temperature of 70°C for three days and then dry weights were recorded and expressed in kg/ha.

5.6. Height to first capsule

The height of the first capsule from the ground level was measured in centimetres in the six observational plants and the average height to the first capsule was worked out and recorded.

5.7. Number of capsules

Number of capsules per plant was recorded at harvest on the sample plants and the average was worked out.

5.8. Length of capsule

Five capsules were selected at random from each of the sample plants at harvest and their length was measured in centimetres. Then the average length of capsule was worked out.

5.9. Number of seeds per capsule

Five capsules were selected at random from each of the sample plants at harvest and the number of seeds in these capsules were counted. The average number of seeds per capsule was then worked out and recorded.

5.10. 1000 seed weight

From the produce obtained from the six observational plants, 200 seeds were counted and their weights recorded after drying. Test weight was expressed as 1000 seed weight in grams.

5.11. Seed yield

Crop was harvested from the net plots, threshed, winnowed and cleaned. Grains were sundried and weight recorded. Yield was estimated in kg/ha. The yield of observational plants was also added to the net plot yield.

5.12. Stover yield

Air dry weight of the plants from the net plots after separating the seeds were recorded. Air dry weight of stover of the observational plants was also added to the net plot weight to get the stover yield. Stover yield was estimated in kg/ha.

5.13. Harvest Index

Harvest index was calculated using the following formula.

$$\text{Harvest Index} = \frac{Y\text{econ}}{Y\text{ biol}}$$ where

Y econ = Dry weight of seeds

Y biol = Total dry weight of plants (excluding roots)

The three observational plants selected for chemical analysis at harvest were used for calculating the harvest index.

6. Chemical Analysis

Plant samples collected for recording dry weight at 30th day and 60th day after sowing were used for chemical analysis. At harvest, the observational plants were collected separately. Out of 6 plants 3 plants were dried with seed and powdered for the estimation of total nitrogen, total phosphorus and total potash contents. Seeds were also analysed separately for total nitrogen and oil contents.

6.1. Total nitrogen content

Total nitrogen content was estimated by modified micro-Kjeldahl method as given by Jackson (1967).

6.2. Uptake of nitrogen

This was calculated from the nitrogen content of the plant and total dry weight of the sample plants for various stages. The uptake values were expressed in kg/ha.

6.3. Total phosphorus content

Phosphorus content was estimated colorimetrically (Jackson, 1967) after wet digestion of the sample using 2:1 mixture of nitric acid and perchloric acid and developing colour by vanado-molybdo-phosphoric yellow colour method and read in spectronic 2000.

6.4. Uptake of phosphorus

This was estimated from the phosphorus content and the dry weight of the plant for various stages. The uptake values were expressed in kg/ha.

6.5. Total potash content

Total potash content in plant was estimated by flame photometric method after wet digestion of the sample using di-acid mixture.

6.6. Uptake of potash

This was calculated based on the dry weight of the plant and the potash content of plant for various stages. The uptake values were expressed in kg/ha.

6.7. Oil content

Oil content of oven dried seeds was estimated by soxhlet extraction using petroleum ether of boiling point 60-80°C (Chopra and Kanwar, 1976). The oil content was expressed as percentage.

6.8. Protein content of seeds

The percentage of protein was calculated by multiplying the percentage of nitrogen in seeds by the factor 6.25 (Simpson *et al*, 1965).

6.9. Soil analysis

Soil samples were taken from the experimental area before and after the experiment. The soil samples colleoted were analysed for total nitrogen, available phosphorus and available potash contents. Total nitrogen content was estimated by modified micro-kjeldahl method. Available phosphorus content was estimated by Bray's method (Jackson, 1967) and available potash by ammonium acetate method (Jackson, 1967).

7. Statistical analysis

Data on yield, yield attributes, growth characters and those on chemical analysis were analysed by employing the technique of analysis of variance for split plot randomised block design and significance was tested by F-test (Cochran and Cox, 1965).

RESULTS

RESULTS

The results of the study on the effect of nitrogen and plant density on the two varieties of sesame are presented below.

A. Growth characters

1. Height of plants

The data on the mean height of plants are presented in Table 1a and 1b and the analysis of variance in Appendix II.

There was significant difference in plant height between the two varieties at the three stages of growth. v_2 recorded higher values during all the stages.

Plant spacing had significant effect on the height of plants during all the stages. During the first stage, the plant height increased with closer spacing and s_3 recorded the highest value. But during the subsequent stages although reduction in plant spacing from s_1 to s_2 increased the plant height, further reduction in plant spacing to s_3 decreased the plant height significantly.

Plant height increased with increase in the levels of nitrogen upto n_3 level during all the growth stages.

The interactions VS, VN and SN were significant during the first stage and the highest value was recorded by v_2s_3, v_2n_3 and s_3n_3 respectively. VN, SN and VSN interactions were found to be significant during the second stage and v_2n_3, s_2n_3 and $v_2s_2n_3$ recorded the highest value respectively. At harvest, VN and VSN interactions were significant and the highest value was recorded by v_2n_3 and $v_2s_2n_3$ respectively.

2. Number of leaves per plant

The data on the number of leaves recorded at different stages of observation are presented in Table 1a and 1b and their analysis of variance in Appendix II.

There was significant difference between the varieties at all the growth stages and v_2 recorded higher number of leaves per plant at all stages.

Plant spacing significantly influenced the number of leaves per plant at all the stages and s_1 recorded the highest value at all the stages, but at the 30th day after

Table 1a Effect of variety, spacing, nitrogen and their two-way combinations on height of plant and number of leaves per plant at different stages

Treatments	Height (cm) 30 DAS	Height (cm) 60 DAS	Height (cm) at harvest	No. of leaves 30 DAS	No. of leaves 60 DAS	No. of leaves at harvest
v_1	13.82	78.44	83.25	9.10	34.49	26.74
v_2	20.35	81.53	89.42	15.01	46.11	39 04
SEm ±	0.10	0.45	0.09	0.07	0.26	0.31
CD(0.05)	0.31	1.35	0.28	0.21	0.79	0.94
s_1	16 14	84.09	92.06	12.32	45.40	37.97
s_2	17.02	86.63	93.2	12.03	40.59	32.85
s_3	18.09	69.25	73.73	11.81	34.92	27.84
SEm ±	0.13	0.55	0.12	0.09	0.32	0.38
CD(0.05)	0 38	1.65	0.35	0.26	0.97	1.15
n_0	14 84	68.79	74.44	10.49	23.44	18.01
n_1	16.93	78.15	83.83	11.92	34.56	28.6
n_2	18.00	84.48	91.04	12.71	50.03	40.09
n_3	18.57	88.53	96.02	13.10	53.18	44.86
SEm ±	0.06	0.16	0.14	0.04	0.19	0.24
CD(0.05)	0.16	0.46	0.38	0.12	0.55	0 68
v_1s_1	13.09	82.14	88.97	9.30	38.36	30.55
v_1s_2	13.84	85.33	89.97	9.14	34.95	26.95
v_1s_3	14.522	67.84	70.81	8.88	30.17	22.72
v_2s_1	19.19	86.03	95.16	15.34	52.43	45.40
v_2s_2	20.19	87.93	96.44	14.94	46.23	38.76
v_2s_3	21.66	70.66	76.66	14.75	39.68	32.97
SEm ±	0.18	0.77	0.16	0.12	0.46	0.54
CD(0.05)	0.54	NS	NS	NS	1.37	1.63
v_1n_0	11.75	68.39	72.21	7.77	20.93	14.33
v_1n_1	13.79	76 83	80.79	9.04	28.40	22.26
v_1n_2	14.61	82.43	87.58	9.65	42.81	33.08
v_1n_3	15.13	86.10	92.42	9.96	45.83	37.38

Contd.

Table 1a (contd)

Treatments	Height (cm) 30 DAS	Height (cm) 60 DAS	Height (cm) at harvest	No of leaves 30 DAS	No. of leaves 60 DAS	No. of leaves at harvest
v_2n_0	17.93	69.19	76.67	13.22	25.95	21.69
v_2n_1	20.05	79.48	86.88	14 81	40.71	34.93
v_2n_2	21.09	86.53	94.5	15.76	57.26	47.10
v_2n_3	22.02	90.95	99.63	16.24	60.53	52.45
SEm ±	0.08	0.23	0.19	0.06	0.27	0.34
CD(0.05)	0.22	0.65	0.54	0.16	0.77	0.96
s_1n_0	14.10	73.40	80.13	10.77	25.79	20.40
s_1n_1	15.94	82.03	89.56	12.15	39.19	32.98
s_1n_2	17.01	88.34	96.56	13.00	56.48	46.65
s_1n_3	17.53	92.59	101.94	13.38	60.13	51.88
s_2n_0	14.89	75.16	81.69	10.54	23.56	18.65
s_2n_1	16.91	85.24	90.44	11.94	34 90	28.29
s_2n_2	17.84	91.36	98.00	12.63	50.52	40.02
s_2n_3	18.44	94.74	102.69	13.02	53.38	44.46
s_3n_0	15.54	57.81	61.44	10 17	20.96	15 00
s_3n_1	17.93	67.19	71.15	11.69	29.59	24.52
s_3n_2	19.15	73.75	78.56	12.50	43.10	33.61
s_3n_3	19.75	78.25	83.44	12.90	46.04	38.25
SEm ±	0.09	0.28	0.23	0.07	0.33	0.42
CD(0 05)	0.27	0.78	NS	NS	0.95	1.18

DAS - Days After Sowing

NS - Not Significant

Table 1b. Combined effect of variety, spacing and nitrogen on height of plant and number of leaves per plant at different stages

Treatments	Height (cm) 30 DAS	Height (cm) 60 DAS	Height (cm) at harvest	No. of leaves 30 DAS	No. of leaves 60 DAS	No. of leaves at harvest
$v_1s_1n_0$	11.25	72.13	76.88	8.00	22.13	15.54
$v_1s_1n_1$	13.00	80.30	86.63	9.21	32.04	25.46
$v_1s_1n_2$	13.88	86.02	93.50	9.88	47.87	38.13
$v_1s_1n_3$	14.25	90.13	98.88	10.13	51.42	43.08
$v_1s_2n_0$	11.88	73.93	79.38	7.88	20.54	14.09
$v_1s_2n_1$	13.88	84.50	87.25	9.08	28.96	22.54
$v_1s_2n_2$	14.50	90.15	94.50	9.63	43.92	34.04
$v_1s_2n_3$	15.13	92.93	98.75	9.96	46.38	37.13
$v_1s_3n_0$	12.13	59.13	60.38	7.42	20.13	13.38
$v_1s_3n_1$	14.50	65.88	68.50	8.83	24.21	18.79
$v_1s_3n_2$	15.45	71.13	74.75	9.46	36.63	27.09
$v_1s_3n_3$	16.00	75.25	79.63	9.79	39.71	31.63
$v_2s_1n_0$	16.95	74.68	83.50	13.54	29.46	25.55
$v_2s_1n_1$	18.88	83.75	92.50	15.08	46.33	40.50
$v_2s_1n_2$	20.15	90.65	99.63	16.13	55.08	55.17
$v_2s_1n_3$	20.80	95.05	105.00	16.63	68.83	60.67
$v_2s_2n_0$	17.90	76.40	84.00	13.21	26.58	23.21
$v_2s_2n_1$	19.95	86.18	93.63	14.79	40.83	34.04
$v_2s_2n_2$	21.18	92.58	101.50	15.63	57.13	46.00
$v_2s_2n_3$	21.75	96.55	106.63	16.08	60.38	51.79
$v_2s_3n_0$	18 95	56.50	62.50	12.92	21.79	16.63
$v_2s_3n_1$	21.35	68.50	74.50	14.54	34.96	30.25
$v_2s_3n_2$	22.85	76.38	82.38	15.54	49.58	40.13
$v_2s_3n_3$	23.50	81.25	87.25	16.00	52.38	44.88
SEm ±	0.134	0.397	0.331	0.10	0.472	0.587
CD(0.05)	NS	1.127	0.940	NS	NS	1.666

DAS - Days After Sowing

NS - Not Significant

sowing no significant difference was observed between s_2 and s_3.

At all the growth stages, a significant increase in the number of leaves produced per plant was observed with increase in the levels of nitrogen upto n_3.

Among the various interactions, only VN combination exerted significant influence during the first stage recording the highest value with v_2n_3. At the second stage, VN and SN interactions had significant effect and the highest value was observed with v_2n_3 and s_1n_3 respectively. At harvest, VS, VN, SN and VSN interactions were significant and the highest value was recorded by v_2s_1, v_2n_3, s_1n_3 and $v_2s_1n_3$.

3. Number of branches per plant

The data on the number of branches produced at the 60th day and at harvest are given in Table 2a and 2b and the analysis of variance in Appendix III.

The varieties differed significantly in the number of branches produced per plant at harvest and v_1 recorded highest number of branches.

Plant spacing significantly influenced branching at both the stages and wider spacing s_1 produced the highest number of branches per plant at both the stages.

The data revealed that there was significant effect of applied nitrogen on the number of branches produced per plant. There was marked increase in the number of branches with increase in the levels of nitrogen upto n_3 during both the stages.

The interactions VS, VN, SN & VSN were found to have significant influence on the number of branches per plant at both the stages and the combinations v_1s_1, v_1n_3, s_1n_3 and $v_1s_1n_3$ recorded the highest value respectively at the two stages.

4. Leaf area index

The data on the influence of spacing and nitrogen levels on leaf area index are presented in Table 2a and 2b and the analysis of variance in Appendix III.

There was significant difference between varieties in leaf area index at all the three stages with v_2 recording the highest values at all stages.

Plant spacing had significant influence on leaf area index at all the stages which increased with closer spacings

Table 2a Effect of variety, spacing, nitrogen and their two-way combinations on the number of branches per plant and leaf area index at different stages

Treatments	No of branches 60 DAS	No. of branches at harvest	LAI 30 DAS	LAI 60 DAS	LAI at harvest
v_1	2.11	2.37	0.76	2.12	1.57
v_2	2.08	2.16	1.12	2.36	1.92
SEm ±	0.02	0.02	0.005	0.009	0.013
CD (0.05)	NS	0.07	0.015	0.026	0.040
s_1	2.34	2.65	0.53	1.56	1.22
s_2	2.09	2.24	0.77	2.10	1.57
s_3	1.85	1.90	1.52	3.06	2.44
SEm ±	0.02	0.03	0.006	0.011	0.016
CD (0.05)	0.07	0.09	0.018	0.032	0.049
n_0	1.68	1.80	0.79	1.33	0.87
n_1	1.93	2.21	0.90	1.82	1.42
n_2	2.28	2.45	1.02	2.82	2.21
n_3	2.49	2.59	1.05	2.98	2.47
SEm ±	0.02	0.02	0.003	0.012	0.012
CD (0.05)	0.05	0.06	0.009	0.034	0.035
v_1s_1	2.36	2.90	0.44	1.42	1.06
v_1s_2	2.18	2.38	0.63	1.94	1.38
v_1s_3	1.78	1.83	1.22	2.99	2.27
v_2s_1	2.32	2.41	0.63	1.69	1.38
v_2s_2	2.00	2.10	0.92	2.26	1.76
v_2s_3	1.93	1.96	1.82	3.12	2.61
SEm ±	0.03	0.04	0.008	0.015	0.023
CD (0.05)	0.09	0.12	0.025	0.045	NS
v_1n_0	1.61	1.72	0.62	1.27	0.69
v_1n_1	1.89	2.26	0.73	1.67	1.29
v_1n_2	2.33	2.65	0.82	2.68	2.02
v_1n_3	2.60	2.83	0.86	2.84	2.29

Contd.

Table 2a (contd)

Treatments	No. of branches 60 DAS	No. of branches at harvest	LAI 30 DAS	LAI 60 DAS	LAI at harvest
v_2n_0	1.75	1.87	0.96	1.39	1.06
v_2n_1	1.97	2.15	1.07	1.97	1.55
v_2n_2	2.24	2.25	1.21	2.96	2.41
v_2n_3	2.38	2.35	1.24	3.12	2.65
SEm ±	0 02	0.03	0.005	0.017	0.018
CD(0.05)	0.06	0.08	0.013	0.049	0.050
s_1n_0	1.77	1.94	0.45	0.85	0.63
s_1n_1	2 08	2.61	0.51	1.29	1.01
s_1n_2	2.65	2.96	0.58	1.98	1.54
s_1n_3	2.86	3 10	0.60	2.10	1.71
s_2n_0	1.69	1.79	0.66	1.17	0.80
s_2n_1	1 89	2.13	0.75	1.75	1.30
s_2n_2	2 27	2.44	0.83	2.68	1.98
s_2n_3	2.51	2.60	0.86	2.81	2.20
s_3n_0	1.58	1.67	1.27	1.97	1.20
s_3n_1	1.81	1.90	1.45	2.43	1.94
s_3n_2	1.94	1.96	1.65	3.80	3.12
s_3n_3	2.09	2.06	1.70	4.03	3.50
SEm ±	0.03	0.04	0.006	0.021	0.021
CD (0.05)	0.08	0.10	0.016	0.059	0.061

DAS - Days After Sowing

NS - Not Significant

LAI - Leaf Area Index

Table 2b Combined effect of variety, spacing and nitrogen on the number of branches per plant and leaf area index at different stages

Treatments	No. of branches 60 DAS	No. of branches at harvest	L A I 30 DAS	L A I 60 DAS	L A I at harvest
$v_1s_1n_0$	1.79	1.92	0.36	0.79	0.52
$v_1s_1n_1$	2.08	2.79	0.42	1.14	0.85
$v_1s_1n_2$	2.63	3.34	0.47	1.81	1.36
$v_1s_1n_3$	2.96	3.54	0.49	1.94	1.53
$v_1s_2n_0$	1.63	1.71	0.52	1.09	0.59
$v_1s_2n_1$	1.87	2.17	0.61	1.58	1.13
$v_1s_2n_2$	2.46	2.71	0.68	2.51	1.82
$v_1s_2n_3$	2.75	2.92	0.71	2.60	1.98
$v_1s_3n_0$	1.42	1.54	0.98	1.93	0.95
$v_1s_3n_1$	1.71	1.83	1.18	2.30	1.88
$v_1s_3n_2$	1.92	1.92	1.33	3.74	2.88
$v_1s_3n_3$	2.09	2.04	1.37	3.99	3.36
$v_2s_1n_0$	1.75	1.96	0.54	0.92	0.73
$v_2s_1n_1$	2.08	2.42	0.60	1.44	1.18
$v_2s_1n_2$	2.67	2.58	0.68	2.15	1.72
$v_2s_1n_3$	2.79	2.67	0.70	2.27	1.89
$v_2s_2n_0$	1.75	1.87	0.79	1.25	1.01
$v_2s_2n_1$	1.92	2.09	0.89	1.92	1.48
$v_2s_2n_2$	2.09	2.17	0.99	2.86	2.15
$v_2s_2n_3$	2.25	2.29	1.02	3.02	2.42
$v_2s_3n_0$	1.75	1.79	1.55	2.01	1.44
$v_2s_3n_1$	1.92	1.96	1.73	2.56	1.99
$v_2s_3n_2$	1.96	2.00	1.97	3.86	3.37
$v_2s_3n_3$	2.09	2.09	2.03	4.07	3.64
SEm ±	0.039	0.050	0.008	0.030	0.030
CD(0.05)	0.110	0.141	0.022	0.084	0.086

DAS - Days After Sowing

and s_3 recorded the highest value at all the stages.

Leaf area index increased with increase in the levels of applied nitrogen upto n_3 at all the growth stages.

The interactions VS, VN, SN and VSN were found to influence the leaf area index significantly at the first two stages with v_2s_3, v_2n_3, s_3n_3 and $v_2s_3n_3$ respectively recording the highest value. But at harvest, the interactions VS, SN and VSN showed significant influence with v_2s_3, s_3n_3 and $v_2s_3n_3$ respectively expressing the highest leaf area index value.

5. Dry matter production

The data on the influence of spacing and nitrogen levels on dry matter production at different growth stages are presented in Table 3a and 3b and the analysis of variance in Appendix IV.

The two varieties differed significantly in dry matter production at all stages of growth. v_2 recorded a higher dry matter yield at all growth stages.

Spacing also exerted a pronounced influence on dry matter production during all the three stages. Closer plant spacing resulted in a higher dry matter yield and s_3 recorded the highest dry matter yield during all growth

Table 3a. Effect of variety, spacing, nitrogen and their two-way combinations on dry matter production at different stages

Treatments	DMP (kg/ha) 30 DAS	DMP (kg/ha) 60 DAS	DMP (kg/ha) at harvest
v_1	255.5	1503.6	1342.2
v_2	271.5	1596.7	1425.5
SEm ±	0.32	1.82	1.70
CD (0.05)	0.97	5.48	5.12
s_1	224.5	1320.0	1178.6
s_2	252.5	1485.6	1327.2
s_3	313.5	1844.9	1645.7
SEm ±	0.39	2.23	2.08
CD (0.05)	1.19	6.72	6.27
n_0	176.4	1037.2	993.8
n_1	250.8	1475.7	1372.1
n_2	303.2	1784.1	1551.8
n_3	323.5	1903.6	1617.7
SEm ±	0.37	2.13	1.95
CD (0.05)	1.04	6.04	5.54
v_1s_1	217.8	1281.4	1142.1
v_1s_2	244.9	1440.9	1288.1
v_1s_3	303.9	1788.3	1596.3
v_2s_1	231.2	1358.7	1215.1
v_2s_2	260.1	1530.2	1366.3
v_2s_3	323.1	1901.4	1695.2
SEm ±	0.56	3.15	2.94
CD (0.05)	1.68	9.50	8.87
v_1n_0	178.2	1048.9	1001.3
v_1n_1	241.2	1419.2	1319.5
v_1n_2	291.6	1715.7	1492.3
v_1n_3	311.1	1830.6	1555.6

Contd.

Table 3a (contd.)

Treatments	DMP (kg/ha) 30 DAS	DMP (kg/ha) 60 DAS	DMP (kg/ha) at harvest
v_2n_0	174.6	1025.4	986.2
v_2n_1	260.4	1532.3	1424.6
v_2n_2	314.9	1852.6	1611.4
v_2n_3	335.9	1976.7	1679.8
SEm ±	0.52	3.01	2.76
CD(0.05)	1.47	8.54	7.84
s_1n_0	156.4	916.7	875.3
s_1n_1	214.8	1264.2	1175.4
s_1n_2	256.0	1500.9	1305.0
s_1n_3	271.7	1598.9	1358.7
s_2n_0	172.9	1017.7	976.6
s_2n_1	240.3	1413.8	1314.4
s_2n_2	291.4	1714.4	1491.1
s_2n_3	305.3	1796.5	1526.7
s_3n_0	200.0	1177.1	1129.4
s_3n_1	297.3	1749.2	1626.3
s_3n_2	363.3	2137.7	1859.4
s_3n_3	393.6	2315.4	1967.8
SEm ±	0.63	3.69	3.38
CD(0.05)2	1.80	10.46	9.60

DAS - Days After Sowing

DMP - Dry Matter Production

Table 3b. Combined effect of variety, spacing and nitrogen on dry matter production at different stages

Treatments	DMP (kg/ha) 30 DAS	DMP (kg/ha) 60 DAS	DMP (kg/ha) at harvest
$v_1s_1n_0$	157.9	929.7	876.5
$v_1s_1n_1$	206.6	1215.6	1130.4
$v_1s_1n_2$	245.2	1442.8	1255.0
$v_1s_1n_3$	261.3	1537.6	1306.7
$v_1s_2n_0$	174.7	1028.0	986.5
$v_1s_2n_1$	231.1	1359.7	1264.1
$v_1s_2n_2$	280.2	1648.7	1433.9
$v_1s_2n_3$	293.6	1727.6	1468.2
$v_1s_3n_0$	202.0	1189.0	1141.0
$v_1s_3n_1$	285.9	1682.2	1564.0
$v_1s_3n_2$	349.4	2055 7	1788.1
$v_1s_3n_3$	378.4	2226.5	1892.1
$v_2s_1n_0$	154.8	903.6	874.1
$v_2s_1n_1$	223.1	1312.7	1220.4
$v_2s_1n_2$	264.8	1558.0	1355.0
$v_2s_1n_3$	282.2	1660.4	1410.8
$v_2s_2n_0$	171.2	1007.4	966.7
$v_2s_2n_1$	249.5	1468.0	1364.8
$v_2s_2n_2$	302.6	1780.0	1548.4
$v_2s_2n_3$	317.1	1865.4	1585.3
$v_2s_3n_0$	198.0	1165.2	1117.9
$v_2s_3n_1$	308.7	1816.3	1688.6
$v_2s_3n_2$	377.3	2219.7	1930.7
$v_2s_3n_3$	408.7	2404.3	2043.4
SEm $\pm$	0.90	5.21	4.78
CD(0.05)	2.55	14.79	13.57

DMP - Dry Matter Production
DAS - Days After Sowing

stages.

Increasing levels of nitrogen increased the dry matter production significantly at all the stages of growth. The highest production of dry matter was recorded with n_3 level at all stages of growth of the plant.

The interactions VS, VN, SN and VSN were found to be significant at all the growth stages and the highest dry matter production was observed with v_2s_3, v_2n_3, s_3n_3 and $v_2s_3n_3$ respectively.

6. <u>Height to first capsule</u>

The data on the height to first capsule site are furnished in Table 4a and 4b and the analysis of variance in Appendix IV.

Only plant spacing had significant effect on the height to first capsule with wider spacing producing capsules at comparatively lower heights. However, the difference between s_2 and s_3 was not significant in this respect.

Neither the varieties nor the nitrogen levels could exert any significant effect on this parameter. The interactions were also not significant.

B. Yield attributes and yield

1. Number of capsules per plant

The data on the number of capsules per plant at harvest are presented in Table 4a and 4b and the analysis of variance in Appendix V.

There was significant difference between varieties in the number of capsules per plant with v_2 recording higher number of capsules per plant.

Plant spacing also significantly influenced this character. Closer spacing resulted in lesser number of capsules per plant and the highest value was observed with the widest spacing s_1.

The number of capsules produced per plant increased with increase in the level of nitrogen upto n_3.

The interactions VS, VN, SN and VSN were found significant and the highest value was recorded by v_2s_1, v_2n_3, s_1n_3 and $v_2s_1n_3$ respectively.

2. Length of capsule

The data on the effect of spacing and nitrogen on the average capsule length of two varieties are presented in Table 4a and 4b and the analysis of variance in Appendix V.

The two varieties were found to be significantly different in this character with v_2 giving higher value.

Plant spacing had no profound influence on the capsule length.

Nitrogen significantly influenced the capsule length. Increase in the level of nitrogen from n_0 to n_1 significantly increased the capsule length but further increase in nitrogen level could not produce any significant increase in this character although there was marginal increase.

None of the interactions was found to have any significant influence on this character.

3. Number of seeds per capsule

The data on the number of seeds per capsule are given in Table 4a and 4b and the analysis of variance in Appendix V.

The varieties differed significantly in the number of seeds per capsule with v_2 recording higher number of seeds per capsule.

Table 4a . Effect of variety, spacing, nitrogen and their two-way combinations on height to first capsule, number of capsules per plant, length of capsule and number of seeds per capsule

Treatments	Height to first capsule (cm)	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule
v_1	32.58	27.4	2.83	36.6
v_2	32.85	29.2	2.91	37.8
SEm ±	0.133	0.059	0.018	0.020
CD (0.05)	NS	0.177	0.054	0.060
s_1	32.12	37.0	2.91	40.0
s_2	32.86	28.9	2.88	38.8
s_3	33.16	19.1	2.83	32.7
SEm ±	0.163	0.072	0.022	0.024
CD (0.05)	0.491	0.217	NS	0.073
n_0	32.45	23.7	2.84	35.3
n_1	32.59	27.8	2.88	36.4
n_2	32.93	30.2	2.88	38.0
n_3	32.88	31.5	2.89	39.0
SEm ±	0.193	0.082	0.009	0.071
CD (0.05)	NS	0.232	0.026	0.202
v_1s_1	32.31	36.0	2.85	39.4
v_1s_2	32.55	27.7	2.82	38.2
v_1s_3	32.88	18.4	2.81	32.1
v_2s_1	31.93	38.0	2.97	40.6
v_2s_2	33.18	30.0	2.93	39.4
v_2s_3	33.44	19.8	2.84	33.3
SEm ±	0.23	0.102	0.031	0.034
CD (0.05)	NS	0.307	NS	NS

Contd.

Table 4a.(contd.)

Treatments	Height to first capsule (cm)	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule
v_1n_0	32.17	24.3	2.80	34.7
v_1n_1	32.35	26.7	2.83	35.8
v_1n_2	32.96	28.6	2.84	37.4
v_1n_3	32.84	30.0	2.85	38.5
v_2n_0	32.73	23.2	2.87	35.9
v_2n_1	32.83	29.0	2.92	36.9
v_2n_2	32.90	31.7	2.92	38.6
v_2n_3	32.93	33.1	2.94	39.6
SEm ±	0.273	0.116	0.013	0.101
CD (0.05)	NS	0.328	NS	NS
s_1n_0	31.99	30.1	2.87	38.2
s_1n_1	31.55	36.6	2.94	39.2
s_1n_2	3?.30	39.7	2.91	40.8
s_1n_3	32.63	41.6	2.92	41.9
s_2n_0	32.41	24.7	2.86	36.9
s_2n_1	32.90	28.1	2.87	38.0
s_2n_2	33 18	30.6	2.89	39.7
s_2n_3	32.96	32.0	2.89	40.7
s_3n_0	32.95	16.4	2.79	30.8
s_3n_1	33.31	18.8	2.82	31.9
s_3n_2	33.31	20.2	2.84	33.5
s_3n_3	33.06	21.0	2.86	34.5
SEm ±	0.334	0.142	0.016	0.124
CD(0.05)	NS	0.402	NS	NS

NS - Not Significant

Table 4b. Combined effect of variety, spacing and nitrogen on height to first capsule, number of capsules per plant, length of capsule and number of seeds per capsule

Treatments	Height to first capsule (cm)	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule
$v_1s_1n_0$	32.10	31.4	2.82	37.6
$v_1s_1n_1$	31.88	35.1	2.88	38.6
$v_1s_1n_2$	32.48	37.9	2.85	40.3
$v_1s_1n_3$	32.78	39.7	2.87	41.3
$v_1s_2n_0$	31 90	25.2	2.81	36.3
$v_1s_2n_1$	32.43	26.7	2.81	37.4
$v_1s_2n_2$	33.10	28 8	2.84	39.1
$v_1s_2n_3$	32.78	30.3	2.84	40.1
$v_1s_3n_0$	32.50	16.3	2.78	30.2
$v_1s_3n_1$	32.75	18.2	2.81	31.3
$v_1s_3n_2$	33.30	19.2	2.84	33.0
$v_1s_3n_3$	32.98	20.0	2.84	34.0
$v_2s_1n_0$	31.88	28.9	2.92	38.7
$v_2s_1n_1$	31.23	38.1	3.01	39.8
$v_2s_1n_2$	32.13	41.5	2.97	41.4
$v_2s_1n_3$	32.48	43.5	2.98	42.5
$v_2s_2n_0$	32.93	24.3	2.91	37.5
$v_2s_2n_1$	33.38	29.5	2.92	38.6
$v_2s_2n_2$	3).25	32.4	2.95	40.3
$v_2s_2n_3$	33.15	33.7	2.95	41.3
$v_2s_3n_0$	33.40	16.5	2 80	31.4
$v_2s_3n_1$	33.88	19.5	2.84	32.5
$v_2s_3n_2$	33.33	21.2	2.85	34.1
$v_2s_3n_3$	33.15	22.0	2.88	35.1
SEm ±	0.473	0.20	0 022	0.17
CD(0.05)	NS	0.57	NS	NS

NS - Not Significant

The number of seeds per oapsule decreased with closer plant spacing. The widest spacing s_1 has given the highest number of seeds per capsule.

Application of nitrogen also increased the number of seeds per capsule upto n_3 level.

None of the interactions was found to be significant.

4. <u>1000 seed weight</u>

The data on 1000 seed weight recorded at harvest are presented in Table 5a and 5b and the analysis of variance in Appendix VI.

The varieties differed significantly in 1000 seed weight with v_2 recording higher value.

Plant spacing did not exert any significant incluence on 1000 seed weight.

Application of nitrogen significantly increased the 1000 seed weight upto n_2 level only and there was no significant difference between n_2 and n_3.

The various interactions did not show any profound influence on 1000 seed weight.

5. <u>Seed yield</u>

The data on seed yield of sesamum are presented in Table 5a and 5b and the analysis of variance in Appendix VI.

There was significant difference between the two varieties in seed yield and v_2 has given a higher seed yield.

The influence of plant spacing on seed yield was found to be significant. s_2 recorded the highest seed yield although the difference between s_1 and s_2 was not significant. Reduction in plant spacing to s_3 was found to significantly reduce the seed yield.

Application of nitrogen was found to influence the total seed yield significantly. Nitrogen application produced marked increase in seed yield upto n_3 level.

The interactions VS, VN, SN and VSN were found to have significant influence on the total seed yield and the treatment combinations v_2s_2, v_2n_3, s_2n_3 and $v_2s_2n_3$ recorded the highest seed yield among the respective combinations.

6. Stover yield

The data on stover yield are presented in Table 5a and 5b and the analysis of variance in Appendix VI.

There was significant difference between the two varieties and v_2 has given higher stover yield.

Table 5a Effect of variety, spacing, nitrogen and their two-way combinations on 1000 seed weight, seed yield and stover yield

Treatments	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
v_1	2.575	244.7	1101.2
v_2	2.650	272.8	1130.5
SEm ±	0.016	0.81	5.85
CD(0.05)	0.049	2.42	17.6
s_1	2.638	275.7	914.4
s_2	2.622	278.1	1049.2
s_3	2.578	222.5	1383.9
SEm ±	0.020	0.98	7.17
CD(0.05)	NS	2.97	21.6
n_0	2.583	192.9	853 2
n_1	2.604	251.6	1121.7
n_2	2.627	285.4	1216.7
n_3	2.635	305.2	1271.8
SEm ±	0.006	1.08	4.53
CD(0.05)	0.018	3.06	12.8
v_1s_1	2.588	265.6	905 8
v_1s_2	2.572	261.6	1050.1
v_1s_3	2.566	207.0	1347.6
v_2s_1	2.688	285.8	923.1
v_2s_2	2.672	294.6	1048.3
v_2s_3	2.591	237.9	1420.3
SEm ±	0.028	1.39	10.14
CD (0.05)	NS	4.20	30.6

Contd.

Table 5 a (contd.)

Treatments	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
v_1n_0	2.546	199.0	907.8
v_1n_1	2.567	234.6	1087.5
v_1n_2	2.592	262.7	1178.4
v_1n_3	2.596	282.7	1231.0
v_2n_0	2.621	186.8	798.7
v_2n_1	2.642	268.5	1155 9
v_2n_2	2.663	308.0	1255.0
v_2n_3	2.675	327.8	1312.6
SEm ±	0.009	1.52	6.4
CD(0.05)	NS	4 32	18.2
s_1n_0	2.613	205.6	735.5
s_1n_1	2.625	271.0	904.3
s_1n_2	2.650	303.8	981.8
s_1n_3	2.663	322.4	1036.1
s_2n_0	2.600	217.4	834.3
s_2n_1	2.613	267.7	1046.6
s_2n_2	2.638	303.4	1131.1
s_2n_3	2.638	324.0	1184.8
s_3n_0	2.538	155.7	989.9
s_3n_1	2.575	216.0	1414.3
s_3n_2	2.594	248.9	1537.3
s_3n_3	2.606	269.3	1594.5
SEm ±	0.011	1.87	7.84
CD(0 05)	NS	5.30	22.2

NS - Not Significant

Table 5b Combined effect of variety, spacing and nitrogen on 1000 seed weight, seed yield and stover yield

Treatments	1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
$v_1s_1n_0$	2.563	219.0	789.0
$v_1s_1n_1$	2.575	255.5	874.8
$v_1s_1n_2$	2.600	285.2	955.5
$v_1s_1n_3$	2.613	302.6	1003.8
$v_1s_2n_0$	2.550	224.1	915.0
$v_1s_2n_1$	2.563	247.1	1017.0
$v_1s_2n_2$	2.588	276.2	1099.8
$v_1s_2n_3$	2.588	299.2	1168.8
$v_1s_3n_0$	2.525	153.9	1019.3
$v_1s_3n_1$	2.563	201.2	1370.8
$v_1s_3n_2$	2.588	226.8	1480.0
$v_1s_3n_3$	2.588	246.2	1520.5
$v_2s_1n_0$	2.663	192.2	682.0
$v_2s_1n_1$	2.675	286.5	933.8
$v_2s_1n_2$	2.700	322.4	1008.0
$v_2s_1n_3$	2.713	342.3	1068.5
$v_2s_2n_0$	2.650	210.8	753.5
$v_2s_2n_1$	2.663	288.3	1076.3
$v_2s_2n_2$	2.688	330.7	1162.5
$v_2s_2n_3$	2.688	348.8	1200.8
$v_2s_3n_0$	2.550	157.4	1960.5
$v_2s_3n_1$	2.588	230.8	1457.8
$v_2s_3n_2$	2 600	271.0	1594.5
$v_2s_3n_3$	2.625	292.4	1668.5
SEm ±	0.016	2.64	11.09
CD (0.05)	NS	7.49	31.45

NS - Not Significant

Plant spacing was also found to have significant influence on stover yield. Closer spacing resulted in higher stover yield and s_3 has given the highest yield of stover.

The yield of stover was significantly influenced by the increased levels of nitrogen. Highest stover yield was given by the highest level of nitrogen (n_3).

The interactions VS, VN and SN were found to be significant and the highest stover yield was given by v_2s_3, v_2n_3 and s_3n_3 respectively.

7. Harvest index

The data on harvest index are given in Table 6a and 6b and the analysis of variance in Appendix VII.

There was significant difference between the two varieties on this character with v_2 giving a higher value.

Plant spacing had significant influence on harvest index. Decrease in plant spacing decreased the harvest index significantly. Wider spacing (s_1) resulted in the highest value.

The harvest index was significantly influenced by nitrogen application, the highest value being recorded by the highest level of nitrogen. However, n_0 and n_1 levels were found to be on par.

Among the interactions, VS and SN interactions exerted significant influence on harvest index with v_2s_1 and s_1n_3 recording the highest value among the respective combinations.

C. Quality attributes

1. Oil content

The data on oil content of seeds are given in Table 6a and 6b and the analysis of variance in Appendix VII.

There was significant difference between the two varieties and v_2 was found to be superior as far as oil content is concerned.

The different plant spacings had no significant effect on the oil content of seeds.

Although there was significant increase in oil content with applied nitrogen upto n_2 level the difference between n_2 and n_3 was not significant.

The various interactions did not significantly influence the oil content.

2. Protein content

The data on the protein content of seeds recorded at harvest are presented in Table 6a and 6b and the analysis of variance in Appendix VII.

There was significant difference between the two varieties in the protein content of seeds. v_2 was found to have a higher seed protein content.

Spacing had significant influence on the protein content of seeds. Closer plant spacing reduced the protein content but the difference between s_1 and s_2 was not significant.

Application of nitrogen was found to increase the protein content of seeds significantly upto n_3 level. But the difference between n_2 and n_3 was not significant.

None of the interactions was found to be significant.

D. Analysis of plant samples

1. Total nitrogen content of plant

The data on total nitrogen content of plant are presented in Table 7a and 7b and the analysis of variance

Table 6a Effect of variety, spacing, nitrogen and their two-way combinations on harvest index, oil content and protein content

Treatments	Harvest index	Oil content (%)	Protein content (%)
v_1	0.253	51 02	20 80
v_2	0.274	51.64	21 40
SEm ±	0.001	0.193	0.124
CD(0 05)	0.004	0 580	0.375
s_1	0.300	51 71	21 46
s_2	0.265	51.37	21 33
s_3	0 226	50.92	20.51
SEm ±	0.002	0 236	0.152
CD (0 05)	0 005	NS	0.459
n_0	0 255	50.60	20 84
n_1	0.257	51 05	21 04
n_2	0.268	51.7	21.23
n_3	0.274	51.97	21 29
SEm ±	0.001	0.153	0 053
CD (0 05)	0.004	0.435	0.151
v_1s_1	0.293	51.38	21 06
v_1s_2	0.249	50.90	20.92
v_1s_3	0 216	50.79	20.42
v_2s_1	0.307	52.05	21.86
v_2s_2	0.281	51.83	21.74
v_2s_3	0.235	51.04	20.61
SEm ±	0.003	0.333	0.216
CD(0 05)	0.008	NS	NS

Contd.

Table 6a.(contd.)

Treatments	Harvest index	Oil content (%)	Protein content (%)
v_1n_0	0.246	50.26	20.54
v_1n_1	0.247	50.69	20.74
v_1n_2	0 255	51.43	20.94
v_1n_3	0 262	51 70	20.98
v_2n_0	0 264	50 94	21.14
v_2n_1	0 266	51.42	21.35
v_2n_2	0.281	51.97	21.52
v_2n_3	0 286	52 24	21 61
SEm ±	0 002	0.217	0.075
CD (0.05)	NS	NS	NS
s_1n_0	0.280	50.91	21.24
s_1n_1	0 299	51.26	21.37
s_1n_2	0 309	52.19	21.56
s_1n_3	0.311	52 49	21.66
s_2n_0	0 263	50 89	21 12
s_2n_1	0.255	51.13	21.27
s_2n_2	0.268	51.69	21.47
s_2n_3	0 273	51.76	21 46
s_3n_0	0.222	50 00	20 15
s_3n_1	0.215	50.78	20 48
s_3n_2	0.228	51.23	20 67
s_3n_3	0.238	51.66	20.76
SEm ±	0.003	0.265	0.092
CD (0.05)	0.007	NS	NS

NS - Not Significant

Table 6b Combined effect of variety, spacing and nitrogen on harvest index, oil content and protein content

Treatments	Harvest index	Oil content (%)	Protein content (%)
$v_1s_1n_0$	0.278	50.45	20 83
$v_1s_1n_1$	0.292	50 80	20 96
$v_1s_1n_2$	0 299	51 98	21.17
$v_1s_1n_3$	0 302	52 28	21 27
$v_1s_2n_0$	0.245	50.43	20.71
$v_1s_2n_1$	0.243	50.65	20.86
$v_1s_2n_2$	0 251	51 23	21.08
$v_1s_2n_3$	0.256	51 30	21.05
$v_1s_3n_0$	0.213	49 90	20 08
$v_1s_3n_1$	0 207	50 63	20 39
$v_1s_3n_2$	0.216	51.10	20.58
$v_1s_3n_3$	0.229	51.53	20.61
$v_2s_1n_0$	0.282	51.38	21.66
$v_2s_1n_1$	0.307	51.73	21.78
$v_2s_1n_2$	0.320	52.40	21.95
$v_2s_1n_3$	0.321	52 70	22.05
$v_2s_2n_0$	0.280	51.35	21.53
$v_2s_2n_1$	0.268	51.60	21.69
$v_2s_2n_2$	0.285	52 15	21.86
$v_2s_2n_3$	0.291	52.23	21.88
$v_2s_3n_0$	0.231	50.10	20.22
$v_2s_3n_1$	0.223	50.93	20.57
$v_2s_3n_2$	0 240	51 35	20.75
$v_2s_3n_3$	0 247	51.80	20 91
SEm ±	0.004	0.375	0.130
CD (0.05)	NS	NS	NS

NS - Not Significant

in Appendix VIII.

The varieties differed significantly in nitrogen content at all the three stages of growth and v_2 contained higher nitrogen content during all the growth stages.

Spacing also significantly influenced the nitrogen content of plant during all the stages. Nitrogen content was found to decrease with closer spacing and the highest nitrogen content was observed in wider spaced plants (s_1) during all the stages.

Nitrogen content of plant increased significantly with increasing levels of applied nitrogen at all the stages of growth. Highest nitrogen content was observed at n_3 level.

The treatment combination SN alone was significant at the first stage and the highest value was recorded by the combination s_1n_3.

During the second and third stages of observation, the interactions VS, VN, SN and VSN were found to have profound influence on nitrogen content and the combinations v_2s_1, v_2n_3, s_1n_3 and $v_2s_1n_3$ respectively recorded the highest nitrogen content.

Table 7a. Effect of variety, spacing, nitrogen and their two-way combinations on the nitrogen content of plant and the uptake of nitrogen at different stages

Treatments	N content(%) 30 DAS	N content(%) 60 DAS	N content(%) at harvest	N uptake (kg/ha) 30 DAS	N uptake (kg/ha) 60 DAS	N uptake (kg/ha) at harvest
v_1	2.53	2.31	1.92	6.51	35.02	25.92
v_2	2.61	2.41	2.02	7.14	38.85	28.96
SEm ±	0.014	0.002	0.0003	0.040	0.059	0.053
CD(0.05)	0.043	0.006	0.001	0.121	0.178	0.160
s_1	2.73	2.54	2.15	6.25	34.31	25.91
s_2	2.61	2.39	2.00	6.71	36.31	27.09
s_3	2.37	2.15	1.76	7.51	40.18	29.33
SEm ±	0.017	0.002	0.0004	0.049	0.072	0.065
CD(0.05)	0.053	0.007	0.001	0.148	0.217	0.196
n_0	2.29	2.06	1.67	4.02	21.33	16.55
n_1	2.46	2.24	1.85	6.13	32.84	25.15
n_2	2.70	2.49	2.10	8.11	43.88	32.15
n_3	2.82	2.65	2.26	9.02	49.69	35.93
SEm ±	0.022	0.003	0.0007	0.064	0.104	0.072
CD(0.05)	0.062	0.008	0.002	0.183	0.296	0.206
v_1s_1	2.71	2.49	2.10	6.01	32.53	24.46
v_1s_2	2.56	2.35	1.96	6.39	34.54	25.68
v_1s_3	2.32	2.10	1.71	7.12	37.98	27.62
v_2s_1	2.75	2.59	2.20	6.49	36.09	27.35
v_2s_2	2.65	2.44	2.04	7.02	38.08	28.50
v_2s_3	2.42	2.20	1.81	7.90	42.39	31.04
SEm ±	0.025	0.003	0.0005	0.070	0.250	0.092
CD(0.05)	NS	0.01	0.002	NS	0.308	0.277

Contd.

Treatments	N content(%) 30 DAS	N content(%) 60 DAS	N content(%) at harvest	N uptake (kg/ha) 30 DAS	N uptake (kg/ha) 60 DAS	N uptake (kg/ha) at harvest
v_1n_0	2.24	2.03	1.63	3.99	21.18	16.28
v_1n_1	2.41	2.19	1.80	5.78	30.92	23.57
v_1n_2	2.65	2.43	2.04	7.63	41.12	30.05
v_1n_3	2.81	2.60	2.21	8.63	46.84	33.78
v_2n_0	2.33	2.10	1.71	4.06	21.49	16.81
v_2n_1	2.51	2.29	1.90	6.48	34.75	26.73
v_2n_2	2.76	2.55	2.16	8.60	46.64	34.24
v_2n_3	2.83	2.70	2.31	9.41	52.54	38.08
SEm ±	0.031	0.004	0.001	0.091	0.148	0.102
CD(0.05)	NS	0.011	0.003	0.258	0.419	0.291
s_1n_0	2.36	2.13	1.74	3.69	19.50	15.20
s_1n_1	2.60	2.38	1.99	5.60	30.12	23.41
s_1n_2	2.92	2.70	2.32	7.45	40.57	30.36
s_1n_3	3.04	2.94	2.55	8.24	47.05	34.67
s_2n_0	2.29	2.07	1.68	3.96	21.09	16.41
s_2n_1	2.48	2.27	1.88	5.97	32.11	24.70
s_2n_2	2.76	2.55	2.16	8.06	43.74	32.19
s_2n_3	2.89	2.69	2.30	8.83	48.31	35.08
s_3n_0	2.21	1.99	1.60	4.42	23.41	18.03
s_3n_1	2.29	2.07	1.68	6.81	36.28	27.35
s_3n_2	2.43	2.21	1.82	8.83	47.32	33.89
s_3n_3	2.53	2.32	1.93	9.98	53.72	38.05
SEm ±	0.038	0.005	0.001	0.112	0.181	0.125
CD(0.05)	0.107	0.013	0.003	0.317	0.513	0.356

DAS - Days After Sowing

NS - Not Significant

Table 7b Combined effect of variety, spacing and nitrogen on the nitrogen content of plant and the uptake of nitrogen at different stages

Treatments	N content (%) 30 DAS	N content (%) 60 DAS	N content (%) at harvest	N uptake (kg/ha) 30 DAS	N uptake (kg/ha) 60 DAS	N uptake (kg/ha) at harvest
$v_1s_1n_0$	2.33	2.10	1.71	3.67	19.53	14.97
$v_1s_1n_1$	2.55	2.33	1.93	5.26	28.27	21.85
$v_1s_1n_2$	2.84	2.63	2.27	6.97	37.94	28.46
$v_1s_1n_3$	3.11	2.89	2.49	8.12	44.37	32.57
$v_1s_2n_0$	2.25	2.05	1.65	3.94	21.03	16.31
$v_1s_2n_1$	2.44	2.21	1.82	5.63	30.09	23.01
$v_1s_2n_2$	2.72	2.49	2.10	7.61	41.10	30.12
$v_1s_2n_3$	2.86	2.66	2.27	8.38	45.96	33.30
$v_1s_3n_0$	2.16	1.93	1.54	4.35	22.98	17.57
$v_1s_3n_1$	2.25	2.05	1.65	6.44	34.41	25.85
$v_1s_3n_2$	2.38	2.16	1.77	8.32	44.31	31.57
$v_1s_3n_3$	2.48	2.26	1.88	9.38	50.21	35.48
$v_2s_1n_0$	2.39	2.16	1.77	3.70	19.47	15.43
$v_2s_1n_1$	2.66	2.44	2.05	5.93	31.97	24.96
$v_2s_1n_2$	2.99	2.77	2.38	7.93	43.20	32.25
$v_2s_1n_3$	2 97	2.99	2.61	8.37	49.73	36.76
$v_2s_2n_0$	2.33	2.10	1.71	3.98	21.16	16.51
$v_2s_2n_1$	2.53	2.33	1.93	6.32	34.14	26.38
$v_2s_2n_2$	2.81	2.61	2.21	8.51	46.38	34.26
$v_2s_2n_3$	2.93	2.72	2.33	9.27	50.65	36.86
$v_2s_3n_0$	2.27	2.05	1.65	4.49	23.83	18.48
$v_2s_3n_1$	2.33	2.10	1.71	7.18	38.15	26 84
$v_2s_3n_2$	2.48	2.27	1.88	9.35	50.34	36.21
$v_2s_3n_3$	2.59	2.38	1.99	10.59	57.23	40.62
SEm ±	0.053	0.007	0.002	0.158	0.256	0.177
CD(0.05)	NS	0.019	0.005	NS	0.726	0.504

DAS - Days After Sowing

NS - Not Significant

2. Total phosphorus content of plant

The data on the total phosphorus content of plant are presented in Table 8a and 8b and the analysis of variance in Appendix IX.

During the first stage, there was no significant difference between varieties in phosphorus content. But during the second and third stages, the phosphorus content of v_2 was found to be significantly higher than v_1.

Spacing significantly influenced the phosphorus content of plants during all growth stages. Reduction in plant phosphorus content was seen with closer spacing. Widest spacing (s_1) recorded the highest phosphorus content at all the stages of observation.

Nitrogen application also exerted significant influence on phosphorus content of plant. Increase in the level of nitrogen significantly increased the phosphorus content of plants upto n_3 level during all the stages of growth.

During the first two stages the interaction VN alone was significant and the combination v_2n_3 recorded the highest value.

At harvest, all the two factor interactions ie. VS, VN and SN were found to be significant and the highest

Table 8a. Effect of variety, spacing, nitrogen and their two-way combinations on the phosphorus content of plant and the uptake of phosphorus at different stages

Treatments	P content(%) 30 DAS	P content(%) 60 DAS	P content(%) at harvest	P uptake (kg/ha) 30 DAS	P uptake (kg/ha) 60 DAS	P uptake (kg/ha) at harvest
v_1	0.376	0.341	0.273	0.98	5.21	3.71
v_2	0.379	0.346	0.276	1.05	5.63	3.99
SEm ±	0.001	0.001	0.0005	0.004	0.017	0.015
CD(0.05)	NS	0.003	0.001	0.013	0.051	0.045
s_1	0.390	0.353	0.284	0.89	4.75	3.39
s_2	0.381	0 346	0.277	0.98	5.24	3.74
s_3	0.361	0.332	0.262	1.16	6.27	4.42
SEm ±	0.002	0.001	0.0006	0.005	0.021	0.018
CD(0.05)	0.005	0.004	0.002	0.016	0.062	0.055
n_0	0.325	0.298	0.236	0.57	3.08	2.33
n_1	0.348	0.325	0.253	0.87	4.78	3.45
n_2	0.410	0.369	0.299	1.24	6.57	4.62
n_3	0.427	0.383	0.310	1.38	7.27	5.00
SEm ±	0.001	0.001	0.0008	0.004	0.023	0.016
CD(0.05)	0.004	0.004	0.002	0.011	0.067	0.046
v_1s_1	0.389	0.351	0.281	0.86	4.57	3.25
v_1s_2	0.379	0.344	0.275	0.95	5.04	3.59
v_1s_3	0.360	0.329	0.262	1.12	6.01	4.27
v_2s_1	0.392	0.356	0.286	0.93	4.93	3.53
v_2s_2	0.383	0.348	0.279	1.02	5.45	3.89
v_2s_3	0.362	0.335	0.263	1.20	6.53	4.56
SEm ±	0.002	0.002	0.0009	0.007	0.029	0.026
CD(0.05)	NS	NS	0.003	NS	0 088	NS

contd.

Table 8a.(contd.)

Treatments	P content(%) 30 DAS	P content(%) 60 DAS	P content(%) at harvest	P uptake (kg/ha) 30 DAS	P uptake (kg/ha) 60 DAS	P uptake (kg/ha) at harvest
v_1n_0	0.325	0.296	0.236	0.58	3.09	2.35
v_1n_1	0.349	0.326	0.253	0.84	4.60	3.32
v_1n_2	0.407	0.364	0.295	1.18	6.23	4.39
v_1n_3	0.423	0.379	0.308	1.31	6.92	4.77
v_2n_0	0.324	0.299	0.236	0.56	3.06	2.31
v_2n_1	0.347	0.325	0.253	0.90	4.96	3.58
v_2n_2	0.413	0.374	0.303	1.30	6.91	4.85
v_2n_3	0.431	0.387	0.313	1.44	7.62	5.24
SEm ±	0.002	0.002	0.001	0.005	0.033	0.023
CD(0.05)	0.005	0.005	0.003	0.015	0.094	0.064
s_1n_0	0.338	0.308	0.250	0.53	2.82	2.19
s_1n_1	0.364	0.338	0.263	0.78	4.27	3.08
s_1n_2	0.421	0.378	0 305	1.07	5.67	3.98
s_1n_3	0.439	0.391	0.318	1.19	6.26	4.32
s_2n_0	0.328	0.299	0.240	0.57	3.04	2.34
s_2n_1	0.351	0.326	0.253	0.84	4.61	3.32
s_2n_2	0.415	0.373	0.303	1.21	6.39	4.51
s_2n_3	0.430	0.386	0.314	1.31	6.94	4.79
s_3n_0	0.309	0.309	0.218	0.62	3.37	2.46
s_3n_1	0.329	0.313	0.243	0.98	5.46	3.94
s_3n_2	0.394	0.358	0.289	1.43	7.64	5.37
s_3n_3	0.413	0.371	0.300	1.62	8.60	5.90
SEm ±	0.002	0.002	0.001	0.006	0.041	0.028
CD(0.05)	NS	NS	0.004	0.018	0.115	0.079

DAS - Days After Sowing

NS - Not Significant

Table 8b. Combined effect of variety, spacing and nitrogen on the phosphorus content of plant and the uptake of phosphorus at different stages

Treatments	P content (%) 30 DAS	P content (%) 60 DAS	P content (%) at harvest	P uptake (kg/ha) 30 DAS	P uptake (kg/ha) 60 DAS	P uptake (kg/ha) at harvest
$v_1s_1n_0$	0.338	0.308	0.250	0.53	2.86	2.19
$v_1s_1n_1$	0.365	0.338	0.263	0.75	4.10	2.97
$v_1s_1n_2$	0.418	0.373	0.300	1.02	5.37	3.76
$v_1s_1n_3$	0.435	0.388	0.313	1.14	5.96	4 08
$v_1s_2n_0$	0.328	0.298	0.240	0.57	3.06	2.37
$v_1s_2n_1$	0.353	0.328	0.253	0.81	4.45	3.19
$v_1s_2n_2$	0.413	0.368	0.298	1.16	6.06	4.26
$v_1s_2n_3$	0.425	0.383	0.310	1.25	6.61	4.55
$v_1s_3n_0$	0.310	0.283	0.218	0.63	3.36	2.48
$v_1s_3n_1$	0.330	0.313	0.243	0.94	5.25	3.79
$v_1s_3n_2$	0.390	0.353	0.288	1.36	7.25	5.14
$v_1s_3n_3$	0.410	0.368	0.300	1.55	8.18	5.67
$v_2s_1n_0$	0.338	0.308	0.250	0.52	2.78	2.18
$v_2s_1n_1$	0.363	0.338	0.263	0.81	4.43	3.20
$v_2s_1n_2$	0.425	0.383	0.310	1.13	5.96	4.20
$v_2s_1n_3$	0.443	0.395	0.323	1.25	6.56	4.65
$v_2s_2n_0$	0.328	0.300	0.240	0.56	3.02	2.32
$v_2s_2n_1$	0.350	0.325	0.253	0.87	4.77	3.45
$v_2s_2n_2$	0.418	0.378	0.308	1.26	6.72	4.76
$v_2s_2n_3$	0.435	0.390	0.318	1.38	7.27	5.03
$v_2s_3n_0$	0.308	0.290	0.218	0.61	3.38	2.43
$v_2s_3n_1$	0.328	0.313	0.243	1.01	5.67	4.09
$v_2s_3n_2$	0.398	0.363	0.290	1.50	8.04	5.70
$v_2s_3n_3$	0.415	0.375	0.300	1.70	9.01	6.13
SEm $\pm$	0.003	0.003	0 002	0.009	0.058	0.039
CD(0.05)	NS	NS	NS	NS	NS	NS

DAS - Days After Sowing
NS - Not Significant

phosphorus content was observed with v_2s_1, v_2n_3 and s_1n_3 respectively.

3. <u>Total potassium content of plant</u>

The data on the total potassium content of plant are presented in Table 9a and 9b and the analysis of variance in Appendix X.

During the first stage, none of the main effects of V, S and N and their interactions were found to be significant in respect of plant potassium content.

During the second and third stages, spacing alone had significant influence on the potassium content of plants s_3 resulted in lowest potassium content, but the difference between s_1 and s_2 was not significant during either of the stages.

4. <u>Total uptake of nitrogen</u>

The data on the total uptake of nitrogen at different stages are furnished in Table 7a and 7b and the analysis of variance in Appendix XI.

Significant difference was observed between the varieties in respect of nitrogen uptake during all the stages of observation. The nitrogen uptake by v_2 was found to be higher.

Table 9a Effect of variety, spacing, nitrogen and their two-way combinations on the potassium content of plant and the uptake of potassium at different stages

Treatments	K content(%) 30 DAS	K content(%) 60 DAS	K content(%) at harvest	K uptake (kg/ha) 30 DAS	K uptake (kg/ha) 60 DAS	K uptake (kg/ha) at harvest
v_1	1.077	1.054	1.002	2.75	15.83	13.42
v_2	1.075	1.052	0.998	2.92	16.76	14.19
SEm ±	0.002	0.003	0.003	0.007	0.038	0.035
CD(0.05)	NS	NS	NS	0.020	0.115	0.105
s_1	1.080	1.059	1.01	2.42	13.98	11.90
s_2	1.078	1.058	1.008	2.72	15.70	13.38
s_3	1.071	1.041	0.981	3.36	19.20	16.13
SEm ±	0.003	0.003	0.003	0.008	0.047	0.043
CD(0.05)	NS	0.008	0.010	0.025	0.141	0.128
n_0	1.077	1.057	1.003	1.90	10.96	9.95
n_1	1.069	1.052	0.999	2.68	15.50	13.69
n_2	1.078	1.049	0.995	3.27	18.68	15.41
n_3	1.080	1.053	1.00	3.49	20.03	16.15
SEm ±	0.003	0.003	0.003	0.01	0.058	0.053
CD(0.05)	NS	NS	NS	0.028	0.164	0.150
v_1s_1	1.080	1.061	1.013	2.35	13.59	11.56
v_1s_2	.079	1.059	1.010	2.64	15.26	13.01
v_1s_3	1.073	1.041	0.983	3.26	18.62	15.68
v_2s_1	1.079	1.058	1.008	2.50	14.37	12.23
v_2s_2	1.076	1.057	1.006	2.80	16.15	13.75
v_2s_3	1.069	1.041	0.979	3.46	19.77	16.57
SEm ±	0.004	0.005	0.005	0.012	0.066	0.06
CD(0.05)	NS	NS	NS	NS	0.20	NS

Contd.

Table 9a (contd.)

Treatments	K content(%) 30 DAS	K content(%) 60 DAS	K content(%) at harvest	K uptake (kg/ha) 30 DAS	K uptake (kg/ha) 60 DAS	K uptake (kg/ha) at harvest
v_1n_0	1.079	1.057	1.005	1.92	11.07	10.04
v_1n_1	1.071	1.053	1.002	2.58	14.93	13.20
v_1n_2	1.078	1.051	0.997	3.14	18.01	14.83
v_1n_3	1.081	1.055	1.004	3.36	19.29	15.59
v_2n_0	1.074	1.057	1.002	1.88	10.85	9.86
v_2n_1	1.068	1.051	0.998	2.78	16.08	14.19
v_2n_2	1.078	1.048	0.994	3.39	19.36	15.99
v_2n_3	1.079	1.052	0.997	3.63	20.77	16.70
SEm ±	0.004	0.004	0.005	0.014	0.081	0.075
CD(0.05)	NS	NS	NS	0.040	0.231	0.213
s_1n_0	1.080	1.064	1.015	1.69	9.79	8.89
s_1n_1	1.075	1.061	1.011	2.31	13.42	11.88
s_1n_2	1.083	1.055	1.005	2.76	15.82	13.11
s_1n_3	1.081	1.058	1.009	2.94	16.91	13.70
s_2n_0	1.081	1.064	1.013	1.87	10.83	9.88
s_2n_1	1.064	1.054	1.005	2.56	14.89	13.23
s_2n_2	1.084	1.056	1.005	3.16	18.08	14.99
s_2n_3	1.081	1.059	1.010	3.30	19.02	15.42
s_3n_0	1.069	1.043	0.983	2.14	12.27	11.09
s_3n_1	1.069	1.041	0.983	3.18	18.21	15.97
s_3n_2	1.068	1.036	0.976	3.88	22.15	18.13
s_3n_3	1.078	1.044	0.983	4.24	24.16	19.32
SEm ±	0.005	0.005	0.006	0.017	0.10	0.092
CD(0.05)	NS	NS	NS	0.049	0.283	0.261

DAS - Days After Sowing

NS - Not Significant

Table 9b. Combined effect of variety, spacing and nitrogen on the potassium content of plant and the uptake of potassium at different stages

Treatments	K content (%) 30 DAS	K Content (%) 60 DAS	K content (%) at harvest	K uptake (kg/ha) 30 DAS	K uptake (kg/ha) 60 DAS	K uptake (kg/ha) at harvest
$v_1s_1n_0$	1.080	1.065	1.018	1.71	9.90	8.92
$v_1s_1n_1$	1.078	1.063	1.013	2.23	12.92	11.45
$v_1s_1n_2$	1.080	1.058	1.008	2.65	15.26	12.64
$v_1s_1n_3$	1.083	1.060	1.013	2.83	16.30	13.23
$v_1s_2n_0$	1.080	1.065	1.018	1.89	10.95	10.04
$v_1s_2n_1$	1.070	1.055	1.005	2.47	14.34	12.71
$v_1s_2n_2$	1.083	1.058	1.005	3.03	17.44	14.41
$v_1s_2n_3$	1.083	1.060	1.013	3.18	18.32	14.87
$v_1s_3n_0$	1.078	1.040	0.980	2.18	12.37	11.18
$v_1s_3n_1$	1.065	1.043	0.988	3.05	17.53	15.44
$v_1s_3n_2$	1.070	1.038	0.978	3.74	21.33	17.44
$v_1s_3n_3$	1.078	1.045	0.988	4.08	23.27	18.68
$v_2s_1n_0$	1.080	1.063	1.013	1.67	9.68	8.85
$v_2s_1n_1$	1.073	1.060	1.010	2.39	13.91	12.32
$v_2s_1n_2$	1.085	1.053	1.003	2.87	16.39	13.58
$v_2s_1n_3$	1.080	1.055	1.005	3.05	17.51	14.18
$v_2s_2n_0$	1.083	1.063	1.008	1.86	10.70	9.73
$v_2s_2n_1$	1.058	1.053	1.005	2.64	15.44	13.75
$v_2s_2n_2$	1.085	1.055	1.005	3.28	18.73	15.56
$v_2s_2n_3$	1.080	1.058	1.008	3.43	19.73	15.97
$v_2s_3n_0$	1.060	1.045	0.985	2.10	12.17	11.01
$v_2s_3n_1$	1.073	1.040	0.978	3.31	18.88	16.50
$v_2s_3n_2$	1.065	1.035	0.975	4.02	22.97	18.82
$v_2s_3n_3$	1.078	1.043	0.978	4.41	25.06	19.97
SEm ±	0.008	0.007	0.008	0.024	0.141	0.130
CD(0.05)	NS	NS	NS	NS	NS	NS

DAS - Days After Sowing
NS - Not Significant

Spacing exerted significant influence on nitrogen uptake at all the three stages. Closer plant spacing resulted in higher nitrogen uptake. s_3 recorded the highest nitrogen uptake during all the stages.

Nitrogen application also significantly influenced the nitrogen uptake at all the stages and the highest amount of nitrogen uptake was observed with the highest level of nitrogen.

During the first stage, the interactions VN and SN were found to be significant and the highest uptake was observed with v_2n_3 and s_3n_3 respectively.

In the 2nd and 3rd stages, all the treatment combinations ie. VS, VN, SN and VSN produced significant effect on nitrogen uptake and the highest value was recorded by v_2s_3, v_2n_3, s_3n_3 and $v_2s_3n_3$ respectively.

5. <u>Total uptake of phosphorus</u>

The data on the uptake of phosphorus are presented in Table 8a and 8b and the analysis of variance in Appendix XII.

The varieties differed significantly with respect to phosphorus uptake during all the stages of observation.

The phosphorus uptake by v_2 was higher.

During all the stages spacing was found to exert significant influence on phosphorus uptake. Highest phosphorus uptake was observed with the closest spacing (s_3).

The phosphorus uptake significantly increased with the level of applied nitrogen upto n_3 level.

During the first stage and at harvest the interactions VN and SN were significant and the highest amount of uptake was recorded by v_2n_3 and s_3n_3 respectively.

During the second stage of observation all the interactions except VSN were found to be significant and the treatment combinations v_2s_3, v_2n_3 and s_3n_3 showed the highest uptake value for total phosphorus among the respective combinations.

6. Total uptake of potassium

The data on the uptake of potassium by plant are given in Table 9a and 9b and the analysis of variance in Appendix XIII.

The two varieties were significantly different in the total uptake of potassium during all the stages of observation. v_2 had a higher uptake at all the stages.

Spacing also significantly influenced the potassium uptake during all the stages. Uptake increased with closer spacing and the highest value was observed with s_3.

Nitrogen also increased the potassium uptake upto n_3 level during all the stages of observation.

During the first stage and at harvest the interactions VN and SN had significant effect on potassium uptake and the combinations v_2n_3 and s_3n_3 recorded the highest uptake value respectively.

During the second stage, the interactions VS, VN and SN were significant and the highest uptake value was recorded by v_2s_3, v_2n_3 and s_3n_3 respectively.

E. Soil Analysis

1. Total nitrogen content of the soil after the experiment

The data on the total nitrogen content of soil after the harvest are furnished in Table 10a and 10b and the analysis of variance in Appendix XIV.

It is seen that the varieties had no effect on the total nitrogen content of soil.

Spacing had significant influence on the total soil nitrogen. Closest spacing s_3 lowered the total nitrogen content of soil. The difference between s_1 and s_2 was not significant with respect to total soil nitrogen.

Total nitrogen content of soil increased with increased application of nitrogen. The highest soil nitrogen content was observed with n_3 level of applied nitrogen. However there was no significant difference between n_0 and n_1.

Among the interactions, SN alone had significant effect and the combinations s_1n_3 and s_2n_3 recorded comparatively higher values of total soil nitrogen.

2. Available phosphorus content of soil after the experiment

The data on the available phosphorus content of soil after the harvest are given in Table 10a and 10b and the analysis of variance in Appendix XIV.

It is seen that neither the varieties nor the nitrogen levels could make any significant influence on the available phosphorus content of soil.

Spacing alone had significant influence on the available phosphorus content of soil and closer spacing reduced the available phosphorus content of soil as compared to wider spacing. The difference between s_1 and s_2 was not significant.

None of the interactions was found to be significant in this respect.

3. Available potassium content of soil after the experiment

The data on the available potassium content of soil are presented in Table 10a and 10b and the analysis of

Table 10a. Effect of variety, spacing, nitrogen and their two-way combinations on the total nitrogen, available phosphorus and available potassium contents of soil after the experiment

Treatments	Total N (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
v_1	0.083	41.08	55.63
v_2	0.083	41.23	55.25
SEm ±	0.0005	0.194	0.060
CD(0.05)	NS	NS	0.182
s_1	0.088	41.81	55.69
s_2	0.088	41.34	55.50
s_3	0.075	40.31	55.13
SEm ±	0.0006	0.237	0.074
CD (0.05)	0.002	0.716	0.223
n_0	0.070	41.08	55.17
n_1	0.075	40.96	55.33
n_2	0.091	41.29	55.58
n_3	0.098	41.29	55.67
SEm ±	0.002	0.236	0.072
CD (0.05)	0.005	NS	0.205
v_1s_1	0.088	41.50	55.75
v_1s_2	0.088	41.13	55.75
v_1s_3	0.075	40.63	55.34
v_2s_1	0.088	42.13	55.63
v_2s_2	0.088	41 56	55.25
v_2s_3	0.075	40.00	55.88
SEm ±	0.0009	0.336	0.105
CD(0.05)	NS	NS	NS

Contd.

Table 10a. (contd.)

Treatments	Total N (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
v_1n_0	0.070	40.92	55.33
v_1n_1	0.075	40.75	55.50
v_1n_2	0.091	41.33	55.83
v_1n_3	0.098	41.33	55.83
v_2n_0	0.070	41.25	55.00
v_2n_1	0.075	41.17	55.17
v_2n_2	0.091	41.25	55.33
v_2n_3	0.098	41.25	55.50
SEm ±	0.002	0.334	0.102
CD(0.05)	NS	NS	NS
s_1n_0	0.070	41.75	55.38
s_1n_1	0.077	41.88	55.50
s_1n_2	0.98	42.00	55.88
s_1n_3	0.105	41.63	56.00
s_2n_0	0.070	41.00	55.25
s_2n_1	0.077	41.38	55.50
s_2n_2	0.098	41.63	55.50
s_2n_3	0.105	41.38	55.75
s_3n_0	0.070	40.50	54.88
s_3n_1	0.070	39.63	55.00
s_3n_2	0.077	40.25	55.34
s_3n_3	0.084	40.88	55.25
SEm ±	0.003	0.409	0.125
CD(0.05)	0.009	NS	NS

NS - Not Significant

Table 10b. Combined effect of variety, spacing and nitrogen on the total nitrogen, available phosphorus and available potassium contents of the soil after the experiment

Treatments	Total N (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
$v_1s_1n_0$	0.070	41.25	55.50
$v_1s_1n_1$	0.077	41.25	55.50
$v_1s_1n_2$	0.098	42.00	56.00
$v_1s_1n_3$	0.105	41.50	56.00
$v_1s_2n_0$	0.070	40.75	55.50
$v_1s_2n_1$	0.077	41.00	55.75
$v_1s_2n_2$	0.098	41.50	55.75
$v_1s_2n_3$	0.105	41.25	56.00
$v_1s_3n_0$	0.070	40.75	55.00
$v_1s_3n_1$	0.070	40.00	55.25
$v_1s_3n_2$	0.077	40.50	55.75
$v_1s_3n_3$	0.084	41.25	55.50
$v_2s_1n_0$	0.070	42.25	55.25
$v_2s_1n_1$	0.077	42.50	55.50
$v_2s_1n_2$	0.098	42.00	55.75
$v_2s_1n_3$	0.105	41.75	56.00
$v_2s_2n_0$	0.070	41.25	55.00
$v_2s_2n_1$	0.077	41.75	55.25
$v_2s_2n_2$	0.098	41.75	55.25
$v_2s_2n_3$	0.106	41.50	55.50
$v_2s_3n_0$	0.070	40.25	54.75
$v_2s_3n_1$	0.070	39.25	54.75
$v_2s_3n_2$	0.077	40.00	55.00
$v_2s_3n_3$	0.084	40.50	55.00
SEm ±	0.004	0.579	0.177
CD(0.05)	NS	NS	NS

NS - Not Significant

variance in Appendix XIV.

It is seen that the variety had significant influence on the available soil potassium. v_1 recorded higher soil potassium content compared to v_2.

Closer spacing reduced the available potassium content of soil. Although the difference between s_1 and s_2 was not significant s_3 resulted in lower soil potassium.

Soil potassium was found to increase with increased levels of nitrogen application. Although increase in level of applied nitrogen from n_0 to n_1 could not make any significant increase in soil potassium, further increase to n_3 level significantly increased the soil potassium. However, there was no significant difference between n_2 and n_3 with respect to available potassium content of soil.

DISCUSSION

DISCUSSION

An investigation was carried out at College of Agriculture, Vellayani to find out the influence of plant density and nitrogen levels on two varieties of sesamum viz. Kayamkulam - 1 and Surya.

Data on biometric characters like height of plants, number of leaves per plant, number of branches per plant, leaf area index, dry matter production and height to first capsule were recorded. Data on yield attributes like number of capsules per plant, length of capsule, number of seeds per capsule, test weight of seed, seed yield, stover yield and harvest index were also recorded. The data obtained on qualitative variables such as oil content and protein content were also studied.

The results obtained on various parameters mentioned above are discussed hereunder.

A. Growth characters

It is seen that the varieties differed significantly in respect of plant height during all the stages of growth with Surya recording higher plant height.

The effect of different plant densities was also significant at different growth stages. While significant increase in plant height was observed with closer spacing on the 30th day after sowing, significant reduction was observed with narrow spacing of 5 cm during the subsequent stages and the medium spacing of 10 cm recorded the highest value during these stages. Thakur and Borulkar (1979) reported marginal increase in plant height of sesamum with closer spacing. A similar trend was observed in the present investigation during the first stage. However, during the subsequent stages as seen from the data the closer spacing of 5 cm resulted in significant reduction in plant height although medium spacing increased plant height as compared to wider spacing. The higher degree of competition between plants under the closest spacing would have resulted in poor development of the root system as well as the aerial parts.

Significant increase in the height of plants was observed due to nitrogen application upto 60 kg/ha during all the stages of growth. The role of nitrogen being the development of vegetative parts, it is quite natural that increasing levels of nitrogen increased the height of plants.

Abdul Rahman et al (1980) and Girija Devi (1985) reported increased plant height with higher levels of nitrogen application.

It is seen from Table 1b that the three factor interaction was significant at 60th day after sowing and at harvest and the maximum plant height was recorded by the variety Surya under 10 cm plant spacing and with 60 kg N/ha during these stages.

There was significant difference between varieties in the number of leaves produced per plant during all the stages of observation. Surya recorded higher number of leaves per plant.

It is seen that the number of leaves per plant was significantly reduced with close planting. From the data presented in Table 2 a it was observed that closer planting decreased the number of branches per plant. Considering the intimate relationship between the number of branches and number of leaves per plant it is quiet natural that closer spacing of plants resulted in decreased number of leaves per plant.

It was observed that nitrogen significantly influenced the number of leaves per plant during all the stages of growth.

As discussed earlier the role of nitrogen is significant in the vegetative growth of the crop. As such, increasing levels of nitrogen would increase the number of leaves per plant also. Similar findings were reported by Girija Devi (1985) and Jalaludeenkutty (1985) in sesamum crop.

At harvest the three factor interaction was significant and the highest number of leaves was recorded by the variety Surya under 15 cm plant spacing and with 60 kg N/ha (Table 1 b)

There was significant difference between the two varieties in respect of the branching characters at harvest. Kayamkulam-1 was found to produce more number of branches per plant as compared to Surya.

It was observed that the number of branches per plant was significantly reduced with close planting and as such wider spacing resulted in more number of branches per plant. The degree of competition was less in wider spacing and due to increased availability of space there was more room for individual plant development resulting in more branches per plant. Bonsu (1977), Thakur and Borulkar (1979), Rao et al (1984) and Narayan and Narayanan (1986) reported similar results in sesamum.

Nitrogen significantly increased the number of branches per plant upto 60 kg/ha. The favourable influence of nitrogen on the vegetative development of plant was universally recognised. Subramanian et al (1979) and Ghosh and Maj (1985) observed increased number of branches per plant in sesamum with increased levels of application of nitrogen. The results of the present investigation are also in agreement with the above findings. The same trend was also reported by Girija Devi (1985) from College of Agriculture, Vellayani.

The three factor interaction was significant with respect to the number of branches per plant during both the stages and Kayamkulam-1 under 15 cm plant spacing and with 60 kg N/ha resulted in maximum number of branches (Table 2b).

There was significant difference between varieties in respect of leaf area index during all the stages and the variety Surya recorded higher leaf area index during all the stages of observation.

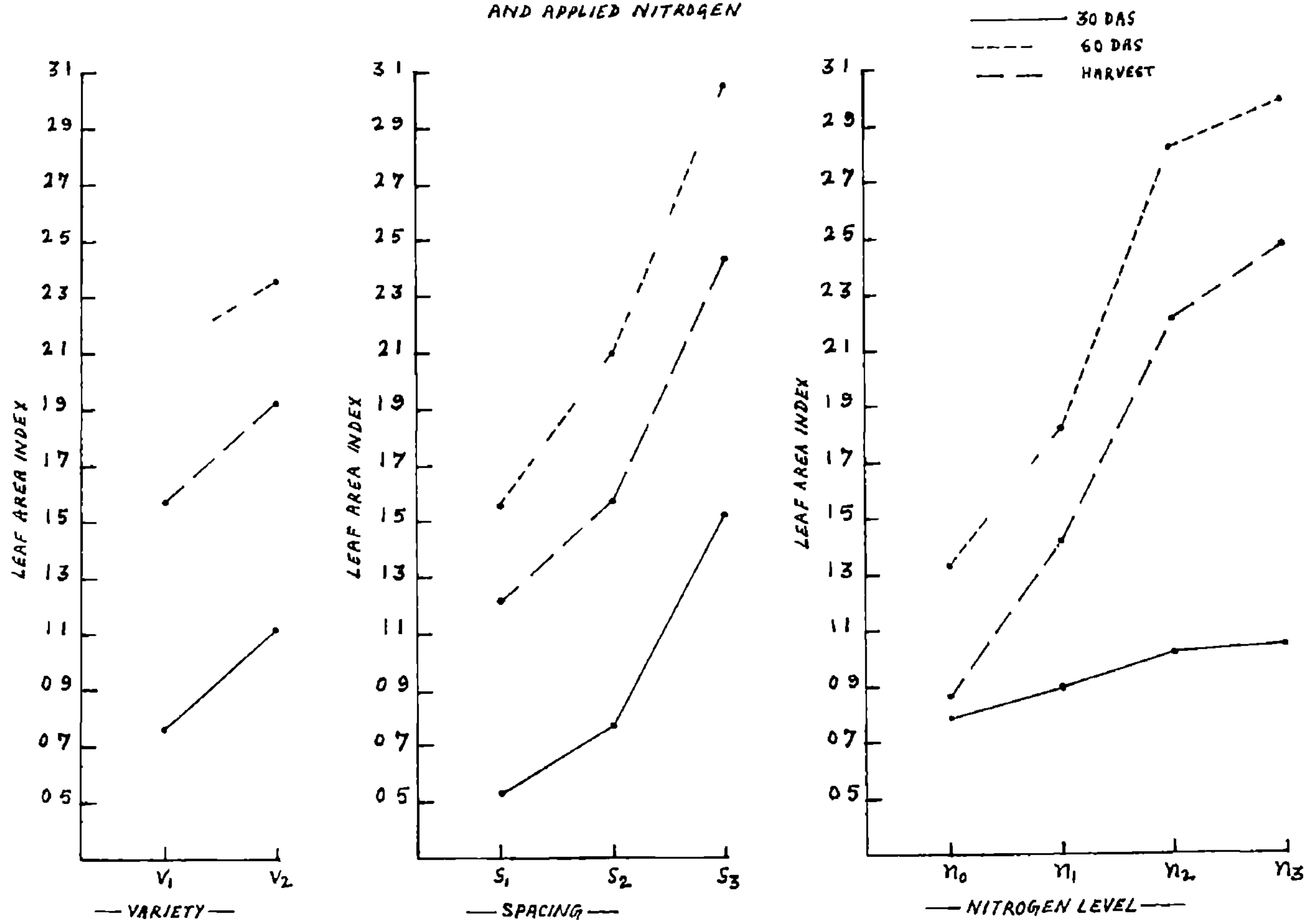
While closer spacing resulted in higher leaf area index, wider spacing significantly lowered the leaf area index. Since leaf area index is the leaf area per unit of land area, reduction in spacing would naturally increase the leaf area index. Although there was a possibility for reduced leaf production per plant on account of reduced spacing the extend of reduction in leaf area was not proportionate to the extend of decrease in land area per plant. This is in agreement with the finding of Bonsu (1977) that close spacing increased leaf area index in sesamum.

It is seen that nitrogen had significant influence on the leaf area index during all the stages of observation. Leaf area index increased with increase in the level of applied nitrogen. The data presented in Table 1a revealed that nitrogen could favourably influence the number of leaves per plant during all the stages. This favourable influence of nitrogen is seen reflected in leaf area index also. The result of the present investigation is in agreement with the findings of Moursi and Abdel Gawad (1966). Similar trend was observed by Jalaludeenkutty (1985) also.

Among the treatment combinations (Table 2b) the combination involving the variety Surya, 5 cm spacing and 60 kg N/ha recorded the highest leaf area index during all the stages.

The varieties differed significantly in respect of dry matter production during all the stages of growth.

FIG 3 LEAF AREA INDEX AS INFLUENCED BY VARIETY, SPACING AND APPLIED NITROGEN

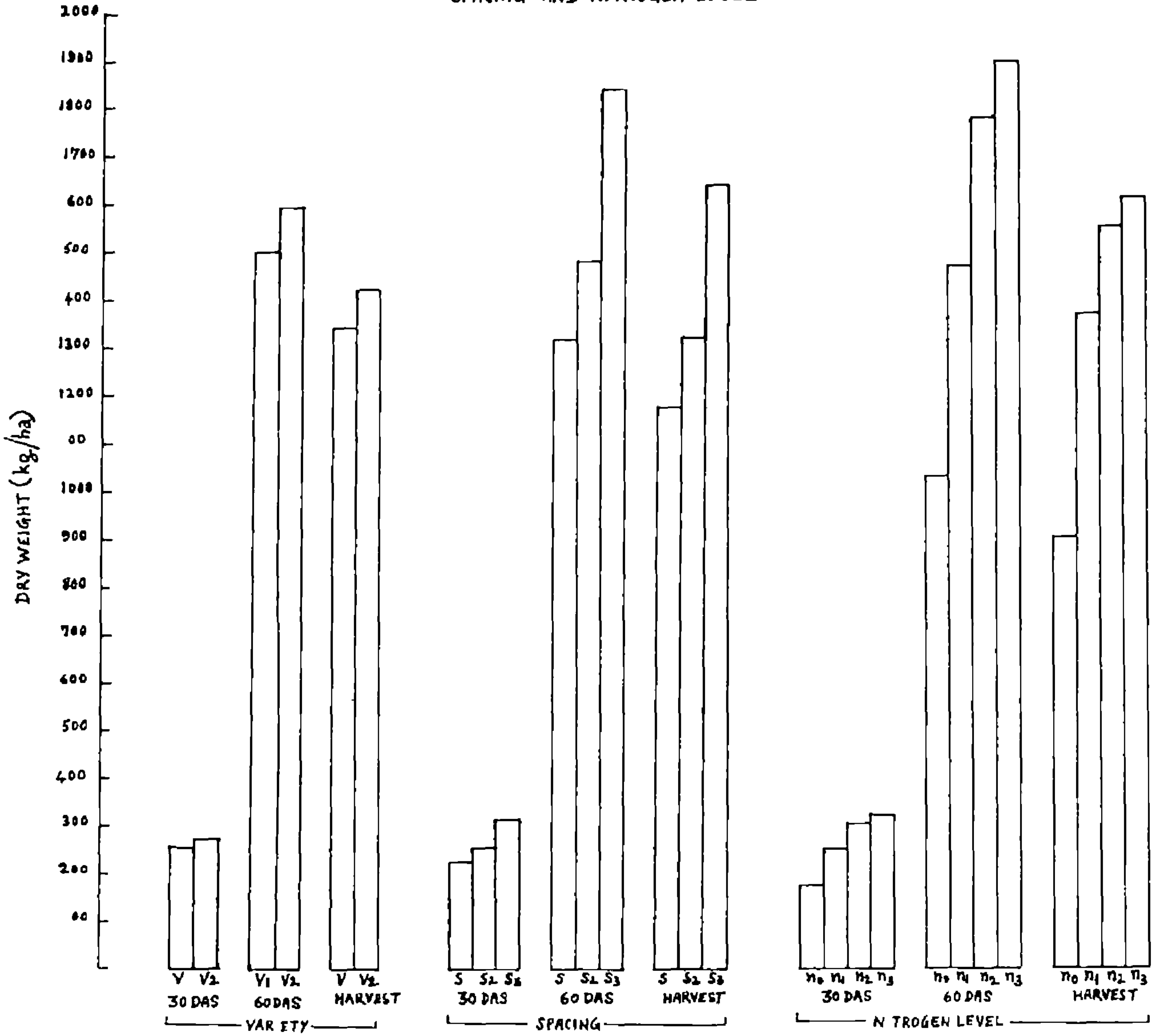


The variety Surya out yielded Kayamkulam-1 in respect of dry matter yield. This could be attributed to the increased height of plants and higher number of leaves per plant in the variety Surya as compared to Kayamkulam-1.

It was observed that close planting resulted in higher dry matter yield per hectare. Although closer planting reduced the number of branches and number of leaves per plant the higher density of population in closer spacing compensated more than the loss in dry weight per plant and resulted in higher dry matter production on unit area basis.

It is seen that the application of nitrogen increased the dry matter production significantly and the highest production was recorded with the highest level of nitrogen at all stages. Nitrogen had a positive role in increasing vegetative characters like height of plant, number of branches, number of leaves, leaf area index etc. Therefore it is but natural that nitrogen could produce increased dry weight of plant. The result of the present investigation is in agreement with the findings of Moursi and Abdel Gawad (1966) and Gopalakrishnan et al (1979) that increased application of nitrogen resulted in an increased dry matter production in sesamum. Similar results were obtained from the works of Vir and Verma (1979) and Pal (1979) in mustard and sunflower

FIG 4 DRY MATTER PRODUCTION (kg/ha) AS INFLUENCED BY VARIETY, SPACING AND NITROGEN LEVEL



respectively. The same trend of response in sesamum was reported by Girija Devi (1985) from the College of Agriculture, Vellayani.

The highest dry matter production was recorded by the variety Surya under 5 cm spacing and with 60 kg N/ha during all the stages (Table 5b). It is worthwhile to note that the maximum leaf area index was also obtained in the above three factor interaction (Table 2b).

Neither the varieties nor the nitrogen levels could exert any significant influence on the height to the first capsule.

Only plant spacing had significant influence on this parameter. Widely spaced plants produced their first capsules at lower heights as compared to close planting. However, the difference between 10 cm and 5 cm plant spacing was not significant in this respect. This is in agreement with the finding of Bonsu (1977) that wider spaced plants produced their first capsules at lower heights.

B. Yield attributes and yield

There was significant difference between the varieties in respect of number of capsules per plant and the variety Surya produced more number of capsules per plant.

The data on the height of plants, number of leaves and leaf area index (Table 1a and 2a) revealed that the variety Surya could perform better with respect to all these biometric characters. Thus the better development of source organs in the variety Surya resulted in more number of capsules per plant. Gowda and Krishnamurthy (1977) reported that sesamum varieties differ in their genitical make up governing the number of capsules per plant.

Plant spacing also significantly influenced this character. Close planting resulted in lesser number of capsules per plant and the highest number of capsules was observed with the widest spacing of 15 cm. Bonsu (1977) reported that the number of pods per plant decreased with close planting. Similar results were observed by Tilak Raj et al (1971), Delgado and Yesmanos (1975) and Thakur and Borulkar (1979) in sesamum.

Increasing levels of nitrogen also increased the number of capsules per plant significantly. Gowda and Krishnamurthy (1977) pointed out that the number of capsules is an important yield contributing character in sesamum. Moursi and Abdel Gawad (1966) pointed out that nitrogen application increased the number of fruits per plant in sesamum. Bonsu (1977), Subramanian et al (1979) and Maiti et al (1980) in sesamum, Rahman et al (1978) in safflower, Singh et al (1978) in mustard also reported increased number of capsules per plant with incremental doses of nitrogen.

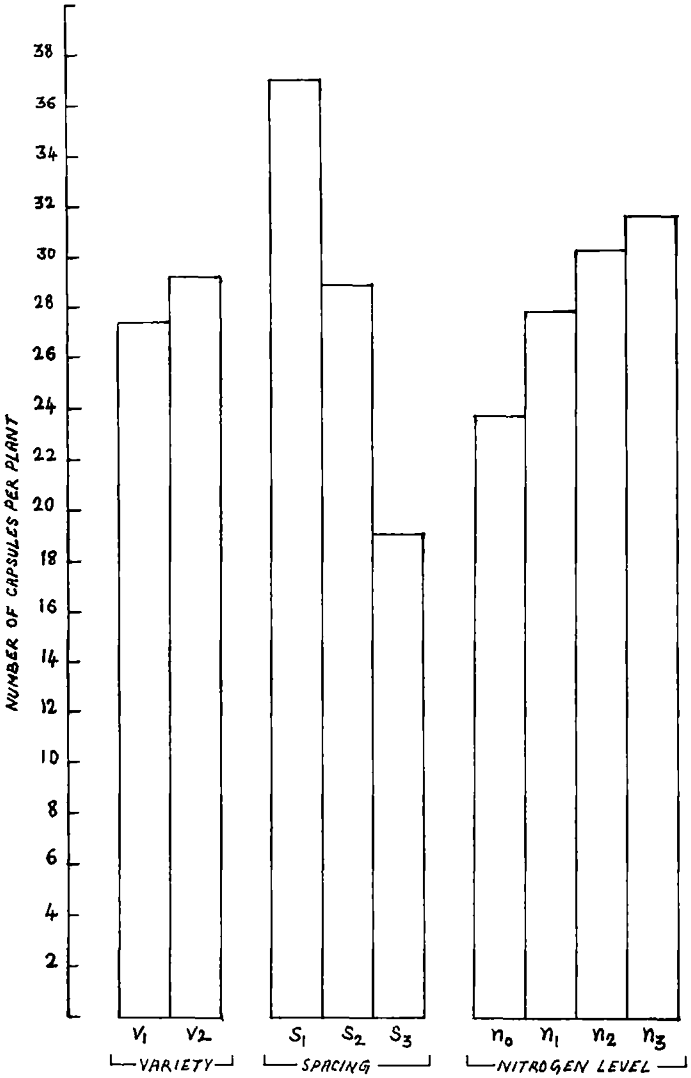
A study of the interactions (Table 4b) revealed that both the varieties recorded the highest number of capsules per plant under 15 cm plant spacing and with 60 kg nitrogen per ha. Surya recorded the highest number of capsules per plant (43.5) under 15 cm plant spacing and with 60 kg nitrogen per ha where as Kayamkulam-1 recorded only 39.7 capsules per plant under the same spacing and with the same level of nitrogen.

The two varieties were significantly different in the length of capsule and the variety Surya produced comparatively longer capsules.

Plant spacing had no profound effect on this character. However, a marginal decrease in capsule length was observed with close planting. Similar trend was reported by Delgado and Yesmanos (1975) in sesamum.

Nitrogen as a nutrient significantly influenced the capsule length. Increase in the level of nitrogen from 0 to 20 kg/ha significantly increased the capsule

FIG 5 EFFECT OF VARIETY, SPACING AND NITROGEN ON NUMBER OF CAPSULES PER PLANT



length, but further increase in nitrogen could not produce any significant increase in this character although marginal increase was observed. This clearly indicates that the length of capsule is a genetic character and as such cannot be altered much by increasing the level of nicrogen.

The varieties differed significantly in the number of seeds per capsule. The variety Surya produced more number of seeds per capsule.

The number of seeds per capsule decreased with closer planting. Widest spacing of 15 cm between plants resulted in the highest number of seeds per capsule. Delgado and Yesmanos (1975) reported that number of seeds per capsule was lower at 2.5 cm plant spacing. Bonsu (1977) reported that mature seeds per pod decreased with close planting. The result of the present investigation is in agreement with the above findings. The data on the nitrogen content of plant (Table 7a) revealed that the highest nitrogen content was seen in the widely spaced plants. This higher content of nitrogen would have been responsible for better filling up of the capsules with more number of seeds.

There was significant increase in the number of seeds per capsule with incremental levels of nitrogen application.

It is seen from the data (Table 4a) that the highest level of nitrogen could produce an average number of thirty nine seeds per capsule. The data on the uptake of nitrogen (Table 7a) revealed that the highest nitrogen uptake was seen with the highest level of nitrogen. This higher amount of nitrogen uptake would have been responsible for a better filling of the capsules with more number of seeds. Ghosh and Maj (1985) reported that in sesamum, the number of grains per pod increased steadily due to nitrogen application upto 90 kg N/ha. Maiti and Jana (1985) also reported improvement in the number of seeds per capsule due to nitrogen application. Girija Devi (1985) obtained similar response in an experiment on sesamum conducted at the College of Agriculture, Vellayani.

The varieties differed significantly in 1000 seed weight and the variety Surya produced comparatively heavier seeds.

Plant spacing could not exert any significant influence on this character. Nadi and Lazin (1974) and Bonsu (1977) reported that plant density had no effect on 1000 seed weight in sesamum.

Application of nitrogen significantly increased this character only upto 40 kg nitrogen/ha although marginal increase was observed at 60 kg nitrogen/ha. The higher amount of nitrogen absorbed by the plant would have been utilized not only for increasing the number of seeds per capsule but also for increasing the size of seeds by proper filling up of the grains. Ghosh and Maj (1985) reported that the test weight increased steadily due to nitrogen application upto 90 kg N/ha in sesamum. Maiti and Jana (1985) also observed similar trend in sesamum.

The data on seed yield presented in Table 5a revealed that the varieties differed significantly in seed yield. The variety Surya out yielded the other in this respect which could be attributed to the significantly increased height, higher number of leaves per plant, higher leaf area index, more number of capsules per plant, higher number of seeds per capsule and higher 1000 seed weight.

The influence of spacing on seed yield was also significant. Medium spacing of 10 cm recorded the highest seed yield of 278.1 kg/ha eventhough the difference between 15 cm and 10 cm plant spacing was not significant. Narrow spacing of 5 cm significantly reduced the seed yield.

Yield of any crop is a very complex competitive character resulting from different factors, the more important of them being the yield per plant and the number of plants per unit area. The yield per plant is controlled by many factors such as the nutrients taken by the plant, its genetic potential and the environmental conditions to which it is subjected during its life cycle. Under close spacing the individual plant is subjected to a higher degree of competition from its counterparts due to less available space in respect of land area as well as environment and this results in lesser number of branches, lesser number of capsules per plant and lesser number of seeds per capsule. However, the medium spacing of 10 cm could give optimum space with comparatively lesser competition and as such resulted in maximum seed yield eventhough the increase in seed yield over 15 cm plant spacing was not significant. But under a narrow spacing of 5 cm, the higher population could not compensate the yield loss per plant due to severe competition and resulted in a significantly lesser yield. Similar trends were reported by Mehrotra et al (1978) and Rao et al (1984) in sesamum. Gowda and Krishnamurthy (1977) reported that 10 cm plant spacing resulted in maximum seed yield compared to 20 and 30 cm plant spacing. The result of the present investigation is in agreement with the above findings.

Nitrogen application exerted significant increase on seed yield. The highest seed yield of 305.2 kg/ha was recorded by 60 kg nitrogen/ha. The data on various yield attributes like number of capsules per plant (Table 4 a), number of seeds per capsule (Table 4a) and 1000 seed weight (Table 5a) revealed the favourable role of nitrogen in increasing the above yield attributes. Therefore it is quite natural that the seed yield which is a final expression of all the yield attributing characters has been increased with incremental doses of nitrogen. This role of nitrogen in increasing the seed yield of sesamum has been studied by several workers and the favourable effect reported abundantly in literature (Tao and Srivatava (1968); Gaur and Trehan (1973); Singh and Kaushal (1975); Gowda (1974); Gowda et al (1977); Mehrotra et al (1978); Satyanarayana (1978); Maiti (1981) and Daulay and Singh (1982). In an experiment conducted at Jalgaon under the All India Co-ordinated Research Project on oil seeds, there was linear response to nitrogen upto the highest level of 60 kg nitrogen/ha (Anon, 1974). Daulay and Singh (1982) observed that seed yield of sesamum increased with increasing nitrogen rates from 0 to 60 kg/ha.

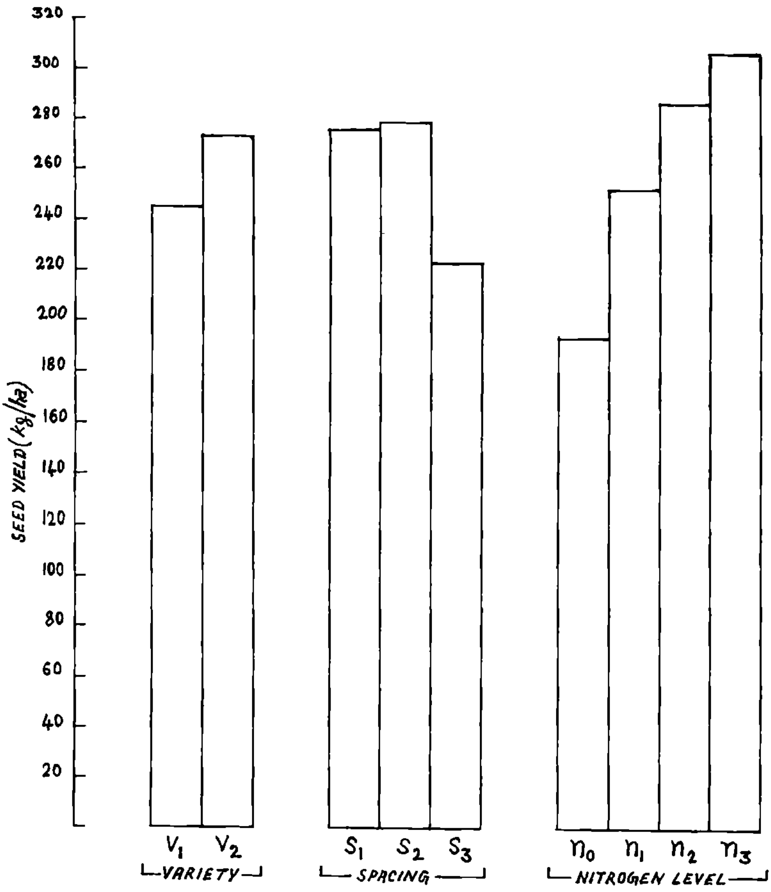
The data on seed yield (Table 5a) revealed that both the varieties recorded significantly higher yield with 60 kg nitrogen per ha. With respect to Surya medium plant spacing of 10 cm produced significantly higher yield as compared to wider and narrow spacing, whereas, with respect to Kayamkulam-1 the difference between 15 cm and 10 cm plant spacing was not significant in this regard.

The three factor interaction was significant with respect to seed yield and the variety Surya under 10 cm plant spacing and with 60 kg N/ha recorded the highest seed yield of 348.84 kg/ha (Table 5b).

There was significant difference between the two varieties in respect of stover yield. The variety Surya has given higher stover yield which may be attributed to the superior vegetative growth of this variety as evident from the maximum height (Table 1a), maximum leaves (Table la) and maximum dry matter production (Table 3a) during all the stages of growth.

Plant spacing also influenced the stover yield significantly. Close planting resulted in higher stover yield. Eventhough close planting supressed the vegetative growth of individual plants, the higher population under close spacing compensated more than the loss in vegetative growth per plant and resulted in higher stover yield on unit area basis.

FIG 6 EFFECT OF VARIETY, SPACING AND NITROGEN ON SEED YIELD

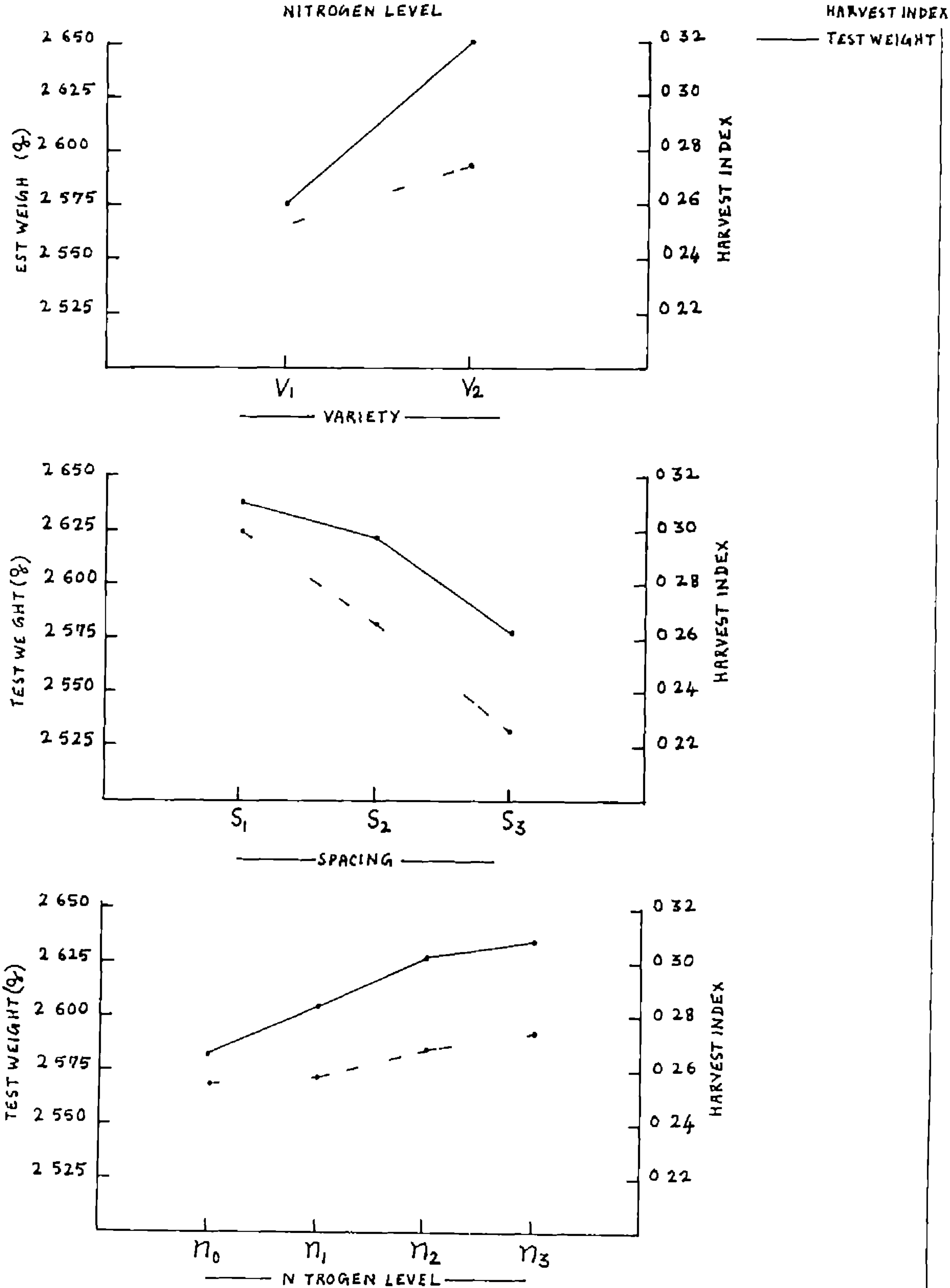


It is seen that there was significant increase in the yield of stover with increasing levels of nitrogen (Table 5a). Nitrogen is well known for its influence on vegetative growth (Moursi and Abdel Gawad (1966); Gopalakrishnan et al (1971); Abdul Rahman et al (1980); Subramanian et al (1979); Vir and Verma (1979) and Pal (1979). Therefore in the present study also the higher levels of nitrogen had increased the vegetative parts of the plant body and thereby increased the stover yield. The data on the uptake of nitrogen (Table 7a) revealed that the highest uptake of nitrogen was in the plot receiving the highest level of nitrogen. This enhanced uptake of nitrogen would have been responsible for the increased vegetative growth. It is seen that all the vegetative characters like dry weight of plants, number of leaves per plant and number of branches per plant were increased due to increased nitrogen levels thereby contributing to higher amount of stover yield.

There was significant difference between the varieties with respect to harvest index. The variety Surya recorded a higher harvest index value.

Plant spacing had significant influence on harvest index ie, decrease in plant spacing decreased the harvest index. Under close planting the individual plants are

FIG 7 HARVEST INDEX AND TEST WEIGHT (1000 GRAIN WEIGHT) AS INFLUENCED BY VARIETY, SPACING AND NITROGEN LEVEL



subjected to a higher degree of competiton the intensity of which will be severe towards the pod formation stage due to lesser availability of nutrients and this would have adversely affected the efficient conversion of the phytomass into productive or reproductive structures so as to get a lesser harvest index value.

In the present study it is seen that the application of nitrogen over 20 kg N/ha significantly increased the harvest index values with the result that the highest value was recorded by the highest level of nitrogen. Applied nitrogen significantly increased all the yield attributing characters like number of capsules per plant, number of seeds per capsule, 1000 seed weight and seed yield. Along with this the vegetative characters were also increased with increasing levels of nitrogen. However, the role of nitrogen was selective in the sense that the vegetative attributes were improved only to the extent to contribute substantially to the productive attributes so as to get a higher harvest index value. Similar trend was observed in sesamum by Girija Devi (1985) in an experiment conducted at the College of Agriculture, Vellayani.

C. <u>Quality Attributes</u>

It is seen that the varieties differed significantly in respect of oil content of seeds. Here again the variety

Surya recorded a higher seed oil content which may be attributed to genitic variation.

The different plant spacings could not significantly influence the oil content of seeds. Mazzani and Cobo (1956) and Gowda and Krishnamurthy (1977) obtained similar result in sesamum and reported that plant spacing failed to produce any significant influence on the oil content of seeds.

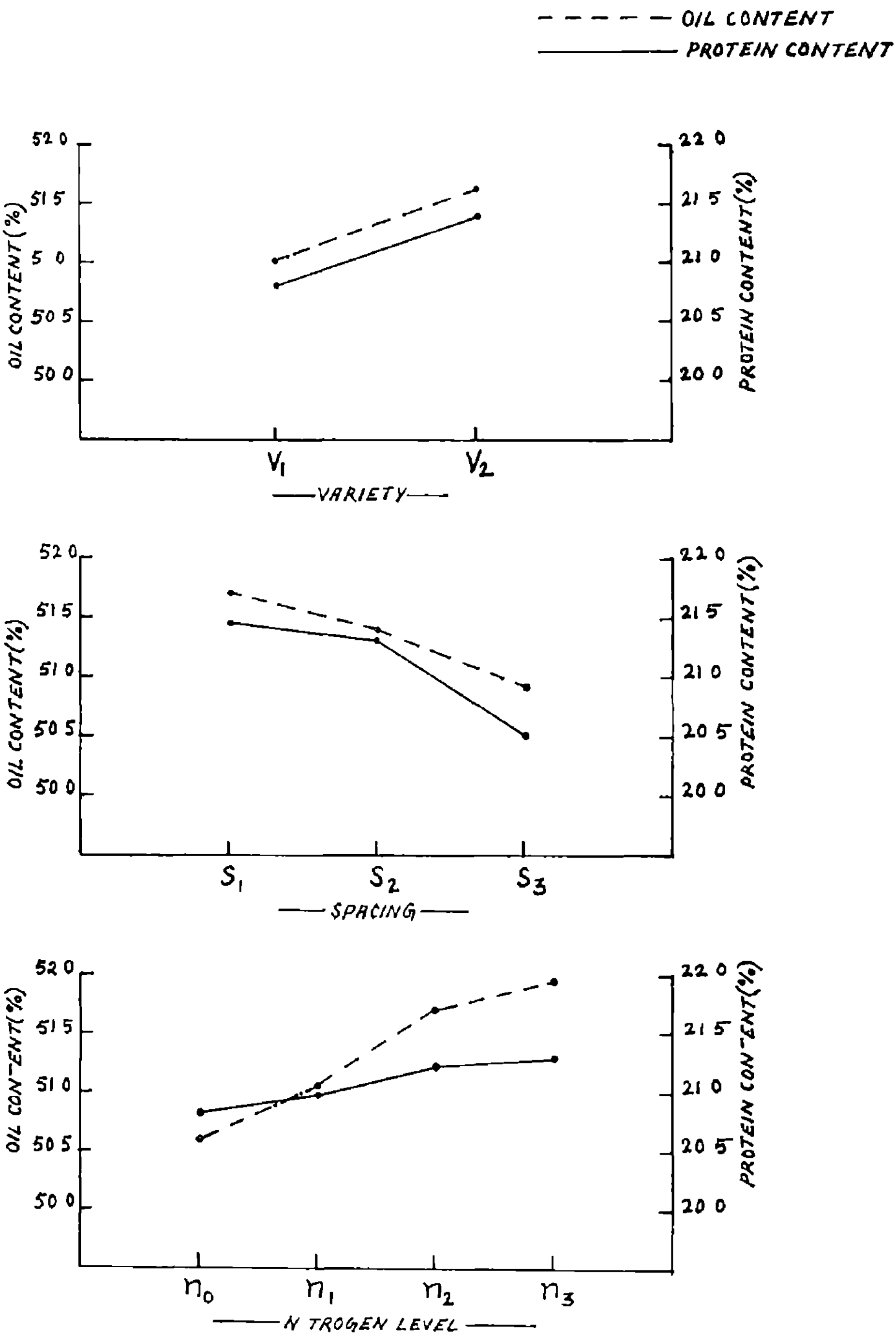
It is observed that nitrogen exerted significant and positive influence on oil content upto 40 kg nitrogen/ha. Further increment in nitrogen to 60 kg N/ha did not produce any significant improvement in this character. Several workers have reported the beneficial effect of nitrogen in enhancing the oil content of sesamum which was higher with the application of 25 kg nitrogen/ha. Similar results were obtained by Mitchell (1974), Singh and Yusuf (1979), Munoz (1979) and Vir and Verma (1979) in different oil seed crops. Metwally et al (1984) reported that highest oil production was obtained at the highest rate of nitrogen application.

There was significant difference between the two varieties in the protein content of seed. As in previous cases the variety Surya had a higher seed protein content.

Spacing had significant influence on the protein content of seeds. Closer planting reduced the protein content of seeds although the difference between 15 cm and 10 cm plant spacing was not significant in this respect. The nitrogen content of plants (Table 7a) decreased with close planting and as nitrogen is an integral part of protein this would have resulted in lower seed protein content under close planting.

The protein content of seeds was significantly increased with increasing levels of nitrogen upto 40 kg N/ha. Further increase in the level of nitrogen to 60 kg N/ha failed to produce any significant improvement in the protein content. It is seen that the nitrogen content of plant (Table 7a) and the total uptake of nitrogen (Table 7a) were increased with incremental doses of nitrogen. As stated earlier nitrogen is an integral part of protein and as such it is quiet natural that incrcased uptake of nitrogen increased the total protein content of seeds in the present study. The result of the present study is in agreement with the findings of several workers like Bhuiya and Chowdhary (1974), Mitchell (1974), Mitchell et al (1974), Mitchell et al (1976) and Skalski (1978). Aulakh et al (1980) also reported marked improvement in the protein content of mustard grain with applied nitrogen.

FIG 8 OIL AND PROTEIN CONTENTS OF SEEDS AS INFLUENCED BY VARIETY, SPACING AND NITROGEN LEVEL



D. <u>Nutrient content of plant</u>

The varieties differed significantly in nitrogen content during all stages of growth with the variety Surya recording a higher value during all stages. The data presented in Table 7a revealed that in both varieties the average nitrogen content was maximum at 30th day after sowing and decreased constantly until it reached the lowest value at harvest. This general trend is seen retained in the case of all the three nutrients studied. According to Reddy and Narayanan (1983) the concentration of nitrogen in plant parts of sesamum increases upto the 6th week after sowing, followed by a gradual decrease towards maturity. The result of the present study is in agreement with the above findings.

The nitrogen content of plant was found to be influenced by spacing and levels of nitrogen during all stages. Close planting significantly reduced the nitrogen content of plants (Table 7a). Higher degree of competition under high density planting would have resulted in poor root development and lesser uptake of nutrients. It was observed that nitrogen content of plant was significantly higher with increasing levels of nitrogen during all stages (Table 7a). Bishnoi and Kanwar (1979) reported that applied nitrogen increased the nitrogen and phosphorus contents and their uptake in raya. Aulakh <u>et al</u> (1980) observed that nitrogen fertilizer significantly increased the concentration and uptake of nitrogen in mustard crop. Present study also revealed the same trend. Girija Devi (1985) also obtained similar results in sesamum.

Among the three factor combinations (Table 7b) the highest nitrogen content was observed with the variety Surya under 15 cm spacing and with 60 kg N/ha.

The varieties differed significantly in the total phosphorus content except during the first stage. The variety Surya recorded a higher phosphorus content during the second and third stages. As in the case of nitrogen the average phosphorus content was maximum at the 30th day and decreased progressively until it reached the lowest value at harvest.

Plant density and nitrogen levels significantly influenced the total phosphorus content (Table 8a) during all the stages of observation. Close planting resulted in significant reduction in total phosphorus content. The reason projected for the nitrogen content of plant is applicable in this case also. Phosphorus content increased with increased application of nitrogen during all stages. Bishnoi and Kanwar (1979) observed increased nitrogen and phosphorus contents of raya with increase in nitrogen levels. Girija Devi (1985) also observed increase in phosphorus content with the application of nitrogen in sesamum. The results of the present study are in agreement with the above findings.

The data revealed that during the first stage, none of the main effects of variety, spacing and nitrogen level and their interactions were significant in respect of plant potassium content. However, during the next two stages, plant spacing had significant influence on the potassium content. Close spacing of 5 cm significantly lowered the potassium content during both the stages. But the difference between 15 cm and 10 cm spacing was not significant in this respect eventhough marginal decrease was observed due to reduction in plant spacing from 15 cm to 10 cm. The reason projected for nitrogen and phosphorus content is applicable in this case also. Nitrogen levels did not produce any significant effect on the potassium content. Similar results were obtained by Girija Devi (1985) and Jalaludeenkutty (1985) in sesamum.

E. Uptake of nutrients

It is seen that the varieties differed significantly in respect of nitrogen uptake and the variety Surya recorded a higher nitrogen uptake during all stages. This variety has given a higher dry matter production (Table 3a) and nitrogen content (Table 7a) and therefore it is but natural that both increased dry matter production and higher nitrogen content resulted in higher nitrogen uptake by this variety. There was progressive increase in the nitrogen uptake till 60th day after sowing and the average nitrogen uptake was maximum at 60th day. It is seen that the total nitrogen uptake decreased at the harvest stage. A perusal of the data on the dry matter production presented in Table 3 a and 3b clearly indicates that the dry weight of plant also decreased considerably from 60th day after sowing to harvest stage. The probable reason for the reduction in the total dry weight of plant may be due to the considerable shedding of leaves, which started from 60th day onwards. Similar results were obtained by Girija Devi (1985) in sesamum at Vellayani.

Close planting eventhough had a negative influence on the nitrogen content of plants the nitrogen uptake was found to be higher under high density planting. The increased dry matter production due to higher population under close spacing (Table 3a) would have resulted in higher nutrient uptake.

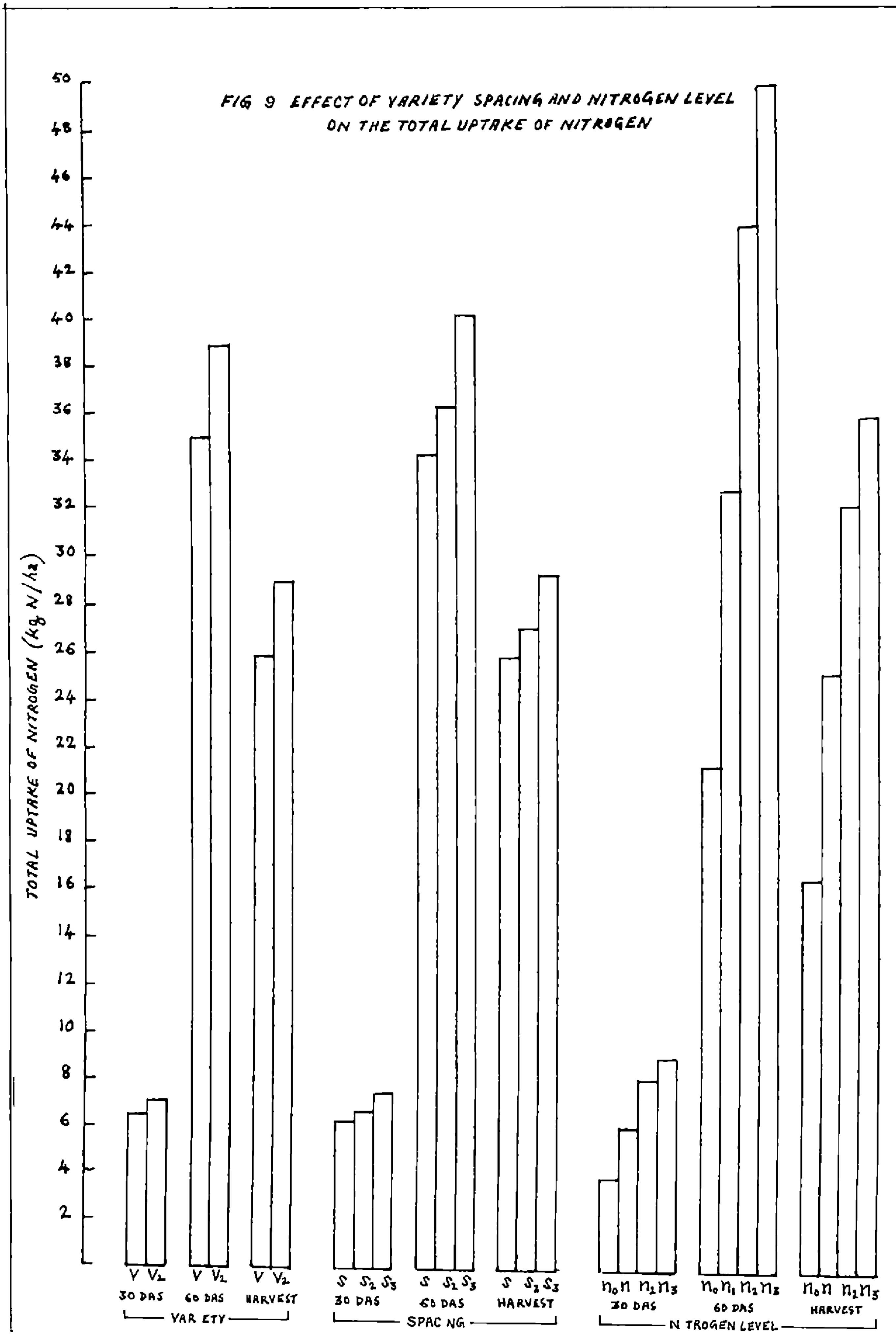


FIG 9 EFFECT OF VARIETY SPACING AND NITROGEN LEVEL ON THE TOTAL UPTAKE OF NITROGEN

It is seen that the effect of nitrogen was significant at all stages on the uptake of nitrogen. Favourable influence of nitrogen on dry matter production and nitrogen content of plant would have resulted in higher uptake with increased level of nitrogen application. Bishnoi and Kanwar (1979) reported that applied nitrogen increased the uptake of nitrogen in raya. Vir and Verma (1979) and Bhati and Rathor (1982) also observed increased uptake of total nitrogen by mustard with increasing level of nitrogen upto 60 kg/ha. Similar results were obtained by Girija Devi (1985) and Jalaludeenkutty (1985) in sesamum.

With respect to nitrogen uptake the highest value was recorded by the variety Surya under 5 cm spacing and with 60 kg N/ha (Table 7b).

In the case of phosphorus uptake also (Table 8a) there was significant difference between varieties with the variety Surya giving a higher phosphorus uptake value. This can be attributed to the increased dry matter production (Table 3a) and higher plant phosphorus content. As in the case of nitrogen uptake, the maximum uptake of phosphorus was seen on the 60th day after sowing which declined at harvest stage. As there was considerable reduction in the dry weight of plants at the harvest stage, the uptake of all the nutrients including phosphorus was less at the harvest stage.

In the case of phosphorus also close planting significantly increased the uptake of this nutrient. Increased dry matter production under high density planting would have resulted in increased uptake of nutrients.

The favourable influence of nitrogen on the uptake of phosphorus was significant during all the stages. Bishnoi and Kanwar (1979) observed that applied nitrogen increased the nitrogen and phosphorus contents and their uptake in raya plant (Brown mustard).

As in the case of nitrogen and phosphorus the variety Surya recorded a higher uptake value for potassium also during all the stages (Table 9a). Here again, the maximum uptake of potassium was seen on the 60th day after sowing which declined towards harvest. The explanation given for nitrogen and phosphorus holds good for the comparatively lower uptake of potassium at harvest stage.

Close planting increased potassium uptake during all the stages. The explanation given for nitrogen and phosphorus holds good in this case also.

Eventhough nitrogen could not exert any significant influence on the potassium content of plant, its favourable

FIG 10 EFFECT OF VARIETY SPACING AND APPLIED NITROGEN ON THE TOTAL UPTAKE OF PHOSPHORUS

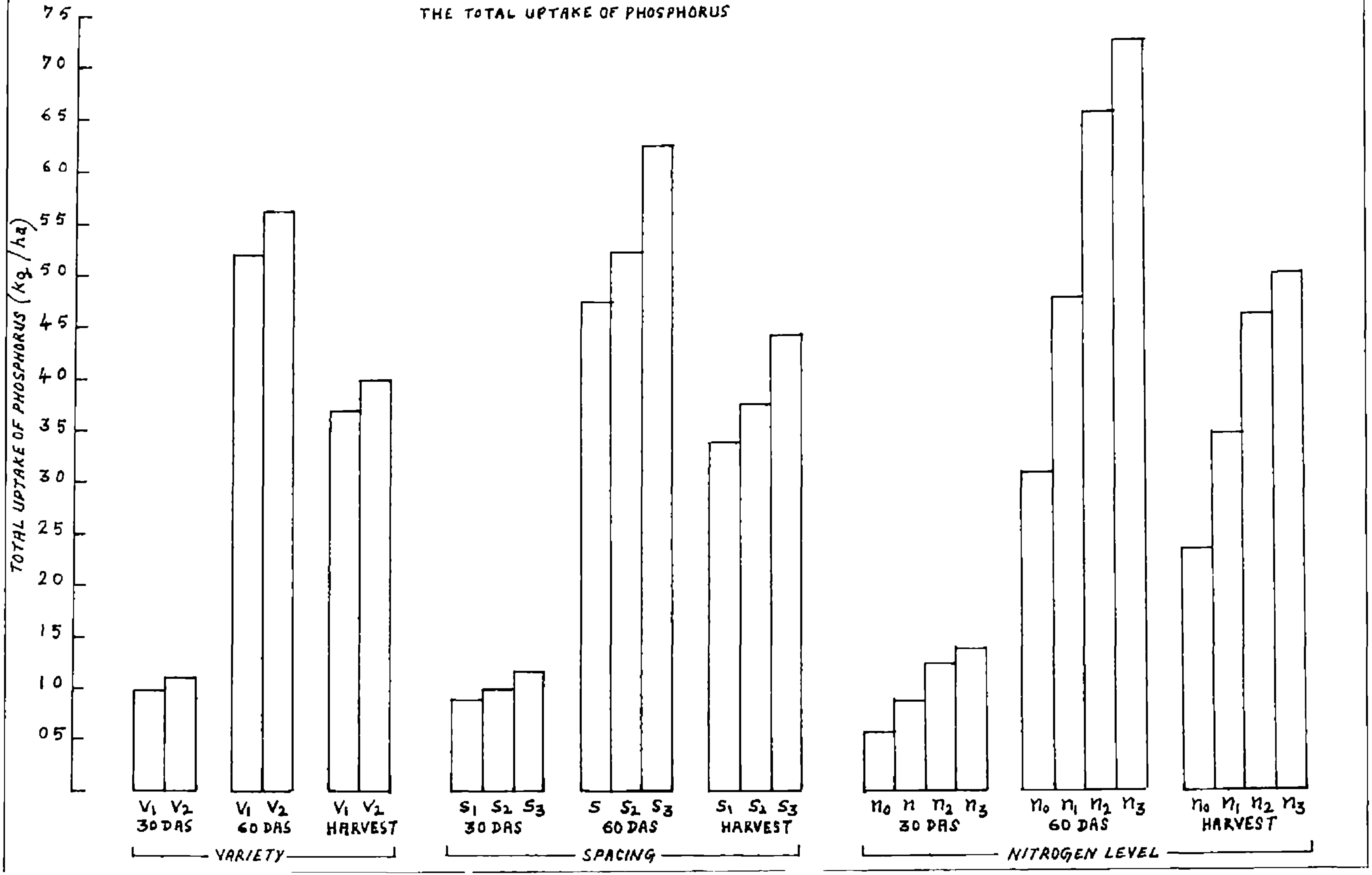
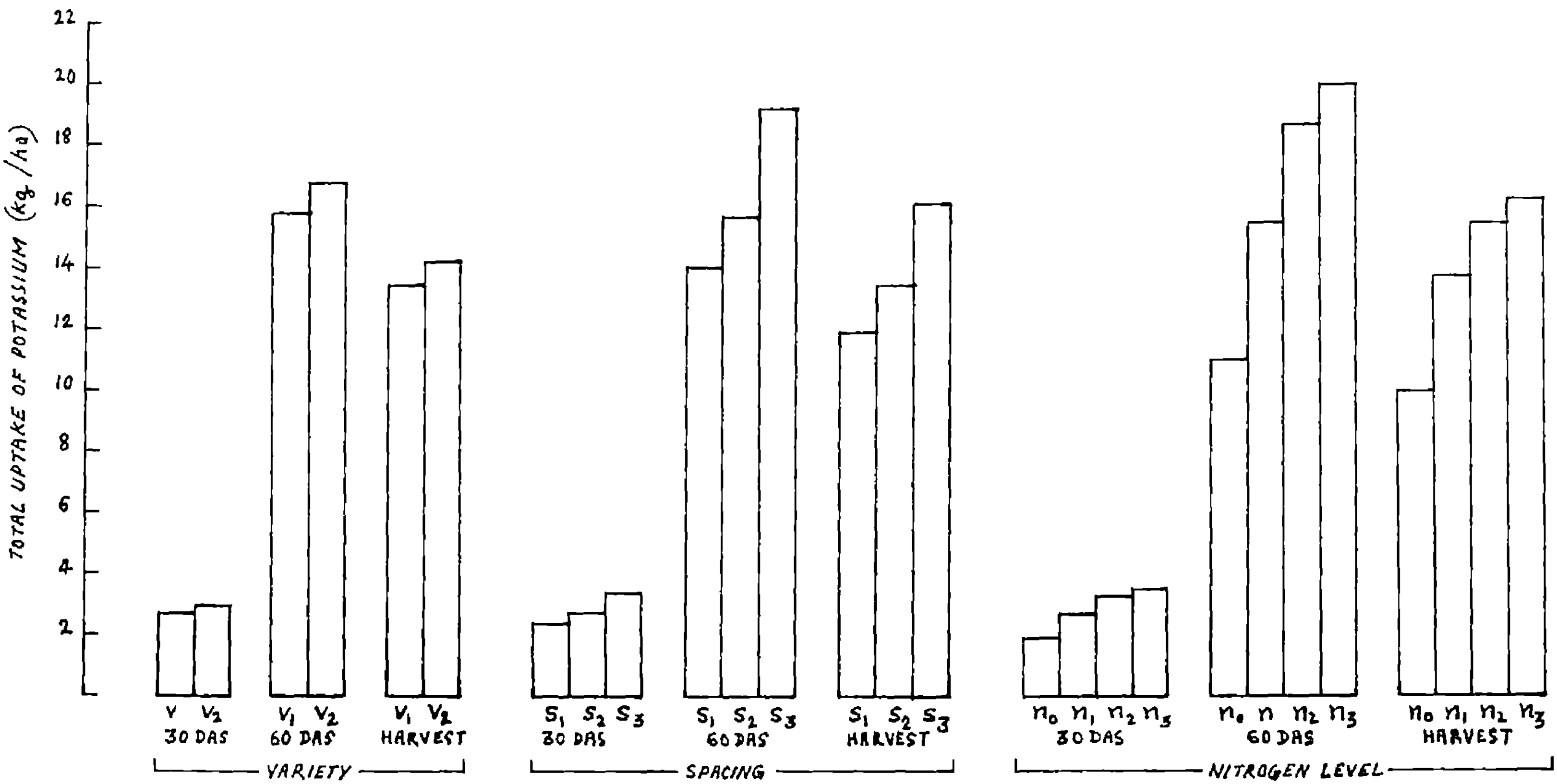


FIG 11 EFFECT OF VARIETY SPACING AND APPLIED NITROGEN ON THE TOTAL UPTAKE OF POTASSIUM



effect on dry matter production resulted in increased uptake of potassium with incremental doses of nitrogen.

F. <u>Soil analysis</u>

The data on soil analysis after the experiment showed that plant density and nitrogen application had significant influence on the total soil nitrogen content after the experiment. Close spacing of 5 cm lowered the total nitrogen content of soil. There was no significant difference between 15 and 10 cm spacings. Higher nitrogen uptake was observed under high density planting (Table 7a) and this would have lowered the total soil nitrogen content. There was a positive increase in soil nitrogen with increased levels of nitrogen application beyond 20 kg N/ha. This indicates the superiority of nitrogen fertilization for improving the nitrogen content of soil.

The data on the available phosphorus content of soil after the experiment (Table 10a) revealed that spacing alone had significant influence on the available soil phosphorus content. Close spacing of 5 cm reduced the available phosphorus content of soil as compared to wider spacing. The difference between 15 and 10 cm spacings was not significant. Nitrogen could not make any appreciable change in the available phosphorus content of soil.

In the case of available potassium content of soil the variety, spacing and nitrogen level had significant influence. Kayamkulam-1 recorded a higher soil potassium content. The potassium uptake of this variety was comparatively low (Table 9a) and therefore it is but natural that this variety recorded a higher available potassium content of soil after the experiment. As in the case of nitrogen and phosphorus close planting resulted in a decrease in the available soil potassium. Although the difference between 15 and 10 cm spacings was not significant 5 cm spacing resulted in lower soil potassium. Soil potassium was found to increase with increased levels of nitrogen application. Although increase in the level of nitrogen from 0 to 20 kg/ha could not make any significant effect, further increase to 40 kg/ha significantly increased the soil potassium. However, there was no significant difference between 40 and 60 kg N/ha with respect to available potassium content of soil.

SUMMARY

SUMMARY

A field experiment on the influence of plant density and nitrogen on growth, yield, quality, chemical composition and uptake of different nutrients by two sesamum varieties Kayamkulam-1 and Surya was undertaken in the red loam soils of Vellayani. The experiment was laid out in the second week of October, 1988, in a split plot design with four replications. The treatments consisted of factorial combinations of two varieties (Kayamkulam-1 and Surya) and three plant spacings (15, 10 and 5 cm) in the main plots and four levels of nitrogen (0, 20, 40 and 60 kg N/ha) in the sub plots.

Observations on biometric characters were recorded on the 30th day, 60th day and at harvest. The chemical composition of the plant at the above three stages was also determined. Observations on yield attributes were also recorded at harvest. The crop was harvested after 79 days and the yield of grain and stover was recorded. The result of the study are summarised below.

There was significant difference between the varieties in respect of height of plant, number of leaves per plant, number of branches per plant, leaf area index and dry matter production. The variety Surya recorded a higher value in respect of all the above growth characters except the number of branches per plant during all the stages of observation. Kayamkulam-1 recorded more number of branches per plant at harvest.

The varieties differed significantly in respect of seed yield, stover yield and the yield attributing characters such as number of capsules per plant, length of capsule, number of seeds per capsule, 1000 seed weight and harvest index. The variety Surya was found to be superior with regard to all the above characters.

The varieties differed significantly in oil content and protein content of seeds. The variety Surya recorded a higher oil and protein content.

The variety Surya was found to have a higher nitrogen content during all the stages of growth. Phosphorus content of the variety Surya was also found to be higher at 60th day after sowing and at harvest. There was no significant difference in the potassium content of the two varieties.

The nitrogen, phosphorus and potassium uptake of the variety Surya was found to be significantly higher as compared to Kayamkulam-1.

Plant spacing had significant influence on all the vegetative characters. Close planting increased the plant height at 30th day after sowing. But during the subsequent stages, although reduction in plant spacing from 15 to 10 cm increased the plant height, further reduction to 5 cm decreased plant height significantly. All the other vegetative characters were negatively influenced by close planting. Number of leaves per plant and number of branches per plant decreased when the plant spacing was reduced from 15 to 5 cm. However, leaf area index and dry matter production increased significantly with close planting. Wider spacing produced capsules at comparatively lower heights eventhough the difference between 10 cm and 5 cm spacing was not significant in this respect.

The yield attributes such as number of capsules per plant, number of seeds per capsule and harvest index were significantly reduced under close planting. Plant spacing did not exert any significant influence on capsule length and 1000 seed weight.

Plant spacing had significant influence on seed yield and stover yield. Reduction in plant spacing from

15 to 10 cm marginally increased the seed yield eventhough the increase was not significant. But close spacing of 5 cm between plants significantly lowered the seed yield. Surya recorded a significantly higher yield under 10 cm spacing as compared to wider and narrow spacings where as with respect to Kayamkulam-1, 15 and 10 cm spacings were on par. The stover yield increased when the plant spacing was reduced from 15 to 5 cm.

Plant spacing had no significant influence on the oil content of seeds. However, close planting reduced the protein content of seeds although the difference between 15 and 10 cm was not significant in this respect.

Close planting significantly decreased the nitrogen and phosphorus content of plants during all stages. The influence of plant spacing on the potassium content was not significant at 30th day after sowing. But during the subsequent stages closer spacing of plants lowered the potassium content although 15 and 10 cm spacings were on par in this respect.

Plant spacing significantly influenced the uptake of major nutrients such as nitrogen, phosphorus and potassium during all the stages. The uptake of all the nutrients increased as the plant spacing was reduced from 15 to 5 cm.

Nitrogen significantly influenced the growth and development of the plants at all the stages of observation. Height of plant, number of leaves per plant, number of branches per plant, leaf area index and dry matter production were increased significantly upto 60 kg N/ha. Nitrogen had no significant influence on the height to first capsule.

Nitrogen application significantly influenced the yield and the yield attributing characters. Number of capsules per plant, number of seeds per capsule, stover yield and seed yield were significantly increased upto 60 kg N/ha. Capsule length and 1000 seed weight were increased only upto 20 and 40 kg N/ha resoectively. Application of nitrogen beyond 20 kg N/ha significantly increased the harvest index and the increase was significant upto 60 kg N/ha.

In the case of oil content of seeds, there was significant influence of applied nitrogen, but no difference was observed between 40 ana 60 kg N/ha. There was significant increase in the protein content of seeds with increase in the level of applied nitrogen upto 40 kg N/ha.

Nitrogen content of plant as well as the total uptake of nitrogen increased significantly with the application of nitrogen during all the stages of observation. The same effect was observed in the case of phosphorus content and total uptake of phosphorus.

Nitrogen did not influence the plant content of potassium. However, the potassium uptake increased significantly with the application of nitrogen during all the stages.

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* Original not seen.

APPENDICES

APPENDIX - I

Weather data during crop period (15th October 1987 to 6th January 1988)

Standard Week	Period From	Period To	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature(°C)	Relative humidity (%)08.30 hrs.	Relative humidity (%) 17.30 hrs.
42	Oct.15	Oct.21	56.6	30.7	24.0	88.1	79.0
43	Oct.22	Oct.28	30.5	31.1	24.3	87.3	80.7
44	Oct.29	Nov.4	56.2	30.9	23.6	88.0	79.4
45	Nov.5	Nov.11	120.9	30.7	23.6	84.7	77.9
46	Nov.12	Nov.18	18.8	31.0	23.5	86.4	75.4
47	Nov.19	Nov.25	36.2	30.7	23.4	83.4	75.3
48	Nov.26	Dec.2	-	31.1	23.4	83.7	81.3
49	Dec.3	Dec.9	111.5	31.2	23.7	86.7	74.9
50	Dec.10	Dec.16	44.0	31.3	23.1	87.9	80.4
51	Dec.17	Dec.23	63.6	31.3	22.8	81.7	70.9
52	Dec.24	Dec.30	14.1	31.3	22.2	86.9	69.7
1	Dec.31	Jan.6	-	30.8	21.0	89.9	74.0

APPENDIX - II

Analysis of variance table for height of plants and number of leaves per plant

Source	df	Mean squares					
		Height of plants (cm)			Number of leaves		
		30th day	60th day	Harvest	30th day	60th day	Harvest
Block	3	6.8949**	72.795**	141.1857**	3.2432**	69.5571**	24.2102*
V	1	1023.758**	230.5625**	912.625**	835.9698**	3239.531**	3632.211**
S	2	30.42381**	2818.5**	3820**	2.1001**	879.3984**	820.9726**
VS	2	2.3789*	3.8438	0.8125	0.1304	42.1484**	43.6055**
Main plot-Error	15	0.5078	9.5667	0.425	0.2423	3.3063	4.6516
N	3	64.8236**	1774.563**	2110.208**	31.7578**	4624.11**	3479.206**
SN	6	0.3089**	1.6354*	0.78125	0.035	36.1589**	31.905**
VN	3	0.7721**	19.125**	9.1667**	0.8053**	123.1979**	71.4115**
VSN	6	0.0091	7.4167**	4.1458**	0.0072	1.8177	4.8177**
Sub plot-Error	54	0.0714	0.6308	0.4387	0.0401	0.8927	1.3783

* Significant at 5% level

** Significant at 1% level

APPENDIX - III

Analysis of variance table for number of branches per plant and leaf area index

Source	df	Mean squares				
		Number of branches		Leaf area index		
		60th day	Harvest	30th day	60th day	Harvest
Block	3	0.2909**	0.3803**	0.0153**	0.1406**	0.05004**
V	1	0.01404	1.0795**	3.1828**	1.4187**	2.8705**
S	2	1.9195**	4.576**	8.3973**	18.4347**	12.597**
VS	2	0.2097**	0.7764**	0.3558**	0.07474**	0.00943
Main plot-Error	15	0.01523	0.0254	0.00112	0.00361	0.008525
N	3	3.1059**	2.895**	0.3373**	15.1402**	12.8908**
SN	6	0.1881**	0.2632**	0.0377**	0.3846**	0.6982**
VN	3	0.1639**	0.5063**	0.00519**	0.0363**	0.02169**
VSN	6	0.0433**	0.06629**	0.00089**	0.0094*	0.030813**
Sub plot-Error	54	0.00597	0.00983	0.00025	0.00351	0.00369

* Significant at 5% level

** Significant at 1% level

APPENDIX - IV

Analysis of variance table for dry matter production and height to first capsule

Source	df	Mean squares			
		Dry matter production (kg/ha)			Height to first capsule (cm)
		30th day	60th day	Harvest	
Block	3	1215.2114**	42466.67**	35566.67**	50.484**
V	1	6095.5**	208320**	166576**	1.712
S	2	66366.75**	2303432**	1822656**	9.258**
VS	2	70.25**	2648**	1528**	2.5255
Main plot-Error	15	4.9667	158.93	138.67	0.8497
N	3	103397.7**	3587152**	1881723**	1.287
SN	6	2585.33**	88320**	54437.33**	0.745
VN	3	1050.17**	37440**	26224**	0.543
VSN	6	11.25**	314.67*	485.33**	0.2373
Sub plot-Error	54	3.222	108.74	91.56	0.8939

* Significant at 5% level

** Significant at 1% level

APPENDIX - V

Analysis of variance table for number of capsules per plant, length of capsule and number of seeds per capsule

Source	df	Mean squares		
		Number of capsules per plant	Length of capsule (cm)	Number of seeds per capsule
Block	3	3.3482**	0.767**	3.7523**
V	1	83.3828**	0.17171**	32.6719**
S	2	2575.379**	0.0559	495.0313**
VS	2	1.50**	0.0205	0.0078
Main plot-Error	15	0.16615	0.01532	0.01875
N	3	279.3255**	0.01407**	67.1615**
SN	6	18.405**	0.00242	0.005208
VN	3	23.6823**	0.000363	0.01042
VSN	6	2.5130**	0.000208	0.0026
Sub plot-Error	54	0.1604	0.001983	0.12211

* Significant at 5% level

** Significant at 1% level

APPENDIX - VI

Analysis of variance table for 1000 seed weight, seed yield and stover yield

Source	df	Mean squares		
		1000 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
Block	3	0.6533**	753.24**	15166.67**
V	1	0.13**	18883**	20704**
S	2	0.0278	31671.25**	1870576**
VS	2	0.0175	371.75**	11992**
Main plot-Error	15	0.01283	31.033	1644.8
N	3	0.0116**	58073.67**	828037.3**
SN	6	0.001283	89.33**	48382.67**
VN	3	0.001733	4487.5**	51301.33**
VSN	6	0.00075	124.417**	1057.33
Sub plot-Error	54	0.000996	27.88	491.56

* Significant at 5% level

** Significant at 1% level

APPENDIX VII

Analysis of variance table for harvest index, oil content and protein content

Source	df	Mean Squares		
		Harvest index	Oil content (%)	Protein Content (%)
Block	3	0.000265	61.558**	43.797**
V	1	0.011484**	9.254*	8.766**
S	2	0.04407**	5.111	8.428**
VS	2	0.000641*	0.927	1.006
Mainplot-Error	15	0.000101	1.779	0.7433
N	3	0.00206**	9.254**	1.0174**
SN	6	0.000385**	0.3438	0.0325
VN	3	0.0000904	0.056	0.00353
VSN	6	0.0000496	0.05733	0.00422
Subplot-Error	54	0.000052	0.56378	0.0680

* Significant at 5% level

** Significant at 1% level

APPENDIX - VIII

Analysis of variance table for nitrogen content (%) of plant at different stages

Source	df	Mean squares		
		30th day	60th day	Harvest
Block	3	0.1935**	0.1265**	0.1301**
V	1	0.1425**	0.2233**	0.2101**
S	2	1.0973**	1.2438**	1.2581**
VS	2	0.00549	0.00095*	0.000488**
Main plot-Error	15	0.00975	0.00017	0.00000407
N	3	1.3877**	1.6148**	1.6366**
SN	6	0.06227**	0.09215**	0.09149**
VN	3	0.01164	0.00238**	0.001322**
VSN	6	0.01169	0.002218**	0.00196**
Sub plot-Error	54	0.01139	0.000181	0.0000107

* Significant at 5% level

** Significant at 1% level

APPENDIX - IX

Analysis of variance table for phosphorus content (%) of plants at different stages

Source	df	Mean squares		
		30th day	60th day	Harvest
Block	3	0.00167**	0.00101**	0.00818**
V	1	0.000176	0.000599**	0.000265**
S	2	0.0072**	0.00383**	0.00391**
VS	2	0.0000043	0.00001	0.000046*
Main plot-Error	15	0.000091	0.000056	0.000012
N	3	0.05752**	0.03724**	0.0309**
SN	6	0.000036	0.0000221	0.000133**
VN	3	0.000157*	0.000136*	0.000092**
VSN	6	0.0000051	0.000008	0.0000154
Sub plot-Error	54	0.0000425	0.000037	0.000016

* Significant at 5% level

** Significant at 1% level

APPENDIX - X

Analysis of variance table for potassium content (%) of plants at different stages

Source	df	Mean squares		
		30th day	60th day	Harvest
Block	3	0.000341	0.00372**	0.00337**
V	1	0.0001304	0.000135	0.000469
S	2	0.000718	0.0034**	0.00847**
VS	2	0.000018	0.000015	0.0000005
Main plot-Error	15	0.000228	0.000342	0.00033
N	3	0.000536	0.000235	0.00026
SN	6	0.000202	0.000059	0.000037
VN	3	0.000036	0.000012	0.000026
VSN	6	0.000161	0.0000103	0.000066
Sub plot-Error	54	0.000225	0.000206	0.000277

* Significant at 5% level

** Significant at 1% level

APPENDIX - XI

Analysis of variance table for nitrogen uptake (kg/ha) at different stages

Source	df	Mean squares		
		30th day	60th day	Harvest
Block	3	2.473**	68.336**	48.229**
V	1	9.5005**	353.742**	222.078**
S	2	13.1355**	285.035**	96.516**
VS	2	0.1824	1.9727**	0.8555*
Main plot-Error	15	0.07764	0.1667	0.1349
N	3	118.465**	3769.06**	1745.537**
SN	6	0.3742**	5.5065**	1.3555**
VN	3	0.9074**	37.4557**	18.5913**
VSN	6	0.1069	0.6107*	0.3581*
Sub plot-Error	54	0.09958	0.2619	0.126

* Significant at 5% level

** Significant at 1% level

APPENDIX - XII

Analysis of variance table for phosphorus uptake (kg/ha) at different stages of growth

Source	df	Mean squares		
		30th day	60th day	Harvest
Block	3	0.0386**	0.3408**	1.5388**
V	1	0.1281**	4.3555**	2.0172**
S	2	0.5992**	19.1582**	8.6827**
VS	2	0.000721	0.0535*	0.000305
Main plot-Error	15	0.000862	0.01364	0.01083
N	3	3.1971**	85.005**	35.1829**
SN	6	0.05127**	1.3674**	0.7509**
VN	3	0.02519**	0.7105**	0.3355**
VSN	6	0.000221	0.00309	0.00175
Sub plot-Error	54	0.000326	0.01324	0.00619

* Significant at 5% level

** Significant at 1% level

APPENDIX - XIII

Analysis of variance table for potassium uptake (kg/ha) at different stages

Source	df	Mean squares		
		30th day	60th day	Harvest
Block	3	0.1367**	3.2657**	2.4032**
V	1	0.6703**	21.15**	14.214**
S	2	7.2935**	225.695**	147.60**
VS	2	0.00485	0.28*	0.098
Main plot-Error	15	0.00213	0.0702	0.058
N	3	12.153**	389.69**	183.21**
SN	6	0.3025**	9.468**	4.885**
VN	3	0.1279**	3.697**	2.439**
VSN	6	0.00372	0.03083	0.035
Sub plot-Error	54	0.00239	0.0797	0.0675

* Significant at 5% level

** Significant at 1% level

APPENDIX - XIV

Analysis of variance table for nitrogen, phosphorus and potash content of the soil after the experiment

Source	df	Mean squares		
		Nitrogen content (%)	Phosphorus content (kg/ha)	Potassium content (kg/ha)
Block	3	0.004826**	22.123**	49.37**
V	1	0.00000018	0.5142	3.37**
S	2	0.001601**	18.846**	2.623**
VS	2	0.000000089	3.634	0.378
Main plot-Error	15	0.0000131	1.8046	0.175
N	3	0.00421**	0.6506	1.262**
SN	6	0.000294**	1.1487	0.098
VN	3	0.00000006	0.4257	0.043
VSN	6	0.00000003	0.2193	0.041
Sub plot-Error	54	0.0000744	1.339	0.125

* Significant at 5% level

** Significant at 1% level

RESPONSE OF TWO SESAMUM VARIETIES (KAYAMKULAM-1 AND SURYA) TO DIFFERENT PLANT DENSITIES AND NITROGEN LEVELS

BY

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ABSTRACT OF A THESIS

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A B S T R A C T

An experiment was conducted at College of Agriculture, Vellayani during 1987 to study the influence of 3 plant densities (30 x 15 cm, 30 x 10 cm and 30 x 5 cm) and 4 levels of nitrogen (0, 20, 40 and 60 kg N/ha) on the growth, yield, oil and protein contents, chemical composition and nutrient uptake pattern of two sesamum varieties (Kayamkulam-1 and Surya). The experiment was laid out in split-plot design with the variety-spacing combinations in the main plots and nitrogen levels in the subplots.

The variety Surya recorded higher values for plant height, number of leaves/plant, leaf area index, drymatter production, seed yield, stover yield, number of capsules/plant, capsule length, number of seeds/capsule, 1000 seed weight, harvest index, oil and protein contents of seeds, nitrogen and phosphorus contents and nitrogen, phosphorus and potassium uptake.

Plant spacing of 10 cm resulted in maximum height. Number of leaves/plant, number of branches/plant, number of capsules/plant, number of seeds/capsule and harvest index were significantly reduced under close planting.

Leaf area index, drymatter production, stover yield and the uptake of nutrients increased with close planting. Surya recorded significantly higher seed yield under 10 cm spacing. No significant difference was observed between 15 and 10 cm spacings with respect to seed yield of Kayamkulam-1 Spacing of 5 cm reduced the protein content of seeds. Close planting decreased the nitrogen, phosphorus and potassium contents of plants.

Plant height, number of leaves/plant, number of branches/plant, leaf area index, drymatter production, number of capsules/plant, number of seeds/capsule and stover yield increased upto 60 kg N/ha. Both the varieties recorded significantly higher seed yield with 60 kg N/ha. Capsule length and 1000 seed weight were increased only up to 20 and 40 kg N/ha respectively. Nitrogen application beyond 20 kg/ha increased the harvest index up to 60 kg/ha. Applied nitrogen significantly influenced the oil and protein contents of seeds up to 40 kg/ha. The uptake of all the nutrients and the nitrogen and phosphorus contents of plant were significantly influenced by applied nitrogen.