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STANDARDISATION OF FERTILIZER SCHEDULE FOR EXPORT ORIENTED PRODUCTION OF BHINDI

BY

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THESIS
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DECLARATION

I hereby declare that this thesis entitled "Standardisation of Fertilizer Schedule for Export Oriented Production of bhindi (Abelmoschus esculentus L. Moench)" 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.

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CERTIFICATE

Certified that this thesis entitled "Standardisation of Fertilizer Schedule for Export Oriented Production of bhindi (*Abelmoschus esculentus* L. Moench)" is a record of research work done independently by Sajitha Rani, T under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

mm	-	Millimetre
cm	-	Centimetre
m	-	Metre
g	-	Gram
kg	-	Kilo Gram
q	-	Quintal
ha	-	Hectare
°C	-	Degree celsius
CGR	-	Crop growth rate
DAS	-	Days after sowing
DMP	-	Dry matter production
DAH	-	Days after harvest
Fig.	-	Figure
WAS	-	Weeks after sowing
No.	-	Number

INTRODUCTION

INTRODUCTION

The importance of vegetables in human nutrition is well known as it is a rich and comparatively cheaper source of vitamins and minerals. Vegetables are the cheapest source of natural protective food and they yield roughly 3 to 4 times the food obtained from the cereal crops in a much short crop duration than cereals.

Consumption of vegetables in sufficient quantities provide taste, palatability and provides fair amount of fibres. They are currently reckoned as important adjunct for maintanance of good health and beneficial in protecting against some degenerative diseases. They also play a key role in neutralising the acids produced during digestion of proteinous and fatty foods and also provide valuable roughage which promotes digestion. India is the World's second largest producer of vegetables next to China. The annual production is estimated around 48.5 million tonnes from a cropped area of 45 million hectares (Sulekha and Mohanakumaran 1992). Though the recommendation given by dieticians is 300g of vegetables per head per day the percapita availability is around 120-130g per day. Vegetables can form a greater portion of diet and can thus help to reduce the pressure on cereal consumption.

In Kerala, vegetables cover an area of 1.62 lakh hectares producing 1.62 lakh tonnes per year. (Anon 1989) and the current requirement is 3 lakh tonnes. About 50 percent of our requirement is at present met by procurement from other states and thus about 90 crores of rupees flows every year to neighbouring states for the purchase of vegetables alone.

Out of 1.62 lakh tonnes produced in our state about 6312 tonnes of vegetables costing Rs.12 crores were exported to foreign countries. This shows the need for boosting up vegetable production in our country.

Among vegetables bhindi occupies an important place on account of its tender green bhindi fruits. Bhindi (Abelmoschus esculentus L Moench) also known as Okra is a member of Malvaceae family and is considered of African and Arabic origin. (De candolle, 1883). In addition to its role as vegetable it has nutritional, economic and medicinal importance too (CSIR, 1959). They are relished for their high mucilage content. The fruits are canned, dehydrated, or frozen alone and used in soups and stews. The ripe seeds, flowers and tender leaves are also used for human consumption. Mucilagineous extracts from bhindi roots & stem are used as clarifier and also in the manufacture of jaggery. Mucilage content of leaves is also used as a substitute for detergents. Nadkarni (1954) reported that Okra has emollient, demulcent, diuretic, cooling and aphrodâsiac actions and is found serviceable in fevers, catarrhal attacks, dysentery and spermatorrhoea.

Due to its easiness of cultivation, and suitability for year round production, bhindi is now cultivated in large scale on commercial basis. Because of its wide acceptability bhindi produced are exported from wholesale markets. Of the different vegetables exported to Arabian countries bhindi occupies an important position constituting 60 percent of the total export (Sulekha and Mohanakumaran 1992).

The development of larger number of improved varieties with wider acceptability and standardization of their production techniques for agro-climatic condition has made it possible to produce vegetables in wider areas and has improved the production of their supply tremendously. In order to cater the demand (internal as well as external) production potential of vegetable bhindi needs further agronomic studies. The package of practices recommendation for the crop is 50:8:30 kg N, P_2O_5 and K_2O ha^{-1}. But the farmers in Kerala are using high quantity of fertilizers in different splits. In addition fertilizer experiments conducted at different centres revealed that the crop responds to higher levels of nutrients than the present recommendation. The T & V workshop for Thiruvananthapuram district has recommended the application of 330:110:220 kg N P_2O_5 and K_2O ha^{-1} in six splits (Anon, 1980).

With this background the study was undertaken with a view to determine the optimum quantity of fertilizers and their application in splits to maximise production of export quality vegetable bhindi, so that a profitable income can be obtained by the farmers in southern zone of Kerala.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

An experiment was conducted to find out the effect of different levels of nutrients and their split application on the growth, yield, quality and nutrient uptake of bhindi Abelmoschus esculentus (L) Moench in the College of Agriculture, Vellayani during kharif 1990. The available literature relating to the above topic is reviewed hereunder. Wherever sufficient literature is not available on bhindi, research work done on similar related crops are also cited.

2.1 Effect of nitrogen

2.1.1 Effect of nitrogen on growth characters

2.1.1.1 Height of plant

Increase in height of plant with increasing levels of nitrogen in bhindi was reported by several workers Singh and Singh (1965), Saimbhi and Padda (1970), Chauhan and Gupta (1973), Subramonian (1980), Zannin and Kimoto (1980), Singh et al (1986) and Lenka et al (1989).

Chonkar and Singh (1963) found that increase in nitrogen concentration upto 210 ppm stimulated height of plant but further increase retarded height.

Singh (1979) observed no significant difference in plant height by increasing the nitrogen dose from 75 to 150 kg ha^{-1}.

In general an increase in plant height with increase in levels of nitrogen was observed.

2.1.1.2 Leaf area index (LAI)

Increased LAI with increasing levels of nitrogen had been reported by several workers. Subramonian (1980) reported that increasing levels of nitrogen significantly increased the LAI both at 30th and 60th day after sowing. Subba Rao (1989) reported that in cucumber N at the rate of 50 kg ha^{-1} increased the leaf area during the 30th, 60th and 90th DAS. Nitrogen enhanced the expansion of leaves which in turn increased the LAI in amaranthus as reported by Rajan (1991).

Verma et al (1970) observed no effect on the number of leaves in bhindi by increasing fertilizer nitrogen from 90-120 kg ha^{-1} and he suggested that this may probably be due to limited amount of plant capacity beyond a certain optimum.

In general an increase in leaf area index with increase in levels of nitrogen was observed.

2.1.1.3 Crop growth rate (CGR)

Palit et al (1976) obtained an increase in CGR with increased application of nitrogen in rice.

Surendran (1985) also reported similar results. Ramakrishnan Nayar (1986) reported that in cassava during the later growth phase (180-240, days) nitrogen upto 150 kg ha^{-1} significantly increased CGR than lower levels.

2.1.1.4 **Drymatter production (DMP)**

Subramonian (1980) observed that in bhindi crop DMP was increased with increasing levels of nitrogen upto 60 kg N ha^{-1} though the statistical significance was observed only upto 30 kg N ha^{-1}. Rajendran (1981) reported that the total DMP at 60 days after sowing and at harvest was increased with increasing levels of nitrogen in pumpkin. Wankhade and Moreg (1986) reported that in chilly nitrogen produced significantly higher DMP upto 100 kg N ha^{-1}. Hedge (1988) found that in water melon increase in DMP occured with increase in nitrogen level upto 120 $kgha^{1}$. Saji John (1989) reported that in chilli there was a progressive increase in dry matter due to increasing levels of nitrogen upto 125 kg ha^{-1}.

In general dry matter production increased with increasing levels of nitrogen.

2.1.2 **Effect of nitrogen on days to 50 percent flowering, yield attributes and yield.**

2.1.2.1 **Time of 50 percent flowering**

Delayed maturity was reported in bhindi with increasing levels of nitrogen by Thompson and Kelly (1957), Yawalker (1969) and Kamalanathan et al (1970). Shrestha (1983) in a study to find out the effect of spacing and nitrogen fertilization in bhindi variety pusa sawani, found that nitrogen fertilization advanced the first harvest by 4-6 days compared with controls receiving no nitrogen.

Chauhan and Gupta (1973) found that there was no significant effect on days to first flowering in bhindi due to different levels of nitrogen.

In general delayed flowering was observed due to nitrogen application.

2.1.2.2 **No. of flowers/plant**

Randhawa and Pannun (1969) in a trial conducted in bhindi with three levels of nitrogen 34, 68 and 102 kg ha^{-1} found that 68 kg N ha^{-1} is the most effective dose for increasing the number of flowers per plant. Chauhan and Gupta (1973) reported that higher dose of nitrogen (67.5 kg N ha^{-1}) gave maximum number of flowers per plant. Subramonian (1980) reported that application of nitrogen resulted in significantly higher number of flowers upto the highest level of 60 kg ha^{-1}.

Chandrasekharan (1965) in an experiment found that nitrogen at 100 lb per acre has only a slight effect in increasing the number of flowers, beyond which a decline is noticed and the result is not statistically significant also.

In general flower formation increased with increasing levels of nitrogen fertilization.

2.1.2.3 **Setting percentage of fruits**

Significant increase in setting percentage by the application of graded dose of nitrogen in chilli was reported by Joseph (1982).

Chandrasekharan (1965) reported higher setting percentage with 100 lb per acre over 125 lb per acre.

Chauhan and Gupta (1973) reported that setting percentage was unaffected by increasing doses of nitrogen upto 67.5 kg ha^{-1} and the lowest dose of nitrogen 22.5 kg N ha^{-1} gave maximum percentage of flower to set fruits. Subramonian (1980) studied the effect of nitrogen at different levels (0:30:60 kg N/ha on the setting percentage and observed that increasing levels of nitrogen tended to reduce the fruit set and 60 kg N ha^{-1} recorded the lowest compared to zero and 30 kg N ha^{-1} which were on par with each other.

In general setting percentage of fruits is not significantly influenced by nitrogen fertilization.

2.1.2.4 No. of fruits/plant

Fertilizer experiment conducted at different locations to study the effect of nitrogen on the fruit yield of bhindi revealed that the response of the crops vary with locations. Verma et al (1970) reported that the number of fruits per plant increased with increasing levels of nitrogen upto 90 kg N ha^{-1}. Nitrogen application significantly increased the fruit yield in bhindi upto 100 kg N ha^{-1} as reported by Gupta and Rao (1979). Shrestha (1983) found that in bhindi pod yield was highest from plots receiving 60 kg N ha^{-1}. Similar results have been reported by Majanbu et al (1985), Mishra and Pandey (1987), Balasubramani (1988) and Lenka et al (1989).

Gupta and Rao (1979) reported that in bhindi application of nitrogen above 100 kg ha^{-1} did not affect the number of fruits per hectare significantly.

In general increased fruit production is recorded by nitrogen fertilization.

2.1.2.5 **Length and girth of fruits**

Verma et al (1970) found that increasing doses of nitrogen increased length of fruits, the maximum being 17.6cm resulted from 120 kg N ha^{-1}. Balasubramani (1988) also reported that in bhindi nitrogen application showed significant increase in fruit length with increasing levels.

Lenka et al (1989) in a study in bhindi with 4 levels of nitrogen (0, 50, 75 and 100 kg ha^{-1}) found that nitrogen at 50, 75 and 100 kg ha^{-1} were on par with respect to length of bhindi fruits.

Chandrasekharan (1965) found that highest level of nitrogen showed a decrease in the length of fruits over lower levels. Singh (1979) reported that when nitrogen dose increased from 75 kg to 150 kg ha^{-1} there was adverse effect on pod length.

Verma et al (1970) found that the fruit diameter increased to maximum of 231 at 90 kg N ha^{-1} as compared with 1.84 cm for zero level of nitrogen. Majanbu et al (1985) reported that nitrogen application significantly increased the pod diameter.

Balasubramoni (1988) observed that fruit girth was increased by the application of nitrogen at 30 kg ha^{-1}.

Gupta and Rao (1979) in an experiment with bhindi found that fruit size was highest at 150 kg N ha^{-1} which was statistically on par with 100 kg N ha^{-1}.

Singh (1979) found that when nitrogen dose increased from 75 kg to 150 kg ha^{-1} there was adverse effect on pod diameter.

In general nitrogen fertilization has not significantly influenced the fruit length or diameter.

2.1.2.6 Total yield of bhindi

Siambhi and Padda (1970) observed increased yield in okra with nitrogen fertilization upto 134 kg N ha^{-1}. Chauhan and Gupta (1973) reported a linear increase in okra yield upto 675 kg N ha^{-1} in sandy loam soils. Sharma and Shukla (1973) obtained highest yield with nitrogen at 120 kg ha^{-1}. Subramonian (1980) reported that highest yield is obtained with 60 kg N ha^{-1}. Similar results have been obtained by Shrestha (1983) Singh et al (1986). Tomar and Rathore (1988) found that yield of bhindi was highest in plants which received 75 kg N ha^{-1}.

Chandrasekharan (1965) found that none of the treatment was significant eventhough there was an increasing trend with the increase in the level of nitrogen.

Verma *et al* (1970) in an experiment in bhindi with five levels of nitrogen (0, 30, 60, 90 & 120 kg ha^{-1}) found that total yield of fruit was maximum at 90 kg N ha^{-1} and beyond that there was a depressing effect.

In general fruit yield increased with increasing levels of nitrogen.

2.1.3 Effect of nitrogen on quality

2.1.3.1 Effect of nitrogen on crude protein

Thampan (1963) observed maximum protein content in bhindi with 75 lb nitrogen per acre. Subramonian (1980) found that application of nitrogen at the highest level of 60 kg ha^{-1} increased the protein content of fruits. He also reported that nitrogen at the rate of zero and 30 kg ha^{-1} were on par as far as protein content is concerned.

Chandrasekharan (1965) found that nitrogen at 75 lb and 100 lb/acre increased the crude protein content while 125 lb nitrogen per acre reduced the crude protein.

In general protein content increased with increasing levels of nitrogen.

2.1.3.2 Effect of nitrogen on ascorbic acid content of fruits

Irene Vethamoni (1988) found that in bhindi application of 55 kg N ha^{-1}, recorded the highest ascorbic acid content of fruits followed by the decreasing levels of nitrogen. Balasubramoni (1988) reported that application of 30 kg N ha^{-1} gave highest ascorbic acid content.

Saji John (1989) found that in chilli application of 100 and 125 kg N ha^{-1} significantly increased the fruit ascorbic acid content compared with N at 75 kg ha^{-1} and the effects due to 100 and 125 kg N ha^{-1} were on par.

However Sinha (1975) showed that every increase in nitrogen dose decreased the ascorbic acid content of fresh chilli fruits.

In general ascorbic acid content increased with increasing levels of nitrogen.

2.1.3.3. Effect of nitrogen on crude fibre

Mani and Ramanathan (1982) reported that crude fibre content of bhindi fruit was significantly decreased by nitrogen fertilization. Application of 80 kg N ha^{-1} recorded least crude fibre content of 12.91% as against 14.2% with zero level of nitrogen. Application of 55 kg N ha^{-1} decreased the crude fibre content of fruits reported by Irene Vethamoni (1988). Balasubramoni (1988) reported least crude fibre content in bhindi fruits with 30 kg ha^{-1}.

However Singh (1970) reported that in bhindi crude fibre percentage had increased by increasing nitrogenous fertilizer.

In general nitrogen fertilization decreased the crude fibre content of fruits.

2.2 Effect of phosphorus

2.2.1 Effect of phosphorus on growth character

2.2.1.1 Height of plant

Chandrasekharan (1965) reported that phosphorus increased the plant height upto 150 lb P_2O_5 per acre. Randhawa _et al_ (1977) in a pot culture experiment with bhindi found that phosphorus upto 60 ppm gave higher plant height. Subramonian (1980) found that in bhindi there was significant increase in plant height upto the highest level of 50 kg $P_2O_5 ha^{-1}$ except from 30th to 60th day, where it was only to the intermediate level of 25 kg P_2O_5 ha^{-1}.

Saimbhi and Padda (1970) reported that there was no significant response to phosphorus application at 34 or 67 kg ha^{-1}.

Chonkar and Singh (1963) obtained increase in height of plant by phosphorus application upto a concentration of 93 ppm beyond which phosphorus had a depressing effect. Singh and Singh (1966) and Singh et al (1967) in a fertilizer trial conducted on bhindi for three seasons observed a considerable decrease in plant height at 50 kg as compared to 25 kg P_2O_5 ha^{-1}.

Generally phosphorus fertilization increased the height of plant.

2.2.1.2 Leaf area index (LAI)

Subramonian (1980) in an experiment with bhindi found that increasing levels of phosphorus significantly increased the LAI both at 30th and 60th day after sowing. Rajendran (1981) reported that in pumpkin, there was significant increase in LAI of plant at all growth stages viz 3oth DAS, 60th DAS and at harvest with increasing levels of phosphorus. George Thomas (1984) reported increased LAI upto 30 kg $P_2O_5ha^{-1}$, in bittergourd.

In general phosphorus application increased the LAI of plants.

2.2.1.3 Crop Growth Rate (CGR)

Ramakrishnan Nayar (1986) obtained an increased CGR with phosphorus upto 100 kg ha^{-1} in cassava.

Generally CGR increased with increase in levels of phosphorus.

2.2.1.4 Drymatter production

According to Chougule and Mahajan (1979) in chilli the dry matter content of leaves, branches and fruits was significantly increased due to graded levels of phosphorus. Subramonian (1980) found that in bhindi application of phosphorus also tended to increase the drymatter yield and the effect was significant only at 30th day after sowing.

Saji John (1989) in chilli reported that phosphorus at 60 kg P_2O_5 ha^{-1} produced the maximum dry matter which was on par with 80 kg $P_2O_5ha^{-1}$.

Generally DMP increased with increasing levels of phosphorus.

2.2.2 Effect of phosphorus on days to 50 percent flowering, yield attributes and yield

2.2.2.1 Time of 50 percent flowering

Thompson and Kelly (1957), Yawalker (1969) reported that phosphorus application induced earliness in Okra. Kamalanathan et al (1970) found that application of phosphorus induced earliness in bhindi. Muraleedharan Nair et al (1978) observed that in groundnut application of P_2O_5 @ 50 kg ha^{-1} significantly reduced the vegetative phase by promoting early flowering. Subramonian (1980) reported that in bhindi, there was significantly earlier flowering with 50 kg P_2O_5 ha^{-1}. He also reported that there was no significant difference between 0 and 25 kg P_2O_5 ha^{-1} with respect to days taken for 50 percent flowering.

2.2.2.2 No. of flowers/plant

Chandrasekharan (1965) reported an increase in the number of flowers in bhindi with the increase in phosphorus levels. Mehrotra et al (1968) found that deficiencies of phosphorus adversely affected flower production in chilli crop, whereby no flowers formed in phosphorus deficient plants. Chandrasekharan and

George (1973) found an increasing trend in flower production with increased doses of phosphorus in brinjal.

Subramonian (1980) reported that flower production was not significantly increased with phosphorus application.

Phosphorus fertilization generally increased the number of flowers formed.

2.2.2.3 Setting percentage

Joseph (1982) also reported that in chilli setting percentage was significantly increased by the application of graded doses of phosphorus.

Subramonian (1980) observed no significant difference in fruit set between 0 and 30 kg ha^{-1}.

Chandrasekharan (1965) found that phosphorus influenced the fruit setting percentage to a greater extend, the lower levels of phosphorus have given an increased setting percentage over the highest level.

In general fruit setting percentage was not affected by phosphorus fertilization.

2.2.4 No. of fruits/plant

Sharma and Shukla (1973) reported that phosphorus application at the rate of 34.88 and 52.32

$kg ha^{-1}$ produced significantly more fruits than 17.44 kg $P ha^{-1}$ in bhindi. Subramonian (1980) reported that the number of bhindi fruits significantly increased with increasing phosphorus levels upto the highest level of 50 $kg ha^{-1}$. Majanbu et al (1985) found that application of phosphorus significantly increased green pod yield in bhindi.

Chandrasekharan (1965) found that in bhindi phosphorus application tends to increase the number of fruits, though the difference between treatments is not significant.

Kamalanathan et al (1970) observed that in bhindi zero kg phosphorus registered an increased yield of 13.24 percent and 17.34 percent over 50 kg phosphorus and 100 kg P/ha^{-1} respectively in terms of number of fruits. Verma et al (1970) also reported that in bhindi various levels of phosphorus had no significant effect.

In general fruit formation increased with increase in levels of phosphorus.

2.2.2.5 Length and girth of fruits

Singh (1979) found that in bhindi when phosphorus doses were increased from 75 to 150 $kg.ha^{-1}$

there were adverse effects on pod length, while phosphorus application had significant effect on pod length as compared to control. The highest level of phosphorus has shown a decrease in the length of fruits over lower levels (Chandrasekharan, 1965). Subramonian (1980) found that fruit length was unaffected upto 25 kg $P_2O_5ha^{-1}$ in bhindi. Khan and Suryanarayana (1977) reported that the girth of chilli pod was maximum by the application of 90 kg P_2O_5 per hectare.

Verma et al (1970) found that in bhindi application of phosphorus had no significant effect with regard to fruit size.

In general fruit length and girth was not affected by phosphorus fertilization.

2.2.2.6 **Total yield of bhindi**

Bhindi gave better response upto 60 kg P_2O_5/ha with respect to yield and yield components (Chonkar & Singh, 1963).

Kamalanathan et al (1970) found that in bhindi, there was a slight increase in yield of 1.2 percent due to the application of 100 kg phosphorus ha^{-1} over no application. Sharma & Shukla (1973) in a two year trial found that 34.8 kg P_2O_5 ha^{-1} has better yield compared to 17.4 and 52.32 kg P_2O_5 ha^{-1}. Randhawa et al (1977) reported that in a pot culture experiment on bhindi upto 60 ppm of phosphorus gave higher yield. This is in confirmity with the findings of Saimbhi and Padda (1970).

Subramonian (1980) reported that in bhindi eventhough there was increase in yield upto the highest level tried (50 kg N ha^{-1}), the difference was significant upto 25 kg P_2O_5 ha^{-1}.

Chandrasekharan (1965) has reported that phosphorus showed a decreasing trend in yield with the increase in its level. Singh and Singh (1966), and Singh et al (1967) in a fertilizer trial conducted on bhindi for three seasons observed considerable decrease in yield at 50 kg P_2O_5 ha^{-1} level as compared to 25 kg P_2O_5 ha^{-1} level.

Generally phosphorus fertilization increased the fruit yield of bhindi.

2.2.3 Effect of phosphorus on quality

2.2.3.1 Effect of phosphorus on protein content

Punoose and George (1974) in a study on the effect of phosphorus on the yield and quality of groundnut found that phosphorus has significantly increased the protein content with increasing levels of its application.

Chandrasekharan (1985) reported that application of phosphorus had no influence in increasing crude protein content in bhindi. Subramonian (1980) found that in bhindi there was no significant difference in crude protein content with application of phosphorus at zero and 25 kg ha^{-1}.

He also reported that phosphorus at 25 kg ha^{-1} recorded higher crude protein content than phosphorus at 50 kg ha^{-1}.

Generally phosphorus application increased the crude protein content of bhindi fruits.

2.2.3.2 Effect of phosphorus on fruit ascorbic acid content

According to Dass & Mishra (1972) phosphorus application significantly increased the fruit ascorbic acid content in chillies. Similar effects of phosphorus in increasing the vitamin C content of fresh fruits of chilli were also reported by Joseph (1982). Patil and Patil (1986) showed that in radish phosphorus at higher dosage enhanced the accumulation of ascorbic acid both in tops and roots.

But, Khan and Suryanarayana (1977) showed that phosphorus did not affect the ascorbic acid content of chilli fruits.

Generally ascorbic acid content increased with increasing levels of phosphorus.

2.2.2.3 Effect of phosphorus on fruit crude fibre content

Singh (1979) in a study on bhindi found that crude fibre percentage increased by increasing phosphatic fertilizer.

Generally crude fibre content increased with phosphorus fertilization.

2.3 Effect of potassium

2.3.1 Effect of potassium on growth characters

2.3.1.1 Height of plant

Singh (1979) found that height of bhindi increased upto a level of 60 kg $K_2O\ ha^{-1}$. Joseph (1982) found that potassium exerted appreciable influence on chilli plant height at the time of final harvest.

Chonkar and Singh (1963) reported that potassium application in sand culture experiment did not have any marked effect on growth of okra plant. Sutton (1963) also observed that application of potassium had no significant effect on the vegetative growth of bhindi. This finding support the findings of

Chandrasekharan (1965) and Singh (1979).

Subramonian (1980) noted that the phosphorus application recorded significant effect in plant height only upto 15th and 30th day after sowing with 25 kg K_2O ha^{-1} and further increase upto 50kg ha^{-1} considerably reduced the plant height.

Generally height of the plant increased with increased potassium application.

2.3.1.2 Leaf Area Index (LAI)

Subramonian (1980) reported
considerable increasein LAI was noted a
sowing due to higher levels of potas
and he also reported that application of potassium decreased the LAI at 30 days after sowing.

Generally LAI increased with potassium application.

2.3.1.3 Crop Growth Rate (CGR)

In cassava the CGR increased significantly with increase in levels of fertilizer upto 150 kg K_2O ha^{-1} and this was on par with 100 kg K_2O ha^{-1} (Rama-Krishnan Nayar, 1986)

Generally an increase in CGR is obtained with increase in levels of potassium fertilizers.

2.3.1.4 **Dry matter production**

Subramonian (1980) found that in the case of potassium the maximum value was recorded at the highest level of 50 kg K_2O ha^{-1}. Joseph (1982) found that higher doses of potassium significantly increased the total dry matter yield per plant in chilli.

But Chougule and Mahajan (1979) indicated that in chilli the dry matter content of leaves and branches was not affected by potassium.

Generally DMP increased with increasing levels of potassium.

2.3.2 **Effect of potassium to days on 50 percent flowering, yield attributes and yield**

2.3.2.1 **Time to 50 percent flowering**

Pimpini (1967) observed that application of 160 kg potassium per hectare promoted earliness in chillies. Saji John (1989) also found that in chilli potassium at 65 kg K_2O ha^{-1} induced earliness significantly.

Chandrasekharan (1965) reported that potassium had not shown any difference for earliness in flowering in bhindi. Similar non significant influence of potassium in earliness in flowering in bhindi was also reported by Singh et al (1967), Kamalanathan et al (1970).

Subramonian (1980) reported that application of potassium resulted in significant delay in flowering in bhindi.

Generally potassium application delayed flowering in bhindi.

2.3.2.2 Number of flowers per plant

Chandrasekharan (1965) reported that increasing the potassium levels, increased the number of flowers in bhindi, Subramonian (1980) found that in bhindi application of potassium resulted in significantly higher number of flowers upto the highest level tried (60 kg ha^{-1}). He further reported that in bhindi potassium at the rate of 0 and 25 kg ha^{-1} were on par as far as number of flowers formed per plant was concerned.

Generally potassium fertilization increased the number of flowers formed.

2.3.2.3 Setting percentage

Chandrasekharan (1965) reported that in bhindi lower levels of potassium ie 50 lb/acre has a low setting percentage compared to higher levels of 75 lb/acre and 100lb/acre and the treatment difference was not significant. Subramonian (1980) also reported that there was no significant difference between different potassium levels in bhindi as far as setting percentage was concerned.

Generally application of potassium has no effect on setting percentage of fruits.

2.3.2.4 Number of fruits per plant

Chandrasekharan (1965) observed an increase in the number of fruits with increase in potassium levels. Subramonian (1980) also reported that application of potassium brought about significant increase in the number of fruits upto the highest level of 50 kg K_2O ha^{-1}. Mishra and Pandey (1987) also reported that potassium at 40 kg ha^{-1} was found effective and significantly increased the number of bhindi fruits per plant.

Kamalanathan et al (1970) found that application of potassium at 30 kg ha^{-1} increased the number of fruits and further increase to 60 kg ha^{-1} did not bring out any increase in fruit number. Singh (1979) reported that potassium application in higher doses from 60 to

120 kg ha^{-1} has no significant effect on number of pods formed in bhindi. Verma et al (1970) reported that in bhindi application of potassium did not increase the number of fruits formed.

Generally potassium application increased the number of fruits formed.

2.3.2.5 **Length and girth of fruits**

Subramonian (1980) found significant increase in fruit length of bhindi at higher levels of potassium.

Singh (1979) reported that there was no significant difference in length of bhindi fruit applied with 60 and 120 kg K_2O ha^{-1}.

Chandrasekharan (1965) reported that the highest level of potassium, 100 lb/acre has shown a decrease in the length of fruit over lower levels.

Joseph (1982) found that potash application increased the girth of chilli pods.

But Singh (1979) reported that potassium application had no significant effect on pod girth in bhindi.

In general potassium fertilizer has no significant effect on length and girth of fruits.

2.3.2.6 **Total yield of bhindi fruits**

Ahmed and Tulloch Reid (1968) reported that application of potassium influenced the total yield of bhindi fruit significantly. Asif and Greig (1972) and Mani and Ramanathan (1980) also reported similar results. Subramonian (1980) found that potassium application significantly influenced the yield of bhindi recording the highest yield with highest dose of 50 kg K_2O ha^{-1}.

Kamalanathan et al (1970) reported that potassium at 30 kg ha^{-1} enhanced the yield and further increase to 60 kg ha^{-1} decreased the yield. Verma et al (1970) also found that total yield of bhindi fruit was maximum at 90 kg ha^{-1} and beyond that there was a depressing effect.

Application of potassium had no significant effect on yield of bhindi as reported by Sutton (1963). This is inconfirmity with the findings of Chonkar and Singh (1963), Chandrasekharan (1965), Singh and Singh (1966), Singh et al (1967).

In general fruit yield increased with increasing levels of potassium.

2.3.3 **Effect of potassium on quality**

2.3.3.1 **Effect of potassium on protein content**

Rajenna *et al* (1987) reported that in potato application of potassium increased the crude protein content significantly.

Chandrasekharan (1965) found that in bhindi potassium application had no influence in increasing the crude protein content.

Subramonian (1980) reported that in bhindi potassium at zero level gave significantly superior crude protein content when compared to potassium at 25 and 50 kg/ha and he further reported no significant difference in protein content with application of potassium at 25 kg and 50 kg. ha^{-1}.

Generally crude protein content increased with potassium application.

2.3.3.2 Effect of Potassium on fruit ascorbic acid content

Dass and Mishra (1972) from their investigation reported that the vitamin C content of fresh fruits of chilli increased with increased levels of potassium application.

Harshad *et al* (1960) reported that in tomato added potassium was found to have no marked effect on the ascorbic acid content. Joseph (1982) also observed that potash had no significant effect on fruit ascorbic acid content of chilli.

Generally ascorbic acid content increased with increasing levels of potassium.

2.3.3.3 **Crude fibre content**

Habben (1973) and Roysell et al (1977) observed increased crude fibre content in carrot and sweet potato respectively, due to potassium application. Singh (1979) found that in bhindi crude fibre percent had increased by increased potassic fertilizer upto the highest level of 120 kg $K_2O\ ha^{-1}$ applied. Mani and Ramanathan (1982) reported that increased levels of potassium application increased the crude fibre content on bhindi fruits.

Generally crude fibre content increased with potassium application.

2.5 Effect of nitrogen, phosphorus and potassium on uptake of nutrients

Asif and Greig (1972) found that in bhindi application of phosphorus and potassium increased the contents of these nutrients in plants. Application of nitrogen increased nitrogen content but decreased phosphorus content. Saimbhi and Padda (1970) also agreed with the above findings. He further observed that the application of phosphorus did not affect the nitrogen content of plant.

Subramonian (1980) reported that in bhindi when the nutrients were applied in combination, the uptake of nitrogen phosphorus and potassium were generally high and the highest uptake was not always with the highest level of nutrients.

Joseph (1982) observed that in chilli total uptake of nitrogen was significantly increased by increased levels of nitrogen, phosphorus and potassium. Subbiah and Raniperumal (1986) observed that in tomato increased application of nitrogen resulted in increased uptake of nitrogen.

Generally uptake of nutrients increased with increasing levels of nutrients.

2.6 Split application of nutrients on growth characters

Peterburgskii et al (1956) while investigating the effectiveness of applied fertilizer under irrigation observed that a basal dressing before ploughing, a top dressing before sowing and supplementary top dressing were found to be effective in giving better growth.

Matev (1966) in a study with mineral fertilizer in capsicum found good response by the plant in terms of growth of areal parts recording highest response with a top dressing of 80 kg N ha^{-1}.

Yawalker (1969) recommended the application of 40 kg N/ha for bhindi with half of its applied one month after sowing and the remaining half one month after the first application for better growth.

Skapski et al (1969) showed that growth of certain varieties of tomato were increased by the application of organic manure (30-60 ha^{-1}) given in conjuction with side dressings of 150-200 kg N ha^{-1}.

Chauhan (1972) recommended top dressing of 30-75 kg N ha^{-1} between rows before fruiting for better growth in terms of plant height in bhindi.

Singh et al (1985) in a study on Amaranthus with nitrogen found that application of 60 kg N ha^{-1} in two splits, first half as basal and the rest as top dressing 8 WAS was found to be the best for getting maximum plant height and optimum leaf/stem ratio resulting in high green leaf yield.

Jayakrishnakumar (1986) reported that application of nitrogen influenced the plant height, LAI and dry matter production significantly in two splits followed by three splits with 50 percent of it as basal compared to three splits with 1/3 nitrogen as basal. Singh et al (1986) in an experiment in bhindi with four split doses at an interval of 10 days starting from one month after sowing found that increasing levels of nitrogen increased plant height.

Generally growth character increased with application of nutrients in splits.

2.7 Yield attributes and yield

Yawalker (1969) found that in bhindi, application of 40 kg N ha^{-1} in two equal splits, one at sowing and another one month after first application recorded higher fruit yield.

Skapski et al (1969) reported that in tomato application of organic manure (30-60 t ha^{-1}) given in conjuction with side dressing of 150-300 kg N ha^{-1}, increased the fruit size and yield.

Chauhan (1972) observed higher fruit yield in bhindi with top dressing of 30-75 kg N ha^{-1} before fruiting.

Hammett et al (1974) obtained higher fruit yield in cucumber by side dressing of 30 lb of nitrogen per acre at 4-6 leaf stage.

Verma et al (1970) recorded the highest fruit yield in bhindi with 150 kg N ha^{-1} applied in the proportion of three foliar:one soil and the foliar sprays were applied at weekly intervals starting from 25 days after sowing.

Bradley et al (1975) in a study on cucumber with nitrogen 80 lb/acre applied either entirely on preplant or 50 or 20 lb/acre preplant followed by one or two supplementary applications one or two weeks after emergence reported that yields and returns tended to be higher with supplementary application.

Chuzhova et al (1975) observed that split application of nitrogen, phosphorus and potassium increased the fruit size and fruit yield of tomato.

Smittle (1976) found increased yield in snap bean by the application of additional nitrogen as top dressing.

Batal and Smittle (1981) observed that yield of capsicum was improved by nitrogen as top dressing.

In an experiment conducted at Vellanikkara, it was found that application of 250 kg ammonium sulphate with half as basal and half one month after sowing gave better growth and higher yield of fruits in bhindi (Anon, 1989). Srinivas and Prabhakar (1982) obtained highest yield of better quality fruits in capsicum with the application of 50 kg N ha^{-1} in three splits namely at planting, 30 days and 60 days after planting.

Lanchow Wing and Rajkomar (1982) in bhindi found no significant difference in yield between a single side dressing of N at 120 kg ha^{-1} applied one month after germination and 2 dressings each of 60 kg ha^{-1} applied at one and 2 months after germination respectively.

Jayakrishnakumar (1986) found that in bhindi application of nitrogen in lesser number of splits significantly influenced the number of fruits per plant, length of fruits and he also reported that though not significant the trend in fruit yield due to split application of nitrogen was in favour of S_1, receiving 50 percent nitrogen as basal and the remaining 50 percent 30 DAS.

Mitsui (1964) reported that in rice plant basal application of phosphorus gave better grain yield than split application. Bharadwaj et al (1974) found marked response of rice to single application of phosphorus at planting.

Balasubramonian et al.(1982) reported that single basal application would be sufficient for the low land rice soils of cauvery delta.

Generally yield and yield attributing characters increased with increasing levels of nutrients,

2.8 Effect of split on quality

Sharma and Prasad (1973) found non significant effect of split application of nitrogen on crude protein content of bhindi fruits. This is in confirmity with the findings of Lanchow wing and Rajkomar (1982) and Jayakarishnakumar (1986) in bhindi.

Dod et al (1983) obtained the best quality fruits of capsicum with regard to crude protein and ascorbic acid content by applying nitrogen in four equal splits namely at transplanting 30 days after transplanting and 21 days after second application and 21 days after the third application.

Generally quality of bhindi fruit increased with increasing level of nutrients.

2.9 Uptake of nutrient

Paulraj and Raniperumal (1980) in an experiment to study the effect of sources and split application of nitrogen on nutrient uptake by tomato found that three split application significantly increased the uptake of nitrogen. Split application of nitrogen influenced the uptake of nitrogen reported by Batel and Smittle (1980) in capsicum. This is in confirmity with the findings of Jayakrishnakumar (1986) in bhindi.

Subbiah *et al* (1984) reported that soil application of potassium in 3 equal splits recorded higher nitrogen uptake.

Split application of nutrients increased the nutrient uptake by plant generally.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The investigation was undertaken at College of Agriculture, Vellayani to determine the optimum quantity and the best method of application of nitrogen, phosphorus and potassium for bhindi. The materials used and the methods adopted for the study are briefly described below.

3.1 Experimental site

The experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani situated at 8,5^{O}N latitude, 76.9^{O}E longitude and at an altitude of 29m above mean sea level.

3.1.2 Soil

The soil of the experimental area was oxisol having a pH of 5.0, low in available nitrogen and potassium, medium in available phosphorus. The physical and chemical composition of the soil are presented in Table 1. Texture of the soil was sandy clay loam.

Table 1 - Physico chemical properties of soil

A. **Physical Composition**

Sl.No.	Paramenter	Content in soil %	Method used
(1)	(2)	(3)	(4)
1.	Coarse sand	36.35	Bouyoucos
2.	Fine sand	15.00	Hydrometer method
3.	Silt	17.50	
4.	Clay	30.00	(Bouyoucos,1962)

B. **Chemical composition**

Sl. No.	Parameter	Content	Rating	Method used
1.	Available N	232.5kgha^{-1}	Low	Alkaline potassium permanganate method (Subbiah and Asija 1956)
2.	Available P_2O_5	40kgha^{-1}	Medium	Bray colorimetric method 1 (Jackson, 1973)
3.	Available K_2O	117kgha^{-1}	Low	Ammonium acetate method (Jackson 1973)
4.	pH	5.0	Acidic	pH meter with glass electrode (Jackson,1973)

3.1.3 Cropping history of the field

The experimental area was lying fallow for 6 months before the experiment.

3.1.4 Season

The crop was sown on 6.8.91 and harvesting was completed by 18.11.91.

3.1.5 Weather condition

The weekly averages of temperature, evaporation, relative humidity and the weekly totals of rain fall during the cropping periods collected from the meteorological observatory at the College of Agriculture, Vellayani are presented in Fig.1 and Table 2

3.1.6 Cultivar used

The cultivar of bhindi used for this study was Kiran (Selection AE-1). This variety was evolved at the College of Agriculture, Vellayani, by single plant selection from locally popular variety 'Kilichundan'. The variety flowers in 35 days period and the first harvest can be done in 45 days. Mean fruit weight is 25-30g. Yield is 11.2 t/ha. It is tolerant to fruit and shoot borer and yellow vein mosaic. This variety is recommended for the southern district of Kerala in red loam, clay loam and laterite soils.

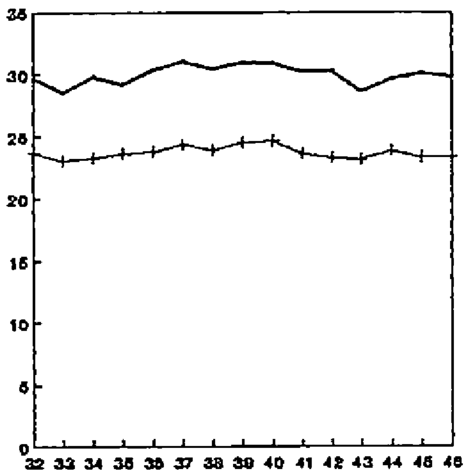
3.1.7 Source of seed material

Seeds of variety Kiran obtained from the

Table 2 Weather data during the cropping period

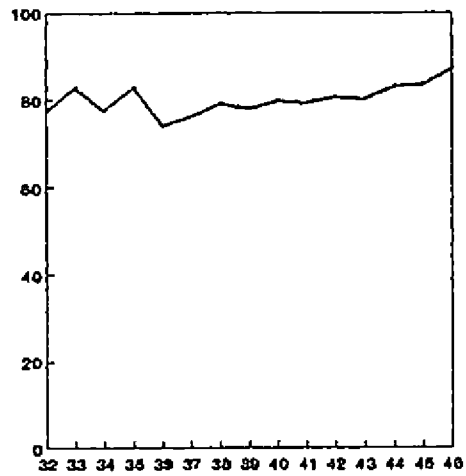
Standard week	Period From	To	Ramfall mm	Maximum Temperature °C	Minimum Temperature °C	Relative humidity %
32	6.8.91	12.8.91	1.1	29.77	23.71	77.29
33	13.8.91	19.8.91	8.84	28.55	23.03	82.79
34	20.8.91	26.8.91	3	29.79	23.23	77.57
35	27.8.91	2.9.91	6.8	29.22	23.63	82.79
36	3.9.91	9.9.91	0	30.42	23.74	74
37	10.9.91	16.9.91	22.4	31.07	24.36	76.14
38.	17.9.91	23.9.91	0	30.5	23.93	79
39.	24.9.91	30.9.91	0	31	24.5	78.07
40.	1.10.91	7.10.91	0	30.89	24.61	79.71
41.	8.10.91	14.10.91	3.63	30.29	23.61	79.21
42.	15.10.91	21.10.91	6.26	30.29	23.21	80.57
43.	22.10.91	28.10.91	10.07	28.66	23.19	80.14
44.	29.10.91	4.11.91	16.78	29.6	23.79	83.07
45.	5.11.91	11.11.91	3.5	30.09	23.34	83.57
46.	12.11.91	18.11.91	33.57	29.82	23.24	87.14

Fig.1. Weather Condition during cropping period



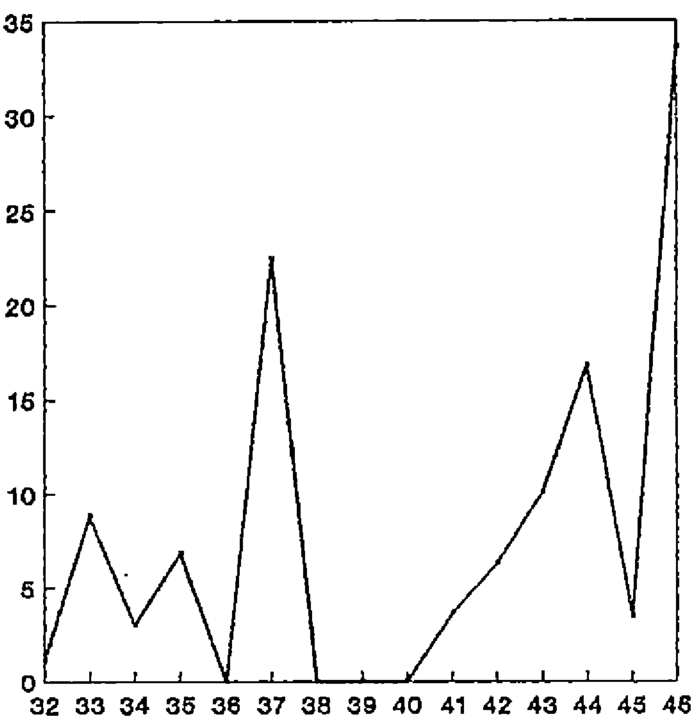
Standard week

÷ Max. Temperature °C
+ Min. Temperature °C



Standard week

- Relative Humidity %



Standard week

Rainfall (mm)

plant breeding department of College of Agriculture, Vellayani was used for the experiment.

3.1.8 Manures and fertilizers

Farm yard manure (0.4%:0.3%:0.2% N : P_2O_5:K_2O) obtained from the department of Animal Husbandry, College of Agriculture, Vellayani was used in the study. Urea (46% N), superphosphate (16% P_2O_5) and muriate of potash (60% K_2O) were used as sources of nitrogen, phosphorus and potassium respectively.

3.2.1 Design and layout

The field experiment was laid out factorial experiment in randomised block design. The layout of the experiment is given in Fig.2.

3.2.2 Treatment details

The treatments comprised of 4 different combination of nitrogen, phosphorus and potassium in 3 different splits. As such 12 treatment combinations replicated four times in randomised block design were experimented. The treatments are enlisted below.

1) Fertilizer nutrient level - 4

	N	P_2O_5	K_2O (kg/ha)	
F_1	330	110	220	(As recommended by the T and V workshops of NARP, Southern Region) (Anon 1980)
F_2	220	73	146	(2/3 of the T and V recommendations)
F_3	110	37	73	(1/3 of the T and V recommendations)
F_4	50	8	30	(Package of practices recommendation of KAU) (Anon 1989a)

2) Split application

S_1 - 2 equal splits of N, P_2O_5 and K_2O applied as basal and 30 DAS

S_2 - 4 equal splits of N, P_2O_5 and K_2O applied as basal, 20 DAS, 40 DAS and 60 DAS

S_3 - 6 equal splits of N, P_2O_5 and K_2O applied as basal, 15 DAS, 25 DAS, 35 DAS, 45 DAS and 55 DAS

Treatment combinations	:	12
Number of replications	:	4
Total number of plots	:	48
Plot size (Gross)	:	$5.4 \times 3.6m^2$
(Net)	:	$3.6 \times 2.7m^2$
Spacing	:	60 x 45 cm
Number of plants per plot		
Gross	:	72
Net	:	28

One row was left as border all around the plots. Five plants in each plot were randomly selected to facilitate periodical observations.

3.2.3 Field culture

3.2.3.1 Land preparation

The experimental plot was dug twice, stubbles were removed, clods were broken and levelled. The field was then laid out into blocks and plots as per the experimental design. 48 plots of 5.4 x 3.6 m^2 size were taken and 72 pits were made at a spacing of 60 x 45 cm in each plot. Each pit was half filled with a mixture of top soil and dried powdered cowdung before sowing of seeds.

3.2.3.2 Application of fertilizers

A uniform dose of cattle manure @ 12 t ha^{-1} was applied to each pit. Fertilizer was applied to all 48 plots as per the treatments.

3.2.3.3 Sowing

Seeds were dibbled at the rate of two seeds $hole^{-1}$ at a depth of 3-5 cm. Ten days after, thinning was done and one plant in each pit was retained.

3.2.3.4 After cultivation

Irrigation was given on alternate days till harvest. Weeding was conducted twice and rows were earthed up thrice during the crop growth period.

Fig. 2. LAYOUT PLAN

N
W E
S

$F_2 S_3$	$F_1 S_2$	$F_3 S_3$	$F_1 S_1$
$F_4 S_3$	$F_4 S_1$	$F_2 S_1$	$F_4 S_2$
$F_3 S_2$	$F_2 S_2$	$F_1 S_3$	$F_3 S_1$

R I

$F_3 S_2$	$F_2 S_3$	$F_2 S_1$	$F_1 S_3$
$F_1 S_1$	$F_4 S_3$	$F_4 S_1$	$F_3 S_3$
$F_3 S_1$	$F_4 S_2$	$F_2 S_2$	$F_1 S_2$

R II

$F_2 S_1$	$F_1 S_1$	$F_3 S_3$	$F_4 S_1$
$F_4 S_2$	$F_3 S_1$	$F_3 S_2$	$F_1 S_3$
$F_2 S_2$	$F_1 S_2$	$F_4 S_3$	$F_2 S_3$

R III

$F_1 S_1$	$F_4 S_3$	$F_3 S_2$	$F_3 S_1$
$F_2 S_2$	$F_4 S_2$	$F_1 S_3$	$F_2 S_1$
$F_2 S_3$	$F_3 S_3$	$F_1 S_2$	$F_4 S_1$

R IV

Treatments

Nutrient level ($kgha^{-1}$)

	N	P_2O_5	K_2O
1	330	110	220
2	220	73	146
3	110	37	73
4	50	8	30

Plot size = 5.4 x 3.6 m^2

Split application of nutrients

S_1 - 1/2 basal + 1/2 30 DAS

S_2 - 1/4 basal + 1/4 20 DAS + 1/4 40 DAS + 1/4 60 DAS

S_3 - 1/6 basal + 1/6 15 DAS + 1/6 25 DAS + 1/6 35 DAS + 1/6 45 DAS + 1/6 55 DAS

3.2.3.5 **Plant protection**

Prophylatic spraying with carbaryl was given against stem borer during the later stages of crop growth.

3.2.3.6 **Harvesting**

The crop was harvested at alternate days from the 45th day onwards after sowing. Altogether 25 harvests were taken over the entire cropping period. Maturity of fruits for harvest was judged by visual observation.

3.3 **Observations recorded**

3.3.1 **Growth characters**

Five plants were selected at random after eliminating the border rows and all the biometric observations were recorded from these plants at various growth stages. Random samples were selected for destructive sampling for dry weight observations.

3.3.1.1 **Height of plants**

From the observational plants the height was measured from the base to the terminal buds and the average was worked out.

3.3.1.2 **Leaf area index (LAI)**

All leaves collected from a single plant was used for measuring the LAI. The leaf area was measured by using leaf area meter. The leaf area per plant was divided by the land area occupied by the plant and expressed as LAI.

3.3.1.3 Crop growth rate (CGR)

Crop growth rate between stages were worked out by using the following formulae as explained by Hunt (1978).

$$\text{Crop growth rate } (gm^{-2}\ day^{-1}) = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{P}$$

Where W_1 = Dry matter production at time T_1,

W_2 = Dry matter production at time T_2,

P = Ground area

3.2.1.4 Dry matter production was recorded during three growth stages viz. 30, 60 and 90 days after sowing. Sample plants were randomly selected for this purpose, at each stage. Plants were cut close to the ground and oven dried at 70 $\pm$ 5°C to a constant weight. The final dry weight was averaged and expressed in Kg ha^{-1}.

3.3.2 Time of flowering, yield attributes and yield

3.3.2.1 Days to 50 percent flowering

Total number of plants flowered was counted daily in each plot and the date on which 50 percent of the plants flowered was taken as the date of 50 percent flowering.

3.3.2.2 Number of flowers formed

Total number of flowers from the 5 selected plants was counted and the average were worked out to get the number of flowers formed per plant.

3.3.2.3 Number of flowers shed

Total number of flowers shed from the 5 observational plants was counted and the average was worked out.

3.3.2.4 Number of fruits/plant

Total number of fruits obtained from 5 observational plants was counted and average were worked out.

3.3.2.5 Length of fruit

The length of 20 fruits from each plot was measured and the average was worked out and expressed in cm.

3.3.2.6 Girth of fruit

Measurement of this attribute was made by winding thread around the middle most length of the individual fruits. The 20 fruits used for measuring the length were used for this purpose also. The mean values were worked out and expressed in cm.

3.3.2.7 **Total fruit yield**

Weight of the fruits from the 25 harvests were totalled up at the end of the cropping season and the yield in quintal per plot was calculated and converted into per hectare yield.

3.4.1 **Quality aspects**

3.4.1.1 **Protein content of plant**

The fruit nitrogen values were multiplied by the factor 6.25 to obtain the protein content of plants and the values were expressed as percentage (Simpson et al 1965).

3.4.1.2 **Ascorbic acid content of fruit**

The ascorbic acid content of fruits was estimated by titrimetric method (Paul Gyorgy and Pearson, 1967).

3.4.1.3 **Fibre content of fruits**

The fibre content of fruits was determined by AOAC method (AOAC, 1960).

3.4.2 **Uptake of nutrients**

The plant samples were analysed for nitrogen phosphorus and potassium at the final harvest. The plant was chopped and dried in air oven at 70 $\pm$ 5°C separately till constant weights were obtained. Samples were ground to pass through a 0.5 mm mesh in a Willey Mill. The required quantity of samples were then weighed out accurately in physical balance and analysed.

3.4.2.1 **Uptake of nitrogen**

The nitrogen content in plant and fruit was estimated separately by the modified microkjeldahl method (Jackson, 1973) and the uptake of nitrogen was calculated by multiplying the nitrogen content of plant or the fruits as the case may be with the total dry weight of plant or fruits. The uptake values were expressed in kgha^{-1}.

3.4.2.2 **Uptake of phosphorus**

The phosphorus content of the plant and fruit samples were colorimetrically determined separately by wet digestion of the sample and developing colour by Vanado-Molybdo phosphoric yellow colour method and read in a Baush and Lomb Spectronic 2000 Spectrophotometer (Jackson, 1973). The uptake of phosphorus was calculated by multiplying the phosphorus content and dry weight of plants as the case may be. The uptake values were expressed kgha^{-1}.

3.4.2.3 Uptake of potassium

The potasssium content in plant and fruit sample was estimated separately by the flame photometric method in the Perkin Elmer 3030 Atomic Absorption Spectrophotometer, after wet digestion of the sample using di-acid mixture. Based on the potassium content in the plant and the dry matter produced at harvest, the uptake was worked out.

3.5 Soil analysis

Soil samples were taken from the experimental area before and after the experiment. The air dried samples were analysed for available nitrogen by the Alkaline potassium permanganate method (Subbiah and Asija, 1956) available P_2O_5 by Bray calorimetric method (Jackson, 1973) and available K_2O by the ammonium acetate method (Jackson, 1973).

3.6 Economics of cultivation

The economics of cultivation of the experiment was worked out as per the formulae given below.

Net return (Rs/ha) = Gross income - cost of cultivation

$$\text{Benefit cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.7 Statistical analysis

The data relating to each character in the experiment was analysed using the analysis of variance technique as applied to randomised block design described by Cochran and Cox (1965). When the effects were found to be significant critical differences were calculated for effecting comparison among the means. Correlation studies were also carried out between yield and yield attributes.

RESULTS

RESULTS

An investigation was conducted in the instructional farm, College of Agriculture, Vellayani during the kharif season of 1990 to maximise production of export quality bhindi by split application of four varying combinations of NPK nutrients so as to generate a profitable income for the farmers. The results obtained from the study were statistically analysed and presented here.

4.1 Growth characters

4.1.1 Height of the plant

The results on mean heig
at 30th, 60th and 90th days after sowing are presented in Table 3.

Nutrient levels caused significant variation in plant height at all growth stages. At 30DAS, F_1 recorded the maximum plant height of 19.6 cm. It was on par with F_2 and significantly superior to F_3 and F_4, which inturn was on par. At 60DAS each higher level was significantly superior to the next lower level and at 90 DAS F_1 and F_2 were on par and significantly superior to F_3 and F_4. F_4 (Package of practices recommendation) was significantly inferior to all the other higher levels of nutrients.

Table 3: Height of plant (cm) as affected by nutrient levels and its split application.

Treatments	Height in cm		
	30 DAS	60 DAS	90 DAS
Nutrient level			
F_1	19.60	57.26	106.75
F_2	18.16	54.03	99.16
F_3	16.71	51.50	91.08
F_4	15.24	37.00	78.81
F 3,3	9.97**	95.68**	8.48**
SE	0.59	0.91	4.10
CD (0.05)	1.71	2.63	11.81
Split application of nutrients			
S_1	18.06	51.36	94.29
S_2	17.40	49.45	93.18
S_3	16.83	49.04	94.38
F 2,33	1.43ns	2.44*	0.04ns
SE	0.51	0.79	3.56
CD (0.05)	-	2.28	-

** - Significant at 1% level
* - Significant at 5% level
ns - Not significant

Split application of nutrients exerted significant influence on plant height only at 60 DAS. Application of nutrients in 2 splits (S_1) showed significant superiority over 6 splits (S_3) and was on par with 4 splits (S_2).

Interaction due to F X S was not significant.

4.1.2 Leaf area index (LAI)

The leaf area index recorded at 30, 60 and 90 days after sowing are presented in table 4.

In general the leaf area index of bhindi was significantly influenced by nutrient levels. At 30 DAS F_1 recorded the highest LAI of 0.84 and this was significantly superior to the other three levels of nutrients which were on par. At 60 DAS, the LAI values increased and the mean value ranged from 1.56 (F_4) to 2.46 (F_1). But at this stage F_1, F_2 and F_3 did not record any significant difference but were superior to F_4. At 90 DAS LAI of F_1 was on par with F_2 but significantly superior to F_3 and F_4. In general an increase in LAI value was observed from 30 days to 60 days period and then the LAI decreased at 90DAS.

Split application of nutrients and FXS interaction showed no significant influence on LAI.

Table 4: Leaf area index of plants as affected by nutrients levels and its split application

Treatments	LAI		
	30 DAS	60 DAS	90 DAS
<u>Nutrient levels</u>			
F_1	0.84	2.46	0.94
F_2	0.72	2.35	0.88
F_3	0.72	2.22	0.82
F_4	0.66	1.56	0.70
F 3,33	3.84*	10.77**	20.38**
SE	0.04	0.12	0.02
CD (0.05)	0.11	0.35	0.07
<u>›lit application of nutrients</u>			
S_1	0.72	2.19	0.84
S_2	0.75	2.12	0.82
S_3	0.73	2.13	0.83
F 2,33	0.15ns	0.10ns	0.29ns
SE	0.03	0.11	0.20
CD (0.05)	-		-

** - Significant at 1% level
* - Significant at 5% level
ns - Not significant

4.1.3 Crop growth rate (CGR)

Crop growth rate of plant between 30th and 60th, and 60th and 90th days after sowing are presented in Table 5.

CGR of plant was found to increase with incremental doses of fertilizer upto F_1. Between 30 DAS and 60 DAS F_1 recorded maximum CGR of 1.21 gm^{-2} day^{-1} and this was significantly superior to the other 3 levels. Treatments F_2 and F_3 were on par and significantly superior to F_4 which recorded the lowest CGR values of 0.70 gm^{-2} day^{-1}. Between 60 and 90 DAS the CGR showed general decline for all the treatments and F_1 and F_2 recorded more or less similar values. These were significantly superior to the other two treatments F_3 and F_4.

The effect of split application of nutrients and FXS interaction were not significant.

4.1.4 Dry matter production (DMP)

The dry matter production per plant recorded at 30 DAS, 60 DAS and 90 DAS are presented in Table 6 a,b,c and d.

The DMP increased with each successive increase in levels of nutrient at all growth stages.

Table 5: Crop growth rate of plants as affected by nutrient levels and its split application

Treatments	CGR Between 30 & 60 DAS	Between 60 & 90 DAS
Nutrient level		
F_1	1.21	0.36
F_2	1.05	0.33
F_3	1.00	0.23
F_4	0.70	0.23
F 3,33	22.01**	8.81**
SE	0.04	0.02
CD (0.05)	0.11	0.069
Split application of nutrients		
S_1	1.02	0.26
S_2	0.96	0.29
S_3	0.99	0.31
F 2,33	0.51 ns	1.65 ns
SE	0.04	0.02
CD (0.05)	-	-

** Significant at 1% level
 * Significant at 5% level
NS - Not significant

At 30 DAS, 60 DAS and 90 DAS, higher doses of nutrients recorded higher DMP. At all growth stages, F_1 recorded maximum DMP and it was significantly superior to all other lower levels. F_4 recorded the lowest DMP at all growth stages. The DMP ranged from 1075 kg ha^{-1} (F_4) to 1761kgha^{-1} (F_1) at 90 DAS.

The effect of split application on DMP was significant and the interaction effect between nutrient levels and method of application was also significant.

At 30 DAS with highest dose of nutrients (F_1), S_1 method of application was found to enhance the DMP, while with reduced fertilization (F_2 and F_3) S_1 and S_2 yielded similar results. Within the package of practices recommendation (F_4) six splits (S_3) recorded the highest DMP of 196.60 kgha^{-1}, when compared with S_2, 189.59 kgha^{-1} and S_1, (183.57 kgha^{-1}). At 60th day two splits (S_1) application was found to be effective with nutrient levels F_1, F_2 and F_3 and six splits (S_3) was found effective for the nutrient level F_4. Maximum DMP was recorded under F_1. At 90 DAS F_1 and F_3 nutrient levels with two splits (S_1) yielded maximum DMP. There was no significant difference with the three methods of application with F_2 nutrient level, while for F_4, six split application was better.

Table 6a: Dry matter production of plants ($kgha^{-1}$) as influenced by nutrient levels and its split application.

Treatments	DMP in $kgha^{-1}$, 30 DAS	60 DAS	90 DAS
Nutrient level			
F_1	245.91	951.10	1761.70
F_2	227.19	987.01	1521.71
F_3	209.48	856.04	1307.65
F_4	189.92	603.55	1075.36
F 3,33	409.61**	47868.63**	1357.26**
SE	1.84	0.70	7.97
CD (0.05)	3.41	2.02	22.93
Split application of nutrients			
S_1	225.42	844.43	1419.14
S_2	217.43	821.14	1398.95
S_3	211.51	815.20	1431.73
F 2,33	46.30**	643.16**	5.75**
SE	1.03	0.61	6.90
CD (0.05)	2.95	1.75	19.86

** - Significant at 1% level
* - Significant at 5% level
ns - Not significant

Table 6b. Combined effect of nutrients and its split application on dry matter production at 30 DAS.

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
Nutrient levels				
F_1	268.87	236.89	231.97	245.91
F_2	234.41	230.65	216.50	227.19
F_3	214.85	212.60	200.98	209.48
F_4	183.57	189.59	196.60	189.48
Mean	225.42	217.43	211.51	

FXS

CD (0.05) 3.51

SE 2.02

Table 6c: Combined effect of nutrients and its split application on dry matter production at 60 DAs

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
<u>Nutrient level</u>				
F_1	1805.55	1719.26	1760.28	1761.70
F_2	1535.00	1530.12	1500.00	1521.71
F_3	1332.48	1300.21	1290.26	1307.65
F_4	1003.51	1046.21	1176.36	1075.36
Mean	1419.14	1398.95	1431.73	

FXS
CD (0.05)- 39.71
SE - 13.80

Table 6d: Combined effect of nutrients and its split application on dry matter production at 90 DAs

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
<u>Nutrient level</u>				
F_1	998.99	930.73	923.59	951.10
F_2	908.64	898.67	883.72	897.01
F_3	880.40	865.45	822.26	856.04
F_4	589.70	589.71	631.23	603.55
Mean	884.43	821.14	815.20	

FXS
CD (0.05)- 39.71
SE - 13.80

4.2 Yield attributes and yield

4.2.1 Days to 50 percent flowering

Mean number of days taken for 50 percent flowering are given in Table 7.

The influence of different levels of nutrients on the number of days to 50 percent flowering was found to be significant. Days to 50 percent flowering was significantly delayed with increasing levels of nutrient. Plants supplied with highest levels of nutrients (F_1) took about 42 days for flowering while those supplied with F_4 or lowest level of nutrients took only 38 days. Nutrient levels F_2 and F_3 took about 40 days for 50 percent flowering.

Split application of nutrients also significantly influenced the days to 50 percent flowering. Application of nutrients in 2 splits significantly delayed days to 50 percent flowering compared to application of nutrient in 6 splits.

The interaction effects between the method of application and the levels of nutrient were not significant.

4.2.2 Number of flowers/plant

The mean number of flowers recorded per plant are shown in Table 7.

The total number of flowers noticed per plant was significantly influenced by the different levels of nutrients. The maximum flower production of 39.69 per plant was obtained with F_1 and it was on par with F_2 and F_3. F_4 level of nutrient recorded the lowest number of flowers which was significantly inferior to all other levels except F_3.

Split application of nutrient did not influence the number of flowers produced per plant, but the highest number of flowers (37.73 per plant) was produced by the application of nutrient in 6 splits (S_3) followed by 2 splits (S_2).

FXS interaction effect on number of flowers was not significant.

4.2.3 Setting percentage of fruits

The data on percentage of fruit set are given in Table 7.

Either the four nutrient levels or the three split applications did not show any significant influence on the setting percentage of fruits.

FXS interaction effect was not significant. In general the fruitset was below 50 percent for all the treatments tried in this experiment.

4.2.4 Number of fruits per plant

The mean number of fruits recorded per plant are shown in Table 7.

There was significant increase in the total number of fruits noticed per plant due to different levels of nutrients. Maximum number of fruits per plant was recorded at the highest dose of nutrient (F_1) and this was significantly superior to the other three levels viz F_2, F_3 and F_4. Minimum number of fruits per plant was recorded under the lowest level of nutrients (F_4).

Split application of nutrient did not produce significant influence on number of fruits recorded per plant and the interaction effect was not significant between the method of application and levels of nutrient.

4.2.5 Length and Girth of fruits

The data on mean length and mean girth of fruits are presented in Table 7.

Table 7: Effect of nutrient levels and its split application on time to 50 percent flowering, number of flowers, percentage of fruit set, number of fruit, length of fruit, girth of fruit

Treatments	Time of 50 per cent flowering (days)	No. of flower/ plant	Percentage of fruit set	No. of fruits/ plant	Length of fruit	Girth of fruit
<u>Nutrient level</u>						
F_1	42.00	39.69	46.71	20.93	16.91	5.98
F_2	40.08	36.49	44.93	17.30	16.73	6.11
F_3	39.67	35.56	46.33	18.24	16.92	6.01
F_4	38.08	30.49	47.16	16.55	17.09	5.90
F 3,33	81.64^{**}	3.92^{*}	0.17^{ns}	2.31^{*}	0.18^{ns}	0.97^{ns},
SE	0.20	1.93	2.33	1.26	0.34	0.09
CD (0.05)	0.51	5.54	-	3.62	-	-
<u>Split application of nutrient</u>						
S_1	40.25	35.04	45.72	18.10	16.91	6.05
S_2	39.94	33.90	48.29	18.16	16.90	5.96
S_3	39.69	37.73	44.84	18.50	16.93	5.99
F 2,33	3.33^{*}	1.39^{ns}	0.79^{ns}	0.04^{ns}	0.03^{ns}	0.32^{ns},
SE	0.15	1.67	2.02	1.09	0.29	0.08
CD (0.05)	0.44	-	-	-	-	-

** - Significant at 1% level
* - Significant at 5% level
NS - Not significant

The length and girth of fruits were not significantly influenced either by the nutrient levels or split application or F X S interaction. The length of fruits varied from 15.99 cm (F_3S_3) to 17.99 cm (F_4S_3) and the girth of fruit varied from 5.72 cm (F_4S_2) to 6.15 cm (F_2S_1).

4.2.6 Fruit yield per plant

The data on fruit yield per plant are presented in Table 8.

The per plant yield of fruits was significantly influenced by different levels of nutrient. Highest level of nutrients (F_1) recorded the highest per plant yield of 2.7 kg and it was on par with F_2 and F_3 levels of nutrient. F_4 (lowest level of nutrients) recorded the lowest per plant yield of 1.94 kg and it was significantly inferior to all the other 3 levels of nutrients.

Split application of nutrients or its interaction with nutrient levels were not significant.

4.2.7 Fruit yield

The data on the yield of fruits are presented in Table 8.

Table 8: Fruit yield per plant ($kgha^{-1}$) and total fruit yield (qha^{-1}) as affected by nutrient levels and its split application.

Treatments	Fruit yield per plant ($kgha^{-1}$)	Total fruit yield (qha^{-1})
<u>Nutrient levels</u>		
F_1	2.66	93.17
F_2	2.53	88.43
F_3	2.51	88.02
F_4	1.93	67.73
F 3,33	9.29**	9.29**
SE	0.11	3.71
CD (0.05)	0.31	10.69
<u>Split application of nutrients</u>		
S_1	2.44	85.33
S_2	2.40	84.15
S_3	2.39	83.53
F 2,33	0.08ns	0.08ns
SE	0.09	3.22
CD 0.05	-	-

** Significant-1% level
* Significant-5% level
ns Not significant

Nutrient levels significantly influenced the fruit yield of bhindi. Fruit yield increased with increasing levels of nutrients. F_1 recorded the highest fruit yield of 93.17 qha^{-1} and it was on par with F_2 and F_3 . All these 3 levels, F_1, F_2 and F_3 were significantly superior to F_4 (67.75 qha^{-1}) or the present package recommendation.

Split application of nutrient showed no significant influence on the fruit yield. However highest yield was obtained with 2 splits (85.43 q ha^{-1}) and lowest with 6 splits (83.53 q ha^{-1}).

The effect due to FXS interatction was not significant. However F_1 S_1 recorded the highest fruit yield of 103.2 q ha^{-1} followed by F_2 S_1 (93.44 q ha^{-1}). The treatment F_4 S_1 recorded the lowest yield of 55.48 qha^{-1}. Further it was observed that with the lowest level of nutrient there was an increase on fruit yield due to increase in the number of splits.

4..3 Quality aspects

4.3.1 Protein content in fruits

The data on protein content of fruits are presented in table 9.

Nutrient application significantly influenced the protein content of fruits. F_1 level of nutrient recorded highest protein content of fruits and it was on par with F_2 & F_3. F_4 was found to be significantly inferior to all other levels.

Application of nutrient in splits had no significant effect in the protein content of fruits.

FXS interaction had no significant influence on protein content in fruits.

4.3.2 **Ascorbic acid content in fruits**

Table 9 gives the mean value of ascorbic acid content of fruits.

The different levels of nutrient showed significant influence on the ascorbic acid content in fresh fruits. F_1, the highest level of nutrient recorded the highest ascorbic acid content of 24.48 mg per 100 g of fresh weight of fruit which was on par with F_2. F_4 recorded the lowest ascorbic acid content of 19.43 mg per 100 g of fruits and was significantly inferior to all other levels.

Split application of nutrients significantly influenced the ascorbic acid content of fruits. 6 splits recorded the maximum ascorbic acid content of 23.91 mg per 100 g fresh weight of fruits and it was

Table 9 : Content of crude protein (%) and ascorbic and (mg/100 gm fresh weight of fruit) as affected by nutrient levels and its split application

Treatments	Crude protein content (%)	Ascorbic acid content (mg/ 100 gm fresh Weight of fruit)
<u>Nutrient levels</u>		
F_1	16.21	24.48
F_2	16.18	23.93
F_3	16.31	21.87
F_4	14.41	19.43
F 3,33	13.26**	14.11**
SE	0.25	0.61
CD	0.72	1.76
<u>Split application of nutrients</u>		
S_1	16.69	20.93
S_2	15.81	22.43
S_3	15.83	23.91
F 2,33	0.12ns	7.94**
SE	0.22	0.53
CD	-	1.52

** - Significant-1% level
* - Significant-5% level
ns - Not significant

significantly superior to 2 splits, but was on par with 4 splits. S_2 and S_3 were on par.

FXS interaction was not significant.

4.3.3 Crude fibre content of fruits

The data on crude fibre content of fruits recorded on 1st, 2nd, 3rd and 4th day after harvest are presented in Table 10.

Nutrient application significantly influenced the crude fibre content of fruit recording lowest crude fibre content with the highest nutrient levels. F_1 recorded 7.36% and F_4 recorded significantly higher crude fibre content of 13.91%.

Split application of nutrients also significantly influenced the crude fibre content recording maximum content with S_1 and minimum with S_3, method of application.

Interaction due to FXS was not significant.

Different levels of nutrients showed significant influence on the crude fibre content of fruits from 1st day after harvest to 4th day after harvest. The crude fibre content increased with decreasing levels of nutrients. Crude fibre content

Table 10 . Crude fibre content of fruit as affected by nutrient levels and its split application. (%)

Treatments	Crude fibre content 1 DAH	2 DAH	3 DAH	4 DAH
Nutrient levels				
F_1	7.00	7.55	7.41	7.49
F_2	9.80	9.81	9.96	10.69
F_3	10.26	10.28	10.28	10.69
F_4	13.76	13.82	13.95	14.10
F 3,33	459.91**	405.87**	7.38.97**	1059.42**
SE	0.13	0.13	0.09	0.08
CD	0.37	0.37	0.29	0.24
Split application of nutrient				
S_1	10.48	10.59	10.72	11.07
S_2	10.42	10.47	10.49	10.67
S_3	9.69	9.84	9.91	10.04
F 2,33	15.28**	18.72**	23.99**	50.76**
SE	0.11	0.11	0.86	0.73
CD	0.32	0.32	0.25	0.21

** - Significant-1% level
* - Significant-5% level
ns - Not significant

was maximum at the lowest level of nutrients (F_4).

Split application of nutrients recorded significant influence on crude fibre content of fruits at 1st, 2nd, 3rd and 4th day after harvest. During 1st 2nd and 3rd day after harvest S_1 recorded the highest crude fibre content in fruits which was on par with S_2. and significantly superior to S_3 method of application. During 4th day after harvest S_1 recorded the highest crude fibre content which was significantly superior to S_2 and S_3. S_2 in turn was significantly superior to S_3.

Interaction due to FXS was not significant from 1st to 4th day after harvest. In all the four days F_1 S_3 recorded the lowest crude fibre content.

4.4 Nutrient uptake

4.4.1 Uptake of nitrogen by plants (excluding fruit)

The data on uptake of nitrogen by plants are presented in Table 11 a and b.

There was a progressive increase in the uptake of nitrogen by plants due to different nutrient levels and the difference was significant. F_1 recorded maximum nitrogen uptake of 35.1 kg ha^{-1} and F_4 the minimum uptake of 20.73 kg ha^{-1}.

Table 11 a.: Uptake of nitrogen, phosphorus and potassium as affected by nutrient levels and its split application by plants ($kg ha^{-1}$)

Treatments	N	P	K
<u>Nutrient levels</u>			
F_1	35.15	19.57	44.28
F_2	33.43	15.57	41.29
F_3	28.68	10.04	34.58
F_4	20.73	6.42	26.87
F 3,33	1085.30**	465.92**	768.40**
SE	0.20	0.27	0.28
CD 0.05	0.56	0.78	0.80
<u>Split application of nutrients</u>			
S_1	30.44	13.21	37.96
S_2	30.06	12.92	36.83
S_3	28.00	12.57	35.48
F 2,33	59.85**	1.92ns	26.47**
SE	0.17	0.23	0.24
CD 0.05	0.49	-	0.70

** - Significant-1% level
* - Significant-5% level
ns - Not significant

Table 11b: Combined effect of nutrients and their split application on uptake of nitrogen by plants ($kg ha^{-1}$).

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
Nutrient level				
F_1	36.15	35.61	33.70	35.15
F_2	34.10	33.88	32.33	33.43
F_3	29.42	28.93	27.69	28.68
F_4	22.10	21.81	18.28	20.73
Mean	30.44	30.06	28.00	

FXS
CD (0.05) - 0.98
SE - 0.34

Split application of nutrients also exerted a significant influence on the uptake of nitrogen by plants. Uptake of nitrogen by S_1 and S_2 were on par and significantly superior to S_3.

The FXS interaction was significant and the treatment combination F_1S_1 recorded the highest uptake of nitrogen 36.15 kg ha^{-1} which was on par with F_1S_2 (35.6 kg ha^{-1}) and was significantly superior to all other treatments. Lowest uptake of nitrogen was recorded by F_4S_3 (18.28 kg ha^{-1}).

4.4.2 Uptake of phosphorus by plants (excluding fruit)

The data on uptake of phosphorus by plants are presented in Table 11a.

Nutrient application significantly influenced the phosphorus uptake by plants, which increased significantly with successive increase in nutrient levels. Maximum uptake was observed in F_1, (19.57 kg ha^{-1}) and least by F_4 (6.42 kg ha^{-1}).

Split application of nutrients did not show any significant influence on phosphorus uptake.

FXS interaction was not significant. The uptake of phosphorus ranged from 19.79 kg ha^{-1} (F_1S_1)

to 6.29 kg ha^{-1} (F_4S_3).

4.4.3 Uptake of potassium by plants (excluding fruit)

The data on uptake of potassium by plants are presented in Table 11a.

Nutrient application significantly influenced the potassium uptake by plants. F_1 recorded the maximum uptake (44.28 kg ha^{-1}) followed by F_2, F_3 and F_4 and these nutrient levels differed significantly among each other.

significantly superior to S_3. S_2 and S_3 were on par.

The FXS interaction effect was significant. F_1 S_1 recorded the highest potassium uptake (44.80 kgha^{-1}) and was on par with F_1S_2 and F_1S_3 and was significantly superior to all other treatments. Lowest potassium uptake of 23.86 kg ha^{-1} was recorded by F_4S_3.

4.4.4 Uptake of nitrogen in fruits

The data on uptake of nitrogen by fruits are presented in Table 12a.

Table 11c: Combined effect of nutrients and its split application on uptake of potassium by plants ($kgha^{-1}$)

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
<u>Nutrient level</u>				
F_1	44.80	44.40	43.65	44.28
F_2	41.80	41.62	40.45	41.29
F_3	34.94	34.80	34.00	34.58
F_4	30.30	26.50	23.86	26.88
Mean	37.96	36.83	35.48	

FXS
CD (0.05) - 1.39
SE - 0.48

There was progressive increase in the uptake of nitrogen by fruits due to different levels of nutrients. The higher levels of fertilizer treatments were significantly superior to the lower levels.

Split application of nutrient had no influence on the uptake of nitrogen by fruits.

FXS interaction was also not significant. The uptake value of nitrogen in fruits ranged from 36.92 kg ha^{-1} (F_1S_1) to 22.20 kg ha^{-1} (F_4S_1).

4.4.5 **Uptake of phosphorus in fruit**

The data on phosphorus uptake by fruits are presented in Table 12a.

Uptake of phosphorus was significantly influenced by the application of nutrients in different doses. Phosphorus uptake increased with successive increase in levels of nutrients.

Split application of nutrients also significantly influenced the phosphorus uptake. S_1, recorded maximum uptake and it was on par with S_2 but significantly superior to S_3. S_2 and S_3 were on par.

FXS interaction on phosphorus uptake was not significant.

Table 12 a.. Uptake of nitrogen, phosphorus and potassium as affected by nutrient levels and its split application by fruits ($kg ha^{-1}$).

Treatments	Uptake of N	Uptake of P	Uptake of K
<u>Nutrient levels</u>			
F_1	36.56	19.41	43.61
F_2	34.74	15.81	41.97
F_3	33.60	9.53	36.33
F_4	22.55	6.35	27.07
F 3,33	842.22**	1671.70**	2463.04**
SE	0.22	0.10	0.15
CD	0.63	0.28	0.43
<u>Split application of nutrients</u>			
S_1	31.38	12.94	37.97
S_2	31.97	12.79	37.16
S_3	31.78	12.60	36.60
F 3,33	0.28ns	4.10*	27.97**
SE	0.19	0.08	0.13
CD	-	0.24	0.37

** - Significant-1% level
* - Significant-5% level
ns - Not significant

4.4.8 Uptake of potassium in fruits

The data on the uptake of potassium by the fruits are presented in Table 12a and b.

The influence of nutrients on the uptake of potassium by plants was significant. There was a progressive increase in the uptake of potassium with incremental doses of nutrients.

Split application of nutrients on potassium uptake by fruits was significant. S_1 was significantly superior to S_2 and S_3, S_2 was significantly superior to S_3.

FXS interaction on potassium uptake in fruits was significant. F_1S_1, F_1S_2 and F_1S_3 were on par and recorded the maximum uptake. F_4S_3 recorded least uptake, which was significantly inferior to all other levels.

4.5 Available nutrient status of soil

4.5.1 Available nitrogen

Table 13a gives the data on the mean content of available nitrogen in soil after the experiment.

Available nitrogen status of the soil after the experiment was significantly influenced by

Table 12b: Combined effect of nutrients and its split application on uptake of potassium by fruits (kgha^{-1})

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
<u>Nutrient level</u>				
F_1	43.82	43.65	43.35	43.61
F_2	42.56	41.72	41.63	41.97
F_3	36.59	36.49	35.92	36.33
F_4	28.92	26.78	25.50	27.07
Mean	37.97	37.16	36.60	

FXS
CD (0.05)- 0.75
SE - 0.26

nutrient application. As the levels of nutrients increased, the available nitrogen status also increased significantly. Highest nitrogen status was observed at F_1 levels of fertilizer (280.93 kg ha^{-1}) which was on par with F_2 (273.12 kg ha^{-1}) and these were significantly superior to the other 2 levels, which inturn were on par.

Application of nutrients in splits also exerted significant influence on the nitrogen status of soil. S_1 recorded the maximum value of 268.52 kg ha^{-1} and was on par with S_2, but was significantly superior to S_3 (255.61 kg ha^{-1}). S_3 and S_2 were on par.

FXS interaction was not significant. The highest value was recorded by F_1S_1 (286.16 kg ha^{-1}) and the lowest by F_4S_3 (235.20 kg ha^{-1}).

4.5.2 **Available phosphorus**

The data on available phosphorus content of the soil after the experiment are given in Table 13a.

Nutrient application significantly influenced the available phosphorus status of soil and each higher level was significantly superior to the next lower level. At F_1 level, the phosphorus status in the soil was maximum recording a value of 49.63kgha^{-1} and the minimum was at F_4 level (46.31kgha^{-1}).

Split application of nutrients also exerted a significant influence on available phosphorus status of soil and the highest value was observed with S_1, which was significantly superior to the other 2 splits which were on par.

FXS interaction was not significant and the ..ailable phosphorus status ranged from 49.72 kg ha^{-1} (F_1S_1) to 46.24 kg ha^{-1} (F_4S_2).

4.5.3 **Available potassium**

The data on the available pot of the soil after the experiment are presented in Table 13a and b.

Nutrient levels significantly influenced the ...lable potassium content of soil. Available potassium status was maximum at F_1 levels (226.10 kg ha^{-1}) which was significantly superior to other three lower levels. F_2 and F_3 levels were on par and significantly superior to F_4, where the available potassium status was only 206.9 kgha^{-1}.

Split application of nutrients also exerted significant influence on available potassium content in soil. S_1 recorded highest status and was significantly

Table 13 a. Available nitrogen, phosphorus and potassium status of soil as affected by nutrient levels and its split application ($kg ha^{-1}$).

Treatments	Nitrogen	Phosphorus	Potassium
Nutrient level			
F_1	280.93	49.63	226.10
F_2	273.12	48.54	212.71
F_3	255.89	47.42	212.21
F_4	243.04	46.31	206.90
F 3,33	13.85**	1195.08**	41.75**
SE	4.58	0.04	1.27
CD(0.05)	13.19	0.12	3.65
Split application of nutrient			
S_1	268.52	48.06	217.71
S_2	265.60	47.93	212.95
S_3	255.61	47.92	212.77
F 3,33	2.91**	4.74*	6.51**
SE	3.96	0.04	1.10
CD (0.05)	11.42	0.10	3.16

** - Significant-1% level
* - Significant-5% level
ns - Not significant

Table 13b.: Combined effect of nutrients and its split application on available potassium status of soil ($kgha^{-1}$)

Treatments	Split application of nutrients			
	S_1	S_2	S_3	Mean
<u>Nutrient level</u>				
F_1	237.00	223.62	217.67	226.10
F_2	213.76	208.25	216.13	212.71
F_3	212.10	212.81	211.71	212.21
F_4	207.97	207.14	205.58	206.90
Mean	217.71	212.95	212.77	

FXS
CD (0.05) - 6.31
SE - 2.19

superior to S_2 and S_3 which were on par.

The FXS interaction was significant on available potassium status of soil. F_1S_1 recorded highest value of 237 $kgha^{-1}$ and it was significantly superior to all other treatment combinations. The available potassium status was lowest for the treatment combinations involving lowest dose of nutrients.

4.6 Economics of cultivation

4.6.1 Net profit

The data on net profit are shown in Table 14.

Significant increase in the net profit was noticed due to nutrient levels. F_3 levels of nutrient found to produce highest net profit and it was on par with F_1 and F_2. F_4 found to produce the lowest net profit in this study.

Split application of nutrients also significantly influenced the net profit from bhindi. Application of fertilizer in two splits (S_1) increased the net profit significantly compared to application of nutrients in six splits(S_3).

FXS interaction was not significant.

Table 14. Economics of cultivation

Treatments	Total cost of production Y (Rs)	Fruit yield (kg)	Value X (Rs)	Net profit X-Y (Rs)	Benefit cost ratio $\frac{X}{Y}$ (Rs)
<u>Nutrient level</u>					
F_1	23587.06	9317.40	37269.60	13682.54	1.58
F_2	22275.99	8843.00	35372.00	13096.01	1.59
F_3	21411.423	8801.6	35206.40	13794.98	1.64
F_4	20184.643	6772.50	27090.00	6905.36	1.34
<u>Split application of fertilizer</u>					
S_1	19422.40	8533.30	34133.20	14710.8	1.76
S_2	22083.00	8414.70	33658.80	11575.8	1.52
S_3	24089.07	8352.8	33411.2	9322.13	1.37

1 kg N Rs.7.61/- 1 kg bhindi Rs 4/-

1 kg P_2O_5 Rs. 7.81/-
1 kg K_2O Rs. 2.5

4.6.2 Benefit cost ratio

The data on benefit cost ratio are presented in table 14.

As in the case of net profit, benefit cost ratio was also increased due to the application of nutrients in different levels. F_3 recorded the maximum benefit cost ratio which was on par with F_1 and F_2, and F_4 recorded minimum benefit cost ratio.

Split application of nutrient also exerted profound influence on benefit cost ratio. Application of nutrients in 2 splits increased the benefit cost ratio and the effects due to 4 splits and 6 splits were statistically on par.

Correlation studies

Simple correlation studies were undertaken with a view to elucidate the relationship of each of the various growth and yield attributing characters and yield. The correlation coefficients of yield with growth characters viz plant height, leaf area index and dry matter production each at 30, 60 & 90 DAS and yield attributing characters like number of flowers, fruit setting percentage, number of fruits, length and girth

Values of simple correlation coefficients

Sl. No.	Character correlated		Correlation coefficients
1.	Yield x height of plant	30 DAS	0.4150**
2.	Yield x "	60 DAS	0.5459**
3.	Yield x "	90 DAS	0.7025**
4.	Yield x LAI	30 DAS	0.6261**
5.	Yield x "	60 DAS	0.6207**
6.	Yield x "	90 DAS	0.6207**
7.	Yield x DMP	30 DAS	0.4572**
8.	Yield x "	60 DAS	0.3585**
9.	Yield x "	90 DAS	0.4180**
10.	Yield x Flower/Plant		0.3371*
11.	Yield x Fruit/Plant		0.3372*
12.	Yield x Length of fruit		0.3732**
13.	Yield x Girth of fruit		0.4351**

of fruits were calculated. The results showed that all the correlation coefficients were statistically significant.

DISCUSSION

5. DISCUSSION

An experiment was conducted to find out the effect of different levels of nutrients and their split application on growth, yield, quality and nutrient uptake of bhindi. The results obtained on this study are briefly discussed in this chapter.

5.1 Growth characters

5.1.1 Height of plant

The results of mean height of the plant are shown in Table 3. As could be observed from the data, the plant height at all growth stages was profoundly influenced by nutrient levels. The effect was maximum at 60 DAS wherein, each incremental dose caused significant variations in plant height. But at the later stage (90 DAS) as the plant advanced its growth, the variation exerted by the higher two levels of nutrient (F_1 and F_2) was not significant, which may be due to the inherent nature of plants which can not grow beyond a certain height even after receiving additional quantity of nutrients. Scrutiny of the Table shows that the mean height of plants was lowest in the treatments which received the nutrients as per the package recommendation (F_4) ie the lowest level of nutrients. It may be seen that the mean plant height ranged from 78.81 cm (F_4) to 106.75 cm (F_1). Increase in plant height obtained at higher levels of nutrient in this study could be attributed to the rapid meristematic activity triggered by plant nutrients especially nitrogen (Crowther, 1935) and the higher rate of metabolic activity coupled with rapid cell division brought about by phosphorus (Bear, 1965). Influence of potassium in promoting the growth of meristematic tissue had also been reported by Tisdale and Nelson (1985). Increase in plant height consequent to increase in levels of nitrogen and phosphorus had also been reported by Subramonian (1980) and due to potassium by Singh (1979).

Split application of nutrients influenced the plant height only at 60 DAS, where the height of the plant was enhanced by S_1 treatment in which the nutrients were applied in 2 equal splits viz one half as basal and other half at 30 DAS. This was followed by 4 splits (S_2). At 60 DAS, the plants were at the active growth stage and the availability of higher amounts of the nutrients due to S_1 treatment might have resulted in increased plant height at this stage. Increase in plant height with application of nitrogen in 2 equal splits have been reported by Jayakrishnakumar (1986) at 40 DAS in bhindi. At early growth stage, method of application offered no appreciable influence on plant height. But still the data reveal that receipt of higher dose of nutrients even half as basal and half/30 DAS stage enhanced the plant height. The increase in plant height observed in this treatment (S_1) reveals that early receipt of higher quantities of nutrient promoted the rapid growth. At later growth stage of the crop the difference in plant height due to method of application was not significant and this might be due to the increased rate of elongation at later growth phase where the crop received adequate quantity of nutrients under S_2 and S_3 treatments. This behaviour of the crop showed that the cell elongation takes place throughout the crop growth period and the growth rate at different stages depend considerably on the availability of nutrients at those growth stages.

A positive correlation is observed between yield and plant height at different growth stages.

5.1.2 Leaf area index (LAI)

The mean LAI values are presented in Table 4 Results on LAI clearly signifies the influence of nutrient levels at the different growth stages of bhindi. The highest nutrient dose recorded the maximum LAI at 30, 60 and 90 DAS. At 30 DAS, the crop exhibited very low LAI. But even at this early stage the F_1 level showed significant superiority over the other 3 levels, which may be due to the effect of potassium to increase the LAI in this tender stage, thus upholding Russel's (1973) statement that potassium increases the leaf area of the crop and photosynthetic efficiency at the early stages of crop growth. As the crop advanced its growth, ie at 60 DAS there was a general increase in the LAI of the crop. It was further noticed that the variation among F_1, F_2 and F_3 were not appreciable. But the lowest level (F_4) recorded significantly lower value. At this stage LAI recorded under F_4 was the lowest, 1.56 and F_1 recorded the highest, 2.46. Here 58 percent increase in LAI was noticed due to highest dose of nutrients. But at the final growth stage (90 DAS) the LAI declined considerably, the values ranging from 0.70 (F_4) to 0.94 (F_1). Verification of the data revealed the fact that the F_1 treatment maintained a higher LAI throughout the life of the crop followed by F_2. The rate of increase in the LAI between stages was also found to be significantly influenced by the nutrient levels. Here the increase in LAI from 30 DAS to 60 DAS was less than 1 for the lowest dose of nutrient (F_4) while it was above 1.5 for both F_2 and F_1. At later growth stages, when there was a declining trend between stages, then also the nutrient levels exerted profound influence recording a low declining rate for F_1 and F_2. This result is a reflection of the statement of Russel

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(1973) who reported that as the nitrogen supply increases, the extra protein produced allows the plant leaves to grow larger and hence to have more surface area available for photosynthesis. This probably may be due to the enhanced production of leaves and increased longevity of leaves exhibited by the plants receiving higher levels of nutrients. In this experiment since the combined effect of N,P and K are studied, the report of Steineek (1964) is worth mentioning ie the more the available nitrogen, the greater the effect of potassium on the growth of shoot and number of leaves and phosphorus increases the longevity of leaves.

Application of nutrients in 2,4 or 6 splits did not cause any significant variation in the LAI of bhindi at any of the growth stages. At 30 DAS, the plants supplied with nutrients in 4 equal splits gave more LAI while at later stages viz 60 and 90 DAS, plants which received 2 equal splits of nutrients recorded higher values. This enhanced LAI at S_1 may probably be due to the increased plant height (51.36cm) observed at 60 DAS (height of plant, Table 3) which promoted the development of more nodes and thus more leaves. At later growth stage, most of the leaves abscissed due to aging and hence the LAI declined considerably. Thus the effect due to method of application becomes nonsignificant which also indirectly substantiates that application of nutrients in small splits does not influence the longevity of leaves.

A positive correlation is found between yield and leaf area index of plant at different stages.

5.1.3 Crop growth rate (CGR)

The mean data on CGR is presented in Table 5. It is evident from the data that the CGR of bhindi plants in this study was significantly influenced by the nutrient levels and the highest growth rate being recorded by F_1 level. The increase in CGR noticed at the first growth phase may be due to the increased LAI recorded by the crop at this stage. From the data it is evident that the general growth rate of the plant was declining at the reproductive phase. But this rate of decline was very low at higher levels of nutrients indicating that the growth rate of bhindi was influenced by the levels at both the vegetative and reproductive phases, and for maintaining the growth rate at a higher level a fertilizer dose of at least (F_2) 220:73:146 Kg ha^{-1} N P_2O_5 and K_2O should be applied. Similar increase in CGR with NPK fertilizers has been reported by Ramakrishnan Nayar (1986) in cassava.

Split application of nutrients did not influence the CGR between 30 and 60 DAS, and 60 and 90 DAS. The non significant effect of split application on plant height at 30 and 90 DAS and that of LAI at different growth stages may be the reason for this. However from the data it is observed that the CGR was more for the S_1 treatment at early growth stages, whereas at later growth stages S_3 recorded higher CGR. Such a trend can be attributed to the rapid rate of growth due to the receipt of higher quantity of nutrients at early growth stage for S_1 which was compensated at a later growth phase when the crop received adequate quantity of nutrients in small splits for S_2 and S_3.

5.1.4 Dry matter production (DMP)

The mean data on dry matter production of plants is shown in Table 6 a,b,c, d and Fig. 3a. In general there was a progressive increase in DMP due to nutrient application at all growth stages. At very early growth stage ie at 30 DAS, a difference of about 20kgha^{-1} was noticed for DMP with each incremental dose of nutrient. With advancement in the age of the plants, there was considerable increase in DMP upto 90 DAS. At all growth stages, the highest nutrient level (F_1) recorded the highest DMP of 1761.70 kgha^{-1}, and the lowest DMP by the lowest nutrient level (F_4), which received nutrients as per the package of practices recommendation. The percentage increase in DMP with

F_1, F_2 and F_3 was 64, 42 and 22 $kgha^{-1}$ respectively over the package of practices recommendation or (F_4) at 90 DAS. The increase in leaf area along with increase in plant height have contributed for the increased DMP at higher nutrient levels. Recalling the data on LAI (Table 4) plant height (Table 3) CGR (Table 5) reveal that these growth parameters have significant contribution on the DMP of bhindi at different growth stages. With advancing age, the DMP increased considerably and the rate of increase was found to be significantly influenced by nutrient levels, (Table No. 6a,b,c & d) Between 30 & 60 DAS the rate of increase in dry weight was 706 $kgha^{-1}$ while it was only 413 $kgha^{-1}$ for F4. Similarly between 60 and 90 DAS there was marked variation in the rate of increase of DMP which varied from 451 $kgha^{-1}$ (F_3) to 810 $kgha^{-1}$ (F_1). According to Black (1973) an adequate supply of nitrogen is associated with vigorous vegetative growth in plants. Nitrogen being an integral part of chlorophyll decides the photosynthetic efficiency. Like wise increased application of nutrient phosphorus increased dry weight. Potassium is reported to have direct influence in the photosynthesis and translocation of assimilates and all these effects together contribute for increased dry-matter accumulation in the present study. Similar increase in dry weight with increased application of nutrient nitrogen, phosphorus and potassium were reported by Subramoniam (1980).

Split application of nutrients significantly influenced the dry matter production recording the highest value by 2 splits on 30 DAS and 60 DAS. This is due to the favourable influence of a higher proportion of nutrient given as basal dressing in this treatment. The data on LAI (Table 4), height of plant (Table 3) at 60 DAS substantiates this result. Similar observations have been reported by Bradely <u>et al</u> (1975) in cucumber, Matev (1966) in Capsicum and Smittle (1976) in Snap beans and Jayakrishnakumar (1986) in bhindi. At 90 DAS (S_3) six splits recorded the maximum dry weight and four splits significantly reduced DMP. This increased dry weight noticed due to the application of nutrients in six splits may be attributed due to the increased utilisation of nutrients when applied in small splits. The maximum height and highest CGR produced under this treatment contributed for increased DMP at this stage. A significant reduction in DMP was also recorded with 4 splits. This might be due to the low LAI and plant height recorded at this stage. Verification of the table shows that the interaction effects of FXS was significant. The combined effect of nutrient and its split application significantly influenced the DMP at

Fig. 3a. Dry matter production at different growth stages as affected by nutrient levels in plants (kgha^{-1})

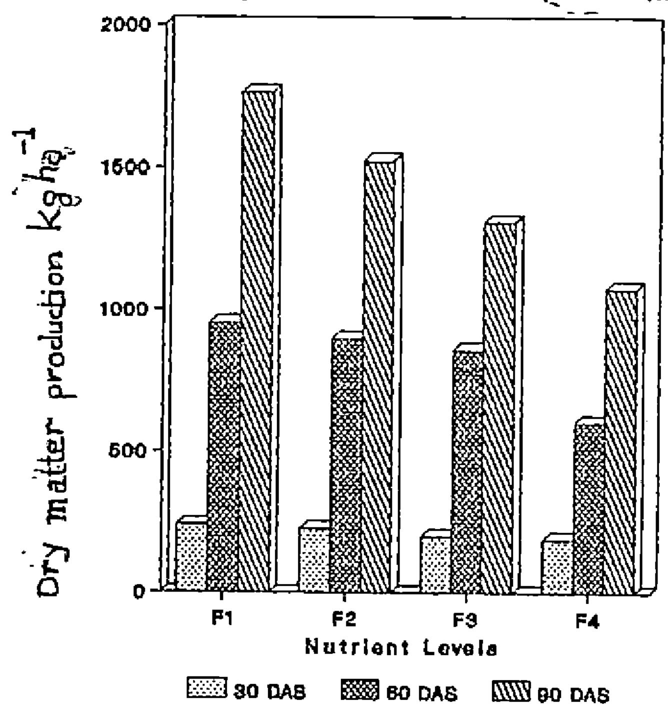
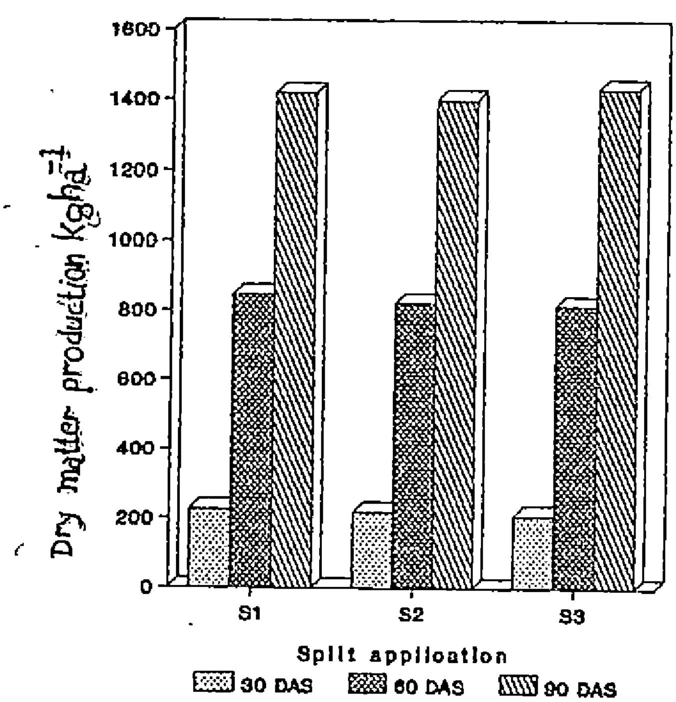


Fig. 3b. Dry matter production at different growth stages as affected by split application of nutrient in plants (kgha^{-1})



all growth stages and the highest values were recorded by F_1S_1 (268.67 $kgha^{-1}$, 998.99 $kgha^{-1}$ and 1805.55 $kgha^{-1}$) at 30, 60 and 90 DAS respectively and the least by F_4S_1, recording the respective values of 183.57 $kgha^{-1}$, 589.70 $kgha^{-1}$ and 1003.51 $kgha^{-1}$ at 30,60 and 90 DAS. The effect of interaction on DMP revealed the profound influence of higher dose of nutrients as basal and the reason for this was well explained under growth characters such as plant height and LAI.

A positive correlation is observed between yield and DMP of plant at different growth stages.

5.2 Time of 50 percent flowering yield components and yield

5.2.1 Days to 50 percent flowering

The data on days to 50 percent flowering is presented in Table 7. Nutrient application significantly influenced the days taken for 50 percent flowering. Delay in flowering was observed due to increased levels of fertilizer. Highest level of nutrient took about 42 days while under F_4 level of nutrient ie package of practices recommendation, it took only 38 days for attaining 50 percent flowering. Increasing the nitrogen supply increases the vegetative growth and delays the maturity as reported by Tisdale and Nelson (1985). The influence of nitrogen in increasing the days to 50 percent flowering is in confirmity with the results obtained in bhindi by Thompson and Kelly (1957) Yawalker (1969) and Kamalanathan *et al* (1970). Though inducing earliness in flowering were reported due to phosphatic nutrient by the above workers, the contradictory results obtained in this experiment may be due to the increased influence of nitrogenous nutrient when compared with that of phosphorus nutrient. Non significant influence of potassium in earliness in flowering have been reported earlier by Chandrasekharan (1965) and Kamalanathan *et al* (1970).

An earliness in flowering was observed when the nutrient was applied in six splits followed by four splits and application of nutrient in two equal splits significantly delayed the flowering. By applying nutrient in 2 splits higher quantity of nutrients are made available to the plants at the early growth stage and this might have resulted in prolonging the vegetative phase. When the fertilizers were applied in four or six splits, a comparatively less quantity of nutrient at each application might have reduced the vegetative phase of plants and thus inducing the earliness.

5.2.2 Number of flowers per plant

The mean data on number of flowers produced per plant are presented in Table 7. Levels of nutrient significantly increased the number of flowers produced per plant. The number of flowers produced per plant increased with incremental doses of nutrient and the flower number varied from 30 per plant (F_4) to 40 per plant (F_1). The higher availability of nutrients might have enabled the plants to produce more number of flower buds. According to Tisdale & Nelson (1985) an adequate supply of phosphorus in early stages of the plant growth is important in the initiation of flower primordia. Increase in the number of flowers with increasing levels of nitrogen and potassium have been reported by Subramonian (1980) and potassium by Chandrasekharan (1965) in bhindi.

Application of nutrients in splits have not resulted in any significant influence on the number of flowers produced per plant. On perusal of data it can be seen that eventhough split application of nutrients did not significantly influence the mean number of flowers formed per plant, more number of flowers were formed with six splits.

A positive correlation is obtained between yield and number of flowers produced per plant.

5.2.3 Setting percentage of fruit

The mean setting percentage of fruit is presented in Table 7. An appraisal of Table revealed that nutrient application had no significant influence on the fruit set in bhindi. In general setting percentage was very low and the value ranged from 44 to 46 percent. The low setting percentage exhibited by the crop may be an inherent character of the variety tried in this experiment. Similar nonsignificant influence of nitrogen, phosphorus and potassium on fruit set have been reported earlier by Subramonian (1980) in bhindi.

Application of nutrient in splits could not exert any significant influence on setting percentage. Fruit set is a varietal character influenced by climatological factors. Moreover the total fruit yield in this experiment was also not influenced by the time of application of nutrients. Therefore it can be inferred that time of application has no effect on percentage of fruit set in bhindi.

5.2.4 Number of fruits per plant

The mean number of fruits produced per plant is shown in Table 7. Number of fruits produced per plant increased significantly with increased application of nutrients. On appraisal of data it can be seen that plots which received nutrients as per package of practices recommendations recorded lesser fruit number compared to higher nutrient levels. Increase in the number of fruits noticed may be due to the increased production of flowers at higher levels of fertilizer application as reported earlier. The favourable influence of nutrient application on this character can be ascribed to the increased availability and uptake of plant nutrients required for production of flowers and development of fruits. Increased application of N, P and K have been reported to increase the number of fruits produced per plant by several workers. Majanbu et al (1985) for nitrogen and potassium and Mishra and Pandey (1987) for phosphorus and potassium.

Application of nutrient in split could not exert any significant influence on number of fruits formed per plant. The nonsignificant influence of split application on the number of fruits and setting percentage is reflected in the number of fruits produced per plant.

A positive correlation was observed between yield and mean number of fruits produced per plant.

5.2.5 Length and girth of fruit

The mean length and girth of fruits are given in Table 7. The data revealed that the levels of nutrients had no effect on the length and girth of the fruit. It is a well established fact that the length and girth of fruits are mostly varietal traits. So the results of the present study point out that application of nutrients cannot exert any influence on further expression of their genetic potential. Non significant effect of nitrogen on fruit length had been reported by Lenka et al (1989), phosphorus on fruit length and girth by Subramonian (1980) and due to potassium application by Singh (1979). However Subramonian (1980) found significant influence of nitrogen on fruit length. The contradictory effect of this character in this experiment may be due to the effect of phosphorus which increased the fruit length.

Application of nutrients in splits could not affect the length and girth of fruits. The different splits recorded more or less similar values of fruit length and girth. As the length and girth of fruits are mostly varietal characters, time of application of nutrients could not influence this character.

A positive correlation was found between yield and length and yield and girth of fruits.

5.2.6 Fruit yield per plant

The mean data on fruit yield per plant are presented in Table 8 and Fig 4a. The per plant yield of fruit was significantly influenced by nutrient levels. Between the higher 3 levels namely F_1, F_2 and F_3 there was no appreciable difference between per plant yield. However the highest dose (F_1) produced the maximum yield of 2.67 kg per plant followed by F_2 and F_3. This clearly showed that the present package of practices recommendations (F_4) 50:8:30 kg N P_2O_5 and K_2O per hectare for bhindi is significantly inferior to all the other levels tried in this experiment which recorded only 1.93 kg fruit per plant. The yield of a crop is a very complex competitive character resulting from different factors, the more important being the yield per plant and the number of plants per unit area (Tanaka <u>et al</u> 1964). The yield per plant is controlled by many factors such as the nutrient taken up by the plants, the genetic potential and the environmental conditions to which it is subjected to during its life cycle. An increase in the application of major nutrients have definitely increased the yield attributes like number of fruit per plant, length and girth of fruit etc, though it does not reach the level of significance in some cases.

Split application of nutrients could not influence the per plant yield of bhindi. The non significant influence of split application on setting percentage of fruits may be the reason behind this. However the application of nutrients in two splits produced comparatively more fruits per plant than four splits. The increase in fruit number obtained with two splits in this study are in agreement with the findings of Chauhan (1972) and Jayakrishnakumar (1986) in bhindi.

5.2.7 **Fruit yield**

The mean data on fruit yield are given in Table 8 and Fig.4a and b. Application of nutrients significantly increased the yield of the bhindi crop. In the present study it can be seen that, the lowest level of nutrient (F_4) ie package of practices recommendation resulted in lowest fruit yield of 61.75 qha^{-1} compared to the highest level of nutrient. The yield of higher levels of nutrient ie F_2 and F_3 were more or less uniform and this inturn was inferior to the highest level of nutrients, though not significant. Yield per hectare is a function of yield per plant and

Fig. 4a Fruit yield of bhindi as affected by nutrient levels (qha^{-1})

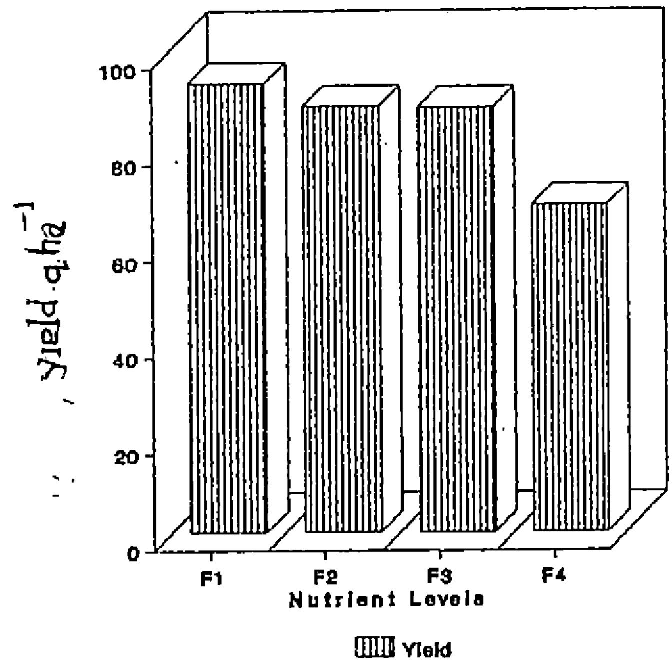
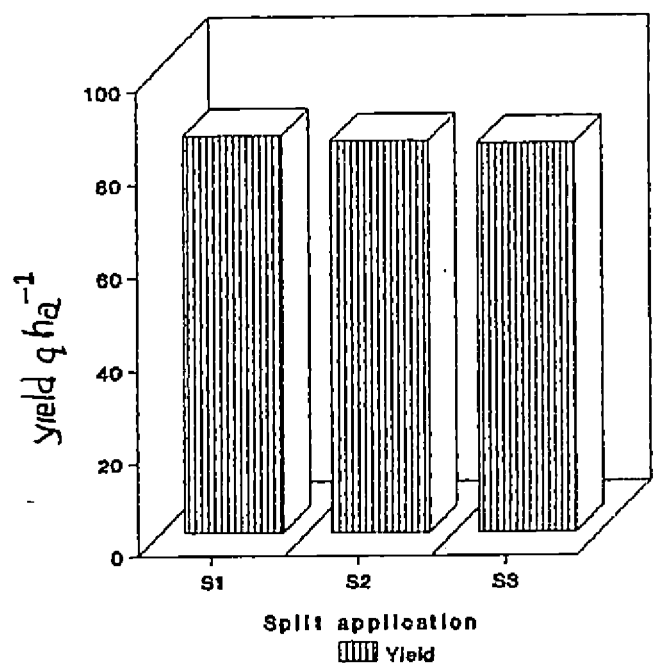


Fig. 4b. Fruit yield of bhindi as affected by split application of nutrient (qha^{-1})



plant population. Plant population being constant, the per hectare yield recorded here was actually a multiple of the per plant yield, which can be observed true on recalling the data (Table 8). Similar results due to nitrogen and phosphorus applications have been reported by Sharma and Shukla (1973) and nitrogen and potassium by Subramonian (1980).

Application of nutrient in splits could not exert significant influence on total yield produced. The non significant effect of split application of nutrients on yield per plant, number of flowers formed per plant, number of fruits per plant, percentage of fruitset and length and girth of fruits may be the reason behind this. Though not significant, application of nutrients in 2 equal splits gave more yield compared to other splits. This is in agreement with the findings of Lanchow Wing and Rajkomar (1982) and Jayakrishnakumar (1986) in Bhindi crops.

5.3 Quality aspect

5.3.1 Protein content

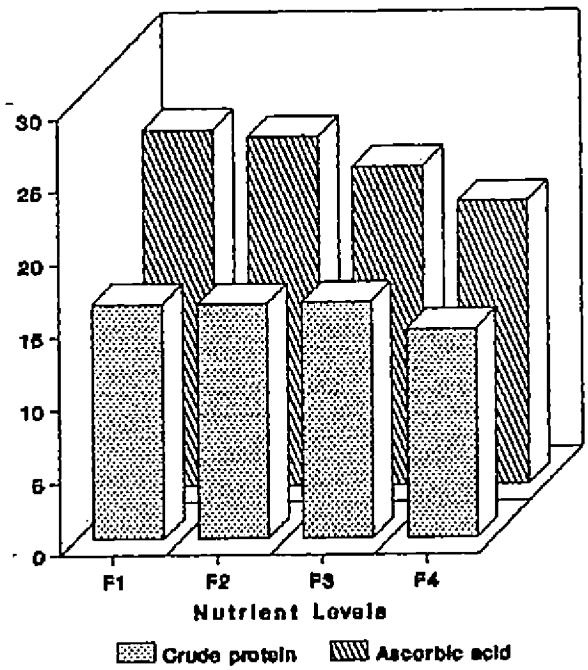
The mean data on protein content of fruits is presented in Table 9 and Fig. 5a and b. It can be seen from Table that plots with package of practices recommendation (F_4), recorded a significant reduction in protein content of fruits as compared to higher nutrient treatments. Application of nutrients exerted significant influence on fruit protein content. This might be due to the favourable effect of nitrogen on protein synthesis. These results are in confirmity with the findings of Thampan (1963), Subramonian (1980). Increased crude protein content with phosphorus was also reported by Punnoose and George (1974). The protein content in potassium deficient plant is relatively low (Mayer & Anderson 1952). This suggest that potassium in the same way is involved in the synthesis of protein from amino acids.

Application of nutrients in split doses could not exert any significant influence on protein content of fruits. The non significant effect of the split application of nutrients on nitrogen content of fruits caused a similar effect on crude protein content. This is in confirmity with the findings of Sharma and Prasad (1973) and Jayakrishnakumar (1986) in bhindi crops.

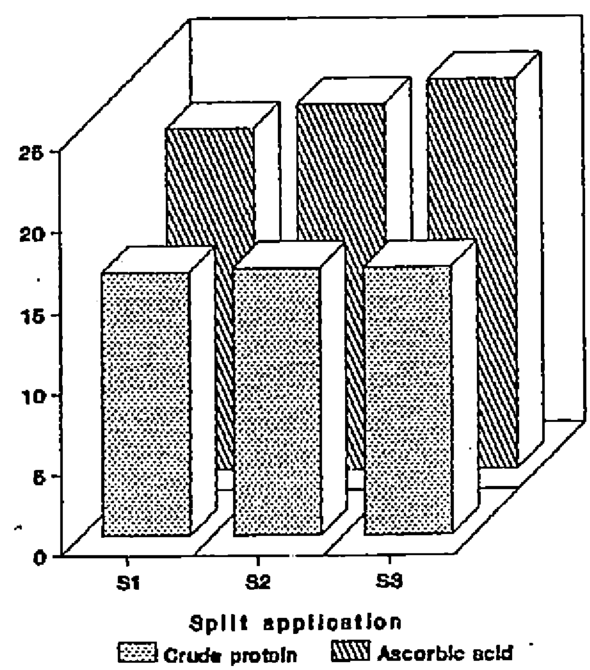
5.3.2 Ascorbic acid content of fruits

The mean data on ascorbic acid content of fruits are shown in Table 9 and Fig.5a and b. The results indicated that fruits with higher doses of nutrients (F_1) recorded maximum ascorbic acid content and the F_4 level recorded minimum. Similar results of

Fig. 5a. Content of protein (%) and ascorbic acid (mg/100g) fresh weight of fruits as affected by nutrient levels



. 5b Content of protein (%) and ascorbic acid (
eight of fruits as affected by split application



increased ascorbic acid content with the application of nitrogen, phosphorus and potassium were reported by De *et al* (1977).

Split application of nutrients significantly influenced the ascorbic acid content of fruits. Application of nutrients in 6 splits recorded higher ascorbic acid content followed by 4 splits. This is in confirmity with the findings of Dod *et al* (1983).

5.3.3 **Crudefibre content**

The mean data on crude fibre content of fruits are presented in table 10 and Fig. 6a and b. Application of nutrients exerted significant influence on crude fibre content of fruits from 1 DAH to 4 DAH. Crude fibre content was maximum at the lowest level of nutrient ie. F_4 (package of practices recommendation). Increasing the levels of nitrogen causing an increase in the succulence could have decreased the crudefibre content. Very often the role of potassium is associated with the strength and thickness of the cell wall of plants. Probably the dominant effect of nitrogen may be responsible for decreased crudefibre content of bhindi fruits even with higher levels of potassium application.

Split application of nutrients significantly influenced the crudefibre content of fruits from 1DAH

Fig.6a. Crude fibre content of fruits (%) as affected by nutrient levels

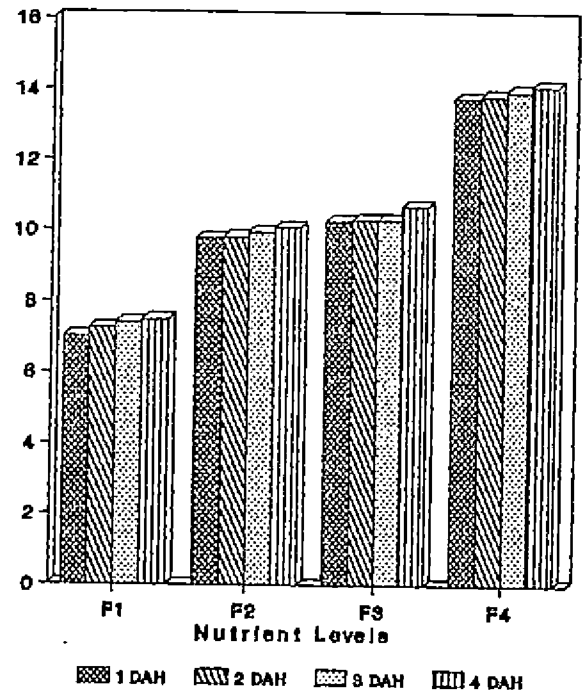
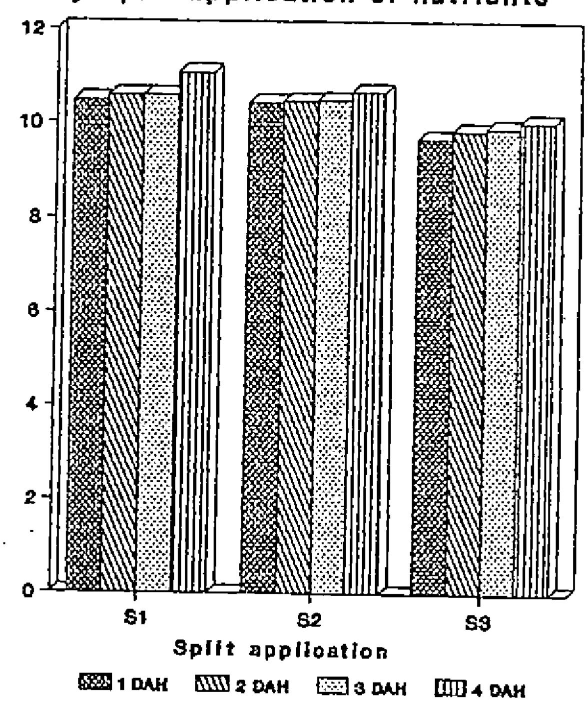


Fig. 6b Crude fibre content of fruits (%) as affect by split application of nutrients



to 4 DAH. Plants supplied with nutrients in 2 splits and 4 splits recorded higher crudefibre content of fruits compared to 6 splits. When fertilizer was applied in small splits the crudefibre content was significantly reduced. The crudefibre content went on increasing with days of storage for all the three methods of application and the value from 1 DAH to 4 DAH ranged from 10.48% to 11.07%, 10.42% to 10.67% and 9.69% to 10.04% for S_1, S_2 and S_3, respectively. However even with the storage of four days, the crude fibre content of fruits from 6 split treatment was lesser than that of freshly harvested fruits from S_1, and S_2.

5.4 Uptake of nutrients

The mean data on uptake of nutrients is given in Table 11 a,b,c, 12 a, b and Fig. 7a,b 8 a and b. It is seen that levels of the nutrient resulted in a marked increase in nitrogen, phosphorus and potassium uptake by both fruits and plants. As the level of nutrients increased, uptake of nitrogen, phosphorus and potassium by both fruits and plants also increased compared to the lower levels. An increased uptake of about 14 kg N ha^{-1} was observed in both plants and fruits between F_1 and F_4 levels. With regard to the uptake of phosphorus there was an increase of about 13 kgha^{-1} for the highest level of nutrient (F_1) over the package of practices recommendation (F_4). Same trend was noticed in the case of potassium also. These results are in agreement with the findings of Brown et al (1960). According to Tanaka et al (1964) the nutrient availability is controlled by factors like nutrient availability on soil, nutrient absorption power of roots and rate of increase in dry matter. A stimulated growth under higher levels of nutrient application might have resulted in better proliferation of root system and increased intake efficiency of plants.

Split application of nutrients showed significant influence on nitrogen and potassium uptake and has no effect on phosphorus uptake by plants. Application of nutrients in two equal splits recorded appreciably higher uptake for nitrogen and potassium compared to four and six splits. The uptake values for N, P_2O_5 and K_2O in plants ranged from 35.15 to 20.72 kgha^{-1} and 19.57 to 6.43 kgha^{-1} and 44.28 to 26.87 kgha^{-1} respectively. Higher availability of nutrients favour better proliferation of root system and thus enhance the intake efficiency resulting in increased uptake of nitrogen and potassium by plants. This is in confirmity with the findings of Jayakrishnakumar

(1986) where there was increased uptake of nitrogen and potassium on the 40th day by S_1, method of application. Vaijayanthi (1986) also reported non significant effect of time of application on uptake of phosphorus in rice. The efffect of interaction due to nutrient levels and split application was significant on nitrogen and potassium uptake. With all the levels of nutrients, S_1 method recorded the maximum uptake of all the nutrients followed by S_2. F_1S_1 recorded the maximum uptake of nitrogen followed by F_1S_2 and F_4S_3 recorded the lowest uptake by plants. On the other hand, split application of nutrients has got significant influence on the uptake of phosphorus and potassium and has no effect on nitrogen uptake by fruits. The effect due to FXS interaction was significant in the case of potassium uptake by fruits. The same trend in uptake as that of plants and fruits was also noticed in the case of total uptake of nutrients (Fig.9a and b). It is evident from the data that about 50 percent of the total nutrients removed by the plant is translocated for the production of fruits. The significant increase in the nitrogen uptake by plants (excluding fruits) for 2 splits and 4 splits may be due to the role of nitrogen in promoting vegetative growth of plants. Similarly the enhanced uptake of phosphorus by fruits may be due to the role of nitrogen in promoting vegetative growth of plants.

Fig.7a Uptake of Nitrogen, Phosphorus and Potassium as affected by nutrient levels in plants (excluding fruit) $kgha^{-1}$

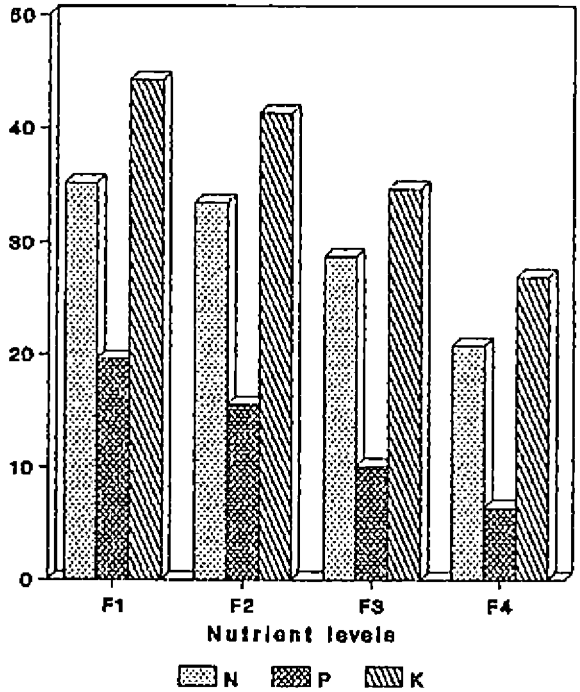


Fig. 7b Uptake of Nitrogen, Phosphorus and Potassium as affected by split application of nutrient in plants (excluding fruit) $kgha^{-1}$

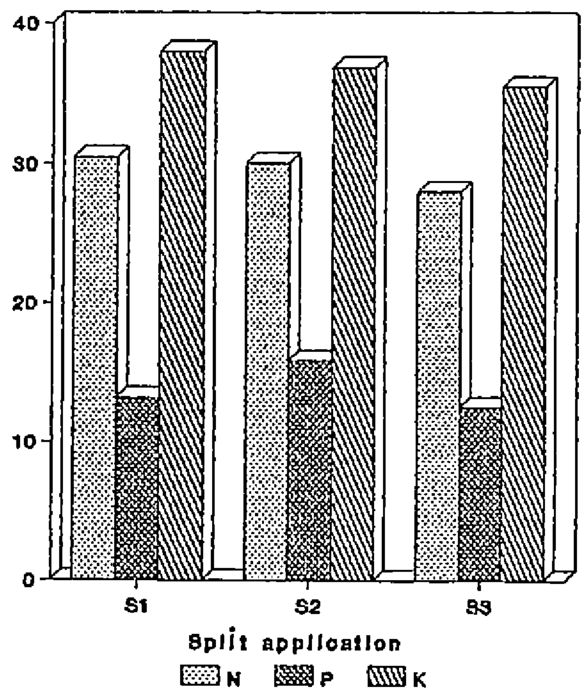


Fig. 8a. . Uptake of Nitrogen, Phosphorus and Potassium as affected by nutrient levels in fruits (kgha^{-1})

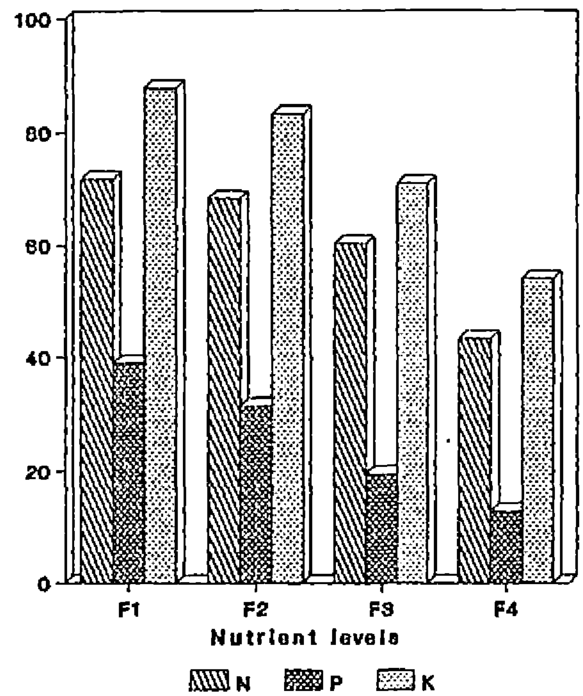


Fig. 8b Uptake of Nitrogen, Phosphorus and Potassium as affected by split application of nutrients in fruits (kgha^{-1})

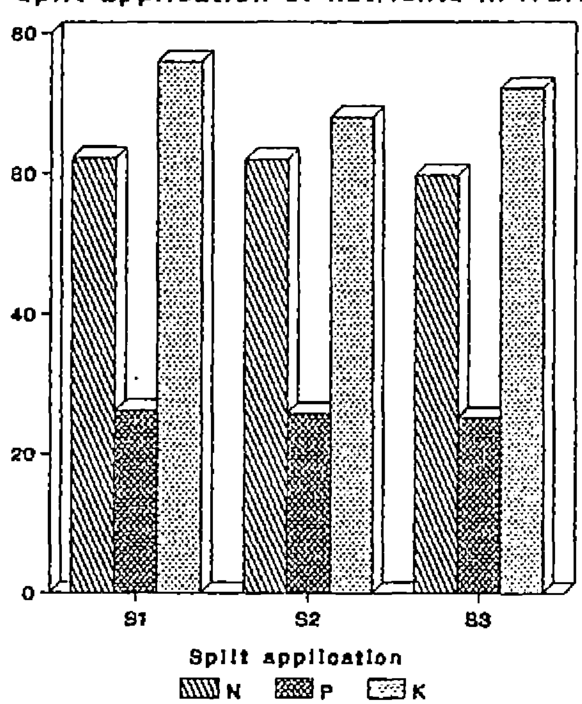


Fig. 9a Total plant uptake as affected by nutrient levels (kgha⁻¹)

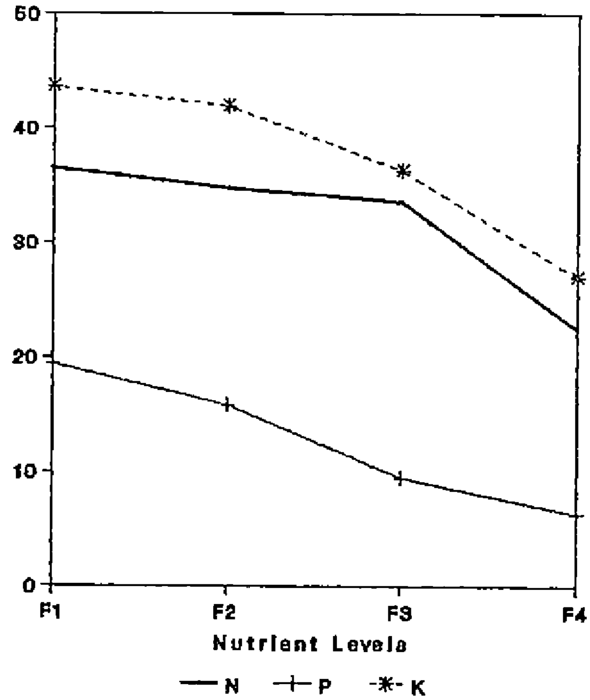
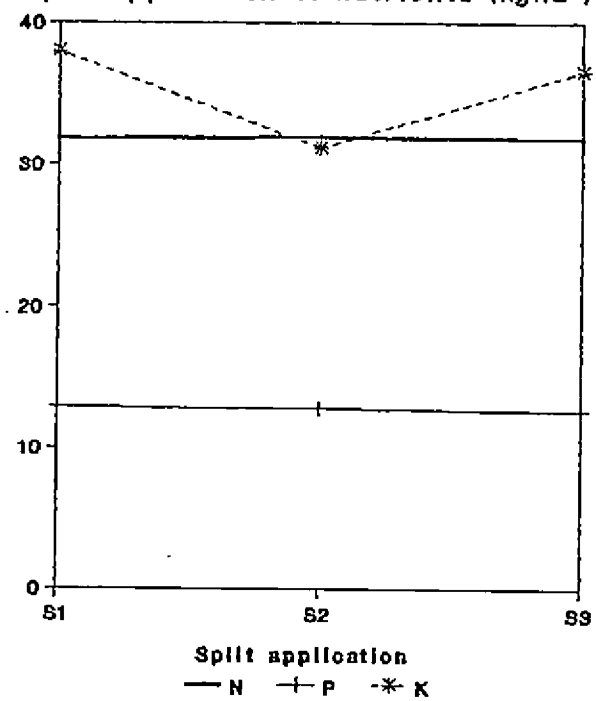


Fig. 9b Total plant uptake as affected by split application of nutrients (kgha⁻¹)



Similarly the enhanced uptake of phosphorus by fruits may be due to the involvement of phosphorus in the reproductive primodia development. With potassium, both the plants and fruits removed high quantities of potassium on high basal application. This can be attributed to the high foraging capacity of the plants received with high quantity of nutrients as basal and also due to the luxury consumption effect of potassium.

5.5 Soil analysis

The mean data on available nutrient status of the soil is presented in Table 13 a and b. The data on soil analysis revealed that the available nitrogen, phosphorus and potassium content was significantly influenced by increasing levels of nutrient application. It is evident from the data that plot treated with package of practices recommendation (F_4) recorded lower available nitrogen, phosphorus and potassium content in soil. The higher status of available nitrogen, phosphorus and potassium at higher levels of nutrients may be due to the direct effect of applied nutrients along with a uniform dose of farm yard manure. More over the farmyard manure had considerable influence on the release and availability of nitrogen, phosphorus and potassium to the plants (Venkata Rao, (1985), Thangavel (1985) and Lavanya (1986)).

Split application of nutrients significantly influenced the available nutrient status of soil. The nitrogen, phosphorus and potassium status in the soil are higher with S_1 method of application. An increased nutritional status of soil is observed after the experiment and this might be due to the crop residue left in the soil.

5.6 Economics of cultivation

The data on economics of cultivation is presented in Table 14 and Fig 10a and b. The results indicated that the net profit increased with increase in levels of nutrient. It is evident from data that F_3 level of nutrient recorded highest net profit of Rs.13794 compared to Rs.6905 in F_4 level (package of practices recommendation). The difference of net profit with F_1, F_2 and F_3 level of nutrient compared to F_4 are Rs.6777.18, Rs.6190.91 and Rs.6889.62 respectively.

It is seen that benefit : cost ratio was maximum with F_3 level of nutrient (1.64) compared to 1.34 in F_4.

Among the split application of nutrient, the highest net profit of Rs.14710.80 was recorded by S_1 (2 equal splits of nutrient applied as basal and 30 DAS)

Fig. 10a Benefit Cost ratio as affected by nutrient levels

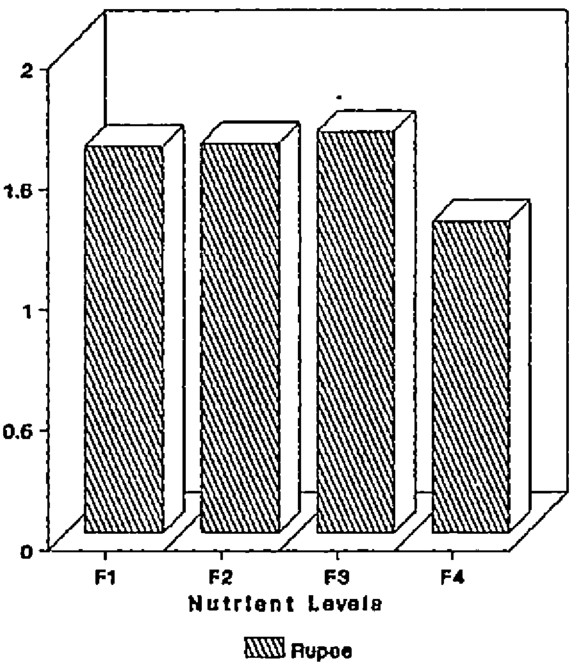
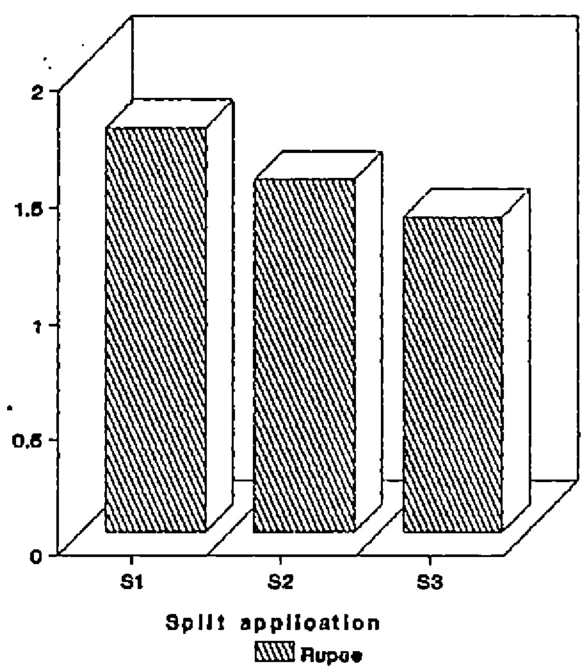


Fig. 10b Benefit Cost ratio as affected by split application of nutrients



and it was Rs.5388.67 and Rs.3135.00 higher than S_3 and S_2 respectively.

The highest benefit cost ratio was recorded by S_1 (1.76). This is in confirmity with the findings of Jayakrishnakumar in bhindi.

Based on the results of the experiment it is concluded that, for getting maximum profit from bhindi, a nutrient dose of 110 KgN, 37 Kg $P_2 O_5$, 73 Kg K_2O ha^{-1} is to be applied in two equal split doses, half as basal and half at 30 DAS.

SUMMARY

SUMMARY

A field experiment was conducted at the Instructional Farm of the College of Agriculture, Vellayani during the Kharif season of 1990, to study the effect of different levels of nutrients and their method of application on the growth, yield, quality and nutrient uptake of bhindi variety, Kiran. The soil of the experimental field was oxisol, Vellayani series with acidic in reaction, low in available nitrogen and potassium, medium in available phosphorus. The treatments were four levels of nutrients viz 330:110:220 kg N, P_2O_5 and K_2Oha^{-1} ie the present T&V recommendation, 2/3 of the T&V recommendation, 1/3 of the T&V recommendation & 50:8:30 kg N,P_2O_5 and K_2Oha^{-1}, the present package of practices recommendation. These nutrients were applied in 2 splits, 4 splits and 6 splits. The experiment was laid out as 4 x 3 factorial experiment in RBD, in four replication. The results of the experiment are summarised below.

1. Highest level of nutrients (F_1) at all growth stages and split application of fertilizer in 2 equal splits (S_1) at 60 DAS significantly increased the plant height.

2. Fertilizer applications significantly increased the LAI of the plants at all growth stages. Application of nutrients in splits could not affect LAI of the plants at any growth stage.

3. Crop growth rate was maximum with F_1 level of nutrients and split application of fertilizer did not affect the crop growth rate significantly.

4. The dry matter production of plant at all growth stages increased progressively with increase in levels of nutrients. Application of nutrients in 2 splits at 30th & 60th day after sowing and application of nutrients in 6 splits at 90th day after sowing significantly increased the DMP. The interaction effect due to nutrients and its split application on dry matter production was significant and F_1 S_1 (Highest dose in two splits) recorded highest value.

5. Increase in levels of nutrients and its application in 2 equal splits significantly delayed days taken for 50 percent flowering.

6. Mean number of flowers produced per plant increased with increase in levels of nutrients and split

application of it did not affect the mean number of flowers produced.

7. Neither the different levels of nutrients nor its split application affected the setting percentage of fruit.

8. Nutrients at higher levels significantly increased the mean number of fruits produced per plant and its split application did not produce significant effect on number of fruits recorded.

9. Either the nutrient levels or its split application could not produce any significant influence on length and girth of fruit.

10. Highest level of nutrient recorded significantly higher fruit yield plant^{-1} and application of fertilizer in splits could not affect the per plant yield of fruit.

11. Fruit yield of bhindi increased with increase in levels of nutrients and the maximum was recorded by F_1, level of nutrients and application of nutrient in splits did not influence the fruit yield of bhindi.

12. Nutrient levels significantly influenced the protein content in fruits. Application of fertilizer

in different splits had no significant effect on the protein content of fruits.

13. The highest level of nutrient recorded the highest ascorbic acid content of fruits and application of fertilizer in six splits recorded maximum ascorbic acid content.

14. Crude fibre content of fruit was significantly decreased with higher levels of nutrients. Application of nutrients in two equal splits significantly increased the crude fibre content. The same trend was noticed from 1st day after harvest to 4th day after harvest.

15. The uptake of nitrogen, phosphorus and potassium by plants significantly increased with increase in levels of nutrients and application of ferilizer in 2 splits significantly increased the nitrogen potassium uptake. Split application of nutrients did not affect the phosphorus uptake.

16. Nitrogen uptake by fruit was significantly influenced by higher levels of nutrients but the method of application did not influence uptake. Phosphorus and potassium uptake by fruits was significantly influenced by higher dose of

fertilizer applications & applications of fertilizer in 2 equal splits significantly increased the phosphorus and potassium uptake by fruits. But phosphorus and potassium uptake by fruits was significantly influenced by levels and methods of application of nutrients.

17. High levels of nutrients and its application in 2 equal splits significantly increased the content of available nitrogen, available phosphorus and available potassium content of soil.

18. Net profit and benetif cost ratio were maximum for F_3 level of nutrients and its application in 2 equal splits.

Future line of work

The present study revealed that though the T. and V recommendation (330:110:220 kg NP_2O_5 and K_2O ha^{-1} gave the maximum yield, it was on par with the other two lower levels viz 2/3 of T and V recommendation (220:73:146 kg N P_2O_5 K_2Oha^{-1}) and 1/3 of T and V recommendation(110:37:73 kg NP_2O_5 and K_2Oha^{-1}). The maximum net profit was obtained with 1/3 of the T and V recommendation. This means that 1/3 of T and V recommendation is sufficient for getting maximum profit. But the next lower dose tried in this experiment was the present package of practices recommendation, which is less than half of the above dose. So it will be worth while to find out whether a dose in between the 1/3 of T and V recommendation and present package will be profitable. This needs further investigation.

More than this at present the cost of fertilizers are increasing day by day and most of these nutrients are subjected to so many ways of losses in soil. Hence while going for a higher level of nutrient, for increasing the utilization efficiency of these nutrients, some attempts should also be made for reducing their losses. This can be carried out using nitrification inhibitors, slow releasing fertilizers etc. Use of bio-fertilizers is also having much scope in a crop like bhindi. So future research work in bhindi has to be oriented towards the above mentioned aspects.

REFERENCE

Balasubramonian, P., J.Krishnarajan and S.P.Palaniappan. (1982). Effect of time of application of phosphorus to low land rice. Madras Agric. J. 69(1) pp. 56-58.

Batal, K.M. and Smittle, D.A. (1981). Response of Bell Pepper to irrigation, nitrogen and plant population. J. Amer. Soc. Hort. Sci. 106(3). pp. 259-262.

Bear, E. Ferman (1965). Chemistry of the soil. Oxford and IBH Publishing Co., Culcutta, 2nd Edn. pp. 395-439.

Bharadwaj, R.B.L., J.V. Rao. and R.C. Gautam. (1974). Response of upland rice to rate and time of application of phosphorus. Indian J. Agron. 19 pp. 113-117.

Black, C.A.(1973) Soil Plant Relationship. 2nd Edition Wiley Eastern Pvt. Ltd. New Delhi. pp.111.

Bouyoucos, G.J. (1962). Hydrometer method improved for making particle size analysis of soil. Agron. J. 54:pp. 464-465.

Bradley, G.A., E.C. Baker, and D.R.Motes (1975). Cultural studies on once over harvested pickling cucumbers. Arkansas Farm Research. 24 (2).

Brown, D.A., C.A. place and J.V. Pettiet (1960). The effect of soil moisture upon cation exchange in soils and nutrient uptake by plants. Trans. 7th. Int. Congr. Soil Sci. 3. pp.433-439.

Chandrasekharan, P. (1965). Studies on the effect of NPK in combination with Spartin on the growth, yield and quality of bhindi (Abelmoschus esculentus (L.) Moench). M.Sc. (Ag.) Thesis submitted to Kerala Agricultural University

Chandrasekharan, P. and C.M. George. (1973). Effect of NPK fertilizer in conjuction with spartin on the growth and yield of brinjal. Agric. Res. J. Kerala 11(2): pp 106-108

Chauhan, D.V.S. (1972). Vegetable Production in India. 2nd edition. Ram Prasad and Sons, India, Agra. p.277.

Chauhan, D.V.S. and M.L. Gupta (1973). Effect of nitrogen, phosphorus and potash on growth and development of Okra (Abelmoschus esculentus (L.) Moench) Indian J. Hort. 40: (1/2): pp 401-6.

Chonkar, V.S. and Singh. S.N. (1963). Studies on inorganic nutrition of bhindi (Abelmoschus esculentus (L.) Moench) in sand culture. Indian J. Hort. 20:PP.51-58.

Chougule, A.B. and Mahajan, P.R. (1979). Effect of varying levels plant population, nitrogen, phosphorus and potash on growth and yield of chilli. Veg. Sci. 6 (2) pp. 73-80.

*Chuzhova, A.P., E.P.Bukin, L.YA Arbuzova, and E.V.Osipova (1975). The effect of split application of mineral fertilizers on agro chemical soil properties and on physiological characteristics and yield of tomatoes. Agrokhimiya 1: pp. 110-130.

Cochran, W.C. and Cox, G.M. (1965). Experimental designs. John Wiley and Sons Inc., New York.

Crowther, E.M. (1935). A note on the availability of organic nitrogen compound in pot experiments. J. Agri. Sci. 15: pp.300-302.

CSIR (1959). The Wealth of India. Raw Materials Vol.5. Council of Scientific and Industrial Research, New Delhi. pp. 82,89.

Dass, R.C. and Mishra, S.N. (1972). Effect of nitrogen, phosphorus and potassium on growth, yield and quality of chilli (Capsicum annuum (L.) Plant. Sci. 4 : 78-83.

De Candolle, A.P. (1883). Originedes plantes cultives Paris. pp. 150-151.

De, S.K., Prasad, R., Singh, N. and Shanker, J. (1977). Ascorbic acid and thiamine content variation in cauliflower (Brassica oleraea van snowball) seedling under different fetilizer stress. Ind J Agrl. Chemistry 10 (1 & 2). 173-175.

Dod, V.N., Joshi. A.T., Kale, P.B. and Kulwal, L.V. (1983). Effect of different levels of nitrogen in split doses on yield and quality of red ripe chilli (Capsicum annuum Linn). CV.G.3. Proceedings of National Seminar on production technique of tomato and chilli TNAU, Coimbatore: pp.152-153.

George Thomas, C. (1984). Water management practices for bittergourd (Mamodica charantia L) under different fertility levels. M.Sc., (Ag). Thesis submitted to Kerala Agricultural University.

Gupta, A. and Rao, G.G. (1979). Studies on the response of Okra (Abelmoschus esculentus (L) Moehch) to nitrogen fertilization and irrigation. Indian. J. Hort 36(2) p.177.

*Habben.J. (1973). The effect of nitrogen and potassium fertilizers on yield and quality of carrots. (Dacus carota L.) Landwirtschaftliche Forschung. 26: pp.156-172.

*Hammett, H.L., Albritton, R.C., Brock, W.A., Crackett, S.P. and Wagganer, B.E. (1974). Production of cucumber for pickes. Bulletin Mississippi Agricultural and Forestry Experiment station No.801:p.14.

* Harshad, M.N., Moursi, M.A. and A.Gomma. (1960). Some factors affecting the ascorbic acid content of tomatoes. An Agric. Sci. Cairo 3 pp.81-89.

Hegde, D.M.(1988). Physiological analysis of growth and yield of water melon (Itrullus lanatus Thumb) in relation to irrigation and nitrogen fertilizers. J. Agron. and Crop Sci. 160: pp. 296-314.

Hunt, R. (1978) Plant growth analysis. Institute of Biology studies in Biology. No. 96.

Irene Vethamoni, P. (1988) studies on the effect of herbicide nitrogen and mulching on growth and yield of bhindi (Abelmoschus esculentus (L) Moench) CV.MDV-1. South Indian Horticulture 36 (4). P. 219.

Jackson, M.L. (1973). Soil Chemical Analysis 2nd Edition. Prentice-Hall of India (Pvt) Ltd., New Delhi. pp. 1-498.

Jayakarishnakumar, V. (1986). Water management in relation to split application of nitrogen on bhindi (Abelmoschus esculentus (L.) Moench). M.Sc. (Ag). Thesis submitted to Kerala Agricultural University.

Joseph, P.A. (1982). Effect of N, P and K on the growth and yield of chilli, variety Pant C-1. M.Sc.(Ag). Thesis submitted to Kerala Agricultural University.

Kamalanathan, S., Sundararajan. S. and Thamburaj, S. (1970). Studies on optimum spacing and manuring of okra (Abelmoschus esculentus (L). Moench). Madras Agric. J. 57 (1):pp 10-17.

Khan, M.A.R. and Suryanarayana, V. (1977). Effect of N, P and K on flowering, fruit size and yield of chill, var. N.P. 46-A. Veg. Sci. 4 (1): 53-60.

Lanchow Wing, K.F., and I. Rajkomar (1982). Effect of planting density and split application of nitrogen on okra (Abelmoschus esculentus (L) Moench). Revue Agricole et Sucriere de ille Maunce 6 (1): pp. 9-14.

Lavanya, P.G. (1986). Organic manures and their interactions with inorganic fertilizers on nutrient availability, content and uptake by crop. M.Sc.(Ag). Thesis, Tamil Nadu Agricultural University.

Lenka, P.C., Das, D.K. and Mishra, H.N. (1989). Effect of nitrogen and phosphorus on seed yield of bhindi C.V. Prabhanikranti. Orissa Agric. Res. 2 (2): pp 125-126.

Majanbu, I.S., Ogunlela, V.B., Ahmed, M.K. and Olarewaju, J.D. (1985) Response of 2 okra (Abelmoschus esculentus (L) Moench) varities to fertilizers, yield and yield ccomponents as influenced by N and P application. Fertilizer research 6 (3).pp. 257-267.

Mani, S and Ramanathan, K.M. (1980). Studies on the available potassium status of soil as influenced by the application of nitrogen and potassium. Madras Agric J. 67 (12). 777-779.

Mani,S. and Ramathan, K.M. (1982). Effect of nitrogen and potassium on the crude fibre content of bhendi fruits at successive stages of pickings. South Indian Hort.

Matev,T. (1966). The time of application of mineral fertilizers to early pepper crop. Grad lozas, Nauke.3: pp 715-722.

Mayer S. Bernad and Anderson B. Donald (1952). Plant physiology, second Edn. D. van Nostrand Company Inc. Princeto, New Jersey, New York.

Mehrotra, O.N., Suxena, H.K. and Mishra, P.H. (1968). Effect of NPK deficiences in chillies. Fert. News 13 (3):pp.34-36.

Mishra, H.P. and Pandey, R.G. (1987). Effect of N and K on the seed production of Okra. (Abelmoschus esculentus mill) in calcareous soil. Indian J. Agron. 32 (4) pp. 425-427.

Mitsui,S. (1964). Dynamic aspects of nutrient uptake. Proc.symp. The mineral nutrition of the rice plant. Johns. Hopkins Press md.p-53.

Muraleedharan Nair, A., C.M.George and N. Sadanandan. (1978). Effect of phosphorus and molybdenum on flowering and pod formation in groundnut. Co.pol - 1. Agri. Res. J. Kerala.13(2). pp.113-116.

Nadkarni, K.M. (1954). Indian Materia Medica. Revised and enlarged by A.K.Nadkarni, Popular Book Depot, Bombay.

Patil, H.B. and Patil, A.A. (1986). Effect of nitrogen phosphorus and potassium and their method of application on nutrients and ascorbic acid contents of radish. South Indian Horticulture 34 (4).pp.266-270.

Palit,P., Kandu, A., Mandal,R.K., Sircar, S.M. (1976). Growth and yield parameters of two dwarf and two tall varities of rice under different fertilizer combinations. Indian J. Agric. Sci. 46(6). pp.292-299.

Paul Gyorgy and Pearson, W.N. (1967). The Vitamin Chemistry. physiology Method. Academic Press, Newyork, 2nd Edn. Vol VII. pp. 235-238.

Paulraj,C. and Raniperumal. (1980). Effect of sources and split application of nitrogen on nutrient uptake by tomato. Madras agric. J. 67(2).pp.106-108.

Peterburgskii, A.V., Asarov and P.M. Smirnov (1956). The effectiveness of fertilizers in the south-eastern regions of the VSSR under irrigation. Izr timirya Zev S-kh Akad. No.2:23-36.

*Pimpini,F. (1967). Experiments on the mineral fertilizing of sweet peppers. Progr. agric. Bologna. 13.pp.915-932.

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

Rajan, S. (1991). Production potential of amaranthus under irrigation and nitrogen levels. M.Sc.(Ag) Thesis, submitted to Kerala Agricultural University.

Rajendran, P.C. (1981). Studies on the effects of graded doses of N.P. and K on growth, yield and quality of pumpkin var. CM-14, M.Sc. (Hort). Thesis, submitted to Kerala Agricultural University.

Rajanna, K.M., K.T. Shivasankar. and K.S.Krishnappa. (1987). Effect of different levels of N, P and K on growth, yield and quality of potato. South Indian Hort. 35(5).pp.347-355.

Ramakrishnan Nayar, T.V. (1986). Production potential of Cassava. (Manihot esculenta Crantz) inter cropped in coconut gardens. Ph.D Thesis submitted to Kerala Agricultural University.

Randhawa, G.S. and M.S. Pannun (1969). The effect of row spacing and levels of nitrogen on the growth and yield of okra. J. Res. Pb. Agric. Univ. 6:320-324.

Randhawa,K.S., Bhandari, N.R. and Singh, Diljit (1977). Influence of phosphorus, zinc application on Okra (Abelmoschus esculentus (L.) Moench). Progressive Hort. 9(2):31-38.

Longman group Ltd., London, 10th Edn. pp. 30-43.

Saimbhi, M.S. and Padda, D.S. (1970) Effect of nitrogen and phosphatic fertilization on the growth and yield of Okra (Abelmoschus esculentus (L) Moench). J. Res. Ludhiana, India 7 (4): 460-463.

Saji John. (1989) Nutrient management in vegetable chilli (Capsicum annuum) variety jwala sakhi. M.Sc.(Ag). Thesis submitted to Kerala Agricultural University.

Sharma, C.B. and Shukla, V. (1973). Nature of response in okra (Abelmoschus esculentus (L.) Moench) to NPK application and their economic optima. Indian J. Agric. Sci. 43 (10). pp. 930-933.

*Sharma, J.P. and R. Prasad (1973). Yield of pods crude protein content and nitrogen uptake by okra (Hibiscus esculentus) as affected by nitrogen and water management. Gartenbauwissens chaft, 38. pp. 163-9 C.F. HA., 45. pp. (7):435(4995).

*Shrestha, G.K. (1983). Effect of spacing and nitrogen fertilizer 'Pusasavani 'Okra' (Abelmarchus esculentus in Nepal Experimental Agriculture. 19.pp. (3) 239-242.

Simpson, J.E., Adair, C.R., Kohler, G.O., Dawson, E.N., Debald, H.A., Kester, E.B. and Klick, J.I. (1965). Quality evaluation studies of foreign and domestic rices. Tech. Bull. No.1331. Services, U.S.D.A..pp.1-86.

*Singh Kirti, Nauriyal, J.P. and Singh, A. (1967). Response of Okra (Abelmoschus esculentus (L.) Moench) to various levels of nitrogen, phosphorus and potassium Proc. Int. Symp.Sub-trop. Trop. Hort., pp.501-509.

*Singh Kirti and Singh, R.P. (1966). Effect of various sources and levels of nitrogen on growth and fruiting responses of bhindi (Abelmoschus esculentus (L.) Moench). Horticulturist Srinagar 1: 76-80.

Singh, M.P., Kashyap, K. and Sharma, C.P. (1986). Effectt of foliar spray of urea in bhindi. (Abelmoschus esculentus (L.) Moench). Indian J. Agric. Res. 20(2). pp 90-92.

Singh, N.P. (1979). Effect of NPK on bhindi (Abelmoschus esculentus (L.) Moench. Prog. Hort. 10 (4).pp.21-28.

Singh, U.C., Sundararajan, S. and Veeraraghavathatham. (1985). Effect of split application of nitrogen on growth and yield of amaranthus (Amaranthus tristis (L.) Co.3. South Indian Hort. 33 (2). pp 100-102.

Sinha, M.M. (1975). Effect of closer spacing and high nutritional doses with or without GA on yield and quality in chilli (Capsicum annum L.). Prog. Hort. 7(1).pp. 41-48.

*Skapski, H.K. Viscardi, and J.jagada (1969). Effect of sprinkling irrigation and mineral and organic fertilizing on yields of certain tomato varieties. Biul. Warzyw. 9. pp 121-136.

Smittle, D.A. (1976). Response of snap beans to irrigation, nitrogen fertilization and plant population. J. Amer. Soc. Hort. Sci. 101 (1). pp. 37-40.

Srinivas, K., and B.S. Prabhakar (1982). Response of capsicum to nitrogen fertilization. Veg. Sci. 9 (2). pp 71-74.

Steineek,O. (1964). Experiments on the reciprocal influence of N and K in their effects on root and shoot of tomato. Badenkultar Ausgabe. A.14. pp.311-326.

Subba Rao (1989). Water management and NK nutrition of cucumber (Cucumis sativus L.) M.Sc. Thesis submitted to Kerala Agricultural University.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. Current Sci 25 (8). pp. 259-260.

Subbiah, K., Muthuswamy, S., Sundara Rajan, S. and Mani.S. (1984) Mode of potassium application on the yield and nutrient uptake in bhindi. South Indian Horticulture. 32(2) pp. 93-96.

Subbiah, K. and Raniperumal (1986). Effect of N and K and $CaCl_2$ on yield and nutrient uptake in tomato. South Indian Horticulture 34 (2). pp. 82-99.

Subramonian (1980) Effect of graded doses of nitrogen phosphorus and potassium on growth, yield and quality of bhindi (Abelmoschus esculentus (L) Moench var. Co) M.Sc.(Ag) Thesis submitted to Kerala Agricultuual University.

Sulekha, G.R. and Mohanakumaran, N. (1992) Vegetable cultivation on commercial basis. Kalpadhenu 19 (4).p.22.

Surendran, K. (1985) Nitrogen management in rice variety Lekshmi (Kayamkulam-1). M.Sc. (Ag). Thesis submitted to Kerala Agricultural University.

Sutton, P. (1963). The response of okra to N, P and K fertilization. Proc. Florida State Hort. Soc. 76: 149-153.

Thampan, P.K. (1963). Effect of Giberellic acid in conjunction with fertilizers on growth and yield of bhindi. (Abelmoschus esculentus, (L .) Moench). M.Sc. (Ag). Thesis submitted to Kerala Agricultural University.

Tanaka, A., S.A. Navasero, C.V. Garcia, G.T. Parao, and E. Remirez (1964). Growth habit of the rice plant in the tropics and its effect on nitrogen response. Int. Rice. Res. Inst. Teck. Bull. 3. pp. 1-80.

Thangavel, P. (1985). Influence of organic manures on transformation, fixation and availability of nutrients. M.Sc.(Ag) Thesis, 1985. Tamil Nadu Agricultural University.

ɔmpson, H.C., and W.C.Kelly (1957). Vegetable Crops. Mc Graw Hill Book Company, New York.

Tisdale, S.L., Nelson, W.L. and Beaton, J.D., (1985). Soil Fertility and Fertilizers. mac Millan Publishing Co., Inc. New York, 4th Edn. pp. 1-733.

Tomar, S. and Rathore, S.S. (1988). Studies on relationship of growth and Sink parameters with nitrogen and duration of picking intervals on yield in Okra (Abelmoschus esculentus (L.) Moench). Gujarat Agrl. Univ. Res. Journal 13(2) pp. 8-11.

Vaijayanthi, C.P. (1986). Fertilizer management in rice variety cheradi. M.Sc. (Ag). Thesis submitted to Kerala Agricultural University.

Venkatesa Rao,K. (1985). Influence of organic manures on nutrient availability, uptake and crop yield. M.Sc.(Ag) Thesis, 1985. Tamil Nadu Agricultural University.

Verma, V.K.K.C., Pundrik, and K.S.Chauhan (1970). Effect of different levels of N, P and K on vegetative growth and yield of Okra. Punjab Hort. J. 10. pp.130-36.

Wankhade, B.N. and Moreg, D.K. (1986). Effect of levels of irrigation, nitrogen and potash on the growth and yield of chilli (Capsicum annuum L.) Punjabrac Krishi Vidyapeeth Res. J. 8(2). pp. 22-25.

Yawalker, K.S. (1969). Vegetable Crops of India. Agri. Hort. Publ. House, Nagpur, India: P.100.

*Zannin, A.C.W. and Kimoto.T. (1980). Effect of plant spacing and fertilizers on Okra seed production. Revista Brasileira de sementes. 2(3):105-112.

* Originals not seen

NDARDISATION OF FERTILIZER SCHEDULE EXPORT ORIENTED PRODUCTION OF BHINDI

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ABSTRACT OF A THESIS
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ABSTRACT

An experiment was conducted at the instructional farm, College of Agriculture, Vellayani to find out the effect of different levels of fertilizers and their split application on the growth, yield, quality and nutrient uptake of bhindi. Abelmoschus esculentus (L) Moench. The treatments consisted of four levels of nutrients viz. (330:110:220 Kg N_2 P_2O_5 & K_2O), the present T & V recommendation, 2/3 of the T & V recommendation, 1/3 of the T & V recommendation and 50:8:30 Kg NP_2O_5 & K_2O per hectare the present package of practices recommendation and 3 methods of application viz. nutrients in 2 splits, 4 splits and 6 splits.

The results revealed that nutrient levels significantly influenced most of the growth and yield contributing characters and yield of bhindi. Biometric characters like plant height, LAI, CGR, DMP and yield contributing characters like days to 50 percent flowering, number of flowers formed, number of fruits formed total yield of fruits and quality parameters like protein content and ascorbic acid content increased with increasing levels of nutrients, recording their maximum value at F_1 level, (T and V recommendation). Uptake of nutrients by plants, fruits and total was also maximum for

the same treatment. However yield attributes viz. setting percentage, length and girth of fruits etc. remain unchanged with increasing levels of nutrients.

Application of fertilizer nutrients in different splits viz. 2,4 or 6 cause significant variation in some of the growth and yield characters. An increase in the plant height at 60 DAS, DMP, days taken for 50 percent flowering and uptake of nutrients was noticed when nutrients were supplied in two equal splits, viz half as basal and half 30 DAS (S_1). On the other hand the ascorbic acid content in fruits was maximum when nutrients were applied in six splits. Application of nutrients in 6 splits caused a significant reduction in the crude fibre content also.

From the economic point of view, the maximum net profit of Rs. 13682.54 was obtained by F_3 level (2/3 of T and V recommendation) and Rs. 14710.8 by S_1 (2 equal splits half as basal and half 30 DAS).