EFFECT OF SEED RATES AND FERTILITY LEVELS ON THE GROWTH, YIELD AND QUALITY OF BOLD SEEDED CHICKPEA (*Cicer arietinum* L.)

BY

ADITYA PARTAP
(98A312M)

Dissertation submitted to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfilment of the requirements for the degree of:

MASTER OF SCIENCE

IN

AGRONOMY

College of Agriculture
Chaudhary Charan Singh
Haryana Agricultural University
Hisar

2002

DEDICATED

TO MY

BELOVED MOTHER

Certificate-I

This is to certify that the thesis entitled, "**Effect of seed rates and fertility levels on the growth, yield and quality of bold seeded chickpea (*Cicer arietinum* L.)**", submitted for the degree of M.Sc., in the subject of Agronomy of the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by Aditya Partap under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

25.7.12

[K.P. Singh]
Major Advisor
Prof. & Controller of examination
CCS Haryana Agricultural University
Hisar -125 004

Certificate-II

This is to certify that this thesis entitled, " **Effect of seed rates and fertility levels on the growth, yield and quality of bold seeded chickpea (C*icer arietinum* L.)**", submitted by Aditya partap to the Chaudhary Charan Singh Haryana Agricultural University, Hisar, in partial fulfilment of the requirement for the degree of M.Sc., in the subject of agronomy has been approved by the Student's Advisory committee after an oral examination on the same.

28.9.02

MAJOR ADVISOR

30/9

HEAD OF DEPARTMENT

30/9/02

DEAN, POST-GRADUATE STUDIES

ACKNOWLEDGEMENT

It is a rare occasion of having an opportunity to work on a research problem when one gets glimpses of the true worth, erudition, enthusiasm and innate nobility of his guide. I therefore, take this opportunity to feel an immense pleasure and honour in expressing my heartiest gratitude and sincere thanks to Dr. K.P. Singh, Controller of examination, Chairman of my Advisory committee, whose expert and creative guidance, keen interest, generous and friendly nature close supervision, constructive criticism and untiring help encouraged me althrough the research work..

My sincere thanks are due to Dr. S.S. Pahuja, Professor of Agronomy; Dr. D.R. Aneja, Assoc. Professor of Statistics; Dr. Vinod Phogat, Asstt. Scientist of Soil Science and Dr. D.S. Ruhal, Professor of Soil Science; members of my advisory committee for their kind suggestions and keen interest in my research work and going through this manuscript.

I am deeply indebted to Mr. Manoj Dahiya for his pious support, peerless wishes, valuable suggestions and timely help during the course of this investigation.

I will be failing in my duties if I don't thank Dr. (Mrs.) K.P. Singh, Dr. B.P. Singh, Dr. Virender Rana for their inspiration and encouragement during the course of this investigation.

I am highly grateful to Dr. R.K. Malik, Head Department of Agronomy for providing me the necessary facilities during the course of this investigation.

I owe my sincere thanks to my friends Devender, Yashpal, Dhakla, Laxman, Vanket, Babu Lal, Sherry, Manoj, Monu and Pinku whose constant inspiration, encouragement and entertaining nature made the tenure of this investigation interesting and cheerful

I shall be utterly failing in my moral duty, if I don't record my sincere gratitude to my better half Sonu for rendering me emotional security, moral support and keeping a constant attitude of patience and sacrifice during this tenure.

My thanks are due to Mr. & Mrs Kuldip Khatri for their valuable suggestions and timely help during the course of this investigation.

Last but not the least, I accord cordial regards from the core of my heart to my Nanaji, Naniji, Baddi mummy and Mummy, Father-in-law, Mother-in-law, Bhaiya and Bhabi (Manoj and Kanta), Sister and Brother-in-law (Anju and Jaideep), Sandeep, Chiku, Motu, Hinnu, Monu, Mona, Diksha, Kunal and my sweetest Bhanji (Guddia) whose blessings, love, encouragement and inspirations have gone a long way in the successful completion of this manuscript.

[Aditya]

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-I

INTRODUCTION

Pulse crops play an important role in Indian agriculture, Indian diet as well as the economy of the country. These crops are rich in protein and minerals and are helpful in maintaining the soil fertility by nitrogen fixation and thus sustain the productivity of various cropping systems. There are particularly important contributors in low input and low productivity farming situations. In India, pulses are cultivated largely under energy starvation conditions, mostly on marginal and sub-marginal lands. Around 80 per cent area under pulses is still rainfed and therefore, productivity of these crops has not increased substantially even after concerted efforts put in by researchers, planners, extension workers, governments and farmers.

In world, India occupies highest area under pulses which is about 22.8 m hectares with an average productivity of 572 kg/ha. The average yield of these crops is much lower in our country than the average productivity of major pulse producing countries of the world. Therefore, it becomes imperative to evolve a technology which may help in increasing the production and productivity of this group of crops.

Among various pulses grown in India, chickpea (*Cicer arietinum* L.) occupies major place which is mainly cultivated in the states of Rajasthan, U.P., M.P., Haryana, Maharashtra and Punjab. It is cultivated on an area of about 8.4 m.ha with a production of about 6.7 m.t. and productivity of about 795 kg/ha (Anonymous, 2000). In Haryana also, chickpea is an important crop and occupies an area of 0.36 m. ha with a production of 0.30 m.t. during 1998-99 (Anonymous, 2000). The productivity of chickpea in the state (850 kg/ha) is higher than national average, however, it is still much lower than potential productivity of the crop. Moreover, presently area under chickpea has been reducing on account of stiff competition from high productive crops like cereals; secondly, chickpea is predominantly grown under rainfed areas where due to low rainfall, area again has reduced. Under these situations there is urgent need to develop technologies which can give higher productivity of chickpea so that it can become a competitive crop under irrigated conditions too. Recently, a bold seeded genotype of chickpea viz.; HC-3 has been released for cultivation in irrigated areas of Haryana. By the adoption of this cultivar the production of chickpea may be enhanced, however, the agronomy of this variety needs to be developed for Haryana conditions.

Seed rate and fertility management are important production factors for exploiting yield potentiality of a cultivar. Bold seeded varieties require more seed rate for optimum plant population per unit area which is an important factor governing the productivity of a crop. Since HC-3 is a bold seeded variety, the recommended seed rate for other varieties of chickpea may not be used for this variety for maintaining optimum plant population per unit area. Therefore, there is need to workout optimum seed rate for this cultivar under irrigated conditions of Haryana.

Fertilizers are important inputs contributing a large share in the productivity of a crop. In pulses phosphorus plays an important role by increasing the root area and number of nodules, thus increasing the N-fixation. Therefore, phosphorus supply in required amount to chickpea crop is essential for higher productivity of the crop. Due to self-nitrogen-feeding, this crop requires lesser amount of nitrogen from the soil. However, during initial stages N application is essential in chickpea for the establishment of the crop. Application of potash is an important factor for balanced fertilization in crops including pulses. With depleting soil fertility, there is need to work out nutritional requirements of a higher yielding variety like HC-3 for irrigated environments. Keeping the above points in view, the present study was, therefore, carried to work out optimum seed rate and fertility level for newly evolved variety of chickpea HC-3. The field investigations were carried out with the following objectives:

1. To study the effect of seed rates and fertility levels on the growth and yield of late sown bold seeded chickpea var. HC-3.

2. To find out the optimum fertilizer dose for economic production of chickpea.

3. To study the effect of seed rates and fertility levels on N, P and K uptake in seed of chickpea.

CHAPTER-II

REVIEW OF LITERATURE

Chickpea crop responds very well to plant population and fertility levels. Lot of research work has been reported in literature on these aspects in chickpea cultivation. In this chapter an attempt has been made to present a brief account of work done in India and abroad pertaining to the problem studied. The literature is reviewed under the following heads :

2.1 Effect of seed rates

2.2 Effect of fertility levels

2.1 Effect of seed rates

Among various factors affectiong plant growth, productivity and quality of a crop, plant population exerts significant influence by way of keeping maximum resource use efficiency. Plant population is governed by seed rate used per unit area. For maintaining optimum plant population it is necessary that proper seed rate should be used. Chickpea crop is highly affected by plant population and thus by seed rate. In the succeeding paragraphs the effect of seed rate and plant population on growth, yield and quality of chickpea as affected by seed rate has been reviewed.

Kumar (1984) reported that dry weight of shoot per plant was higher under 50 kg over 75 kg seed/ha. Similarly, Rathore and Patel (1991) observed that increase in seed rate resulted in reduced dry matter/plant and lesser branches but the plant height increased with increasing seed rates in gram. Singh *et al.* (1993) also revealed that significantly taller plants were observed with dense planting density. Saini and Faroda (1996) found that at 120 days after sowing dry matter accumulation per plant was at par between 50 and 75 kg seed rate ha^{-1} but it was significantly higher than 100 kg seed rate ha^{-1}. Increasing rates resulted in significant decrease in dry matter accumulation per plant at 150 DAS and at maturity.

Saini *et al.* (1996) reported that significantly higher values of LAI and LAD were noticed with each successive increase in seed rate. NAR increased with increasing seed rate at 91-120 DAS but trend was just reversed at 121-150 DAS. Higher values of RGR were noticed with 75 kg ha^{-1} seed rate over 50 and 100 kg ha^{-1} seed rate from 121-150 DAS. Saini and Faroda (1997) further reported that increase in seed rate resulted in an increase in plant height but there was reduction in leaf area/plant and dry matter accumulation/plant.

Nodulation in pulse crops have also been influenced by seed rate and according to Kumar (1984) number of active nodules declined with increase in seed rate in chickpea crop but flower initiation remained unaffected due to variations in seed rate. Similarly, Vaishya *et al.* (1995) observed that nodules/plant decreased significantly with increasing seed rate from 75 to 125 kg ha^{-1} at 90 DAS in gram.

Singh *et al.* (1984) reported that number of pods/plant and test weight decreased significantly with the increase in seed rates. A seed rate of 75 kg ha^{-1} gave significantly higher grain and straw yields than 50 kg ha^{-1}. Ahlawat *et al.* (1985) reported that seed rate of 100 kg ha^{-1} produced significantly higher grain yield than 75 kg ha^{-1} but Singh and Singh (1985) reported that grain yields were significantly lower at the highest seed rates of gram. Shakhtawat and Sharma (1985) at Durgapura, revealed that use of higher seed-rate reduced the grains/pod but test weight was not affected and use of 100 kg seed ha^{-1} produced maximum grain yield. Straw yield was not much influenced due to seed rates except at 75 kg seed ha^{-1} which resulted in significantly lower straw yield.

Singh and Yadav (1985) observed that increasing seed rates reduced the number of pods/plant. Variations in seed rate did not alter the test weight. Increase in seed rate, upto 75 kg ha^{-1} increased the grain yield/plant. Among different seed rates gram yielded highest at 75 kg ha^{-1} which was higher than 50 kg ha^{-1}. Higher rate of seeding (100 kg ha^{-1}) also resulted in significant reduction in yield.

Rathore and Patel (1991) observed that seed rates of 100 and 125 kg ha^{-1}, being at par gave significantly higher yield over 75 kg ha^{-1}.

Increase in seed rate resulted in reduced dry matter/plant and yield attributes (branches, pods and grains/plant and 100-grain weight). Increase in seed rate beyond 100 kg ha^{-1}, however, did not prove advantageous in respect of grain yield.

Singh *et al.* (1993) reported that plant density of 55 plants/m^2, being at par with 44 plants/m^2, produced significantly more yield than 66 plants/m^2. However, the number of pods/plant was significantly higher with lowest planting density than dense canopy of 66 plants/m^2. Vaishya *et al.* (1995) reported that the seed yield decreased with an increase in seed rate from 75 to 125 kg ha^{-1}. Saini and Faroda (1997 and 1998) observed that the grain yield/ha increased with the increasing seeds rates, but the differences were significant only up to 75 kg ha^{-1} seed rate. Increase in seed rate resulted in reduced number of pods/plant and number of seeds/pod. Each successive increase in the seed rate resulted in significant increase in straw yield. Grain yield with 75 and 100 kg ha^{-1} seed rates was statistically at par but significantly higher than that with 50 kg seed rate/ha.

Singh *et al.* (1984) reported that a seed rate of 75 kg ha^{-1} recorded significantly higher P uptake than 50 kg seed ha^{-1} through grain and straw. No significant increase in P uptake was observed in higher seed rate of 100 kg ha^{-1}. Kumar (1984) reported that nitrogen, phosphorus, potassium and zinc uptake was not affected by seed rates. He further, observed that protein content was not affected by varying seed rates in gram.

2.2 Effect of fertility levels

Chickpea responds to application of fertilizers containing N, P and K but is more responsive to higher dose of phosphorus. Singh *et al.* (1984) observed that application of 17 kg P ha^{-1} improved plant productivity and enhanced the pods/plant, 100-seed weight, grain and straw yields and P uptake significantly over no phosphate application. The optimum dose of phosphate was worked out to be 26 kg ha^{-1}. Singh *et al.* (1984) observed that phosphate fertilization is an important input for legumes since the root nodule bacteria requires adequate supply of available source of phosphate for efficient functioning.

Nagarajan *et al.* (1985) observed significant increase in shoot, root and total dry mass due to P application. Mishra (1986) reported that increasing P_2O_5 rates increased the number of pods/plant and seed and straw yields. Ahlawat *et al.* (1985) revealed that phosphorus increased the yield significantly up to 40 kg ha^{-1}. The economic optimum level of phosphorus was 54.9 kg ha^{-1}. Shaktawat and Sharma (1985) reported that different levels of phosphorus also exerted significant effect on the grain yield of chickpea as compared with control. Application of 25, 50 and 75 kg P_2O_5 ha^{-1} increased the grain yield by 0.9, 2.1 and 2.9 q/ha representing 10.2, 23.7 and 32.7 per cent increase, respectively. Singh and Yadav (1985) revealed that increased level of phosphorus up to 80 kg P_2O_5 ha^{-1} increased the number of pods/plant and grain as well as straw yields. Roy and Tripathi (1985) reported that application of 75 kg P_2O_5 ha^{-1}

increased the nutrient concentration both in grain straw. Saini and Faroda (1998) found that increasing N + P_2O_5 levels improved pods/plant and 1000-seed weights. Application of 30 kg N + 60 kg P_2O_5 ha^{-1} resulted in signiifcantly higher grain yield than the lower level. The optimum dose of P_2O_5 came out to be 51.0 kg/ha for 75 kg/ha seed rate. The application of phosphorus increased the test weight, number of pods per plant and seed yield (Shah *et al.*, 1986).

Minhas *et al.* (1987) reported that the highest yield (1.66 t ha^{-1}) was obtained with the application of 20 kg N + 60 kg P_2O_5 + 15 kg K_2O ha^{-1}. Joshi *et al.* (1988) reported that application of 40 kg P_2O_5 ha^{-1} in addition to N increased yield by 39 and 40 per cent at the low N (10 kg N ha^{-1}) and high N (20 kg N ha^{-1}), respectively. Kar *et al.* (1989) found that 40 kg N + 80 kg P along with K produced highest branch number. All growth and yield parameters increased with increase in phosphorus application. Dahiya and Singh (1993) observed that height per plant and number of branches recorded at various growth stages were significantly influenced due to fertilizer applications. More plant height and more number of branches per plant were recorded with higher doses of fertilizer applications than recommended dose or no application of fertilizer. Singh *et al.* (1993) revealed that varying fertility levels did not bring any significant change in plant height of gram. Saini and Faroda (1996) reported that increasing fertility levels resulted in higher accumulation of dry matter over control at all the stages of crop growth. Deolankar and

Berad (1999) found that application of 150 per cent more fertilizer than recommended dose being at par with 125 per cent level exhibited signiifcantly more plant height than rest of treatments. Saini (1999) recorded 30 + 60 kg ha^{-1} as the dose of N and P for significantly increasing the dry matter accumulation per plant. Kumar *et al.* (1994) found that higher dose of fertilizer 27 kg N + 69 kg P_2O_5/ha caused excess vegetative growth in terms of plant height.

Parihar and Tripathi (1989) reported that P application promoted nodulation and increased nodule dry weight. Raut and Kohire (1991) observed that increasing rate of P application increased the number, dry weight of nodules and seed yield significantly. Yadav and Mandal (1992) also reported similar results. Nodulation was increased by increasing phosphorus along with sulpher rates (Kumpawat and Manohar, 1994; Joseph and Verma, 1994). Similar results were also observed by Chandra (1995) during the early stages of chickpea. Mane and Jadhav (1991) also reported that the application of 20 kg N + 50 kg P_2O_5 ha^{-1} produced significantly more root nodules and their weight than control and 12.5 kg N + 20 kg P_2O_5 ha^{-1}. Habib *et al.* (1992) revealed that highest grain yield of chickpea (2.34 t/ha) was obtained with 20 kg N + 50 kg P_2O_5 ha^{-1}.

Vadavia *et al.* (1991) did not find differences in yields between the application of 20 kg N + 40 kg P_2O_5/ha with or without *Rhizobium*. Rathore and Patel (1991) observed better development of growth characters i.e. plant height, number of branches and due to increasing levels of phosphorus.

Dahiya and ꞉ Singh (1993) found increase in chickpea yields with the increase in fertilizer doses to 27 kg N + 69 kg P_2O_5 ha^{-1}. Similarly, Arunachalam and Ravichandran (1995) observed that fertilizer application at the rate of of 50 kg DAP ha^{-1} had produced higher seed yield. Verma (1994) reported that application of N + P_2O_5 improved both growth and yield components except the seed size. Tomar and Raghuwanshi (1995) found that chickpea seed yield and net return increased significantly only upto 60 kg P_2O_5 ha^{-1}. On the other hand Paikaray *et al.* (1995) recorded highest seed yield with 40 kg N + 80 kg P_2O_5. Kurhade and Nagre (1995) reported that both height and branches were improved significantly with the application of 25 kg P ha^{-1} than control. Reddy and Ahlawat (1999) observed that application of 18 kg N + 46 kg P_2O_5+ 5.25 kg Zn ha^{-1} increased growth and yield attributes, seed and straw yields, N and P uptake, protein content and yield, available soil N and P status at harvesting than no fertilizer. Jain *et al.* (1991) observed that phosphorus application markedly increased nodulation, pods/plant and seed and stover yields.

Fertilizer application influences the uptake of different nutrients and quality of pulse produce. Misra (1971) and Mishra and Dwivedi (1977) observed an increase in the concentration of phosphorus as well as its uptake due to the application of phosphorus. Bhuiya *et al.* (1979) found that 20 kg N increased the grain crude protein content. There have been increases in the uptake of N, P, K and quality of chickpea with increasing level of phosphorus from 0 to 60 kg/ha (Singh and Sharma, 1980; Singh *et al.*, 1983).

Arvadia and Patel (1987) found higher protein content of gram with the application of 25 kg N ha^{-1} than no nitrogen application. Khokhar and Warsi (1987) reported that application of 18 kg N + 40 kg P_2O_5 + 60 kg K_2O ha^{-1} resulted into higher N and P uptake over control. Parihar and Tripathi (1989) reported that phosphorus application promoted the N, P, K concentration in grain and straw.

Singh and Ram (1991) revealed that the highest total P uptake and P concentration in nodules, seeds, straw and in total plant increased upto 26 kg P and 80 kg S ha^{-1}. Enania and Vyas (1994) observed that P uptake increased by increasing P rate.

Similarly, several other workers observed response of chickpea to fertilizer N, P_2O_5 and K_2O, which indicate that N, P and K fertilization is necessary in this crop for higher productivity.

CHAPTER-III

MATERIALS AND METHODS

The present study entitled, "Effect of seed rates and fertility levels on growth, yield and quality of bold seeded chickpea (*Cicer arietinum* L.)" was conducted during the *rabi* season of 2000-01. The details of the prevailing weather conditions during the experimental period, methodology and techniques adopted during the conduct of the present study are described in this chapter.

3.1 Experimental site and location

The field experiment was conducted at the Students' Farm of the Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar which lies in 29°10' latitude North and 75°46' longitude East at an elevation of 215.2 meters above mean sea level in Haryana state of India.

3.2 Climate and weather conditions

Hisar has a semi-arid and sub-tropical climate with hot dry and desiccating winds during summer and severe cold during winter season. The mean maximum and minimum temperatures, therefore, show wide

Table 1: Weekly weather data for the year 2000-2001

Standard week	Temperature (°C)		Relative humidity (%)		Sunshine (hours)	Evaporation (mm)	Rainfall (mm)
	Max.	Min.	Morn.	Even.			
47	27.6	8.7	86	37	7.1	3.1	0.0
48	24.5	4.1	85	26	7.4	2.9	0.0
49	25.9	2.9	81	21	8.9	2.5	0.0
50	24.6	3.4	87	28	8.1	2.4	0.0
51	24.4	3.3	89	28	8.4	2.8	0.0
52	23.2	3.4	89	43	7.4	1.7	0.0
1	15.1	6.07	95.5	78.5	2.2	0.7	2.14
2	15.9	1.04	96.4	65.0	5.6	1.0	0.0
3	17.6	1.2	94.8	52.7	6.3	1.2	0.0
4	23.6	2.0	93.7	33.2	8.0	1.8	0.0
5	22.5	2.8	89.1	29.1	9.3	3.0	0.0
6	23.4	2.0	88.2	28.5	9.4	2.7	0.0
7	25.3	7.4	83.1	38.5	8.8	3.1	0.0
8	27.0	10.0	88.0	37.4	6.7	2.9	1.3
9	25.2	5.5	91.7	26.7	9.8	3.4	0.0
10	29.2	6.1	83.7	20.8	9.6	3.9	0.0
11	30.3	11.1	78.2	31.85	8.67	4.6	0.0
12	30.9	11.0	80.4	34.28	7.5	4.2	0.0
13	31.9	12.6	78.8	32.2	8.21	5.1	0.0
14	33.6	12.5	66.8	20.7	10.2	6.68	0.0
15	37.5	18.9	49.0	18.1	7.6	8.8	0.47
16	30.4	15.1	77.0	46.0	8.2	6.3	6.18

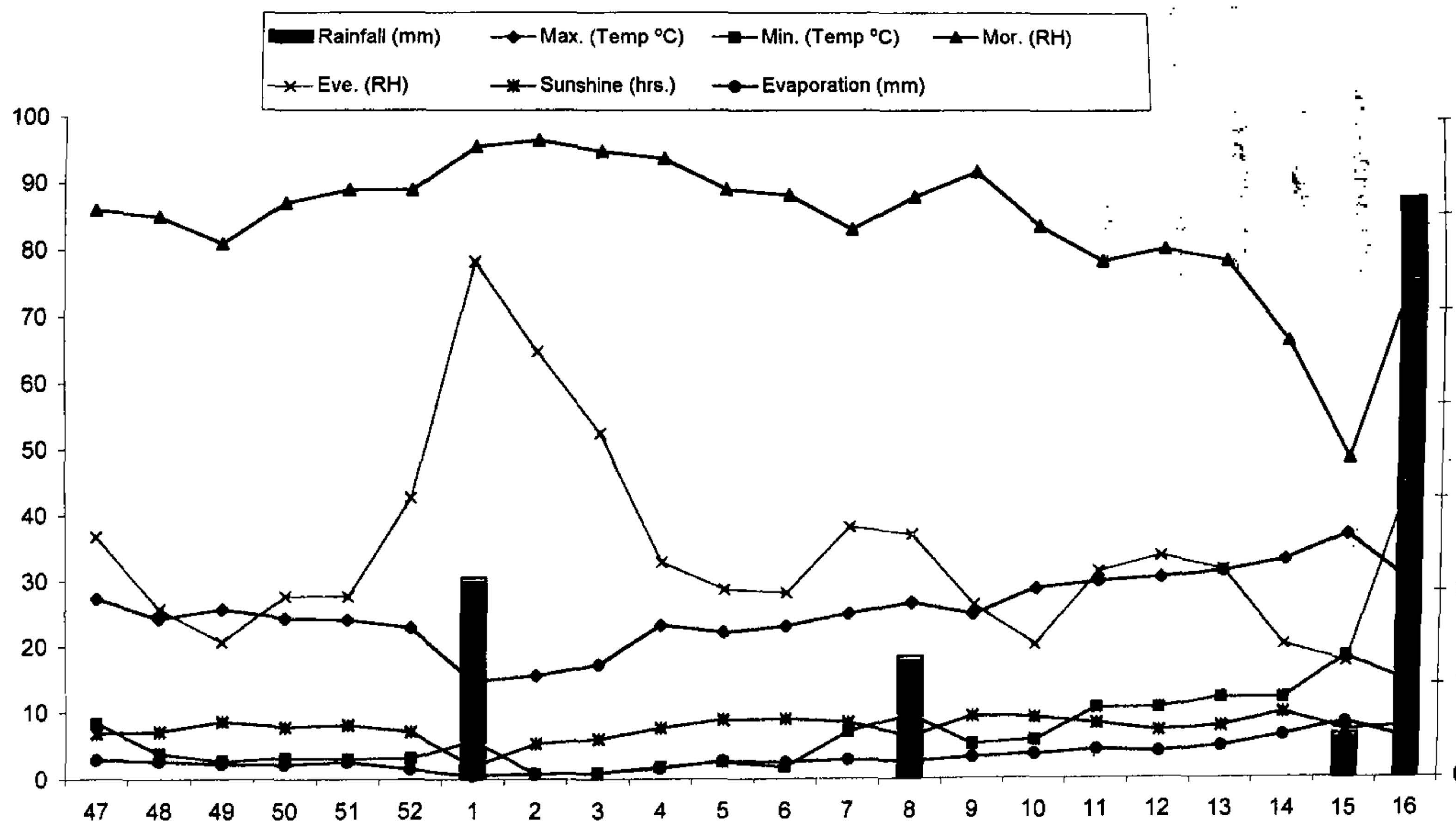

Fig. 1: Mean weekly weather data during the crop season

fluctuations during both summer and winter months. The mean monthly maximum temperature during summer months of May to July is around 42 to 45°C, while the minimum temperature during winter months of December and January sometimes goes as low as 0°C or even lower.

The average annual rainfall of Hisar is about 425 mm which is unevenly distributed, and more than 75 per cent of it is received from July to September with a few showers of cyclonic rains received in winter or late spring season. Mean weekly values of important weather parameters during the crop season recorded at the Meteorological Observatory of the Research Farm, CCS HAU, Hisar are given in Table 1 and depicted in Fig. 1. A perusal of meteorological data showed that 10.09 mm rain was received during growing period of chickpea in 2000-01. The mean maximum and minimum temperatures ranged between 37.5°C and 1.2°C, respectively.

3.3 Physico-chemical properties of soil

To determine the mechanical and physico-chemical properties of the soil of experimental plot, two representative samples were taken from 0-30 cm depth at the time of preparation of land before application of organic manures. The data on mechanical analysis presented in Table 2 indicate that the soil of the experimental site was sandy loam in texture.

Table 2 Mechanical analysis of soil

Component	Value	Method of determination
A. Soil separates (%)		
- Sand	62.4	International Pipette method (Piper, 1966)
- Silt	19.8	
- Clay	17.8	
B. Physical constants		
- Field Capacity (Moisture content at -0.3 MPa)	19.82	Field method (Coleman, 1944)
- Permanent wilting point (Moisutre content at -1.5 MPa)	7.82	Pressure Membrane Apparatus (Richards, 1943)
- Bulk density (g/cc)	1.42	Core sampling (Piper, 1966).

Data in Table 3 indicate that soil of the experimental field was slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium.

Table 3 **Chemical analysis of soil**

Particulars	Value	Method used
Soil pH	8.0	pH meter with glass electrode (Jackson, 1973)
Organic carbon (%)	0.38	Walkley and Blacks and oxidation method (Jackson 1973)
Organic matter (%)	0.67	It was calculated by multiplying organic carbon content by 1.732
Available nitrogen (kg/ha)	198.4	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (kg/ha)	17.6	Olsen's method (Olsen, 1954)
Available K (kg/ha)	469.0	Flame Photometer method (Richards, 1954)
EC (dSm^{-1} at 25°C)	0.93	Conductivity Bridge Meter (Richards, 1954)

3.5 Cropping history of the experimental field

The cropping history of experimental field from 1998-99 onward is presented in Table 4.

Table 4 **Cropping history of experimental field**

Year	Crop season *Kharif*	*Rabi*
1998-1999	Sunflower	oats (fodder)
1999-2000	Sunflower	oats (fodder)

3.6 Experimental details

The experiment was laid out in a factorial randomized block design (RBD) with fifteen treatment combinations comprising combinations of three seed rates and five fertility levels, replicated thrice as shown in Fig. 2. The details of the treatments are as follows:

Treatments

A. **Seed rate (kg/ha)**	**Symbol**
1. 60	S_1
2. 80	S_2
3. 100	S_3

B. **Fertility levels** [$N+P_2O_5 + K_2O$ (kg ha^{-1})]	**Symbol**
1. 0+0+0	F_0
2. 15+30+20	F_1
3. 20+40+30	F_2
4. 25+50+40	F_3
5. 30+60+50	F_4

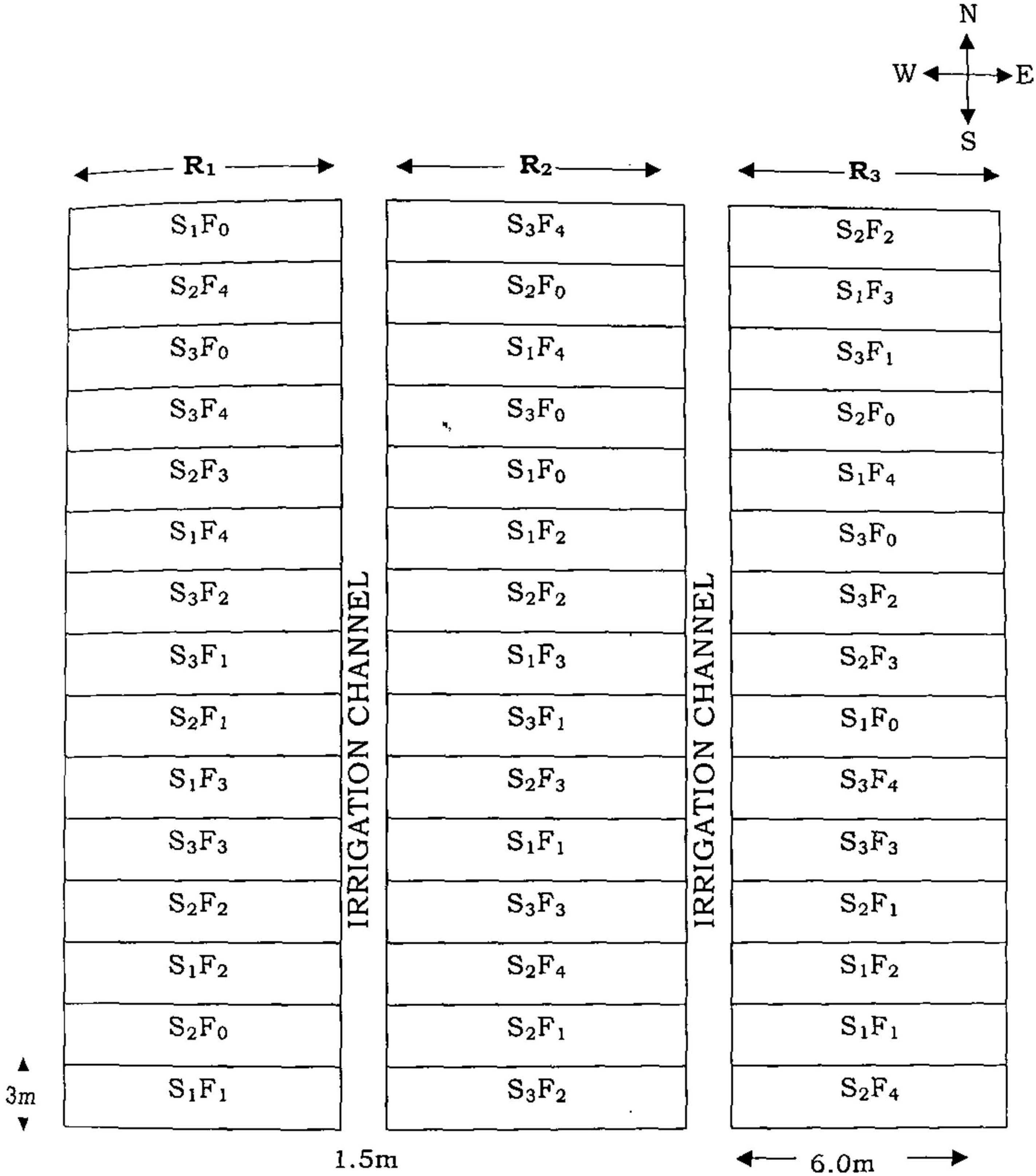

Fig. 2: Layout Plan of Experiment

Total no. of treatments	3 x 5 = 15
Design	Factorial RBD
Replications	Three
Total no. of plots	15 x 3 = 45
Variety	HC-3
Sowing date	25-11-2000
Gross plot size	3.0 m x 6.0 m
Net plot size	2.4 m x 5.0 m

3.7 CULTURAL OPERATIONS

The details of cultural operations carried out during pre-and post-sowing of chickpea crop are presented in Table 5.

3.7.1 Field operations

The field was given one pre-sowing irrigation to facilitate preparatory tillage and seed germination. The seedbed was prepared by harrowing followed by planking to attain a proper tilth. The plots were bounded by bunds and layout was also made for irrigation channel.

3.7.2 Fertilizer application

All the fertilizers viz. urea (46% N), single super phosphate (16% P_2O_5) and MOP (60% K_2O) were broadcasted over the plots before sowing of the crop as per treatments.

Table 5 **Schedule of cultural oeprations carried out in chickpea**

Operation	Date	Details of operation
Field ploughing	26.10.2000	Field was ploughed twice with disc harrow
Pre-sowing irrigation	12.11.2000	Canal water was applied
Field preparation	22.11.2000	Field was harrowed once by disc harrow followed by two cultivation by cultivator and planking
Lay out	22.11.2000	Layout was done
Fertilizers application	22.11.2000	Plot wise urea, SSP and MOP were applied as per treatment and incorporated in the soil manually
Sowing	25.11.2000	Seeds of chickpea variety HC-3 were sown in lines - 30 cm apart
Final layout	02.12.2000	Layout was done permanently
Gap filling	15,16.12.2000	Overnight water soaked seeds were placed in soil to fill in the gap
Interculture	8-24.12.2000	Hand weeding was done
Rainfall	1.1.2001	Rainfall was received at 35 DAS
Irrigation	18.02.2001	Irrigation was given
Harvesting	16,17.4.2001	The crop in each plot was harvested separately with the help of sickles
Threshing	20.04.2001	After thorough drying in sun the crop was threshed manually by beating with stick, winnowed and grain yield per plot was recorded.

3.7.3 Sowing

The crop was sown with the help of hand plough at a distance of 30 cm apart in rows.

3.7.4 Gap filling

To maintain the proper (10 cm) plant-to-plant spacing, gap filling was done by sowing the water soaked seeds.

3.7.5 Interculture

Hand weeding was done two times to manage the weeds in the crop.

3.7.6 Irrigation

Due to rainfall at 35 DAS, only one post sowing irrigation was given at 85 DAS in addition to one pre-sowing irrigation.

3.7.7 Harvesting and threshing

For recording seed yield, the crop was harvested from the central rows, leaving one row on each side (breadth-wise) and half metre on each side (length-wise), which formed the net plot. The crop was threshed plot-wise after complete sun drying.

3.8 TREATMENT EVALUATION

3.8.1 Growth studies

3.8.1.1 Plant population

After gap filling, number of plants was counted per running metre row length in each plot at three randomly selected spots at 30 DAS and at harvest. Both ends of one-metre row distance were marked with sticks.

3.8.1.2 Plant height

Five randomly selected plants in each plot were tagged and used for recording observation of the height of plant. Height of these selected plants was measured in centimetres from ground level to the base of the fully unfolded leaf at the top and mean values were recorded. These observations were recorded at different growth stages.

3.8.1.3 Number of branches per plant

The total number of branches from five tagged plants from each plot was counted at different growth stages and average number of branches per plant was computed.

3.8.1.4 Number of nodules per plant

Five plants in each plot from sample rows were randomly selected and uprooted carefully using *khurpi* without damaging the roots. The roots were washed with running water using a 0.5 mm^2 mesh size sieve and the nodules thus collected were counted and reported as nodules per plant.

3.8.1.5 Days taken to 50 per cent flowering

Number of days taken to 50 per cent flowering in chickpea were recorded in terms of number of days taken by the crop to reach to a particular crop growth stage as described by Boote (1982). Determination of days taken to 50 per cent flowering was done on the basis of visual observations.

3.8.2 Observations on yield and yield attributes

These studies were recorded on a sample of five tagged plants. These plants were harvested separately just before the harvest of the experimental crop.

3.8.2.1 Number of pods per plant

The total number of pods from five tagged plants were picked and counted and the average number of pods/plant was recorded.

3.8.2.2 Number of seeds per pod

Ten pods from five tagged plants in each plot were threshed and total number of seeds were counted. The average value indicated the number of seeds per pod.

3.8.2.3 100-seed weight (g)

A random sample of seeds was drawn from the produce of each plot, 100-seed from each sample were counted and their weight was recorded.

3.8.2.4 Seed yield per plant

Threshing of five tagged plants were done and average seed yield per plant was recorded in grams.

3.8.2.5 Biological yield per plant

The weighing of five tagged plants excluding roots was done and average biological yield per plant was recorded.

3.8.2.6 Seed yield per hectare

Net area from each plot was harvested and threshed separately. Seed yield from each plot was recorded and converted into seed yield in q ha^{-1}.

3.8.2.7 Biological yield per hectare

Weighing of total dry matter harvested from the net plot was done after sun drying and biological yield/ha was computed.

3.8.2.8 Harvest index (%)

Harvest index of each plot was computed by using the following formula:

$$\text{Harvest index} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.8.3 Chemical analysis for qualitative studies

3.8.3.1 Nitrogen content in seeds (%)

Seed samples were ground and digested. Nitrogen content in digested seed material was determined by Nessler's Reagent method (Linder, 1944).

3.8.3.2 Nitrogen uptake in seeds (kg/ha)

Per cent nitrogen content in seeds was multiplied by their yield to determine nitrogen uptake by seeds.

3.8.3.3 Protein content in seeds (%)

Protein content was computed by the following formula :

$$\text{Protein (\%)} = \frac{\text{N \% in seeds}}{100} \times 6.25$$

3.8.3.4 Phosphorus content in seeds (%)

Phosphorus content in seeds was determined by Vanadomolybdo-phosphoric acid yellow colour method (Koeing and Johnson, 1942) at harvest.

3.8.3.5 Phosphorus uptake in seeds (kg/ha)

Per cent phosphorus content of seed was multiplied by their yield (kg ha^{-1}) to determine the phosphorus uptake by seed.

3.8.3.6 Potassium content in seeds (%)

Per cent potassium content in seed was estimated by Flame Photometer method (Richards, 1954).

3.8.3.7 Potassium uptake in seeds (kg/ha)

Per cent potassium content of seed was multiplied by their yield (kg/ha) to determine the uptake of potassium by seed.

3.9 ECONOMICS

Economics of different treatments was determined to find best treatment.

3.9.1 Net returns (Rs ha^{-1})

It was calculated using the formula given below :

Net returns = Gross returns - cost of cultivation

3.9.2 Benefit : Cost ratio (B:C) ratio

It is calculating using the following formula :

$$B : C \text{ ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

3.10 Statistical analysis

All the experimental data for various growth, yield and quality characters were statistically analysed by the method of Analysis of Variance as described by Panse and Sukhatme (1978). The difference of treatment effect was judged with the help of 'F' (Variance Ratio) test. Appropriate Standard Error along with Critical Difference (CD at 5%) was worked out for differentiating the treatment effects from those of chance effects.

$$CD = \frac{\sqrt{2 \text{ Error Variance}}}{N} \times t$$

where

CD = Critical Difference

N = Number of replications of that factor for which CD is to be calculated.

t = The value from Fisher's Table (1948) for Error Degree of Freedom at 5% level of significance.

CHAPTER-IV

EXPERIMENTAL RESULTS

The results of the experiment entitled "Effect of seed rates and fertility levels on the growth, yield and quality of bold seeded chickpea (*Cicer arietinum* L.)" conducted during the *Rabi* season of 2000-2001 are presented in this chapter with the help of appropriate tables and suitable diagrams.

4.1 GROWTH STUDIES

4.1.1 Plant stand

The data on plant stand recorded at 30 days after sowing (DAS) and at harvest are presented in Table 6. The perusal of data reveals that plant population (plants per metre row length) increased significantly with the increasing seed rates. Various fertility levels did not influence significantly the germination count as well as the number of plants per metre row length at both the stages.

4.1.2 Plant height (cm)

The data on plant height at different stages of observations as influenced by various treatments are presented in Table 7. The plant

Table 6: **Effect of seed rates and fertility levels on plant stand of chickpea per running meter row length**

Treatments	Plant population	
	30 DAS	At harvest
Seed rate (kg/ha)		
60	9.25	9.10
80	10.85	10.65
100	12.60	12.35
S.Em±	0.42	0.40
CD at 5%	1.40	1.30
Fertility levels (kg/ha N + P_2O_5 + K_2O)		
0+0+0	9.95	9.90
15+30+20	10.80	10.75
20+40+30	11.10	11.00
25+50+40	11.20	11.05
30+60+50	11.40	11.20
SEm±	0.87	0.74
CD at 5%	N.S	N.S

Table 7: **Effect of seed rates and fertility levels on plant height (cm)**

Treatments	Days after sowing				
	30	55	80	105	130
Seed rate (kg/ha)					
60	8.50	14.56	28.45	45.30	55.33
80	9.10	15.07	30.05	50.29	56.33
100	9.90	15.78	30.97	53.03	58.06
S.Em±	0.57	0.54	0.08	0.17	0.18
CD at 5%	0.16	0.16	0.25	0.50	0.54
Fertility levels (kg/ha N + P_2O_5 + K_2O)					
0+0+0	8.50	13.80	27.96	42.58	47.11
15+30+20	8.80	13.40	28.78	46.13	52.78
20+40+30	9.10	14.90	29.73	49.81	57.88
25+50+40	9.50	15.40	30.71	53.87	61.55
30+60+50	10.00	16.20	31.96	55.31	64.22
SEm±	0.74	0.07	0.11	0.22	0.24
CD at 5%	0.21	0.20	0.32	0.65	0.69

height increased significantly with the increasing seed rates as well as fertility levels. The maximum plant height (9.90) was recorded with seed rate of 100 kg ha^{-1} and fertility level of 30 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1}.

4.1.3 Number of branches per plant

The data presented in Table 8 reveal that the number of branches per plant did not differ significantly with increasing levels of seed rate at all stages of obsrevations except at 30 DAS where 100 kg ha^{-1} seed rate resulted into significantly highest number of branches (FIg. 3a).

The increasing fertility levels increased the number of branches. The fertility level of 30 + 60 + 50 produced highest number (3.0) of branches per plant which was at par with number of branches at fertility level of 25 + 50 + 40 (Table 8 and Fig. 3b).

4.1.4 Number of nodules per plant

The data on nodules per plant recorded at 50 DAS presented in Table 9 reveal that significantly highest and lowest number of nodules per plant were recorded with seed rate of 60 and 100 kg/ha, respectively. The increasing level of fertility increased the number of nodules significantly.

4.1.5 Days taken to 50 per cent flowering

The data on days taken to 50 per cent flowering are presented in Table 9. Maximum days (84.26) to 50 per cent flowering were taken by the gram crop when it was sown at the rate of 60 kg ha^{-1} of seed rate which was at par with 100 kg ha^{-1} seed rate. Lowest days (83.46) taken to 50 flowering were recorded with 80 kg seed rate.

Table 8: **Effect of seed rates and fertility levels on number of branches per plant**

Treatments	Days after sowing				
	30	**55**	**80**	**105**	**130**
Seed rate (kg/ha)					
60	2.70	4.60	6.46	6.58	6.66
80	2.70	4.70	6.41	6.58	6.65
100	2.80	4.80	6.70	6.77	6.86
S.Em±	0.03	0.11	0.08	0.07	0.07
CD at 5%	0.09	N.S	N.S	N.S	N.S
Fertility levels (kg/ha N + P_2O_5 + K_2O)					
0+0+0	2.30	3.65	5.54	5.71	5.77
15+30+20	2.60	4.26	6.10	6.26	6.37
20+40+30	2.80	4.81	6.61	6.77	6.86
25+50+40	2.90	5.17	7.09	7.13	7.20
30+60+50	3.00	5.59	7.38	7.34	7.41
SEm±	0.04	0.15	0.11	0.09	0.08
CD at 5%	0.11	0.43	0.32	0.28	0.25

Table 8: **Effect of seed rates and fertility levels on number of branches per plant**

Treatments	Days after sowing				
	30	55	80	105	130
Seed rate (kg/ha)					
60	2.70	4.60	6.46	6.58	6.66
80	2.70	4.70	6.41	6.58	6.65
100	2.80	4.80	6.70	6.77	6.86
S.Em±	0.03	0.11	0.08	0.07	0.07
CD at 5%	0.09	N.S	N.S	N.S	N.S
Fertility levels (kg/ha N + P_2O_5 + K_2O)					
0+0+0	2.30	3.65	5.54	5.71	5.77
15+30+20	2.60	4.26	6.10	6.26	6.37
20+40+30	2.80	4.81	6.61	6.77	6.86
25+50+40	2.90	5.17	7.09	7.13	7.20
30+60+50	3.00	5.59	7.38	7.34	7.41
SEm±	0.04	0.15	0.11	0.09	0.08
CD at 5%	0.11	0.43	0.32	0.28	0.25

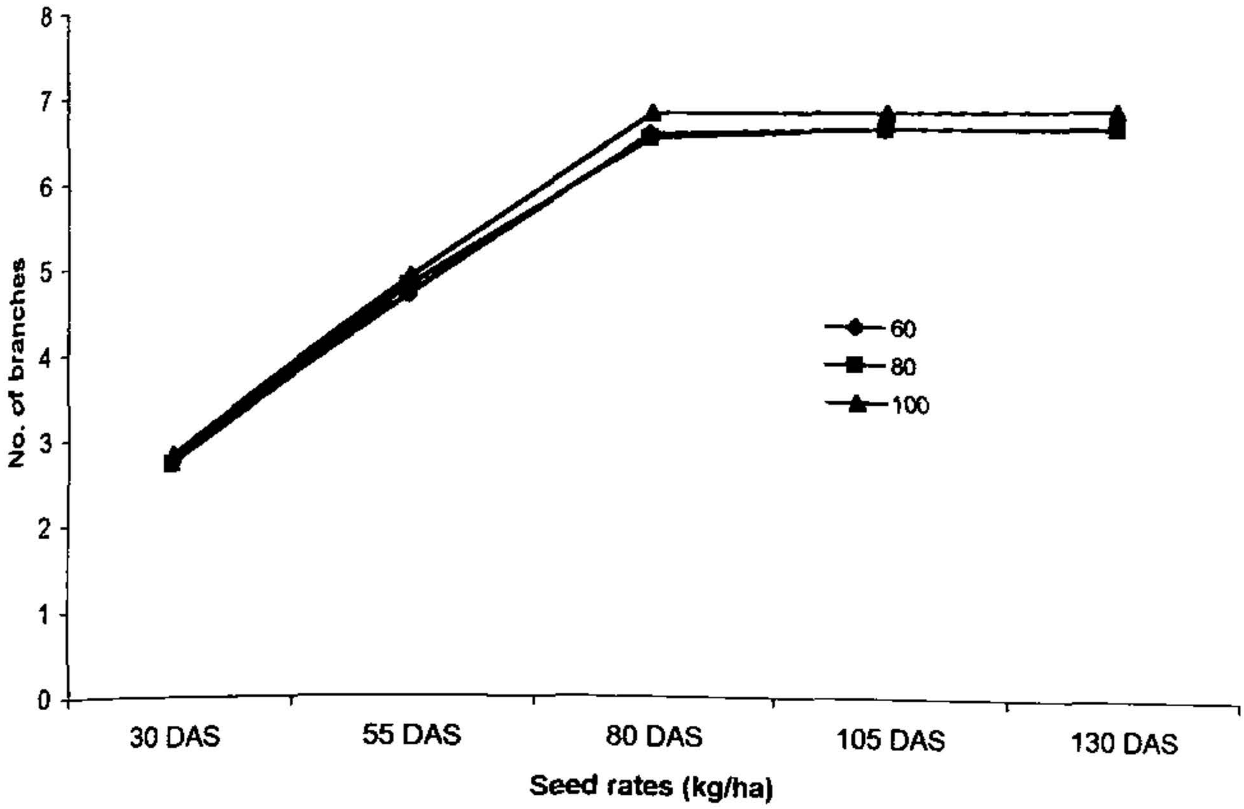

Fig. 3(a): Effect of seed rates on number of branches of per plant

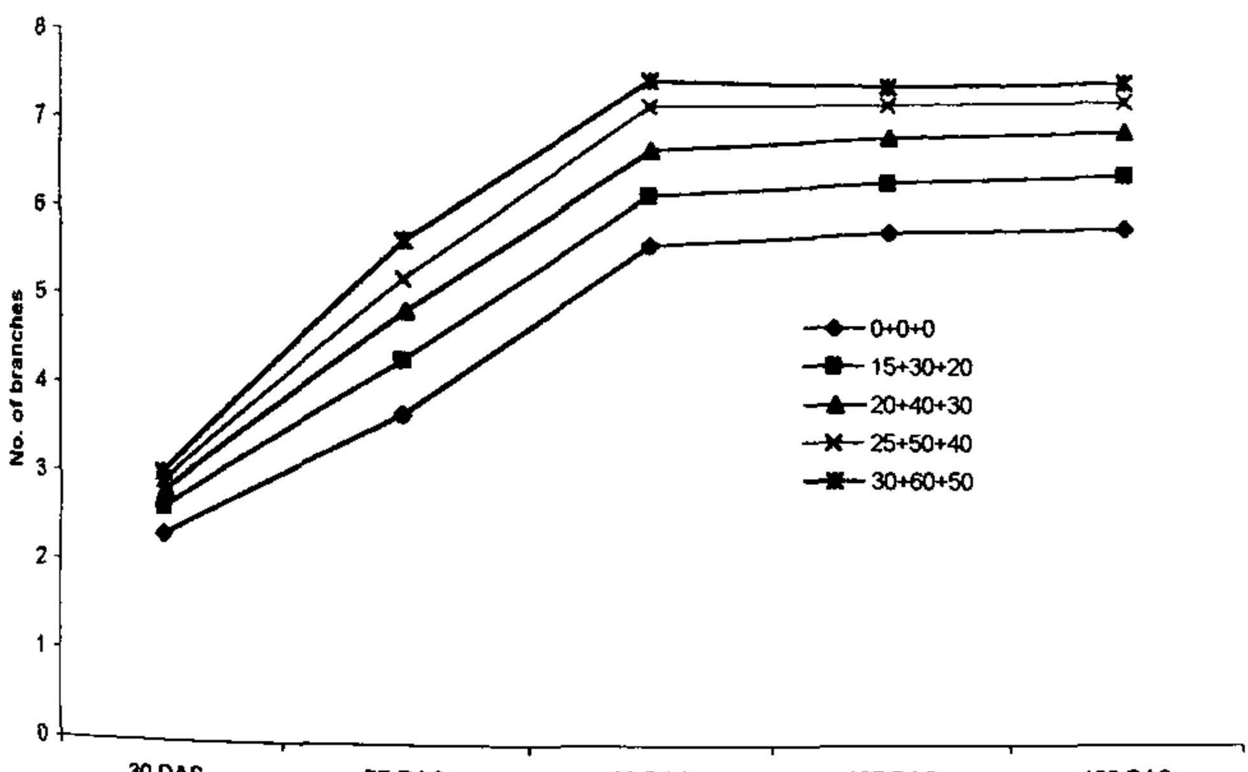

Fig. 3(b): Effect of fertility levels on number of branches of per plant

Table 9: **Effect of seed rates and fertility levels on number of nodules (at 50 DAS) and days taken to 50% flowering**

Treatments	Number of nodules	Days taken to 50% flowering
Seed rate (kg/ha)		
60	0.48	84.26
80	0.43	83.46
100	0.36	84.06
S.Em±	0.003	0.13
CD at 5%	0.009	0.39
Fertility levels (kg/ha N + P_2O_5 + K_2O)		
0+0+0	0.26	82.88
15+30+20	0.37	83.55
20+40+30	0.45	83.88
25+50+40	0.50	84.44
30+60+50	0.55	84.88
SEm±	0.003	0.17
CD at 5%	0.010	0.50

The increasing fertility levels resulted into increasing number of days for 50 per cent flowering. Fertility level of 30 + 60 + 50 recorded highest days which differed non-significantly with fertility level of 25 + 50 + 40.

4.2. YIELD AND YIELD ATTRIBUTES

4.2.1 No. of pods per plant

The data for number of pods per plant presented in Table 10 and Fig. 4 indicate that the number of pods per plant decreased significantly with the increasing seed rates upto 100 kg ha^{-1}. Highest number of pods per plant were recorded with 60 kg ha^{-1} seed rate.

The number of pods per plant increased significantly with the increasing levels of fertility and highest were recorded under the 30 + 60 + 50 fertility level.

4.2.2 Number of seeds/pod

The data pertaining to number of seeds per pod are presented in Table 10 and Fig. 4. There was no significant difference among the seed rates for number of seeds per pod.

The number of seeds/pod increased non-significantly with the increasing level of fertility upto 25+50+40 and thereafter, there was no more increase.

4.2.3 100-seed weight (g)

A perusal of data related to 100-seed weight presented in Table 11 and Fig. 4 indicate that different seed rates could not bring about any significant difference in respect of 100-seeds weight.

Table 10: Effect of seed rates and fertility levels on yield attributing characters of chickpea

Treatments	No. of pods/ plant	No. of grains/ pod	100-seed weight (g)
Seed rate (kg/ha)			
60	50.86	1.78	31.73
80	49.20	1.83	31.66
100	47.46	1.86	31.53
S.Em±	0.16	0.10	0.16
CD at 5%	0.44	N.S	N.S
Fertility levels (kg/ha N + P_2O_5 + K_2O)			
0+0+0	43.66	1.55	30.55
15+30+20	47.33	1.88	31.66
20+40+30	49.77	1.93	32.00
25+50+40	51.66	2.00	32.00
30+60+50	53.44	2.00	32.00
SEm±	0.19	0.13	0.20
CD at 5%	0.57	N.S	0.59

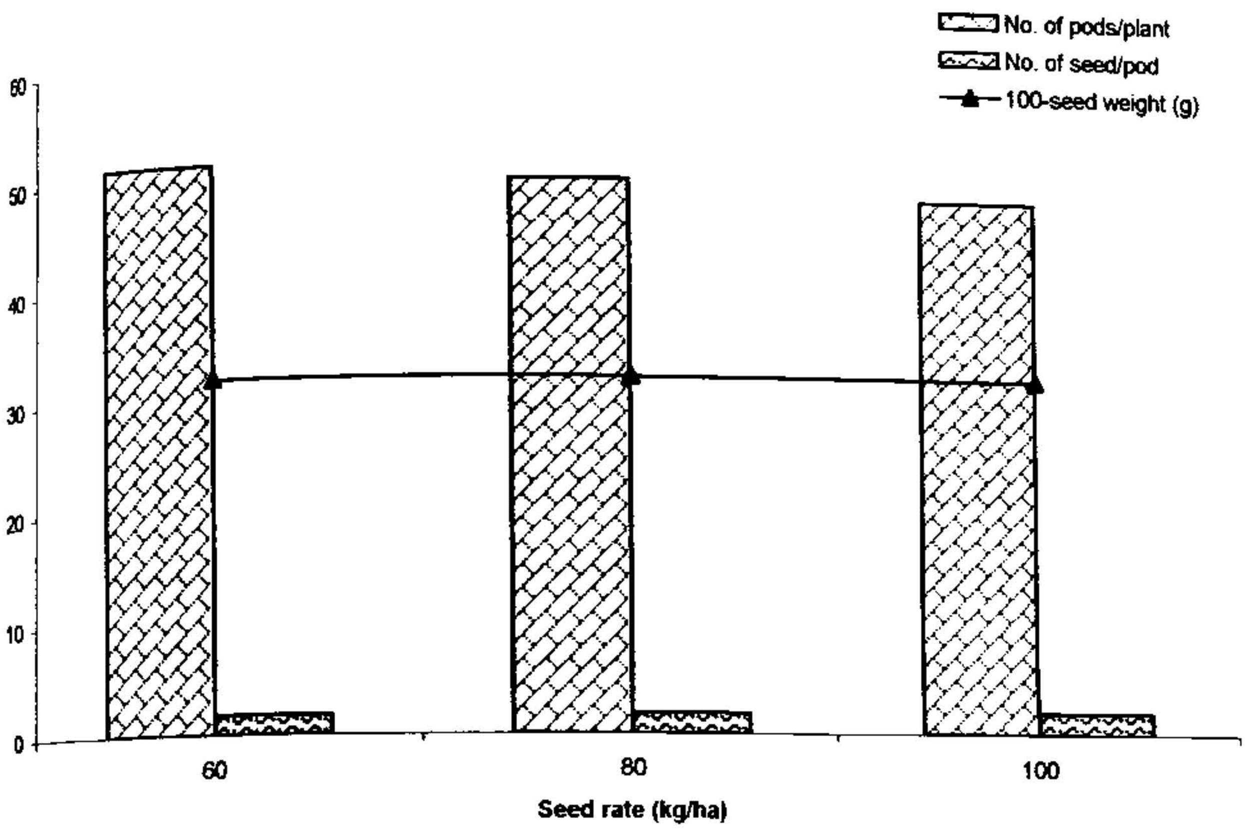

Fig. 4(a): Effect of seed rates on yield attributing characters of chickpea

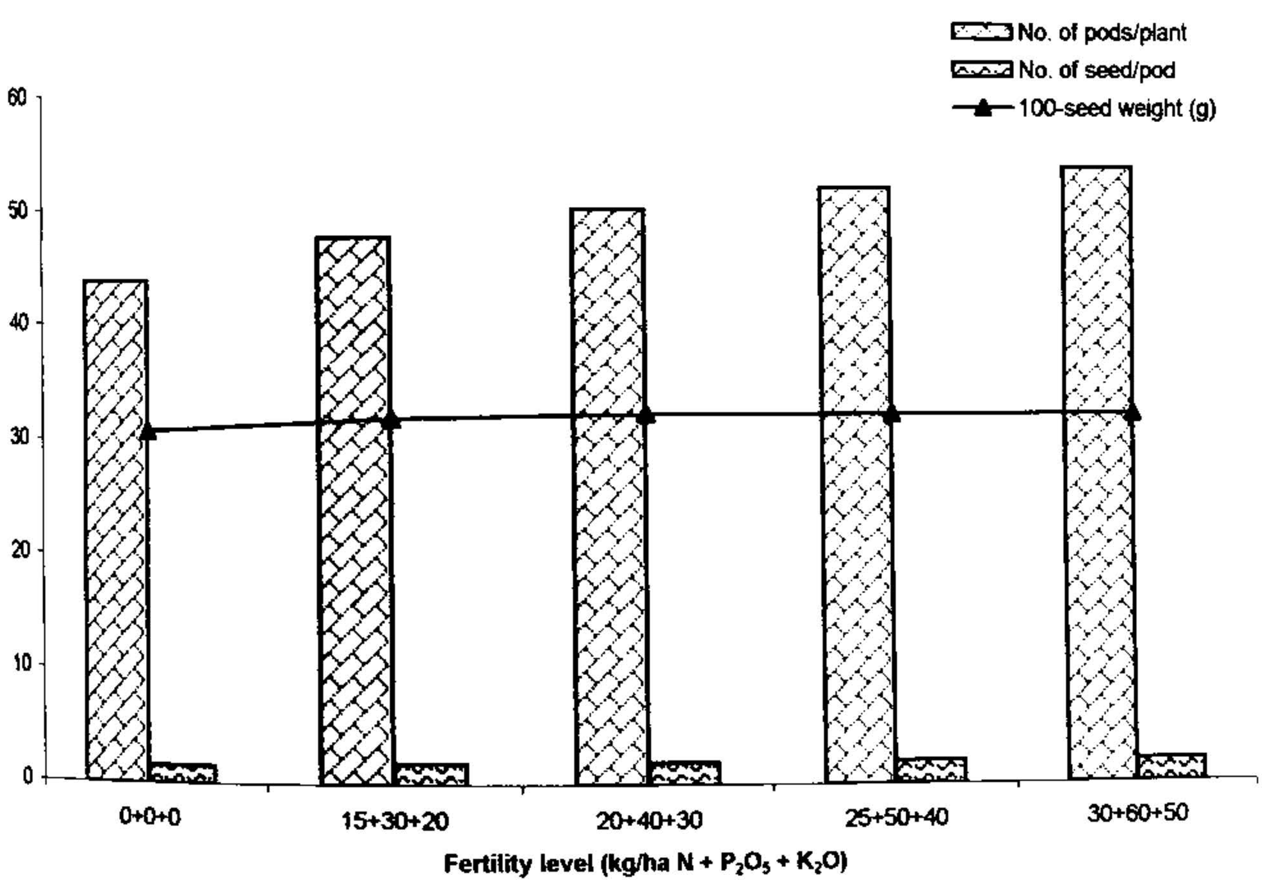

Fig. 4(b): Effect of fertility levels on yield attributing characters of chickpea

The 100-seed weight increased significantly by application of fertilizers over control but was not significant due to increasing fertility levels.

4.2.4 Seed yield per plant (g)

The data regarding seed yield per plant (g) are presented in Table 11. The data reveal that different seed rates did not result into significant difference in seed yield per plant. However 60 kg ha^{-1} seed rate resulted in highest seed yield per plant (22.54g).

The increasing fertility levels significantly increased the seed yield per plant upto 30 + 60 + 50 and minimum seed yield per plant was observed in no fertilizer, control.

4.2.5 Biological yield per plant (g)

A close perusal of data related to biological yield per plant presented in Table 11 reveals that the increasing seed rates from 60 to 100 kg ha^{-1} increased the biological yield per plant [illegible] significantly. 100-kg seed rate recorded highest biological yield per plant.

Each successive increase in fertility level resulted into significant increase in biological yield per plant maximum (5209 kg ha^{-1}) and minimum (4215 kg ha^{-1}) was recorded in 30 + 60 + 50 and control, respectively.

4.2.6 Seed yield (q/ha)

The data related to seed yield of chickpea in quintals per hectare as influenced by various treatments are presented in Table 12 and depicted in Fig. 5.

Table 11: **Effect of seed rates and fertility levels on seed and biological yield per plant (g)**

Treatments	Seed yield/plant (g)	Biological yield/plant (g)
Seed rate (kg/ha)		
60	22.54	51.69
80	22.34	52.24
100	22.04	53.06
S.Em±	0.25	0.68
CD at 5%	N.S	N.S
Fertility levels (kg/ha N + P_2O_5 + K_2O)		
0+0+0	18.91	47.30
15+30+20	20.87	49.57
20+40+30	22.33	51.82
25+50+40	23.60	55.33
30+60+50	24.82	57.64
SEm±	0.33	0.88
CD at 5%	0.96	2.26

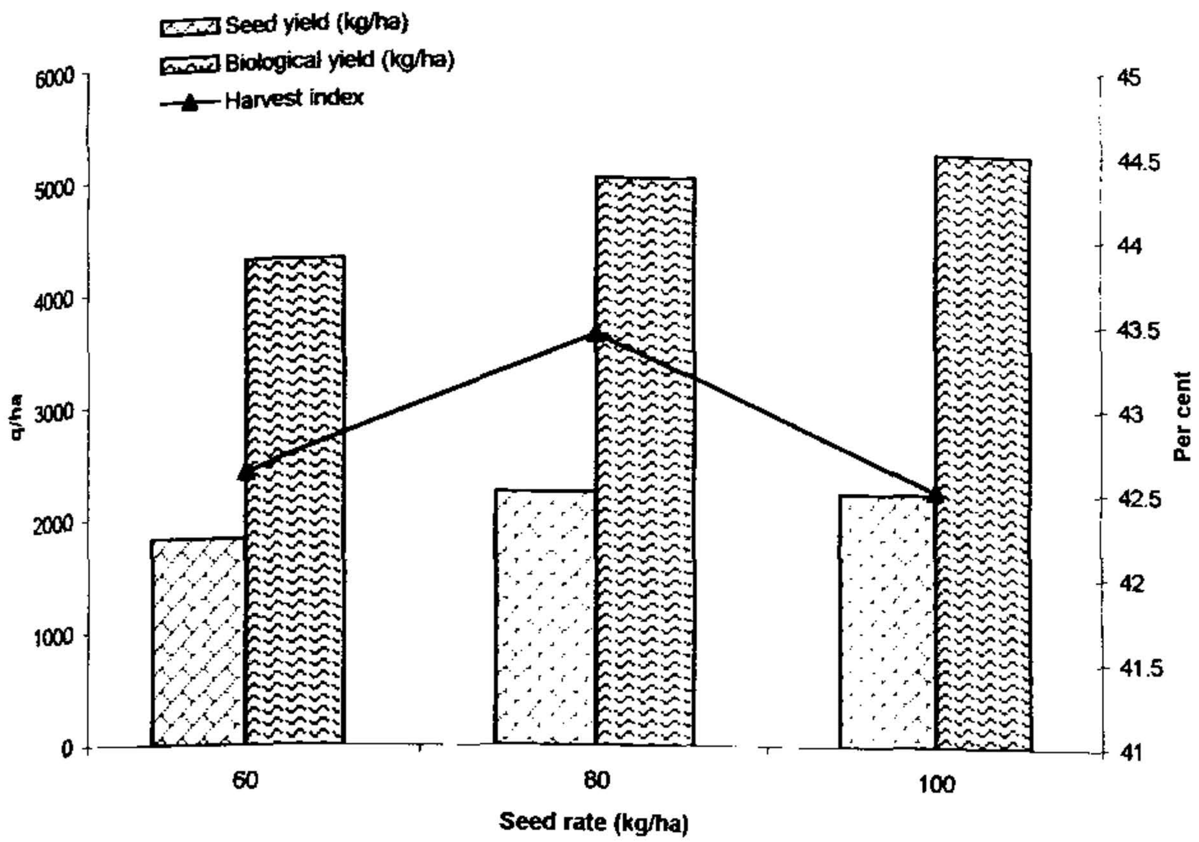

Fig. 5(a) : Effect of seeds rates on yield and harvest index of chickpea

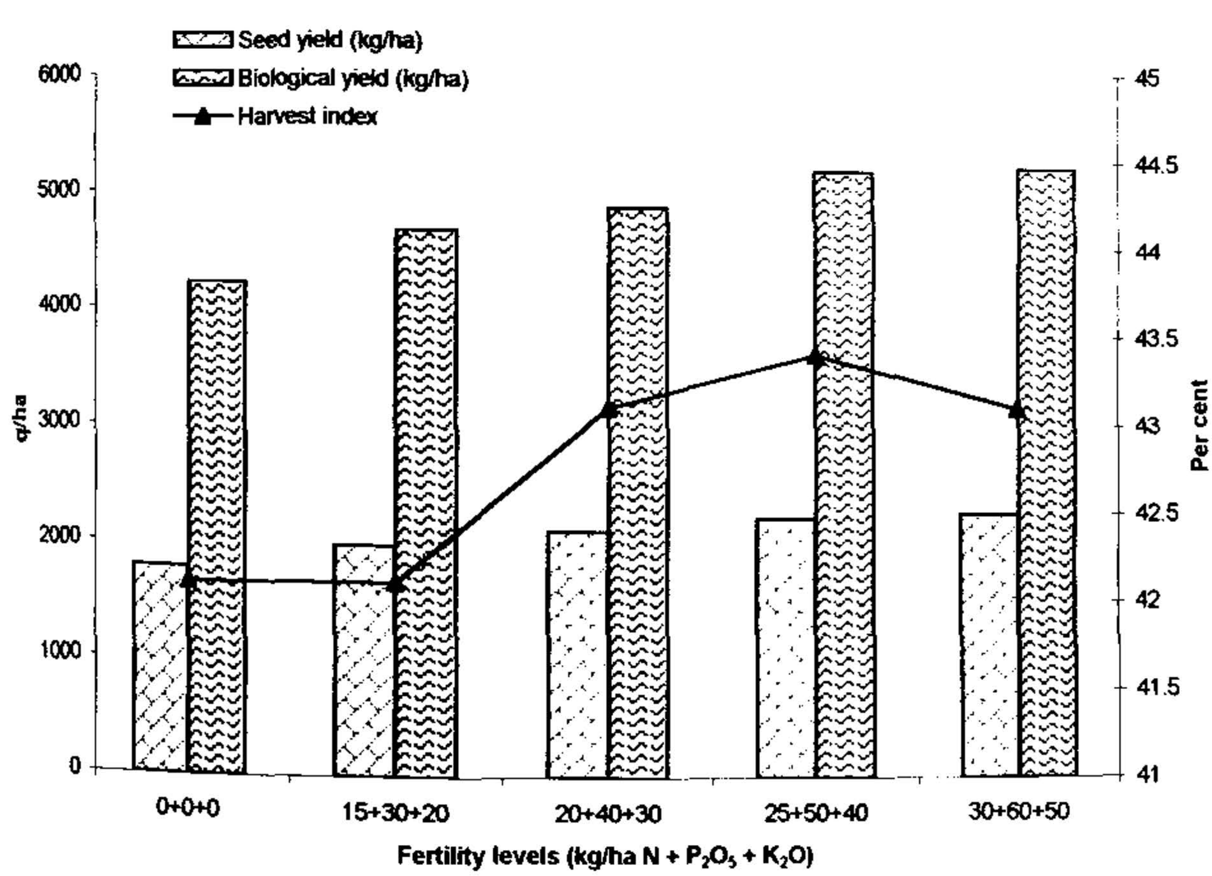

Fig. 5(b): Effect of fertility levels on yield and harvest index of chickpea

Table 12 **Effect of seed rates and fertility levels on yield and harvest index of chickpea**

Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Seed rate (kg/ha)			
60	1816	4260	42.6
80	2211	4977	43.4
100	2226	5240	42.5
S.Em±	64	294	0.22
CD at 5%	18	85	N.S
Fertility levels (kg/ha N + P_2O_5 + K_2O)			
0+0+0	1776	4215	42.1
15+30+20	1965	4669	42.1
20+40+30	2095	4861	43.1
25+50+40	2206	5174	43.4
30+60+50	2242	5209	43.1
S.Em±	83	38	0.28
CD at 5%	24	110	0.8

100 kg ha^{-1} seed rate recorded significantly highest seed yield (22.26 q ha^{-1}) which was at par with seed yield under 80 kg ha^{-1} seed rate (22.11 q ha^{-1}). Significantly lowest seed yield was recorded with 60 kg seed rate (18.16.q ha^{-1}).

The increasing fertility levels resulted in significant increase in seed yield. Maximum seed yield (22.41 q ha^{-1}) was recorded with 30 + 60 + 50 followed by in 25 + 50 + 40 (22.06 q ha^{-1}), 20 + 40 + 30 (20.4 q ha^{-1}) and lowest seed yield of 17.70 q ha^{-1} was observed in control.

4.2.7 Biological yield (q/ha)

A perusal of data presented in Table 12 and Fig. 5 for biological yield indicates that increasing seed rates resulted in a significant increase in biological yield per hectare. Maximum biological yield (52.44 q ha^{-1}) was recorded with 100 kg ha^{-1} seed, followed by 51.5 q ha^{-1} under 80 kg/ ha seed and minimum (42.60 q/ha) with 60 kg/ha seed.

Successive increase in fertility levels resulted in a significant increase in biological yield, yielding maximum (52.09 q ha^{-1}) under 30 + 60 + 50 and minimum (43.16 q ha^{-1}) under control.

4.2.8 Harvest index

The data related to harvest index is presented in Table 12. Different seed rates could not cause any significant difference in respect of harvest index.

The fertility level of 25 + 50 + 40 recorded significantly highest harvest index. The harvest index was similar at fertility levels of 20 + 40 + 30 and 30 + 60 + 50 which was significantly more than the harvest index under control 15 + 30 + 20.

4.3 QUALITATIVE ASPECTS

4.3.1 Nitrogen, protein, phosphorus and potassium contents in seed

Data on nitrogen, protein, phosphorus and potassium concentrations (%) in seed at harvest are given in Table 13. A perusal of data shows that seed rate of 80 and 100 kg ha^{-1} resulted in similar N content in seed which was significantly more than N content at 60 kg ha^{-1}, while the P and K contents increased significantly with increasing seed rates, with maximum recorded at 100 kg ha^{-1} seed.

The increasing fertility levels significantly increased the N, P and K contents upto 30 + 60 + 50 except for N content for which 25 + 50 + 40 and 30+60+50 were at par.

Protein content increased with the increasing seed rates upto 100 kg/ha seed which was at par with protein content in seed at 80 kg ha^{-1}. The successive increase in fertility levels up to 30 + 60 + 50 significantly increased the protein content in seed.

4.3.2 Nitrogen, phosphorus and potassium uptake by seed at harvest

The data pertaining to uptake of N, P and K by seed at harvest are presented in Table 14. The study of data in Table 14 reveal that the uptake of N, P and K increased significantly with increasing seed rates up to 100 kg ha^{-1}.

The increasing levels of fertility also recorded increasing trend for N, P and K uptake i.e. successive increase in fertility levels resulted into a significant increase in N, P and K uptake by seed.

Table 13: **Effect of seed rates and fertility levels on nutrient and protein content in seed of chickpea**

Treatments	N content (%)	P content (%)	K content (%)	Protein content (%)
Seed rate (kg/ha)				
60	2.72	0.28	0.84	17.00
80	2.75	0.31	0.86	17.20
100	2.75	0.34	0.88	17.22
S.Em±	0.004	0.004	0.056	0.025
CD at 5%	0.012	0.01	0.02	0.073
Fertility levels (kg/ha N + P_2O_5 + K_2O)				
0+0+0	2.64	0.24	0.74	16.53
15+30+20	2.71	0.28	0.83	16.96
20+40+30	2.75	0.32	0.88	17.25
25+50+40	2.79	0.35	0.91	17.42
30+60+50	2.80	0.37	0.94	17.54
SEm±	0.005	0.006	0.007	0.032
CD at 5%	0.015	0.016	0.022	0.094

Table 14: **Effect of seed rates and fertility levels on nutrient (N, P and K) uptake by seed in chickpea (kg/ha)**

Treatments	N	P	K
Seed rate (kg/ha)			
60	49.51	5.08	15.39
80	58.59	6.60	18.31
100	61.42	7.80	19.59
S.Em±	0.19	0.08	0.12
CD at 5%	0.56	0.25	0.35
Fertility levels (kg/ha N + P_2O_5 + K_2O)			
0+0+0	46.96	4.45	13.18
15+30+20	53.37	5.51	16.48
20+40+30	57.90	6.84	18.49
25+50+40	61.56	7.79	20.07
30+60+50	62.76	8.45	21.28
SEm±	0.25	0.11	0.16
CD at 5%	0.72	0.32	0.46

4.4 ECONOMICS

The economics of treatments was worked out and data are presented in Table 15 and depicited in Fig. 6 perusal of data reveals that gross as well as net returns of chickpea cultivation was highest with 100 kg seed rate i.e. (Rs. 29660 ha^{-1} and Rs. 21654 ha^{-1}, respectively) which was closely followed by 80 kg seed rate which returnd Rs. 29,240 ha^{-1} and Rs. 20,624 ha^{-1}, respectively. However, 80 kg and 100 kg ha^{-1} were equal in benefit : cost ratio (2.60 : 1.0).

The increasing fertility levels resulted into an increase in gross as net returns/ha. fertility level of 30+60+50 resulted into highest gross returns of Rs. 29,840 ha^{-1} while maximum net returns (Rs. 21,154) was recorded with 25+50+40 (kg/ha $N+P_2O_5+K_2O$).

Maximum benefit : cost ratio of 2.70 : 1.00 was recorded with lower levels of fertioity (control and 15+30+20 kg ha_{-1} $N+P_2O_5+K_2O$).

The data in Table 16 reveals that gross returns was maximum in the combination of highest seed rate with highest fertility level. However, net returns were higher in 25+50+40 fertility levels with all seed rates. The cost benefit ratio was higher under the combinations of lower levels of both factors of study.

Table : 15 Gross and net returns (Rs/ha) of chickpea as effected by seed rates and fertility levels

Treatments	Common charges (Rs/ha)	Additional inputs (seed rate/fertilizer) (Rs./ha)	Total cost of cultivation (Rs./ha)	Seed yield (qha)	Seed price (Rs./ha)	Stover yield (q/ha)	Stover price (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit : cost
A. Seed rate (kg/ha)										
60	7546	00.00	7546	18.1	21720	24.5	2440	24170	16624	2.2
80	7546	240	7786	21.3	25560	28.5	2850	28240	20624	2.6
100	7546	240	8026	22.2	26640	30.2	3020	29660	21634	2.6
B. Fertility levels (kg/ha) N + P_2O_5 + K_2O										
0+0+0	6286	00.00	6286	17.8	21360	24.3	2430	23790	17504	2.7
15+30+20	6286	750	7036	19.6	23520	27.1	2710	26230	19194	2.7
20+40+30	6286	750	7786	20.9	25080	27.7	2770	27850	20064	2.5
25+50+40	6286	750	8536	22.1	26520	29.7	2970	29690	21154	2.4
30+60+50	6286	750	9286	22.4	26880	29.6	2960	29840	20554	2.2

- Price of seed Rs. 12/-per kg
- Price of Stover Rs.1/-per kg

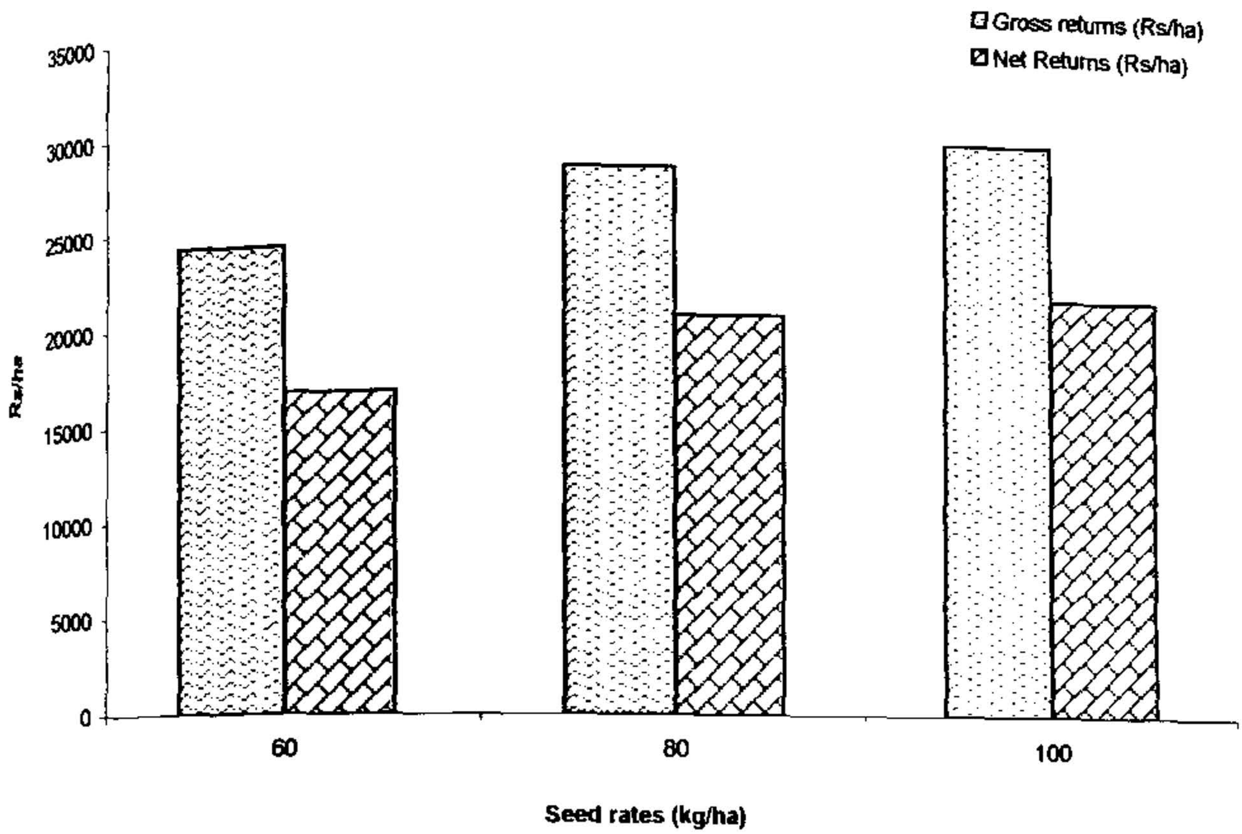

Fig. 6 (a): Gross and net returns (Rs/ha) of chickpea as affected by seed rates

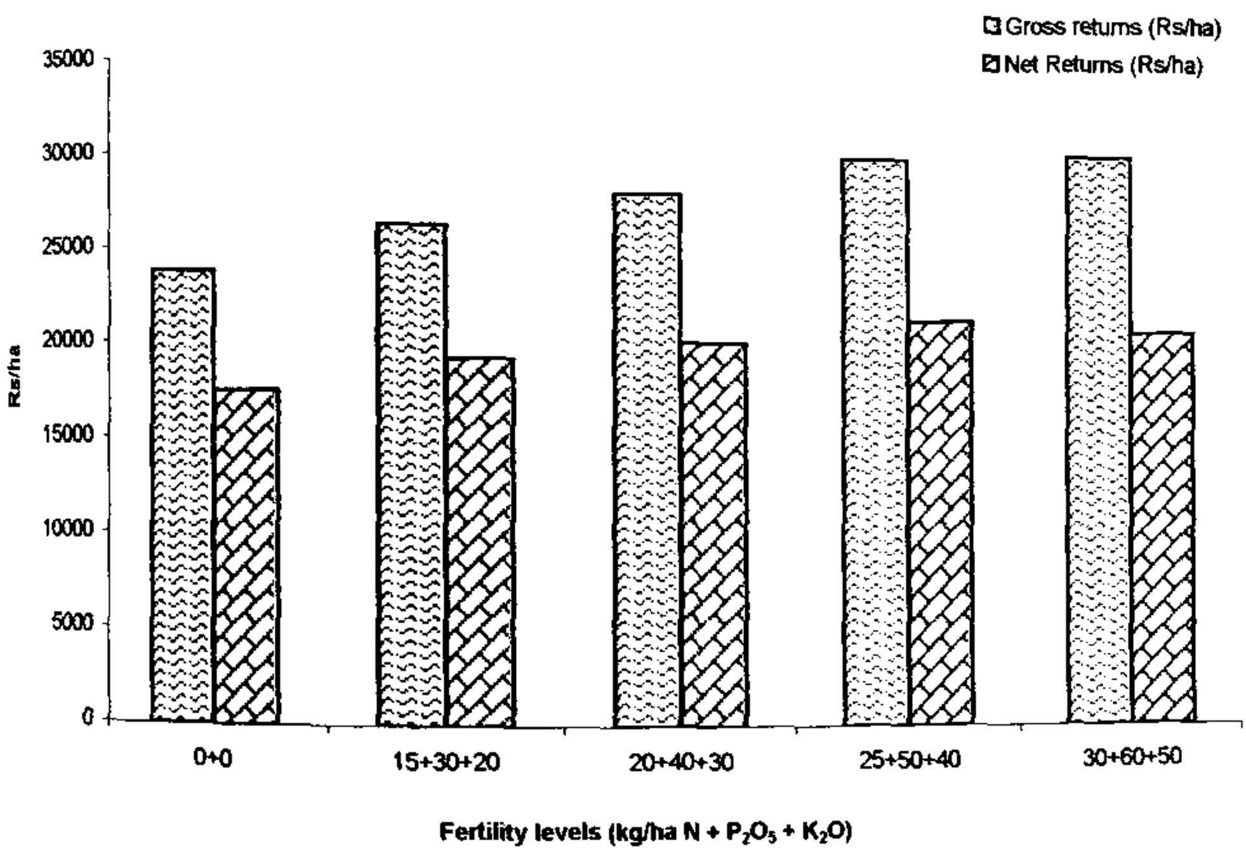

Fig. 6(b): Gross and net returns (Rs/ha) of chickpea as affected by fertility levels

Table : 16 Economics of various treatments

Treatments	Total cost of cultivation (Rs./ha)	Seed yield (qha)	Seed price (Rs.)	Stover yield (q/ha)	Stover price (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit : cost
S_1F_0	6040	15.8	18960	22.5	2250	21210	15164	2.5
S_1F_1	6796	17.2	20640	23.5	2350	22990	16194	2.3
S_1F_2	7546	18.3	21940	24.7	2470	24430	16884	2.2
S_1F_3	8596	19.4	23280	25.8	2580	25860	17564	2.1
S_1F_4	9046	19.9	23880	25.8	2580	26460	17414	1.9
S_2F_0	6286	18.4	22080	25.8	2580	24660	18374	2.9
S_2F_1	7036	20.4	24480	28.2	2820	27300	20264	2.8
S_2F_2	7786	21.6	25920	27.9	2790	28710	20924	2.6
S_2F_3	8536	22.8	27360	30.6	3060	30420	21886	2.5
S_2F_4	9286	23.1	27720	30.0	3000	30720	21434	2.3
S_3F_0	6526	19.0	22800	24.8	2480	25280	18724	2.8
S_3F_1	7276	21.3	25560	29.4	2940	28500	21224	2.9
S_3F_2	8026	22.9	27480	30.4	3040	30520	22494	2.8
S_3F_3	8776	23.9	28680	32.7	3290	31970	23194	2.6
S_3F_4	9526	24.1	28920	33.4	3340	32260	22734	2.3

* Price of seed Rs. 12/-per kg *Price of Stover Rs.1/-per kg

CHAPTER-V

DISCUSSION

The results of experiment entitled "Effect of seed rates and fertility levels on the growth, yield and quality of bold seeded chickpea" described in previous chapter reveal that various characters were affected by different treatments. In this chapter an attempt has been made to assign reasons responsible for variations that occurred due to different treatments. The results are discussed and explained in light of available information reported by other workers.

5.1 Effect of seed rates

5.1.1 Growth, yield attributes and yield

Significantly higher plant stand (no. of plants per running metre row length) was recorded at higher seed rates both in initial (30 DAS) and final (harvest) stages of crop growth (Table 6). It clearly shows that at higher seed rates, there was no mortality of seedlings due to plant competition. More plants per metre running row length due to increased seed rate were because lesser space had to accomode more seeds for germination. These results corroborate the findings reported by Rakesh Kumar (1996) and Saini and Faroda (1997). Significantly taller plants

(Table 7) were recorded at higher seed rates due to more competition for space and light because of increased plant population per unit area. Similar results in respect of plant height of chickpea were reported by Rakesh Kumar (1997) and Saini and Faroda (1997). There was no significant difference in number of branches among various seed rates (Table 8, Fig, 3). This might be attributed due to sufficient space available to each plant for lateral development.

Number of nodules decreased significantly with increased seed rates because of increased competition in rhizosphere for root development under more seed rate. Lowest seed rate (60 kg ha^{-1}) recorded significantly highest nodules (0.48) per plant (Table 9). It might be attributed to better root growth and balanced growth conditions. Rakesh Kumar (1994) and Vaishya *et al.* (1995) also reported similar results in favour of more nodules under lower seed rate.

The yield of crop plants depends on the source-sink relationship and different components of the sink viz., number of pods/plant, number of seeds/pod, test weight and seed yield/plant. Source components may be number of leaves, branches and dry matter of plant before the anthesis. Final yield in chickpea is the function of number of pods/plant, number of grains/pod, test weight and seeds yield per plant. Seed yield, being the ultimate economic objectives of the producers, assumes a vital importance and as such offers basis for the comparison of values of a particular treatment with other.

Increased seed rates resulted in reduced number of pods per plant, 100-seed weight and grain yield per plant (Table 10, Fig. 4). Thus, higher seed rates of 100 kg ha^{-1} resulted in greater competition to the extent that its adverse effect on yield components could not be propotionately counteracted by the increase in plant population. A seed rate of 80 kg ha^{-1} gave significantly higher seed and biological yields than 60 kg ha^{-1}. However, no additional gain in seed yield was obtained when the seed rate was raised to 100 kg ha^{-1} (Table 11, Fig. 5). The improvement in yield attributes at lower seed rate could be attributed to a relatively lesser competition for light, nutrients and moisture enabling the plants to develop better than their counterparts in higher seed rate. These results are well corroborated with the findings of Singh *et al.* (1984), Shaktawat and Sharma (1985), Singh and Yadav (1985), Rathore and Patel (1991), Saini and Faroda (1997) and Saini and Faroda (1998). Each successive increase in seed rate resulted in significant increase in biological yield (Table 11, Fig. 5) because of increased straw yield. Saini and Faroda (1997) also reported similar results.

The N, P and K uptake by seed in chickpea (Table 114) increased with increasing seed rates because of increased seed yield as a result of increased seed rate. Similar results were observed by Singh *et al.* (1984) and Rakesh Kuamr (1997).

5.2 Effect of fertility levels

Chickpea responds significantly to application of nitrogen, phosphorus and potassium and is more responsive to higher dose of phosphorus.

Fertilizer application always has beneficial effect on growth and development of plant (Tisdale *et al*., 1975).

5.2.1 Growth, yield attributes and yield

Application of different levels of $N+P_2O_5+K_2O$ did not effect the plant population at both stages i.e. 30 DAS and at harvest (Table 6). However, various growth parameters viz., plant height (Table 7) and number of branches (Table 8, Fig. 3) were increased significantly by successive levels of $N+P_2O_5+K_2O$. Both these growth parameters were recorded maximum at 30+60+50 NPK kg/ha. Significant improvement in the number of branches per plant due to N, P_2O_5 and K_2O application has also been reported by Kar *et al*. (1989) and Uma (2002).

The results presented in Table 9 reveal that different levels of fertilizers affected the nodules number at 50 DAS significantly and maximum number of nodules were recorded at fertility level of 30 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1}. This is probably due to the fact that phosphorus might have stimulatory effects on the bacteria. In the presence of phosphorus the bacterial cells become motile and flagellate, a pre-requisite for migration where as in the absence of phosphorus the infection remain latent leading to the poor development of nodules. Corroborative findings have also been reported by Raut and Kohire (1991), Parihar (1989), Mane and Jadhav (1991), Yadav and Mandal (1992), Chandra (1995) and Uma (2002).

Fertilizer levels also delayed days taken to 50 per cent flowering stage (Table 9) in chickpea crop. Maximum days taken to 50 per cent flowering stage were generally observed at 30+60+50 level of $N+P_2O_5+K_2O$

which was at par with 25+50+40 level of fertilizer. Similar results have also been reported by Uma (2002).

Application of different levels of fertilizers had significant effect on various yield attributes and seed and total biological yields of crop. The yield attributing characters (Table 10, Fig. 4) including number of pods per plant, number of seeds per pod and 100-seed weight were higher under the fertility level of 30 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} than control and other lower levels. Corroborative results have also been reported by Mishra (1986), Shah *et al.* (1986), Kar *et al.* (1989), Jain *et al.* (1999) and Uma (2002).

The data presented in Table 12 reveal that application of increasing level of $N+P_2O_5+K_2O$ significantly increased the seed and biological yields. Maximum yield (22.41 q/ha) was recorded at 30 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} followed by 25+50+40 kg N, P_2O_5 and K_2O (22.06 q/ha). The improvement in the yield due to increasing levels of fertilizers dose was brought about mainly due to effect of fertilizer levels on various yield-attributing components.

The favourable effect of increased level of fertilizers ($N+P_2O_5+K_2O$) on yield and its attributes might be ascribed to the availability of sufficient amount of phosphorus as well as nitrogen throughout growth period which resulted into more plant vigour and superior yield attributes. Cumulative effects on yield attributing components were mainly responsible for higher seed yield. The findings are in accordance with those of Mishra (1986), Shah *et al.* (1986), Joshi *et al.* (1988), Kalaria (1991), Reddy and Ahlawat (1999), Jain *et al.* (1999) and Uma (2002).

Harvest index

The results of present study indicate that there was significant increase in nitrogen, phosphorus and potassium concentrations of seed with successive increase in fertilizers over control (Table 13). Similarly NPK uptake by seed at harvest improved significantly with increasing levels of $N+P_2O_5+K_2O$. Maximum uptake was recorded with fertility levels of 30 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} (Table 14). Application of nitrogen, phosphorus and potassium might have resulted in increased availability of N, P and K in soil and also increased cation exchange capacity of roots, which enhanced N, P and K absorption in plants (Elgabaly, 1962). Thus there was increased concentration of these nutrients in seed at harvest. Singh and Sharma (1980), Singh *et al.* (1983), Parihar and Tripathi (1989), Enania and Vyas (1994), Reddy and Ahlawat (1999) and Uma (2002) were of the same opinion. Increase in nutrient availability resulted in higher seed and straw yields and thereby significant improvement in the uptake of NPK.

Similarly protein content was affected significantly by increasing levels N, P and K. Maximum protein content was recorded with application of 30 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} (Table 13). Uma (2002) also recorded similar trends.

Economics

Highest net returns were recorded with 100 kg seed rate. This was due to higher seed as well as biological yields of chickpea var. HC-3 under 100 kg seed ha^{-1}. The gross as well as net returns were very close in 100 and 80 kg seed rate/ha (Table 15, Fig. 6). Maximum net returns were recorded with 25+50+40 (kg/ha $N+P_2O_5+K_2O$) fertility level which was closely followed by 30+60+50 fertility level. However, benefit cost ratio was higher with lower levels of fertility. Gross returns was highest in the combination 25+50+40 (kg ha^{-1} $N+P_2O_5+K_2O$) (Table 16).

CHAPTER-VI

SUMMARY AND CONCLUSIONS

A field experiment entitled "Effect of seed rates and fertility levels on the growth, yield and quality of bold seeded chickpea" was conducted during *rabi* season of 2000-2001 at students' farm of Department of Agronomy, CCS Haryana Agricultural University, Hisar. The experiment was laid out in factorial RBD with three replications. Experiment was constituted of 3 seed rates viz., *60, 80 and 100 kg* ha^{-1} *and five fertility* levels viz., control (0+0+0), 15+30+20, 20+40+30, 25+50+40 and 30+60+50 kg/ha^{-1} N+P_2O_5+K_2O. The findings of the present investigations are summarised below :

6.1 EFFECT OF SEED RATE

6.1.1 The increasing seed rates resulted into significant increase in *plant population (plants/metre row length)* at 30 DAS and at harvest.

6.1.2 The plant height increased significantly with the increasing seed rates upto 100 kg/ha, at various stages of crop growth.

6.1.3 Number of branches per plant did not differ significantly with increasing seed rates at all stages of crop growth.

6.1.4 Significantly highest and lowest number of nodules per plant at 50 DAS were recorded with seed rates of 60 and 100 kg/ha, respectively.

6.1.5 Lowest days to 50 per cent flowering were taken at 80 kg/ha seed rate. 60 and 100 kg/ha did not differ significantly in this respect.

6.1.6 The number of pods per plant decreased significantly with increasing seed rates upto 100 kg/ha.

6.1.7 Number of seeds per pod did not differ significantly with various seed rates.

6.1.8 Different seed rates did not cause any significant difference in respect of 100-seed weight.

6.1.9 Seed rate of 60 kg/ha resulted in highest seed yield per plant which differed non-signiifcantly from other seed rates.

6.1.10 Biological yield per plant increased non-significantly with the increasing seed rates up to 100 kg/ha.

6.1.11 100 kg seed rate resulted into highest seed yield per ha which was at par with 80 kg/ha seed rate.

6.1.12 Biological yield/ha increased significantly with the increasing seed rates.

6.1.13 Various seed rates could not cause any significant difference in harvest index.

6.1.14 N content in seed was similar at 80 and 100 kg seed rate which was significantly more than 60 kg seed rate. P and K contents increased significantly with increasing seed rates. 100 kg seed rate resulted into highest protein content which was at par with 80 kg/ha.

6.1.15 Uptake of N, P and K by seed increased significantly with increasing seed rates up to 100 kg/ha.

6.2 EFFECT OF FERTILITY LEVELS

6.1.2 Various fertility levels did not result into significant difference in respect of plant stand at 30 DAS and at harvest.

6.2.2 The plant height increased significantly with the increasing fertility levels up to 30 kg N + 60 kg P_2O_5 + 50 kg K_2O/ha.

6.2.3 Increasing fertility levels resulted into a significant increase in number of branches per plant only up to 25+50+40 kg/ha N+P_2O_5 + K_2O and the increase after this level was non-significant.

6.2.4 Number of nodules per plant increased significantly with the increasing fertility levels.

6.2.5 Increasing fertility levels resulted into increased number of days taken for 50 per cent flowering.

6.2.6 The fertility levels of 30+60+50 kg/ha N+P_2O_5 + K_2O resulted into significantly highest number of pods per plant.

6.2.7 The number of seeds/pod increased non-significantly with the increasing fertility levels up to 25+50+40 and after that there was no increase.

6.2.8 The difference in 100-seed weight was non-significant with various fertility levels except for control where it was significantly lowest.

6.2.9 Increasing fertility levels resulted into significant increase in seed and biological yields per plant. Maximum and minimum were recorded with 30+60+50 and control, respectively.

6.2.10 The seed and biological yields/ha increased significantly with increasing fertility levels. Fertility level of 30+60+50 and control resulted into significantly highest and lowest grain and biological yields/ha, respectively.

6.2.11 Fertility level of 25+50+40 and control recorded significantly highest and lowest harvest index, respectively.

6.2.12 The increasing fertility levels resulted into a significant increase in N, P, K and protein contents in seed upto 30+60+50 kg/ha except for N for which 25+50+40 and 30+60+50 were at par.

6.2.13 There was a significant increase in N, P and K uptake by gram seed with increasing fertility levels up to 30+60+50 kg/ha.

6.3 INTRACTION EFFECT

6.3.1 Interaction of seed rates and fertility levels did not affect any of the growth, yield and qualitative parameters of chickpea.

6.4 ECONOMICS

6.4.1 Highest gross and net returns were recorded with 100 kg/ha seed rate which was closely followed by 80 kg/ha seed rate.

6.4.2 Fertility level of 30+60+50 gave maximum gross returns while 25+50+40 (kg/ha $N+P_2O_5+K_2O$) gave maximum net returns.

6.4.3 Gross returns were higher under highest levels of seed rate and fertility. However, the combination of 25+50+40 with any of the seed rate gave higher net returns. Among all the treatment combinations maximum net returns was observed with 100 kg seed rate along with 25+50+40 kg/ha ($N+P_2O_5+K_2O$).

CONCLUSIONS

The results of one year study conducted during 2000-2001 indicate that for a bold seeded variety like HC-3, higher seed rate @ 80 or 100 kg/ha is required for better productivity of chickpea crop under irrigated conditions of Haryana. This variety may give higher yields under high and balanced fertility level of 30+60+50 or 25+50+40. (kg/ha $N+P_2O_5 + K_2O$) Best economics was obtained under treatment combinations of 100 kg seed with 25+50+40 kg/ha $N+P_2O_5+K_2O$. However, for final recommendations more studies should be conducted on these aspects at least for one more year.

LITERATURE CITED

Ahlawat, I.P.S.; Saraf, C.S. and Singh, A. (1985). Effect of cultivars blending seed rates and phosphate fertilization on chickpea. *Indian J. Agron.* **30** (3): 373-376.

Anonymous (2000). Agricultural statistics at a glance.

Arunachalam, L. and Ravichandran, V.K. (1995). Influence of spacing and fertilizer levels on the performance of chickpea genotypes under rainfed conditions. *Haryana J. Agron.* **11** (1): 95-96.

Arvadia, M.K. and Patel, Z.G. (1987). Effects of dates of sowing and fertilizer on yield, quality and economics of gram. *Gujrat Agric. Univ. Res. J.* **13** (L): 53-55.

Bhuiya, Z.H.; Hussain, F. and Mian, M.H. (1979). Response of gram to NPK fertilizers. *Thai Agric. Sci.* **12** (3): 191-199.

Boote, K.J. 1982. Growth stages of peanut (*Arachis hypogea* L.). *Peanut Sci.* **9**: 35-40.

Chandra, R. (1995). Response and economics of Rhizobium, phosphorus and zinc application in gram in western U.P. plains. *Legume Res.,* **18** (2): 103-108.

Coleman, E.A. (1944). The dependence of field capacity upon the depth of wetting of field soils. *Soil Sci.* **58**: 43-50.

Dahiya, S. and Mehar Singh (1993). Relative growth performance of chickpea genotypes to irrigation and fertilizers application. *Haryana J. Agron.* **9** (2): 172-175.

Dahiya, S. and Mehar Singh. (1993). Effect of fertilizer doses and irrigation scheduling on yield and yield attributes of chickpea. *Crop Res.* **6** (3): 529-531.

Deolankar, K.P. and Berad, S.M. (1999). Effect of fertilziation on growth, yield and water use efficiency of chickpea (*Cicer arietinum*). *Indian J. Agron.* **44** (3): 581-583.

Elgabaly, M.M. 1962. On the mechanism of anion uptake by plant root. 2. Effect of the cation exchange capacity of plant roots on CL^{-1} uptake. *Soil Sci.* **93**: 350-352.

Enania, A.R. and Vyas, A.K. (1994). Effect of phosphorus and zinc application on growth, biomass and nutrient uptake by chickpea in calcareous soil. *Ann. Agric. Res.* **15** (4): 397-399.

Fisher, R.A. 1948. Statistical Methods for Research workers Ed. 10 Oliver and Boyd. Edinburg and London.

Habib-Ur-Rahman Khan; Haqqani, A.M.; Khan, M.A. and Malik, B.A. (1992). Biological and chemical fertilizer studies in chickpea grown under arid conditions of Thal. Sarhad, *J. Agric.* **8** (3): 321-327.

Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. pp: 498.

Jain, P.C.; Kushwaha, P.S.; Dhakad, U.S.; Khan, and Trivedi, S.K. (1991). Response of chickpea (*Cicer arictinum* L.) to phosphorus and biofertilziers. *Legume Research* **22** (4): 241-244.

Joseph, B. and Verma, S.C. (1994). Response of rainfed chickpea (*Cicer arietinum* L.) to jalshakti incorporation, phosphorus and sulpher fertilization. *Indian J. Agron.* **39** (2): 312-314.

Joshi, A.C.; Aparadh, V.H.; Rao, K.V. and Umrani, N.K. (1988). Response of Bengal gram to NPK fertilizers under protective irrigation in Sangli District. *J. Maharashtra Agric. Univ.* **13** (2): 168-170.

Kar, P.C.; Patro, G.K. and Mohanty, K. (1989). Effect of level of fertilizers on growth and yield of Bengal gram. Current Res. Univ. *Agric. Sci.,* **18** (6): 80-81.

Khokar, R.K. and Warsi, A.S. (1987). Nutrient uptake studies in gram. *Seeds and Farms.* **13** (11): 26-28.

Koeing, R.A. and Johnson, C.R. (1942). Colorimetric determination of phosphorus in biological materials. *Ind. Eng. Chem. (Analyt.)* **14**: 155-156.

Kumar, R.; Singh, R.C. and Maher Singh (1994). Response of chickpea (*Kabuli*) genotypes to fertility levels under limited and adequate water supply. *Haryana J. Agron.* **10** (2): 195-197.

Kumar, Rakesh, (1984). Response of chickpea genotypes to seed rates and fertilizer application. Ph.D. Thesis, Haryana Agric. Univ., Hisar.

Kumpawat, B.S. and Manohar, S.S. (1994). Effect of Rhizobium inoculation, phosphorus and micronutrients on nodulation and protein content of gram. *Madras Agric. J.* **81** (11): 630-631.

Kurhade, N.G. and Nagre, K.T. (1995). Yield attributing characters and yield of chickpea genotypes as influenced by nitrogen and phosphorus application *PKV Res. J.* **19** (1): 81-82.

Linder, R.C. 1944. Rapid analytical method for some of the more common inorganic constituents of plant tissue. *Pl. Physiol.* **19**: 76-89.

Mane, B.M. and Jadhav, A.S. (1991). Dry matter accumulation and nodulation of gram as influenced by fertilizer and plant densities. *J. Maharashtra Agric. Univ.* **16** (1): 39-42.

Minhas, R.S.; Jaggi, R.C. and Sharma, P. (1987). Response of gram to NPK application in wet temperate zone of Himachal Pradesh. *Indian J. Agric. Chem.* **20** (11): 95-99.

Mishra, S.G. and Dwivedi, R.S. (1977). Effect of copper phosphate interaction on the availability of nutrients. *J. Indian Soc. Soil Sci.* **25** (1): 41-46.

Misra, M.N. (1971). Effect of doses and method of phosphorus placement on growth, yield and uptake of phosphorus by gram (*Cicer arientium* L.) under irrigated conditions. *Indian J. Agron.* **16** (1): 60-63.

Nagarajan, R.; Krishnamoorthy, K.K. and Manickam, T.S. (1985). Response of bengalgram to application of copper, phosphorus and Rhizobium inculation. *Madras Agric. J.* **72**: 361-366.

Olsen, S.R.; Cole, C.V.; Watanable, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil extraction with sodium carbonate Circ. U.S. Dept. Agric. 939, Washington, D.C.

Paikaray, R.K. Misra, R.C. Halder, J.; Mohapatra, A.K. and Rao, S.V. (1995). Response of rabi sunflower to various levels of nitrogen phosphorus and potassium. *Environment and Ecology*. **13**: 4-7.

Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers, ICAR, New Delhi.

Parihar, S.S. and Tripathi, R.S. (1989). Dry matter, nodulation and nutrient uptake in chickpea (*Cicern arietinum* L.) as influenced by irrigation and phosphorus. *Experimental Agriculture*. **25**: 349-355.

Piper, C.S. (1966). Soil and Plant Analysis. Hans Publications, Bombay.

Rathore, A.L. and Patel, S.L. (1991). Response of late sown chickpea to method of sowing, seed rate and fertilizer. *Indian J. Agron.* **36** (2): 180-183.

Raut; R.S. and Kohire, O.D. (1991). Phosphorus response in chickpea (*Cicer arietinum* L.) with *Rhizobium* inoculation. *Legume Res.*, **14** (2): 78-82.

Reddy, N.R.N. and Ahlawat, I.P.S. (1999). Response of chickpea (*Cicer arietinum*) genotype to irrigation and fertilizers under late sown conditions. *Indian J. Agron.* **43** (1): 95-101.

Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils USDA Handbook No. 60, Washington, D.C.

Richards, L.A. and Weaver, L.R. (1943). Fifteen atmosphere percentage as related to the permanent wilting point. *Soil Sci.* **56**: 331-339.

Roy, R.K. and Tripathi, R.S. (1985). Effect of irrigation and phosphorus on yield, nodulation, WUE and nutrient concentration in chickpea. *Indian J. Agron.* **30** (4): 401-406.

Saini, S.S. and Faroda, A.S. (1996). Growth of chickpea as influenced by seed rates and fertility levels. *Haryana J. Agron.* **12** (1): 57-60.

Saini, S.S. and Faroda, A.S. (1997). Effect of sowing tie its pattern and seed rate on growth and yield of H 186-143 chickpea (*Cicer arietinum*). *Indian J. Agron.* **42** (1): 645-649.

Saini, S.S. and Faroda, A.S. (1998). Response of chickpea (*Cicer arietinum*) genotype 'H 86-143' to seeding rates and fertility levels. *Indian J. Agron.* **43** (1): 90-94.

Saini, S.S. and Faroda, A.S. (1998). Response of chickpea (Cicer arietinum) genotype 'H 86-143' to seedling rates and fertility levels. *Indian J. Agronomy* **43** (1): 90-94.

Saini, S.S.; Anoop Singh and Faroda, A.S. (1996). Growth of chickpea as influenced by varying sowing dates its pattern and seed rates. *Haryana J. Agron.* **12**: 119-124.

Shah, S.H.; Rana, M.S.; Iqbal, M. and Asghar, M.M. (1986). Nitrogen, phosphorus and potash requirements of chickpea crop. *J. Agric. Res. Pakistan.* **24** (4): 295-298.

Shaktawat, M.S. and Sharma, R.K. (1985). Response of chickpea varieties to seed rate and phosphorus. *Indian J. Agron.* **30** (3): 389-390.

Singh, A.; Ahlawar, I.P.S. and Saraf, C.S. (1984). Response of chickpea (*Cicer arietinum* L.) cultivars to seeding rates and phosphate levels. *Indian J. Agron.* **29** (3): 331-334.

Singh, Kalyan, Rao, K.L.; Jamwal, J.S. and Bohra, J.S. (1983). Effects of phosphors and biofertilizers on growth, yield and quality of chickpea (*Cicer arietinum* L.). *Trans. Indian Soc. Desert Technol. And Univ. Center, Studies,* **8** (1): 33-38.

Singh, O.N. and Singh, R.S. (1985). Seed rate, row spacing and planting method for late planted chickpea ICN **13**: 13.

Singh, P.N. and Ram, H. (1991). Phosphorus and sulphur interactions in relation to yield, uptake and utilization of phosphorus in chickpea. *J. Maharashtra Agric. Univ.* **16** (3): 391-394.

Singh, R.C.; Mehar Singh and Kumar, R. (1993). Response of chickpea genotypes of varying density and fertility levels. *Haryana Agric. Univ. J. Res.* **23**: 115-118.

Singh, S.C. and Yadav, D.S. (1985). Response of chickpea (*Cicer arietinum* L.) varieties to phosphorus levels and seeding rates. *Indian J. Agron.* **30** (4): 414-416.

Singh, Surinder and Sharma, H.C. (1980). Effect of profile soil moisture and phosphorus levels on the growth, yield and nutrient uptake by chickpea. *Indian J. Agric. Sci.* **50** (12): 943-947.

Subbiah, B.V. and Asija, C.L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Current Sci.* **32**: 172-194.

Tisdale, S.L. and Nelson, W.L. 1975. Soil Fertility and Fertilizers. Macmillan Publ. Co. Inc., New York. Pp: 68-124.

Tomar, R.K.S. and Raghuwanshi, R.S. (1995). Effect of nutrients on yield of chickpea under irrigated conditions. *Bhartiya Krishi Anusandhan Patrika,* **10** (1-2): 7-10.

Uma Devi (2002). Integrated Nutrient Management in chickpea (*Cicer arietinum* L.) Thesis, CCS HAU, Hisar.

Vadavia, A.T.; Kalaria, K.K.; Patel, J.C. and Baldha, N.M. (1991). Influence of organic, inorganic and biofertilizers on growth, yield and nodulation of chickpea. *Indian J. Agron.* **36** (2): 263-264.

Vaishya, R.D.; Fayaz, M.; Sher Singh and Rajput, A.L. (1995). Effect of seed rate and weed management practice on nodulation and yield of chickpea (*Cicer arietinum*). *Indian J. Agron.* **40** (2): 312-313.

Verma, V.K. (1994). Response of irrigated chickpea (*Cicer arietinum* L.) to NPK in light soils and its economics. *Adv. Pl. Sci.* **7** (1): 138-142.

Yadav, K and Mandal, K. (1992). Effect of Rhizobium strains of different origin on nodulation, nitrogenase activity and grain yield of chickpea (*Cicer arietinum* L.) *J. Res. Birsa Agric. Univ.* **4** (2): 167-168.