

**“Effect of Nitrogen Levels on Yield and Quality of Seed in
French Bean”**



THESIS

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In

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(Vegetable Science)

By

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2011

CERTIFICATE - I

This is to certify that the thesis entitled “**Effect of Nitrogen Levels on Yield and Quality of Seed in French Bean**”, submitted in the partial fulfillment of the requirements of the degree of **MASTER OF SCIENCE IN HORTICULTURE (VEGETABLE SCIENCE)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.), is a record of the bonafide research work carried out by **Mr. Balvant Singh Mourya**, ID. No. **RH/MS/687/2008** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published / published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been acknowledged by him.

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CERTIFICATE II

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Place – Mandsaur

Date -

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ABBREVIATIONS USED IN TEXT

Symbol	Particular
&	: and
@	: At the rate of
/	: Per
%	: Percentage
⁰ C	: Degree Celsius
ANOVA	: Analysis of variance
C:B	: Cost Benefit ratio
C.D	: Critical difference
cm.	: Centimeter
cv.	: Cultivar
DAT	: Days after transplanting
D.F.	: Degree of Freedom
DAP	: Di Ammonium Phosphate
<i>et.al</i>	: and others
Fig.	: Figure
g	: Gram
ha	: Hectare
i.e.	: That is
K	: Potassium
Kg	: Kilogram
Kg/ha	: Kilogram per hectare
Max.	: Maximum
mg	: Milligram
Min.	: Minimum
MOP	: Muriate of potash
M.S.S	: Mean sum of square
m. sq.	: Meter square
N	: Nitrogen
No.	: Number

NS	:	Non significant
P	:	Phosphorus
q/ha	:	Quintal per hectare
R.H.	:	Relative humidity
Rs.	:	Rupees
R.V.S.K.V.V	:	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
S	:	Sulphur
SEm	:	Standard Error of Mean
Sig.	:	Significant
SSP	:	Singal super phosphate
Viz.	:	(Videlicet) Namely

CHAPTER I

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is one of the most important leguminous vegetable crops in India. It is also known as rajmah or rajma (Hindi) or haricot bean or kidney bean or common bean or snap bean and navy bean. French bean has evolved in the highlands of Middle America from a wild vine over a period of 7000-8000 years. Vavilov (1951) reported Mexico and Central America as the primary and Peruvian-Ecuador-Bolivian region of South America as the secondary centers of origin of french bean. The crop is sown in two seasons from February-March and September-October in the tropical and subtropical climate.

French bean is valued for its protein (23%) rich seeds. Seeds are also rich in calcium, phosphorus and iron. The fresh pods are used as vegetable. As a nutritious vegetable, it contains calcium (50mg), phosphorus (28mg), iron (1.7mg), carotene (132mg), thiamine (0.08mg), riboflavin (0.06mg) and vitamin C (24.0mg) in each 100g of edible pods (Chadha, 2001). In Western World (USA, Western Europe), both the fresh pod and processed pod consumption is quite substantial. The countries producing substantial dry beans are Brazil, Mexico, Argentina, Chile, Central America and Latin America.

Brazil is the largest producer of french bean in the world followed by Myanmar, India, China, United States of America and Mexico. With an area of 3.78 million ha Brazil produces 3461.19 thousand MT of french bean with an average productivity of 0.81 MT per ha. India ranks first in area with 8.0 million ha and ranks third with a production of 3010 thousand MT of french bean (F.A.O., 2011). It is largely grown in hilly areas of Himachal Pradesh, Jammu and Kashmir and north-eastern states during summer and winter and autumn crop in parts of Uttar Pradesh, Maharashtra, Karnataka and Andhra Pradesh. In northern plains, it is cultivated on a limited scale as autumn or spring crop, because of susceptibility to low as well as high temperatures (Chadha, 2001).

Its yield is mostly dependent on the genetical constitution of the variety, environmental factor, soil, crop management practices and nutrition. The improved varieties in general gave higher yields, if supplied with optimum quantity of nutrition and grown under favourable conditions (Farkade and Pawar, 2002). The crop is

especially characterized by lack of nodulation owing to the absence of NOD gene regulator even though it is a leguminous crop. French bean is highly sensitive and responds well to nitrogen (Sushant *et al.*, 1999). French bean responds well to nitrogen application (Ahlawat and Sharma, 1989).

French bean is the main source of plant protein for a large part of the world population, mainly which is of low income and nitrogen is the main constituent of these proteins. Nitrogen is necessary for growth and chlorophyll synthesis and is a part of the chlorophyll. In the plains french bean seldom forms nodules and due to this the crop responds sharply to high doses of nitrogen (Ghosal *et al.*, 2000). It improves the quality of fruit, vegetable and grain crops. Nitrogen is essential constituent of amino acid and helps in protein synthesis, fruit formation.

Majority of population in India are vegetarians and increased production and consumption of french bean as a pulse as well as vegetable can appropriately supplement their nutritional requirement. Introduction of improved french bean varieties in the non-traditional areas particularly in the Malwa region with appropriate production technology offers good possibilities to increase its production and productivity in India.

Thus, as compared to other leguminous crops, nodule formation in roots of french bean is very less or even absent in the plains in India. Therefore it is high nutrient demanding crop. French bean cultivation in Malwa region is not common. Introduction of this crop in the region may provide more opportunity to the common people as well as farmers for getting nutritious food and a good source of income. The standardization of nitrogen dose and identification of suitable variety may help in the popularization of the cultivation of french bean crop among farmers of Malwa region of Madhya Pradesh.

Hence, an experiment entitled “Effect of nitrogen levels on yield and quality of seed in french bean” was undertaken with the following objectives:

- To study the performance of french bean varieties for seed production.
- To find out the effect of nitrogen levels on growth, yield and quality of french bean seed.
- To study the combined effect of varieties and nitrogen levels.
- To evaluate the economics of different treatments.

CHAPTER II

REVIEW OF LITERATURE

The growth, yield and quality of french bean, besides genetic factors largely depend upon climate and management practices, such as time of sowing, nutrients, irrigation, spacing, plant protection etc. A brief resume of research work done by various scientists in India and abroad on “Effect of nitrogen levels on yield and quality of seed in french bean” and related aspects has been briefly reviewed and presented in chronological order in this chapter.

2.1 Effect of varieties:

Stradiotto and Oliveira (1977) reported that nitrogen content varied between 3.09 and 4.38% in eight varieties and contents of methionine and caseine were generally low. Digestibility varied between 43 and 77%. The nitrogen balance was positive in two and negative in three varieties. It was concluded that the nutritive value of the varieties differed and that different parameters should be considered when assessing their nutritional qualities.

Amaral *et al.* (1980) investigated plants of 90 varieties by determining the N, P and K contents of leaves, stems, roots, pods and seeds. The range of the content of each element both in particular organs and in whole plants was large and seed yield displayed no close dependence on nutrient uptake. Intervarietal differences in the efficiency of nutrient utilization were indicated. Seed crude protein content varied between 20.6 and 34.4% and, assuming a crop density of 250000 plants/ha, seed yield ranged up to 5.1 t/ha.

Badiyala *et al.* (1992) conducted field experiment on *Phaseolus vulgaris* cv. Him 1 (Chitra) and Jawala. They applied 0-100 kg N/ha. Seed yields were highest with 60 kg N. Him 1 (Chitra) gave higher seed yield than Jawala (2.10 v/s. 1.45 t/ha).

Ahlawat (1996) studied the performance of french bean varieties and their response to plant density and P₂O₅. It was noted that among the varieties, PDR 14 had the tallest plants with highest number of seeds per pod and have bolder seeds.

Arya and Rana (1999) studied on variability, correlation and path co-efficient analysis in 25 indigenous and exotic genotypes of French bean. Highest variances

were observed for green pod yield per plant followed by pods per plant, 100-seed weight and seed vigour and plant height. The genotypic and phenotypic co-efficients of variation were highest for pods per plant followed by green pod yield per plant, branches per plant, seed vigour and 100-seed weight. There were positive and significant correlations of green pod yield with pods per plant, branches per plant, plant height and seed vigour and 100-seed weight. Plant height and branches per plant showed a strong positive association with pod number per plant. Path analysis showed the highest direct effect of pods per plant on green pod yield followed by plant height, branches per plant, days to 50% flowering and pod breadth. Discriminant function analysis revealed that pods per plant contributed most towards green pod yield and VPF-191 was the superior cultivar among the genotypes studied.

Delfin *et al.* (1999) conducted a field experiment to assess the nitrogen fixation activity of 14 bush and 19 pole snap bean varieties. The relative ureide levels (RUL) varied among varieties with values ranging from 15.76-40.58% and 20-37% for bush and pole snap beans, respectively. These varieties were also noted to have different nodulating abilities. The presence of native *rhizobia* was also noted in uninoculated plots and formed comparable number of nodules as the inoculant strain. The composition of the xylem sap of bush snap beans was significantly influenced by the treatment applied. Inoculated plants had higher relative ureide content than plants which were fertilized with chicken manure. The chicken manure fertilized plants had higher relative amino acid content than those inoculated with *Rhizobium tropici*.

Chavan *et al.* (2000) conducted a field experiment on french bean (*Phaseolus vulgaris* L.) cultivars viz., Contender, Arka Komal and Waghya sown on 31 December 1989 were supplied with 3 rates of N (0, 25 and 50 kg/ha) and 3 rates of P (0, 25 and 75 kg/ha). Seeds were evaluated for N, P and K contents, total dry matter and protein production. The highest P uptake (6.3 kg/ha) by seeds and straw was recorded in both Waghya and Arka Komal. Waghya recorded the highest total dry matter (17.2 q/ha), seed protein production (128.0 kg/ha) and N and K uptake (31.7 and 12.0 kg/ha, respectively). The highest total P uptake (8.5 kg/ha) was recorded from the highest N rate (50 kg/ha). Total P uptake increased linearly with increase in P rates.

Kumar and Puri (2002) conducted a field experiment to study the response of two french bean (*Phaseolus vulgaris*) cultivars (Jawala and Local) to phosphorus (0, 25 and 50 kg/ha) and farmyard manure (FYM) application (0 and 10 t/ha) under rainfed conditions. Between the cultivars, Jawala recorded higher number of pods per plant, seeds per pod, 1000-seed weight and harvest index, consequently recording higher grain (10.0 q/ha) and straw yields (12.3 q/ha) than Local (8.3 and 11.7 q/ha, respectively). Among the treatments, application of 50 kg P/ha + 10 t FYM/ha resulted in the highest plant height, pods per plant, seeds per pod and 1000-seed weight and thereby the highest yield (13.8 q/ha).

Ceyhan (2006) carried out trials on grain samples, collected for analysis of six dry bean cultivars (Sehirali-90, Karacasehir, Akman-98, Goynuk-98, Onculer-98 and Yunus-90) which are currently cultivated in Turkey. These were analyzed for their thousand seed weight, protein, oil, cellulose, ash, potassium, calcium, phosphorus, magnesium, sodium, iron and zinc content. Analyses of variance were important differences amongst the cultivars for all the properties studied and different groups were obtained by LSD range test. The highest protein content (28.78%) was obtained in Karacasehir.

Moniruzzaman *et al.* (2007) conducted field experiment on french bean having three varieties (BARI Jhar Seem-1, BARI Jhar Seem-2 and Local) and six sowing dates at 10 days interval from (November 01 to December 20) to find out the suitable variety and optimum sowing date for getting higher pod yield. Both the varieties of BARI Jhar Seem-1 and BARI Jhar Seem-2 yielded higher from local variety but the first two varieties were statistically at par in respect of pod yield. BARI Jhar Seem-1 and BARI Jhar Seem-2 produced maximum pod yield of french bean when sown on either November 10 or November 20.

Pawar *et al.* (2007) carried out an experiment with four varieties namely HPR-35, PDR-14, HUR-15 and VL-63 and three spacing that is 30 x 10, 45 x 10 and 45 x 15 cm. The results revealed the significant difference among the varieties for plant height, branches per plant, functional leaves per plant, leaf area, grains per pod, grains per plant, pod weight, grain yield per plant, test weight, grain yield per hectare, biological yield and straw yield. Variety PDR- 14 showed significantly superior performance over other varieties.

Araujo and Teixeira (2008) investigated the relationships between grain yield, biomass production and N and P accumulation at reproductive stages of common bean (*Phaseolus vulgaris*) cultivars. Crop biomass was sampled at four growth stages (flowering R6, pod setting R7, beginning of pod filling R8, and mid-pod filling R8.5). Grain yield was measured at maturity, and N and P concentrations were determined in plant tissues. In both years, bean cultivars differed in grain yield, in root mass at R6 and R7 stages, and in shoot mass at R6 and R8.5, whereas at R7 and R8 differences in shoot mass were significant in 1998 only. In both years, grain yield did not correlate with shoot mass at R6 and R7 and with root mass at R6. Grain yield correlated with shoot mass at R8 in 1999 but not in 1998, with shoot mass at R8.5 and with root mass at R7 in both years.

Kimani and Tongoona (2008) conducted a study to determine the mode of inheritance and the genetic mechanisms associated with bean nitrogen use efficiency under low soil nitrogen. Eight widely grown and well adapted low soil N tolerant lines (CAL143, CIM9314-36, and AFR708) and non-tolerant varieties (E5, E8, GLP-2, CAL96, and SCAM80-CM/15) were crossed in a half diallel mating design. The parents and their F₁ generations were evaluated under low soil N and moderate soil N conditions. Genotypes that had well-developed basal root systems performed better than those with less developed basal roots. F₁ hybrids from crosses between low N tolerant and non-tolerant parents performed better under nitrogen stressed conditions compared with those between susceptible parents. Hybrids involving CAL143 as one of the parents showed high levels of tolerance to low soil nitrogen conditions. Among parents, CAL143 showed the best performance for basal root length, root dry weight, nodule numbers, leaf area and grain yield.

2.2 Effect of nitrogen levels:

Sharma *et al.* (1976) sown *Phaseolus* beans cv. Pusa Parvati, in May or July and the effects of N at 0, 40 or 60 kg/ha and P₂O₅ at 0, 60 or 90 kg/ha were compared in all combinations. With May sowing, the highest yields were obtained from N at 40 kg/ha and P₂O₅ at 60 kg/ha, with little or no benefit from higher application rates. With July sowing each nutrient element at 60 kg/ha gave the best results.

Singh (1987) Reported that green pod yield of french bean increased with the increase in the rates of N up to 60 kg/ha. The optimum dose of N was 67.3 kg/ha.

Srinivas and Naik (1988) conducted field trial with cv. Arka Komal, during the rainy season (Aug-Oct.) with 5 N levels (0, 40, 80, 120, and 160 kg/ha) and 3 P levels (0, 17.5, and 34.9 kg/ha). Pod yield increased proportionately to N levels up to 160 kg/ha; however, the difference between 80 and 120 kg and between 120 and 180 kg/ha was not significant. Production increase in response to N fertilization increased wt. and number of pods/plant and Harvest Index. P levels of up to 34.9 kg/ha increased pod production significantly with increases of 17 and 20 per cent with P levels of 17.5 and 34.9 kg/ha, resp. Production increases were observed in terms of greater pod number and weight. Optimum fertilizer levels of 125.6 and 62.6 kg N and P/ha, resp., generated production levels of 13,117 and 12,250 kg/ha, respectively.

Srinivas and Naik (1990) carried out trials on a sandy loam soil of low fertility. The crop received N at 0, 40, 80, 120 and 160 kg/ha and P₂O₅ at 0, 40 and 80 kg/ha. Both N and P application increased plant growth, nutrient uptake and yield of green pods. One factor quadratic response functions fitted to the yield data indicated optimum N and P application rates to be 125.6 and 143.3 kg/ha, respectively.

Nleya (1992) conducted a field experiment during 1985-88 at gwebi variety testing centre, horticulture research centre (HRC) and Matopos research station, Zimbabwe on *Phaseolus vulgaris* cv. Ex-Rico was given 0, 30, 60, 90 or 120 kg N/ha with and without recommended P and K according to the site. Response to N was observed consistently at HRC, during the 1st season at Gwebi and never at Matopos. There was no significant interaction between N and P + K.

Silveira *et al.* (1993) carried out a field experiment to determine the effects of N and K fertilization on yield and yield components of common beans cultivated under irrigation by a center pivote system. The soil of the experimental site was an Oxisol with sandy texture. The treatments consisted of 0, 40, 80, and 120 kg K₂ O ha⁻¹ and 0-30-60 and 90 kg N ha⁻¹. Production of dry matter, concentration and accumulation of N in the tops and number of pods per plant increased with increasing levels of N.

Dwivedi *et al.* (1994) reported that seed yields of french bean increased due to increasing levels of N up to 100 kg/ha. However, differences between 80 and 100 kg N/ha was non-significant.

Koli and Akashe (1995) conducted a field experiment on french bean (*Phaseolus vulgaris*) sown in rows at 22.5 or 30 cm apart at plant densities of 222222, 333333 or 444444 plants/ha and was given 0, 30 or 60 kg N/ha. Total dry matter at 20, 40 and 60 days after sowing and pod yield at harvest was highest with rows 30 cm apart and 222222 plants/ha and they increased with rate of N application.

Burns (1996) grown lettuce (cv. Saladin), cauliflower (cv. Masai) and french bean (cv. White Rock) crops, hydroponically. Results showed that restricting N supply affected growth and development independently, with the latter being less sensitive to the availability of N. Maturity was delayed in lettuce with short periods of N deficiency, allowing yields to recover partially from the adverse effects on growth. Reducing N at curd initiation advanced maturity in cauliflower but at other stages of growth it had little or no effect on the rate of development. French bean maturity was not affected by N restriction regardless of when it occurred.

Dahatonde and Nalamwar (1996) conducted a study to investigate the effects of N fertilizer application (0, 30, 60, 90 or 120 kg N/ha) and irrigation (at 1.2, 1.0, 0.8 or 0.6 irrigation water (IW): cumulative pan evaporation (CPE) ratios) on *Phaseolus vulgaris* cv. HUR 15. A significant increase in seed yield to N fertilizer application was observed up to 90 kg N/ha. Application of 120 kg N/ha did not result in any further increase in yields compared with the 90 kg N/ha application. Irrigation at 1.2 IW:CPE ratio + 90 kg N/ha application resulted in the highest seed yield due to a positive significant interaction effect.

Guvenc (1996) investigated the effect of foliar application of 0.2, 0.4 or 0.6% urea on pod properties, pod yield and mineral contents of *Phaseolus vulgaris*. Three application of urea at 15 days of intervals were used during the growth period. He found that there were no significant effects of the treatments on length and width of pods. All the levels of foliar application of urea significantly increased the number of pods per plot and pod yield, but 0.4% urea was the most effective.

Ibijbijen *et al.* (1996) conducted a pot experiment under glasshouse conditions to investigate the effect of inoculation with four *arbuscular mycorrhizal* (AM) fungi, to three nodulating bean (*Phaseolus vulgaris*) cultivars (Carioca, Negro Argel and Rio Tibagi). N derived from the atmosphere increased significantly with AM fungi inoculation, with Carioca showing the best response, followed by Negro Argel and Rio Tibagi, thereby showing the indirect and positive effect of AM fungi inoculation on the N₂ fixing association between *Rhizobium* and *Phaseolus vulgaris*.

Singh *et al.* (1996) carried out a field trial on *P. vulgaris* cv. HUR 15. Crop was irrigated at 0, 0.25, 0.50, 0.75 or 1.00 irrigation water:cumulative pan evaporation (IW:CPE) ratios and given no NPK fertilizers, 40:30:20 kg N:P₂O₅:K₂O/ha, or 2 or 3 times these application rates. Seed yield and net returns increased with up to 0.75 IW:CPE ratio and the highest NPK rate. Uptake of N, P and K increased with fertilizer rate and was highest at 0.75 IW: CPE.

Sharma *et al.* (1996) conducted an experiment to study the response of *Phaseolus vulgaris* cv. Uday to 40, 80 or 120 kg N/ha applied as 100% basal, 50% basal + 50% at 1st irrigation, 50% basal + 50% at 2nd irrigation or 33% each at basal, 1st and 2nd irrigation. They found that increasing level of N significantly increased seed yield, number and weight of pods/ plant and number of seeds/ pod up to 120 kg N/ha. Application of N in three equal splits gave higher seed yield and yield attributes of the crop.

El-Nabarawy (1997) conducted a greenhouse study to evaluate the effect of the presence or absence of N at various periods of growth of bean plants (*Phaseolus vulgaris* cv. Giza 3) in sand culture. Plants were either (i) deprived of N after initial growth in complete nutrient solution or (ii) treated with N after initial growth under nutrient deprivation. The presence or absence of N during the first 14 weeks after planting (12 weeks after thinning) was considered very important for bean growth, development and green pod production. Omission of N for the first 3 weeks significantly reduced shoot and whole plant dry matter as well as the accumulation of N, P and K in different plant organs. Such reduction increased with increasing periods of initial N deprivation. The highest N efficiency ratio for green pod dry matter production was achieved when N was applied during the first 12 weeks after thinning. The highest dry matter production and N, P and K absorption was recorded for plants treated with N at 6-9 weeks after thinning.

Nandan and Prasad (1998) carried out a field trial in which *P. vulgaris* cv. Uday was given 6 irrigation treatments based on either IW:CPE ratio or different fixed intervals, and received 40, 80 or 120 kg N/ha. They observed that seed yield in the first year was highest (1.31 t/ha) when given 3 irrigations at 25, 50 and 75 days after sowing, while in the second year the highest yield of 1.35 t was obtained with irrigating at a 0.8 IW:CPE [irrigation water:cumulative pan evaporation] ratio. Yield and water use efficiency increased with increasing N rate in both years.

Rana *et al.* (1998) conducted a field trial to study the effect of N (0, 40, 80 and 120 kg N/ha) and P (0, 50 and 100 kg P₂O₅/ha) on dry matter production and uptake of N and P in french bean (*Phaseolus vulgaris* cv. PDR 14) on sandy loam soil. Dry matter production (seed and straw) increased significantly up to 120 kg N/ha. N content and uptake of N and P also exhibited a similar trend. Increase in seed dry matter, P content and uptake of N and P was significant up to 100 kg P₂O₅/ha. Straw dry matter increased significantly up to 50 kg P₂O₅/ha.

Rana and Singh (1998) conducted a field trial in which *Phaseolus vulgaris* cv. PDR 14 grown on sandy-loam soil (pH 7.6, low in organic carbon and available N and medium in available P and K) was given 0, 40, 80 or 120 kg N and 0, 50 or 100 kg P₂O₅/ha. They concluded that seed and straw yields increased significantly with each increment in N rate in both seasons. The mean increases in seed yield with 120 kg N/ha compared with 0, 40 and 80 kg N/ha was 66.6, 21.7 and 7.0% respectively. Growth and yield parameters generally followed the same trend. Seed yield was also increased by applied P and 100 kg P₂O₅/ha gave 39.8 and 7.4% more yield than 0 and 50 kg P₂O₅/ha, respectively.

Arya *et al.* (1999) reported that different doses of NPK combinations (N at 25 and 50 kg/ha, P₂O₅ at 50, 75, 100 and 125 kg/ha, and K₂O at 50 and 100 kg/ha) were applied to *P. vulgaris* cv. Contender. High doses of N and K increased the days to 50% flowering (e.g., 50 days with N50 + P75 + K100), but high P and lower K induced early flowering (e.g., 47 days with N50 + P100 + K50). Highest 100-seed weight (46.78 g) was achieved with N50 + P125 + K50. The highest seed germination percentage (90.2%) and seed vigour index (916.0) were recorded with N25 + P50 + K50. Seed yield was highest (13.27 q/ha) with N25 + P75 + K100. They concluded that N promotes growth and delays the generative phase and that P

positively affects seed yield. It is suggested that N25 + P75 + K50 is the best combination in terms of economics and seed yield.

Parmar *et al.* (1999) conducted an experiment on french bean treated with 3 N (0, 15 and 30 kg/ha) and 4 P rates (0, 30, 60 and 90 kg/ha). They observed that plant height, nodules per plant, number of pod per plant, seeds per pod, seed yield and N and P uptake increased with increased rates of N and P.

Sharma and Pathania (1999) reported that french bean grown with different N and P rates increased the yield with increasing N rates (0-60 kg/ha) and was highest with 60 kg P₂O₅/ha.

Tewari and Singh (2000) conducted a study to determine the optimum and economical dose of nitrogen (0, 40, 80, 120 or 160 kg/ha) and phosphorus (0, 20, 40 or 60 kg/ha) for better growth and seed yield of french bean. They found that plant height, number of branches and length of pod increased with successive increase in the doses of nitrogen as well as phosphorus. Application of 120 kg N/ha produced significantly higher number of pods per plant, weight of seeds per plant, number of seeds per pod and seed yield. Whereas 160 kg N/ha significantly reduced seed yield. The highest values on the above yield attributes were recorded with 60 kg P₂O₅/ha. The combination of 120 kg N + 60 kg P₂O₅/ha along with 60 kg K₂O/ha gave the highest seed yield, net profit and net return per rupee investment followed by 120 kg N + 40 kg P₂O₅/ha.

Ramakrishna *et al.* (2001) carried out a field experiment to study the effects of spacing (30x15, 30x20 and 40x20 cm²) and N fertilizer (45, 60 and 75 kg/ha) on leaf area and leaf area index of french bean (*Phaseolus vulgaris*) cultivars Arka Komal and Burpee Stringless. The highest leaf area was obtained with Burpee Stringless, 40x20 cm² spacing and 75 kg N/ha at 30, 45 and 60 days after sowing and at harvest. On the other hand, leaf area index was highest with Arka Komal, 30x15 cm² spacing and 75 kg N/ha.

Sharma (2001) conducted an experiment on french bean with 4 levels (40, 80, 120 and 180 kg/ha) of N and 3 levels (30, 60 or 90 kg/ha) of P. The highest green pod and seed yield were obtained at 120 kg N/ha. P application also showed positive response. The effect of interaction between N and P was also significant.

Singh *et al.* (2001) carried out a field experiment to evaluate the effects of N (80, 160 and 240 kg/ha) and S (0, 20, 40 and 60 kg/ha) on the nutrient uptake and grain yield of french bean (*Phaseolus vulgaris*) cv. HUR 137. N at 240 kg/ha recorded the highest grain (2091 kg/ha) and straw (3331 kg/ha) yields and the highest total N (90.70 kg/ha) and S (6.58 kg/ha) uptake. S at 40 kg/ha recorded the highest grain yield (1811 kg/ha) and the highest total N (77.45 kg/ha) and S (6.06 kg/ha) uptake. S at 60 kg/ha recorded the highest straw yield (2578 kg/ha), which was at par with that obtained with S at 40 kg/ha (2558 kg/ha). Analysis of the interaction between N and S showed that N at 240 kg/ha+S at 40 kg/ha had the highest grain protein content (21.49%).

Singh and Verma (2002a) reported that a marked increase in growth, yield attributes and yield was observed due to application of organic and inorganic, alone and in combinations. FYM @ 10 tones and their combinations, FYM @ 10 tonnes + 75% of recommended dose of fertilizer gave the higher net return and benefit.

Singh and Verma (2002b) conducted an experiment for two years with 5 nitrogen (0, 30, 60, 90 and 120 kg/ha) and 3 phosphorus (0, 30 and 60 kg/ha) levels to study their impact on the growth, yield attributes, yield and economics of french bean (*Phaseolus vulgaris*) cv. PDR 14. They found that highest rates of nitrogen (120 kg/ha) and phosphorus (60 kg/ha) resulted in the highest plant height, branches per plant, pods per plant, seeds per pod, 100-seed weight, net return and grain (19.17 and 21.19 q/ha with 120 kg N/ha; and 16.65 and 18.68 q/ha with 60 kg P/ha) and straw yields (24.79 and 29.76 q/ha with 120 kg N/ha; and 21.77 and 24.76 q/ha with 60 kg P/ha) in 1995-96 and 1996-97 respectively.

Datt *et al.* (2003) studied the effect of NPK fertilization with and without FYM on productivity of vegetable pea cv. Azad Pea-1. The NPK fertilization in combination with FYM increased all these characters significantly. Application of FYM alone at the rate of 10t/ha increased the green pod yield by 60% over the control. A consistent increase in pod yield, uptake by nutrients and improvement in fertility status was observed with each increment in NPK fertilizers alone with a constant level of FYM. Maximum green pod yield was recorded in NPK 30: 39.3: 37.5 along with 10t FYM which was statistically superior to rest of the treatments. The yield recorded under NPK 20:26.2:25 alone thereby curtailing the recommended dose by 25 per cent.

Prajapati *et al.* (2003) reported that unweeded crop without nitrogen application reduced the seed yield of french bean by 51.5 and 18.0 % as compared with pendimethalin 0.75 kg/ha + one hand weeding at 45 DAS and 120 kg/ha N respectively. Application of 120 kg N/ha enhanced significantly higher growth and yield attributing parameters as well as seed yield of french bean.

Santos *et al.* (2003) reported that maximum economical grain yield of 2.700 kg/ha was obtained in Perola with the application of 167 kg/ha N incorporated in the soil at 20 days after plant emergence. The N rate of 108 kg/ha provided 90% of maximum grain yield.

Lal (2004) investigated the effects of N (at 0, 20, 40 and 60 kg/ha) and P (at 0, 30, 60 and 90 kg/ha) on the seed yield of pea cv. Arkel and french bean (*Phaseolus vulgaris*) cv. Contender. He concluded that N at 40 kg/ha was optimum for obtaining the maximum pea and bean seed yields. Seed yield of both crops increased with increasing P rates up to 60 kg/ha.

Bildiric and Yilmaz (2005) carried out the experiment to find out the effects of bacteria inoculation, four different nitrogen (0, 20, 40, 60 kg/ha N) and four different phosphorus (0, 40, 60, 80 kg/ha) doses on field bean. Although the effects of the applications showed differences depending on years, nitrogen application exerted a significant and positive effect on pod number, grain yield and raw protein proportion, whereas no significant effect was seen on seed number per pod and weight of thousand seeds. As for the effects of phosphorus doses, they weren't found to be significant for all of the factors. On the other hand, bacteria inoculation exerted a significant and positive effect on pod number per plant and grain yield, whereas no effect of this application was seen on weight of thousand seeds and raw protein rate.

Band *et al.* (2007) conducted an experiment during rabi season to study the effect of nutrient management treatments on growth and yield of french bean. Results showed that 100% RDF (90 kg N and 60 kg P₂O₅ha⁻¹) recorded significantly more plant height, functional leaves, leaf area plant⁻¹, number of branches plant⁻¹ and dry matter straw yield ha⁻¹. Results further indicated that, 100% RN was at par with the application of 75% RN + 25% N through FYM or vermicompost + biofertilizers (*Rhizobium* + PSB). Uptake of N, P, and K was maximum with the application of 100% RDF. Total N (%) was found to be increased to the tune of 7.0%

over full RDF due to 50% RN + 50% N through FYM or vermicompost and also biofertilizers. However, available N, P, K was increased to the tune of 14.0, 24 and 11% due to 50% RN + 50% N through FYM.

Mahase *et al.* (2007) conducted an experiment to study the effects of nitrogen and irrigation levels on french bean (*P. vulgaris* cv. VL-63). They reported that the nitrogen level 105 kg N ha⁻¹ proved significantly superior with respect to yield attributes, yield and water use efficiency than 75 kg N ha⁻¹ and 45 kg N through urea + 45 kg N through FYM, while 90 kg N ha⁻¹ was at par in terms of yield attributes and yield with 105 kg N ha⁻¹. Among the interaction effects for grain yield, irrigation at an IW: CPE ratio of 1:00 and 90 or 105 kg N ha⁻¹ was superior.

Rahman *et al.* (2007) carried out a trial to find out the optimum rates of N and P for yield maximization of french bean. Four levels of nitrogen (0, 100, 150 and 200 kg/ha) and 3 levels of phosphorus (0, 40 and 60 kg/ha) were used in the experiment. Among the N levels, the highest pod yield (13.33 t ha⁻¹ at Jamalpur & 14.68 t ha⁻¹ at Joydebpur) was obtained with 150 kg N ha⁻¹. Interaction effect was not significant. However, highest pod yield was obtained from 150 kg N plus 60 kg P ha⁻¹. Economic analysis showed that 150 kg N plus 40 kg P ha⁻¹ gave the highest gross margin of Tk. 1,66,684/ha.

Kovacs *et al.* (2008) conducted a greenhouse pot experiment to investigate the effects of nitrogen (N) and sulphur (S) fertilization on the yield of garden bean (*Phaseolus vulgaris* L.). Four levels of nitrogen (0.36, 0.66, 0.96, 1.27 g/pot as NH₄NO₃ and NH₄ H₂PO₄ in combination with three levels of S (0.23, 0.46, 0.92 g/pot as K₂SO₄) were tested as treatments. It was concluded, that neither nitrogen nor sulphur has any statistical effect on the quantity of straw, they increased only the weight the pods. With increasing nitrogen the ratio of fresh and dry weights of crop yield to straw increased significantly.

Chaudhry (2009) conducted a field experiment during the winter seasons to study the effect of row spacing, seed rate and nitrogen levels on growth and yield of french bean (*Phaseolus vulgaris*). He reported that grain yield showed significant increase up to 160 kg N/ha. The optimum economic dose computed from quadratic response equation was found 152.5 kg N/ha with estimated grain yield of 29.15q/ha. Stover yield also behaved in almost similar manner under different treatments.

Singh *et al.* (2009) carried out a field study to assess the effect of nitrogen doses on growth and yield parameters of french bean varieties during kharif and rabi. Three levels (180 kg/ha, 120 kg/ha and 80 kg/ha) of nitrogen doses were applied on ten varieties. Among the varieties, the variety CH-812 recorded highest green pods per plot, number of pods per plant, pod diameter, number of green seeds per pod and green pod yield per plant in addition to earliest in flowering. It was observed that varieties early in flowering recorded higher green pod yield under all three N application regimes. Variety VL-65 recorded the highest number of branches per plant and pod length. Variety Pant Anupama and IVRFB-3 showed highest response for days to flowering and green pods per plot respectively, with higher dose of nitrogen application. Variety CH-812 was found most suitable for cultivation with high nitrogen application (180 kg/ha) for higher green pod yield in hilly areas of J&K.

2.3 Interaction effect of varieties and nitrogen levels:

Baboo *et al.* (1998) reported that in a field experiment 3 *Phaseolus vulgaris* cultivars (Contender, UPF 626 and PDR 14) were given 0, 40, 80 and 120 kg/ha N and 0, 50 and 100 kg P₂O₅/ha. All the varieties differed significantly among themselves in respect of growth and yield in both years. Cultivar PDR 14 gave the highest yield followed by UPF 626 and Contender. Nitrogen application significantly enhanced the growth, yield attributes and yield of french bean during both the season. Seed yield increased significantly with each successive increment in N upto 120 kg/ha during both years. However difference in yield due to 40 and 80 kg N/ha during 1992-93 was not significant.

Farkade and Pawar (2002) conducted a field experiment to determine the effect of N:P fertilizers at 60:45, 90:75 and 120:75 kg/ha on *Phaseolus vulgaris* cultivars PDR-14, HUR-137 and VL-63. The yield and growth characters increased with increasing N:P fertilizer level and the highest (15.93 q/ha) was observed in VL-63 at 120:75 kg/ha.

Vishwakarma *et al.* (2002) studied the response of two french bean (*Phaseolus vulgaris* L.) cultivars (Holland 84 and PDR 14) to different nitrogen application rates (0, 30, 60 and 90 kg/ha) on sandy loam soil. They reported that both cultivars showed differential performance for growth and yield attributes.

Holland 84 was the tallest, whereas PDR 14 recorded the highest dry matter production per plant as well as pods per plant, grains per pod, grains per plant, pod length and 100-grain weight. The growth, yield attributes and yield (grain and stover) increased with increasing rates of nitrogen up to 90 kg/ha.

Begum *et al.* (2003) conducted experiment to find out morphological variability in response to different sowing time and fertilizer treatments with two varieties of french bean. Fertilizer treatments had significantly different effects on plant height and number of pods per plant. The interaction of sowing dates and varieties had significant effects on the above characters except plant height. The best morphological and reproductive attributes performance was observed in January sowing and highest fertilizer treatments combination.

Abdel-Mawgoud *et al.* (2005) carried out experiment to evaluate the growth and yield performance of some french bean varieties (*Phaseolus vulgaris* L.) i.e. Royal Nel, Duel, Coby and Julia and their responses to different levels of NPK fertilization. The four mentioned varieties were fertilized with four NPK levels i.e. 20: 32: 24; 30: 48: 36; 40: 64: 48; or 50: 80: 54. Data showed that cvs. Royal Nel and Coby recorded the highest values in vegetative growth while cv. Julia was the lowest. Increasing the level of NPK resulted in a positive response in the vegetative growth. Coby and Royal Nel cultivars recorded the highest and lowest pod yield, respectively. Early and exportable yields were about 10 and 71 % of total yield, respectively. Yield increased as the level of NPK increased meanwhile, pod quality i.e. pod length, thickness and fiber content were not significantly affected by the level of NPK applications. With the same pattern of response to NPK Level, genotype of each cultivar was the predominant factor in the interactive response.

Filho *et al.* (2007) conducted an experiment to evaluate the response of common bean cultivars (Perola and IAC Una) to top dressed nitrogen (0, 50, 100 & 150 kg/ha of nitrogen) in a no-tillage system. The cultivar Perola, in comparison with IAC Una showed greater response and efficiency in the use of top dressed nitrogen, and this resulted in higher yield. Top dressed nitrogen doses promote linear increase in yield of Perola in a no-tillage system.

CHAPTER III

MATERIAL AND METHODS

This chapter comprises of the methods employed and material used during the course of investigation entitled “Effect of nitrogen levels on yield and quality of seed in french bean”. The details of the material and methods are being given under the following heads:

3.1 Experimental Site:

The experiment was conducted during Rabi season of 2009-10 at Bahadari farm, College of Horticulture, Mandsaur, Madhya Pradesh. Mandsaur lies in western part of Madhya Pradesh, between latitude of 23° 45' to 24° 13' North, longitude of 74° 44' to 75° 18' East and at an altitude of 435.20 m above mean sea level. This region is under Malwa Plateau agro climatic zone of the state. The topography of the experimental field is plain.

3.2 Climatic Conditions:

Mandsaur has sub-tropical and semi-arid climatic conditions with a temperature range of 4°C minimum and 45°C maximum in winter and summer respectively. In this region maximum rainfall is received during mid June to September. The average annual rainfall is 537.65 mm. South - West monsoon is responsible for major part of annual precipitation. Meteorological data recorded during the period of investigation are presented in Table 3.1 and Figure 3.1.

Table 3.1: Meteorological data during the period of investigation from October 15, 2009 to February 18, 2010

Months and year	Standard meteorological week	Average weekly Temperature (°C)		Mean RH (%)	Soil Temp. (°C)	Weekly Rainfall (mm)
		Min.	Max.			
Oct.' 09	41	21.30	30.31	64.00	21.20	Nil
	42	20.89	29.05	50.42	20.75	Nil
	43	20.95	28.50	41.40	21.50	Nil
Nov.' 09	44	20.00	29.00	38.41	20.00	Nil
	45	18.90	28.81	45.85	20.00	Nil
	46	10.00	26.45	44.85	20.00	Nil
	47	9.77	27.78	51.00	20.00	Nil
Dec.' 09	48	12.20	29.14	72.57	20.00	Nil
	49	11.34	25.4	87.14	20.50	Nil
	50	10.05	26.74	64.28	20.00	Nil
	51	7.88	23.75	75.42	20.00	7.5
	52	4.91	23.14	54.14	20.00	Nil
Jan.' 10	01	6.24	27.4	52.4	20.00	Nil
	02	11.48	29.31	45.14	20.00	Nil
	03	12.78	29.51	46.00	20.00	Nil
	04	11.84	29.07	50.23	20.00	Nil
Feb.' 10	05	10.63	28.41	45.14	20.00	Nil
	06	15.70	29.55	44.85	20.00	Nil
	07	16.00	30.10	45.20	20.00	Nil

Source: Meteorological observatory of the College of Horticulture, Mandsaur (M. P.)

3. Soil:

The soil of the experimental field was medium black (Vertisols), clay in texture with uniform topography. Soil samples were collected randomly up to a depth of 20 cm from the experimental field with the help of soil auger before sowing of seeds. All the soil samples were mixed to prepare a homogeneous sample, sieved through 2 mm sieve and finally used for physical and chemical analysis. The results are presented in Table 3.2.

Table 3.2: Physico-chemical properties of soil

S.N.	Composition	Content	Category	Methods
(i)	Sand	46%	-	By Bouyoucos Hydrometer
(ii)	Silt	34 %	-	By Bouyoucos Hydrometer
(iii)	Clay	20%	-	By Bouyoucos Hydrometer
(iv)	Texture	-	Clay	
(v)	Soil pH	7.3	Normal	Glass electrode pH meter
(vi)	Electrical Conductivity (dSm ⁻¹)	0.34	-	By conductivity bridge at 25°C
(vii)	Available Nitrogen (Kg/ha)	180.0	Low	Walkley and Black (1934)
(viii)	Available Phosphorus (Kg/ha)	18.0	Medium	Olson's extraction method (Olson <i>et al.</i> 1954)
(ix)	Available Potassium (Kg/ha)	360.0	High	Flame photometer (Ghosh <i>et al.</i> 1981)

Table 3.3: Previous year crop history of the experimental field

Year	Season	
	Kharif	Rabi
2008 - 2009	Soybean	Opium
2009 - 2010	Moong	

3.4 Experimental Details:

3.4.1 Experimental Design and Layout:

1. Design of Experiment : Factorial Randomized Block Design
2. Number of replications : 3
3. Number of treatments : 15
4. Total number of plots : 45
5. Name of crop : French bean (*Phaseolus vulgaris* L.)
6. Spacing
 - Row to Row : 45 cm
 - Plant to plant : 15 cm
7. Plot Size
 - Gross : $2.40 \times 3.15 \text{ m}^2 = 7.56 \text{ m}^2$
 - Net : $2.10 \times 2.25 \text{ m}^2 = 4.72 \text{ m}^2$
8. Distance between treatments : 0.5 m
9. Distance between replications : 1.0 m
10. Gross area of experiment : 492.35 m^2
11. Season : Rabi 2009-10
12. Date of sowing : 15th October 2009
13. Date of harvesting : 18th February 2010

3.4.2 Treatment Details :

The details of the treatment are given below along with their notations.

Varieties : 3

V_1 : Swaran Priya

V_2 : Arka Komal

V_3 : Contender

Nitrogen levels : 5

N_1 - 25 kg /ha N

N_2 - 50 kg /ha N

N_3 - 75 kg /ha N

N_4 - 100 kg /ha N

N_5 - 125 kg /ha N

3.4.3 Treatment Combinations :

The following treatment combination were tested under this investigation

$T_1 - V_1N_1$

$T_6 - V_2N_1$

$T_{11} - V_3N_1$

$T_2 - V_1N_2$

$T_7 - V_2N_2$

$T_{12} - V_3N_2$

$T_3 - V_1N_3$

$T_8 - V_2N_3$

$T_{13} - V_3N_3$

$T_4 - V_1N_4$

$T_9 - V_2N_4$

$T_{14} - V_3N_4$

$T_5 - V_1N_5$

$T_{10} - V_2N_5$

$T_{15} - V_3N_5$

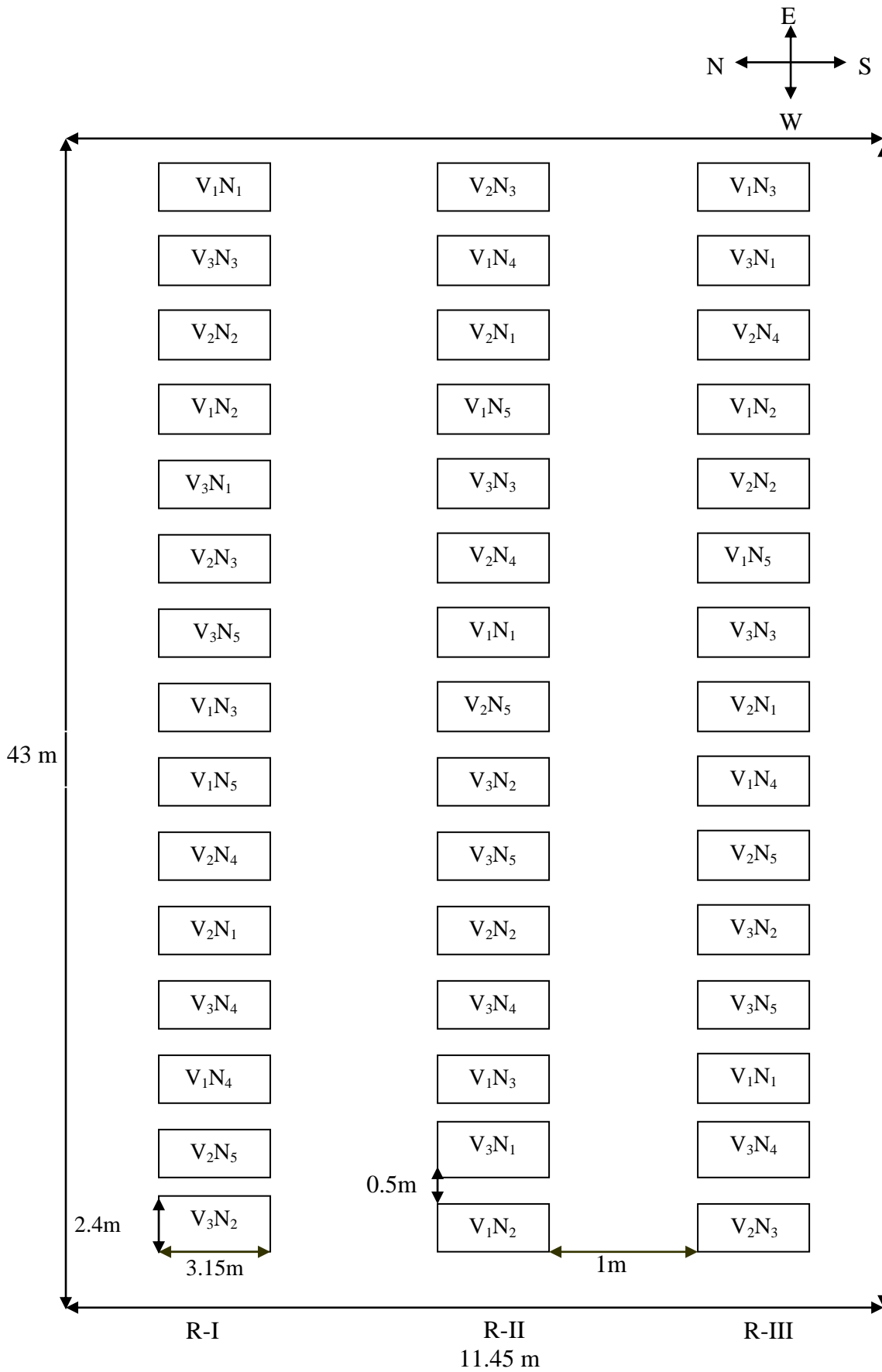


Fig. 3.2 Layout plan of the experimental field

3.5 Experimental Operations:

3.5.1 Field Preparation:

Field was ploughed with tractor drawn mould board plough. Thereafter cross harrowing was done followed by planking to make the field leveled and of good tilth.

3.5.2 Fertilizer Application:

Nitrogen, phosphorus and potassium were provided through Urea, DAP, SSP and Muriate of Potash. Sulphur was supplied through elemental sulphur. According to the treatment, the full quantity of phosphorus, potash and sulphur and half of nitrogen was applied as basal at the time of sowing. While the remaining ½ quantity of nitrogen was applied 30 days after sowing.

3.5.3 Seed:

Pure, healthy and good quality seed of french bean varieties viz., Swaran Priya, Arka Komal and Contender were obtained from Department of Vegetable Science, College of Horticulture, Mandasaur, RVSKVV, Gwalior.

3.5.4 Sowing of Seed:

The seed was sown in furrows at a spacing of 45 x 15 cm at a depth of 3 - 4 cm.

3.5.5 Irrigation :

Irrigation was given as per need of the crop as given in table 3.4 below

Table 3.4: Irrigation schedule

S. No.	Irrigation	Date of irrigation
1	1 st	14 October 2009
2	2 nd	26 November 2009
3	3 rd	17 December 2009
4	4 th	31 December 2009
5	5 th	18 January 2010

3.5.6 Gap Filling:

The gap filling was carried out after 7 days of sowing, to maintain the plant population.

3.5.7 Intercultural Operation:

Weeding was done manually as well as by hand hoe three times at 25 days after sowing (DAS), 45 DAS and 65 DAS to remove weeds and to provide aeration.

3.5.8 Plant Protection Measures:

Seeds were treated with Mancozeb 75% WP before sowing. Dimethoate 30 EC (1ml/litre) were applied for the control of thrips. Spray of Endosulfan 35 EC (2ml/litre) + Neem oil (5ml/litre) was done to check the other insect pests. Prophylactic spray of Mancozeb 75% WP (2g/litre) was done to check the diseases.

3.5.9 Harvesting

Harvesting was done when the plants started drying up, pods became yellow and leaves started dropping.

3.6 Observations Recorded:

The observations were recorded at various successive growth stages. For taking observations five plants were selected randomly from each plot.

3.6.1 Growth Parameters:

(i) Plant height (cm): The height of five tagged plants was measured with the help of meter scale at 30, 45 and 60 days after sowing and at harvesting stage.

(ii) Number of leaves per plant: The number of leaves was counted in five tagged plant in each experimental plot at 30, 45 and 60 days after sowing. Thereafter, average number of leaves per plant was calculated at each stage.

(iii) Number of branch per plant: The number of branches in five tagged plants of each experimental plot was counted at 30, 45 and 60 days after sowing and their averages were worked out.

(iv) Leaf area index: The leaf area of five randomly selected plants in each experimental plot was measured with Systronics leaf area meter Licor 211 at 30, 45

and 60 days after sowing and thereafter averages were worked out at each stage. Leaf area index was calculated with the following formula

$$\text{Leaf area index} = \frac{\text{Leaf area per plant}}{45 \times 15}$$

(v) Fresh weight of shoot per plant (g): The fresh weight of five randomly selected plants from each plot was determined at 30, 45 and 60 days after sowing and at harvesting time.

(vi) Dry weight of shoot per plant (g): After taking fresh weight, plants were put in hot air oven at 65 ± 2 °C temperature for drying till constant weight. Final weight was noted and average was worked out at each stage.

(vii) Days to 50 per cent flowering: The date on which 50% plants were flowered was recorded and days taken for 50% flowering were worked out from the date of sowing.

3.6.2 Yield Parameters and Yield:

(i) Number of pods per plant: The total numbers of pods of five tagged plants were counted at harvesting and average was work out for each treatment.

(ii) Number of seed per pod: The total number of seed per pod was recorded from randomly selected five plants at the time of harvesting from each treatment. Thereafter, average was worked out.

(iii) Pod length (cm): Length of 10 randomly selected pods was measured and mean was calculated for each treatments.

(iv) Pod yield per plant (g): Pods were collected from five tagged plants at harvest and there weight was taken with the help of electronic balance. The readings were noted in grams and mean pod yield per plant was calculated.

(v) Pod yield (q) per hectare: Pod yield per hectare was calculated by following formula:

$$\text{Pod yield (q/ha)} = \frac{\text{Fresh weight of pod/plot (g)}}{\text{Net plot area} \times 1000 \times 100} \times 10000$$

(vi) Seed yield (g) per plant: The seed obtained from all the pods of each observational plant was weighed and mean seed yield per plant was calculated.

(vii) Seed yield (q) per hectare: Seed yield per hectare was calculated with the following formula:

$$\text{Seed yield (q/ha)} = \frac{\text{Seed yield/plot (g)}}{\text{Net plot area} \times 1000 \times 100} \times 10000$$

(viii) Shelling percentage: Shelling percentage was calculated by dividing total weight of seed with total weight of pods in the plot by following formula:

$$\text{Shelling percentage} = \frac{\text{Total weight of seed} \times 100}{\text{Total weight of pods}}$$

(ix) Harvest index: The harvest index was obtained by dividing the economic yield (seed yield) with total biological yield (pod yield + straw yield) and expressed as percentage.

$$\text{Harvest Index (\%)} = \frac{\text{Seed yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

3.6.3 Seed Quality Parameters:

(i) Test weight (g): One hundred seeds were taken randomly from different plants of each plot and their weight was recorded with the help of digital electronic balance. The average of seed weight was noted as test weight or weight of 100 seeds.

(ii) Germination percentage: One hundred seeds from each plot were kept in BOD Incubator at 20°C for determining the germination percentage. It was calculated with following formula:

$$\text{Germination (\%)} = \frac{\text{No. of normal germinated seeds}}{\text{Total No. of seed}} \times 100$$

(iii) Crude protein content (%)

Crude protein content in french bean seed was determined as given below:

Procedure for crude protein content in french bean seed

- (i) Weigh 0.5 g of plant sample into 500 ml dry (corning/borosil) conical flask.
- (ii) Add 25 ml of H_2SO_4 and add 1g Digestion mixture and digested the content on kel plus-kes-12 digestion.
- (iii) The digested samples were distilled off on kel-plus automatic nitrogen analyzer.
- (iv) Distill the sample by adding concentrate NaOH and steam for 10 minutes.
- (v) Absorb the ammonia gas in 20 ml standard boric acid added with drop of methyl red indicator.
- (vi) The protein content of the sample was calculated by multiplying percent nitrogen content in sample with the factor 6.25 (A.O.A.C., 1960).

3.6.4 Post Harvest Analysis of Soil:

3.6.4.1 Available nitrogen (Walkley and Black, 1934)

Procedure for available nitrogen analysis

- (i) 1 g of soil sample was taken into 500 ml dry distillation tube.
- (ii) Added 10 ml of $KMnO_4$ and 20ml of NaOH to it and distilled on kel-plus distil EM automatic nitrogen analyzer.
- (iii) 20 ml of Boric acid was taken in a conical flask.
- (iv) Added one drop of Methyl red indicator to it and absorb the distillate in the boric acid for 15 minutes.
- (v) 1 N HCl solution was taken in 50 ml burette.
- (vi) The Titrated contents until pink colour starts appearing for the reading for calculation.
- (vii) When the value was <6, repeated the procedure taking 0.2 to 0.5 g of soil sample.

3.6.4.2 Available phosphorus (Olsen *et al.* 1954)

Procedure for available phosphorus analysis

- (i) 2.5 g of soil sample was taken in 100 ml conical flask.
- (ii) A pinch of Darco G-60 and 50 ml of Olsen's reagents (0.5 M NaHCO₃, pH 8.5) added in 100 ml conical flask.
- (iii) Conical flask was shaken for 30 minutes on a mechanical shaker.
- (iv) The sample was kept under conical flask was filter through whatman's no. 1 filter paper.
- (v) 5 ml of clear and colorless filtrate transferd into a 25 ml volumetric flask.
- (vi) Gradually, 5 ml of ammonium molybdate solution containing 400 ml of 10N HCL per liter was added into filtrate.
- (vii) Shaken slowly and carefully to drive out the CO₂ evolved.
- (viii) When frothing completely ceases, distilled water added, washing down the sides, to bring the volume to about 22 ml.
- (ix) 1 ml of freshly diluted SnCl₂ solution was added into 22 ml volume and shaken little and made the volume up to 25 ml.
- (x) Reading of the blue colour intensity at 660 nm was recorded.

3.6.4.3 Available potassium (Ghosh *et al.* 1981)

Procedure for available potassium analysis

- (i) 5 g of soil sample was taken in 100 ml conical flask.
- (ii) 25 ml of the neutral 1 N ammonium acetate solution was added in 100 ml conical flask and it was shaken for 5 minutes.
- (iii) The solution prepared was filtered through whatman's no.1 filter paper.
- (iv) Using flame photometer, K concentration was measured in the filtrate.

3.6.4.4 Available Sulphur (Chesnin and Yein, 1951)

Procedure for available sulphur analysis

- (i) 2 gm of soil sample was taken in 100 ml conical flask.
- (ii) 25 ml of the neutral 1N ammonium acetate solution was added in 100 ml conical flask and shake for 5 minute.
- (iii) The solution prepared was filtered through Whatman's No.1 filter paper.

- (iv) 10 ml of the aliquot was transferred into a 25 ml volumetric flask.
- (v) 2 gm of Barium chloride and 2 ml of gum acacia was added in it and shaken it for 1 minute and made the volume up to 25 ml.
- (vi) Turbidity was measured, 25 to 30 minute after precipitation and read the white colour intensity at 420 nm with the help of spectrophotometer.
- (vii) Run a blank and prepared standard curve under identical manner.

3.6.5 Economics of the Treatments:

The cost of cultivation per hectare under different treatments was calculated on the basis of expenditure incurred on different operations for growing the crop separately under each treatment. The treatment wise net income was worked out by deducting the cost of cultivation from gross income per hectare. The cost: benefit ratio was also calculated by dividing gross income with cost of cultivation.

3.6 Statistical Analysis:

The data obtained from set of observation for each character were subjected to "Analysis of Variance" as advocated by Panse and Sukhatme (1984). The Skeleton of ANOVA as per design is as given in Table 3.5

Table 3.5: Skeleton of analysis of variance

Source of variation	Degree of freedom	Sum of square	Mean sum of square	"F" Value Calculated	"F" tab at _{5%}
Replication	r-1	RSS	RMS	RMS/EMS	
Varieties (V)	v-1	(V)SS	VMS	VMS/EMS	
Nitrogen level (N)	n-1	(N)SS	(N)MS	(N) MS/EMS	
Interaction (VxN)	v-1xn-1	(VN)SS	(VN)MS	(VN) MS/EMS	
Error	(r-1)(vn-1)	ESS	EMS		
Total	(rxvx n-1)				

The significance of the treatment difference was judged by using critical difference (C.D.), which was calculated by using formula given by Panse and Sukhatme (1984).

(i) C.D. for varieties:

$$\sqrt{\frac{\text{Error variance (EMS)} \times 2}{r \times n = 15}} \times t_{5\%} \text{ (3.34)}$$

(ii) C.D. for nitrogen levels:

$$\sqrt{\frac{\text{Error variance (EMS)} \times 2}{r \times v = 9}} \times t_{5\%} \text{ (2.71)}$$

(iii) C.D. for Interaction (VXF):

$$\sqrt{\frac{\text{Error variance (EMS)} \times 2}{r = 3}} \times t_{5\%} \text{ (2.29)}$$

Where,

r = Number of replications

f = Number of Nitrogen levels

V= Number of varieties

t ='t' Table value at error degree of freedom

CHAPTER - IV

RESULTS

The findings of the study entitled “Effect of nitrogen levels on yield and quality of seed in french bean” in relation to growth attributes, yield attributes, yield and seed quality as well as post harvest analysis of available nutrients in the soil have been presented after due statistical analysis as given below :

4.1 Growth Parameters:

The growth of french bean was studied with respect to plant height, number of leaves per plant, number of branch per plant, leaf area index, fresh weight of shoot and dry weight of shoot (g) per plant at various stages:

4.1.1 Plant height (cm)

The plant height was recorded at 30, 45, 60 days after sowing (DAS) and at the time of harvesting. The results presented in Table 4.1 and depicted in Figure 4.1 revealed significant differences of varieties and nitrogen levels at all the stages. There was linear increase in plant height with advancement of crop period which was reduced slightly at harvesting stage as compared to 45 and 60 days after sowing.

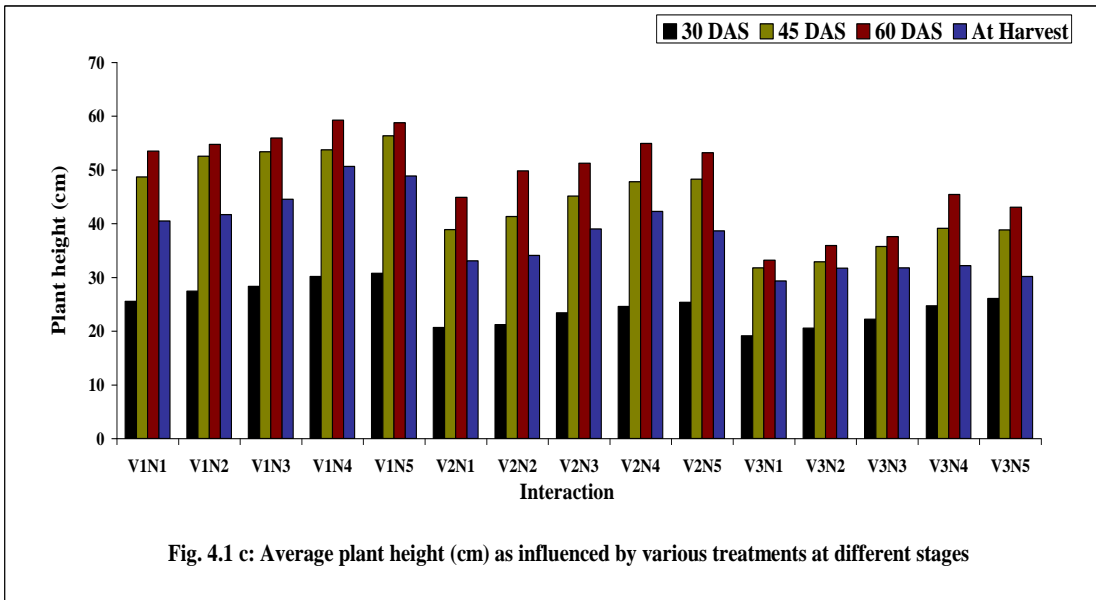
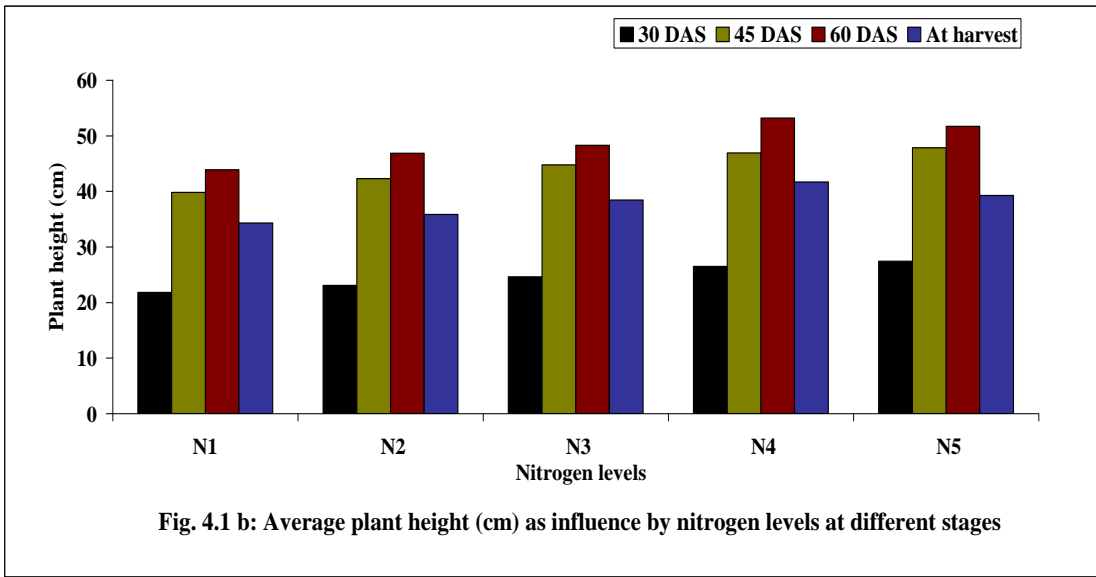
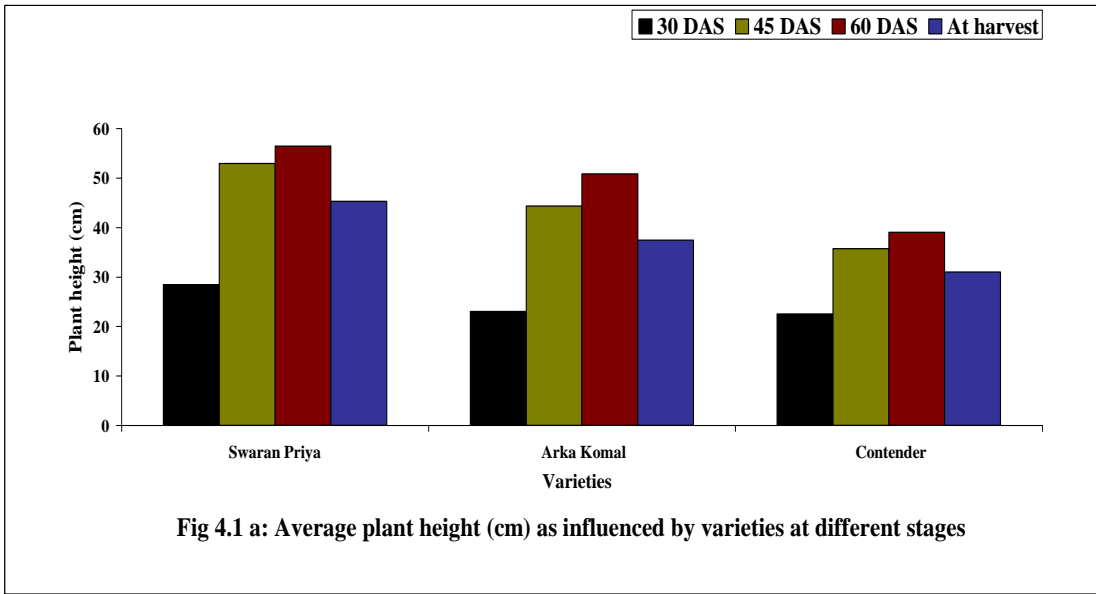
Among the different varieties highest plant height was recorded in Swaran Priya followed by Arka Komal and Contender with significant difference at all the stages. Though the difference between Arka Komal and Contender at 30 days after sowing was non significant.

There was increase in plant height with increased dose of nitrogen at 30 and 45 DAS. However, at 60 DAS and at harvesting stage increase in plant height was observed up to 100 kg/ha nitrogen. Further increase in nitrogen application showed a slight reduction in plant height, which was non significant.

Combined effect of nitrogen levels did not significant influence on plant height at any stages.

Table 4.1: Average plant height (cm) as influenced by varieties, nitrogen levels and their combinations

Treatment	30 DAS	45 DAS	60 DAS	At harvest
Varieties (V)				
V ₁ (Swaran Priya)	28.44	52.94	56.44	45.25
V ₂ (Arka Komal)	23.04	44.29	50.81	37.40
V ₃ (Contender)	22.52	35.68	39.04	31.02
S.Em±	0.92	1.44	1.21	0.70
CD at 5%	2.67	4.17	3.50	2.03
Nitrogen levels (N)				
N ₁ (25 kg/ha N)	21.77	39.80	43.84	34.29
N ₂ (50 kg/ha N)	23.06	42.26	46.82	35.81
N ₃ (75 kg/ha N)	24.63	44.74	48.27	38.43
N ₄ (100 kg/ha N)	26.48	46.88	53.20	41.70
N ₅ (125 kg/ha N)	27.39	47.81	51.69	39.22
S.Em±	1.19	1.86	1.56	0.90
CD at 5%	3.45	5.38	4.52	2.62
Interaction (V x N)				
V ₁ N ₁	25.52	48.71	53.47	40.50
V ₁ N ₂	27.42	52.55	54.73	41.70
V ₁ N ₃	28.33	53.37	55.93	44.53
V ₁ N ₄	30.17	53.72	59.27	50.65
V ₁ N ₅	30.76	56.33	58.80	48.86
V ₂ N ₁	20.68	38.91	44.87	33.06
V ₂ N ₂	21.22	41.35	49.81	34.06
V ₂ N ₃	23.36	45.11	51.27	39.00
V ₂ N ₄	24.59	47.77	54.93	42.26
V ₂ N ₅	25.33	48.29	53.20	38.63
V ₃ N ₁	19.12	31.77	33.20	29.30
V ₃ N ₂	20.54	32.90	35.93	31.68
V ₃ N ₃	22.18	35.75	37.60	31.75
V ₃ N ₄	24.67	39.15	45.40	32.17
V ₃ N ₅	26.09	38.81	43.07	30.18
S.Em±	2.06	3.22	2.70	1.56
CD at 5%	NS	NS	NS	NS



4.1.2 Number of leaves per plant

Number of leaves per plant was recorded at 30, 45 and 60 days after sowing. The findings presented in Table 4.2 and depicted in Figure 4.2 exhibited significant influence of varieties and level of nitrogen. Combined effect of nitrogen and variety showed no significant effect on number of leaves per plant.

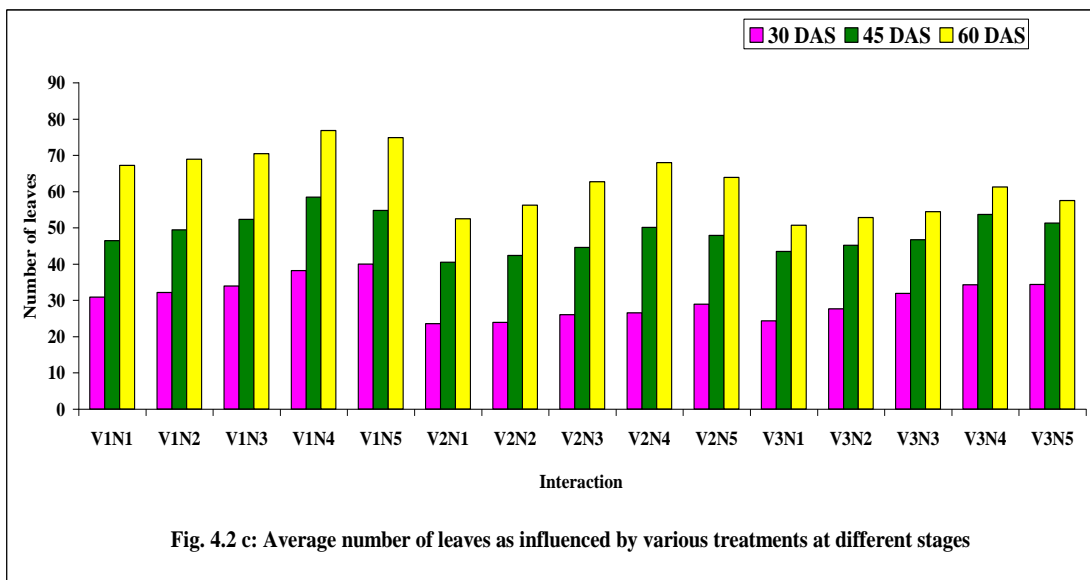
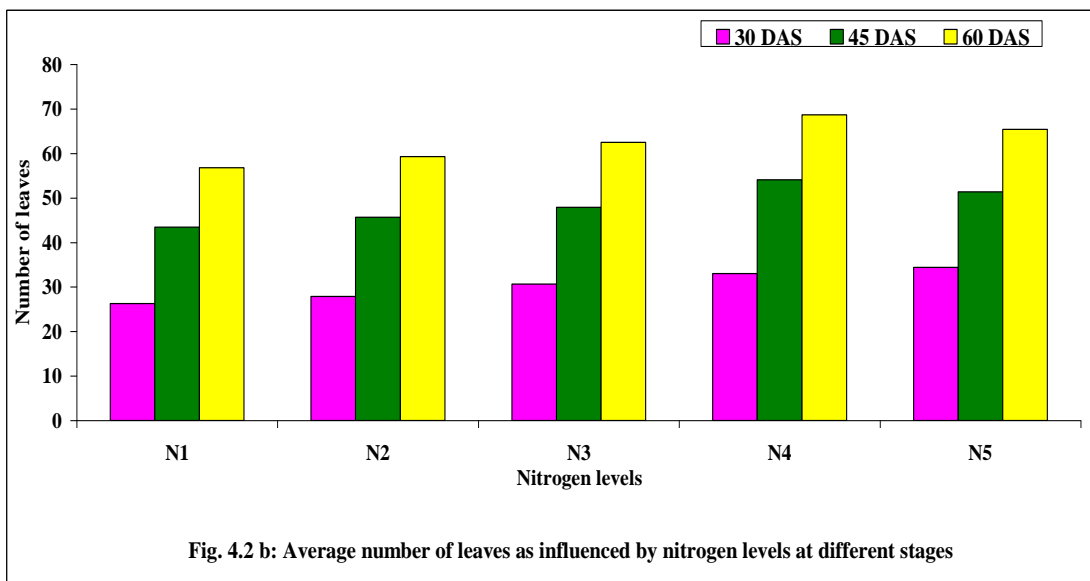
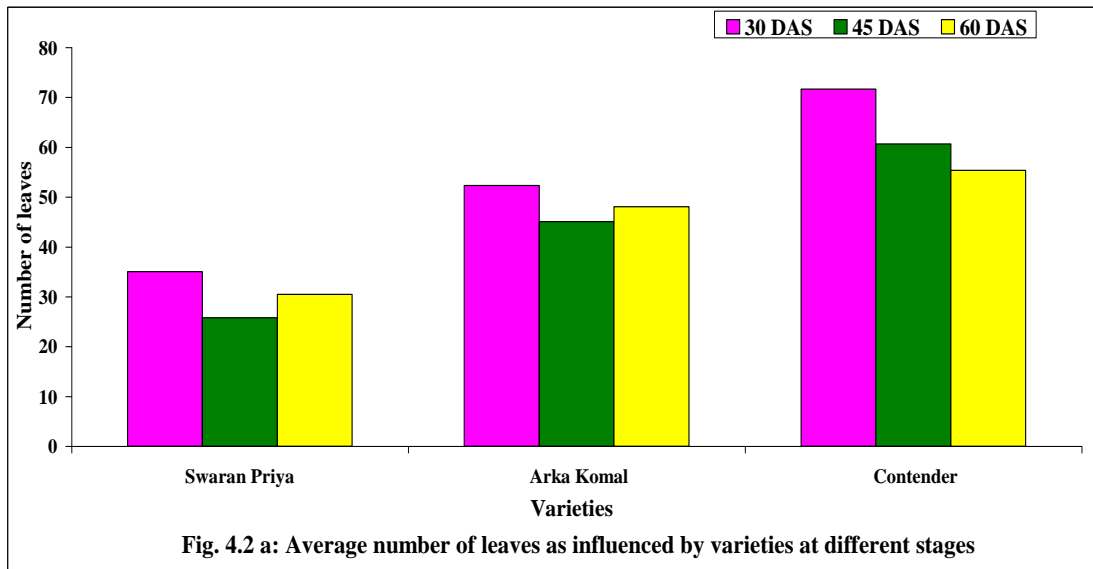
Among the varieties maximum number of leaves was recorded with Swaran priya followed by Contender and Arka komal at 30 and 45 days after sowing. At 60 days after sowing variety Swaran Priya showed maximum number of leaves followed by Arka Komal and Contender in descending order.

Nitrogen levels showed increase in number of leaves with each increase in nitrogen levels up to 100 kg per hectare. Further increase in nitrogen application showed no remarkable influence or slight reduction.

Combined effect of varieties and nitrogen level showed non significant influence on number of leaves per plant at 30, 45 days after sowing as well as 60 days after sowing. Though numerically 30 days after sowing maximum number of leaves was recorded with variety Swaran Priya under application of 125 kg nitrogen per hectare, followed by V_1N_4 , V_3N_5 , V_3N_4 and least number of leaves was recorded in V_2N_1 . Whereas 45 and 60 days after sowing maximum number of leaves was recorded with V_1N_4 followed by V_1N_5 .

Table 4.2: Average number of leaves per plant as influenced by varieties, nitrogen levels and their combinations

Treatment	30 DAS	45 DAS	60 DAS
Varieties (V)			
V ₁ (Swaran Priya)	35.03	52.29	71.6
V ₂ (Arka Komal)	25.80	45.11	60.6
V ₃ (Contender)	30.49	48.05	55.3
S.Em±	1.11	1.43	1.73
CD at 5%	3.21	4.15	5.01
Nitrogen levels (N)			
N ₁ (25 kg/ha N)	26.27	43.47	56.80
N ₂ (50 kg/ha N)	27.89	45.64	59.31
N ₃ (75 kg/ha N)	30.62	47.89	62.51
N ₄ (100 kg/ha N)	33.00	54.09	68.67
N ₅ (125 kg/ha N)	34.42	51.33	65.40
S.Em±	1.43	1.85	2.23
CD at 5%	4.15	5.36	6.47
Interaction (V x N)			
V ₁ N ₁	30.87	46.47	67.20
V ₁ N ₂	32.13	49.40	68.93
V ₁ N ₃	33.93	52.33	70.40
V ₁ N ₄	38.20	58.47	76.80
V ₁ N ₅	40.00	54.80	74.87
V ₂ N ₁	23.60	40.47	52.47
V ₂ N ₂	23.87	42.40	56.20
V ₂ N ₃	26.07	44.60	62.73
V ₂ N ₄	26.53	50.13	67.93
V ₂ N ₅	28.93	47.93	63.87
V ₃ N ₁	24.33	43.47	50.73
V ₃ N ₂	27.67	45.13	52.80
V ₃ N ₃	31.87	46.73	54.40
V ₃ N ₄	34.27	53.67	61.27
V ₃ N ₅	34.33	51.27	57.47
S.Em±	2.48	3.20	3.87
CD at 5%	NS	NS	NS



4.1.3 Number of branches per plant

Number of branches per plant was recorded at 30, 45 and 60 days after sowing. The result presented in Table 4.3 and depicted in Figure 4.3 revealed significant influences of varieties, nitrogen levels and combined effect of varieties and nitrogen levels. Among the varieties Swaran Priya recorded significantly the highest number of branches per plant as compared to other varieties. It was followed by Arka Komal and Contender, though the difference between these two varieties at 45 and 60 days after sowing was non significant. Though at 30 days after sowing variety Contender showed higher number of branches than Arka komal.

Application of nitrogen revealed significant influence on number of branch per plant. There was linear increase in number of branches with increasing dose of nitrogen up to 100 kg per hectare. Further increase in nitrogen level showed significant reduction in number of branches at 125 kg per hectare. Whereas at 30 days after sowing the difference in number of branches at 100 kg per hectare and 125 kg per hectare was non significant.

Combined effect of variety and nitrogen levels showed non significant influence on number of branches per plant at all the stages. Numerically 30 days after sowing, maximum number of branches was observed for variety Swaran Priya under 125 kg nitrogen applications. It was followed by V_3N_5 , V_1N_4 and least number of branches was recorded for V_2N_1 . At 45 and 60 days maximum number of branches where recorded with V_1N_4 .

Table 4.3: Average number of branch per plant as influenced by varieties, nitrogen levels and their combinations

Treatment	30 DAS	45 DAS	60 DAS
Varieties (V)			
V ₁ (Swaran Priya)	11.2	14.52	18.89
V ₂ (Arka Komal)	8.7	11.92	16.53
V ₃ (Contender)	10.2	12.56	16.11
S.Em±	0.38	0.50	0.78
CD at 5%	1.09	1.44	2.26
Nitrogen levels (N)			
N ₁ (25 kg/ha N)	8.73	10.56	14.00
N ₂ (50 kg/ha N)	9.27	11.71	15.58
N ₃ (75 kg/ha N)	9.96	12.98	17.38
N ₄ (100 kg/ha N)	10.62	16.31	21.38
N ₅ (125 kg/ha N)	11.58	13.44	17.57
S.Em±	0.49	0.64	1.01
CD at 5%	1.41	1.85	2.92
Interaction (V x N)			
V ₁ N ₁	10.13	12.27	15.13
V ₁ N ₂	10.27	13.27	16.40
V ₁ N ₃	10.93	14.47	19.00
V ₁ N ₄	11.53	17.80	23.07
V ₁ N ₅	13.13	14.80	20.87
V ₂ N ₁	7.86	9.33	13.60
V ₂ N ₂	7.87	10.53	15.67
V ₂ N ₃	8.27	11.93	16.80
V ₂ N ₄	9.60	15.33	20.67
V ₂ N ₅	9.73	12.47	15.93
V ₃ N ₁	8.20	10.07	13.27
V ₃ N ₂	9.67	11.33	14.67
V ₃ N ₃	10.67	12.53	16.33
V ₃ N ₄	10.73	15.80	20.40
V ₃ N ₅	11.87	13.07	15.90
S.Em±	0.84	1.11	1.75
CD at 5%	NS	NS	NS

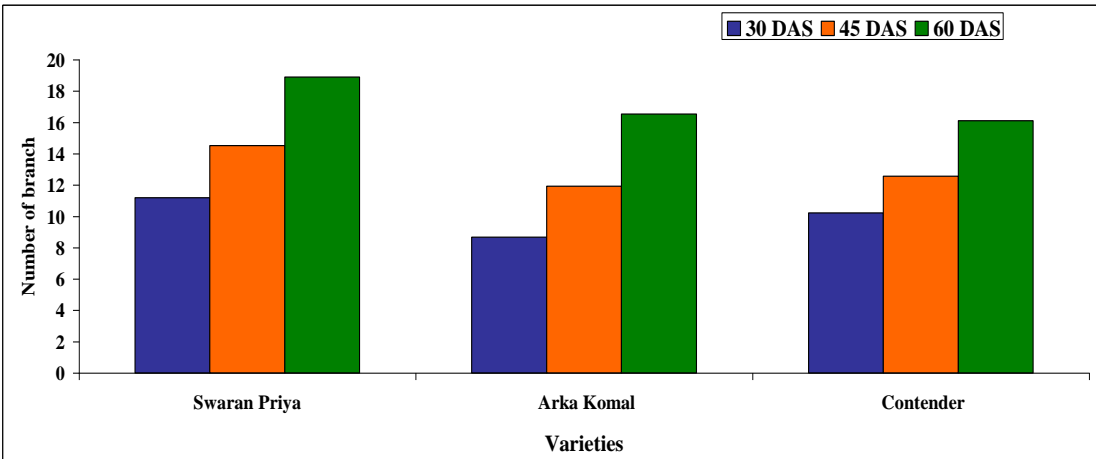


Fig. 4.3 a: Average number of branch per plant as influenced by varieties at different stages

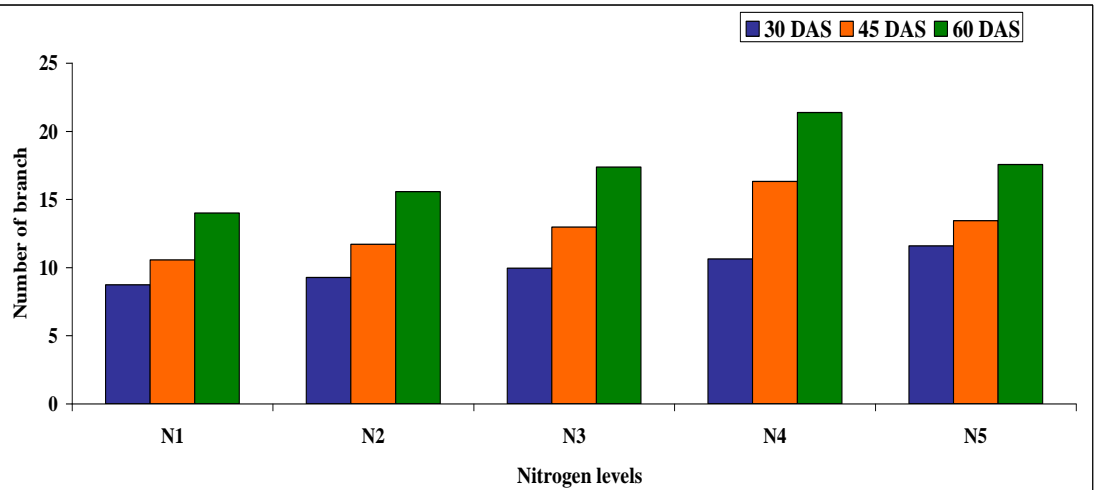


Fig. 4.3 b: Average number of branch per plant as influenced by nitrogen levels at different stages

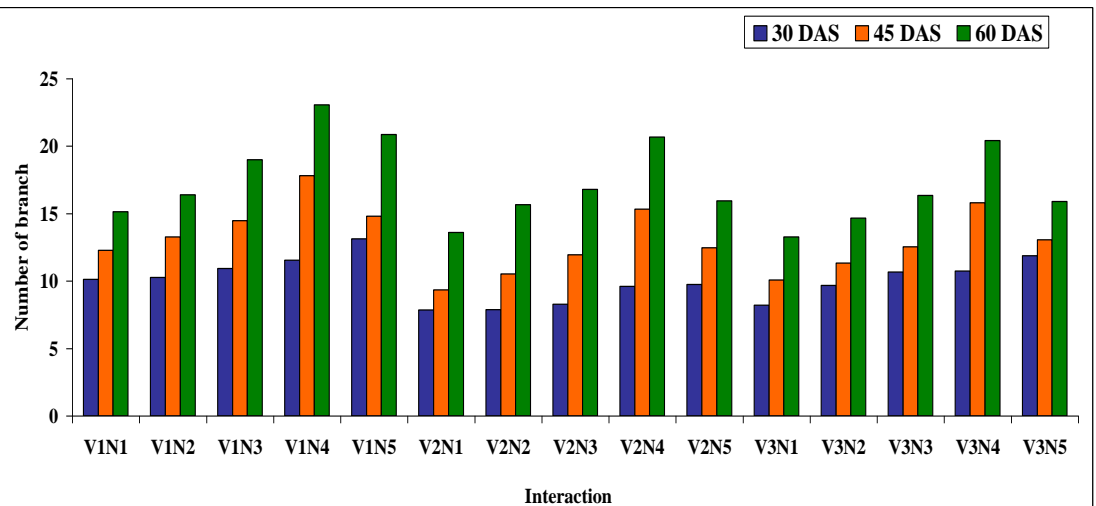


Fig. 4.3 c: Average number of branch per plant as influenced by various treatments at different stages

4.1.4 Leaf area index per plant

The findings presented in Table 4.4 and depicted in Figure 4.4 revealed that varieties and nitrogen levels had significant influence on leaf area index at all the stages.

Interaction effects of variety and nitrogen levels showed no remarkable influence on leaf area index at 30, 45 and 60 days after sowing.

Among the varieties, Swaran Priya recorded maximum leaf area index at 30 days after sowing and 60 days after sowing. At 45 days after sowing variety Arka Komal recorded the highest leaf area index followed by variety Swaran Priya with non significant difference.

Application of nitrogen exhibited significant influence on leaf area index at all the stages. There was linear increase in leaf area index up to 100 kg per hectare nitrogen at 30 days after sowing and 45 days after sowing. Whereas at 60 days after sowing there was linear increase in leaf area index up to 125 kg per hectare nitrogen and the highest leaf area index was noted with application of 125 kg per hectare nitrogen which was significantly higher over other levels of nitrogen. The lowest leaf area index was noted under 25 kg nitrogen per hectare.

Combined effect of varieties and nitrogen levels revealed non significant influence on leaf area index per plant.

Table 4.4: Average leaf area index per plant as influenced by varieties, nitrogen levels and their combinations

Treatment	30 DAS	45 DAS	60 DAS
Varieties (V)			
V ₁ (Swaran Priya)	0.339	0.370	0.595
V ₂ (Arka Komal)	0.283	0.392	0.551
V ₃ (Contender)	0.324	0.355	0.482
S.Em±	0.007	0.008	0.009
CD at 5%	0.020	0.025	0.026
Nitrogen levels (N)			
N ₁ (25 kg/ha N)	0.266	0.321	0.427
N ₂ (50 kg/ha N)	0.297	0.337	0.481
N ₃ (75 kg/ha N)	0.310	0.359	0.523
N ₄ (100 kg/ha N)	0.363	0.438	0.590
N ₅ (125 kg/ha N)	0.342	0.407	0.692
S.Em±	0.009	0.011	0.011
CD at 5%	0.026	0.032	0.033
Interaction (V x N)			
V ₁ N ₁	0.287	0.330	0.483
V ₁ N ₂	0.303	0.353	0.507
V ₁ N ₃	0.330	0.367	0.563
V ₁ N ₄	0.383	0.413	0.643
V ₁ N ₅	0.393	0.387	0.780
V ₂ N ₁	0.230	0.340	0.400
V ₂ N ₂	0.270	0.350	0.513
V ₂ N ₃	0.273	0.363	0.533
V ₂ N ₄	0.343	0.470	0.623
V ₂ N ₅	0.300	0.437	0.683
V ₃ N ₁	0.280	0.293	0.397
V ₃ N ₂	0.317	0.307	0.423
V ₃ N ₃	0.327	0.347	0.473
V ₃ N ₄	0.363	0.430	0.503
V ₃ N ₅	0.333	0.397	0.613
S.Em±	0.016	0.019	0.020
CD at 5%	NS	NS	NS

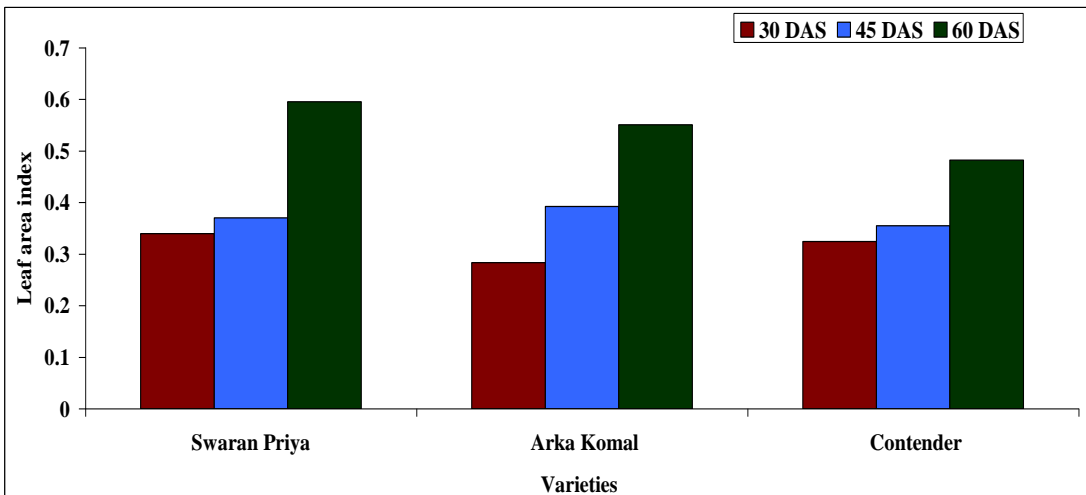


Fig. 4.4 a: Average leaf area index per plant as influenced by varieties at different stages

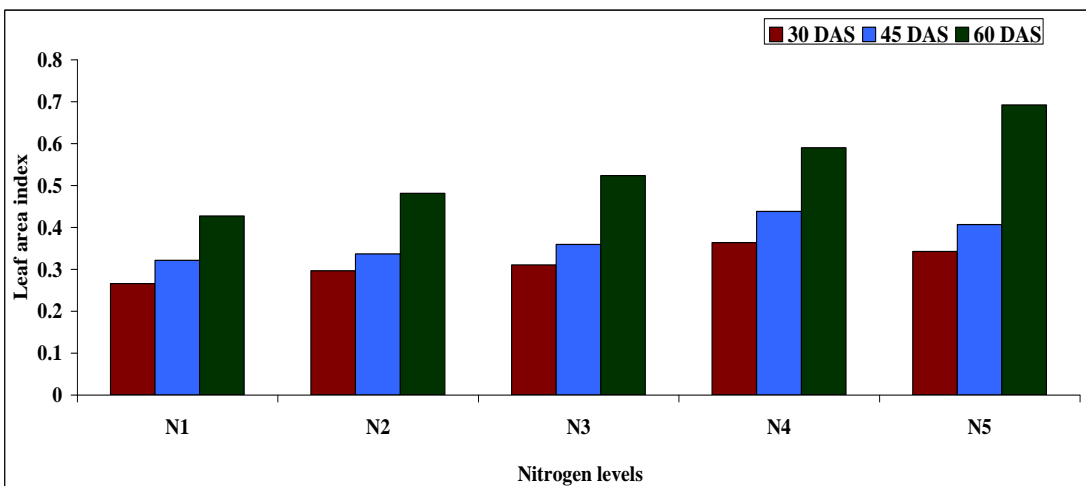


Fig. 4.4 b: Average leaf area index per plant as influenced by nitrogen levels at different stages

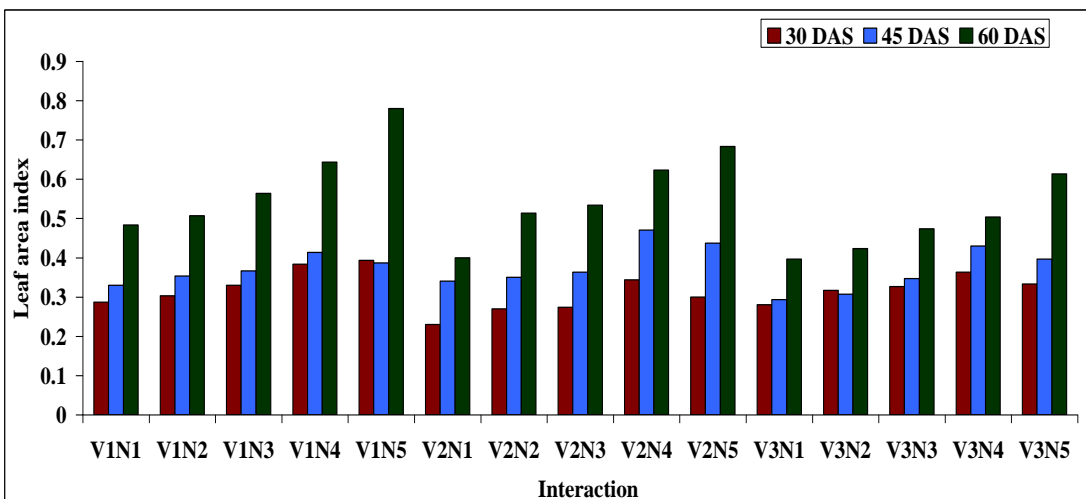


Fig. 4.4 c: Average leaf area index per plant as influenced by various treatments at different stages

4.1.5 Fresh weight of shoot per plant (g)

Fresh weight of shoot per plant was presented in Table 4.5 and depicted in Figure 4.5 at 30, 45 and 60 days after sowing as well as at harvesting stage. The observations revealed significant influence of variety and nitrogen levels on fresh weight of shoot per plant at all the stages.

Among the varieties, Swaran Priya recorded maximum fresh weight of shoot per plant, which was significantly superior over other varieties. It was followed by Arka Komal. The lowest fresh weight of shoot per plant was recorded with variety Contender at all the stages.

Nitrogen application showed increase in fresh weight of shoot with each increasing dose up to 100 kg per hectare. Further increase in nitrogen levels had not show any remarkable influence on fresh weight of shoot per plant.

Combined effect of variety and nitrogen levels did not show any remarkable influence on fresh weight of shoot per plant at any stage.

Table 4.5: Average fresh weight (g) of shoot per plant as influenced by varieties, nitrogen levels and their combinations

Treatment	30 DAS	45 DAS	60 DAS	At harvest
Varieties (V)				
V ₁ (Swaran Priya)	16.11	41.64	70.81	45.07
V ₂ (Arka Komal)	14.69	38.84	67.41	41.33
V ₃ (Contender)	13.28	37.54	66.61	37.69
S.Em±	0.41	0.78	0.83	0.81
CD at 5%	1.18	2.27	2.40	2.35
Nitrogen levels (N)				
N ₁ (25 kg/ha N)	12.18	36.02	63.08	38.10
N ₂ (50 kg/ha N)	13.56	37.95	65.95	40.12
N ₃ (75 kg/ha N)	14.86	38.90	68.52	41.13
N ₄ (100 kg/ha N)	17.34	42.34	72.97	44.08
N ₅ (125 kg/ha N)	15.53	41.48	70.86	43.39
S.Em±	0.53	1.01	1.07	1.05
CD at 5%	1.53	2.94	3.09	3.03
Interaction (V x N)				
V ₁ N ₁	13.15	38.81	65.47	42.21
V ₁ N ₂	15.27	40.01	69.13	44.19
V ₁ N ₃	16.26	40.39	71.39	44.71
V ₁ N ₄	18.75	45.35	75.51	47.47
V ₁ N ₅	17.13	43.65	72.56	46.75
V ₂ N ₁	12.43	35.01	62.19	37.69
V ₂ N ₂	13.25	36.81	64.79	39.72
V ₂ N ₃	14.71	38.95	67.30	41.59
V ₂ N ₄	17.47	42.16	72.15	44.17
V ₂ N ₅	15.60	41.25	70.61	43.51
V ₃ N ₁	10.97	34.23	61.59	34.41
V ₃ N ₂	12.17	37.03	63.93	36.44
V ₃ N ₃	13.63	37.37	66.87	37.09
V ₃ N ₄	15.80	39.53	71.25	40.61
V ₃ N ₅	13.85	39.55	69.41	39.90
S.Em±	0.91	1.75	1.85	1.81
CD at 5%	NS	NS	NS	NS

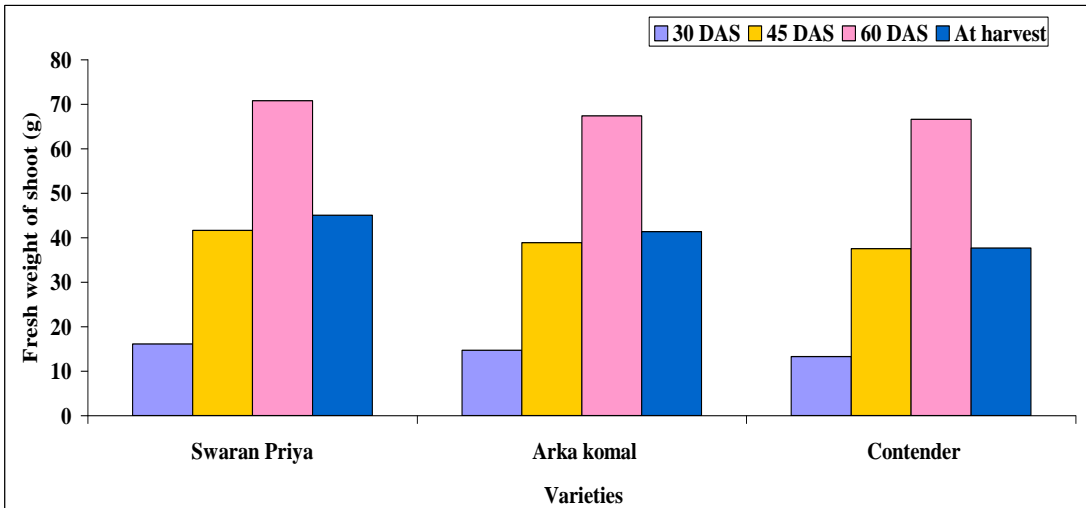


Fig. 4.5 a: Average fresh weight of shoot (g) per plant as influenced by varieties at different stages

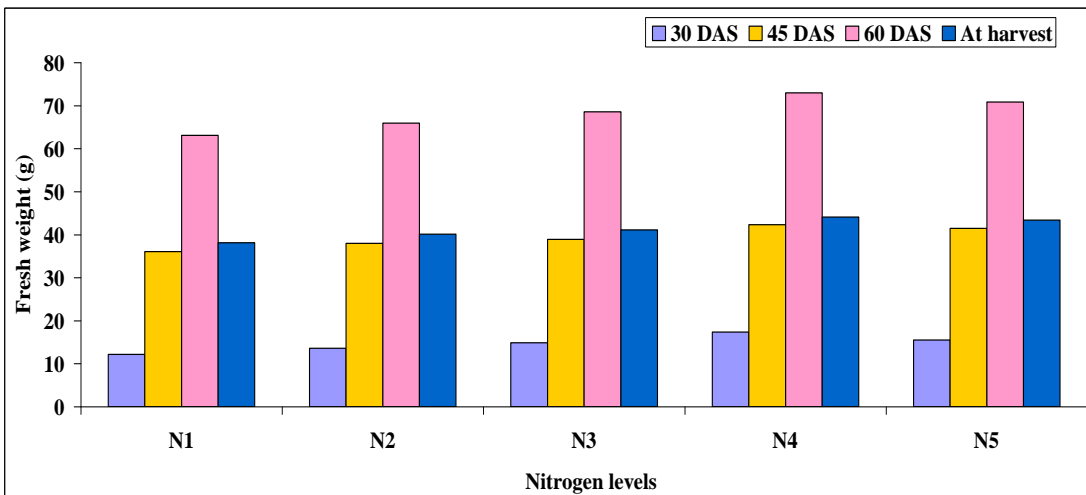


Fig. 4.5 b: Average fresh weight of shoot (g) of shoot per plant as influenced by nitrogen levels at different stages

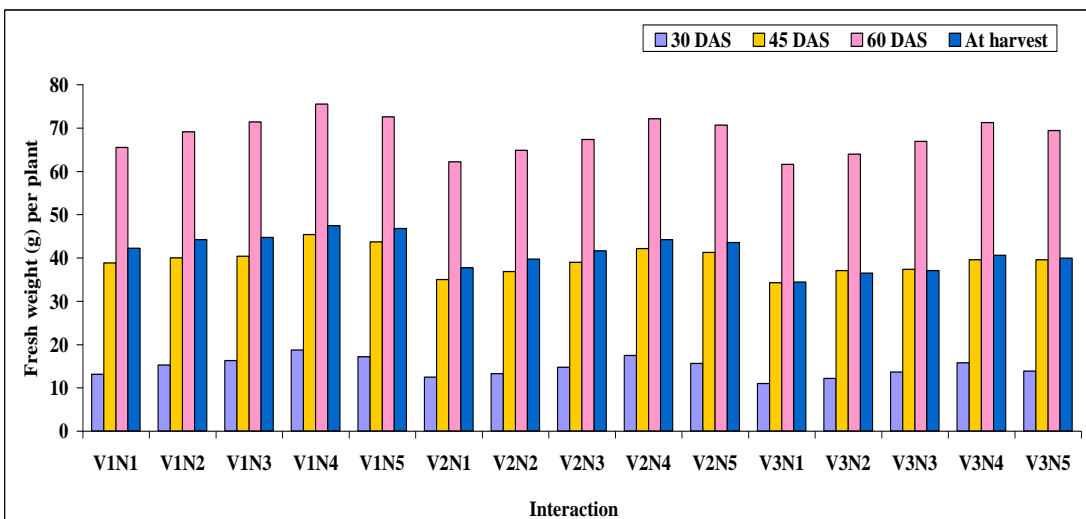


Fig. 4.5 c: Average fresh weight of shoot (g) per plant as influenced by various treatments at different stages

4.1.6 Dry weight of shoot per plant (g)

Dry weight of shoot per plant, presented in Table 4.6 and depicted in Figure 4.6 revealed significant influences of varieties and nitrogen levels. Whereas combined effect of variety and nitrogen level had no significant influence on dry weight of shoot per plant.

Maximum dry weight of shoot per plant was recorded with variety Swaran Priya followed by Arka Komal and Contender. Variety Swaran Priya was significantly superior over both Arka Komal and Contender.

Application of nitrogen exhibited significant influence on dry weight of shoot per plant at all the stages. There was increase in dry weight of shoot per plant with each increasing dose of nitrogen up to 100 kg per hectare. Further increase in nitrogen application showed significant reduction in dry weight of shoot per plant at 30, 45 and 60 days after sowing. Whereas at harvesting stage no significant difference was observed between 100 kg and 125 kg of nitrogen application per hectare.

Combined effect of variety and nitrogen levels had not showed any remarkable influence on dry weight of shoot per plant at any stage of the crop under study.

Table 4.6: Average dry weight (g) of shoot per plant as influenced by varieties, nitrogen levels and their combinations

Treatment	30 DAS	45 DAS	60 DAS	At harvest
Varieties (V)				
V ₁ (Swaran Priya)	2.19	5.75	7.84	14.56
V ₂ (Arka Komal)	1.84	4.89	6.68	13.58
V ₃ (Contender)	1.53	4.19	6.91	13.36
S.Em±	0.05	0.09	0.15	0.21
CD at 5%	0.15	0.27	0.45	0.60
Nitrogen levels (N)				
N ₁ (25 kg/ha N)	1.56	4.32	6.38	12.17
N ₂ (50 kg/ha N)	1.73	4.74	6.86	13.25
N ₃ (75 kg/ha N)	1.89	5.06	7.08	13.79
N ₄ (100 kg/ha N)	2.24	5.70	7.91	15.78
N ₅ (125 kg/ha N)	1.86	4.91	7.50	14.17
S.Em±	0.07	0.12	0.20	0.27
CD at 5%	0.19	0.34	0.58	0.77
Interaction (V x N)				
V ₁ N ₁	2.00	5.17	6.95	12.93
V ₁ N ₂	2.09	5.40	7.64	13.60
V ₁ N ₃	2.23	5.76	7.74	14.83
V ₁ N ₄	2.58	6.73	8.65	16.58
V ₁ N ₅	2.04	5.71	8.23	14.85
V ₂ N ₁	1.40	4.10	5.80	11.82
V ₂ N ₂	1.71	4.81	6.28	13.19
V ₂ N ₃	1.83	5.09	6.70	13.39
V ₂ N ₄	2.29	5.51	7.55	15.51
V ₂ N ₅	1.98	4.95	7.09	13.97
V ₃ N ₁	1.27	3.70	6.38	11.77
V ₃ N ₂	1.39	4.00	6.66	12.95
V ₃ N ₃	1.60	4.33	6.81	13.15
V ₃ N ₄	1.83	4.86	7.54	15.27
V ₃ N ₅	1.57	4.08	7.17	13.68
S.Em±	0.11	0.20	0.35	0.46
CD at 5%	NS	NS	NS	NS

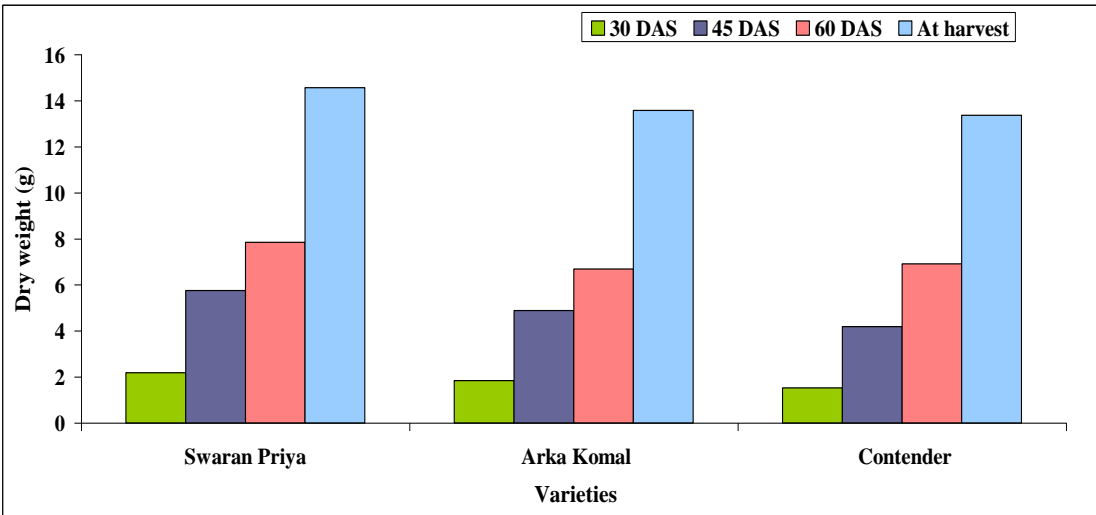


Fig. 4.6 a: Average dry weight of shoot (g) per plant as influenced by varieties at different stages

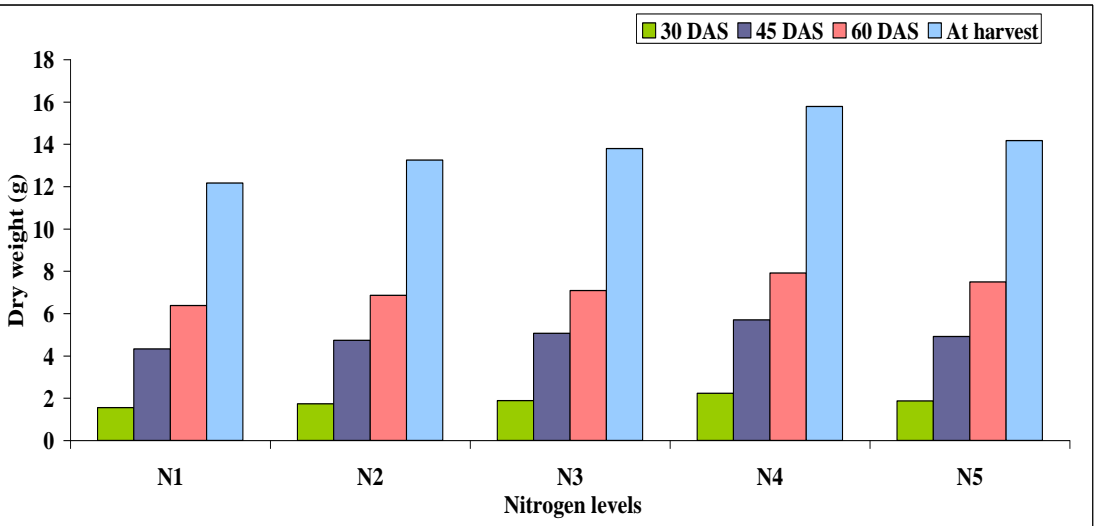


Fig. 4.6 b: Average dry weight of shoot (g) as influenced by nitrogen levels at different stages

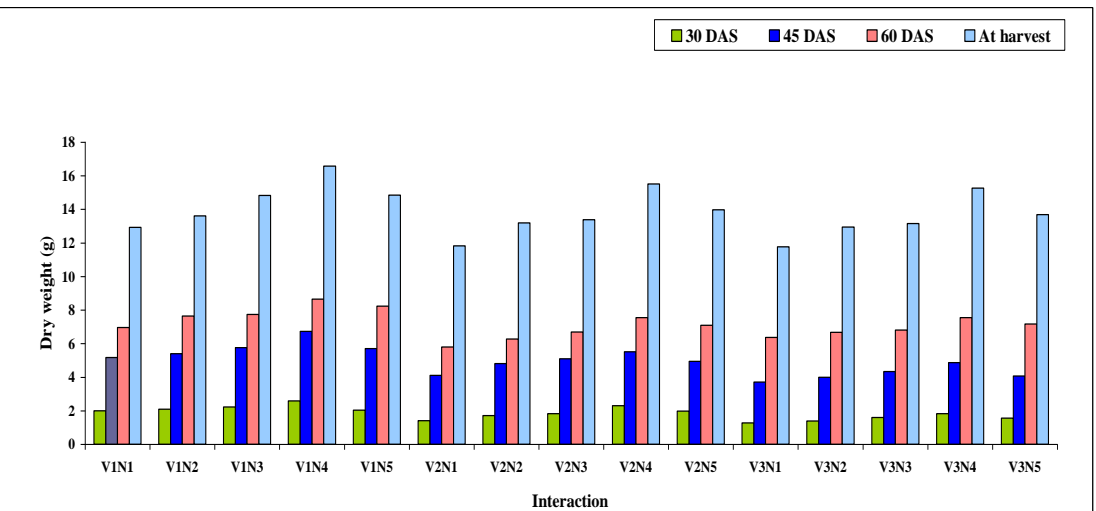


Fig. 4.6 c: Average dry weight of shoot (g) per plant as influenced by various treatments at different at different stages

4.1.7 Days taken to 50 per cent flowering

The findings presented in Table 4.7 and depicted in Figure 4.7 revealed significant effects of varieties and nitrogen levels on days to 50 per cent flowering in french bean. Though combined effect of variety and nitrogen levels did not showed any significant influence on days taken to 50 per cent flowering.

Maximum days to 50 per cent flowering were taken by variety Swaran Priya which was followed by Arka Komal and Contender. All the variety differs significantly with each other.

Application of nitrogen delayed the flowering in french bean. Maximum days to 50 per cent flowering were taken with application of 125 kg of nitrogen per hectare which were significantly more than other nitrogen levels. Earliest 50 per cent flowering was observed with application of 25 kg nitrogen per hectare.

Combined effect of nitrogen and varieties had no remarkable influence of number of days taken to 50 per cent flowering.

Table 4.7: Effect of varieties, nitrogen levels and their combination on days to 50% flowering in french bean

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	42.40	43.60	45.87	51.13	54.33	47.47
V ₂	38.53	39.67	41.67	46.93	49.93	43.35
V ₃	35.60	36.67	38.80	43.80	46.87	40.35
MEAN	38.84	39.98	42.11	47.29	50.38	43.72

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.17	0.49
Varieties	0.13	0.38
Interaction	0.30	NS

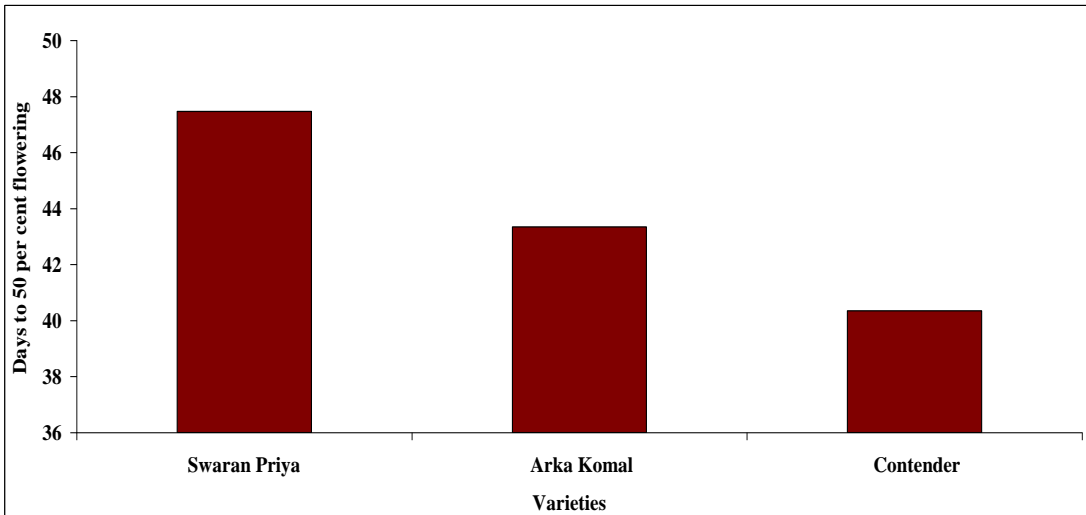


Fig. 4.7 a: Days taken to 50 per cent flowering as influenced by varieties

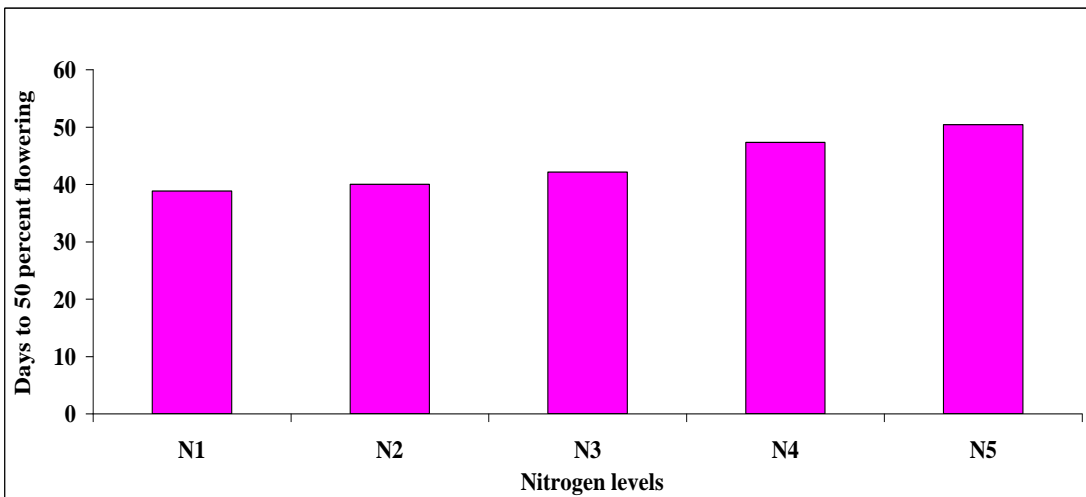


Fig. 4.7 b: Days taken to 50 per cent flowering as influenced by nitrogen levels

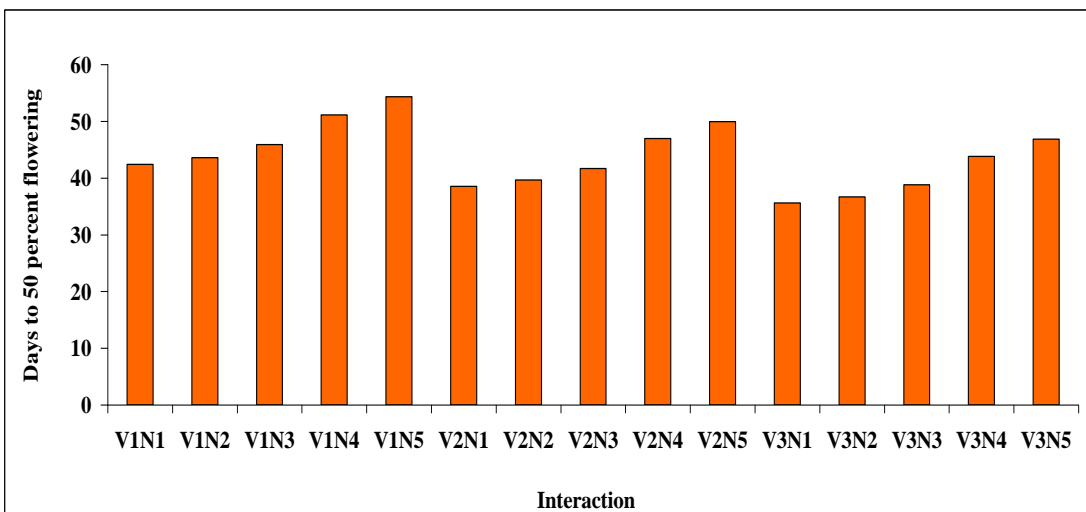


Fig. 4.7 c: Days taken to 50 per cent flowering as influenced by various treatments

4.2 Yield Parameters and Yield:

Yield parameters i.e. Number of pod per plant, number of seed per pod, length of pod (cm), pod yield per plant (g) and shelling percentage was recorded, analyzed and presented as follows:

4.2.1 Number of pod per plant

Number of pod per plant as presented in Table 4.8 and depicted in Figure 4.8 revealed significant influence of varieties as well as nitrogen levels. However combined effect of variety and nitrogen levels had no significant influence on number of pod per plant.

Maximum number of pod per plant was counted under Swaran Priya which was significantly superior to Arka Komal and Contender. The lowest number of pod per plant was recorded in variety Contender.

Application of nitrogen showed positive response for number of pod per plant. There was increase in number of pod with each increasing dose of nitrogen. The highest number of pod per plant was recorded with 125 kg of nitrogen level per hectare.

Table 4.8: Effect of varieties, nitrogen levels and their combination on number of pods per plant in french bean

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	29.93	32.87	34.53	37.20	37.00	34.31
V ₂	26.60	29.73	31.73	35.47	32.53	31.21
V ₃	24.60	26.13	25.27	30.53	28.40	26.99
MEAN	27.04	29.58	30.51	34.40	32.64	30.83

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.55	1.59
Varieties	0.42	1.23
Interaction	0.95	NS

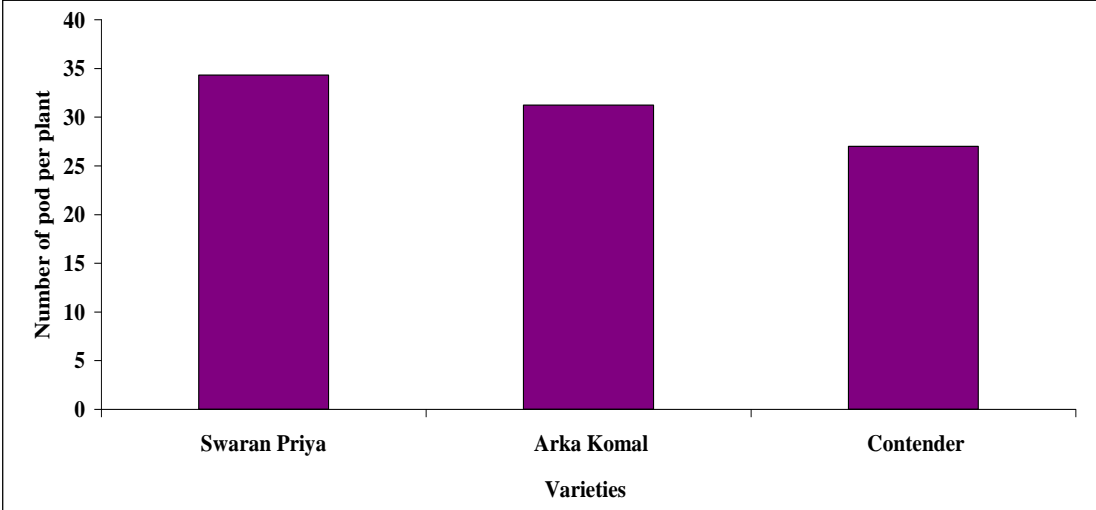


Fig. 4.8 a: Average number of pod per plant as influenced by varieties

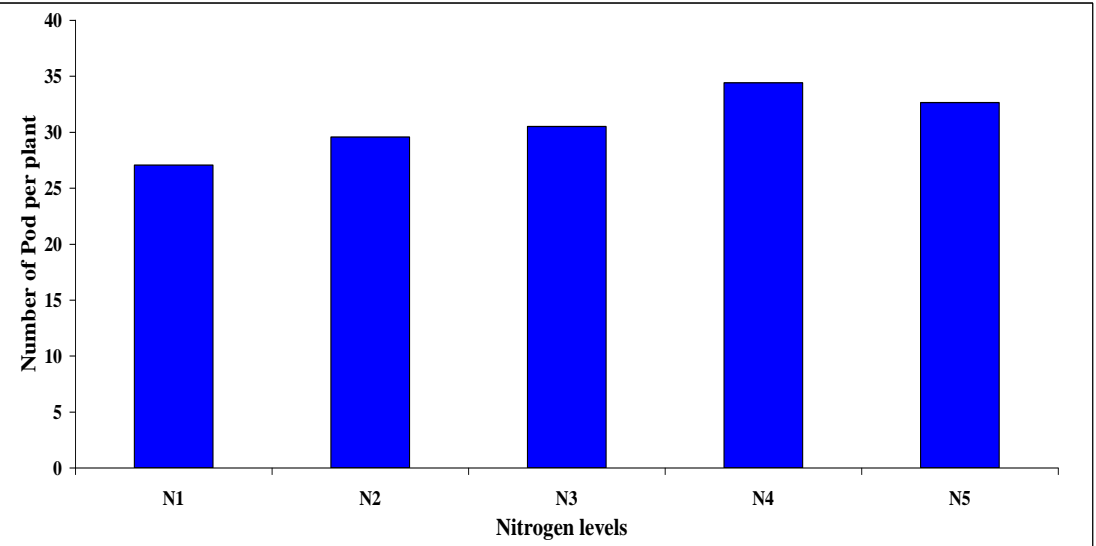


Fig.4.8 b: Average number of pod per plant as influenced by nitrogen levels

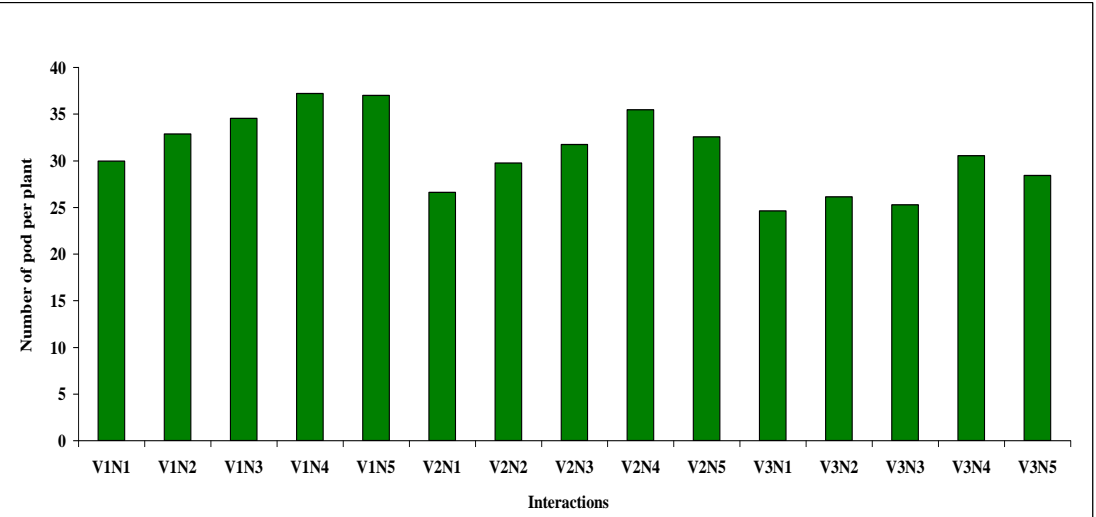


Fig. 4.8 c: Average number of pod per plant as influenced by various treatments

4.2.2 Number of seed per pod

The result presented in Table 4.9 and depicted in Figure 4.9 exhibited significant influence on number of seed per plant with varieties as well as nitrogen levels. Combined effect of variety and nitrogen levels did not showed any significant influence on number of seed per plant.

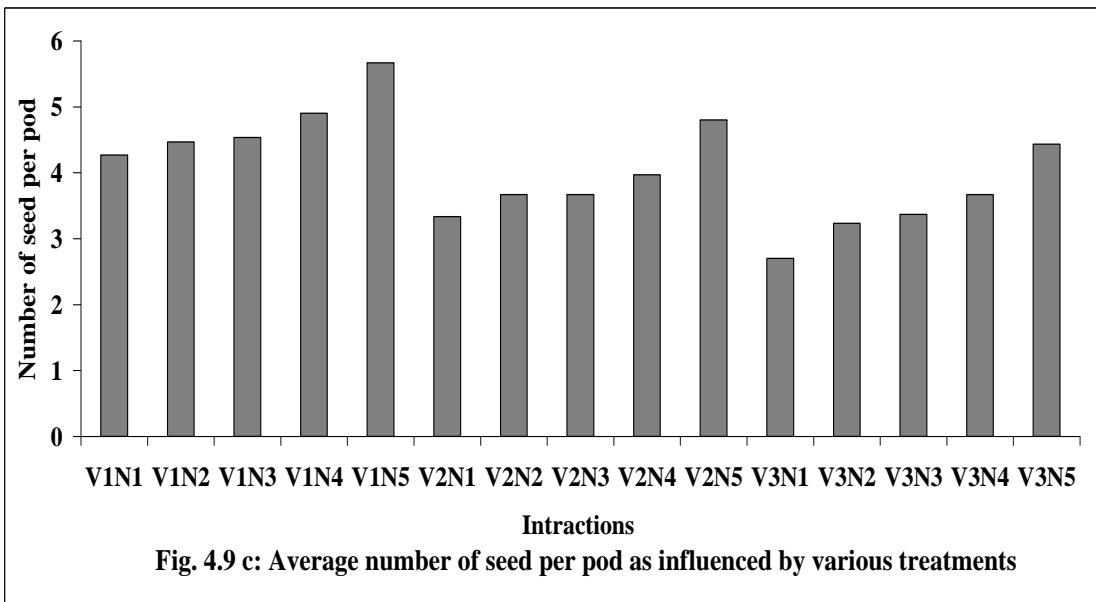
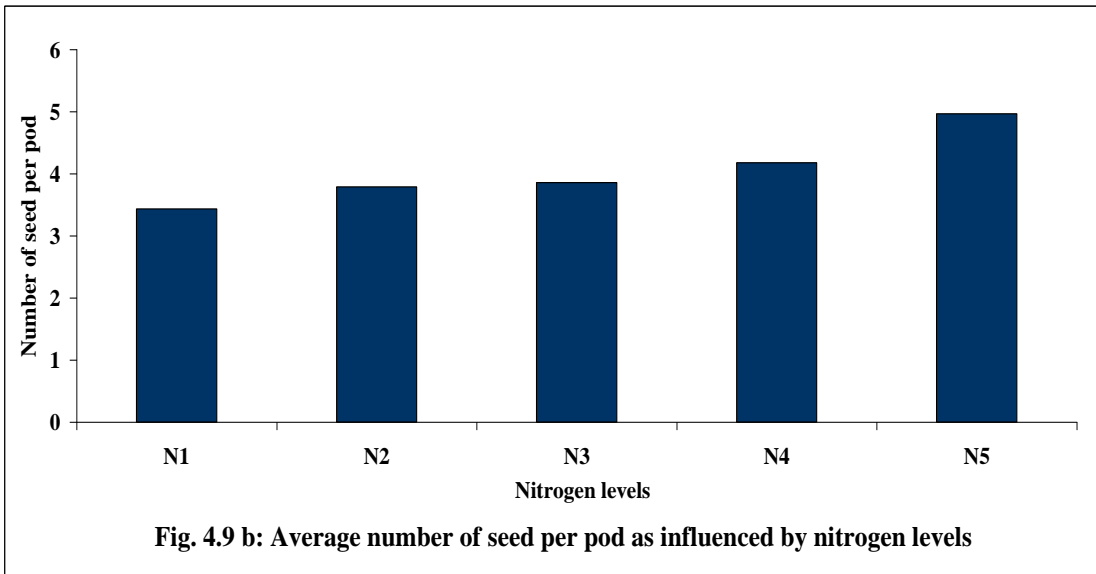
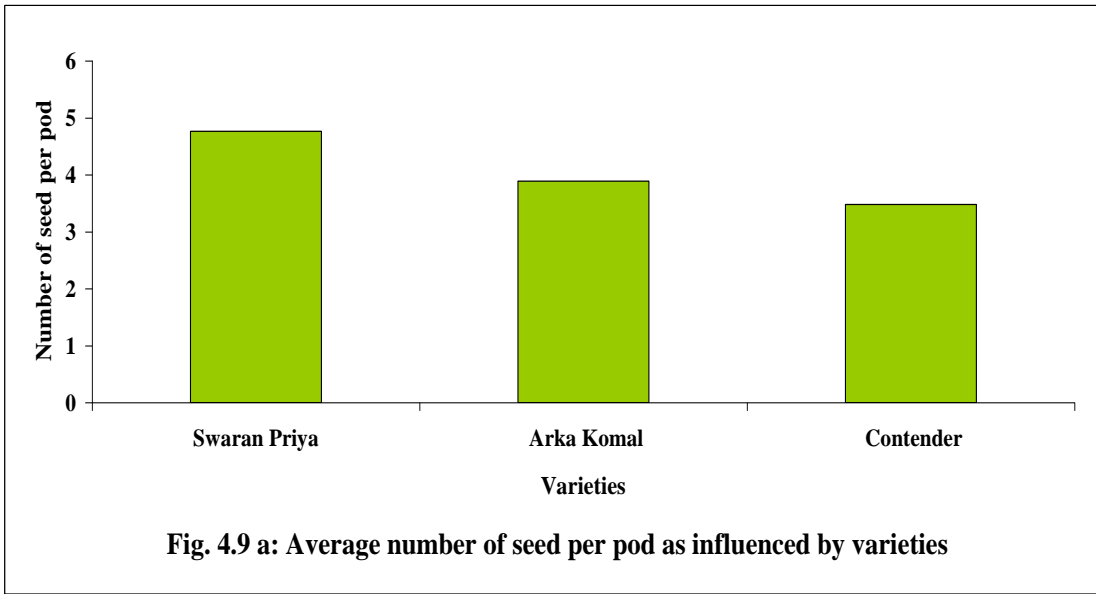
The highest number of seed per plant was observed with variety Swaran Priya followed by Arka Komal and Contender. There was significant difference between all the varieties.

Number of seed per pod increased with each increase in nitrogen levels. The Highest number of seed per pod was recorded with application of 125 kg of nitrogen per hectare which was significantly superior over other nitrogen levels. Minimum numbers of seed per pod were observed with application of 125 kg nitrogen per hectare.

Table 4.9: Number of seeds per pod as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	4.27	4.47	4.53	4.90	5.67	4.77
V ₂	3.33	3.67	3.67	3.97	4.80	3.89
V ₃	2.70	3.23	3.37	3.67	4.43	3.48
MEAN	3.43	3.79	3.86	4.18	4.97	4.04

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.11	0.32
Varieties	0.09	0.25
Interaction	0.19	NS



4.2.3 Length of pod (cm)

Length of pod as presented in Table 4.10 and depicted in Figure 4.10 revealed significant effects of varieties and nitrogen levels, whereas combined effect of nitrogen levels and varieties had no remarkable influence on pod length in french bean.

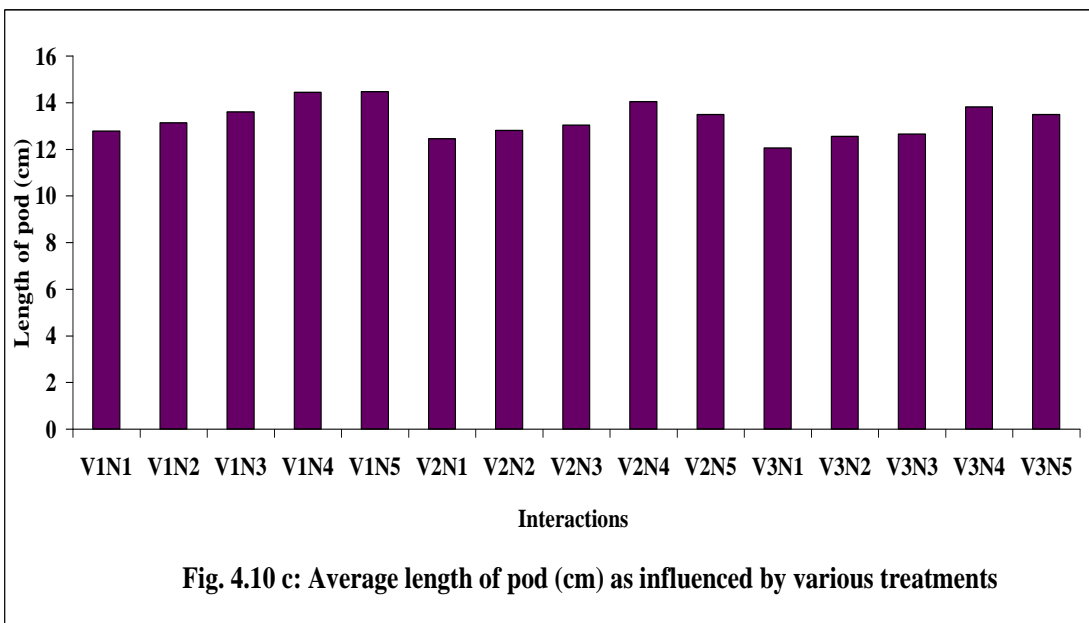
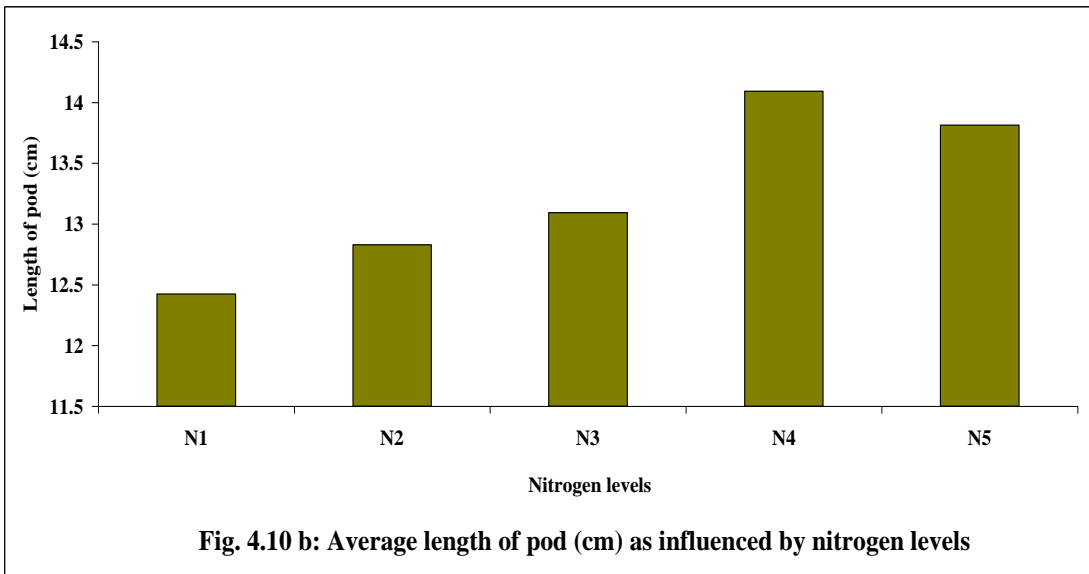
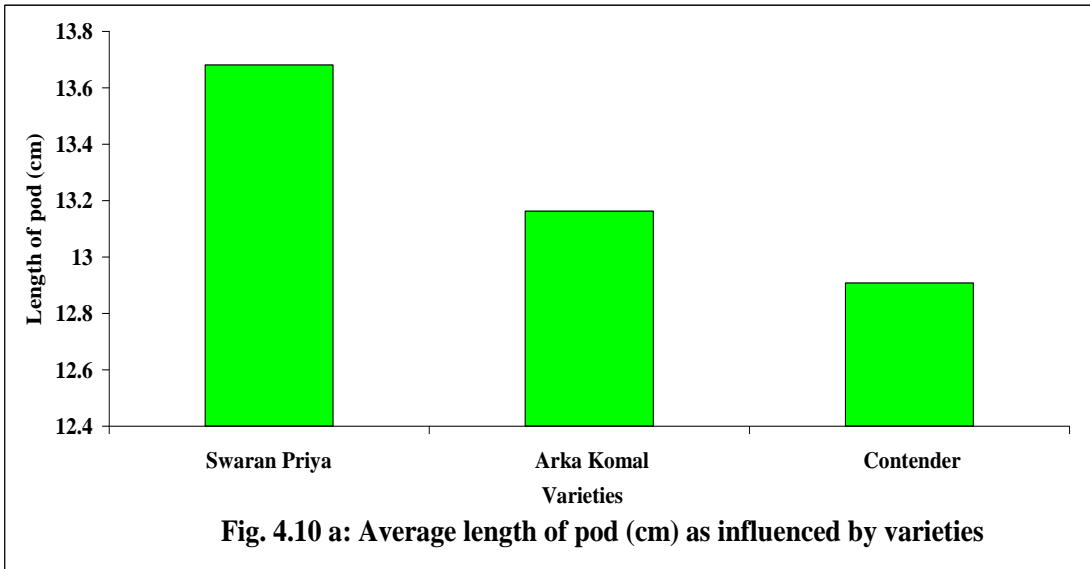
Among the varieties, Swaran Priya recorded the longest pod followed by Arka Komal and Contender. All the varieties differed significantly to each other.

Application of nitrogen exhibited significant positive effect on pod length up to 100 kg nitrogen per hectare. Further increase in nitrogen dose had no significant influence. Maximum pod length was recorded application of 100 kg per hectare nitrogen which was significantly superior over N₁, N₂ and N₃ and at par to N₅.

Table 4.10: Average length (cm) of pod as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	12.78	13.13	13.59	14.43	14.47	13.68
V ₂	12.45	12.81	13.03	14.04	13.49	13.16
V ₃	12.05	12.55	12.65	13.81	13.48	12.91
MEAN	12.42	12.83	13.09	14.09	13.81	13.25

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.19	0.54
Varieties	0.15	0.42
Interaction	0.32	NS



4.2.4 Pod yield per plant

The data presented in Table 4.11 and depicted in Figure 4.11 showed significant effects of varieties and nitrogen levels on pod yield per plant. Combined effect of variety and nitrogen levels exhibited non significant effect on pod yield per plant.

Variety Swaran Priya ranked first for pod yield per plant which was significantly superior over other varieties. The lowest pod yield per plant was recorded with variety Contender.

Application of nitrogen revealed that increasing dose up to 100 kg per hectare showed linear increase in pod yield which was reduced at 125 kg nitrogen per hectare.

Table 4.11: Average pod yield (g) per plant as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	44.17	47.44	48.33	54.41	50.50	48.97
V ₂	40.04	42.27	43.73	48.48	44.49	43.80
V ₃	36.11	38.48	40.36	44.59	39.64	39.84
MEAN	40.11	42.73	44.14	49.16	44.88	44.20

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.55	1.59
Varieties	0.43	1.23
Interaction	0.95	NS

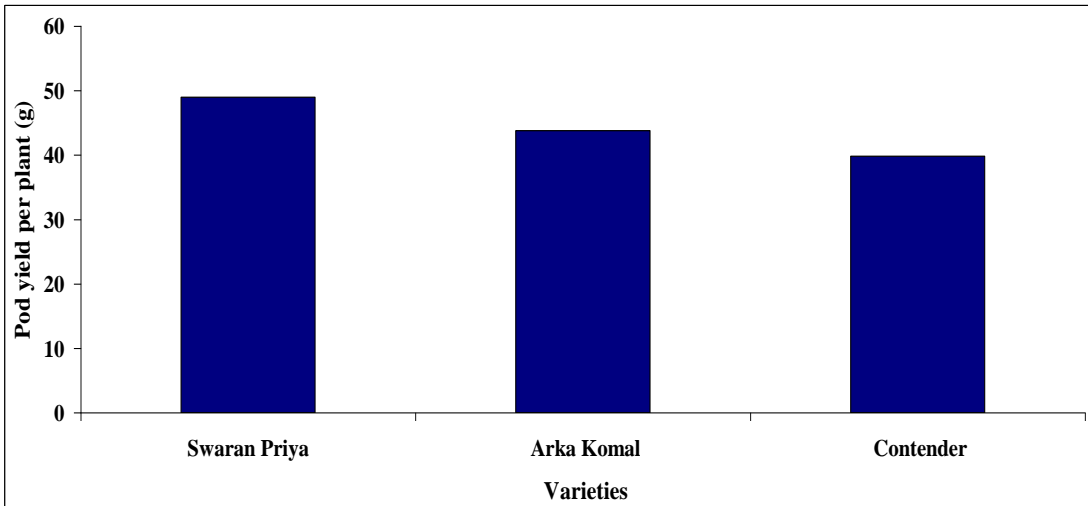


Fig. 4.11 a: Average pod yield per plant (g) as influenced by varieties

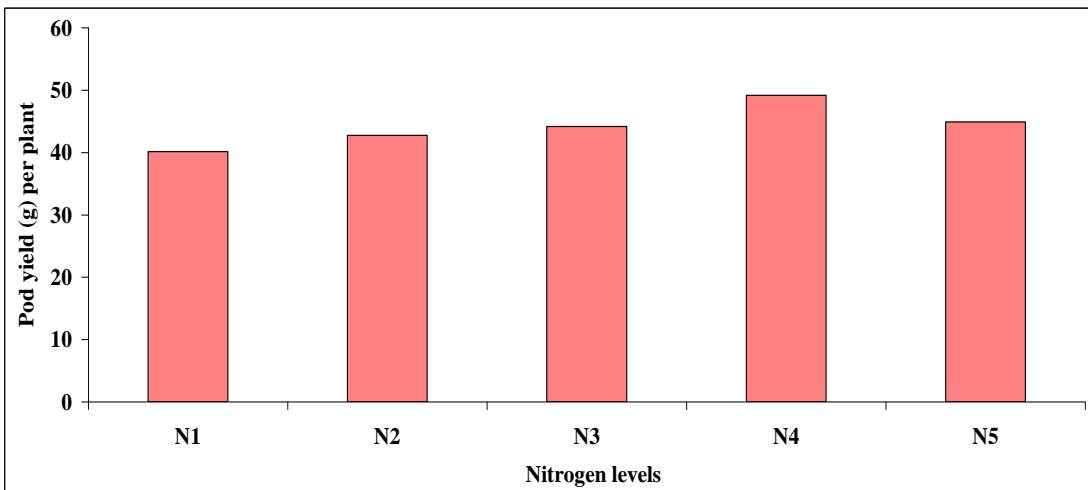


Fig. 4.11 b: Average pod yield (g) per plant as influenced by nitrogen levels

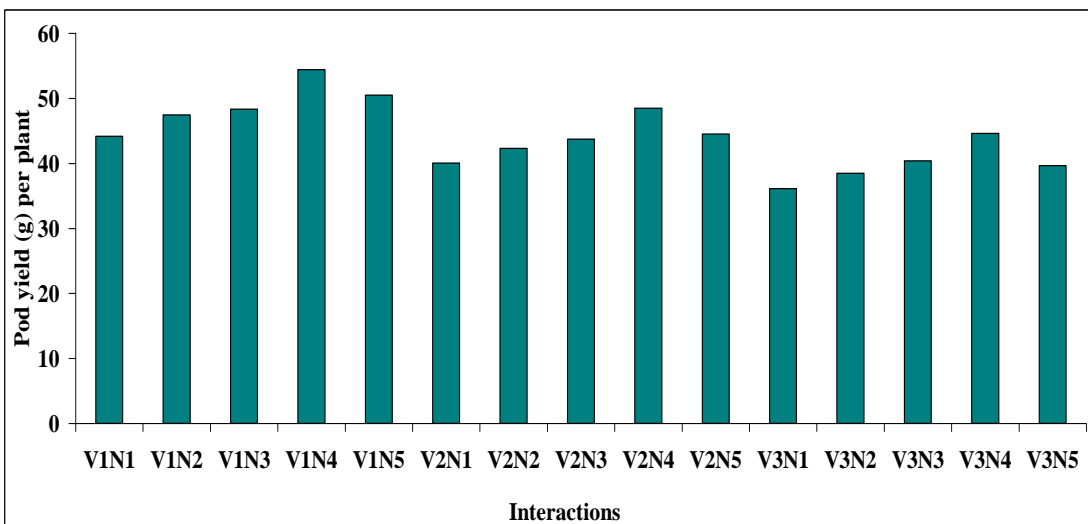


Fig. 4.11 c: Average pod yield (g) per plant as influenced by various treatments

4.2.5 Pod yield (q) per hectare

The data pertaining in Table 4.12 and depicted in Figure 4.12 to average pod yield per hectare revealed significant influence of variety as well as nitrogen levels.

There was significant effect of varieties on pod yield. Variety Swaran Priya recorded maximum pod yield which was significantly superior over Arka Komal as well as Contender. Variety Arka Komal showed significantly higher yield over Contender.

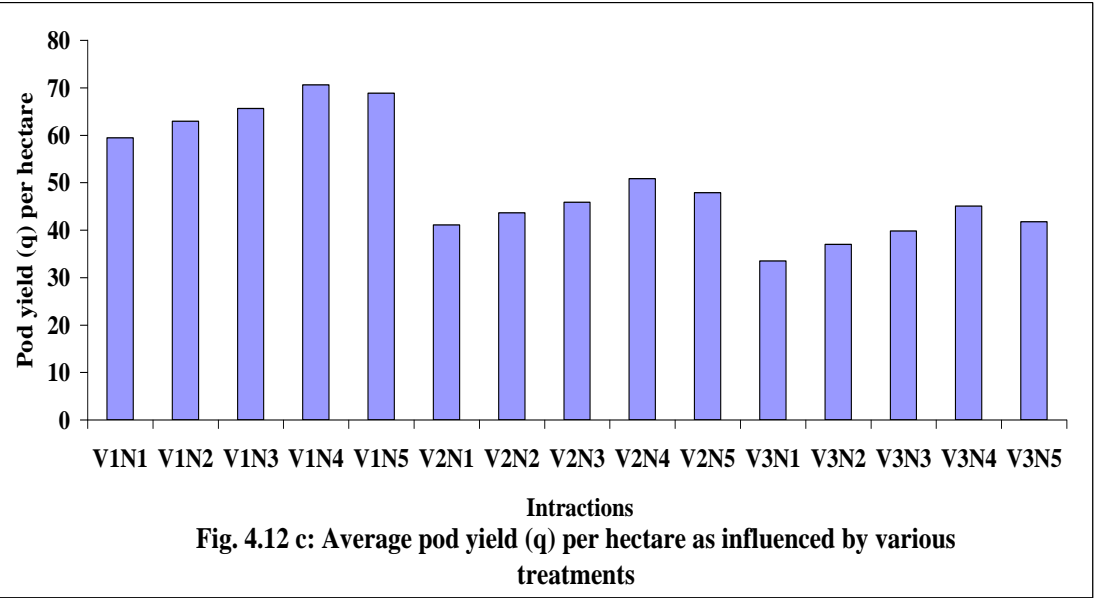
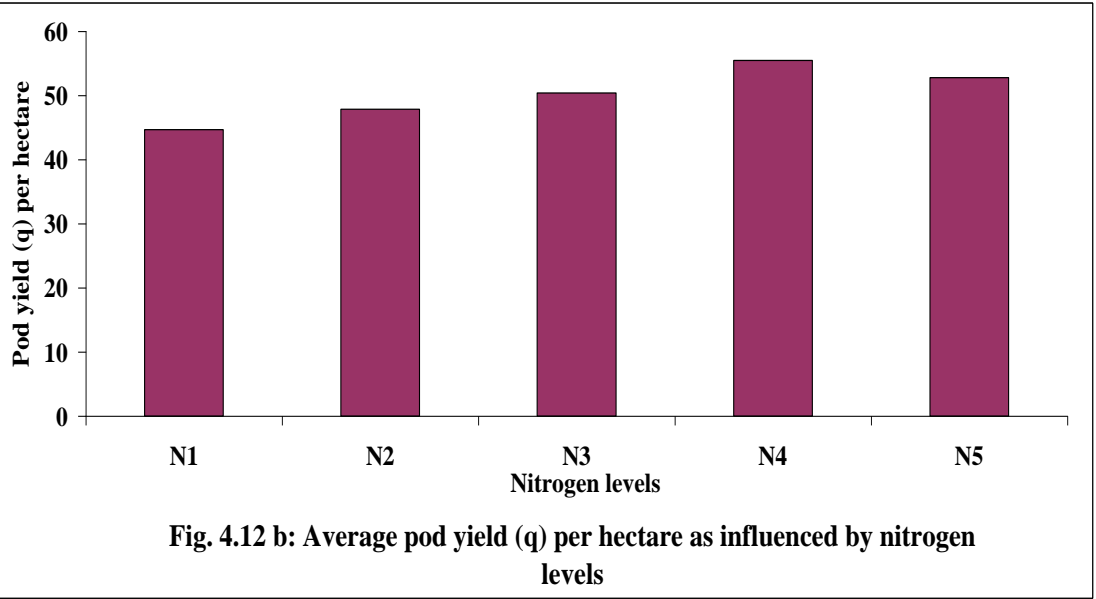
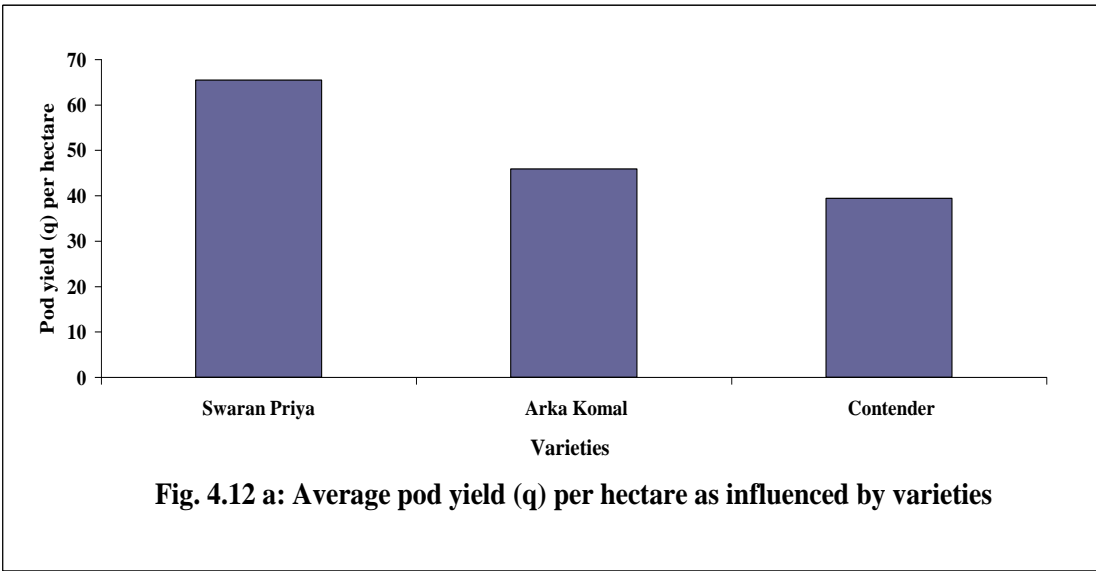
Application of nitrogen exhibited significant influence on pod yield per hectare. Each increasing dose of nitrogen from N₁ to N₄ caused significant increase in pod yield per hectare. Further increase in nitrogen level had no beneficial effect rather reduced the yield.

Combined effect of variety and nitrogen had no significant influence on pod yield per hectare.

Table 4.12: Average pod yield (q) per hectare as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	59.44	62.94	65.59	70.56	68.81	65.47
V ₂	41.11	43.66	45.82	50.84	47.87	45.86
V ₃	33.49	37.01	39.79	45.06	41.72	39.41
MEAN	44.68	47.87	50.40	55.49	52.80	50.25

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.82	2.37
Varieties	0.63	1.83
Interaction	1.41	NS



4.2.6 Seed yield (g) per plant

Seed yield per plant as presented in Table 4.13 and depicted in Figure 4.13 revealed significant influence of varieties as well as nitrogen levels.

Amongst the varieties, highest seed yield per plant was recorded with variety Swaran Priya which was significantly superior over Arka Komal and Contender. The lowest seed yield per plant was recorded with variety Contender.

Nitrogen application showed increase in seed yield. There was significant increase in seed yield with each increasing dose of nitrogen up to 100 kg per hectare. Further increase in nitrogen level showed reduction in seed yield.

Combined effect of varieties and nitrogen levels had no remarkable effect on seed yield per plant.

Table 4.13: Average seed yield (g) per plant as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	32.68	35.58	37.70	42.00	37.87	37.17
V ₂	28.53	30.68	31.92	35.31	31.44	31.58
V ₃	23.65	25.39	26.55	29.11	25.37	26.02
MEAN	28.29	30.55	32.06	35.47	31.56	31.59

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.40	1.17
Varieties	0.31	0.91
Interaction	0.70	NS

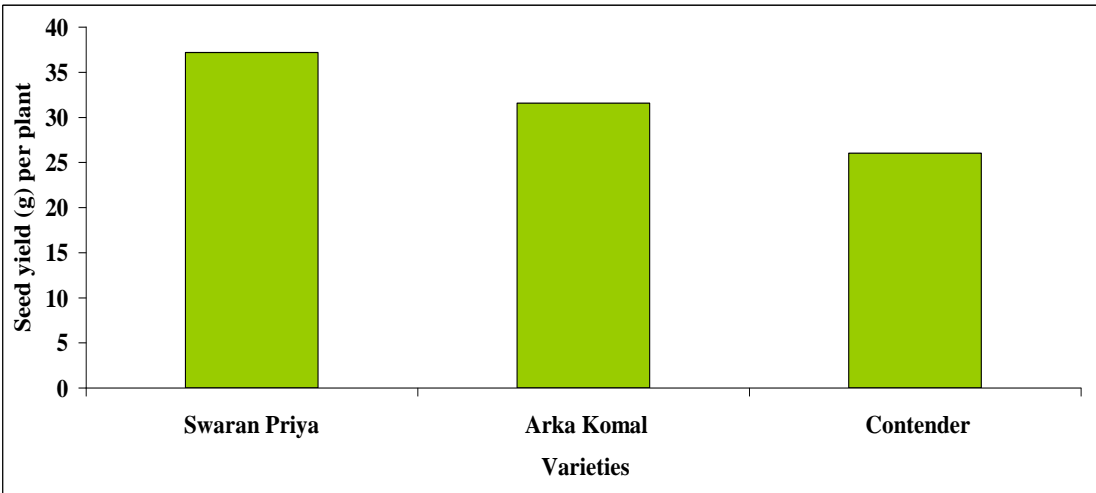


Fig. 4.13 a: Average seed yield (g) per plant as influenced by varieties

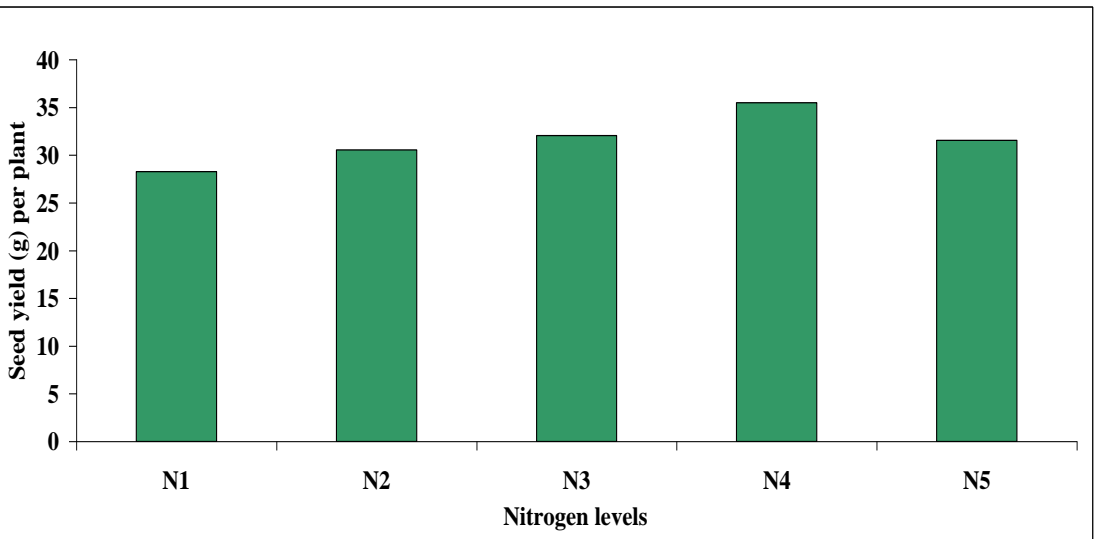


Fig. 4.13 b: Average seed yield (g) per plant as influenced by nitrogen levels

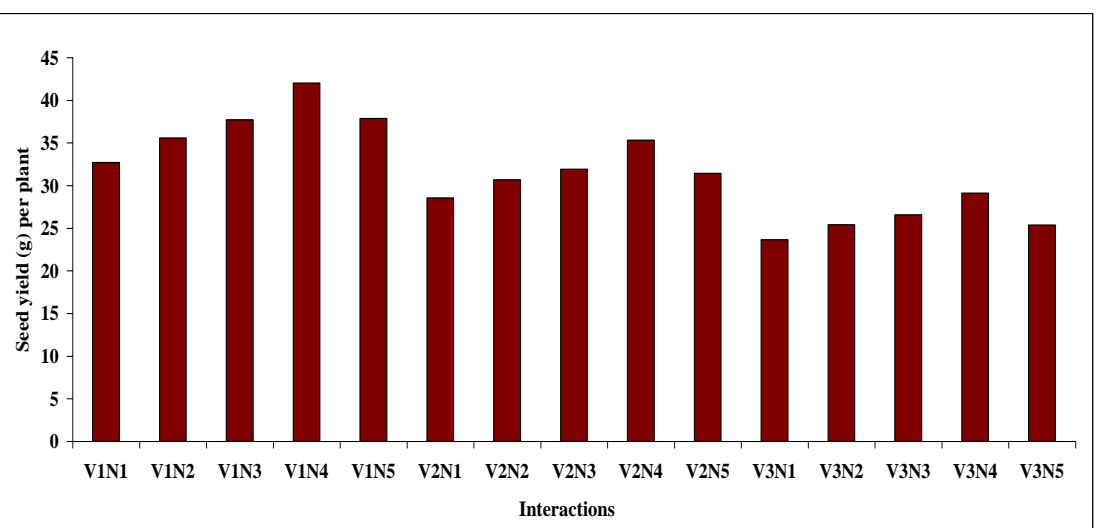


Fig. 4.13 c: Average seed yield (g) per plant as influenced by various treatments

4.2.7 Seed yield (q) per hectare

The data presented in Table 4.14 and depicted in Figure 4.14 revealed significant influences on variety and nitrogen levels on seed yield per hectare. Combined effect of nitrogen and varieties had not showed any remarkable influence.

The highest seed yield per hectare was recorded with variety Swaran Priya which was followed by Arka Komal and Contender in descending order. All the varieties differed significantly which each other.

There was increase in seed yield with each increasing dose of nitrogen up to 100 kg per hectare. Further higher level of nitrogen showed significant reduction in seed yield.

Table 4.14: Average seed yield (q) per hectare as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	17.42	19.71	24.85	27.18	25.11	22.85
V ₂	17.26	19.45	21.29	24.31	21.57	20.77
V ₃	10.03	12.61	14.33	17.12	15.57	13.94
MEAN	14.90	17.26	20.16	22.87	20.75	19.19

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.60	1.73
Varieties	0.46	1.34
Interaction	1.03	NS

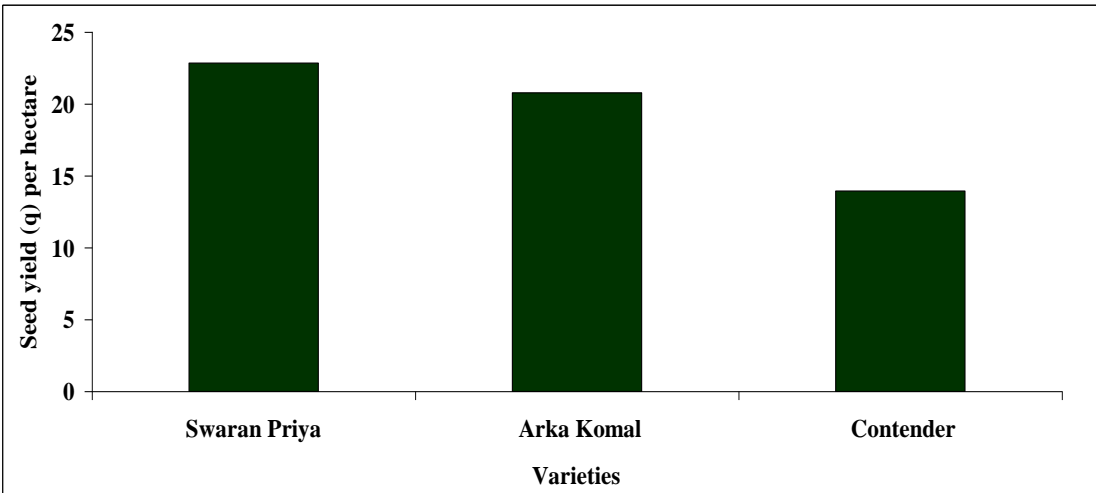


Fig. 4.14 a: Average seed yield (q) per hectare as influenced by varieties

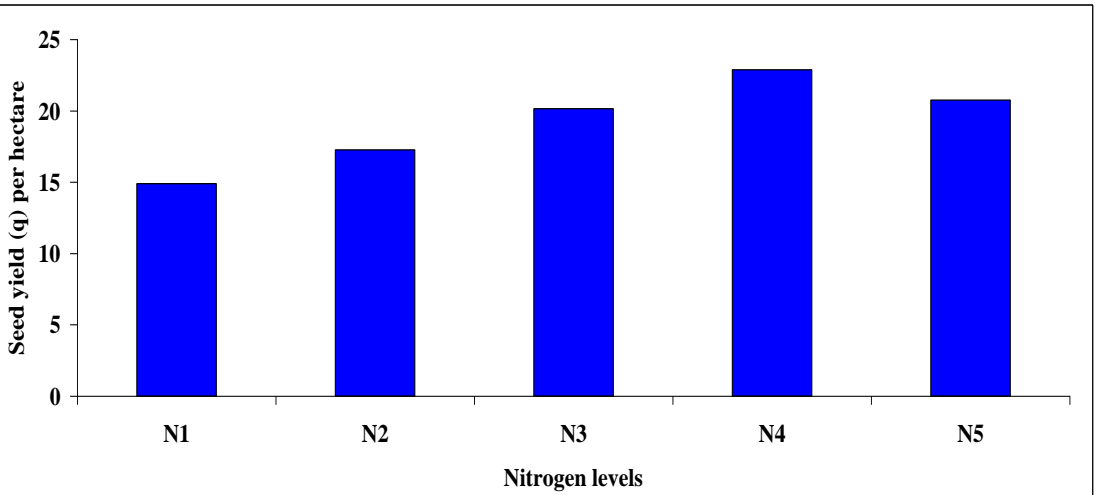


Fig. 4.14 b: Average seed yield (q) per hectare as influenced by nitrogen levels

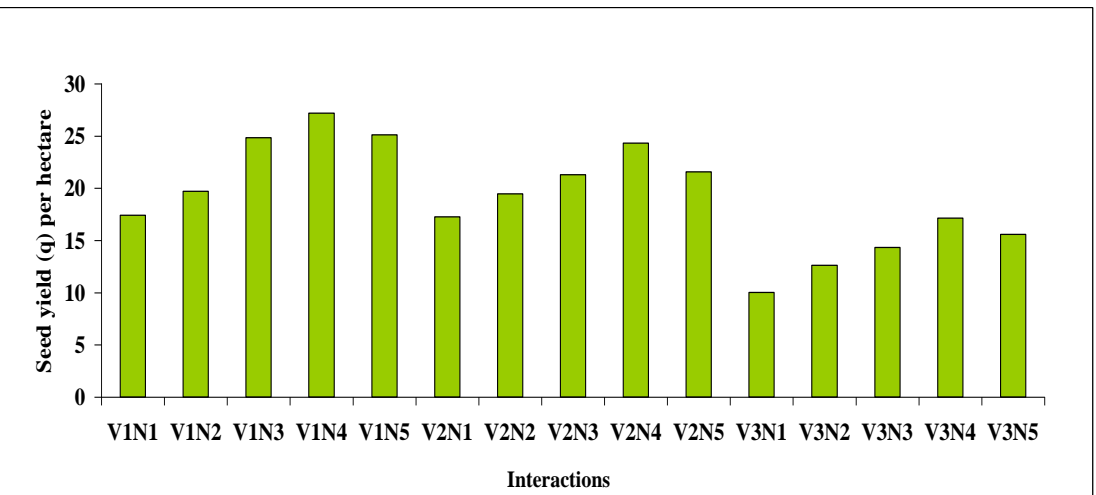


Fig. 4.14 c: Average seed yield (q) per hectare as influenced by various treatments

4.2.8 Shelling percentage

The findings presented in Table 4.15 and depicted in Figure 4.15 revealed significant effects of varieties and nitrogen levels on shelling percentage in french bean. However, combined effect of variety and nitrogen levels had no remarkable influence.

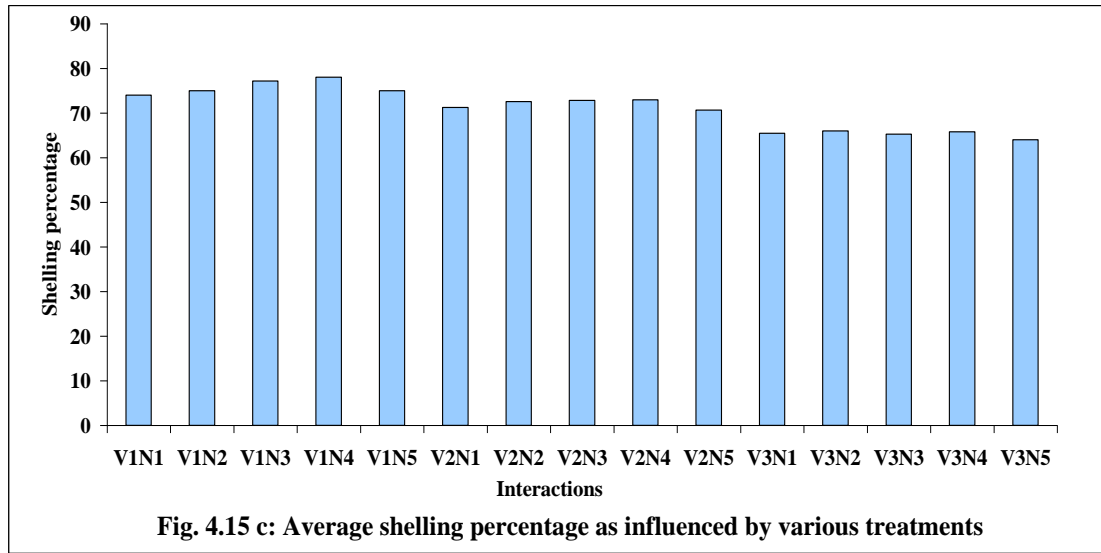
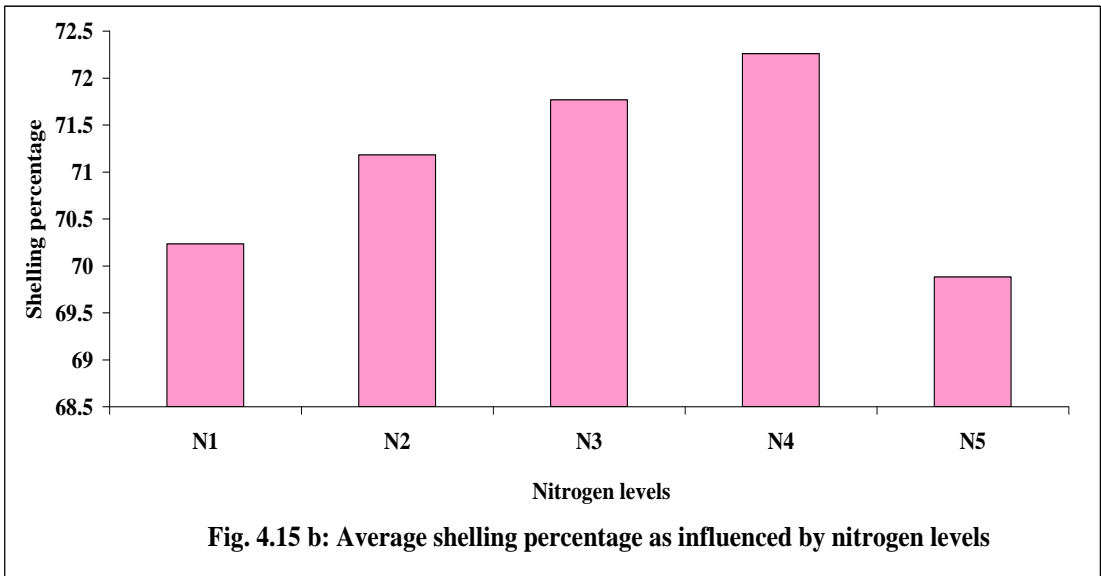
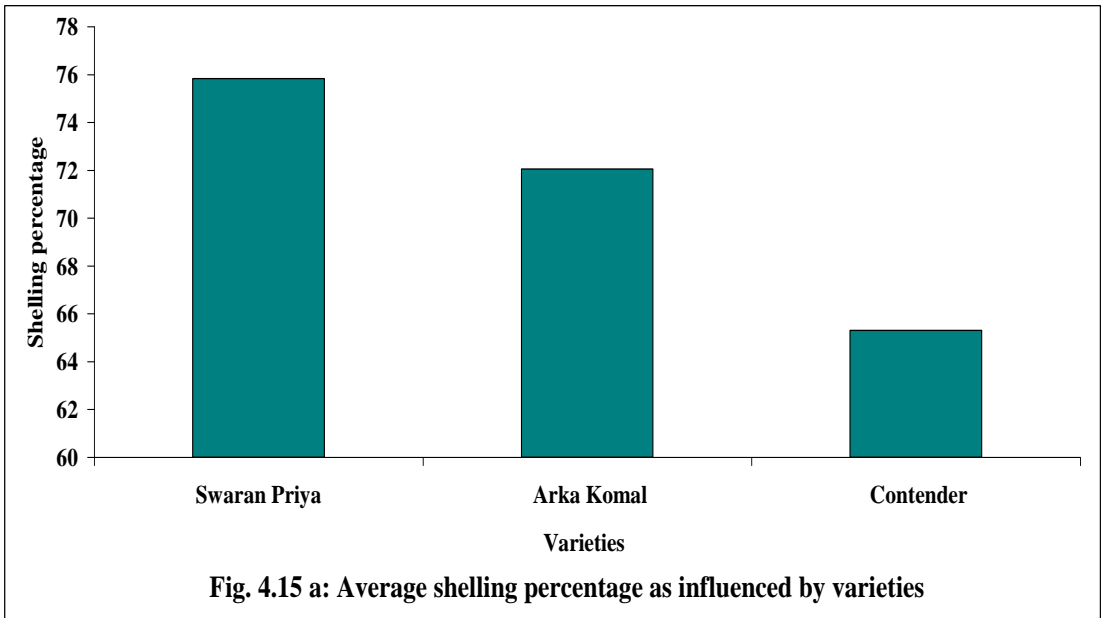
Among the varieties, Swaran Priya recorded maximum shelling percentage. It was followed by Arka Komal and Contender with significant difference.

Application of nitrogen showed significant effect on shelling percentage. There was increase in shelling percentage with each increasing dose of nitrogen up to 100 kg per hectare which was reduced at 125 kg nitrogen per hectare. The difference between 75 kg per hectare nitrogen and 100 kg per hectare nitrogen was non significant.

Table 4.15: Average shelling percentage as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	73.98	75.00	77.19	78.00	74.99	75.83
V ₂	71.24	72.56	72.83	72.99	70.66	72.06
V ₃	65.48	65.98	65.28	65.79	63.99	65.30
MEAN	70.23	71.18	71.77	72.26	69.88	71.06

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.34	0.99
Varieties	0.27	0.77
Interaction	0.59	NS



4.2.9 Harvest index

As indicated in Table 4.16 and depicted in Figure 4.16 there was significant effect of varieties and nitrogen levels on harvest index. However, combined effect of varieties and nitrogen levels did not show any remarkable influence on harvest index.

Amongst the varieties, the highest harvest index was recorded in variety Arka Komal which was followed by Swaran Priya and Contender with significant difference.

Application of nitrogen showed increase in harvest index up to 75 kg nitrogen per hectare. Further increase in nitrogen doses had no remarkable influence.

Table 4.16: Average harvest (%) index as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	14.27	15.34	18.81	19.28	18.21	17.18
V ₂	17.82	18.87	19.82	20.90	19.19	19.32
V ₃	11.88	13.88	15.12	16.26	15.50	14.53
MEAN	14.66	16.03	17.91	18.81	17.63	17.01

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.44	1.27
Varieties	0.34	0.98
Interaction	0.76	NS

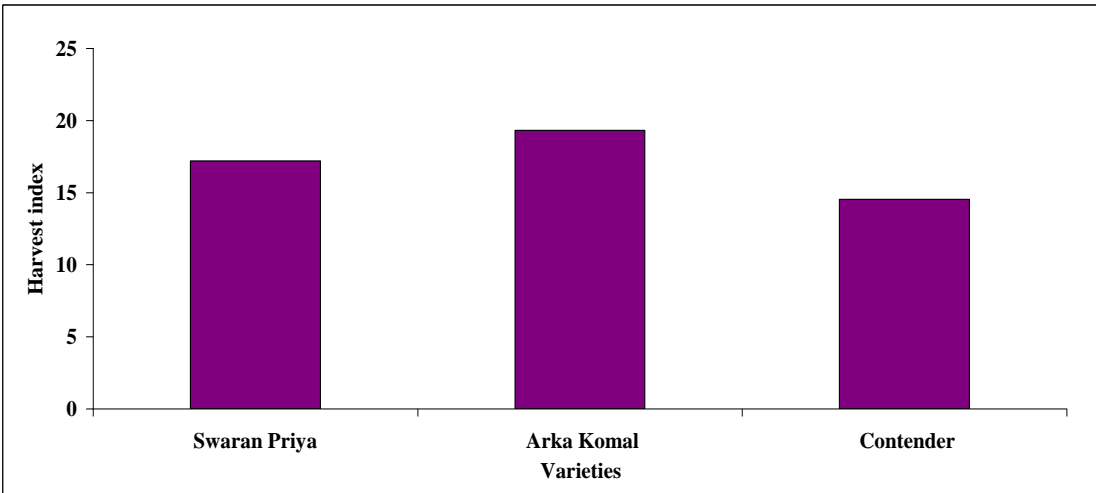


Fig.4.16 a: Average harvest index as influenced by varieties

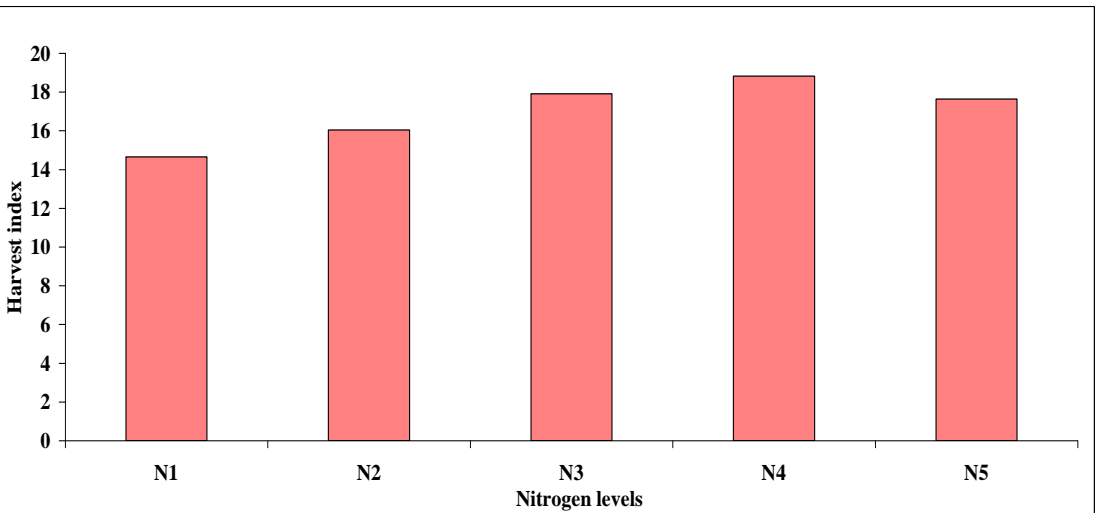


Fig. 4.16 b: Average harvest index as influenced by nitrogen levels

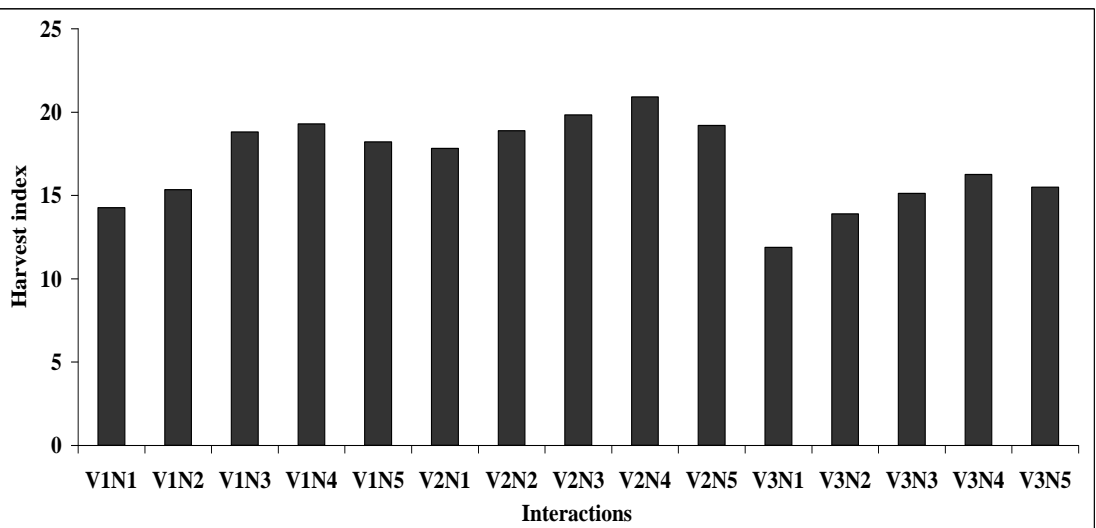


Fig. 4.16 c: Average harvest index as influenced by various treatments

4.3 Seed Quality Parameters:

4.3.1 Test weight of seed (g)

Test weight of seed as presented in Table 4.17 and depicted in Figure 4.17 revealed significant effects of varieties and nitrogen levels. Whereas combined effect of varieties and nitrogen levels did not show any significant influence on test weight of seed. Maximum test weight was recorded with variety Swaran Priya which was significantly superior over both the varieties. Variety Contender ranked second followed by Arka Komal with significant difference in test weight of seed.

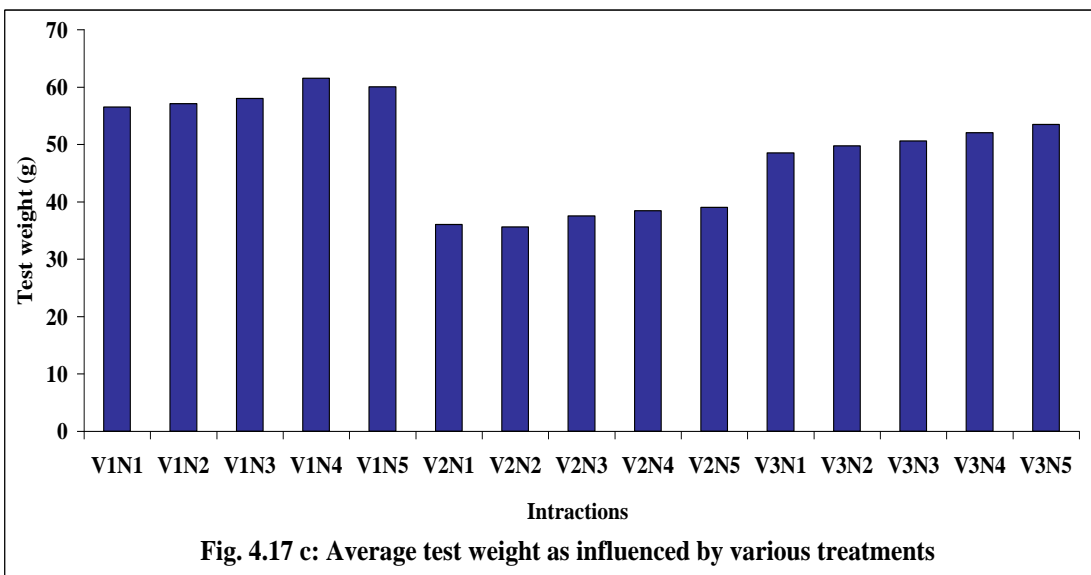
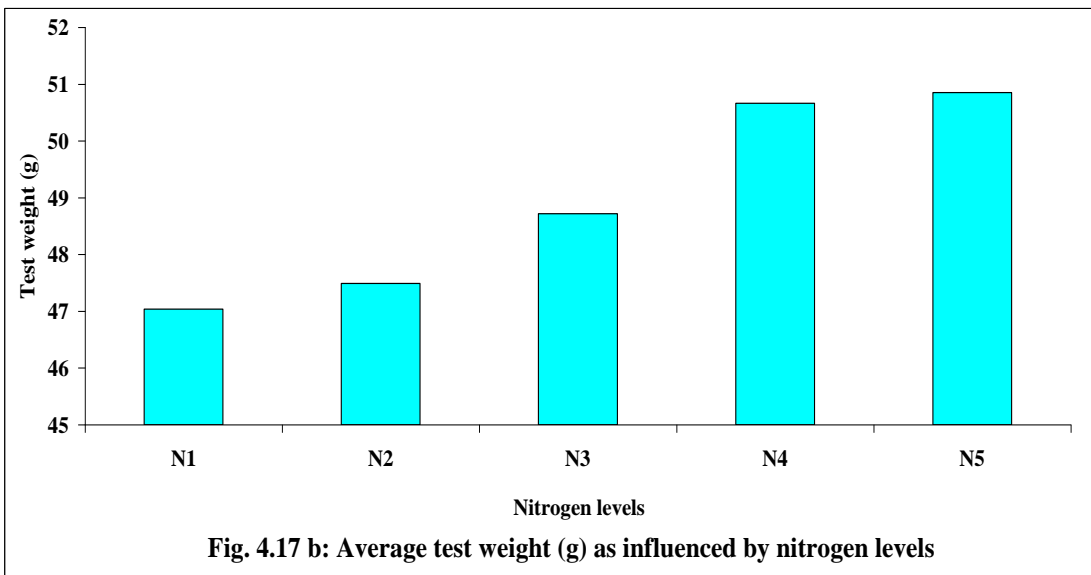
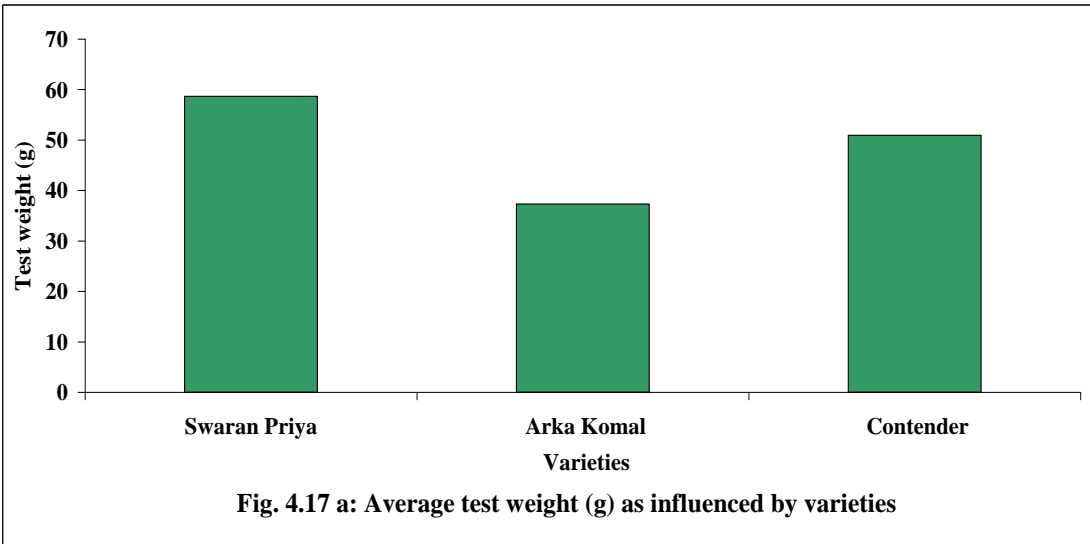
Application of nitrogen recorded increase in test weight of seed with each increasing dose of nitrogen. The highest test weight was recorded with 125 kg per hectare nitrogen which was at par to 100 kg per hectare nitrogen application.

Combined effect of variety and nitrogen levels did not showed any significant effect on test weight of seed in french bean.

Table 4.17: Average test weight as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	56.53	57.10	57.99	61.51	60.05	58.64
V ₂	36.04	35.60	37.55	38.42	39.03	37.33
V ₃	48.53	49.77	50.62	52.06	53.47	50.89
MEAN	47.04	47.49	48.72	50.66	50.85	48.95

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.54	1.56
Varieties	0.42	1.21
Interaction	0.93	NS



4.3.2 Crude protein content (%) in seed

Crude protein content in seed was determined and data are presented in Table 4.18 and depicted in Figure 4.18. It revealed that application of nitrogen imparted significant influence. Whereas varieties, and combined effect of nitrogen and varieties had no significant influence on crude protein content.

Application of nitrogen showed increase in crude protein content in seed with each increasing dose of nitrogen. The highest crude protein was recorded with application of 125 kg per hectare nitrogen which was followed by 100 kg per hectare nitrogen with no significant difference. Other lower levels of nitrogen application showed significantly lower values of crude protein in seed.

Table 4.18: Average crude protein content (%) in seed as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	20.06	20.50	21.19	22.69	23.13	21.51
V ₂	20.56	21.29	21.38	22.63	22.81	21.73
V ₃	19.94	20.25	21.25	22.31	23.06	21.36
MEAN	20.19	20.68	21.27	22.54	23.00	21.54

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.24	0.70
Varieties	0.19	NS
Interaction	0.42	NS

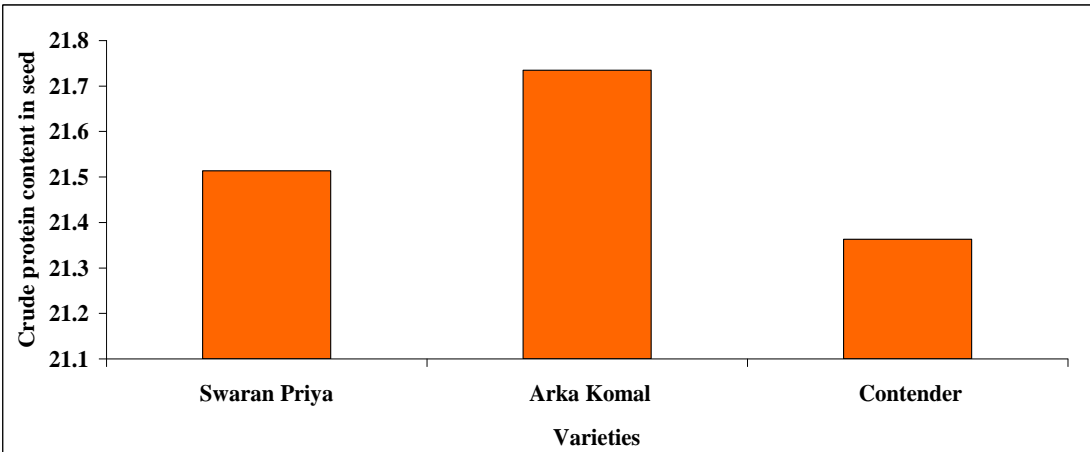


Fig. 4.18 a: Average crude protein content in seed as influenced by varieties

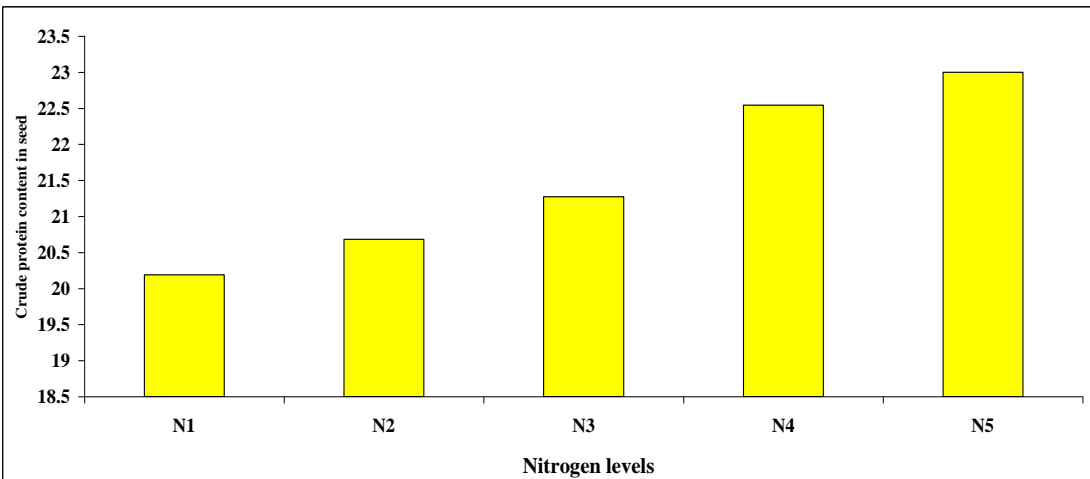


Fig. 4.18 b: Average crude protein content in seed as influenced by nitrogen levels

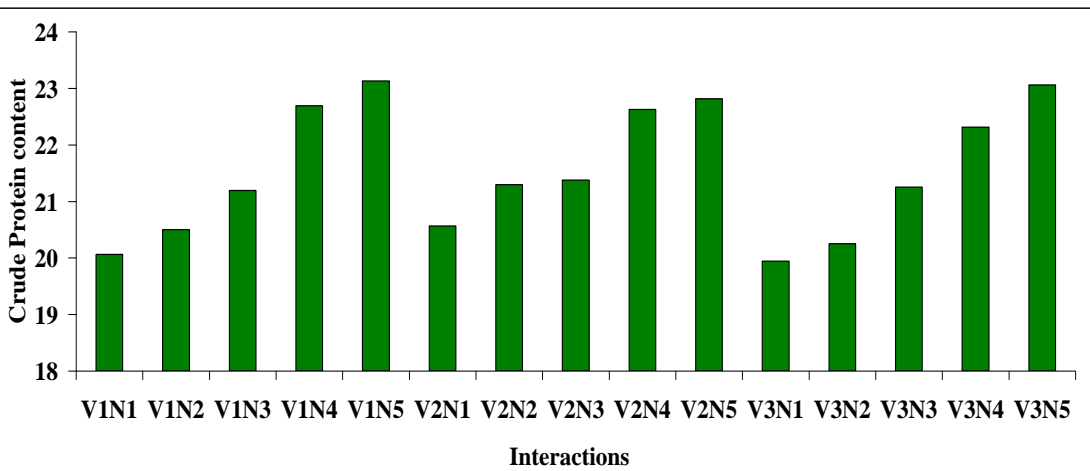


Fig. 4.18 c: Average crude protein content in seed as influenced by various treatment

4.3.3 Germination percentage in seed

Germination percentage in seed as presented in Table 4.19 and depicted in Figure 4.19 exhibited significant influences of varieties as well as nitrogen levels. Combined effect of varieties and nitrogen levels showed non significant effect on germination of seed.

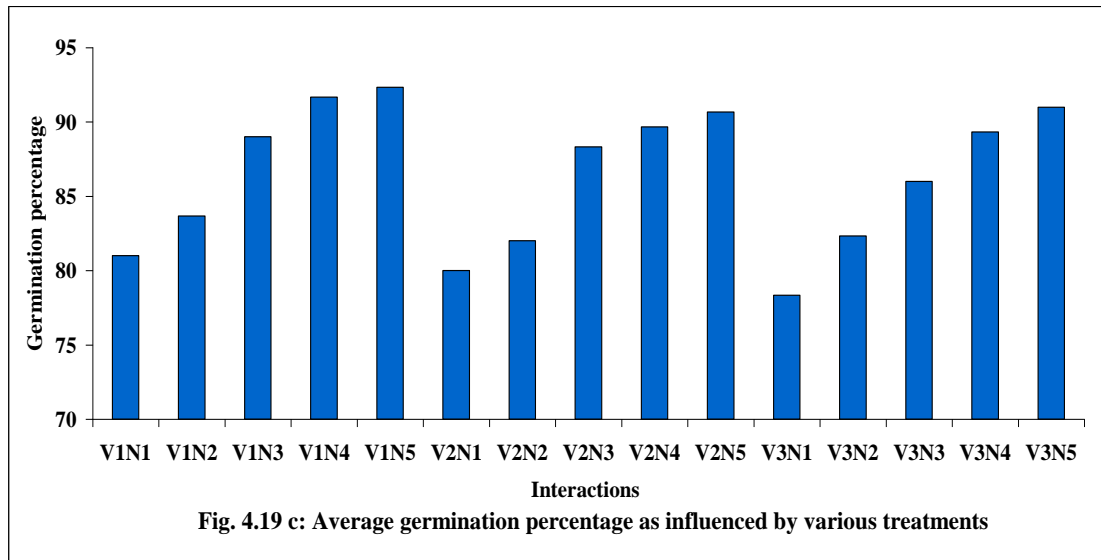
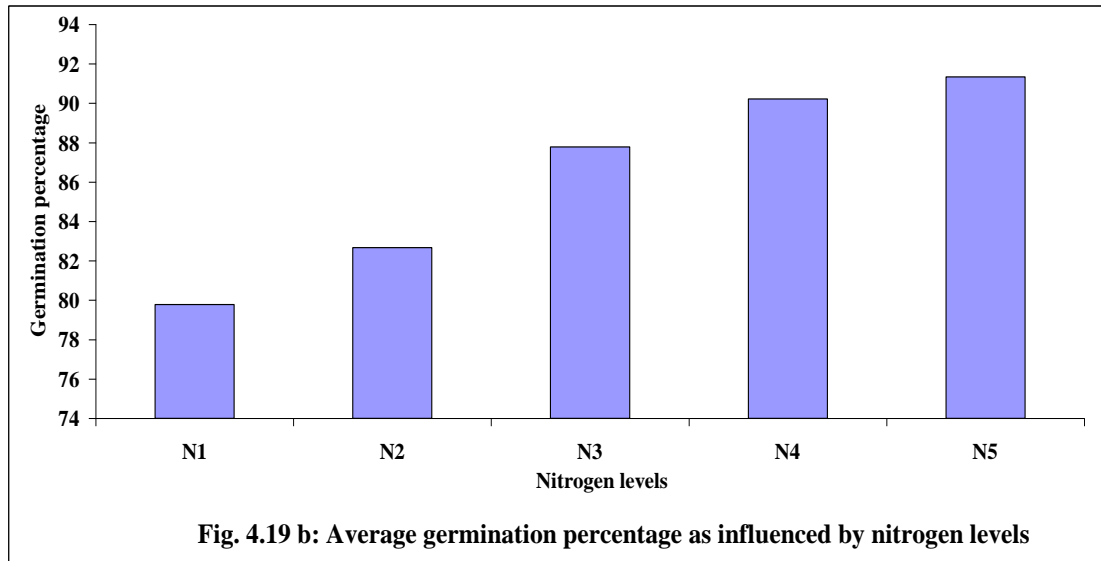
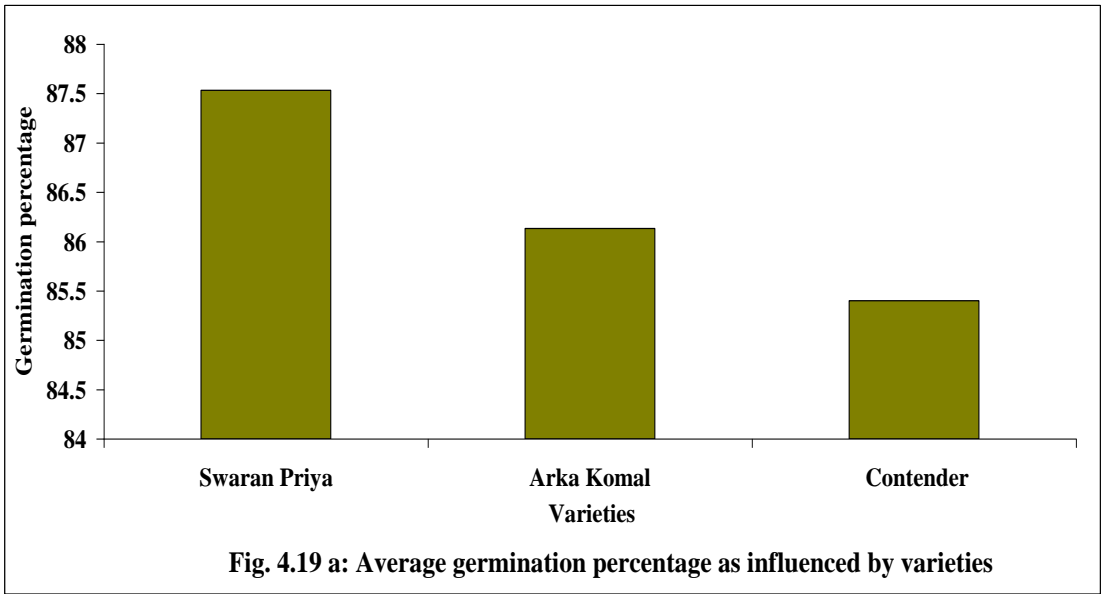
The highest germination in seed was recorded in variety Swaran Priya followed by Arka Komal and Contender. Variety Arka Komal and Contender were at par.

Application of nitrogen showed increase in germination percentage with each increasing dose up to 125 kg per hectare. The highest germination was recorded at 125 kg per hectare nitrogen which was at par to 100 kg per hectare nitrogen but significantly higher over other lower levels of nitrogen.

Table 4.19: Average germination (%) in seed as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	81.00	83.67	89.00	91.67	92.33	87.53
V ₂	80.00	82.00	88.33	89.67	90.67	86.13
V ₃	78.33	82.33	86.00	89.33	91.00	85.40
MEAN	79.78	82.67	87.78	90.22	91.33	86.36

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.40	1.15
Varieties	0.31	0.89
Interaction	0.69	NS



4.4 Post Harvest Analysis of Soil

4.4.1 Available nitrogen (kg/ha) in soil

The data presented in Table 4.20 and depicted in Figure 4.20 showed significant influence of variety and nitrogen levels as well as their combined effect on available nitrogen in soil after harvesting.

The highest available nitrogen in soil was recorded under variety Contender which was followed by Arka Komal and Swaran Priya in descending order. All the varieties differed significantly with each other.

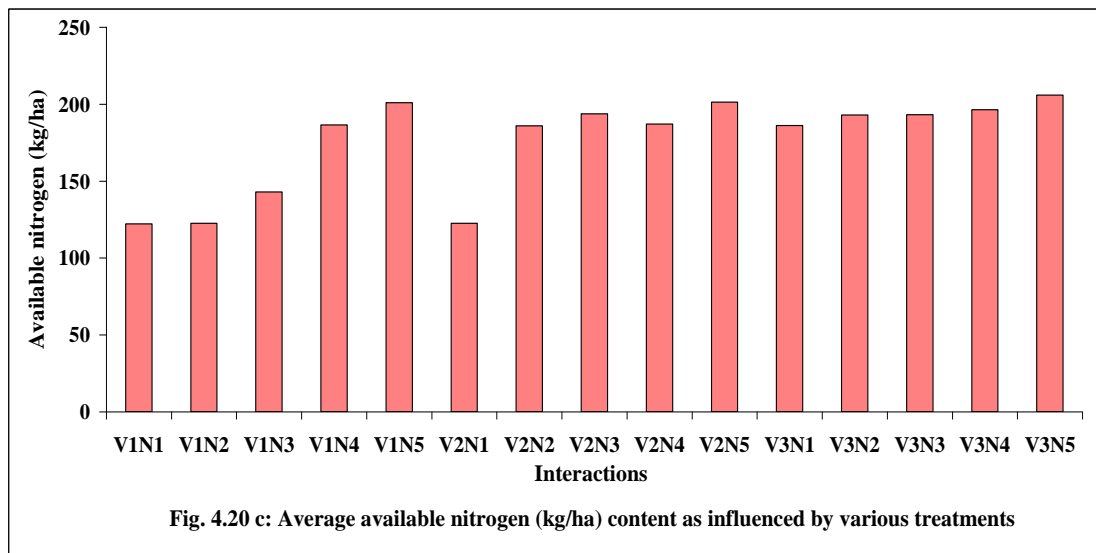
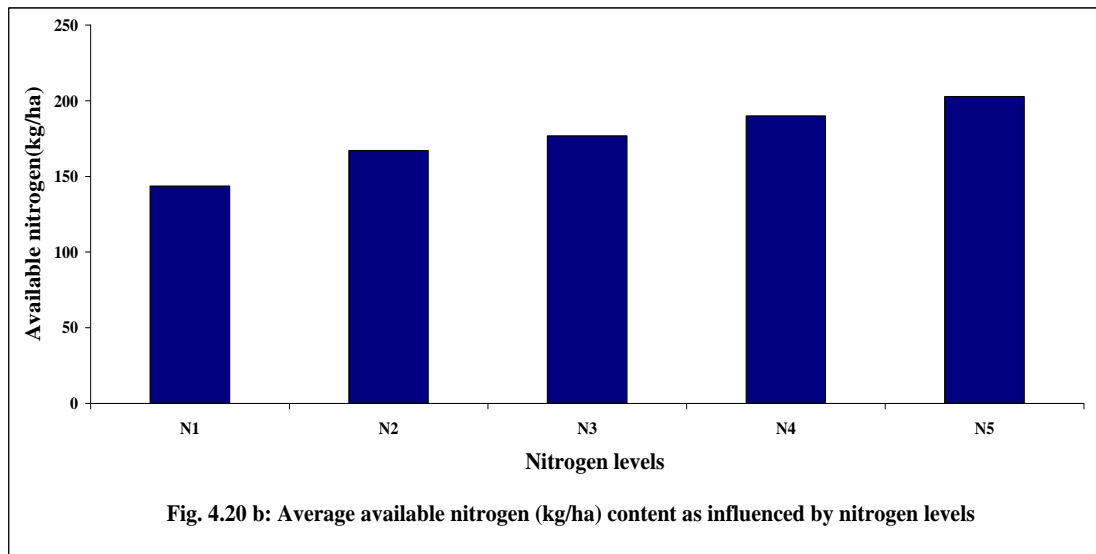
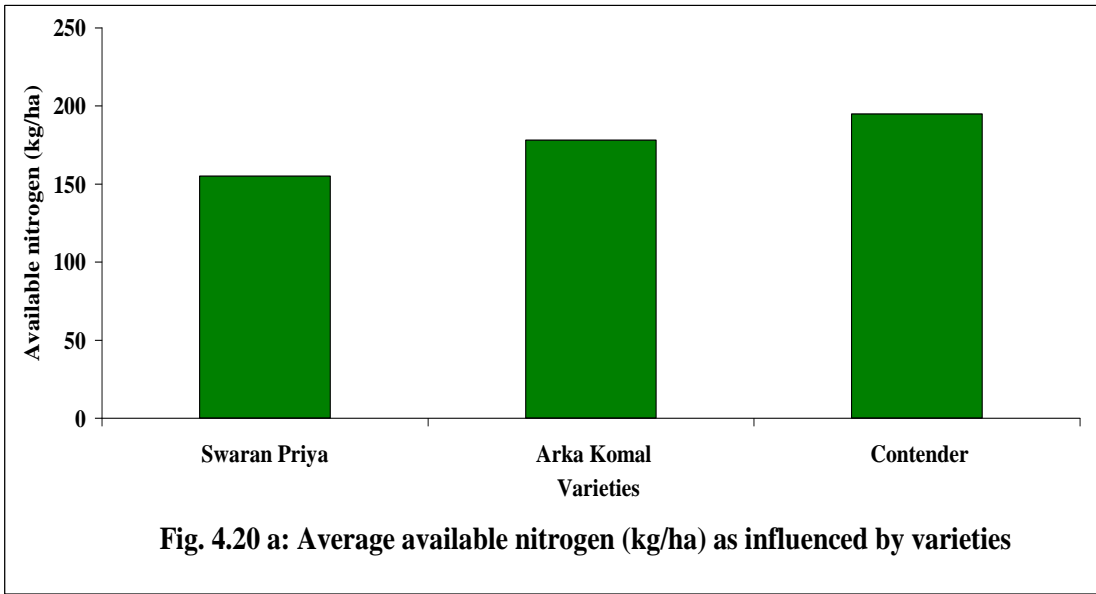
Application of nitrogen showed higher available nitrogen with each increasing dose. All the doses differed significantly with each other. The highest available nitrogen was recorded with 125 kg per hectare nitrogen application.

Combined effect of varieties and nitrogen showed the highest available nitrogen with application V_3N_5 which was followed by V_2N_5 and V_1N_5 . The lowest available nitrogen was recorded were V_1N_1 . In general there was increase in available nitrogen with increasing dose of nitrogen application in respective of the variety. But variety V_2 showed sharp increase at N_2 whereas V_1 showed sharp increase at N_4 level.

Table 4.20: Average available nitrogen (kg/ha) in soil as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N_1	N_2	N_3	N_4	N_5	
V_1	122.07	122.43	142.90	186.43	200.87	154.94
V_2	122.47	185.83	193.77	187.03	201.20	178.06
V_3	186.13	192.90	193.20	196.43	205.80	194.89
MEAN	143.56	167.06	176.62	189.97	202.62	175.96

Treatments	S.Em \pm	CD at 5%
Nitrogen levels	3.01	8.71
Varieties	2.33	6.75
Interaction	5.21	15.09



4.4.2 Available phosphorus (kg/ha) in soil

The data presented in Table 4.21 and depicted in Figure 4.21 showed significant influence of varieties, nitrogen levels as well as their interaction effect on available phosphorus content in soil after harvesting.

Among the varieties, Contender recorded maximum available phosphorus content followed by Arka Komal and Swaran Priya. There was no significant difference between variety Contender and Arka Komal but both were significantly superior over Swaran Priya.

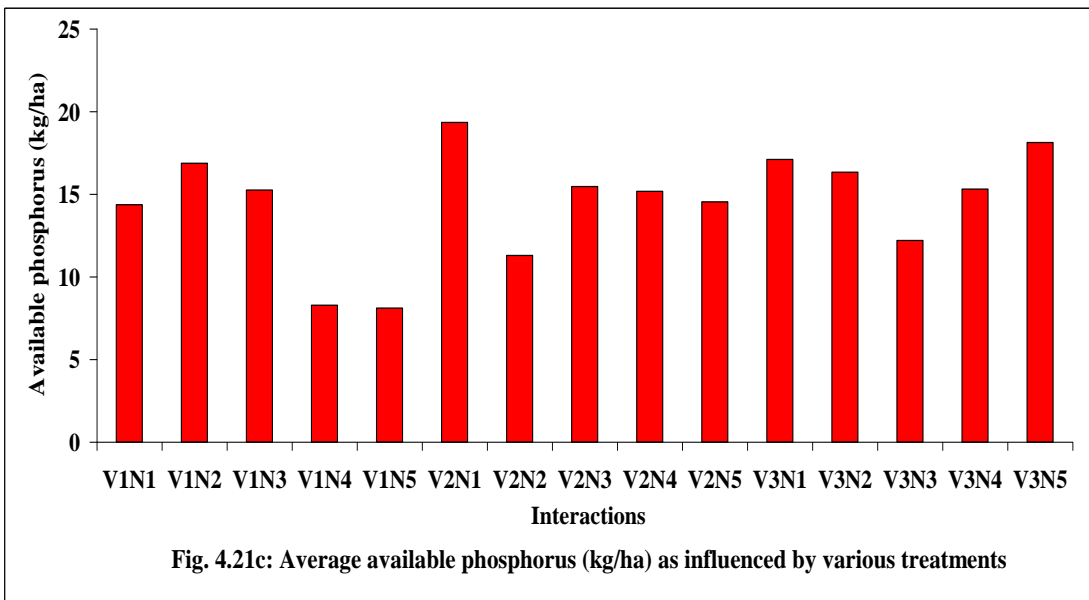
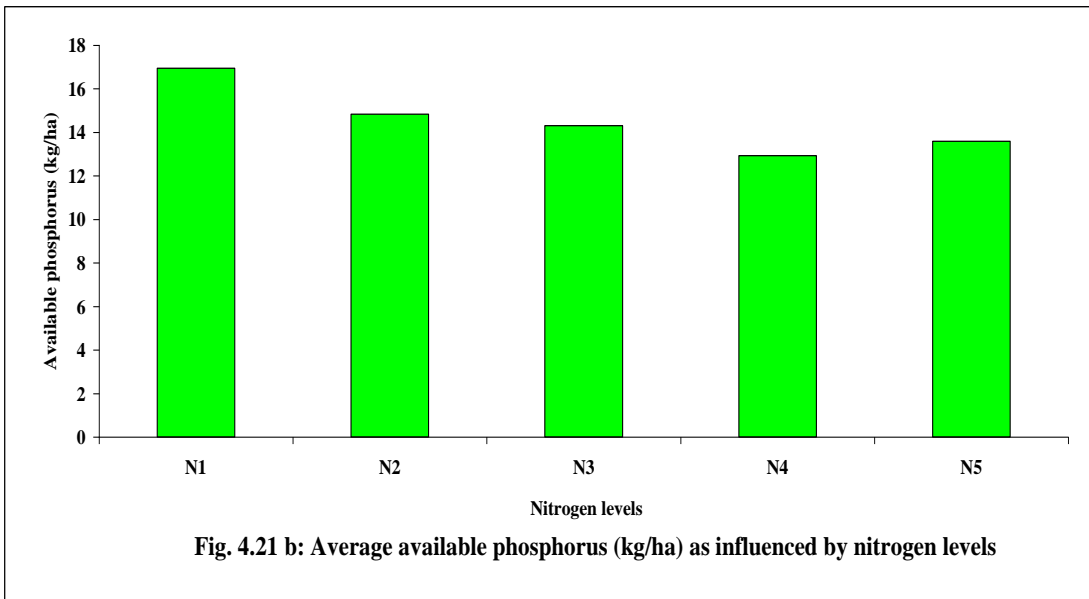
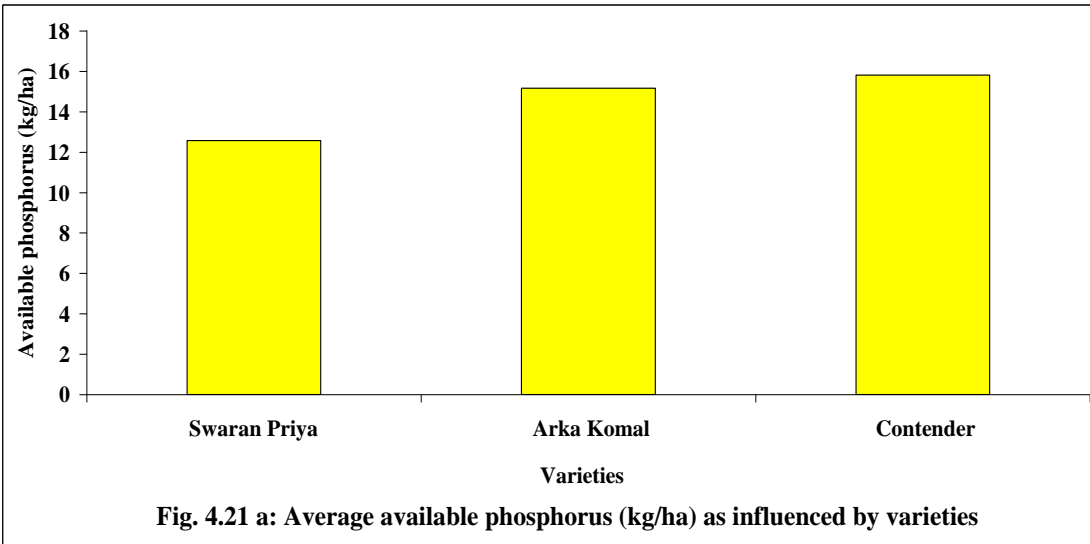
Application of nitrogen caused depletion of phosphorus with increasing dose. The highest available phosphorus content was recorded under 25 kg nitrogen per hectare which gradually decreased with increasing dose of nitrogen. Minimum phosphorus content was recorded at 100 kg nitrogen per hectare.

Combined effect of variety and nitrogen showed maximum available phosphorus under Arka Komal along with 25 kg nitrogen application which was followed by Contender with 25 kg nitrogen application and Contender with 75 kg nitrogen application. Minimum phosphorus content was recorded with Swaran Priya under 125 kg nitrogen application.

Table 4.21: Average available phosphorus (kg/ha) in soil as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	14.36	16.87	15.25	8.29	8.12	12.58
V ₂	19.35	11.30	15.46	15.18	14.54	15.16
V ₃	17.11	16.32	12.20	15.30	18.12	15.81
MEAN	16.94	14.83	14.30	12.92	13.59	14.52

Treatments	S.Em±	CD at 5%
Nitrogen levels	0.45	1.30
Varieties	0.35	1.01
Interaction	0.78	2.26



4.4.3 Available potassium (kg/ha) in soil

Potassium content in soil as presented in Table 4.2 and depicted in Figure 4.22 revealed significant effects of varieties, nitrogen levels as well as their combined effects.

Variety Contender recorded the highest available potassium content in soil followed by Arka Komal and Swaran Priya. All the varieties differ significantly to each other.

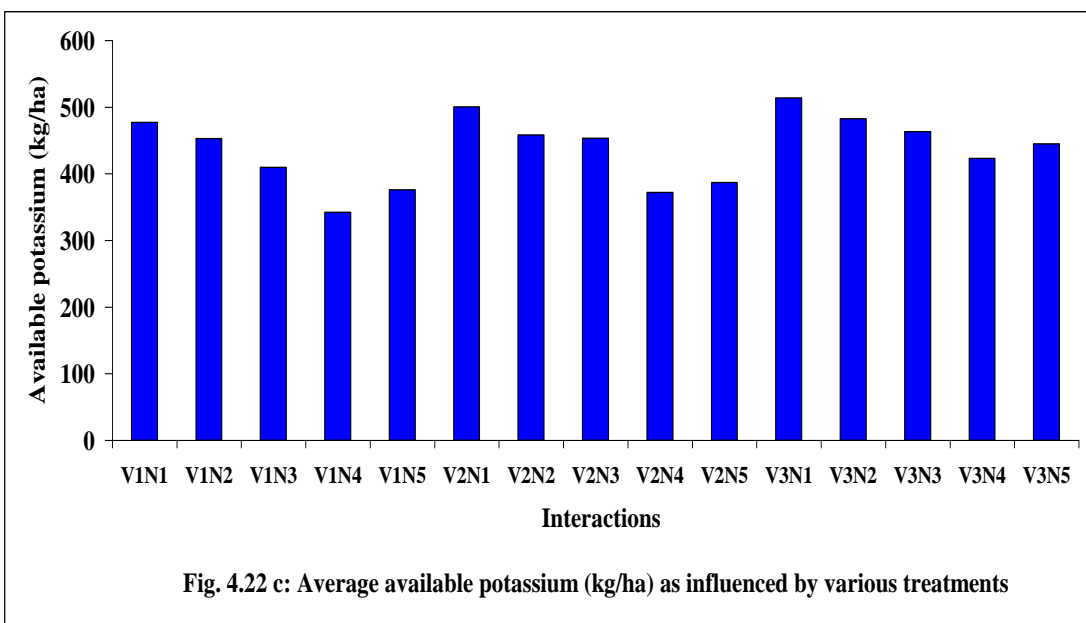
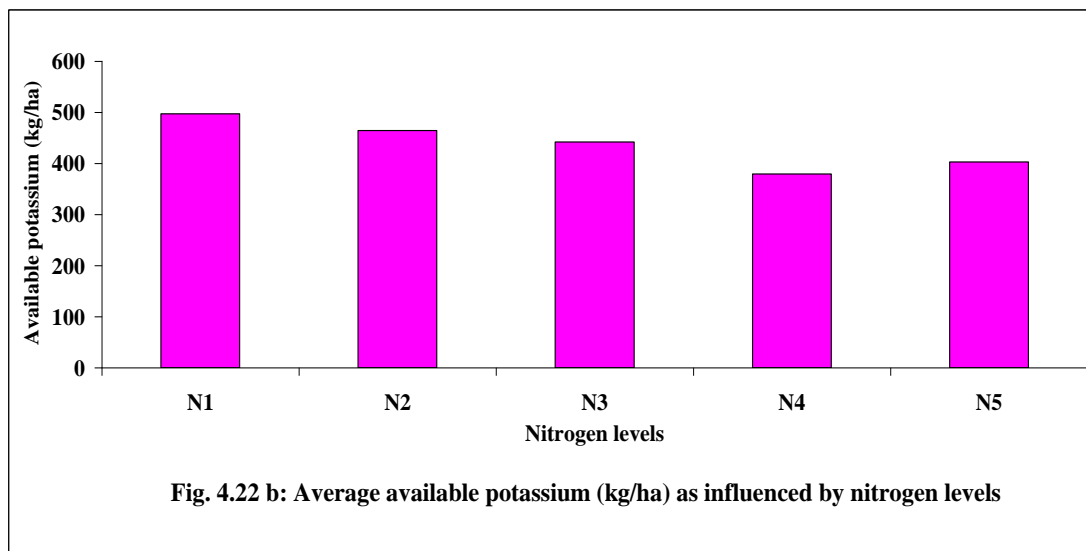
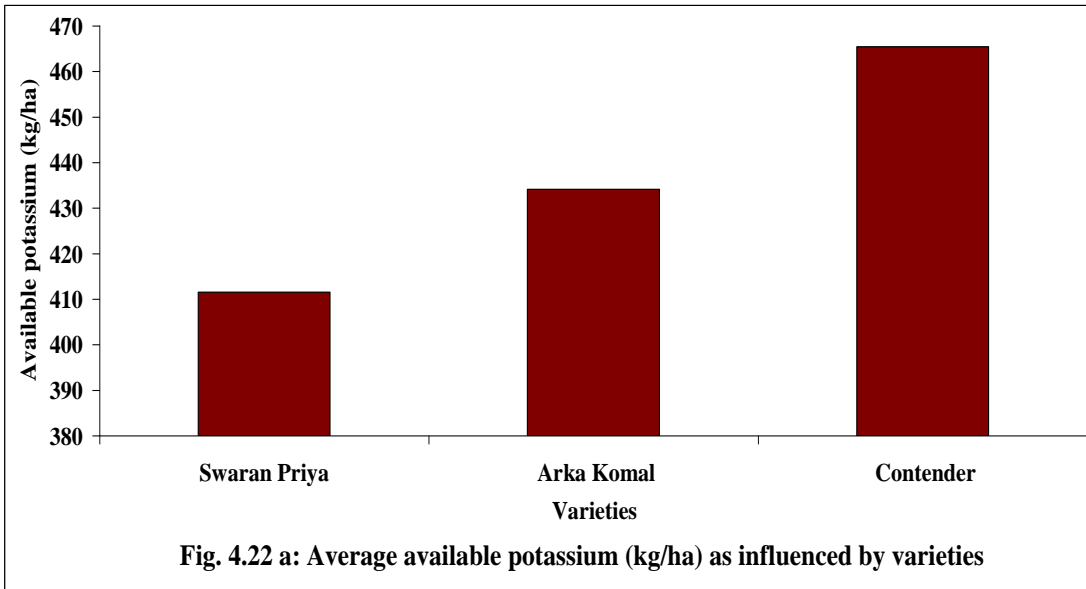
There was decrease in available potassium content with each increasing dose of nitrogen up to 100 kg nitrogen per hectare. However further increase in nitrogen showed slight increase in available potassium content in the soil.

Combined effect of nitrogen and variety revealed that variety Contender with application of 25 kg nitrogen recorded maximum available potassium followed by Arka Komal at the same level of nitrogen application. Increasing dose of nitrogen showed decreasing level of available potassium content in soil under each variety up to 100 kg nitrogen per hectare which was higher at 125 kg nitrogen per hectare as compare to N₄ level of nitrogen in general lowest available potassium was noted under Swaran Priya at each level of nitrogen application.

Table 4.22: Average available potassium (kg/ha) in soil as influenced by varieties, nitrogen levels and their combinations

Varieties	Nitrogen levels					MEAN
	N ₁	N ₂	N ₃	N ₄	N ₅	
V ₁	476.87	452.91	409.43	342.32	376.11	411.53
V ₂	500.37	457.97	453.35	371.93	386.86	434.09
V ₃	513.63	482.57	463.01	423.08	444.90	465.44
MEAN	496.96	464.48	441.93	379.11	402.62	437.02

Treatments	S.Em±	CD at 5%
Nitrogen levels	4.91	14.24
Varieties	3.81	11.03
Interaction	8.51	24.66



4.5 Economic evaluation of different treatments for seed production

Data presented in Table 4.23 and depicted in Figure 4.23 revealed that variety Swaran Priya with application of N_4 (100 kg/ha N) gave maximum gross return per hectare followed by Swaran Priya under N_5 (125 kg/ha N), Swaran Priya under N_3 (75 kg/ha N), Arka Komal with N_4 (100 kg/ha N), Arka Komal with N_5 (125 kg/ha N), Arka Komal with N_3 (75 kg/ha N), Swaran Priya under N_2 (50 kg/ha N), Arka Komal with N_2 (50 kg/ha N), Swaran Priya under N_1 (25 kg/ha N), Contender with N_4 (100 kg/ha N), Contender with N_5 (125 kg/ha N), Contender with N_3 (75 kg/ha N), Contender with N_2 (50 kg/ha N) and Contender with N_1 (25 kg/ha N) in descending order. Minimum gross return was obtained with V_3N_1 .

Maximum net return was obtained with Swaran Priya under N_4 (100 kg/ha N) application followed by Arka Komal with N_4 (100 kg/ha N) application and Contender with N_4 (100 kg/ha N) application. The lowest net profit was found under V_3N_1 (Contender with 25 kg/ha N).

Cost: benefit ratio showed maximum value with Swaran Priya under N_4 (100 kg/ha N) followed by Swaran Priya under N_3 (75 kg/ha N), Swaran Priya under N_5 (125 kg/ha N) and Arka Komal with N_4 (100 kg/ha N). The lowest cost: benefit ratio was obtained with Contender with N_1 (25 kg/ha N) application.

Table 4.23: Economic evaluation of different treatments for seed production in french bean

Treatment	Common Expenditure (Rs/ha)	Expenditure on fertilizer (Rs/ha)	Total Cost of cultivation (Rs/ha)	Seed Yield (q/ha)	Gross return/ha (Rs.)	Net profit (Rs/ha)	Cost : Benefit ratio
V ₁ N ₁	25175.5	3163.03	28338.53	17.42	78390	50051.47	1:2.76
V ₁ N ₂	25175.5	4207.26	29382.76	19.71	88695	59312.24	1:3.01
V ₁ N ₃	25175.5	4955.37	30130.87	24.85	111825	81694.13	1:3.71
V ₁ N ₄	25175.5	5428.77	30604.27	27.18	122310	91705.73	1:3.99
V ₁ N ₅	25175.5	5834.43	31009.93	25.11	112995	81985.07	1:3.64
V ₂ N ₁	25175.5	3163.03	28338.53	17.26	77670	49331.47	1:2.74
V ₂ N ₂	25175.5	4207.26	29382.76	19.45	87525	58142.24	1:2.97
V ₂ N ₃	25175.5	4955.37	30130.87	21.29	95805	65674.13	1:3.17
V ₂ N ₄	25175.5	5428.77	30604.27	24.31	109395	78790.73	1:3.57
V ₂ N ₅	25175.5	5834.43	31009.93	21.57	97065	66055.07	1:3.13
V ₃ N ₁	25175.5	3163.03	28338.53	10.03	45135	16796.47	1:1.59
V ₃ N ₂	25175.5	4207.26	29382.76	12.61	56745	27362.24	1:1.93
V ₃ N ₃	25175.5	4955.37	30130.87	14.33	64485	34354.13	1:2.14
V ₃ N ₄	25175.5	5428.77	30604.27	17.12	77040	46435.73	1:2.51
V ₃ N ₅	25175.5	5834.43	31009.93	15.57	70065	39055.07	1:2.25

Cost and price are given in Appendix X.

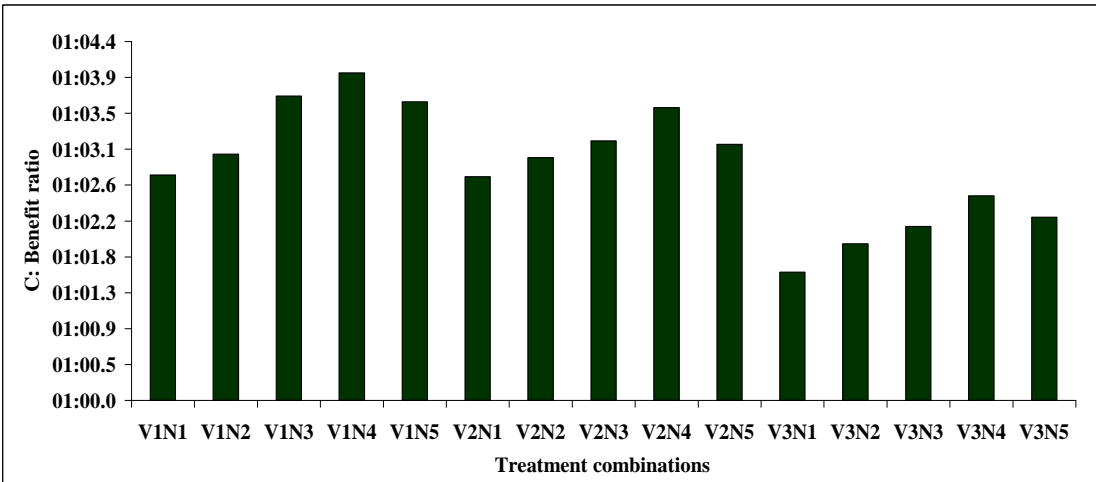


Fig. 4.23 a: C:Benefit ratio for seed production as influenced with different treatments

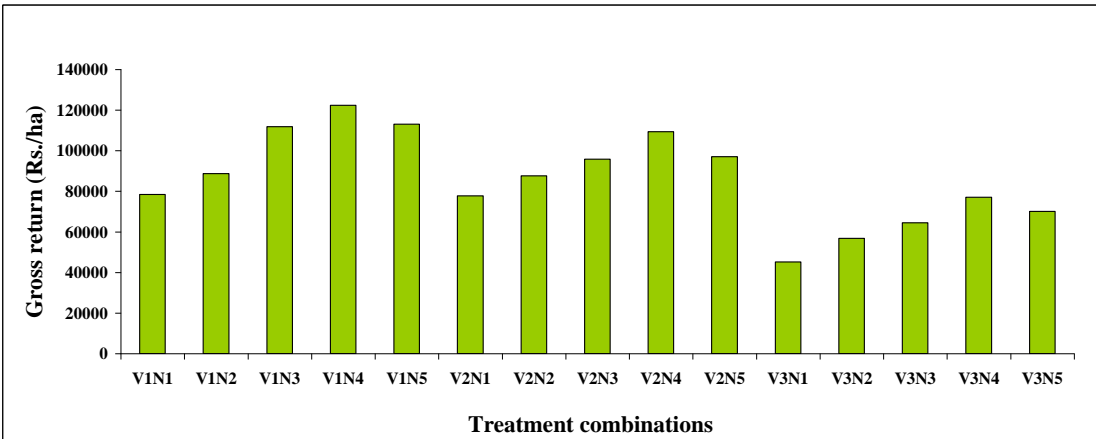


Fig. 4.23 b: C:B ratio for gross return as influenced with different treatments

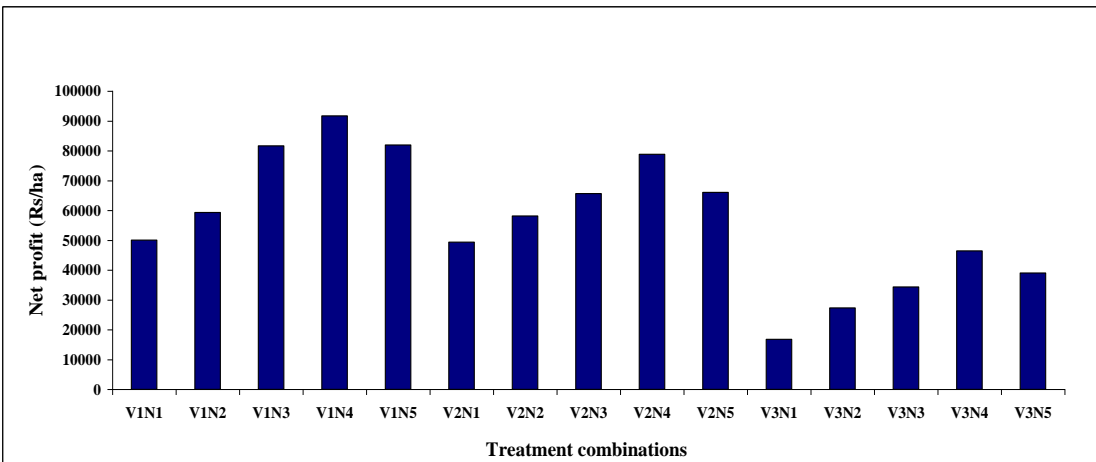


Fig.4.23 c: C:B ratio for net profit as influenced with different treatments

CHAPTER - V

DISCUSSION

The results obtained from the investigation entitled “Effect of nitrogen levels on yield and quality of seed in french bean” carried out at Bahadari farm College of Horticulture, Mandsaur during 2009-10 are discussed in this chapter under the following headings:

5.1 Growth parameters

5.2 Yield parameters and yield

5.3 Seed quality parameters

5.4 Post harvest analysis of soil

5.5 Economics

5.1 Growth Parameters:

Growth parameters were recorded at 30, 45, 60 DAS and at harvesting stage. The findings showed significant influence of varieties and nitrogen levels on various growth parameters viz., plant height (cm), and number of leaves per plant, number of branch per plant, leaf area index, fresh weight and dry weight (g) of shoot per plant. There was linear increase in plant height with advancement of crop period which was reduced slightly at harvesting stage as compared to 45 and 60 days after sowing. It was due to the drying and dropping of the upper part of the plant.

Plant height showed maximum values with variety Swaran Priya as compared to Arka Komal and least under Contender. Arya and Rana (1999) and Rahman *et al.* (2007) also reported significant influence of varieties on plant height. Number of leaves per plant was recorded maximum under Swaran Priya at all the three growth stages followed by Contender and Arka Komal. Maximum values for leaf area index, number of branches per plant, fresh weight (g) of shoot as well as dry weight (g) of shoot per plant were recorded with variety Swaran Priya. These findings are in line with findings of Singh *et al.* (2009) in french bean.

Application of nitrogen exerted significant influence on growth parameters. Maximum plant height, number of leaves per plant, leaf area index, number of branches per plant, fresh weight and dry weight (g) of shoot per plant were recorded under application of nitrogen at the rate of 100 kg/ha followed by 125 kg/ha >75

kg/ha > 50kg/ha > 25 kg/ha in descending order at all the growth stages. Similar findings have been reported by Farkade and Pawar (2002) and Singh and Verma (2002b) in french bean.

Combined effect of varieties and nitrogen had exerted non significant influence on growth parameters viz., plant height and number of leaves per plant, number of branches per plant, leaf area index, fresh weight and dry weight (g) of shoot per plant at all the growth stages. However, leaf area index exhibited significant difference at 60 days after sowing. Maximum plant height, number of leaves per plant, leaf area index, number of branches per plant, fresh weight and dry weight (g) of shoot per plant were recorded with Swaran Priya under N₄ (100 kg/ha N) application. Minimum plant height, number of leaves per plant, leaf area index, number of branches per plant, fresh weight and dry weight (g) of shoot per plant were observed with variety Contender under N₁ (25 kg/ha N) application. More availability of nitrogen under (100 kg/ha N) and better absorption and utilization by variety Swaran Priya might have resulted in superior performance of the combination V₁N₄ (Swaran Priya with nitrogen 100 kg/ha).

Significant difference in days taken to 50 per cent flowering was recorded under different varieties of french bean. The Earliest 50 per cent flowering was observed in Contender followed by Swaran Priya. Both these varieties were statistically at par. Significantly higher numbers of days to 50 per cent flowering were taken by variety Arka Komal. Similar results were obtained by Singh *et al.* (2009) in french bean.

Nitrogen application showed significant influence on days taken to 50 per cent flowering. Higher levels of nitrogen resulted in delay of flowering. Application of nitrogen at N₅ (125 kg/ha N) caused maximum days to 50 per cent flowering followed by 100 kg/ha >75 kg/ha > 50kg/ha > 25 kg/ha in descending order. Higher doses of nitrogen prolonged growth period and delayed flowering. Arya *et al.* (1999) also reported increase in days taken to 50 per cent flowering with higher doses of nitrogen in french bean.

Combination of varieties and nitrogen levels did not showed any remarkable influence on commencement of 50 per cent flowering in french bean.

5.2 Yield Parameters and Yield:

Yield parameters showed significant influence of varieties and nitrogen levels. Whereas, combined effect of varieties and nitrogen levels had no significant influence on number of pod per plant, number of seed per pod, length of pod (cm), pod yield (g) per plant, pod yield (q) per hectare and seed yield (g) per plant, seed yield (q) per hectare and shelling percentage. Variety Swaran Priya recorded maximum value for number of pod per plant, number of seed per pod, length of pod (cm), pod yield (g) per plant, pod yield (q) per hectare, seed yield (g) per plant, seed yield (q) per hectare and shelling percentage. It was followed by variety Arka Komal and Contender. Harvest index was maximum in Arka Komal followed by Swaran Priya and Contender. Higher photosynthetic area, more dry matter accumulation might have resulted in highest yield parameters and yield in variety Swaran Priya. Farkade and Pawar (2002) also reported influence of varieties on number of seed per pod as well as seed yield (q) per hectare. Kumar and Puri (2002) found significant influence of french bean varieties on number of pod per plant, number of seed per plant as well as seed yield per hectare.

Nitrogen application exhibited significant effect on yield parameters in french bean. There was linear increase in yield parameters with increasing levels of nitrogen. Maximum number of pod per plant, number of seed per pod, length (cm) of pod, pod yield (g) per plant, pod yield (q) per hectare, seed yield (g) per plant, seed yield (q) per hectare, shelling percentage and harvest index were found with application of nitrogen at the rate of 100 kg/ha Nitrogen. It was followed by 125 kg/ha >75 kg/ha > 50kg/ha > 25 kg/ha in descending order. More availability of nitrogen might have resulted in higher growth parameters, yield parameters and yield with higher levels of nitrogen application. Srinivas and Naik (1988), Farkade and Pawar (2002), Singh and Verma (2002b) and Lal (2004) also reported higher growth parameters and yield with higher doses of nitrogen in french bean.

Combined effect of varieties and nitrogen levels showed non significant influence on number of pods per plant, number of seed per pod, length (cm) of pod, pod yield (g) per plant, pod yield (q) per hectare, seed yield (g) per plant, seed yield (q) per hectare, shelling percentage and harvest index. Numerically maximum number of seed per pod, length (cm) of pod, pod yield (g) per plant, pod yield (q) per hectare, seed yield (g) per plant, seed yield (q) per hectare, shelling percentage were found with variety Swaran Priya under N₄ (100 Kg/ha N) application. Whereas

numerical values of harvest index was highest with Arka Komal under N₄ (100 kg/ha N) application.

5.3 Quality Parameters:

Seed quality was studied with respect to test weight, crude protein content and germination percentage in seed. The results revealed that there was no remarkable difference between varieties for crude protein content. Test weight and germination percentage in seed were significantly influenced with varieties as well as nitrogen levels.

Maximum value for test weight was recorded with variety Swaran Priya followed by Contender and Arka Komal. Highest crude protein content was recorded with variety Arka Komal followed by Swaran Priya and Contender. Germination percentage in seed showed significant difference between the varieties. Maximum value for germination percentage in seed was determined for variety Swaran Priya followed by Arka Komal and Contender. Arya *et al.* (1999) and Singh and Verma (2002b) also reported increase in 100 seed weight with higher dose of nitrogen.

Nitrogen levels exerted significant influence on quality parameters viz., test weight, crude protein content and germination percentage in seed. There was significant increase in test weight, crude protein content as well as germination percentage in seed with increasing levels of nitrogen. Maximum value for test weight, crude protein content and germination percentage in seed were found with application of N₅ (125 kg/ha N) which was at par to N₄ (100 kg/ha N) nitrogen level. Both of these treatments were significantly superior over other nitrogen levels. Similar findings were also reported by Amaral *et al.* (1980) and Chavan *et al.* (2000) in french bean.

Combined effect of varieties and nitrogen levels exhibited non significant influence on test weight, germination percentage in seed and crude protein content. However numerically maximum test weight was found with variety Swaran Priya under N₄ (100 kg/ha N) application. Values of crude protein content and germination percentage in seed were highest with Swaran Priya under N₅ (125 kg/ha N) application. However both of these combinations were statistically at par. Minimum values of germination percentage in seed and crude protein content were found with

Contender under N₁ (25 kg/ha N) application. Test weight was recorded minimum with Arka Komal under N₂ (50 kg/ha N) application.

5.4 Post Harvest Analysis of Soil:

Post harvest analysis of soil showed significant influence of varieties, nitrogen levels and their combinations on available nitrogen, phosphorus and potassium. Maximum available nitrogen, phosphorus and potassium were recorded under variety Contender followed by Arka Komal and Swaran Priya. Higher utilization of nitrogen, phosphorus and potassium by Swaran Priya might have resulted in more depletion of nutrient from the soil. Inter varietal difference in the efficiency of nutrient utilization is also reported by Amaral *et al.* (1980).

Application of nitrogen had significant influence on available nitrogen, phosphorus and potassium in soil after harvesting in french bean. Maximum available nitrogen was recorded under application of N₅ (125 kg/ha N). The available nitrogen in soil exhibited linear increase with increasing nitrogen levels may be due to increasing dose of nitrogen. Highest available phosphorus content was recorded under 25 kg nitrogen per hectare which gradually decreased with increasing dose. Maximum value for available potassium was recorded under N₁ (25 kg/ha N). There was decrease in available potassium content with each increasing dose of nitrogen up to 100 kg nitrogen per hectare. Increasing dose of nitrogen might have enhanced on uptake of phosphorus and potassium which consequently resulted in yield and decrease in available phosphorus and potassium under higher dose of nitrogen.

Combined effect of varieties and nitrogen levels exerted significant influence on available nutrient in soil after harvesting. Highest available nitrogen was recorded with variety Contender and N₅ (125 kg/ha N) application and highest available potassium was recorded with Contender under N₁ (25 kg/ha N) application. Highest available phosphorus was recorded with variety Arka Komal under N₁ (25 kg/ha N) application. Whereas lowest value of available phosphorus was recorded with Swaran Priya under N₅ (125 kg/ha N) application. Variety Swaran Priya with N₁ (25 kg/ha N) application showed minimum available nitrogen. Lowest available potassium was determined with variety Swaran Priya under N₄ (100 kg/ha N) application. Higher uptake of NPK with higher N application coupled with higher

utilization efficiency of variety Swaran Priya resulted in lower available of NPK as compared to other varieties at same level of nitrogen application.

5.5 Economics of Seed Production in French Bean:

Economic of seed production revealed highest gross return under V_1N_4 (Swaran Priya with 100 kg/ha N) followed by V_1N_5 (Swaran Priya with 125 kg/ha N), V_1N_3 (Swaran Priya with 75 kg/ha N), V_2N_4 (Arka Komal with 100 kg/ha N), V_2N_5 (Arka Komal with 125 kg/ha N) and V_2N_3 (Arka Komal with 75 kg/ha N). Minimum gross return was obtained with Contender under N_1 (25 kg/ha N) application.

Highest net return was realized with Swaran Priya under N_4 (100 kg/ha N). Application which was followed by V_2N_4 (Arka Komal with 100 kg/ha N), V_3N_4 (Contender with 100 kg/ha N) application. Minimum net return was obtained under V_3N_1 (Contender with 25 kg/ha N).

Highest net return per rupees investment was obtained with Swaran Priya with N_4 (100 kg/ha N) application which was followed by V_1N_5 (Swaran Priya with 125 kg/ha N), V_1N_3 (Swaran Priya with 75 kg/ha N), V_2N_4 (Arka Komal with 100 kg/ha N) application. Lowest cost: benefit ratio was obtained with Contender under N_1 (25 kg/ha N) application.

More increase in yield as compared to expenditure at higher nitrogen levels resulted in more gross return and net profit. Tewari and Singh (2000) and Rahman *et al.* (2007) also reported increase in gross return net return and C: B ratio with higher doses of fertilizers.

CHAPTER VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary :

A field experiment entitled “Effect of nitrogen levels on yield and quality of seed in french bean” was carried out with factorial randomized block design consisting 3 varieties (Swarna priya, Arka komal, Contender) and 5 levels of nitrogen (25,50,75,100 and 125 kg/ha) having 15 treatment combinations were replicated thrice at Bahadari farm, College of Horticulture, Mandsaur during rabi 2009-10. The findings obtained from the investigation have been summarized as given below:

Significant influence on variation in growth, yield and quality parameters and yield were noted under different varieties of french bean. Maximum plant height, number of leaves per plant, number of branches per plant, leaf area index, fresh weight and dry weight of shoot per plant, was recorded with variety Swaran Priya, Arka Komal and Contender. Earliest 50 per cent flowering was commenced in Contender followed by Swaran Priya with no remarkable difference. Maximum value for number of pod per plant, seed per pod, length (cm) of pod, pod yield (g) per plant, pod yield (q) per hectare ,seed yield (g) per plant, seed yield (q) per hectare, shelling percentage, test weight as well as germination percentage were recorded under Swaran Priya. It was followed by Arka Komal and Contender. Harvest index and crude protein content in seed were maximum in Arka Komal followed by Swaran Priya and Contender.

Application of nitrogen levels indicated significant influence on growth, yield and seed quality parameters. Maximum plant height, number of leaves per plant, number of branches per plant, leaf area index, fresh weight and dry weight of shoot per plant were observed with application of N₄ (100 kg/ha N) followed by 125 kg/ha > 75 kg/ha > 50 kg/ha > 25 kg/ha in descending order. The earliest 50 per cent flowering was observed under N₁ (25 kg/ha N) application. There was delay in flowering with increasing level of nitrogen application and maximum days to 50 per cent flowering were taken under application of N₅ (125 kg/ha N). Maximum value for number of pod per plant, pod length (cm), pod yield (g) per plant, pod yield (q) per

hectare, seed yield (g) per plant, seed yield (q) per hectare, shelling percentage, harvest index were recorded with application of N₄ (100 kg/ha N). It was followed by 125 kg/ha > 75 kg/ha > 50 kg/ha > 25 kg/ha in descending order. Maximum value for seed per pod, test weight, crude protein content in seed and germination percentage were determined with application of N₅ (125 kg/ha N).

Combined effect of varieties and nitrogen levels showed non significant influence on plant height, number of leaves per plant and number of branches per plant. Leaf area index, fresh weight and dry weight of shoot per plant did not showed any remarkable influence on interaction effect of varieties and nitrogen levels. Maximum plant height, number of leaves per plant and number of branches per plant were observed with Swaran Priya under N₅ (125 kg/ha N) application. Commencement of 50 per cent flowering, number of pod per plant, number of seed per pod, length of pod (cm), pod yield (g) per plant, pod yield (q) per hectare, seed yield (g) per plant, seed yield (q) per hectare, shelling percentage, harvest index, test weight of seed, crude protein content in seed and germination percentage in seed did not show any remarkable impact of interaction effect of varieties and nitrogen levels. Maximum number of pod per plant, pod yield (g) per plant, pod yield (q) per hectare, seed yield (g) per plant, seed yield (q) per hectare and shelling percentage were recorded with variety Swaran Priya and N₄ (100 kg/ha N) application. Maximum crude protein content in seed were found with variety Arka Komal under N₅ (125 kg/ha N) application and variety Swaran Priya under N₅ (125 kg/ha N) application respectively. Though both these combination were statistically at par for both attributes.

Post harvest analysis of soil revealed significant effect of varieties on available nitrogen, phosphorus and potassium in soil. Maximum available nitrogen was determined with variety Contender followed by Arka Komal and Swaran Priya. Available phosphorus was highest with variety Contender which was followed by Arka Komal and Swaran Priya. Variety Contender recorded maximum available potassium in the soil which was followed by Arka Komal and Swaran Priya.

Nitrogen application exhibited significant effect on available phosphorus and potassium in the soil. Maximum value for quantity of available nitrogen was recorded under application of N₅ (125 kg/ha N). Application of nitrogen showed higher available nitrogen with each increasing dose. Application of nitrogen caused

depletion of phosphorus with increasing dose. Increasing dose of nitrogen showed decreased level of available potassium in soil.

Combined effect of varieties and nitrogen levels showed significant influence on available nitrogen, phosphorus and potassium content in soil. The highest available nitrogen were observed with variety Contender under N₅ (125 kg/ha N) application. Available phosphorus was highest with variety Arka Komal along with 25 kg nitrogen application which was followed by Contender and Swaran Priya. Variety Contender with application of 25 kg nitrogen recorded maximum available potassium followed by Arka Komal at the same level of nitrogen application.

Economic evaluation of different treatment showed great influence due to varieties as well as nitrogen levels. The highest gross return and net return as well as cost: benefit ratio for seed production obtained with Swaran Priya under N₄ (100 kg/ha N) application.

6.2 Conclusion :

It may be concluded from the findings of the present study that among the different varieties of french bean, Swaran Priya showed superior performance for growth attributes, yield attributes, yield and quality. Among the nitrogen levels application of N₄ (100 kg/ha N) resulted in the highest growth parameters, yield parameters, yield and quality of french bean seed. Though, it caused delay in commencement of 50 per cent flowering. Combinations of varieties with nitrogen levels showed the best performance of Swaran Priya with N₄ (100 kg/ha N) application. Economic evaluation showed that variety Swaran Priya with N₄ (100 kg/ha N) application resulted in maximum gross return, net return and cost: benefit ratio for seed production.

6.3 Suggestions :

- The investigation should be repeated for confirmation of the result
- In the future studies application of bioinoculants along with more varieties may be tested.
- Quality parameters like vitamins and minerals composition (calcium, iron) content may also be studied.

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APPENDICES

Appendix I: Analysis of variances for plant height and No. of leaves/ plant at different growth stages

Source of Variation	Mean Sum of Squares						
	Plant height (cm)				No. of leaves per plant		
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS
Replication (R)	6.45	56.99	11.00	15.45	0.69	35.88	80.68
Nitrogen levels (N)	48.71	98.13	127.00	76.11	104.33	164.53	200.45
Variety (V)	161.42	1117.24	1182.62	762.15	319.27	195.77	1037.67
Interaction (VxN)	0.96	4.05	6.74	15.04	6.89	1.07	7.89
Error	12.74	31.02	21.89	7.34	18.44	30.81	44.91
(CV)	14.47	12.57	9.59	7.15	14.11	11.45	10.72
Mean	24.67	44.30	48.76	37.89	30.44	48.48	62.54

Appendix II: Analysis of variances for number of branches and leaf area per plant at different growth stages

Source of Variation	Mean Sum of Squares					
	Number of branch per plant			Leaf area index per plant		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
Replication (R)	0.57	0.61	1.50	0.002	0.0005	0.0001
Nitrogen levels (N)	11.31	42.30	68.60	0.013	0.0215	0.0950
Variety (V)	24.54	27.53	33.69	0.013	0.0053	0.0489
Interaction (VxN)	0.71	0.05	2.15	0.001	0.0009	0.0026
Error	2.14	3.68	9.15	0.001	0.0011	0.0012
(CV)	14.59	14.77	17.61	8.547	8.8419	6.3249
Mean	10.03	13.00	17.18	0.316	0.3722	0.5427

Appendix III: Analysis of variances for fresh weight and dry weight of shoot at different growth stages

Source of Variation	Mean Sum of Squares							
	Fresh weight of shoot (g)				Dry weight of shoot (g)			
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest
Replication (R)	0.94	12.36	1.87	4.50	0.01	0.361	1.052	1.506
Nitrogen levels (N)	34.46	60.22	137.54	53.38	0.56	2.272	3.130	15.792
Variety(V)	29.99	65.89	74.53	204.07	1.62	9.168	5.656	6.095
Interaction (VxN)	0.26	1.69	0.77	0.49	0.03	0.073	0.060	0.144
Error	2.50	9.24	10.26	9.88	0.04	0.126	0.359	0.633
(CV)	10.76	7.73	4.69	7.60	10.70	7.168	8.389	5.751
Mean	14.70	39.34	68.28	41.36	1.85	4.946	7.145	13.833

Appendix IV: Analysis of variances for days to 50 per cent flowering

Source of Variation	Mean Sum of Squares
	Days to 50% flowering
Replication (R)	0.06
Nitrogen levels (N)	219.21
Variety(V)	191.67
Interaction (VxN)	0.07
Error	0.26
(CV)	1.17
Mean	43.72

Appendix V: Analysis of variances for No. of pod/plant, No. of seed per pod and pod length

Source of Variation	Mean Sum of Squares		
	Number of pods per plant	Number of seeds per pod	Length (cm) of pod
Replication (R)	0.252	0.255	0.705
Nitrogen levels (N)	72.084	3.021	4.302
Variety (V)	202.540	6.488	2.330
Interaction (VxN)	3.113	0.024	0.067
Error	2.709	0.113	0.316
(CV)	5.337	8.293	4.242
Mean	30.836	4.044	13.250

Appendix VI: Analysis of variances for pod yield/plant, pod yield/ha and seed yield/plant

Source of Variation	Mean Sum of Squares		
	Pod yield (g) per plant	Pod yield (q) per hectare	Seed yield (g) per plant
Replication (R)	0.10	0.46	0.08
Nitrogen levels (N)	98.89	159.03	61.42
Variety (V)	314.49	2762.15	466.32
Interaction (VxN)	1.23	0.89	2.00
Error	2.73	6.00	1.47
(CV)	3.74	4.87	3.83
Mean	44.20	50.25	31.59

Appendix VII: Analysis of variances for seed yield/ha, shelling percentage and harvest index

Source of Variation	Mean Sum of Squares		
	Seed yield (q) per hectare	Shelling percentage	Harvest index
Replication (R)	0.17	0.58	0.52
Nitrogen levels (N)	87.85	9.07	24.63
Variety (V)	326.46	426.82	86.40
Interaction (VxN)	2.86	2.28	1.52
Error	3.21	1.06	1.73
(CV)	9.33	1.45	7.73
Mean	19.19	71.06	17.01

Appendix VIII: Analysis of variances for seed quality parameters

Source of Variation	Mean Sum of Squares		
	Test weight (g)	Crude protein content (%) in seed	Germination (%)
Replication (R)	1.53	37.43	3.09
Nitrogen levels (N)	27.88	13.00	221.91
Variety (V)	1744.63	0.53	17.62
Interaction (VxN)	1.49	0.23	1.18
Error	2.61	0.53	1.42
(CV)	3.30	3.38	1.38
Mean	48.95	21.54	86.36

Appendix IX: Analysis of variances for available NPK in soil after harvesting

Source of variation	Mean Sum of Squares		
	Available Nitrogen	Available Phosphorus	Available Potassium
Replication (R)	3.31	5.12	417.20
Nitrogen levels (N)	4582.88	21.16	20042.08
Variety(V)	6035.41	43.94	10993.51
Interaction (VxN)	1309.32	34.62	590.62
Error	81.38	1.82	217.34
(CV)	5.13	9.30	3.37
Mean	175.96	14.52	437.02

Appendix X: Cost and prices of different materials and operations used/performed in the experiment

S.No.	Material/Operation			Cost (Rs.)
1.	Land preparation	Deep ploughing-1	Harrowing-2	1500.00
2.	Seed	Rs70/kg	65 kg/ha	4550.00
3.	Sowing	Rs110/labour	15 labour	1650.00
4.	Seed treatment	Carbandazim @1g/kg	Mancozeb @2g/kg	97.50
5.	Fertilizer	N ₁ 25 kg/ha		3163.03
		N ₂ 50 kg/ha		4207.26
		N ₃ 75 kg/ha		4955.37
		N ₄ 100 kg/ha		5428.77
		N ₅ 125 kg/ha		5834.43
6.	Weeding	3 weeding	15 labour per weeding	4950.00
7.	Plant Protection			
	Endosulfan	2 spray		1704.00
	Dimethoate	2 spray		1876.00
	Mancozeb	2 spray		974.00
	Carbandazim	2 spray		1826.00
8.	Harvesting	20 labour		2200.00
9.	Threshing	15 labour		1650.00
10	Seed sale rate	Rs.4500/Quintal		
11.	Rate of fertilizers			
	DAP	@Rs.10.54/kg		
	Urea	@Rs.5.63/kg		
	SSP	@Rs.3.60/kg		
	MOP	@Rs.4.72/kg		
	Elemental Sulphur	@Rs.28/kg		

VITA

The author of this thesis **Balvant Singh Mourya** was born on 20 March 1987 at Jhabua (M.P.). He passed his higher secondary school certificate examination with first division in 2003, from Govt. Higher Secondary School, Rama Dist. Jhabua (M.P.).

In 2004 he joined JNKVV, College of Horticulture, Mandasaur (M.P.) and successfully completed the degree of B.Sc. (Horticulture) during the year 2007-08 with 1st division securing an OGPA of 6.54 on 10.00 point scale.

After graduation, he joined M.Sc. (Horticulture) course in the 1st semester, 2008-09 at college of Horticulture, Mandasaur to specialize in "Vegetable Science". He was completed the entire course requirement for above said Master's Degree in the year 2010-2011 with an OGPA of 7.06 on a 10 point scale.

He was allotted an interesting research problem entitled "Effect of nitrogen levels on yield and quality of seed in french bean" of his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.