YIELD, QUALITY AND VIGOUR OF BHINDI SEED AS INFLUENCED BY NUMBER OF HARVESTS AND NUTRIENT SOURCES

By

Sheeba Rebecca Isaac

THESIS

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For You, Amma

DECLARATION

I hereby declare that this thesis entitled "Yield, quality and vigour of bhindi seed as influenced by number of harvests and nutrient sources" is a bonafide record of the research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellayani
15.10.97

SHEEBA REBECCA ISAAC

CERTIFICATE

Certified that this thesis entitled "Yield, quality and vigour of bhindi seed as influenced by number of harvests and nutrient sources" is a record of research work done independently by **Kum. Sheeba Rebecca Isaac** 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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03.11.97

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Assoc. Prof. of Agronomy
College of Agriculture

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2. **Dr. V. Muraleedharan Nair**
3. **Dr. (Mrs) P. Saraswathy**

External Examiner

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LIST OF ABBREVIAIONS

FYM	-	Farm yard manure
LAI	-	Leaf Area Index
BC	-	Benefit Cost
et al	-	and others
N	-	Nitrogen
P_2O_5	-	Phosphorus
K_2O	-	Potash
DAS	-	Days after sowing
ml	-	Millilitre
cm	-	centimeter
m	-	metre
g	-	gram
kg ha^{-1}	-	kilogram per hectare
Rs	-	Rupees
CD	-	Critical difference
SE	-	Standard error
cv	-	cultivar
^{o}C	-	Degree celsius
Fig	-	figure
viz	-	namely
KAU	-	Kerala Agricultural University
No.	-	Number
temp	-	temperature
%	-	per cent
t	-	tonnes

Introduction

INTRODUCTION

Good seed forms the basic but the cheapest and most remunerative input in crop production especially in vegetables as the quality and uniformity of the produce are very important to consumer sales. Quality seeds offer enormous scope to realise production targets as well as increase export earnings significantly. Crops raised from poor quality seeds are not healthy and thus rendered uneconomical. The non availablity of quality seeds due to inadequate production is the major constraint in the vegetable cultivation of India. The present requirement of vegetable seeds in the country is 29 500 t annually (Seshadiri, 1990) and 72 t in the State of which only 20 to 25 per cent are supplied by authorised agencies (KAU, 1991).

Hence the vegetable seed yield has to be stepped up from the present level to ensure the timely supply of seeds in adequate quantities to the growers.

In seed production the twin objectives of yield and quality have to be realised and for this proper growth of the mother plant and its fruits are desired. Recent findings in seed technology research have indicated that mother plant nutrition, particularly nitrogen, is one of the most important factors in the production of quality seeds. The sources of nitrogen available are many. Traditionally organic manures like poultry manure and farm yard manure were commonly used in agriculture. The importance of organic manures came under shadow during the last few decades on account of the rapid increase in the use of chemical fertilisers but now again the high cost of fertilisers and the need to maintain soil productivity and ecological stability have led to fresh appraisal of their role and scope vis-a-vis chemical fertilisers. In the present decade of sustainable agriculture the integrated plant nutrient system, in which, organic manures are coupled with chemical fertilisers, is of prime importance to achieve best results at low cost. This is highly relevant in seed production also.

Furthermore it is a common practice among farmers to sell the best produce and keep the worst and last formed for seed - the exact opposite of what should be done. Such practices can only lead to a rapid decline in productivity of the crop and quality of the produce. Combining vegetable production with seed production may be possible as periodic removal of early formed fruits as vegetable stimulated the growth of the crop and thereby increasing its yielding capacity (Nandpuri *et al.*, 1974). So instead of using the leftovers for seed, a good yield of quality seeds along with some vegetable can be obtained by this practice.

However there is a paucity of scientific information on these aspects and hence the present investigation was attempted in bhindi with the following objectives:

i) To assess the effect of vegetable harvests on the seed yield, quality and vigour.

ii) To standardise the optimum number of vegetable harvests for maximum production of quality seeds.

iii) To assess the best source of nutrient for better seed yield and quality.

iv) To study the economics of the different practices and arrive at the best for recommendation.

Review of Literature

REVIEW OF LITERATURE

In vegetables, among the several factors which account for the better quality of seeds, green fruit picking and nutrient supplied, especially nitrogen to mother plant are found to have a profound influence. Though the research efforts on these aspects are meagre all the available information documented in literature are reviewed in this section.

2.1 Effect of vegetable harvests

As precise information on the effect of vegetable harvests on the seed yield and quality in bhindi is lacking those available on related crops are also included.

2.1.1. Effect of vegetable harvests on growth characters

The significant influence of vegetable harvests on plant growth has been reported by several authors.

Velumani and Ramaswami (1980) in an experiment to find out the effect of green fruit picking on plant height and seed yield in bhindi observed that the height of plants varied from 65.97 cm when all fruits were left to mature for seed, to 130.67 cm when the first formed twelve fruits were harvested as vegetable. Similar increase in plant height with increasing number of green fruit pickings was reported by Wankhade and Morey (1981) in chilli and Tyagi and Khandelwal(1985) in bhindi. Stunted growth of plants was observed when all the fruits were left to mature for seed without green fruit picking (Garris and Holfmann, 1946, Shanmughasundaram, 1950, Kolhe and Chavan, 1967, Kamalanathan et al, 1968, Bhuibar et al, 1989).

Khan and Jaiswal (1988) reported that green fruit pickings (0,1,2 and 3) had no effect on the plant height of bhindi.

In general better plant height could be observed with vegetable harvesting.

2.1.2 Effect of vegetable harvests on fruit yield and yield attributes

2.1.2.1 Yield of green fruits

Significant influence of different green fruit pickings (0,1,2,3 and 4) on the length, number and weight of green fruits plant^{-1} has been reported by Grewalet al(1974). With each picking there was a linear increase in the number as well as weight of green fruits plant^{-1} whereas each picking decreased the length of pods.

Green fruit yield was reported to be proportionately high when more number of vegetable harvests were done (Madhava Rao, 1953). Bhuibar *et al.* (1989) observed that when zero, one, two, three and four pickings of green fruits were done, the highest yield of green fruits was obtained with four pickings.

2.1.2.2 Yield of mature fruits

Pandey *et al.* (1976) reported maximum number of dried fruits plant^{-1} with three green fruit pickings but there was not much difference between three and four fruit pickings. Khan and Jaiswal (1988) observed that the number and weight of dried fruits plant^{-1} were significantly influenced by fruit picking over no picking and the maximum weight and number of fruits plant^{-1} were harvested under two fruit pickings.

On the contrary the highest number and weight of dried fruits were obtained under no green fruit picking by Grewal *et al.* (1974) and Bhuibar *et al* (1989).

2.1.2.3 Total number of fruits plant^{-1}

Plants in which maximum number of fruits were harvested for vegetable produced more number of fruits

(Shanmughasundaram, 1950). Similar results were reported by Perkins et al (1952), Grewal et al (1974) and Velumani and Ramaswamy (1980). Kolhe and Chavan (1967) concluded that allowing fruits to mature right from the beginning for seed reduced the number of fruits to one third. Tyagi and Khandelwal (1985) observed that three pickings produced higher number of fruits over the control of no fruit picking.

Thus it is evident that periodical removal of green fruits stimulated fruit production in bhindi.

2.1.3 Effect of vegetable harvests on seed and seedling characters

2.1.3.1 Number of seeds fruit^{-1}

Kanwar and Saimbhi (1987) reported that in bhindi the number of mature seeds and seed weight fruit^{-1} were highest 35 days after anthesis. Further delay in harvesting increased the number of damaged seeds and decreased the seed weight fruit^{-1}.

Rode (1979) observed the maximum number of seeds fruit^{-1} in plants which were left to mature for seeds without green fruit picking. Similar results have been obtained by Velumani and Ramaswamy (1980), Deshmukhe and Tayde (1986) and Bhuibar et al (1989).

Wankhade and Morey (1981) reported that in chilli green fruit picking had no significant effect on the number of seeds fruit^{-1}. The same was observed in bhindi by Khan and Jaiswal (1988).

2.1.3.2 Weight of seeds fruit^{-1}

The weight of seeds fruit^{-1} was found to be superior with zero or two green fruit pickings compared to four, six, eight, ten and twelve fruit pickings (Velumani and Ramaswamy, 1980). They also reported that the seed weight fruit^{-1} in the first picking was always significantly more than in the subsequent pickings.

On the other hand, Deshmukhe and Tayde (1986) observed lowest seed weight fruit^{-1} in plants with no green fruit picking.

In chilli no significant influence of green fruit picking on the weight of seeds fruit^{-1} was reported by Wankhade and Morey (1981).

2.1.3.3 1000 seed weight

Grewal *et al.*(1973) observed significantly lower 100 seed weight in plants where three to four green

According to Tyagi and Khandelwal (1985) and Natraj *et al.* (1992) picking of the first formed fruits (1, 2, 3 and 4) for vegetable had no effect on the germination percentage.

2.1.3.6 Seedling characters

Velumani (1976) observed that the shoot and root length of the seedlings, vigour index and dry weight of seedlings recorded maximum values in the fourth picking with lower values in the previous and subsequent pickings in the pure seed crop of bhindi.

Asokmehta and Ramakrishnan (1986) found no significant variation in the root length of chilli seedlings with fruit pickings in the two varieties (Co-1 and Co-2) tried while the shoot length of the first three pickings were on par in Co-1, the highest being in third picking. In Co-2 also the third picking showed the highest shoot length, this being on par with that of sixth picking. Vigour index in Co-1 was highest in the second picking recording a value of 1593 which however was on par with that of other pickings. Seeds of Co-2 showed the highest vigour index of 1876 in the third picking and the lowest in the first picking.

fruit pickings were done. However the same authors observed no appreciable difference in 100 seed weight due to one or two green fruit pickings. Similar reports on the progressive decrease in seed weight with increase in the number of fruits harvested for vegetable were given by Velumani and Ramaswamy (1980), Khan and Jaiswal (1988) and Bhuibar *et al*.(1989).

2.1.3.4 **Seed Yield**

Several workers have opined that the seed yield of bhindi is significantly influenced by the number of green fruit pickings.

Kolhe and Chavan (1967) recorded a seed yield of 876 and 692 kg ha^{-1} respectively in a pure seed crop and pure crop used partly for vegetable and partly for seed purpose. Grewal *et al*.(1973) observed that the yield of A and B grade seeds and recovery per cent of A grade seed were higher in plots from which three to four pickings of green fruits were taken. Pandey *et al*. (1976) observed a significant increase in seed yield upto picking of two fruits and the yield from three green fruits pickings was significantly at par with the control of no fruit picking. But picking of four fruits significantly reduced seed yield. Velumani

(1976) reported that the seed yield was significantly high when the first formed two fruits were harvested as vegetable and this was on par with no green fruit picking. Khan and Jaiswal (1988) also obtained maximum seed yield with two pickings of green fruits followed by one, zero and three pickings.

Tyagi and Khandelwal (1985) recorded highest seed yield in plants without any green fruit picking.

2.1.3.5 **Germination percentage**

Seeds from the early formed fruits gave a higher germination percentage in cotton (Selvaraj and Ramaswamy, 1976) and in chilli (Sriramachandra Murthy, 1979 and Dharmatti and Kulkarni, 1988) whereas in bhindi Velumani (1976) reported germination to be maximum in the fourth picking with decreased values in the previous and subsequent pickings when all fruits were allowed to mature for seed.

Grewal et al. (1973) found that plants in which no green fruit picking was done gave the highest germination percentage and Bhuibar et al. (1989) observed a reduction in germination percentage as the number of green fruit pickings increased from one to four.

Natraj *et al.* (1992) reported that in bhindi there was no significant difference in the seedling root and shoot length and vigour index when the early formed fruits, upto four green fruits, were harvested for vegetable compared to no vegetable harvesting.

2.1.3.7 Seed protein

Protein content of the seed was not found to be significantly influenced by picking of zero, one, two, three or four fruits for vegetable (Natraj *et al.*, 1992).

Thus the review clearly reveals the influence of vegetable harvesting on the important seed and seedling characters. It is also worth noting that the different crops and varieties respond differentially to these aspects.

2.2 Seed yield and quality as influenced by nutrients

Results of studies have shown that of the macronutrients, nitrogen is the key nutrient to increase the seed yield as it exhibits a high positive response in bhindi (Fagaria *et al.*, 1993) The favourable influence of nitrogen on the growth, yield and quality of seed crops have been reported by several workers.

2.2.1 **Effect of N on growth, yield and seed characters**

Application of nitrogen was found to significantly increase the seed crop growth characters viz. plant height and number of leaves plant^{-1} (Pandey and Singh, 1979, Chakrabarti _et al_., 1980, Singh _et al_., 1982, Chakrabarti, 1983, Singh _et al_., 1988 and Sharma, 1994).

Gupta and Gill (1988) reported that nitrogen could induce earliness in flowering though this did not have any effect on fruit setting and yield.

Several workers have observed that the number of seeds fruit^{-1}, 1000 seed weight and seed yield were significantly higher with nitrogen application than that in its absence. (Pandey and Singh, 1979, Hooda _et al_., 1981, Chakrabarti, 1983, Norestagard, 1985, Mishra and Pandey, 1987 and Sharma, 1994)

Vijayakumar (1992) in snakegourd tried three levels of NPK (6:12:6, 9:15:9 and 12:24:12 g NPK pit^{-1}) and three spacings for good seed yield and quality. The results revealed that 12:24:12g NPK pit^{-1} and

2.0x2.5m spacing were optimum for higher seed yield, high recovery of large sized seeds, high 100 seed weight, germination percentage, shoot length, root length and vigour index.

On the contrary Rastogi _et al_. (1987), Singh _et al_. (1991) and Lovato _et al_. (1994) reported that nitrogen fertilisation had no significant effect on seed weight and germination.

Significant increase in the seed protein content with increase in nitrogen was reported in different crops, Nandisha and Mahadevappa (1984) in rice and Natraj _et al_. (1992) in bhindi whereas Lovato _et al_. (1994) concluded that nitrogen fertilisation did not significantly influence the seed nitrogen in turnip.

In general, application of nitrogen resulted in vigorous plant growth which had favourable effects on seed yield and quality characters.

The nitrogen needed by the seed crop can be given either through organic or inorganic sources. Organic manures in addition to supplying macro and micronutrients, improve the physical, chemical and biological properties of the soil (Hegde and Dwivedi, 1993). The efficacy of organic and inorganic sources of nitrogen in vegetable crops have been studied by several workers but the works regarding its influence on the yield and quality of seed are very meagre. So the available literature on this aspect pertaining to crops other than bhindi are also reviewed here.

2.2.2 Effect of source of N on growth characters

Many workers have reported significant variation in the growth of plants under different sources of N.

Chinnaswami (1963) observed that the height of chilli plants increased with the application of manures, the inorganic manures being superior. A combination of organic and inorganic manures proved better.

Application of chemical fertilisers in the absence of FYM retarded formation of vegetative organs and subsequently the reproductive organs. FYM favourably affected the vegetative mass, dry weight, plant height, rate of dry matter increment per unit leaf area and hence the photosynthetic yield. (Cerna, 1980 and Valsikova and Ivanic, 1982).

Subbaih et al (1985) reported that vegetable crops responded well to FYM and macronutrients and in general 10-20 t ha^{-1} of FYM was found to be beneficial.

In fodder sorghum, plant height was significantly higher with 100 per cent inorganic fertiliser followed by 6 t FYM + 50 per cent recommended dose of fertilisers (Gangwar and Niranjan, 1991).

Singh *et al*. (1973) observed a progressive increase in the growth of potato plants with successive increments in the levels of nitrogen through various combination of poultry manure, FYM and fertilisers. Poultry manure exhibited better response than FYM on the different attributes viz. height of the plant, number of shoots and number of leaves $plant^{-1}$ at every level and combination, the best being the combination of poultry manure and fertiliser at 160 kg N ha^{-1}, each supplying 80 kg N ha^{-1}. Enhanced plant growth with the application of poultry manure and inorganic fertiliser has been reported by Abusaleha (1981) in bhindi, Dhandpani (1982) in cauliflower and Jose *et al*. (1988) in brinjal.

Kale and Bano (1983) reported the performance of vermiculture as a fertiliser in rice crop nursery. The seedlings showed significant increase in growth in the plots applied with vermicompost compared to FYM application. On transplantation of seedlings to plots applied with wormcast and chemical fertiliser respectively, it was found that vegetative growth was better influenced by worm cast than the fertiliser.

Singh and Tiwari (1966) tried different sources of N (FYM, leaf mould, castor cake and neem cake) in garlic and observed that these did not affect the growth characters, as, though bulky, they contained the same amount of nitrogen.

2.2.3 Effect of source of N on yield and yield attributes

As in the case of growth, yield also varied significantly with the source of N.

Chinnaswami (1963) concluded from the organic manure study in tomato using FYM, groundnut cake and two inorganic mixtures containing the same amounts of N, P and K as in FYM, that inclusion of inorganic sources could induce earliness in harvest and hence a better yield of fruits.

Subbiah et al (1983) reported that the yield of brinjal fruits was significantly influenced by the levels of FYM (0,12.5, 25.0 and 37.5 t ha^{-1}) but not by the levels of fertilisers (0, 50, 100 and 150 per cent of the recommended dose) or by the interaction due to

FYM and inorganic fertilisers. Application of 12.5 t ha^{-1} of FYM recorded the highest yield of 54.28 t ha^{-1}. Among the inorganics 50 per cent of the recommended dose recorded the highest yield of 50.89 t ha^{-1}. A combination of 12.5 t ha^{-1} FYM + 50 per cent recommended dose of fertiliser was found to be beneficial for improving yield.

Rawankar *et al.* (1984) revealed that application of FYM produced significantly higher seed cotton yield by 41.1 per cent over its no application.

Nair and Peter (1990) reported highest yield in chilli with 15 t FYM + 175:40:25 kg NPK ha^{-1} in the three seasons tried when compared to FYM alone or inorganic fertilisers alone.

Studies conducted in KAU revealed that organic and inorganic fertilisers and their combinations had significant influence on vegetable productivity and, higher rates of N along with FYM induced earliness and increased the fruit yield in clustered chilli. (Kerala Agricultural University, 1991).

Subbaih and Sunderarajan (1993) found that combined application of 12.5 t ha^{-1} FYM + recommended dose of macronutrients + 25 kg $ZnSO_4$ ha^{-1} in bhindi was better than FYM alone or combinations of 25 t ha^{-1} FYM with the recommended dose of fertilisers with or without micronutrients.

A study on the optimum level of poultry manure requirement for cauliflower by Singh et al. (1970) revealed a progressive increase in growth and yield of cauliflower when the doses were increased from 0 to 169.6 q ha^{-1}. Singh et al. (1973) reported that in potato 160 kg N ha^{-1} applied 50 per cent through fertiliser and the remaining 50 per cent through poultry manure gave maximum yield compared to 80 or 120 kg N ha^{-1} applied as FYM or poultry manure or in combination with fertilisers. Abusaleha (1981) reported early flowering and highest yield of 18.02 t ha^{-1} with the application of half nitrogen through ammonium sulphate and the remaining half through poultry manure in bhindi.

In lettuce, poultry manure applied at 0, 20 and $40m^3$ ha^{-1} either as entire basal dose or in splits increased the yield from 0.66 to 0.88 and 0.90 kg $plant^{-1}$ (Anez and Tavira, 1984).

Jose *et al* (1988) observed that plants supplied with 50 kg nitrogen as poultry manure and 50 kg nitrogen as urea recorded the highest yield of brinjal fruits (51.03 t ha^{-1}) followed by plants suplied with 50 kg nitrogen as pig manure and 50 kg as urea (45.80 t ha^{-1}).

Desai (1993) reported that the capsicum yield in vermiculture treated plots was 16 t $acre^{-1}$ compared to chemical fertiliser applied plots of 18 t $acre^{-1}$. But tomato grown after chilli harvest gave yields similar to that of fertiliser treated plots (18 t $acre^{-1}$) revealing a residual effect.

Gunjal (1993) reported an increase in fruit yield to the tune of 40 per cent and 36 per cent due to application of chemical fertilisers and vermicompost respectively over the control of no nutrient application.

No significant variation in the grain yield of rice with vermicompost application compared to fertiliser application has been reported by Kale and Bano (1986).

Combined application of organic and inorganic sources resulted in improved growth and yield.

2.2.4 Effect of source of N on seed characters

Studies on this aspect are very meagre and the few available are reviewed hereunder.

Naidu (1987) concluded that in cow pea cv. Co-4, application of FYM + NPK at 25:50:0 kg ha^{-1} recorded the highest fresh and dry weight of seed, volume, germination, vigour and dry weight of seedling.

Girija et al (1993) observed that nutrition of rice through the organic source of cow dung recorded 4.54 per cent more viability of seeds than the exclusive use of inorganics alone.

A combined application of FYM and fertiliser nitrogen was found to significantly increase the protein content of grains in red gram (Muthuvel et al, 1985), ragi (Chellamuthu, 1987) and wheat (Patel et al, 1993) than when either applied alone.

The influence of the different sources of nitrogen on crop growth and yield attributes are confirmed from the above literature. In general, a combination of organic and inorganic sources is found be better for a good crop stand and seed yield of superior quality. But information regarding its influence on the seed characters of vegetables is totally lacking and hence the present study in bhindi is attempted.

Materials and Methods

MATERIALS AND METHODS

An experiment was conducted at the College of Agriculture, Vellayani to study the effect of vegetable harvests and source of nitrogen on the quality, yield and vigour of bhindi seeds. The details of the materials used and methods adopted are presented in this chapter.

3.1 Materials

3.1.1 **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 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 4.8, low in available potassium, medium in available nitrogen and high in available phosphorus. The physico chemcial properties of the experimental site 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.	Parameter	Content in soil per cent	Method used
(1)	(2)	(3)	(4)
1	Coarse sand	36.35	Bouyoucos
2	Fine sand	15.00	Hydrometer method
3	Silt	17.50	(Bouyoucos,1962)
4	Clay	30.00	

B. Chemical composition

Sl. No.	Parameter	Content	Rating	Method used
1.	Available N	486.06 kg ha^{-1}	medium	Alkaline potassium permanganate methoc (Subbiah & Asija, 1956)
2.	Available P_2O_5	66.00 kg ha^{-1}	high	Bray colorimetric method 1 (Jackson, 1973)
3.	Available K_2O	28.00 kg ha^{-1}	low	Ammonium acetate method (Jackson, 1973)
4.	pH	4.80	Acidic	pH meter with glas: electrode (Jackson 1973)

3.1.3 Cropping history of the field.

The experimental area was previously cropped with vegetables and was under bulk cultivation of tapioca prior to the layout of the experiment.

3.1.4 Season

The experiment was conducted during October to January of 1994-95.

3.1.5 Weather conditions

The weekly averages of temperature, relative humidity and the weekly total of rainfall during the cropping period collected from the meteorological observatory at the College of Agriculture, Vellayani are presented in Appendix 1 and Fig. 1.

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

3.1.6 Cultivar used

The cultivar of bhindi used for this study was Kiran (Selection AE-1). This variety was evolved at

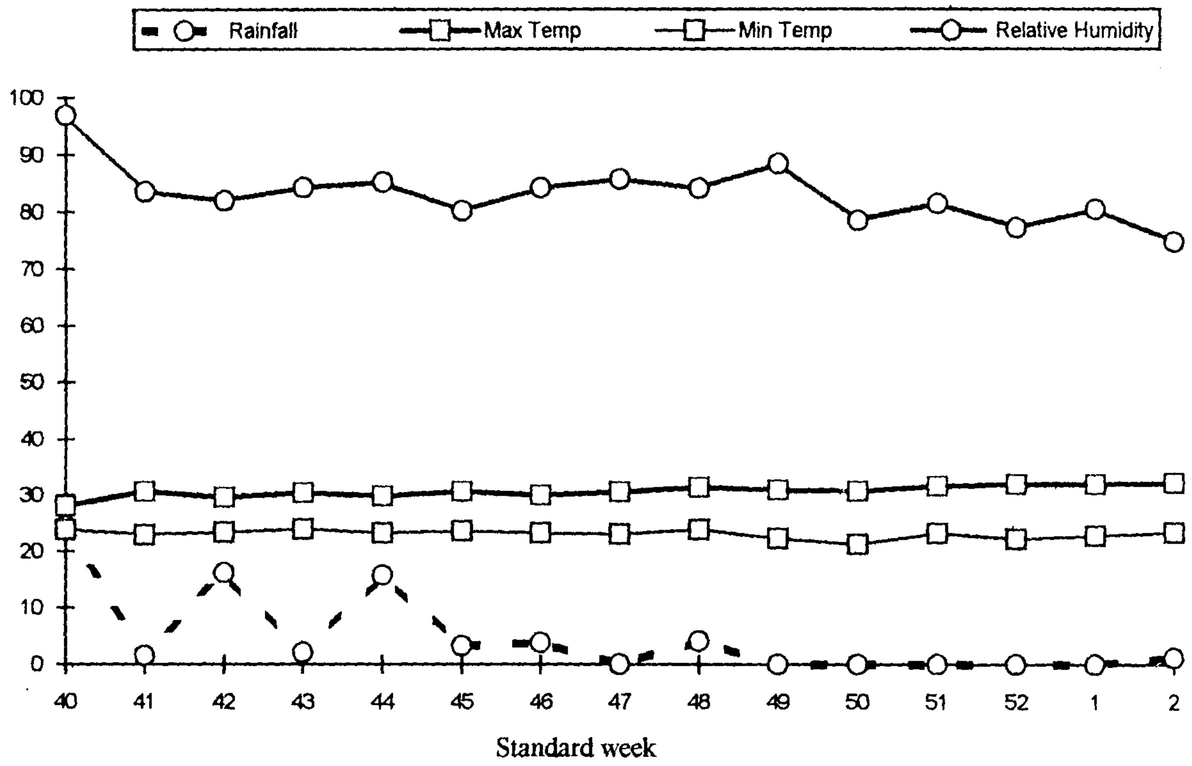


Fig. 1 Weather data during the cropping period from 4 Oct. 1994 to 14 Jan. 1995

the College of Agriculture, Vellayani by single plant selection from a locally popular variety 'Kilichundan'. 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 Krishi Vigyan Kendra, Mithraniketan, Vellanad were used for the experiment.

3.1.8 Manures and fertilisers

Farm yard manure (0.49% N), vermicompost (1.0% N) and poultry manure (3.0% N) were used as organic sources of N and ammonium sulphate (20.5% N), mussori rock phosphate (20.0% P_2O_5) and muriate of potash (60.0% K_2O) as the inorganic sources for N, P_2O_5 and K_2O respectively.

3.2 Methods

3.2.1 Design and layout

The field experiemnt was laid out in strip plot design. The layout of the experiment is given in Fig.2.

The details of the layout are given below.

Number of treatment combinations	:	16
Number of replications	:	4
Total number of plots	:	64
Gross plot size	:	3.6m x 3.6m
Net plot size	:	3.0m x 3.0m
Spacing	:	60cm x 30cm

3.2.2 Treatments

The treatments consisted of combinations of nutrient sources and varying number of vegetable harvests.

A. Vegetable harvests

H_1 : No vegetable harvest

H_2 : 2 vegetable harvests

H_3 : 4 vegetable harvests

H_4 : 6 vegetable harvests

B. Sources of nutrient

S_1 : 12t FYM + chemical fertilisers (110: 37:73 kg N, P_2O_5, K_2O)

S_2 : 12 t FYM + 3.6 t poultry manure

S_3 : 12 t FYM + 11 t vermicompost

S_4 : 6 t FYM + chemical fertilisers (110: 37:73 kg N, P_2O_5, K_2O)

3.2.3 Treatment Combinations

T_1 :	H_1S_1	T_9 :	H_3S_1
T_2 :	H_1S_2	T_{10} :	H_3S_2
T_3 :	H_1S_3	T_{11} :	H_3S_3
T_4 :	H_1S_4	T_{12} :	H_3S_4
T_5 :	H_2S_1	T_{13} :	H_4S_1
T_6 :	H_2S_2	T_{14} :	H_4S_2
T_7 :	H_2S_3	T_{15} :	H_4S_3
T_8 :	H_2S_4	T_{16} :	H_4S_4

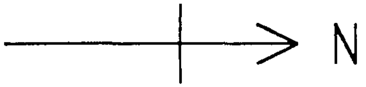
3.2.4 Field culture

3.2.4.1 Land preparation

The experimental area was first cleared of weeds and stubbles. The field was laid out into strips and plots as per the design and individual plots dug well and levelled. In the plots of 3.6m x 3.6m size, pits were taken at 60 x 30cm spacing. Each pit was half filled with a mixture of top soil and powdered FYM as per treatment before sowing.

3.2.4.2 Application of manures

FYM was applied to the plots as specified in the treatments. Half the quantity of nitrogen (55.0 kg ha^{-1}) was given basally through the different sources;



H_4S_4	H_4S_2	H_4S_3	H_4S_1	H_3S_4	H_3S_1	H_3S_3	H_3S_2	H_2S_3	H_2S_4	H_2S_2	H_2S_1	H_1S_2	H_1S_1	H_1S_3	H_1S_4
H_3S_4	H_3S_2	H_3S_3	H_3S_1	H_2S_4	H_2S_1	H_2S_3	H_2S_2	H_4S_3	H_4S_4	H_4S_2	H_4S_1	H_2S_2	H_2S_1	H_2S_3	H_2S_4
H_1S_4	H_1S_2	H_1S_3	H_1S_1	H_4S_4	H_4S_1	H_4S_3	H_4S_2	H_1S_3	H_1S_4	H_1S_2	H_1S_1	H_3S_2	H_3S_1	H_3S_3	H_3S_4
H_2S_4	H_2S_2	H_2S_3	H_2S_1	H_1S_4	H_1S_1	H_1S_3	H_1S_2	H_3S_3	H_3S_4	H_3S_2	H_3S_1	H_4S_2	H_4S_1	H_4S_3	H_4S_4

Replication 1 Replication 2 Replication 3 Replication 4

Fig. 2 Layout of the experiment

viz. ammonium sulphate (268.30 kg ha^{-1}), vermicompost (5.50 t ha^{-1}) and poultry manure (1.80 t ha^{-1}) and the remaining half 30 DAS. Full dose of phosphorus and potassium was applied basally in the plots with chemical fertiliser treatment.

3.2.4.3 Seeds and sowing

Two seeds were dibbled in each pit at a depth of 3-5 cm. Gap filling was done in a week followed by thinning two weeks later so as to retain one plant pit^{-1}

3.2.4.4. After cultivation

The crop was irrigated and weeded as and when required. Top dressing was done one month after sowing along with the intercultural operations.

3.2.4.5 **Plant Protection**

As a prophylactic measure against nematodes and petiole maggots, soil application of Furadan 3G at the time of sowing was practised. Repeated spraying of Roger against white flies and, Ekalux against shoot and fruit borers were done for getting satisfactory fruit and seed yield.

3.2.4.6 Harvesting

The crop was harvested for vegetable on alternate days from the 45th day onwards as per treatment. Harvesting for seeds commenced 75 DAS and was repeated on alternate days until the mature fruits in all plots were harvested. Stage of seed harvesting was decided by the drying and cracking of fruits along the ridges.

3.3. Observations recorded

3.3.1 **Biometric observations**

Three plants were selected after eliminating the border rows in each plot and all biometric observations were recorded from these plants at monthly intervals.

3.3.1.1. **Height of the plant**

From the observation plants the height was measured from the base to the terminal bud and the average was worked out and expressed in cm at monthly intervals.

3.3.1.2 Height of the first **bearing** node

The height of the node at which the first fruit was formed was measured from the ground level in all observation plants and their mean was worked out and expressed in cm.

3.3.1.3 Leaf Area Index (LAI)

LAI was worked out at 30 DAS and 60 DAS. Area of all the leaves produced $plant^{-1}$ was recorded using LI - 3100 leaf area meter and LAI was worked out with the formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

As the crop was left to full maturity of fruits, all leaves were shed by the 90th day after sowing making it impossible to compute LAI.

3.3.1.4 Root spread at final harvest

The observation plants were uprooted after final harvest and the lateral roots of the root system was spread over a plain paper. The length of the longest lateral root on both sides of the tap root was measured using a scale, the mean worked out and expressed in cm.

3.3.1.5 Days to 50 percent flowering

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

3.3.1.6 Setting percentage

From the total number of flowers bloomed and the number of fruits formed, setting percentage was calculated for the observational plants and the mean worked out.

3.3.2 Yield Observations

3.3.2.1 Total number of green fruits harvested plant^{-1}

From the total number of fruits harvested as vegetable from the observation plants the per plant fruit number was calculated.

3.3.2.2 Length of the fruit

The length of the fruits harvested from the observation plants in each harvest was measured, the mean worked out and expressed in cm.

3.3.2.3 Girth of the fruit

The same fruits used for measuring the length were used for finding the girth. Measurement was effected by winding a thread around individual fruits. The mean values were worked out and expressed in cm.

3.3.2.8 Total number of fruits harvested plant^{-1}

The total number of fruits harvested from the observation plants was calculated at the end of the cropping season and the mean recorded.

3.3.3 **Seed Characters**

3.3.3.1 Number of seeds fruit^{-1}

20 fruits were taken from the observation plants at random, the number of seeds were counted and the average worked out.

3.3.3.2 Weight of seeds fruit^{-1}

The fruits used to record the number of seeds fruit^{-1} were used for noting the weight of seeds fruit^{-1}.

3.3.3.3 Fruit to seed ratio

This observation was also taken from the fruits used to record the number and weight of seeds fruit^{-1}. The fruit to seed ratio of individual fruits were calculated first and the mean worked out.

3.3.3.4 1000 seed weight

100 seeds were counted at random from the observation plants and weighed. These values were multiplied by 10 to obtain the 1000 seed weight and expressed in g.

3.3.3.5 Seed yield

The total weight of seeds from the net plot area was calculated at the end of the cropping season and the yield in kg ha^{-1} computed.

3.3.3.6 Germination percentage

Pure seed fraction of the different treatments were tested for germination. Forty seeds per treatment were sown on Whatman paper in petri dishes of 9 cm size. The paper was kept moist until the final count was taken on the 21st day. The number of seeds germinated were counted on the last day and the percentage worked out.

3.3.3.7 Seed Viability

Seed viability test was done using topographical tetrazolium chloride method.

10 seeds of each treatment were pre-conditioned by soaking in water for 12h, dissected longitudinally through the embryo and then kept in 0.1% colourless tetrazolium chloride solution. Living tissues attained a red stain in tetrazolium solution indicating viability of seeds.

3.3.3.8 Seedling root length

10 seeds selected at random from each treatment were sown in germination trays with sand as the medium. The seeds were allowed to sprout with daily watering and after 10 days they were uprooted and the length of roots was measured from the collar region to the root tip. The average was worked out and recorded in cm.

3.3.3.9 Seedling shoot length

The seedlings used to measure the root length were used for this purpose also. The shoot length was measured from the collar region to the base of terminal bud, the mean worked out and expressed in cm.

3.3.3.10 Seed vigour test

The brick gravel method was adopted for seed vigour test. A layer of soil was spread on the petri dish and 10 seeds of each treatment were sown in each dish. Over this brick gravel (2-3 mm size) layer of 1 cm was placed and kept for germination. The number of seedlings that emerged through the layer of brick gravel were counted and expressed as number of vigorous seeds.

3.3.3.11 Seedling vigour

Seedling vigour index (VI) was calculated by adopting the formula suggested by Abdul - Baki and Anderson (1973) and expressed as a number.

VI = Germination % x (root length + shoot length)

The data recorded on observations 3.3.3.6, 3.3.3.8 and 3.3.3.9 were used for the purpose. The mean was calculated and expressed as seedling vigour.

3.3.3.12 **Dry matter accumulation in seedling**

The seedlings used to measure root and shoot length were dried at 105°C in an air oven for 17 $\pm$ 1 hours and the dry weight noted. The mean dry weight was worked out and expressed as g seedling^{-1}.

3.3.3.13 **Seed moisture content**

Seed samples taken at random from composite seed lots of each treatment were ground and moisture content determined by gravimetric method.

3.3.3.14 **100 seed volume**

Seed volume was found out by immersing the seeds in water and noting the rise in water level from the initial level. 100 seeds from each treatment were used for the observation and the value expressed in ml.

3.4 Chemical Analysis

3.4.1 **Seed Analysis**

3.4.1.1 Protein Analysis

Seed nitrogen was estimated by the modified micro-kjeldhal method (Jackson, 1973) and the values were expressed as percentage. The seed protein content in per cent was worked out by multiplying the seed N value by a factor 6.25 (Simpson et al, 1965).

3.4.2 **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 alkaline potassium permanganate method (Subbiah and Asija, 1956), available P_2O_5 by Bray colorimetric method (Jackson, 1973) and available K_2O by the ammonium acetate method (Jackson, 1973).

3.5 Economics of cultivation

The economics of cultivation was worked out based on the various input costs.

$$\text{Net income (Rs.ha}^{-1}\text{)} = \text{Gross income} - \text{Cost of cultivation}$$

$$\text{Benifit - cost ratio} = \frac{\text{Gross Income}}{\text{Cost of cultivation}}$$

3.6 **Statistical Analysis**

The data generated from the experiment were subjected to Analysis of Variance (ANOVA) technique as applied to strip plot design (Cochran and Cox, 1965). Correlation studies were also made.

Results

RESULTS

The results regarding the effect of vegetable harvests and nitrogen sources on the growth, seed yield and quality in bhindi are given below.

4.1 Growth characters

4.1.1 Height of the plant

The results on the mean height of the plants recorded at 30, 60 and 90 DAS are presented in Table.2.

The different treatments viz. the vegetable harvests done from 45th day after sowing and the different sources of nitrogen did not exert any significant influence on the plant height at 30 DAS.

At 60 DAS, vegetable harvesting did not influence the plant height significantly whereas the effect of the sources of nitrogen was statistically significant. The organic sources when used alone (S_2 and S_3) showed poor performance compared to the inclusion of inorganic sources in the treatments (S_1 and S_4). The maximum plant height was observed in S_4 thus showing an enhancement in the height with the reduction of FYM by

Table 2 Effect of vegetable harvests and nitrogen sources on height of the plant.

Treatments	30 DAS	60 DAS	90 DAS
Harvests			
H_1	25.20	67.59	103.2
H_2	23.71	62.88	101.88
H_3	23.01	63.47	92.32
H_4	23.69	80.63	117.76
$F_{(3,9)}$	1.12^{ns}	3.22^{ns}	6.95^{*}
SE	1.22	6.51	5.63
CD	-	-	12.74
Sources			
S_1	25.25	74.34	111.76
S_2	23.06	63.50	95.87
S_3	20.98	56.22	90.20
S_4	26.32	80.50	117.42
$F_{(3,9)}$	3.24^{ns}	6.3^{*}	5.62^{*}
SE	1.86	6.12	7.67
CD	-	13.84	17.34

ns not significant
* significant at 5% level

6 t ha^{-1}. Poultry manure performed almost similar to S_1. However vermicompost applied plants resulted in lower plant height compared to the use of inorganic sources but was on par with S_2.

Plant height at 90 DAS varied significantly with both the treatments. Maximum number of vegetable harvests (H_4) recorded the highest value of 117.76 cm and was significantly superior to four (H_3), two (H_2) and zero (H_1) vegetable harvests which were on par with each other.

Sources of nitrogen showed almost the same trend as observed with 60 DAS with 12 t FYM + chemical fertilisers (S_1) being on par with 6 t FYM + chemical fertilisers (S_4). Shortest plants were observed in vermicompost treatment.

The interaction HxS was not significant.

4.1.2 Leaf area index

The leaf area index recorded at 30 and 60 DAS are presented in Table.3.

LAI did not show significant variation with vegetable harvests done from 45th day after sowing.

Table 3 Effect of vegetable harvests and nitrogen sources on LAI.

Treatments	30 DAS	60 DAS
Harvests		
H_1	0.433	0.863
H_2	0.559	1.249
H_3	0.472	1.074
H_4	0.579	1.191
$F_{(3,9)}$	2.470^{ns}	1.806^{ns}
SE	0.070	0.180
CD	-	-
Sources		
S_1	0.534	1.226
S_2	0.414	0.830
S_3	0.412	0.988
S_4	0.664	1.330
$F_{(3,9)}$	4.460^{*}	5.680^{*}
SE	0.080	0.130
CD	0.182	0.305

ns not significant
* significant at 5% level

4.1.4 Root spread at final harvest

The data on the root spread recroded at the final harvest stage are given in Table.4.

There was no appreciable variation in the spread of roots due to vegetable harvests.

The influence of the sources of nitrogen was statistically significant. 6 t FYM with fertilisers (S_4) gave the highest value of 44.05 cm and the use of chemical fertilisers or poultry manure along with 12 t FYM as sources produced more on less the same root spread.

The interaction HxS was not significant.

4.1.5 Days to 50 per cent flowering

The mean number of days taken for 50 per cent flowering are given in Table.4.

This was not significantly influenced by any of treatments tried.

Table 4. Growth characters of bhindi as influenced by vegetable harvests nitrogen sources.

Treatments	Height of the first bearing node cm	Root spread at final harvest cm	Days to 50% flowering	Setting
Harvests				
H_1	18.79	38.20	39.81	46.47
H_2	18.46	36.83	40.06	43.60
H_3	17.84	39.22	39.75	41.57
H_4	18.38	42.13	39.69	44.51
$F_{(3,9)}$	0.67^{ns}	2.33^{ns}	3.83^{ns}	2.70^{ns}
SE	0.68	2.08	0.12	1.75
Sources				
S_1	19.14	39.44	39.75	49.85
S_2	18.66	38.91	40.13	39.68
S_3	17.03	33.99	40.00	36.14
S_4	18.65	44.05	39.34	50.50
$F_{(3,9)}$	1.65^{ns}	4.11^{*}	0.30^{ns}	55.10^{*}
SE	1.02	2.87	0.78	1.38
CD	-	5.57	-	3.12

** significant at 1% level
* significant at 5% level
ns not significant

4.1.6 Setting percentage

The data on the setting percentage of plants are presented in Table.4.

The setting percentage was not influenced by vegetable harvests but the different sources of nitrogen showed significant influence. A reduction in FYM to half the recommended dose (S_4) resulted in a slight improvement in setting percentage compared to the full dose of 12 t ha^{-1} (S_1). S_4 was significantly superior to S_2 and S_3 and the lowest value of 36.14% was recorded with vermicompost application (S_3).

4.2 Yield observations

4.2.1 Number of green fruits harvested $plant^{-1}$

The mean number of green fruits harvested $plant^{-1}$ are presented in Table.5.

The number of green fruits harvested varied significantly with vegetable harvests, the maximum number being with six vegetable harvests (H_4) and this was significantly superior to all other vegetable harvest treatments.

The sources of nitrogen and the interaction HxS were found to be not significant.

4.2.2 Length and girth of green fruits

The mean length and girth of fruits are given in Table.5.

It is evident from the table that neither the length nor the girth of fruits varied significantly with vegetable harvest and sources of nitrogen. The interaction effect of HxS was also not significant.

4.2.3 Weight of green fruits plant^{-1}

The mean weight of green fruits plant^{-1} are furnished in Table.5.

Vegetable harvesting showed significant influence on the weight of green fruits plant^{-1}. There was a significant increase in the weight of green fruits with increase in the number of vegetable harvests and H_4 recorded the maximum of 255.44 g plant^{-1} .

The effect of sources of nitrogen and interaction were not significant.

Table 5 Green fruit yield and yield attributes as influenced by vegetab[illegible] harvests and nitrogen sources.

Treatments	Length of fruit	Girth of fruit	No. of green fruits $plant^{-1}$	Weight of green fruit $plant^{-1}$	Green fruit yield
	cm			g $plant^{-1}$	kg ha^{-1}
Harvests					
H_1	-	-	-	-	-
H_2	19.00	5.60	3.44	107.97	2131.70
H_3	18.68	5.63	5.59	179.84	3245.61
H_4	18.17	5.68	8.00	255.44	4446.03
$F_{(2,6)}$	0.54^{ns}	0.19^{ns}	108.86^{**}	31.68^{**}	13.98^{**}
SE	0.39	0.06	0.15	8.82	208.42
CD	-	-	0.76	45.34	1071.27
Sources					
S_1	18.85	5.60	5.92	195.00	3997.43
S_2	18.32	5.60	5.67	174.75	3001.13
S_3	17.91	5.57	5.33	158.33	2848.70
S_4	19.38	5.76	5.79	196.25	3250.53
$F_{(3,9)}$	1.44^{ns}	1.19^{ns}	1.37^{ns}	1.80^{ns}	4.01^{*}
SE	0.75	0.11	0.31	19.07	360.34
CD	-	-	-	-	814.40

ns not significant
* significant at 5% level
** significant at 1% level

4.1.4 Green fruit yield

The average green fruit yield are presented in Table.5.

Significant increase in the yield of green fruits with increase in the number of vegetable harvests was observed. Six vegetable harvests gave the highest fruit yield of 4446.03 kg ha^{-1} followed by four and two harvests.

Green fruit yield varied significantly with the sources of nitrogen also. High yields were obtained in treatments which included inorganic sources (S_1 and S_2) with S_1 (12 t FYM + chemical fertilisers) recording the highest value, 3997.43 kg ha^{-1}. Organic sources of poultry manure and vermicompost when used with 12 t FYM gave comparitively lower yields and vermicompost treatment showed poorest performance.

The interaction HxS was not significant.

4.2.5 Weight of mature fruits $plant^{-1}$

The mean weight of mature fruits $plant^{-1}$ are presented in Table.6.

Table 6. Effect of vegetable harvests and nitrogen sources on weight of mature fruits $plant^{-1}$, mature fruit yield, total number of fruits $plant^{-1}$, fruit to seed ratio and seed yield.

Treatments	Weight of mature fruits plant ($g\ plant^{-1}$)	Mature fruit yield ($kg\ ha^{-1}$)	Total no.of fruits $plant^{-1}$	Fruit to seed ratio	Seed yield ($kg\ ha^{-1}$)
Harvests					
H_1	35.76	868.64	6.57	1.92	453.85
H_2	23.20	617.02	7.40	1.90	341.99
H_3	19.90	540.88	10.37	1.87	289.86
H_4	16.24	400.25	11.78	1.88	207.26
$F_{(3,9)}$	21.28^{**}	6.47^{*}	23.02^{**}	0.49^{ns}	7.02^{**}
SE	2.47	109.17	0.72	0.05	55.10
CD	5.58	246.95	1.63	-	124.64
Sources					
S_1	27.71	765.05	9.31	1.97	390.85
S_2	19.86	481.14	8.41	1.87	264.74
S_3	20.22	488.62	8.92	1.90	268.41
S_4	27.30	691.98	9.42	1.83	368.96
$F_{(3,9)}$	6.48^{**}	10.47^{**}	0.61^{ns}	1.35^{ns}	8.65^{**}
SE	2.46	62.86	0.85	0.07	31.76
CD	5.57	142.19	-	-	71.85

ns not significant
* significant at 5% level
** significant at 1% level

Table 6a Combined effect of vegetable harvests and nitrogen sources on the weight of mature fruits plant^{-1}

Sources / Harvests	S_1	S_2	S_3	S_4	Mean
H_1	47.39	24.96	30.16	40.56	35.76
H_2	24.98	21.84	19.43	26.53	23.20
H_3	21.50	17.01	17.20	23.91	19.9
H_4	16.98	15.65	14.10	18.21	16.24
Mean	27.71	19.86	20.22	27.3	

$F_{(9,27)}$ 3.09*

SE 3.05

CD 6.89

* significant at 5% level.

Vegetable harvests, sources of nitrogen and their interaction were found to influence the weight of mature fruits plant^{-1} significantly.

As the number of vegetable harvests increased the weight of mature fruits plant^{-1} showed a decreasing trend. The highest value of 35.76 g plant^{-1} was recorded by zero vegetable harvest and the lowest of 16.74 g plant^{-1} by six vegetable harvests.

Among the sources, S_1 and S_4 which included inorganic sources were on par and significantly superior to the use of organic sources alone, S_2 and S_3, but these in turn produced no significant difference in the weight of mature fruits plant^{-1}.

Plants in which no vegetable harvest was done, S_1 (12 t FYM + chemical fertilisers) gave the highest yield plant^{-1} and was significantly higher than S_2 and S_3 in which organic sources alone were used.

When two vegetable harvests were done, 6 t FYM with chemical fertilisers recorded the highest value, which was on par with S_1 and S_2 but significantly superior to S_3.

Plants in which four and six vegetable harvests were done, there was no significant variation in the weight of mature fruits plant^{-1} whatever the source of nitrogen used.

4.2.6 Mature fruit yield

The mean yield of mature fruits are presented in Table.6.

The same trend as observed for the weight of mature fruits plant^{-1} was recorded for the mature fruit yield ha^{-1} also. The vegetable harvests and sources of nitrogen produced significant influence but the interaction HxS was not significant.

4.2.7 Total number of fruits plant^{-1}

The mean number of fruits produced plant^{-1} are given in Table.6.

Significant increase in the number of fruits plant^{-1} was observed with increase in the number of vegetable harvests. Six vegetable harvests produced a mean of 11.78 fruits plant^{-1} whereas zero vegetable harvest produced only 6.57 fruits plant^{-1}. No green fruit picking and two pickings were on par. Similarly four and six vegetable harvests were on par but significantly superior to the other two.

Neither the sources of nitrogen nor the interaction HxS had any significant effect.

4.3 Seed Characters

4.3.1 Number of seeds fruit^{-1}

The mean number of seeds fruit^{-1} are presented in Table.7.

The number of seeds fruit^{-1} was not found to be significantly influenced either by the vegetable harvests or by the sources of nitrogen.

The interaction HxS was also not significant.

4.3.2 Weight of seeds fruit^{-1}

The mean weight of seeds fruit are given in Table.7.

Table 7 Effect of vegetable harvests and nitrogen sources on the number, weight of seeds $fruit^{-1}$ and 1000 seed weight.

Treatments	No. of seeds $fruit^{-1}$	Weight of seeds $fruit^{-1}$ g	1000 seed weight g
Harvests			
H_1	59.95	2.97	50.18
H_2	60.58	3.19	54.15
H_3	56.33	2.26	41.52
H_4	57.69	2.47	43.70
$F_{(3,9)}$	0.95^{ns}	13.18^{**}	3.74^{ns}
SE	2.86	0.17	4.26
CD	-	0.38	-
Sources			
S_1	55.55	2.88	52.68
S_2	63.91	2.68	42.37
S_3	58.10	2.29	39.60
S_4	57.01	3.07	54.89
$F_{(3,9)}$	3.58^{ns}	13.86^{**}	10.19^{**}
SE	2.74	0.13	3.34
CD	-	0.29	7.55

ns not significant
** significant at 1% level

The weight of seeds fruit^{-1} showed significant variation with number of vegetable harvests. The maximum weight of 3.19 g was recorded with two vegetable harvests (H_2) which was on par with no vegetable harvest (H_1) and significantly superior to four (H_3) and six (H_4) vegetable harvests.

The sources of nitrogen also significantly influenced the weight of seeds fruit^{-1}, the maximum being with S_4 (3.07 g) which was on par with S_1 and significantly superior to organic manure alone treated plants (S_2 and S_3).

The interaction HxS was non significant.

4.3.3 **Fruit to seed ratio**

The data on the mean fruit to seed ratio are presented in Table.6.

Neither the vegetable harvests nor the sources of nitrogen showed any significant variation in the fruit to seed ratio. The interaction HxS was also not significant.

4.3.4 1000 seed weight

The mean of 1000 seed weight are presented in Table.7.

The effect of vegetable harvests on 1000 seed weight was not significant. However two vegetable harvests recorded the highest value (54.15 g).

The sources of nitrogen significantly influenced 1000 seed weight. 6 t FYM + chemical fertiliser gave the highest weight of 1000 seeds but was on par with 12 t FYM + chemical fertilisers and significantly superior to the use of FYM with poultry manure or with vermicompost.

The interaction HxS was not significant.

4.3.5 **Seed yield**

The mean seed yield data are given in Table.6.

The influence of vegetable harvests on seed yield was statistically significant. Seed yield decreased with increase in number of vegetable harvests and the maximum yield of 453.85 ha^{-1} was observed with zero vegetable harvests which was on par with two harvests but significantly superior to the other treatments.

The seed yield varied significantly with the sources of nitrogen also. S_1 (12 t FYM + chemical fertilisers) recorded the maximum yield of 390.85 kg ha^{-1} and was on par with that of S_4 (6 t FYM + chemical fertilisers). The organic sources when used alone gave significantly lower yields, but were on par with each other.

The interaction effect of HxS on seed yield was not significant.

4.3.6 Germination percentage

Table 8. gives the mean germination percentage of seeds.

Germination percentage showed no significant variation either due to the different number of vegetable harvests or due to the sources of nitrogen. The interaction effect of HxS was also not significant.

Table 8. Effect of vegetable harvests and nitrogen sources on seed seedling characters.

Treatment	Germination %	Seedling root length cm	Seedling shoot length cm	Vigour inde
Harvests				
H_1	95.99	5.54	15.38	1926.26
H_2	94.92	6.13	16.55	2115.73
H_3	91.30	4.85	13.82	1684.20
H_4	94.02	5.71	16.77	2053.48
$F_{(3,9)}$	2.40^{ns}	6.05^{*}	5.28^{*}	7.57^{**}
SE	2.17	0.31	0.83	98.10
CD	-	0.69	1.88	221.90
Sources				
S_1	96.44	5.58	14.95	1897.67
S_2	92.69	5.39	15.96	1933.50
S_3	94.84	5.68	16.61	2076.19
S_4	92.24	5.57	15.00	1872.32
$F_{(3,9)}$	0.97^{ns}	0.20^{ns}	1.65^{ns}	1.01^{ns}
SE	3.53	0.38	0.89	128.36
CD	-	-	-	-

** significant at 1% level
* significant at 5% level
ns not significant

4.3.7 Seed viability

The viability of seeds was tested one month after harvest. All the treatments showed 100 per cent viability at this stage of the seed.

4.3.8 Seedling root length

The average seedling root length are presented in Table 8.

The different vegetable harvests had significant effect on seedling root length. The root length was maximum in two vegetable harvests (6.13 cm) but it was significantly superior to four vegetable harvests (4.85 cm).

The sources of nitrogen showed no significant influence on root length.

The interaction HxS was significant. In zero, two and six vegetable harvests, the influence of the different sources was not significant whereas when four vegetable harvests were done, 6 t FYM + fertilisers recorded a lower value compared to use of 12 t FYM + fertilisers.

Table 8a Combined effect of vegetable harvests and nitrogen sources on the seedling root length.

Sources / Harvests	S_1	S_2	S_3	S_4	Mean
H_1	5.55	3.06	5.27	6.27	5.53
H_2	5.22	5.86	6.92	6.51	6.13
H_3	5.57	4.76	4.98	4.11	4.85
H_4	5.99	5.89	5.56	5.41	5.71
Mean	5.58	5.39	5.68	5.57	

$F_{(9,27)}$ 2.83*

SE 0.49
CD 1.10
* significant at 5% level

4.3.9 Seedling shoot length

Table 8. gives the mean seedling shoot length

Seedling shoot length varied significantly with the number of vegetable harvests. Six, two and zero vegetable harvests produced almost similar results but four vegetable harvests was significantly inferior.

Sources of nitrogen and interaction HxS had no significant influence.

4.3.10 Seed vigour

The mean number of vigorous seeds are furnished in Table. 9.

The seed vigour was not significantly influenced by the vegetable harvests.

Among the sources, 12 t FYM + vermicompost gave significantly superior number of vigorous seeds while other treatements were on par with each other.

The effect of interaction HxS was non significant.

Table 9. Effect of vegetable harvests and nitrogen sources on dry matter accumulation in seedlings and seed vigour.

Treatments	Dry matter accumulation g	Seed vigour no.
Harvests		
H_1	0.044	8.25
H_2	0.050	7.81
H_3	0.036	7.81
H_4	0.055	8.00
$F_{(3,9)}$	4.300^{*}	0.76^{ns}
SE	0.006	0.34
CD	0.012	-
Sources		
S_1	0.045	7.75
S_2	0.048	7.94
S_3	0.050	8.56
S_4	0.042	7.63
$F_{(3,9)}$	4.12^{*}	5.05^{*}
SE	0.003	0.26
CD	0.006	-

ns not significant
* significant at 5% level

4.3.11 Seedling vigour

The vigour index of seedlings are given in Table.8

The number of vegetable harvests exerted significant influence on the vigour index and the trend observed was same as in the seedling root and shoot length. Six, two and zero vegetable harvests were statistically on par but four vegetable harvests showed significantly lower value.

The effect of sources of nitrogen and interaction HxS were non significant.

4.3.12 Dry matter accumulation in seedling

The data on the dry matter accumulation in seedlings are given in Table 9.

The dry matter of seedlings was significantly low in four vegetable harvests compared to two and six vegetable harvests but on par with zero vegetable harvest. Zero,two and six vegetable harvests did not cause appreciable variation in the seedling dry matter.

As observed with seedling root and shoot length 12 t FYM + vermicompost proved to be the superior source in comparison to other sources which showed almost similar values.

Interaction effect of HxS was not significant.

4.3.13 Seed moisture content

Table 10. gives the average seed moisture content.

Seed moisture content did not show significant variation with vegetable harvests but the sources of nitrogen exerted significant influence. Inclusion of chemical fertilisers increased moisture content of seeds and was significantly higher than when organic sources alone were used. S_1 gave higher value but was on par with S_4.

The interaction HxS was observed to be not significant.

4.3.14 100 seed volume

Table 10. depicts the effect of vegetable harvests and nitrogen sources on 100 seed volume.

Table 10 Influence of vegetable harvests and nitrogen sources on seed parameters.

Treatments	100 seed volume ml	Seed moisture %	Seed protein %
Harvests			
H_1	5.49	12.12	15.15
H_2	6.02	11.94	14.83
H_3	4.64	11.93	14.46
H_4	5.03	12.08	14.62
$F_{(3,9)}$	2.52^{ns}	0.28^{ns}	0.30^{ns}
SE	0.53	0.25	0.77
CD	-	-	-
Sources			
S_1	5.95	12.46	15.89
S_2	4.58	11.56	13.68
S_3	4.40	11.81	13.41
S_4	6.25	12.35	16.09
$F_{(3,9)}$	9.17^{**}	37.39^{**}	3.64^{ns}
SE	0.44	0.13	1.05
CD	1.00	0.29	-

ns not significant
** significant at 1% level

Though the effect of vegetable harvests was non significant, the sources of nitrogen produced remarkable variation in 100 seed volume. The treatments in which organic manures alone were used (S_2 and S_3) showed significantly lower values compared to inclusion of inorganic manures in the treatment (S_1 and S_4).

The interaction HxS also was not significant.

4.4 Seed nitrogen content

4.4.1 Seed protein

The mean seed protein content are given in Table. 10.

It is evident from the data that vegetable harvests and sources of nitrogen produced no significant difference in the seed protein content.

4.5 Soil nutrient status after the experiment

4.5.1 Available nitrogen

Table 11. gives the mean content of nitrogen in soil after the experiment.

The available nitrogen status of the soil after the experiment was not significantly influenced by the vegetable harvests but influenced by the sources of nitrogen. 12 t FYM + vermicompost (S_3) showed the highest nitrogen status (400.02 kg ha^{-1}) and this was significantly superior to all other sources. 12 t FYM + poultry manure (S_2) and 6 t FYM + chemical fertiliser (S_4) were on par and S_4 was on par with S_1 (12 t FYM + chemical fertiliser) which recorded the lowest value (325.41 kg ha^{-1})

The interaction effect of HxS was not significant.

4.5.2 Available phosphorus

The available phosphorus status in soil after the experiment are given in Table 11.

Vegetable harvests showed a significant influence on the soil P_2O_5 status after the experiment with four vegetable harvests (H_3) recording the highest value and significantly superior to the other treatments. Zero, two, six vegetable harvests were on par.

Table 11. Effect of vegetable harvests and nitrogen sources on soil nutrient status.

Treatments	Available N kg ha^{-1}	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}
Harvests			
H_1	368.48	92.26	27.22
H_2	367.40	85.54	30.66
H_3	355.60	116.05	29.94
H_4	344.31	84.04	31.82
$F_{(3,9)}$	2.72^{ns}	4.46^{*}	0.93^{ns}
SE	9.74	9.92	2.86
CD	-	22.44	-
Sources			
S_1	325.41	77.54	27.36
S_2	359.58	91.27	32.72
S_3	400.02	107.46	36.73
S_4	350.84	101.62	22.83
$F_{(3,9)}$	14.04^{**}	3.31^{ns}	36.09^{**}
SE	11.69	10.19	1.43
CD	26.44	-	3.24

ns - not significant
* - significant at 5% level
** - significant at 1% level

Table 11a Combined effect of vegetable harvests and nitrogen sources on the soil available potassium status.

Sources / Harvests	S_1	S_2	S_3	S_4	Mean
H_1	27.33	31.02	33.79	16.75	27.22
H_2	27.61	35.60	36.16	23.26	30.66
H_3	27.15	30.93	34.72	26.97	29.94
H_4	27.36	33.33	42.25	24.33	31.82
Mean	27.36	32.72	36.73	22.83	

$F_{(9,27)}$ 2.90^*

SE 2.09
CD 4.73
* significant at 5% level

Sources of nitrogen and interaction HxS did not cause any significant variation though among the sources 12 t FYM + vermicompost (S_3) showed maximum content of available P_2O_5 after the experiment.

4.5.3 Available potassium

The available potassium content of soil after the experiment are presented in Table.11.

Vegetable harvests showed no significant influence on the available K_2O status of soil after the experiment but it varied significantly with sources of nitrogen applied. 12 t FYM + vermicompost (S_3) recorded significantly higher K_2O value than other sources and each showed significant variation with the other.

The interaction HxS was also significant. When zero, two, four and six vegetable harvests were done vermicompost treated plots showed higher values for the available K_2O content in soil whereas 6 t FYM + chemical fertilisers gave the lowest value.

4.6 Economics of cultivation

4.6.1 Net income

The net income obtained are shown in Table.12.

Though a decrease in income was observed with the

Table 12. **Economics of cultivation**

Treatment	Cost of cultivation Rs.	Gross Income Rs.	Net Income Rs.	B.C ratio
Harvests				
H_1	29899.25	68077.50	38434.50	2.52
H_2	29797.00	61957.00	32196.96	2.32
H_3	28466.75	59707.05	30865.00	2.15
H_4	29447.00	53318.12	23933.62	1.97
$F_{(3,9)}$			0.73^{ns}	0.86^{ns}
SE			9814.14	0.36
Sources				
S_1	25483.13	78614.65	48389.33	2.92
S_2	25608.13	54716.65	25131.84	1.98
S_3	43820.00	54505.00	7840.41	1.19
S_4	23464.00	71596.65	44068.83	2.88
$F_{(3,9)}$			18.05^{**}	29.60^{**}
SE			6207.67	0.21

** significant at 1% level
ns not significant

Cost of 1 t FYM - Rs. 340.00
Cost of 1 t poultry manure - Rs. 1000.00
Cost of 1 t vermicompost - Rs. 2000.00
Cost of 1 kg ammonium sulphate - Rs. 4.60
Cost of 1 kg mussoriphos - Rs. 2.25
Cost of 1 kg muriate of potash - Rs. 3.50

increase in the number of vegetable harvests, the decline was not statistically significant.

The sources of nitrogen significantly influenced the net income. The greatest profit was obtained with 12 t FYM + chemical fertilisers (S_1) followed by 6 t FYM + chemical fertilisers (S_4). Vermicompost was significantly inferior.

HxS interaction was not significant.

4.6.2 Benefit cost ratio

The variation in the benefit cost ratio with different vegetable harvests and nitrogen sources are given in Table.12.

As in the case of net income, benefit cost ratio was not significantly influenced by the number of vegetable harvests but a decreasing trend was observed with increase in the number of vegetable harvests.

Among the sources 12 t FYM + chemical fertilisers (S_1) gave the highest ratio but was statistcally on par with 12 t FYM applied in combination with poultry manure and 6 t FYM with chemical fertilisers but significantly higher than 12 t FYM + vermicompost.

Table 13. Values of simple correlation coefficients.

Sl. No.	Character correlated	Correlation coefficients
1.	Seed yield x Height of plant 90 DAS	0.142
2.	Seed yield x LAI	0.072
3.	Seed yield x Root spread	0.088
4.	Seed yield x Height of first bearing node	0.451
5.	Seed yield x weight of mature fruits $plant^{-1}$	0.953^{**}
6.	Seed yield x Mature fruit yield	0.982^{**}
7.	Seed yield x Number of seeds $fruit^{-1}$	0.099
8.	Seed yield x Weight of seeds $fruit^{-1}$	0.669
9.	Seed yield x Fruit to seed ratio	0.329
10.	Seed yield x 1000 seed weight	0.725^{*}
11.	Seed yield x 100 seed volume	0.660
12.	1000 seed weight x protein	0.864^{**}
13.	1000 seed weight x moisture content	0.725^{*}
14.	1000 seed weight x vigour index	0.078
15.	1000 seed weight x germination	0.341
16.	1000 seed weight x 100 seed volume	0.990^{**}

The interaction effect of HxS did not significantly influence the benefit cost ratio.

Correlation Studies

Simple correlation studies were undertaken with a view to elucidate the relationship of various growth and yield attributing characters and yield. The correlation coefficients of seed yield with the characters of height of the plant, LAI, root spread, height of first bearing node, weight of mature fruits plant^{-1}, mature fruit yield, number and weight of seeds fruit^{-1}, fruit seed ratio, 1000 seed weight and 100 seed volume were positive with weight of mature fruits plant^{-1} and mature fruit yield being statistically significant. Among the seed characters, protein, moisture content, vigour index, germination and 100 seed volume were positively correlated with 1000 seed weight.

Discussion

DISCUSSION

The results of the present study showed wide variation in fruit and seed yield of bhindi. The seed quality measured in terms of number and weight of seeds $fruit^{-1}$, 1000 seed weight, 100 seed volume, seedling root and shoot length, vigour index and seed vigour were also found to vary appreciably due to vegetable harvests and different sources of nitrogen.

Effect of vegetable harvests on the yield of fruits and seeds

The total number of fruits produced $plant^{-1}$ in bhindi increased with increase in the number of vegetable harvests as observed from the data (Table 6). This is in accordance with the works of Perkins et al. (1952), Madhava Rao (1953), Khalil and Hamid (1964), Kolhe and Chavan (1967) and Grewal et al. (1974) in bhindi. The treatment having six vegetable harvests produced maximum number of fruits $plant^{-1}$(11.58). It was nearly twice as that produced by plants without vegetable harvests,ie. in which all the fruits were left to mature for seed. Due to the constant harvesting of fruits from the plant, the translocation of food materials to the growing point was better and this resulted in enhanced flower bud formation and fruit production as compared to no vegetable harvest treatment. (Grewal et al., 1974).

The green fruit number (Fig. 3) and also the weight of green fruits plant^{-1} were maximum with six vegetable harvests, but the corrresponding difference in length and girth of the fruits was not at all significant. Hence it can be concluded that the increased weight of fruits plant^{-1} was actually contributed by the increased number of green fruits and not by the size of fruits. Slight improvement in the length of fruits was observed in two vegetable harvests (19.0 cm) as compared to four and six vegetable harvests (18.68 and 18.17 cm respectively). Similar results have been reported by Grewal et al. (1974) and Tyagi and Khandelwal (1985). It is an approved fact that when plants enter the reproductive phase they show more potentiality, which results in the production of larger fruits as compared to the subsequent pickings. In two vegetable harvest treatments, harvests were carried out on the early formed fruits which were comparitively larger. The reduction in length in four and six vegetable harvests treatments might be due to the effect of averaging the length of fruits obtained

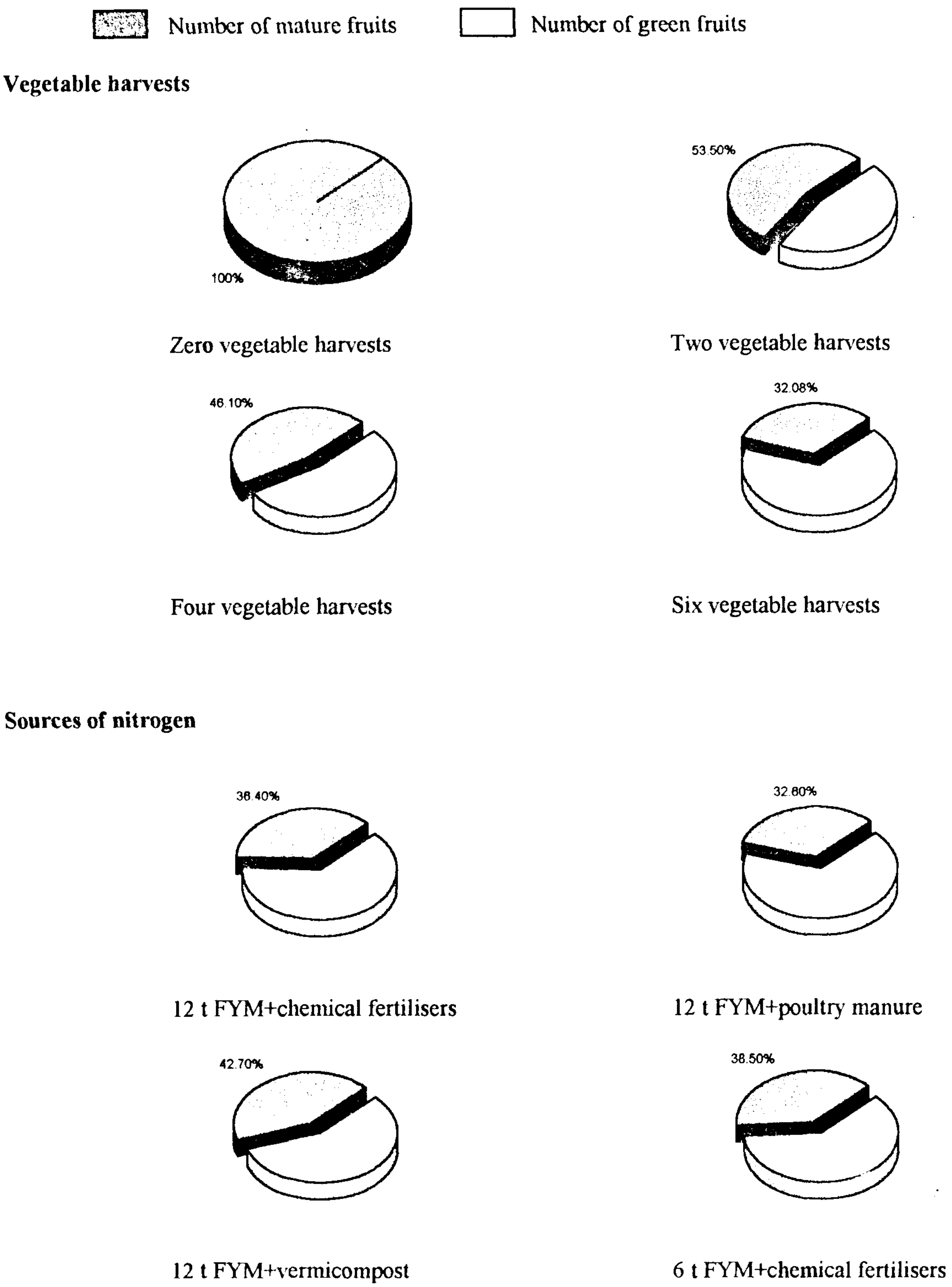


Fig.3 Variation in the number of fruits left to mature for seed due to the different treatments

in all four and six vegetable harvests which included the late formed smaller fruits also.

As in the case of green fruit number and weight plant^{-1}, green fruit yield was also maximum for six vegetable harvests (Fig.5). For this treatment about 45 quintals of fruits were obtained which is mainly on account of the increased number of vegetable harvests done. Six vegetable harvests showed nearly 52 and 27 per cent increase in yield over two and four vegetable harvests respectively. The lower number and weight of green fruits plant^{-1} coupled with lesser number of vegetable harvests resulted in the lower green fruit yield in two and four vegetable harvest treatments. The increase in green fruit yield with increase in vegetable harvests was also reported by Madhava Rao (1953) and Bhuibar et al. (1989).

The higher vegetable yield recorded by the treatment involving six vegetable harvests may also probably be the reflection of the better growth expressed by it as observed from the data (Tables. 2, 3 and 4).

Though there was no significant difference in most of the growth parameters, the plants were the

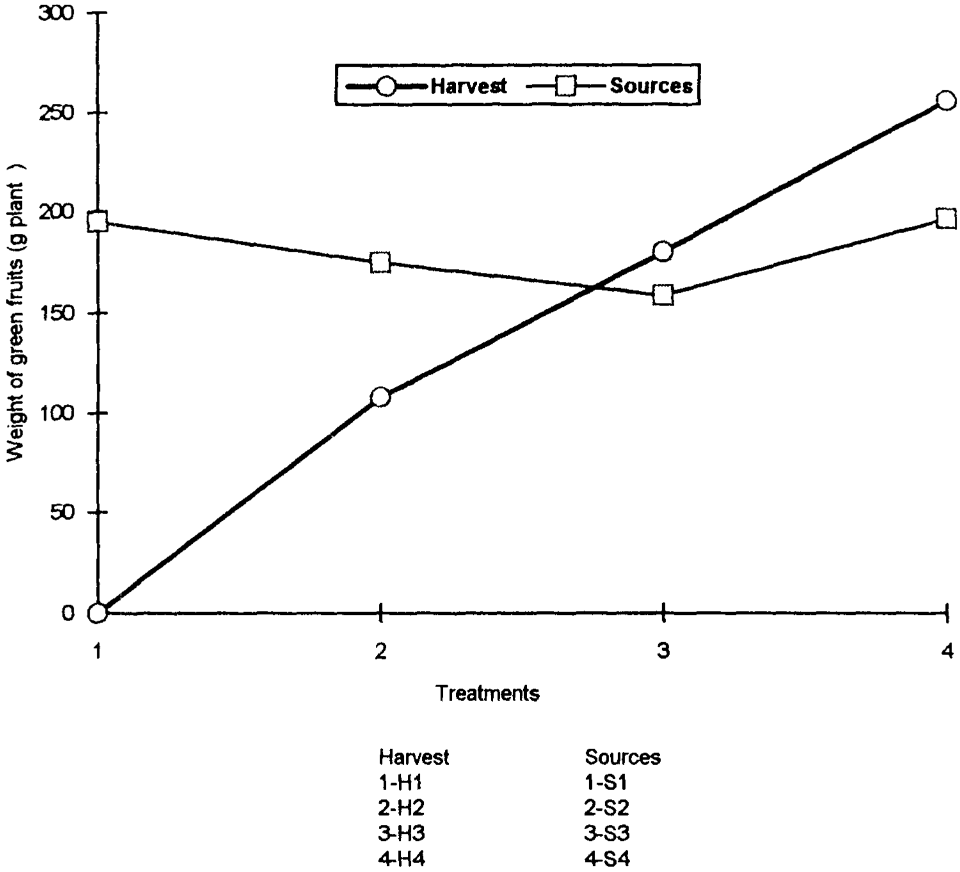
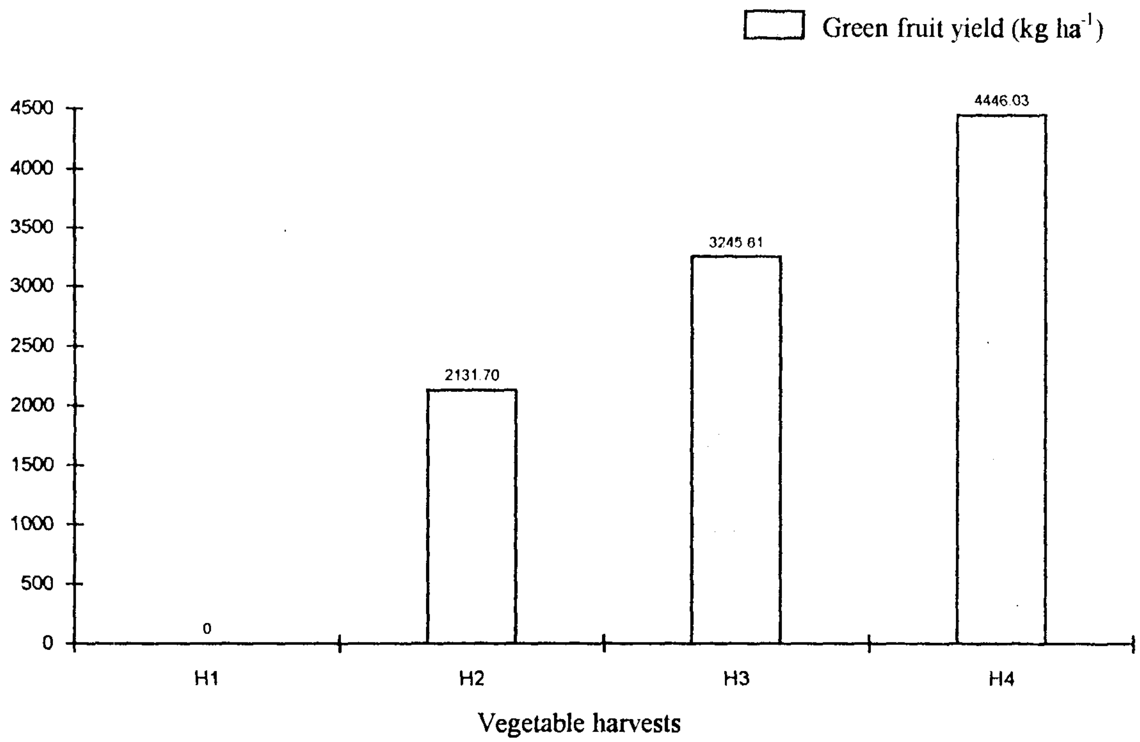


Fig.4 Variation in the weight of green fruits plant^{-1} due to vegetable harvests and sources of nitrogen.

tallest for six vegetable harvests (Fig. 6) with maximum root spread which ensured better absorption of nutrients. The increased plant height may be mainly due to the stimulation of the apical growth of plants with periodic removal of fruits. The photosynthates got translocated to the growing tips rather than accumulating in the developing fruits. Garris and Hoffmann (1946) reported that plant height is checked if the oldest pods are not removed often.

An appraisal of the data on LAI revealed that at 60 DAS LAI was less than 1 for zero vegetable harvests whereas it was more than 1 in all other treatments. This is probably due to the positive influence of periodic removal of fruits which promoted the production of more photosynthetic area. Peat (1986) had reported that the assimilate supply plays a major role in the formation of sink and thus the potential yields. Defoliation results in extreme limitation of source and subsequent availability of carbohydrates to the sink and thereby reducing yields. Similarly an inverse relationship with the removal of sink encouraging vegetative growth and thus higher leaf production may also exist. Bhuibar et al. (1989) observed production of more number of leaves with periodical picking of green fruits as this gave plants



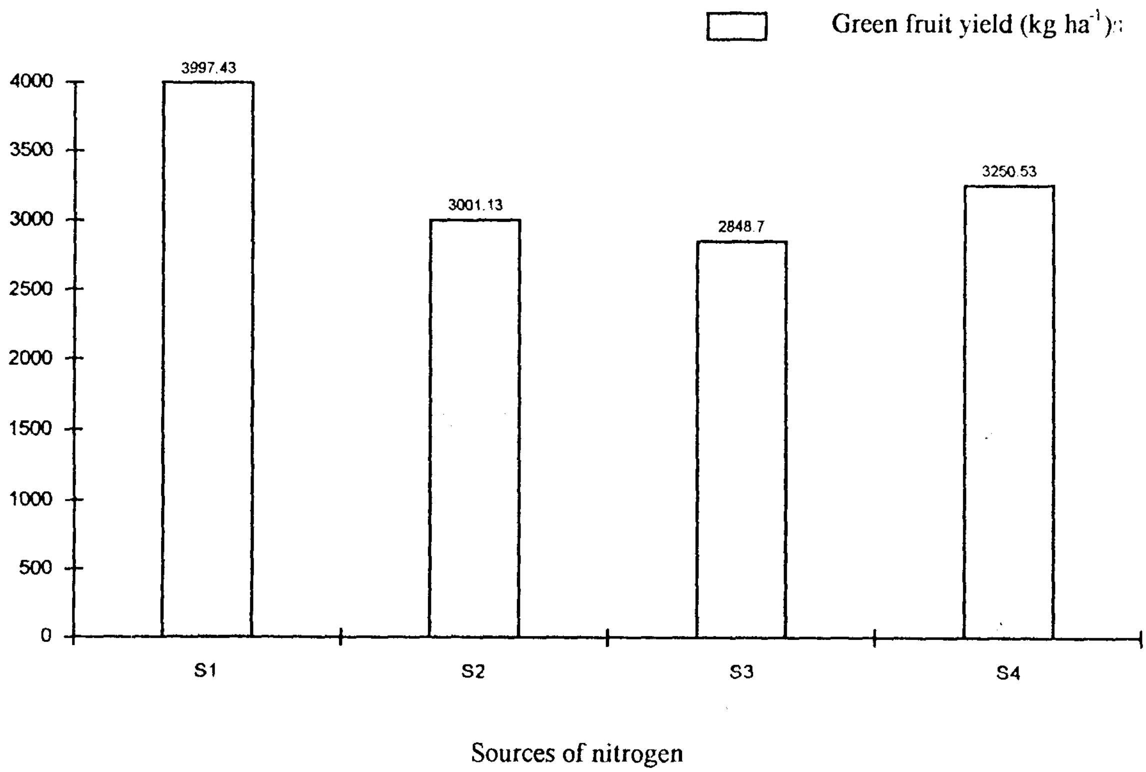


Fig.5 Effect of vegetable harvets and nitrogen sources on green fruit yield

more time for vegetative development in early stage. Enhanced LAI with six vegetable harvests could be due to the increased plant height which promoted the development of more nodes and thus more leaves as reported by Sajitharani (1993).

There exists a positive correlation between the plant height and fruit yield on account of the higher number of fruiting nodes in taller plants. The height of the first bearing node is also correlated to yield as observed from the data (Table.13). Thus, though plants with four vegetable harvests (H_3) were short in stature, they were able to keep the trend in yield due to the production of fruits from the lower nodes as compared to other treatments.

Days to 50 per cent flowering and setting percentage did not vary significantly with the different number of vegetable harvests as evident from the data (Table.4).

As in the case of green fruit yield, seed production in bhindi also was significantly influenced by vegetable harvests.

Seed yield in bhindi was significantly high when all fruits were left to mature for seed (Fig.7). This was on par with two vegetable harvests and significantly superior to four and six vegetable harvests. The highest seed yield with zero vegetable harvests is due to the highest number of fruits left to mature for seed and it is in confirmity with the results of Velumani and Ramaswamy (1980), Tyagi and Khandelwal (1985) and Bhuibar et al.(1989). The data on the seed yield attributes viz. weight of mature fruits plant^{-1}, mature fruit yield ha^{-1}, number and weight of seeds fruit^{-1}, 1000 seed weight and 100 seed volume indicated that the corresponding values were highest for zero and two vegetable harvests.

The weight of mature fruits plant^{-1} and mature fruit yield ha^{-1} were significantly superior for zero vegetable harvest (H_1) followed by two, four and six vegetable harvests. Progressive decrease in mean weight of mature fruits with increase in number of fruits harvested for vegetable was observed by Shanmughasundaram (1950). Kolhe and Chavan (1967) reported that the weight of fruit is directly dependent on the length and thickness of fruit. Early formed fruits are larger in size as the plants are at the peak of vitality when they enter the reproductive stage and thus are able to produce larger fruits compared to successive pickings. In zero and two vegetable harvest these good fruits are retained for seed whereas in four and six vegetable harvests, it is the late formed smaller fruits that are used for seed purpose. Each genotype has limited period in its life span to bloom and reproduce and also there is a limit upon its bearing capcity. When green fruits are picked, it reflects adversely on the total fruits that are to mature on plant. This also could be the cause for higher weight of mature fruits plant^{-1} with no green fruit picking. The results are in agreement with those of Velumani (1976), Grewal et al.(1974) and Bhuibar et al.(1989). This higher weight of mature fruits plant^{-1} would also have contributed to treatments, zero and two vegetable harvests giving almost similar results with regard to the number and weight of seeds fruit^{-1}.

Thousand seed weight was highest for two vegetable harvests closely followed by zero vegetable harvest. Four and six vegetable harvests recorded lower values.Grewal et al.(1973) also pointed out the lower 100 seed weight in plants where three to four pickings of green fruits were taken. The 100 seed volume also showed the same trend which is in accordance with the results of Roy et al. (1994) where heavier seeds exhibited higher values. The lower weight and volume were harvested as vegetable leaving only less than 33 per cent of the fruits for seed purpose. Grewal et al. (1973) and Velumani (1976) also reported a reduction in the number and yield of fruits harvested for seed with increase in number of fruits harvested as vegetable.

The high viablity of seeds shown in all treatments might be due to the protein reserves in bhindi seed. This is in agreement with report of Prabhakar and Mukherjee (1980).

Higher values of germination percentage were observed in zero and two vegetable harvests though the effect of the treatment was not significant. The non significant influence of green fruit picking on germination percentage is supported by the works of Tyagi and Khandelwal (1985) and Natraj et al.(1992) in bhindi. The seed vigour was also not significantly influenced by vegetable harvests. Zero and two vegetable harvests were on par with regard to the seedling root length, shoot length, vigour index (Fig.8 and 9) and dry matter accumulation of seedlings. This can be attributed to the higher seed weights and hence the greater amount of food reserves contained and greater embryo size, or both. (Wood et al., 1977). Hewston (1964) had already reported that larger sized of seeds from late formed fruits in four and six vegetable treatments indicates the decrease in seed quality with plant age which might be due to the reduction in net assimilation rate at later stages of growth (Farbrother,1954). Bazhkova (1973) found that the 100 seed weight in cotton was strongly influenced by the position of the boll on the plant and the weight decreased from the bottom of the plant upwards emphasising the low weight of seeds in the top formed fruits. The better filling of seeds resulting in bolder seeds is also evident from the higher values for seed moisture and protein content in zero and two harvest treatments.The positive correlation between 1000 seed weight and protein content as reported by Nandisha and Mahadevappa (1984) too is observed in this experiment. The low seed weight of four and six vegtable harvest treatments might be due to the utilisation of food materials by a proportionately higher number of fruits.

Thus from the results it is observed that though the total number of fruits produced was maximum in six vegetable harvests, the seed yield is lowest compared to four, two and zero vegetable harvests. This is because about more than 67 per cent of the fruits produced in the treatment of six vegetable harvests seeds produced vigorous seedlings and small seeds, weaker seedlings. The close association of seed weight and seedling vigour has been reported by Palaniswamy and Ramaswamy (1985) and Roy et al. (1994). The first formed seeds produced by the plant germinate better than seeds developed at later stage of physiological maturity of the crop (Dharmatti and Kulkarni (1988). Shanmughasundaram (1950) also reported that the quality of seeds from plants in which more fruits were picked for vegetable purpose was comparitively poorer. This substantiates the poor performance of seeds in four and six vegetable harvest treatments. Two vegetable harvests showed slight superiority over zero vegetable harvest as the fruits for seed in former were produced at the peak growth stage of the plant ensuring better filling and hence good quality of seeds.

The lowest germination percentage reported by the four vegetable harvest treatment may be due to the low seed weight indicating poor filling and low food reserves available for germination. Germination percentage of seeds is reported to be related to the seed phosphorus content also (Austin, 1966). He observed that freshly harvested seeds from phosphorus deficient plants had a slower rate of germination and lower final percentage germination than normal ones. Supporting this view, in the present experiment a high soil phosphorus status was reported for the above treatment which indicates a low phosphorus uptake and thereby a low phosphorus content of seed. However it is to be noted that despite the treatment of four harvests having the least number and weight of seeds $fruit^{-1}$, it gave an yield higher than in six vegetable harvests on account of the higher number of mature fruits left for seed (Fig. 3).

The available nitrogen content decreased with increase in number of vegetable harvests and this can be attributed to the utilisation of nitrogen for the higher number of fruits produced. Four vegetable harvests recorded highest value of available phosphorus in soil indicating its low uptake. In bhindi Perkins et al. (1952) has clearly brought out the phenomenon of alternate bearing with a period of no fruit production between the initial and later stages of heavy fruit production. In four vegetable harvests, seed formation might have occured at the dormant stage as per the report of Perkins et al. (1952) and this probably might have resulted in poor absorption of phosphorus. The soil potassium status was not significantly influenced by the vegetable harvests.

With regard to the economics of cultivation, there was no significant difference though a maximum profit of Rs. 38434.50 was observed when no vegetable harvest was made followed by two vegetable harvests (Rs.32196.96). Six vegetable harvests could earn only Rs.23933.00 as net profit. This reveals that by taking vegetables six times from a seed crop, the profit is reduced by Rs.14500.00 when compared to zero vegetable harvest. The low seed yield is responsible for the poor returns though green fruit yield compensated it to the level of non significance.

Even though zero vegetable harvest recorded maximum profit, the quality of seed as observed from the seed characters like 1000 seed weight, 100 seed volume, length of seedling root and shoot and vigour index, were best when two vegetable harvests were done and the rest of the fruits were left for seed production. Seed is the most important input in crop production and all other inputs like fertilisers, plant protection chemicals etc. will fail to pay dividends once it is of poor quality. So for better seeds, two vegetable harvests is best.

Effect of sources of nitrogen on the yield of fruits and seeds

Organic and inorganic sources of nitrogen are available for crop production and there is significant difference in the effect of these sources on the growth and yield as clearly illustrated in Chapter 2.

The green fruit yield attributes viz.length and girth of fruits, number and weight $plant^{-1}$ were not significantly influenced by the sources used but comparitively higher values were observed when organic manures were applied in conjunction with inorganic manures compared to its sole application. This probably had a positive bearing on the green fruit yields which was signficantly higher in combined application. Farm yard manure at 12 t with chemcial fertilisers gave the maximum yield of 3997.43 kg ha^{-1} followed by 6 t FYM + chemical fertilisers (3250.53 kg ha^{-1}). Of the organic sources, 12 t FYM + poultry manure gave a better yield than 12 t FYM + vermicompost(Fig. 5). The treatments involving inorganic sources did not show any significant variation between the two. The improved performance in the combined use of nitrogen sources may be attributed to the better availablity and uptake of nutrients.

Release of nutrients is slow in organic manures(Guar *etal*., 1984). The efficacy of inorganic fertilisers is much pronounced when combined with organic manures as it resulted in better uptake (Saravanan *et al*., 1987) and this would have increased vegetative growth. The combined application may result in a balanced C/N ratio within the plant and this might have increased the synthesis of carbohydrates which resulted in the vigorous growth and hence higher yields (Kurup,1994). The better performance of poultry manure treated plants compared to vermicompost application might probably be due to the higher phosphorus content and increased availability (Singh *et al*, 1973).

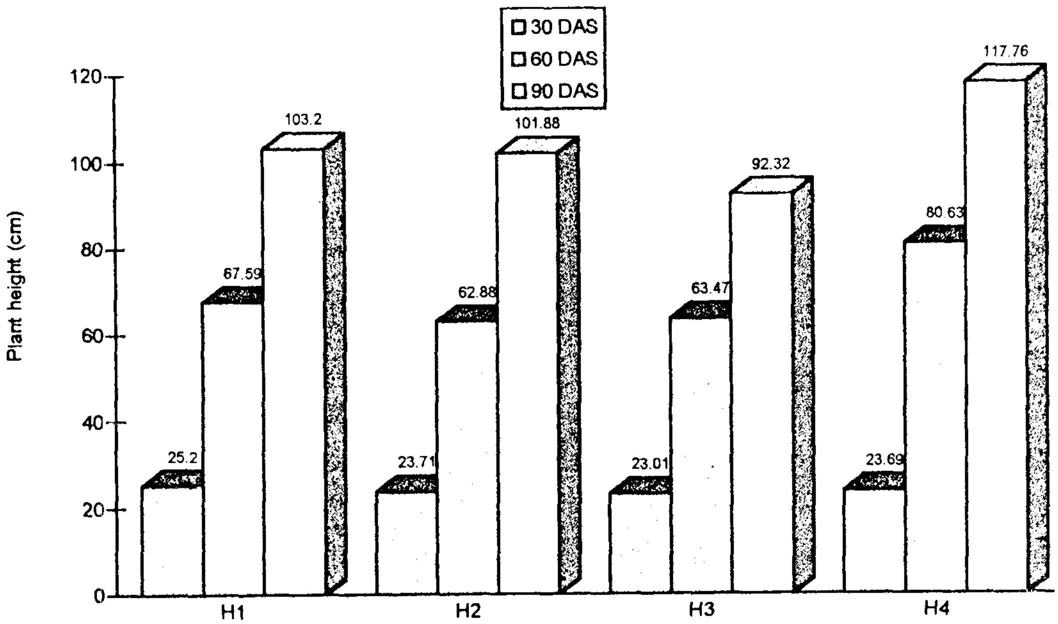
Days to 50 per cent flowering did not vary significantly with sources used though a slight earliness was observed in the treatments including inorganic sources. This is in agreement with the results of Chinnaswami (1963) in tomato.

Setting percentage was significantly high when chemical fertilisers were used along with organic manures. The continued availability of nutrients through organic and inorganic sources at all growth stages of the crop may be the contributing factor for the high setting percentage. The reports of Joseph (1982) and Kurup (1994) are in accordance with the result.

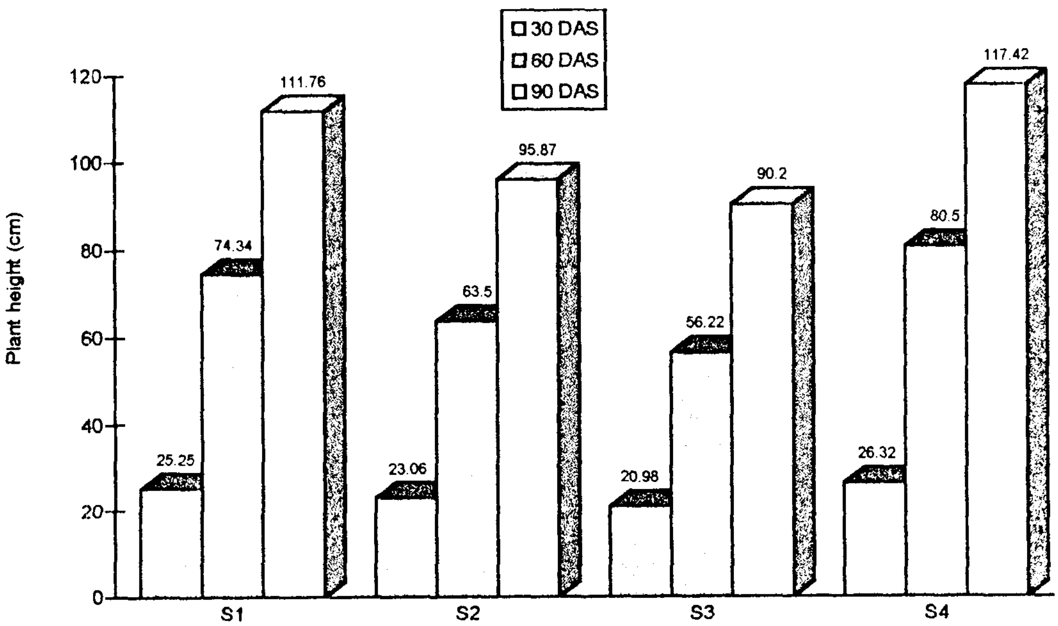
The tables on the different growth parameters showed superiority of combined nutrient source application over organic manures alone and this resulted in higher yields of the respective treatments.

The plant height, LAI and root spread were more pronounced with FYM + chemical fertilisers compared to sole organic manure application. Similar findings on the combined application of organic and inorganic manures resulting in enhanced vegetative growth, root spread and better absorption of water and nutrients to give higher yields were reported by Muthuvel *et al.* (1985). Farm yard manure at 12 or 6 t when applied with chemical fertilisers produced statistically similar results, with 6 t FYM recording higher values. Hence it can be suggested that for proper growth expression of the plant the nutrient supplied through 6 t FYM + chemical fertilisers is sufficient as against the recommended dose of 12 t FYM + chemical fertilisers. Pandey and Singh (1979) observed better plant height with 100 kg nitrogen ha^{-1} than 150 kg nitrogen ha^{-1}.

Higher LAI values with organic-inorganic combination may be due to the enhanced production of leaves and increased longivity exhibited by the plants



Vegetable harvests



Sources of nitrogen

Fig.6 Effect of vegetable harvests and sources of nitrogen on the height of the plants with increased availability of nutrients. Russel (1973) observed that the amount of leaf area available for photosynthesis is roughly proportional to the amount of nitrogen supplied. Though quantity of nitrogen supplied through the different sources is same, the better and uniform availability would have promoted leaf development in organic + inorganic manure application.

Higher doses of nitrogen improved the vegetative growth and delayed onset of maturity as this promoted translocation of nutrients for vegetative growth rather than for reproductive phase (Gupta et al., 1981).

Seed yield was found to be significantly high in the treatments which included inorganic sources (Fig.7) and is in confirmity with the findings of Helkiah et al. (1981), Muthuvel et al.(1985) and Rathore et al. (1995).Farm yard manure at 12 t + chemical fertilisers recorded the highest yield (390.85 kg ha^{-1}) and the increase was 46 and 47 per cent over vermicompost and poultry manure treatments respectively. The higher and better availability of nitrogen throughout the growth stage contributed to the increased yield. Gupta and Gill (1988) also reported higher seed yield with split application of nitrogen due to better utlisation of

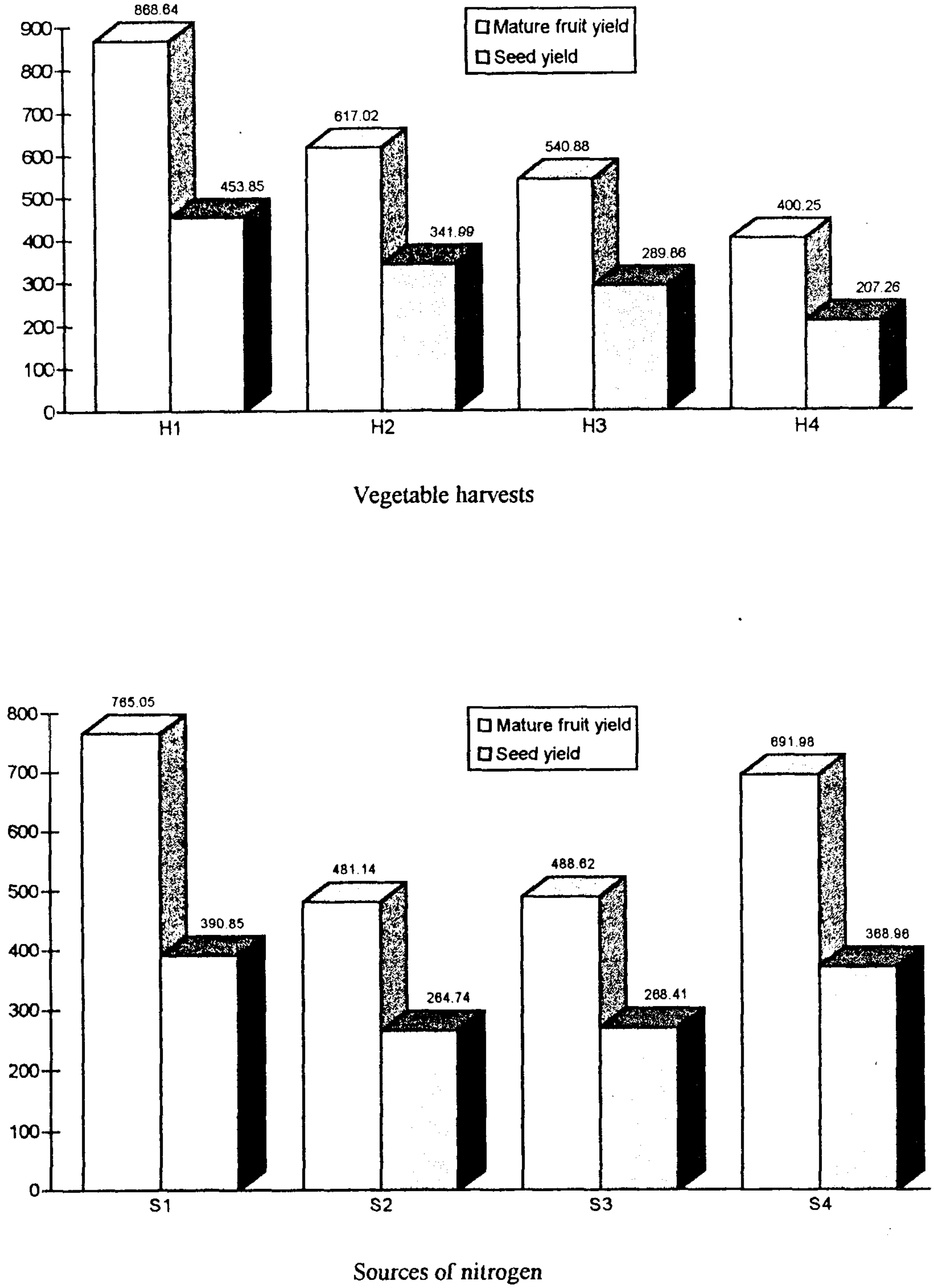


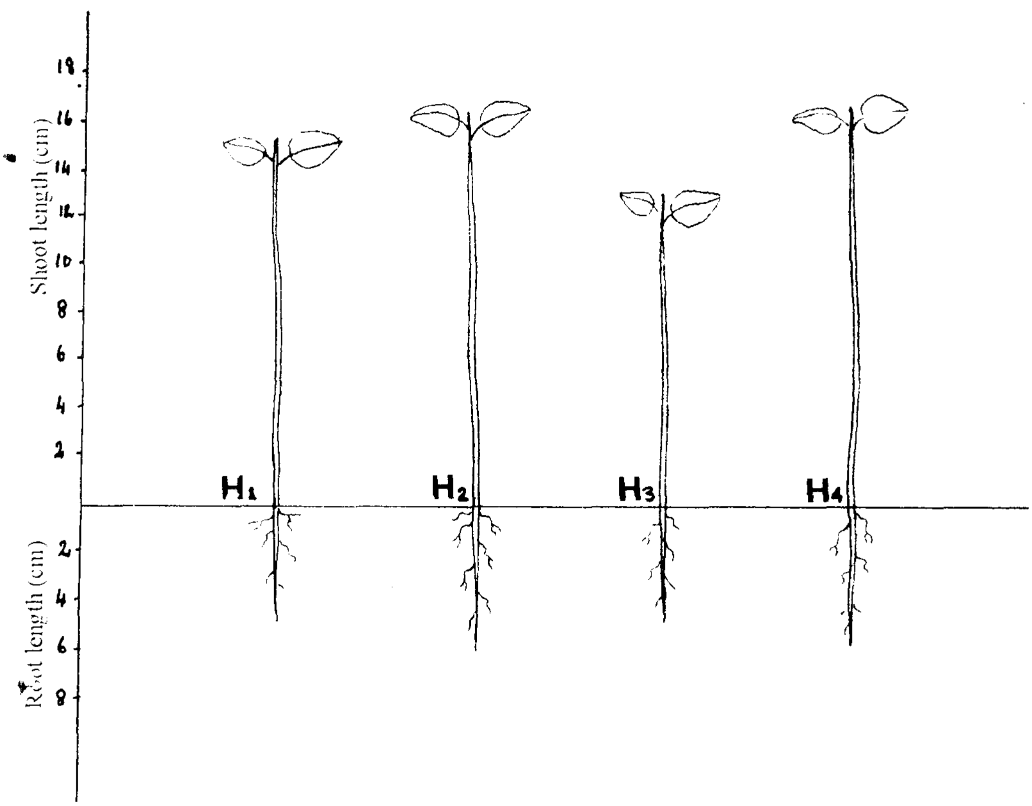
Fig.7 Effect of vegetable harvests and nitrogen sources on mature fruit yield (kg ha^{-1}) and seed yield (kg ha^{-1})

nitrogen over a long period by the crop. The higher values for weight of mature fruits plant^{-1}, mature fruit yield and weight of seeds fruit^{-1} due to the significant influence of sources might have paved way for higher seed yield. The increased availability of nitrogen when inorganic source was also included, induced the formation of proteins and enzymes which would have acted on the metabolites in leaves and stem enhancing their conversion, transportation and accumulation in seeds (Tisdale et al., 1990).

The seed protein content also showed comparitively higher values in the combined application of nitrogen due to better synthesis and translocation of proteins to seeds, however, the effect was not significant. Muthuvel et al. (1985), Chellamuthu (1987) and Patel et al. (1993) reported significantly high values of seed protein in combined application. Seed moisture content varied significantly with the sources. The variation in moisture content could be due to the differences in composition of reserve food accumulating in them (Delouche, 1973).

It is apparent from the data (Table.8) that variation in germination percentage, seedling root and shoot length and vigour index due to the different

Vegetable harvests



Sources of nitrogen

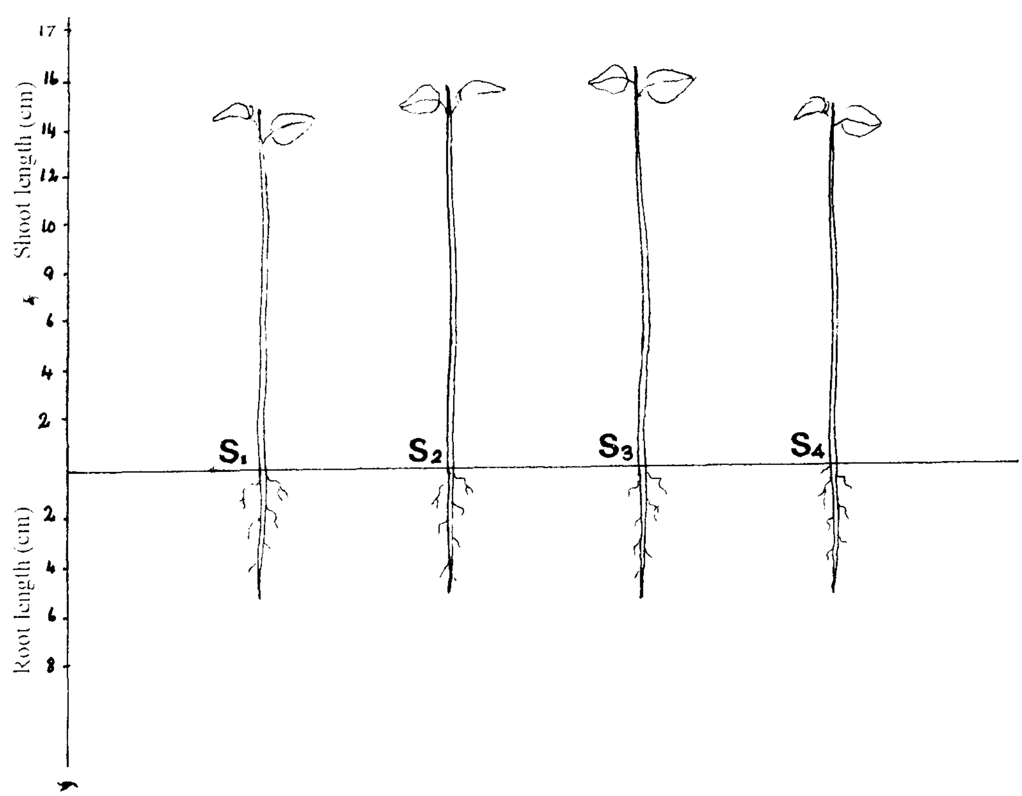


Fig. 8 Variation in seedling length due to vegetable harvests and nitrogen sources

sources of nitrogen were negligible. However seeds from vermicompost and poultry manure treated plants showed slightly higher values for these parameters. Better quality characters of produce with vermicompost application have been reported earlier. Barve (1993) observed that the quality of grape bunches from vermicompost plots were better in taste and more attractive in lustre. Similarly Khamker (1993) conclusively proved the better keeping quality of vegetables in vermicompost treated crop compared to chemical fertiliser applied crop. The better quality characters of seeds might be because of the accumulation of some enzyme or growth promoting substance in the seeds in addition to protein, promoting germination. Kale et al. (1987) reported that the materials ingested by earth worms undergo bio-chemical changes and the ejected cast contains growth substances in plant assimilable form. The vigour of seeds also showed significantly higher values for the vermicompost treatment. Presence of growth promoting substance in poultry manure also has been reported by Jose et al (1988).

The interaction effect of harvests and nitrogen sources on seedling root length was significant. The combination of four vegetable harvests (H_3) with 6 t

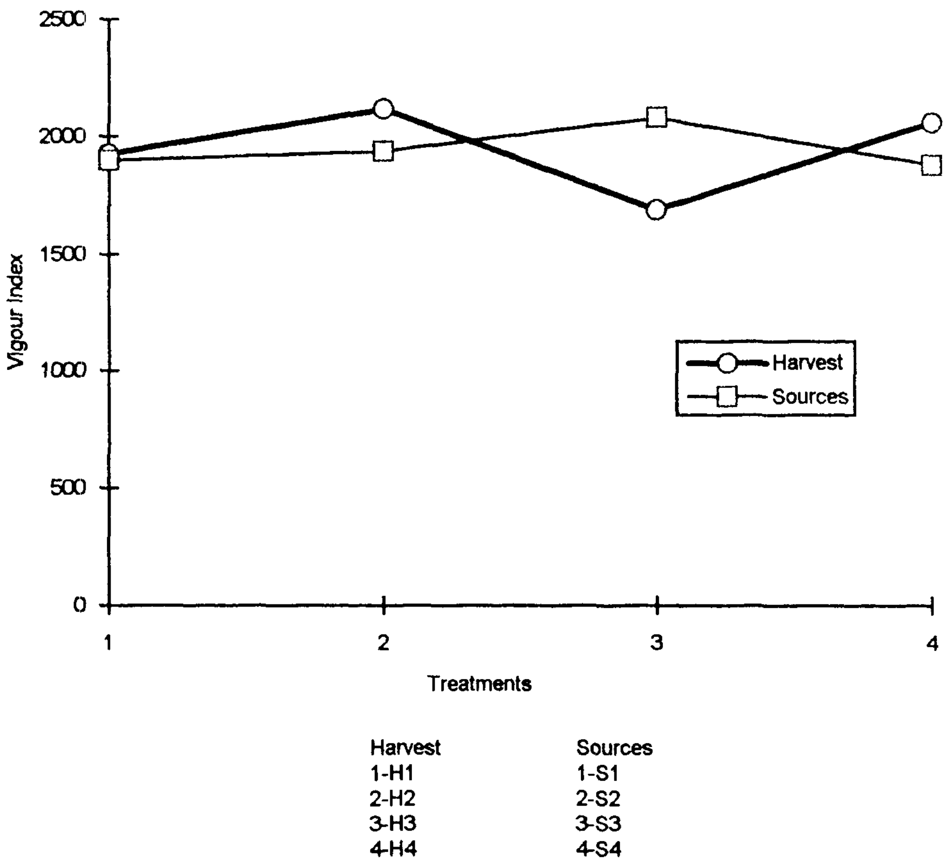
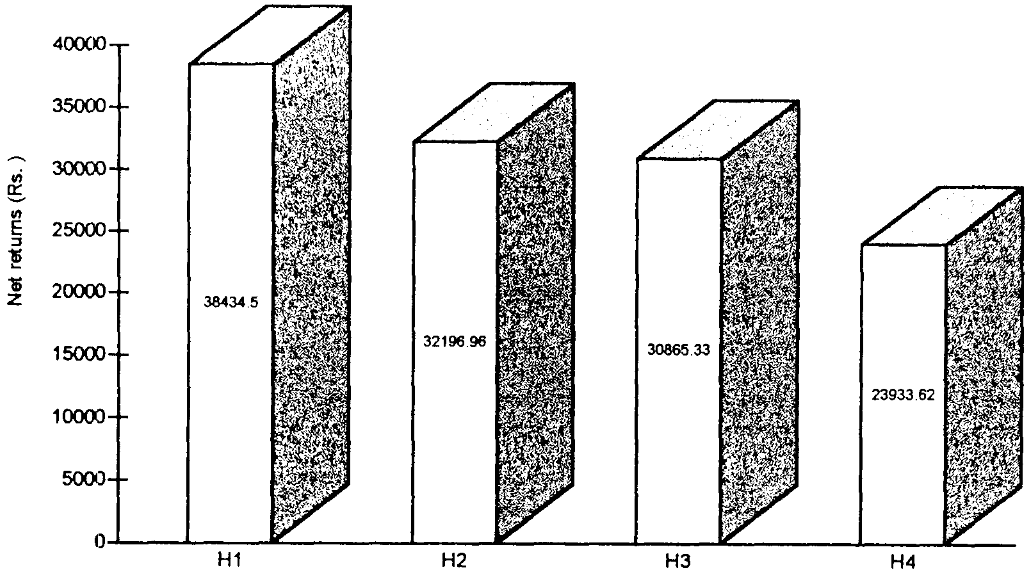


Fig.9 Vigour Index of seedlings as influenced by vegetable harvests and sources of nitrogen

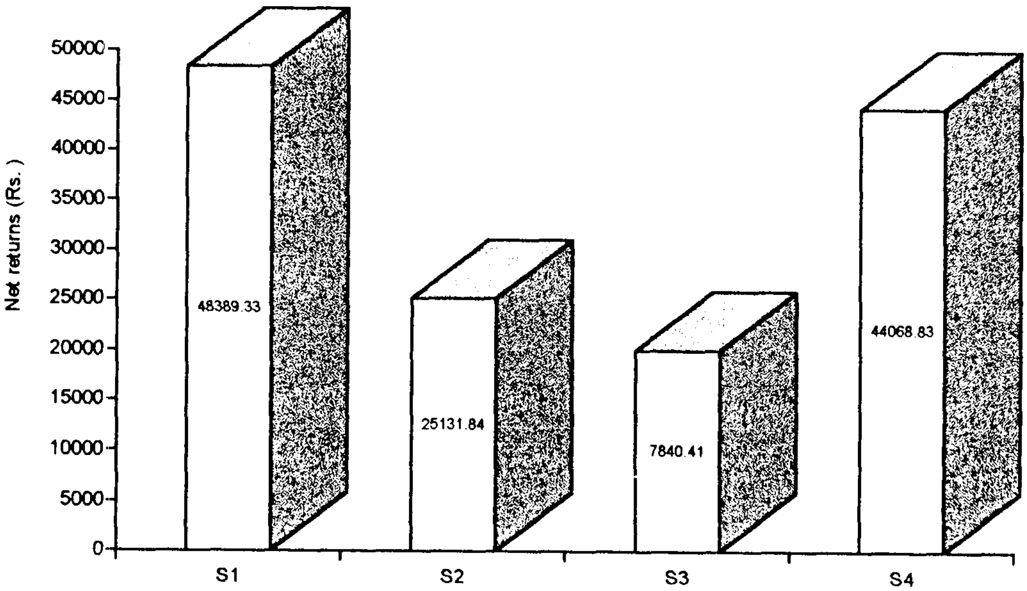
FYM + chemical fertilisers (S_4) recorded lowest value. In six vegetable harvests (H_4) also the same source recorded lowest value. This is because of the higher number of fruit production in H_3 and H_4. Along with this the amount of nutrient supplied by 6 t FYM + chemical fertilisers may not be adequate for the later formed fruits for proper development of seeds and hence their poor germination.

The soil nutrient status data (Table. 12) clearly indicates the residual effect of organic manures. The available nitrogen, phosphorus and potassium status after the experiment were considerably high in poultry manure and vermicompost treated plots. This confirms the reports on the slow release of nutrients from organic manures (Guar et al 1984). It could also explain the poor performance of the crops receiving these treatments. The interaction table on the effect on soil potassium status also indicated the low availability of potassium from vermicompost in all the different vegetable harvests done. The best uptake was when 6 t FYM was applied with chemical fertilisers.

The net returns obtained in seed production was highest when FYM was applied along with chemical fertilisers and was significantly superior to its application with poultry manure or vermicompost (Table.12 and Fig. 10). A profit of nearly Rs.48399.33 was obtained with the use of 12 t FYM with chemical fertilisers. When FYM was reduced to 6 t a reduction in the profit of Rs.4000.00 was observed. The increase in profit was mainly due to better seed production and vegetable production in the treatment. Though the cost of cultivation was less by Rs. 2340.00 when 6 t FYM + chemical fertilisers was used, this reduction was not seen reflected in the net profit. This is because of the lower production of both vegetable and seed compared to that when 12 t FYM was used. The percentage reduction in vegetable and seed yield were 18.71 and 5.60 over 12 t + chemical fertiliser treatment. Poultry manure and vermicompost recorded low profits of (Rs.25131.84 and 7840.41 respectively) mainly because of the low yield obtained. In both, green fruit and seed yield, though there was not much difference between the two treatments, the profit was reduced by Rs.17291.43 for vermicompost treatment on account of the very high cost (Rs.2.00 kg^{-1}) and the low N content (1.00 %) necessitating a bulkier quantity of the manure to meet the nitrogen requirement. Hence if vermicompost could be produced by the farmer himself, which involves a very low cost,



Vegetable harvests



Sources of nitrogen

Fig.10 Economics of cultivation

then this treatment could also yield a better net profit. Quality wise also vermicompost treatment was slightly better than the other sources.

The benefit cost ratio followed the same trend as net returns. The highest value of 2.92 was observed with 12 t FYM + chemical fertilisers followed by 6 t FYM + chemical fertilisers (2.88), FYM + poultry manure (1.98) and FYM + vermicompost (1.19). Thus for bhindi seed production 12 or 6 t FYM can be recommended with inorganic sources.

Based on the above discussions it can be concluded that increased number of vegetable harvests reduced the seed yield, quality and vigour. Though zero vegetable harvest recorded the highest seed yield, quality wise two vegetable harvests proved to be better especially in seed characters like 1000 seed weight, vigour index etc. Hence for maximum production of quality seeds, two vegetable harvests is best. Twelve tones of FYM + chemical fertilisers gave the highest seed yield but considering the availability of FYM the dose can be reduced to 6 t when applied with chemical fertilisers. The reduction in FYM did not reduce the seed yield or net returns significantly.

The economic analysis of the practices reveals that leaving the plants entirely for seed production with 12 or 6 t FYM and chemical fertilisers gave the highest net profit, but as quality of seeds is fundamental in crop production, the combination of organic and inorganic manures with two vegetable harvests can be practised even though the net profit was reduced, as the reduction observed was not significant.

Plate 1. Stature of the crop under different sources of nitrogen

(i)

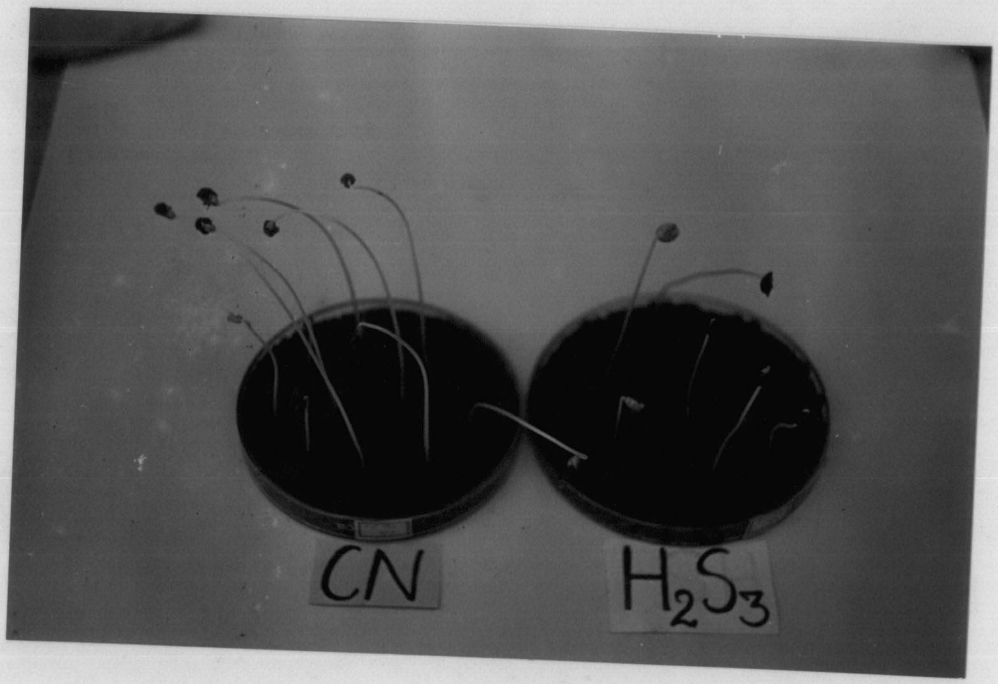
(ii)

(iii)

(iv)

Plate 2. Gérmination of seeds

Plate 3. Brick gravel method



Summary

SUMMARY

A field investigation was undertaken at the College of Agriculture, Vellayani to study the influence of vegetable harvests and different souces of nutrients on the yield and quality of bhindi seeds. The treatments included two factors, four different number of vegetable harvests, viz. zero, two, four and six and four sources of nutrients, 12 t FYM + 110:37:74 kg N, P_2O_5 and K_2O ha^{-1}, 12 t FYM + 3.6 t poultry manure, 12 t FYM + 11 t vermicompost and 6 t FYM + 110:37:74 kg N, P_2O_5 and K_2O ha^{-1}. Thus 16 treatment combinations of the two factors were tried in the experiment which was laid out in strip plot design with 4 replications.

The results of the investigation are summarised below:

The plant height was not significantly influenced by the vegetable harvests at 60 DAS though six vegetable harvests recorded the highest value whereas at 90 DAS, this treatment recorded significantly high value of 117.76 cm. The sources of nitrogen did not exhibit any significant influence on plant height at 30 DAS. However at 60

and 90 DAS the influence was significant and maximum plant height was observed with 6 t FYM + chemical fertilisers.

Vegetable harvest did not influence LAI at 60 DAS significantly. LAI showed significant variation with the different sources of nitrogen at 30 and 60 DAS. 6 t FYM + chemical fertilisers recorded the highest value at both stages.

Neither the vegetable harvests nor the sources of nitrogen exerted any significant influence on the height of the first bearing node.

Root spread at final harvest was not significantly influenced by the vegetable harvests but the effect of the different sources of nitrogen was statistically significant.

The different vegetable harvests and sources of nitrogen did not influence the number of days taken for 50 per cent flowering significantly.

Setting percentage was not significantly influenced by the vegetable harvests whereas the sources of nitrogen exerted significant influence.

The number and weight of green fruits harvested $plant^{-1}$ significantly increased with increasing number of vegetable harvests but the sources of nitrogen did not show any significant influence.

Neither the length non the girth of green fruits varied significantly with vegetable harvests and sources of nitrogen.

Green fruit yield was remarkably high with six vegetable harvests (4446.03 kg ha^{-1}) and among the sources 12 t FYM + chemical fertilisers recorded the highest yield (3997.43 kg ha^{-1}).

The weight of mature fruits $plant^{-1}$ was significantly influenced by vegetable harvests, nitrogen sources and the interaction. The maximum was recorded by H_1S_1 (47.39 g $plant^{-1}$), the combination of zero vegetable harvests and 12 t FYM + chemical fertilisers.

The treatment of zero vegetable harvests recorded a significantly high yield of mature fruits (868.64 kg ha^{-1}). The sources of nitrogen also exerted significant influence and highest yield was with 12 t FYM + chemical fertilisers (765.05 kg ha^{-1}).

Vegetable harvests produced appreciable variation in the total number of fruits $plant^{-1}$, the highest being with six vegetable harvests (11.57). The effect of sources of nitrogen was not significant.

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The number of seeds $fruit^{-1}$ and fruit to seed ratio were not significantly influenced either by vegetable harvests or by sources of nitrogen.

Both , vegetable harvests and sources of nitrogen significantly influenced the weight of seeds $fruit^{-1}$. Two vegetable harvests recorded highest seed weight $fruit^{-1}$(3.19 g) and among the sources 6 t FYM + chemical fertilisers gave the maximum value of 3.07 g.

1000 seed weight and 100 seed volume were maximum with two vegetable harvests, 54.15 g and 6.02 ml respectively however the effect was not significant. Sources of nitrogen significantly influenced the two characters with 6 t FYM + chemical fertilisers recording the highest values of 52.68 g and 6.25 ml for 1000 seed weight and 100 seed volume respectively.

Seed yield was significantly influenced by vegetable harvests and sources of nitrogen. Zero vegetable harvests recorded the maximum yield of 453.85 kg ha^{1} and among the sources 12 t FYM + chemical fertilisers gave the highest seed yield of 390.85 kg ha^{-1} followed by 6 t FYM + chemical fertilisers (368.96 kg ha^{-1}).

Germination percentage of seeds was not significantly influenced either by vegetable harvests or by sources of nitrogen.

Vegetable harvest significantly influenced the seedling root length, shoot length and vigour index. Zero, two and six vegetable harvests recorded almost similar results but four vegetable harvests was significantly inferior. The effect of sources of nitrogen was not significant.

The treatments did not exert any significant influence on seed viablity observed one month after harvest.

The dry matter accumulation in seedling was significantly influenced by both treatments.

Vigour of seeds was not significantly influenced by vegetable harvests. The sources of nitrogen exerted significant influence and the highest number of vigorous seeds was observed with 12 t FYM + vermicompost.

The vegetable harvests and sources of nitrogen did not produce any significant variation in the seed protein content.

Vegetable harvests did not influence the seed moisture content significantly whereas the effect of sources of nitrogen was significant.

Available nitrogen and potassium status of soil did not vary significantly with vegetable harvests while the sources of nitrogen produced significant variation.

Vegetable harvests significantly influenced the available phosphorus status of soil after the experiment. The effect of the sources was not significant.

The net profit and benefit cost ratio were not significantly influenced by vegetable harvests. However the highest returns and benefit cost ratio were obtained with zero vegetable harvests (Rs.38434.50 and 2.52 respectively) followed by two vegetable harvests (Rs.32196.96 and 2.32 respectively). Sources of nitrogen caused significant variation with 12 t FYM + chemical fertilisers recording highest values of Rs. 48389.33 and 2.92 respectively for net returns and benefit cost ratio.

From the results summarised above it is obvious that the highest seed yield was obtained when the crop was left entirely for seed purpose without any vegetable picking. Considering the quality aspects of seed such as number of seeds $fruit^{-1}$, 1000 seed weight,100 seed volume,seedling root and shoot length,vigour index etc.,two vegetable harvest treatment recorded slightly superior values. Picking of a few fruits such as in two vegetable harvests did not reduce the seed yield significantly. Hence for a good yield of quality seeds, two vegetable harvests can be considered as ideal.

Among the sources, though 12 t FYM +chemical fertilisers recorded highest seed yield of commendable quality, reducing the FYM dose to 6 t ha^{-1} did not cause any appreciable variation in either the seed yield or quality. A combination of organic and inorganic sources of nutrients is always best.

The returns and benefit cost ratio between zero and two vegetable harvests or between 12 t and 6 t FYM with chemical fertilisers did not vary significantly in each case. The interaction efect also was not significant indicating that each treatment was independent of the other.

Thus it can be concluded that in bhindi seed production, for a good yield of quality seeds two vegetable harvests and leaving the rest for seed production with 12 t or 6 t FYM + chemical fertilisers as sources of nutrients can be recommended.

Future line of work

1. The same experiment may be repeated to confirm the trend of results obtained in the present experiment.

2. Experiments may be conducted to assess the field performance of the seeds obtained from this experiment.

3. An experiment involving the combination of the each of the different organic manures used in this experiment with chemical fertilisers may be carried out.

4. The quality aspects of seeds in each picking of mature fruits left for seed may also be tried.

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* Originals not seen

Appendices

Appendix 1

Weather data during the cropping period 4 Oct. 1994 to 14 Jan. 1995.

Standard week	Period from	to	Rainfall mm	Maximum temp. C	Minimum temp. C	Relative humidity
40	Oct. 01	Oct. 07	24.4	28.0	23.7	96.9
41	08	14	1.5	30.5	22.3	83.6
42	15	21	16.1	29.5	23.3	82.0
43	22	28	2.1	30.3	23.9	84.3
44	Oct. 29	Nov. 04	15.7	29.7	23.2	85.2
45	Nov. 05	11	3.3	30.5	23.5	80.2
46	12	18	3.8	29.9	23.2	84.2
47	19	25	-	30.4	23.0	85.7
48	26	Dec. 02	4.1	31.2	23.8	84.1
49	Dec. 03	09	-	30.8	22.1	88.4
50	10	16	-	30.5	21.1	78.5
51	17	23	-	31.5	23.1	81.5
52	24	31	-	31.8	22.0	77.2
01	Jan. 01	07	-	31.8	22.6	80.4
02	08	14	1.2	32.0	23.2	74.7

YIELD, QUALITY AND VIGOUR OF BHINDI SEED AS INFLUENCED BY NUMBER OF HARVESTS AND NUTRIENT SOURCES

By

Sheeba Rebecca Isaac

ABSTRACT OF THE THESIS

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ABSTRACT

An experiment was conducted at the College of Agriculture, Vellayani to study the influence of vegetable harvests and nitrogen sources on the seed yield and quality in bhindi. The treatments consisted of combinations of four different number of vegetable harvests (0, 2, 4, 6) and four sources (12 t FYM + 110:37:74 kg N, P_2O_5 and K_2O ha^{-1}, 12 t FYM + 3.6 t poultry manure, 12 t FYM + 11 t vermicompost and 6 t FYM + 110:37:74 kg N, P_2O_5 and K_2O ha^{-1}.

The results revealed that growth characters of bhindi crop were not significantly influenced by vegetable harvests except for the height 90 DAS. Frequent picking of green fruits in bhindi improved the bearing capacity of the plant but the mature fruit yield, seed yield and quality were significantly reduced. Highest seed yield was observed with zero vegetable harvest but was on par with two vegetable harvests. Among the seed characters, germination percentage, 1000 seed weight, 100 seed volume, seed protein and seed moisture content were not significantly influenced by the vegetable harvests while seedling root and shoot length and vigour index

values were better for two vegetable harvest treatments. This treatment apart from a good yield of quality seeds, yielded some vegetable also.

The effect of the sources of nitrogen on the germination percentage, seedling root and shoot length and vigour index was not significant while mother crop growth parameters, mature fruit yield and seed yield were significantly high when organic manures were used in conjunction with chemical fertilisers. Farm yard manure at 12 or 6 t coupled with chemical fertilisers gave statistically similar results with regard to the seed yield and quality.

Considering the economics, better profits could always be realised when FYM was applied along with chemical fertilisers without any vegetable harvest but, for a satisfactory yield of quality seed and some vegetable, this source should be combined with two vegetable harvests.