EFFECT OF VARIETY, IRRIGATION INTERVAL AND PHOSPHORUS LEVEL ON GROWTH AND YIELD OF CHICKPEA (Cicer arietinum L.)

BY

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in Agronomy

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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CERTIFICATION

This thesis entitled "Effect of variety, irrigation interval and phosphorus level on growth and yield of chickpea (Cicer arietinum L.)" by Aminu A. Muhammad meets the regulations governing the award of the Degree of Master of Science of the Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my parents, brothers and sisters in gratitude for what they have done to me for so long.

And to my wife FATIMA and our child Muhammad Aminu (Junior) in appreciation for their love, patience and understanding at all times.

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ABSTRACT

Replicated field experiments were conducted at the Kadawa Irrigation Research Station (11°39 'N, 08°02 'E and 500m above sea level) located in the Sudan savanna ecological zone of Nigeria during the 1995/96 and 1996/97 dry seasons. The aim was to study the effect of irrigation interval (5,10,15 and 20 day) and phosphorus level (0,11 and 22kgP/ha) on growth and yield of three chickpea (Cicer arietinum L.) varieties.

The results revealed that the three varieties significantly differed in all of the growth parameters assessed with K850 having an edge over the other two varieties although the differences were not significant in both trials. The effect of irrigation was inconsistent and less-marked. Stand count, numbers of branches per plant and nodes per main branch were significantly influenced by varying irrigation interval at 10 WAS in 1995/96 trial. Number of leaves per plant was also significant at same period in 1996/97 trial. In both trials where the effect of irrigation was significant, 10-day interval produced significantly higher values of these parameters than other intervals due to the moderate moisture regime. Phosphorus application did not significantly affect growth parameters except crop dry weight and number of leaves per plant at 8 WAS in 1996/97 trial.

In terms of yield and it attributes, variety K850 out- yielded ICCV1 and C235 with respect to pod diameter, 100-seed weight and also pod and grain yields in both trials. Shelling percentage (1996/97) and number of seeds per pod (1995/96) were also

significantly influenced by variety. Different irrigation treatments also resulted in varying significant effects on shelling percentage, pod and grain yields in 1996/97 trials with 10-day irrigation being superior to other intervals. However, none of the yield parameters was significantly influenced by irrigation in 1995/96 trial. Also, phosphorus application at 11 kgP/ha resulted in significantly higher shelling percentage, pod and grain yields than other levels in 1996/97 trial. The effect of phosphorus on other yield parameters was not significant in both trials.

Significant and positive correlations (P=0.01) were observed between chickpea grain yield and plant height, number of branches per plant and number of leaves per plant in 1995/96 trial; while 100-seed weight was significantly correlated with grain yield in 1996/97 trial only. Crop dry weight was significantly and positively correlated (P = 0.01) with grain yield in both trials.

The study showed that K850 significantly outyielded C235 and ICCV1 and 10-day irrigation appeared to be suitable for chickpea production. Phosphorus fertilization at 11 kgP/ha was found to be optimum for the growth and yield of the crop.

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CHAPTER ONE

INTRODUCTION

Chickpea (Cicer arietinum L.) belongs to the family Leguminosaea (Kupicha, 1981). It is believed to have originated from Asia and Mediterranean region (Kay, 1979 and van der Maeson, 1987). Chickpea is mainly grown during summer in temperate countries and also as a winter crop in tropical climates. The crop is considered one of the most important among pulses in the Indian subcontinent and in North Africa where it is cultivated on residual soil moisture, under irrigation or as a rainfed legume. In Nigeria, it is cultivated on a minor scale in parts of Jigawa, Kano, Yobe and Bauchi states (Anonymous, 1988).

There are two types of chickpea, "desi" and 'Kabuli' types (Saxena,1987). Although they are botanically similar, the seeds of'Kabuli' are large and light coloured with ram head shape, smooth surface and white flowers. On the other hand, 'desi' chickpea has coloured flower, small seeds with yellow to black testa and angular seed shape. It contains higher percentage of fibre than 'Kabuli' chickpea. The crop is also classified into three maturity groups: early, medium and late varieties (Nene, 1987). Early varieties take 90 to 100 days to mature, medium maturing types require 110 - 140 days while late varieties take 130 - 170 days to mature. The plant could be of semi-erect, basally branching or semi-spreading habit with apical branches.

Smithson et al. (1985), identified four major chickpea production regions. These were the Indian subcontinent including

Burma and West Asia, North Africa and European region. Others included Ethiopian and East African Highland region as well as the Americas and Australia. The first two regions grow 'desi' types which constitutes 85 percent of total world production (ICRISAT, 1989) while the latter regions grow exclusively'Kabuli' varieties.

Chickpea is a subtropical crop and requires warm dry weather. Saxena et al. (1983), reported that diurnal sequence of cool nights and warm days is optimum for its growth and yield. Germination is optimum at 20°C (Ozdemir, 1996). The crop is drought resistant but sensitive to waterlogging, cloudy weather, high humidity and saline conditions. It grows on a wide range of soil types but deep loams or silty clay loams are preferred. Chickpea tolerates a pH range of 6 to 9 and it does best at elevations of 300 to 1200m above sea level (Kay. 1979).

Most of the chickpea produced is consumed locally. India, being the largest producer accounts for 80 percent of the 5.6 million tonnes annual world production (Nene, 1987). The crop is grown on over 10 million hectares annually. Average yield is about 700kg/ha with a potential of 4000kg/ha at experimental stations (FAO, 1992). Much of the production is on small farms with little or no improved management practices. About 93 and 89 percents of the area and output respectively of chickpea are concentrated in the semi-arid parts of the tropics (Jodha and Subba Rao, 1987).

The crop has a high nutritive value because of its quality protein content (23%), high digestibility and relative freedom from flatulence factors. It is also richer in phosphorus and calcium

than other grain legumes. Mature whole dried seeds (gram) are either boiled, roasted or fried; spiced and eaten alone or with cereals. Alternatively seeds are split (dhal) or ground into flour (besan)and used in preparation of varied confectionery (Pushpamma and Geervani, 1987). In Nigeria, "moimoi" and "akara" have successfully been tried with chickpea. Green immature crop is consumed as green vegetable. The immature pods contain less starch and protein but more soluble sugars than mature ones and thus are easily digested even when eaten raw. Like groundnuts, podded chickpeas are boiled, roasted, shelled and consumed (Kay, 1979). In Bangladesh, immature top shoots of chickpea plant are plucked by women and used or sold as green vegetable. Chickpea is a valuable fodder crop. The straw and husks are also used for animal feed.The seeds are also used as concentrates for horses. New chickpea products like bean chips, bread and soups have recently been developed (Pushpamma and Geervani, 1987).

Despite the potentials and growing importance of this crop, there is no tangible research information on chickpea production in Nigeria. Chickpea's reputation as a drought resistant and low-input requiring crop of short duration make it an economically potent legume for the dry savanna ecology of this country. It could easily fit well into the dry cropping season of the region where it will not compete much with main crops. In view of the paucity of data on chickpea production in Nigeria, this study, which is a preliminary step toward, finding ways of increasing the crop's production, was carried out with the following specific objectives:

1. To determine the growth and yield responses of three chickpea varieties to varying irrigation interval and phosphatic fertilizer rates; and
2. To study the interaction between irrigation interval and phosphorus on growth and yield of the three chickpea varieties with a view to determing optimum levels of the input factors.

CHAPTER TWO

LITERATURE REVIEW

A lot has been reported on chickpea from other parts of the world, notably India. Some of the research findings have not been consistent even within the same ecological environment because the crop's response to input treatments is often very location-specific. The available findings on chickpea production and management are thus summerized in this review.

2.1 Effect of Irrigation on Growth and Yield

The response of chickpea to water regime has been found to be cultivar-specific (Saxena, 1987). It also depended on soil type, water demand and growth stage of the crop. In temperate countries where chickpea is grown on residual soil moisture, supplemental irrigation at critical stages of crop growth has been reported to result in substantial yield increases (Saxena, 1980). The same author suggested irrigation during early vegetative growth on light soils and/or later at flowering and early pod-fill stages on deep, heavy soils. In the Nile valleys of Egypt and the Sudan, chickpea is exclusively grown under irrigation (Saxena, 1987). Palled et al (1985) documented that seedling stage, flowering and pod development stages were the most sensitive to moisture stress.

Studies on scheduling irrigation indicated that two to three irrigations were beneficial to chickpea growth and yield, Several workers reported that two irrigations at flowering and pod development produced good yield with high water use efficiencies (Poonia, 1984; Katare and Bhale, 1989) while Dumbre and Desmukh

(1983) and Grewal et al (1984) observed that presowing and flowering stage irrigations were best for chickpea growth and yield. Shinde et al (1985) also found three irrigations at sowing, branching and pod development to give maximum consumptive use, minimum WUE and 50 percent higher yield than sowing irrigation alone. For the methods of cultivation and irrigation, Malik et al (1984) found surface basin of $50m^2$ to be most suitable for chickpea on black cotton soil of south Gujarat, India. In Nigeria, Anonymous (1988) reported that a fortnightly irrigation by surface flooding the basin was best for chickpea.

Irrigation has a significant influence on growth and development of chickpea. Growth was inhibited by soil moisture stress and this effect increased with the increase in intensity and duration of the stress (Gurmit and Rai, 1980). The inhibition in growth was cultivar-specific, with a negative correlation between growth and water saturation deficit. Saxena et al (1982) found that germination was reduced with decrease in soil moisture from 22 to 21 percent. Similarly, a reduction in seedling emergence with a decrease in soil moisture from 83 to 54 percent was observed. They concluded that water stress could be critical for proper germination and plant stand establishment. Fruit development and rate of leaf senescence were found to be related with the onset of water stress. Khanna-chopra and Sinha (1987) reported that at normal moisture condition, pods developed and matured over a long period and senescence was slow. On the other hand, the crop senescensed prematurely under stress condition coupled with a rise

in temperature. They concluded that nitrogen fixation was highly sensitive to water stress.

Nitrogen partitioning during fruit development was found to have increased in favour of pods and fruits at the onset of water stress. Khanna-chopra (1984) observed that flowering stage irrigation increased total nitrogen accumulation in post-flowering period from 5.2 to 16.8 N/m^2 in cultivar JG62. He concluded that nitrogen fixation was highly sensitive to water stress. Similarly, root nodulation and seed protein content of cultivar K850 was found to increase with flowering stage irrigation (ICRISAT, 1983). Singh and Rai (1982), reported increases in shoot protein, total and soluble nitrogen contents as well as a decrease in the protein: soluble nitrogen ratio of cultivar C214 (a drought sensitive variety) in response to irrigation when compared to G130 which is more susceptible to drought.

Saxena (1990) reported a close to linear correlation ($r = 0.85$) between amount of water used and yield of chickpea. Irrigation increased yield through increases in pod number, seed number per plant and 100 seed weight (Khanna-chopra and Sinha, 1987). Several workers reported increases in yield due to irrigation ranging from 25 to 75 percent (ICRISAT, 1981., Katare et al, 1984). Sharma and Bhargave, (1981) found that rate of increase in yield in response to irrigation ranged from 0.91 to 1.16 t/ha over a stressed yield of 0.67 t/ha. Yield variation in chickpea depended on the duration of vegetative growth and moisture availability in the post-flowering phase. Longer duration of

vegetative growth enabled the development of large photosynthetic surface and many sites for the reproductive sink. Khanna-chopra and Sinha (1987) reported that this increased sink potential is supported by higher dry matter accumulation in the post-flowering phase and the two (source and sink) complemented each other to ensure a higher yield. On the other hand, moisture availability in the post-flowering phase determined the differences in yield and yield component of chickpea. Singh et al (1980) observed that water stress decreased the number of pod, nodule dry weight and seeds per pod while Singh and Rai (1982) reported that stress tolerance was cultivar-specific. They also observed that the stress was positively correlated with nitrogen uptake, protein content and yield of non-irrigated, high-yielding chickpea varieties.

2.2 Effect of Phosphorus on Growth and Yield.

Chickpea is efficient with respect to phosphorus uptake and utilization (ICRISAT, 1991). Panwar et al (1977) reported a quadratic response between the crop yield and phosphorus fertilization. Singh and Ram (1989) working on soils low in available phosphorus ($\leq$ 2.5ppm) found that chickpea responded positively to applied phosphorus up to 35 kgP/ha. Other workers reported that optimum rates ranged from 17.5 to 22 kgP/ha (Manjunath and Shedavantar 1988; Varma and Bohra, 1983). In India, different methods of fertilizer application had no effect on chickpea. This was attributed to the high phosphate-fixing capacity of the soils (Anhara and Okada, 1991; Kamprath, 1991). However, other workers reported no significant crop response to phosphorus

application in soils with medium amount (5ppm) of available phosphorus (Anonymous, 1976; and Saxena, 1984).

Kalyan et al (1983) found that phosphorus application increased the growth, yield and quality of chickpea. In a pot experiment at Zaria, Musa (1991) found that plant height, numbers of branches per plant and leaves per plant, plant dry weight and yield increased progressively with increasing levels of phosphorus from 26 to 52 kgp/ha. Bhuiya et al, (1979) reported that application of 8.8kgP/ha gave the best nodulation while doubling the rate increased grain protein content and yield. In another experiment, Singh and Ram (1989) found that application of 13 and 26 kgP/ha increased phosphorus level content and uptake in both seed and haulm. Increasing the phosphorus level to 39 kgP/ha gave no further increase in either the content or uptake. They also reported that the seed had higher phosphorus content than the haulm. Similarly, Prasad and Senaria (1981) observed that application of 22 kgP/ha resluted in higher yield, while tripling the rateto 66 kgP/ha only increased grain protein content by 14.78 percent.

2.3 Irrigation and Phosphorus Interaction

Little work has been reported on the interaction between irrigation frequency and phosphorus application in chickpea. Prabhakar et al. (1987) reported that crop canopy and phosphorus uptake efficency increased with irrigation due to the crop's ability to fix and solubilise phosphorus in the soil. Application of phosphorus improved water use efficiency and induced the crop to

utilize more water from deeper layers of soil (Nayer and Singh,1985). These workers also found that cultivar M119 used more water with higher efficiency than BG 209. In another experiement, Surrinder and Sharma (1980) observed that irrigation, coupled with phosphorus application upto 13.5 kgP/ha increased nitrogen and phosphorus uptake by 71.5 and 51.3 percents respectively as well as grain yield of chickpea compared with non-irrigated treatment. Shinde et al (1980) found that cultivar PG-2 had 33 percent increase in yield under irrigation when half of the recommended phosphorus rate was applied in Maharashtra region, India. However, this treatment recorded highest consumptive water use and lowest water use efficiency. Similar results were obtained by Rahman et al (1983) who reported that increasing levels of irrigation decreased water use efficiency. Sharma and Bhargave, (1981) and Chandra et al (1983) reported that phosphorus application should be combined with less frequent irrigation for maximum economic yield.

CHAPTER THREE

3.0 MATERIALS AND METHODS

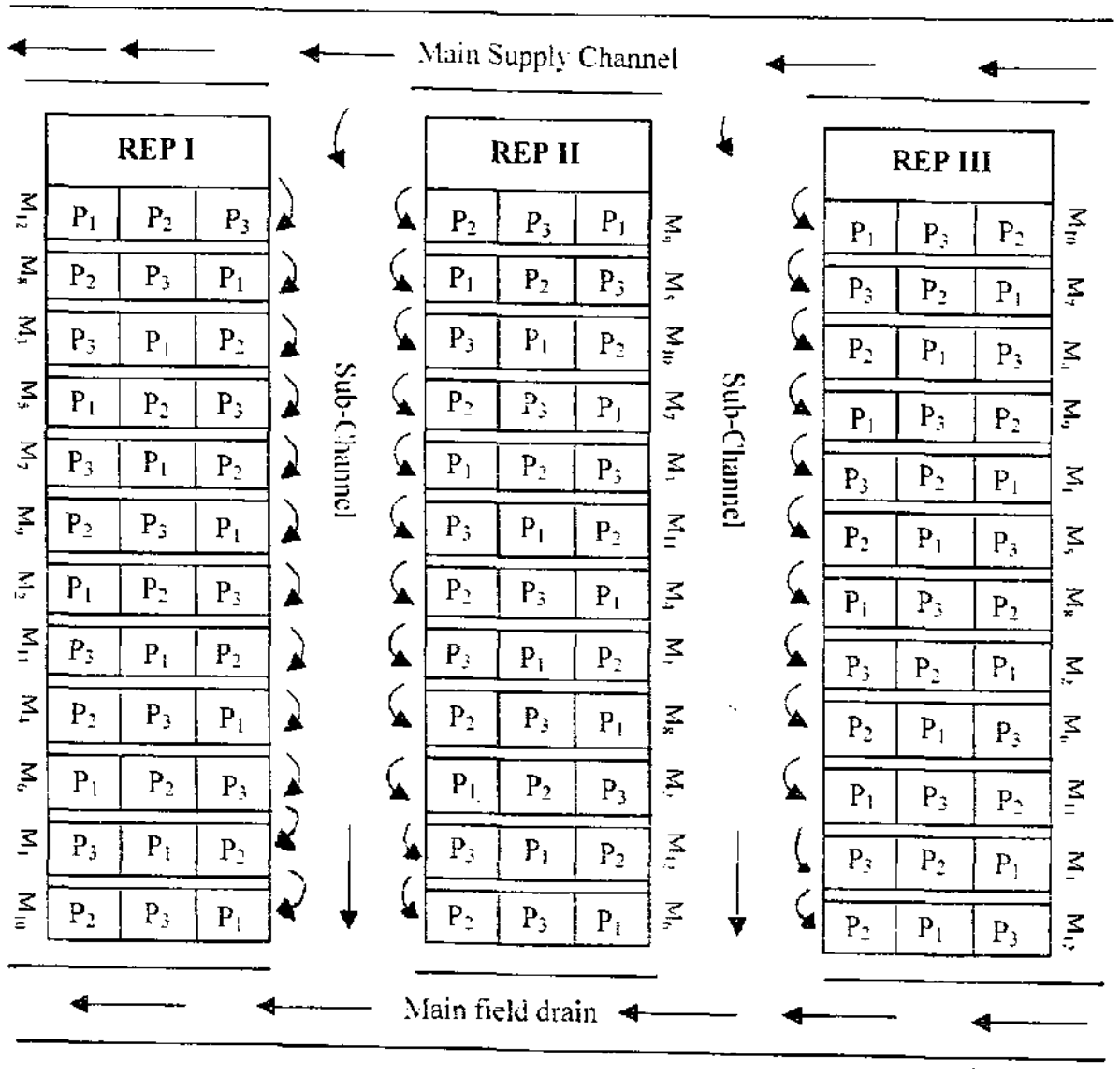
3.1 Experimental Site

The experiment was conducted during the 1995/96 and 1996/1997 dry seasons at Kadawa Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University, Zaria. Kadawa ($11^0 39'N; 08^0\ 02'E$ and 500m above sea level) is located within the Sudan savanna ecological zone of Nigeria. The soil of the site was sandy loam. Details of the physico-chemical analysis of the soil and meteorological records are contained in Appendices I and II, respectively.

3.2 Experimental Design and Plot size

The treatments consisted of combinations of three chickpea varieties (ICCV1, K850 and C235), four irrigation intervals (5,10,15 and 20-day) and three levels of phosphorus (0,11 and 22 kgP/ha). These were arranged in a split plot design with three replications. The factorial combinations of varieties and irrigation intervals were assigned to the main-plots while levels of phosphorus were placed in the subplots. The main and subplots sizes were $12m^2$ and $4m^2$, respectively. Subsequent mention of plot refers to the subplot. Field lay out is shown in figure 1.

Figure 1: Layout of the experimental field.



KEY

$M_1 = I_1V_1$
$M_2 = I_1V_2$
$M_3 = I_1V_3$
$M_4 = I_2V_1$
$M_5 = I_2V_2$
$M_6 = I_2V_3$
$M_7 = I_3V_1$
$M_8 = I_3V_2$
$M_9 = I_3V_3$
$M_{10} = I_4V_1$
$M_{11} = I_4V_2$
$M_{12} = I_4V_3$

Irrigation interval(days)

I_1 = 5
I_2 = 10
I_3 = 15
I_4 = 20

Variety

V_1 = ICCV1
V_2 = K850
V_3 = C235

Phosphorus level (kgP/ha)

P_1 = 0
P_2 = 11
P_3 = 22

3.3 Treatment Details

3.3.1 Varieties

Three chickpea varieties were used in this study. These are:

ICCV 1

This is a semi-erect, basal-branching variety. It's seed is characterised by small-size and brown colour. This desi chickpea is adapted to rainfed, irrigated and late-sown situations. It is a medium duration variety (110 - 140 days) and flowers between 60 and 70 days. Potential seed yield is 2000 kg/ha (ICRISAT 1984). It has 21 percent crude protein content and mean 100-seed weight of 16g.

K850

This is a 'desi' chickpea. The seeds are brown and larger than ICCV1. K850 matures earlier and flowers within 55 days. It is suited to both rainfed and irrigated conditions and the variety is adapted to medium and late sowing with a mean potential grain yield of 3560 kg/ha in India.

C235

Like the other two varieties, C235 is also a 'desi' chickpea with white seeds of medium size. It is resistant to pod damage by Heliocoverpa armigera and has a 100-seed weight of 13g. It is also adapted to rainfed, irrigated and late-sowing conditions with potential grain yield of 1720 kg/ha.

These three varieties were chosen for this trial because of their relative promising performance in the Nigerian savanna (Gupta, 1995; personal communication).

3.3.2 Irrigation interval

The four irrigation intervals tested were 5,10,15 and 20 days. Treatment variation commenced at 3 weeks after sowing (WAS).Prior to that, plots were uniformly irrigated at 7 - day intervals by surface flooding.

3.3.3 Phosphorus level

The three levels of phosphorus fertilizer investigated were 0,11 and 22 kgP/ha. The source of phosphorus was single superphosphate (7.8%P). The fertilizer was broadcasted on the date of sowing.

3.4 Cultural Practices

3.4.1 Land Preparation

The experimental site was pre-irrigated to facilitate cultivation. The land was then disc-ploughed and harrowed to a fine tilth. The plots were laid out in form of basins with borders and water channels.

3.4.2 Sowing

Two seeds were sown per hole in rows 40cm apart and at 30cm spacing within the rows.

3.4.3 Basal fertilizer application

All plots recieved a uniform application of nitrogenous fertilizer at the rate of 20 kgN/ha. This was applied in form of urea (46%N) and was incorporated into the soil at planting.

3.4.4 Weed Control

Weeds were controlled manually by hoe-weeding. This was done as the need arose throughout the experimental period.

3.4.5 Disease and Pest Control

In the 1995/96 season, mild Fusarium wilt and pod borer damage were observed. No major disease or pest attack was observed in 1996/97 season. The crop maintained a healthy appearance throughout its growth.

3.4.6 Harvesting, threshing and cleaning of grains

Harvesting was carried at maturity as indicated by the pod drying and leaf senescence. The plants were cut with pods and allowed to properly dry under the sun before the pods were picked, threshed and winnowed. Threshing, winnowing and cleaning of seeds were all done manually.

3.5 Determination of soil nutrient status

Soil samples were collected from random locations on the experimental field to a depth of 30cm before land preparation and were analysed for physical and chemical properties. The texture was determined by the hygrometer method (Boyoucos, 1951) and textural class identified by the soil textural triangle.

Total nitrogen was detemined by the Macro-Kjeldhal proceedure (Bremmer, 1965; IITA, 1975) while available phosphorus was determined by the method described by Trough (1930) and extractable phosphorus by molybdate blue colours (Bray and Kurtz, 1945). Exchangeable cations were determined by the acetic acid method (Reith 1967). Magnesium, calcuim and potassium were determined by the atomic absorption spectro-photometry using Perkin Elmers Model 403. Sodium was determined by flame emission method while cation exchange capacity (CEC) was determined using ammonium molybdate method.

3.6 Data Collection

Three plants from each plot were randomly picked and tagged for purposes of collecting data on some growth and yield parameters. All growth parameters were taken at 8 and 10 WAS except stand count which was taken at 4 WAS and at harvest. Final yield parameters were taken after harvest.

3.6.1 Stand Count

All plants within each plot were counted and the number recorded.

3.6.2 Plant height

Height was measured from ground level to the tip of the terminal apex of plant in centimeters (cm). The average values for the three samples were recorded per plot.

3.6.3 Number of branches per plant

The number of branches per plant were counted and averaged for the three plant samples recorded per plot.

3.6.4 Number of leaves per plant

The number of leaves per plant on the plants sampled were counted and the means recorded per plant.

3.6.5 Number of nodes per main branch

The number of nodes on the main branch of each of the three plant sample were counted and averaged on per plot basis.

3.6.6 Crop dry weight

After taking the above parameters, the plant samples were oven dried at 70°C to attain constant weights and the weights were recorded in grammes.

3.6.7 Pod diameter

At harvest a sample of three pods from each plot were used to measure their diameters in millimeters using thread and ruler. The average readings were recorded per plot.

3.6.8 Number of seeds per pod

The number of seeds per pod on a sample of three pods from each plot were counted and the means recorded.

3.6.9 Pod and grain yields

At final crop harvest, the total weights of the pods and grains from each plot were recorded and the values adjusted to per hectare.

3.6.10 100-seed weight

This was obtained by determining the weight of 100 seeds from each plot.

3.6.11 Shelling percentage(%)

The ratio of the seed to total pod weight from each plot was calculated as shown by the equation.

$$\text{Shelling } \% = \frac{\text{Seed yield}}{\text{total pod yield}} \times 100$$

3.6.12 Grain protein content (%)

Seed samples from each plot were collected and ground with a Wiley mill. The grinding machine and receptacle bag were cleaned after grinding each sample to prevent contamination of flour. From each ground seed sample, three sub-samples were taken and analysed for nitrogen content. Readings from the subsamples were averaged and recorded per plot. Determination of total nitrogen content of

grain was done using the Micro-Kjeldahl method (Bremmer, 1965). The percent nitrogen content was converted to percent protein content using a conversion factor of 6.25 as recommended by A.O.A.C (1975) and described by Guiragossian et al. (1977).

3.7 Statistical Analysis of Data

The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran (1967). Where the 'F' test showed significant differences, the means of such treatments were compared using Duncan Multiple Range Test (Duncan, 1955). Correlation analysis was also carried out among yield and some other characters to evaluate the degree of their association.

CHAPTER FOUR

4.0 RESULTS

4.1.0 Growth Characters of Chickpea as Affected by the Treatments.

4.1.1 Stand count

The stand count per plot taken at 4 and 10 WAS is shown in Table 4.1. There were no significant differences between the three chickpea varieties in 1995/96 season trial, but in the 1996/97 season trial, C235 had the least stand count. This difference was significant when compared with the other two varieties at 4 WAS but not with ICCV1 at 10 WAS. The difference between ICCV1 and K850 at both periods was not significant.

There was also no significant difference in stand count as influenced by irrigation interval except in 1995/96 at 10 WAS. At this period, the stand count under 5-day irrigation interval was significantly less than at 15-day interval. However, the differences among the 10, 15 and 20-day intervals as well as between 5 with 10 and 10 with 20-day intervals were not significant.

Stand count at 4 and 10 WAS during both seasons was not significantly affected by phosphorus application. Similarly, none of the first or second order interaction was found to be significant.

Table 4.1 Stand count of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	4 WAS[1]		10 WAS	
	1995/96	1996/97	1995/96	1996/97
Variety (V)				
ICCV1	28.08	28.72a	21.69	19.00ab
K850	24.86	26.64a	20.75	20.03a
C235	28.03	20.75b	23.31	14.86b
SE ±	1.14	1.44	1.02	1.62
Significance	NS[2]	**	NS	*
Irrigation interval,days(I)				
5	24.48	24.63	19.44c	17.78
10	27.67	27.82	21.41abc	19.00
15	27.63	24.74	23.67a	18.00
20	28.19	24.30	23.15ab	17.07
SE ±	1.31	1.66	1.18	1.88
Significance	NS	NS	*	NS
Phosphorus,KgP/ha(P)				
0	26.92	25.89	21.61	18.34
11	27.33	24.92	22.72	17.86
22	26.72	25.31	21.42	17.67
SE ±	0.87	0.85	0.91	0.99
Significance	NS	NS	NS	NS
Interaction				
V x I	NS	NS	NS	NS
V x P	NS	NS	NS	NS
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT

[1]WAS = Weeks after sowing

NS = Not significant

* and ** = significant at P ≥ 0.05 and 0.01 percent probability levels respectively.

4.1.2 Plant height.

The data on plant height as affected by treatments is presented in Table 4.2. The differences in height among varieties were significant in 1996/97 trial and at 8 WAS in 1995/96 trial when variety K850 produced significantly taller plants as compared with the other two varieties. The differences in plant height between ICCV1 and C235 at these periods as well as between ICCV1 and K850 at 10 WAS in 1996/97 trial were not significant.

Plant height was not significantly affected by irrigation interval. Also, phosphorus application had no significant influence on plant height of chickpea.

The interaction effects of variety, irrigation interval and phosphorus application were not significant.

4.1.3 Number of branches per plant.

Table 4.3 shows the effects of treatments on number of branches per plant. The differences in branch number per plant among varieties was only significant at 10 WAS in 1996/97 trial. At this period, ICCV1 produced significantly more branches per plant than the other two varieties although the difference in number of branches per plant between this same ICCV1 and C235 was not significant.

Table 4.2 Plant height of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	8 WAS[1]		10 WAS	
	1995/96	1996/97	1995/96	1996/97
Variety (V)				
ICCV1	19.32b	22.64b	29.50	27.57ab
K850	21.19a	26.23a	31.54	30.03a
C235	19.86ab	23.03b	32.38	26.77b
SE ±	0.61	0.77	1.08	1.03
Significance	*	**	NS	*
Irrigation interval,days (I)				
5	20.76	23.18	30.33	27.37
10	20.48	23.82	33.35	28.84
15	19.06	23.49	30.47	28.27
20	20.20	25.39	30.41	28.01
SE ±	0.70	0.89	1.25	1.19
Significance	NS	NS	NS	NS
Phosphorus,KgP/ha (P)				
0	21.04	23.56	32.36	28.22
11	19.95	24.65	31.30	28.26
22	19.39	23.69	29.76	27.89
SE ±	0.56	0.61	1.16	0.71
Significance	NS	NS	NS	NS
Interaction				
V x I	NS	NS	NS	NS
V x P	NS	NS	NS	NS
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT

[1]WAS = Weeks after sowing

NS = Not significant

* and ** = significant at P ≥ 0.05 and 0.01 percent probability levels respectively.

Table 4.3 Number of branches per plant of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	8 WAS[1]		10 WAS	
	1995/96	1996/97	1995/96	1996/97
Variety (V)				
ICCV1	8.08	4.49	6.69	6.44a
K850	7.08	4.97	5.44	4.81b
C235	8.11	4.81	8.36	5.89a
SE+	0.47	0.26	1.00	0.31
Significance	NS	NS	NS	**
Irrigation interval,days (I)				
5	7.26	4.78	4.81b	5.62
10	7.89	4.85	10.07a	6.26
15	7.93	4.89	6.89ab	5.56
20	7.96	4.78	5.56b	5.41
SE ±	0.54	0.30	1.15	0.35
Significance	NS	NS	*	NS
Phosphorus, (KgP/ha)				
0	8.11	4.69	5.92	5.64
11	7.08	4.86	7.14	5.69
22	8.08	4.92	7.44	5.81
SE ±	0.45	0.24	0.85	0.33
Significance	NS	NS	NS	NS
Interaction				
V x I	*	NS	NS	NS
V x P	NS	NS	NS	**
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT
[1]WAS = Weeks after sowing
NS = Not significant
* and ** = significant at P ≥ 0.05 and 0.01 percent probability respectively.

The effect of irrigation interval on number of branches per plant at 8 WAS in both trials was not significant. However, at 10 WAS in 1995/96 trial, irrigating every 10 days resulted in siginficantly more branches per plant than at 5 or 20 days. The differences in number of branches per plant between the 10 and 15-day intervals as well as among 5, 15 and 20 days were observed to be statistically similar.

Phosphorus application did not significantly affect number of branches per plant.

Significant interaction was observed between variety and irrigation interval on the number of branches per plant (Table 4.4) The interaction showed that inceasing irrigation interval had no significant effect on variety K850. But for C235, 15-day irrigation led to the production of more branches than other intervals while ICCV1 had the least number of branches at this interval. Also, the three varieties had statistically similar number of branches per plant under 5-day irrigation. However, K850 had the least branches than all others under 5-day irrigation.

There was also a significant variety x phosphorus interaction on number of branches per plant (Table 4.4). This showed that K850 produced significantly more branches per plant than C235 under 22 KgP/ha while all three varieties produced statistically similar number of branches per plant at 0 KgP/ha.Also increasing response to phosphorous fertilization up to 11 KgP/ha among the three varieties was observed. Beyond this level, the response decreased, though the differences were not always significant.

Table 4.4 Interaction between variety with irrigation and phosphorus levels for number of branches per plant of chickpea during, 1995/96 dry seasons at Kadawa

Treatment	Irrigation Interval (days)				Phosphorus (KgP/ha)		
	5	10	15	20	0	11	22
Variety	1995/96				1996/97		
ICCV1	7.56b-e	9.00abc	6.11cde	9.67ab	5.92abc	6.50a	6.25ab
K850	8.33a-e	8.00b-e	6.67c-e	8.33a-e	5.08bcd	7.17a	6.33a
C235	8.89a-d	6.67c-e	11.00a	5.89e	4.50c	4.83cd	4.83cd
SE ± 0.93					SE± 0.57		

Means followed by unlike letters within a treatment group are significantly different at P = 0.05 using DMRT.

4.1.4 Number of leaves per plant

The variations in number of leaves per plant due to variety, irrigation interval and phosphorus level are shown in Table 4.5. The differences among the varieties were not significant except at 10 WAS in 1996/97 trial when ICCV1 had a significantly larger number of leaves per plant than either K850 or C235 which recorded statistically similar number of leaves per plant.

Irrigation significantly influenced leaf number at 10 WAS in 1996/97 trial. The number of leaves per plant was found to significantly decrease when the irrigation interval was increased from 10 to 20 days. Irrigating every 10 days produced the highest number of leaves per plant, although the difference between this and that obtained at 5-day interval was not significant. Similarly difference in leaf number obtained at 5 and 15-day irrigation intervals were not significant. Number of leaves per plant was not significantly affected by phosphorus application.

Table 4.6 shows the interaction effect of variety x irrigation interval on number of leaves per plant at 8 WAS. It was observed that different irrigation interval had no significant effect on varieties except at 15 days where C235 produced more leaves per plant than either ICCV1 or K850. Similarly, when irrigation interval was kept constant, the three varieties recorded statistically similar number of leaves per plant except this same C235 which exceeded other varieties under 5-day irrigation regime.

Variety and phosphorous interaction on number of leaves per plant at 10 WAS in 1996/97 trial was also significant (Table

4.6).It was observed that ICCV1 produced significantly more leaves per plant at 0 KgP/ha than other two varieties whose means were statistically similar under 22 kgP/ha. When phosphrous levels were held constant, while comparing the varieties, the same ICCV1 had significantly larger number of leaves per plant than either K850 or C235.

Table 4.5 Number of leaves per plant of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	8 WAS[1]		10 WAS	
	1995/96	1996/97	1995/96	1996/97
Variety (V)				
ICCV1	93.60	109.81	127.75	229.47a
K850	85.60	110.64	115.62	184.59b
C235	95.60	100.64	117.61	184.25b
SE ±	6.36	3.56	10.44	6.95
Significance	NS	NS	NS	**
Irrigation interval,days (I)				
5	90.80	108.41	144.00	200.4b
10	94.30	112.52	118.37	223.93a
15	88.50	100.48	110.67	199.78b
20	92.90	106.70	108.26	173.56c
SE ±	7.34	4.11	12.06	8.02
Significance	NS	NS	NS	**
Phosphorus,KgP/ha(P)				
0	94.60	101.44b	128.08	208.28
11	85.30	117.11a	112.50	199.17
22	94.90	102.53b	120.39	190.38
SE ±	6.05	3.76	6.44	6.01
Significance	NS	*	NS	NS
Interaction				
V x I	*	NS	NS	NS
V x P	NS	NS	NS	**
I x P	NS	NS	NS	NS
I x V x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT
[1]WAS = Weeks after sowing
NS = Not significant
* and ** = significant at P ≥ 0.05 and 0.01 percent probability levels respectively.

Table 4.6 Interaction between variety with irrigation and phosphorus levels for number of leaves per plant of chickpea during, 1995/96 dry seasons at Kadawa

Treatment	Irrigation Interval (days) 5	10	15	20	Phosphorus (KgP/ha) 0	11	22
Variety	1995/96				1996/97		
ICCV1	100.0ab	99.0ab	69.1b	106.4ab	244.50a	234.67ab	211.25bc
K850	71.9b	99.6ab	73.4b	97.7ab	173.33ef	198.58de	181.75c-f
C235	101.4ab	84.2b	123.0a	74.6b	207.00bcd	179.50def	166.25f
SE ±	12.7				SE± 10.41		

Means followed by unlike letters within a treatment group are significantly different at P = 0.05 using DMRT.

4.1.5 Number of nodes per main branch.

Treatment effects on number of nodes per main branch is presented in Table 4.7. Average number of nodes per main branch was significantly influenced by variety at 8 WAS in 1995/96 and at 10 WAS in 1996/97 trial. At these periods K850 produced higher number of nodes per main branch than other two varieties. However, the nodes per main branch recorded by K850 and C235 in 1995/96 and also by ICCV1 and K850 in 1996/97 were statistically at par. Also, ICCV1 and C235 produced statistically similar nodes per main branch at 8 WAS in 1995/96 trial. This parameter was not significantly affected by variety at 8 and 10 WAS in 1996/97 and 1995/96 trials, respectively.

Irrigation did not significantly affect number of nodes per main branch except at 10 WAS in 1995/96 trial. Increasing the interval from 5 to 20 days significantly reduced the number of nodes per main branch, although the differences in this parameter produced under 5,10 and 15-day intervals as well as between 10, 15 and 20-days were not significant. Phosphorus application and the interactions among treatments were not significant.

4.1.6 Crop dry weight.

The data on crop dry weight per plant as affected by treatments is shown in Table 4.8. Variety K850 recorded significantly higher crop dry weight per plant than other two varieties at 10WAS in both trials. However ICCVI and C235 at

10 WAS in 1995/96 and also K850 and ICCV1 at 8WAS in 1996/97 produced similar crop dry weights. Different irrigation intervals resulted in no significant effect on crop dry weight while phosphorus application was significant at 8 WAS in 1996/97 trial only. At this period, application of 11 kgP/ha recorded significantly higher dry weight than at other levels. However, 11 and 22 kgP/ha as well as 0 and 22 kgP/ha produced statistically similar weights. Both first and second order interactions were not significant.

Table 4.7 Number of nodes per main branch of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	8 WAS[1] 1995/96	8 WAS[1] 1996/97	10 WAS 1995/96	10 WAS 1996/97
Variety (V)				
ICCV1	13.43b	19.08	24.00	26.53a
K850	15.13a	18.58	22.11	26.81a
C235	13.96ab	18.64	23.33	23.78b
SE ±	0.44	0.98	0.76	0.89
Significance	*	NS	NS	*
Irrigation interval,days (I)				
5	14.83	19.30	24.89a	24.30
10	14.52	18.33	23.26ab	25.48
15	13.49	17.85	23.22ab	24.89
20	13.86	19.59	21.22b	26.82
SE ±	0.51	1.13	0.87	0.98
Significance	NS[2]	NS	*	N S
Phosphorus, KgP/ha (p)				
0	14.08	18.61	23.53	25.72
11	14.26	18.75	22.64	25.17
22	14.19	18.94	23.28	25.22
SE ±	0.39	0.59	0.70	0.67
Significance	NS	NS	NS	NS
Interaction				
V x I	NS	NS	NS	NS
V x P	NS	NS	NS	NS
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT

[1]WAS = Weeks after sowing

NS = Not significant

* and ** = significant at P ≥ 0.05 and 0.01 percent probability level respectively.

Table 4.8 Crop dry weight (g/plant) of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	8 WAS[1] 1995/96	8 WAS[1] 1996/97	10 WAS 1995/96	10 WAS 1996/97
Variety (V)				
ICCV1	4.18	2.63a	4.67b	3.27c
K850	4.61	2.46a	7.04a	4.53a
C235	3.68	2.03b	4.47b	3.79b
SE ±	0.37	0.13	0.77	0.17
Significance	NS	**	*	**
Irrigation interval,days (I)				
5	4.44	2.30	4.48	4.02
10	4.27	2.60	5.33	3.70
15	3.58	2.45	5.16	3.79
20	4.34	2.14	6.24	3.39
SE ±	0.43	0.15	0.88	0.19
Significance	NS[2]	NS	NS	NS
Phosphorus, KgP/ha (P)				
0	4.15	2.13b	5.62	3.90
11	4.31	2.60a	6.03	3.92
22	4.01	2.39ab	4.52	3.76
SE ±	0.24	0.11	0.63	0.19
Significance	NS	**	NS	NS
Interaction				
V x I	NS	NS	NS	NS
V x P	NS	NS	NS	NS
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT

[1]WAS = Weeks after sowing

NS = Not significant

* and ** = significant at (P ≥ 0.05 and 0.01 percent probability level respectively.

4.2.0 Yield and Yield Components of Chickpea as Affected by the Treatments.

4.2.1 Pod diameter (cm)

Table 4.9 presents the effects of treatments on pod diameter. Variety significantly affected pod diameter in both trials where K850 recorded higher diameter than other varieties.However,the difference in pod diameter between ICCV1 and C235 in 1996/97 trial was not significant while C235 recorded least diameter in 1995/96 trial.

There were no significant differences in the pod diameter of chickpea varieties as a result of irrigation at different intervals in both trial.Similarly,phosphorus application did not significantly affect pod diameter in the two year trial. The first and second order interactions were not significant.

4.2.2 Number of seeds per pod.

The variations in number of seeds per pod due to variety, irrigation interval and phosphorus level are shown in Table 4.9. Differences among the varieties were significant in 1995/96 trial only where variety C235 produced significantly more seeds per pod than ICCV1 and K850 whose means were statistically similar.

The effects of varying irrigation interval and phosphorus level on the number of seeds per pod were not significant in both trials. Similarly,the interaction effects of variety, irrigation interval and phosphorus application were not significant.

Table 4.9 Pod diameter(cm) and number of seeds per pod of chickpea as influenced by variety, irrigation interval and phosphorus level during 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	Pod diameter(cm) 1995/96	Pod diameter(cm) 1996/97	No. of seed/pod 1995/96	No. of seed/pod 1996/97
Variety (V)				
ICCV1	2.65b	2.44b	1.36b	1.75
K850	3.15a	3.00a	1.41b	1.28
C235	2.47	2.65b	1.74a	1.47
SE ±	0.04	0.07	0.07	0.15
Significance	**	**	**	NS
Irrigation interval,days (I)				
5	2.74	2.71	1.37	1.56
10	2.80	2.67	1.52	1.44
15	2.80	2.77	1.49	1.41
20	2.69	2.72	1.62	1.59
SE ±	0.04	0.08	0.08	0.51
Significance	NS	NS	NS	NS
Phosphorus,KgP/ha (P)				
0	2.75	2.69	1.48	1.53
11	2.77	2.73	1.53	1.47
22	2.75	2.73	1.50	1.50
SE ±	0.03	0.04	0.05	0.10
Significance	NS	NS	NS	NS
Interaction				
V x I	NS	NS	NS	NS
V x P	NS	NS	NS	**
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT
NS = Not significant
* and ** = significant at P ≥ 0.05 and 0.01 percent

probability level respectively.

4.2.3 Pod yield per hectare

The data on pod yield (kg/ha) as affected by treatments is presented in Table 4.10. Variety K850 recorded significantly higher pod yield than ICCV1 and C235 in the two trials.It was also observed that differences in pod yield between ICCV1 and K850 in 1996/97 and among K850 and C235 as well as ICCV1 and C235 both in 1995/96 trial were not significant.

Chickpea pod yield decreased significantly with increasing irrigation interval from 15 to 20 days in 1996-97 although differences in pod yield among 5, 10 and 15-day intervals were not significant. The effects of irrigation on pod yield in 1995/96 trial were not significant.

The result also revealed that increasing levels of phosphorus application significantly increased pod yield per hectare in 1996/97 trial. However, the differences in pod yield produced under 0 and 11 kgP/ha were not significant. The effect of phosphorus application on pod yield in 1995/96 trial was also not significant.The interaction effects of variety, irrigation interval and phosphorus level were not significant in both trials.

4.2.4 Shelling percentage

Table 4.10 presents treatment variations on shelling percentage. Variety had significant effect on shelling percentage in 1996/97 trial when K850 recorded higher

percentage than ICCV1 and C235. ICCV1 had the least shelling percentage while the effect was not significant in 1995/96 trial.

Irrigation was also found to significantly affect shelling percentage in 1996/97 trial. Irrigation at 10 and 15-day intervals resulted in significantly higher and similar shelling percentages than under 5 and 20 days which were also statisically similar. The effect of irrigation on shelling percentage was not significant in 1995/96 trial.

Phosphorus application had also a significant effect on shelling percentage in 1996/97 trial where 0 and 11 kgP/ha gave significantly lower but similar shelling percentage than that obtained under 22 kgP/ha. None of the treatment interaction effects was significant.

Table 4.10 Pod yield (kg/ha) and shelling percentage (%) of chickpea as influenced by variety, irrigation interval and phosphorus level during the 1995/96 and 1996/97 dry seasons at Kadawa.

Treatment	Pod yield (kg/ha) 1995/96	Pod yield (kg/ha) 1996/97	Shelling % 1995/96	Shelling % 1996/97
Variety (V)				
ICCV1	282b	716a	89.7	63.5c
K850	465a	742a	72.4	86.1a
C235	410ab	670b	72.6	74.8b
SE ±	56	14	10.1	1.7
Significance	*	**	NS	**
Irrigation interval,days (I)				
5	331	741a	72.1	63.7b
10	426	755a	97.1	81.7a
15	418	756a	74.7	87.1a
20	367	585b	68.9	68.9b
SE ±	64	16	11.0	2.1
Significance	NS[1]	**	NS	**
Phosphorus, KgP/ha (P)				
0	373	672b	72.9	71.9b
11	380	683b	71.3	73.8b
22	404	774a	90.3	78.7a
SE ±	30	13	10.3	1.5
Significance	NS	**	NS	**
Interaction				
V x I	NS	NS	NS	NS
V x P	NS	NS	NS	NS
I x P	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT
NS = Not significant
* and ** = significant at P ≥ 0.05 and 0.01 percent probability level respectively.

4.2.5 Grain yield per hectare(Kg/ha)

Variations in grain yield per hectare due to variety, irrigation interval and phosphorus application are shown in Table 4.11. Variety had significant influence on grain yield and K850 significantly outyielded other two varieties. However, average grain yields recorded by K850 and C235 as well as means of ICCV1 and C235 in 1995/96 were statistically similar while ICCV1 had the least yield in the second trial.

The grain yield was significantly affected by irrigation interval in 1996/97 trial only where 10-day irrigation significantly produced more grain yield than other intervals. Average grain yield produced under 15 and 20-day intervals were statistically similar and significantly higher than that obtained under 5-day interval. Water application did not significantly affect grain yield in 1995/96 trial.

Similarly, varying phosphorus levels significantly influenced grain yield in 1996/97 trial with 11 kgP/ha recording significantly higher yield than other levels, although this was statistically similar to the mean grain yield under 0 kgP/ha.

Table 4.12 shows the interaction effect of variety and irrigation interval on grain yield per hectare in 1996/97 trial. It was observed that when irrigation intervals were held constant, K850 outyielded other two varieties except at 10-day interval when all three varieties produced statistically similar grain yield. On the other hand, 10-day

irrigation interval produced significantly higher grain yield irrespective of variety than other intervals although K850 recorded the highest yield under 15-day irrigation.

The variety x phosphorus interaction on grain yield was also significant in 1996/97 trial. (Table 4.12) which showed that irrespective of level of phosphorus applied, K850 yielded higher than ICCV1 and C235. It was also noted that the highest grain yield was recorded by same K850 under 22 kgP/ha. Similarly, C235 outyielded ICCV1 at all phosphorus levels except under 0 kgP/ha when both recorded statistically similar grain yields.

4.2.6 100-seed weight

Treatment effects on 100-seed weight is presented in Table 4.11. The differences in 100-seed weight among varieties were significant in both trials where K850 recorded higher 100-seed weight than ICCV1 and C235. In 1995/96, C235 recorded least 100-seed weight while the means of ICCV1 and C235 were statistically similar in the second trial.

There was also no significant difference in 100-seed weight as influenced by irrigation interval in both trials. Phosphorus application too did not significantly affect 100-seed weight. The interaction effect of variety, irrigation interval and phosphorus levels were not significant.

Table 4.11 **Grain yield (kg/ha) and 100-seed weight (gm) of chickpea as influenced by variety, irrigati interval and phosphorus level during the 1995/ and 1996/97 dry seasons and the combined yield at Kadawa.**

Treatment	Grain yield (kg/ha) 1995/96	1996/97	combined	100-seed weight (g 1995/96	1996/97
Variety (V)					
ICCV1	200b	417c•	308c	14.00b	11.59b
K850	349a	629a	489a	20.78a	22.12a
C235	291ab	487b	309b	10.43c	12.90b
SE ±	42	8	26	0.91	0.80
Significance	**	**	*	*	**
Irrigation interval,days (I)					
5	238	447c	343c	15.20	15.64
10	321	592a	447a	16.29	15.60
15	302	505b	413ab	15.00	16.56
20	259	500b	479bc	13.78	14.34
SE ±	49	10	28	1.06	0.93
Significance	NS[1]	**	*	NS	NS
Phosphorus, KgP/ha (P)					
0	277	523a	388	14.75	14.95
11	292	525a	400	15.73	15.66
22	271	485b	398	14.73	16.01
SE ±	22	10	20	0.78	0.49
Significance	NS	**	NS	NS	NS
Interaction					
V x I	NS	**	**	NS	NS
V x P	NS	**	*	NS	NS
I x P	NS	NS	NS	NS	NS
V x I x P	NS	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0. using DMRT
NS = Not significant
*and ** = significant at P ≥ 0.05 and 0.01 percent probabili level respectively.

Table 4.12 Interaction between variety with irrigation and phosphorus levels for chickpea grain yield during, 1996/97 dry season and as contained in the combined analysis at Kadawa.

Treatment	Irrigation Interval (days)				Phosphorus (KgP/ha)		
	5	10	15	20	0	11	22
Variety (V)		1996/97				1996/97	
ICCV1	349f	589b	314f	414d	399e	462d	388e
K850	586b	615b	738a	578b	604b	613b	672a
C235	406e	570b	462cd	509c	380e	566bc	515cd
SE ± 17					SE ± 18		
Combined analysis							
Variety							
ICCV1	276d	426bcd	299cd	301cd	290e	479ab	326de
K850	414bcd	500ab	604a	440bc	346cde	491ab	431abc
C235	338cd	414bcd	406cd	398bc	289e	498a	407a-d
SE ± 52					SE ± 35		

Means followed by unlike letters within a treatment group are significantly different at P = 0.05 using DMRT.

4.2.7 Grain Protein Content

The data on grain protein content as affected by treatments is presented in Table 4.13. The difference in percent grain prote content among the chickpea varieties was only significant in 1996/97 trial. Variety ICCV1 recorded significantly higher gra protein content than K850 and C235. However, the differenc between K850 and C235 as well as between ICCV1 and C235 were n significant.

Grain protein content was not significantly affected by irrigation interval. Also, phosphorus application had no significant influence on grain protein content of chickpea. No significant interaction effect was recorded on the grain prote content.

4.2.8 Simple correlation coefficent analysis

The simple correlation coefficents involving pairs of important growth and yield parameters during for both trials a presented in Tables 4.14 and 4.15, respectively. These paramete include grain yield per hectare, number of seeds per pod, 100-se weight, shelling percentage, pod diameter, pod yield, grain prote content, plant height, number of branches per plant, number of leaves per plant, number of nodes per main branch and crop d weight.

In 1995/96 trial, the correlation studies showed a very stro and positive correlation (P=0.01) between grain yield and p diameter, pod yield, plant height; number of branches number of leaves and crop dry weight. There were no significant correlati

between grain yield and number of seeds per pod, 100-seed weigh shelling percentage, grain protein content and number of node Also, a positive and significant correlation (P=0.01) was observ between pod yield and plant height, number of branches, number of leaves and crop dry weight.

The simple correlation coefficient analysis in 1996/97 tri revealed that 100-seed weight, shelling percentage, pod diamet and crop dry weight were significantly and positively correlated to grain yield (p=0.01). No significant correlation was observ between grain yield and number of seeds per pod, pod yield, gra protein content, plant height, number of branches, number of leav and number of nodes of chikpea. In the same trial, positive a significant correlation (P=0.01) was recorded between number of seeds per pod and shelling percentage, number of leaves and numb of nodes per main branch. However 100-seed weight was negative and significantly correlated to number of seed per pod (p=0.01) in both trials.

Table 4.13 Grain protein content (%) of chickpea as influenced by variety, irrigation interval and phosphorus level during 1995/96 and 1996/97 dry season at Kadawa.

Treatment	1995/96	1996/97
Variety (V)		
ICCV1	18.69	18.27a
K850	16.93	16.38b
C235	17.02	16.85ab
SE ±	0.43	0.58
Significance	NS	*
Irrigation interval, days (I)		
5	16.03	15.94
10	16.85	16.22
15	17.47	16.88
20	17.18	16.96
SE ±	0.52	0.67
Significance	NS[1]	NS
Phosphorus, KgP/ha (P)		
0	17.05	16.23
11	16.57	16.64
22	17.08	16.63
SE ±	0.34	0.61
Significance	NS	NS
Interaction		
V x I	NS	NS
V x P	NS	NS
I x P	NS	NS
I x V x P	NS	NS

Means followed by unlike letter(s) within a treatment group for a particular character are statistically significant at P = 0.05 using DMRT
NS = Not significant
* and ** = significant at P ≥ 0.05 and 0.01 percent probability level respectively.

Table 4.14: Matrix of correlation coefficients between grain yield and some growth and yield parameters as affected by variety, irrigation interval, and phosphorus level during 1995/96 dry season at Kadawa

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.142NS	1.000										
3	0.141NS	-0.344**	1.000									
4	0.066NS	-0.090NS	-0.011NS	1.000								
5	0.332**	-0.044NS	-0.571NS	-0.036NS	1.000							
6	0.983**	0.174NS	0.117NS	0.040NS	0.305**	1.000						
7	0.053NS	0.049NS	-0.055NS	-0.140NS	-0.079NS	0.064NS	1.000					
8	0.308**	0.155NS	-0.086NS	0.113NS	0.079NS	0.289**	-0.182NS	1.000				
9	0.365**	0.015NS	0.001NS	0.078NS	-0.143NS	0.371**	-0.134NS	0.257**	1.000			
10	0.308**	-0.040NS	-0.020NS	0.112NS	0.152NS	0.2317**	-0.002NS	0.163NS	-0.126NS	1.000		
11	-0.019NS	-0.074NS	-0.162NS	-0.038NS	-0.105NS	0.006NS	0.101NS	0.055NS	-0.254**	0.156NS	1.000	
12	0.538**	0.101NS	0.0179NS	0.108NS	0.314**	0.532**	-0.140NS	0.370**	0.312**	0.154NS	-0.041NS	1.000

1. Grain yield (kg/ha) 2. Number of seeds/pod 3. 100-seed weight(g) 4. Shelling percentage 5. Pod diameter(cm)

6. Pod yield (kg/ha) 7. Grain protein content(%) 8. Plant height at 10 WAS. 9. Number of branches/plant at 10 WAS

10. Number of leaves/plant at 10 WAS 11. Number of nodes/main branch at 10 WAS 12. Crop dry weight (g/plant) at 10 WAS

NS = Non significant difference, * = Significant at P = 0.05, ** = Significant at P = 0.01.

Table 4.15: Matrix of correlation coefficients between grain yield and some growth and yield parameters as affected by variety, irrigation interval, and phosphorus level during 1996/97 dry season at Kadawa

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	-0.135NS	1.000										
3	0.042**	-0.310**	1.000									
4	0.485**	0.305**	0.285**	1.000								
5	0.392**	-0.163NS	0.184NS	0.305**	1.000							
6	-0.075NS	0.059NS	0.156NS	-0.423**	0.126NS	1.000						
7	-0.120NS	0.030NS	-0.004NS	0.062NS	0.033NS	-0.180NS	1.000					
8	0.079NS	0.143NS	0.192*	0.106NS	0.150NS	-0.022NS	-0.024NS	1.000				
9	-0.030NS	0.136NS	-0.316**	-0.038NS	-0.333**	-0.002NS	-0.116NS	0.141NS	1.000			
10	-0.031NS	0.234*	-0.201*	-0.059NS	-0.271**	-0.020NS	-0.175NS	0.072NS	0.547**	1.000		
11	-0.076NS	0.320**	-0.070NS	0.052NS	-0.150NS	-0.146NS	0.074NS	0.608**	0.179NS	0.239*	1.000	
12	0.247**	-0.073NS	0.380**	0.247**	0.452**	-0.001NS	-0.013NS	0.257**	-0.186*	-0.181NS	0.084NS	1.000

1. Grain yield (kg/ha) 2. Number of seeds/pod 3. 100-seed weight(g) 4. Shelling percentage 5. Pod diameter(cm)

6. Pod yield (kg/ha) 7. Grain protein content(%) 8. Plant height at 10 WAS. 9. Number of branches/plant at 10 WAS

10. Number of leaves/plant at 10 WAS 11. Number of nodes/main branch at 10 WAS 12. Crop dry weight (g/plant) at 10 WAS

NS = Non significant difference, * = Significant at P = 0.05, ** = Significant at P = 0.01.

CHAPTER FIVE

DISCUSSION

5.1 Growth and Development of Chickpea.

In this study, it was observed that the yield obtained from 1995/96 trial was lower than that obtained in 1996/97 season (Table 4.11). The low yield in 1995/96 was probably due to the Fusarium wilt (F.Oxysporium) and pod borer (Heliocoverpa armigera) which led to loss of some plant stands and poor grain formation respectively. In India, Nene and Raddy (1987); Reed et al (1987) each recorded 10 percent loss in yield due to fusarium wilt and pod damage respectively in most chickpea growing areas. In the same season 1995/96, weed growth and competion must have partly contributed to the low yield.

5.1.1 Varietal influence

The ability of any seed to germinate and establish is dependent upon its viability and certain environmental conditions like temperature and moisture. This study revealed that under similar conditions, the three varieties did not differ significantly with regards to crop establishment in 1995/96 trial. This confirmed an earlier germination test which indicated that all three varieties had about 90 percent viability. The result also tallied with the findings of Ozdemir (1996) who reported no significant differences among chickpea cultivars in seed germination and crop establishment. However, significant difference in stand count among the varieties was observed in 1996/97 trial with K850 being superior to ICCV1 and C235 in stand establishment because of its high adoptation to the environment. This could be

related to seasonal temperature fluctuation during the growth period of chickpea. In 1996/97 season, the night temperatures ranged from 10-21°c while the day temperatures ranged from 32 - 43°c during the experimental period which contrasted with the previous season as shown in Appendix II.

Plant height of the three varieties significantly differed in the two season trial. The varietal difference in plant height indicated that K850 was taller than ICCV1 and C235 possibly due to genetic variability or that K850 proved to be more adaptable to the growing condition than other two varieties. The three varieties produced identical vegetative characteristics in terms of similar numbers of branches and leaves plant although ICCV1 produced an average of 6.44 branches per plant and 229.47 leaves per plant in 1996/97 trial and thus exhibited a large crop canopy cover than K850 and C235. However, the differences in number of nodes per main branch were significant in both trials. On the average, K850 and ICCV1 recorded larger nodes per main branch than C235 in 1995/96 and 1996/97 trials respectively, although they produced statistically similar number of nodes per main branch in the second trial. Saxena and Sheldrake (1980) and Ortega et al (1996) reported similar findings.

There were significant differences among the varieties in the accumulation of dry matter despite similar crop canopies produced. The variety which recorded the least numbers of branches and leaves (K850) gave higher dry weight than other two varieties in both trials because it was taller and recorded the largest number of nodes. This tallied with the findings of Raghue and Choubey (1983).

It is worth mentioning that plant height, numbers of leaves and nodes per main branch as well as crop dry weight increased with advancing in age in both trials during the vegetative growth of the crop.

5.1.2 Response to Irrigation

Moisture is one of the most important requirements of irrigated crops. Growth and development of these crops, chickpea inclusive, depended on application of water especially in the tropics characterised by dry weather. However, irrigation treatment, as noted in this study, did not significantly affect some of the growth characters of the crop.

Stand count which was taken at different periods of vegetative growth was found to be significantly increased with increasing irrigation interval up to 15-day at 10 WAS in 1995/96 trial. The rate of increase in stand count (between 5 to 15-days) was constant after which it slowed down. This indicated that moderate irrigation intervals, provides a more favourable soil moisture regime for vegetative growth, hence the high stand count. This findings conformed with that of Saxena, et al (1983) who reported that germination and seedling growth decreased with declining soil moisture. Karan and Afria (1985) also reported that water uptake, seedling growth and vigour declined with increasing soil moisture stress.

Irrigation treatment had no significant influence on the height of chickpea varieties. This could be attributed to the fact that plant height is genetically controlled and environment has little influence on the height of the crop.

The numbers of branches per plant and leaves per plant are important growth parameters that affect the yield potentiality of chickpea. Differences in the number of branches, and number of leaves at 10 WAS in 1995/96 and 1996/97 trials respectively as a result of varying irrigation intervals could be attributed to the profound effect of moisture regime on the vegetative growth of the crop. At closer intervals, plants had enough moisture, thus produced more leaves and branches. Similar findings were reported by Gurmit and Rai, (1980) and Surrinder and Sharma (1980). Irrigation as noted earlier, increased stand count which had direct effect on on the number of branches per plant. Subsequently the number of branches significantly increased the number of leaves per plant. However, the reduction in number of leaves per plant at 20-day interval could be attributed to the fact that as the crops started to flower, the little soil moisture absorbed was utilized towards flower formation and grain development at the expense of vegetative growth. Also, as the varieties approached physiological maturity, the leaves started to dry until they finally senescenced and dropped. Khanna-chopra and Sinha (1987) reported a similar observation.

Number of nodes per main brach at 10 WAS in 1995/96 decreased as the irrigation interval was increased from 5 to 20-day possibly due to different soil moisture regimes. At wider intervals, plants were stressed due to low moisture profile and thus produced few nodes per main branch. Similar results were obtained by Singh and Rai (1982). However the genetic make-up of the varieties, their drought tolerant nature and growth duration probably explained the

non- significant response of irrigation treatment on crop dry weight. This results disagreed with the findings of Yusuf et al (1980) and Singh et al (1980) who reported significant response of irrigation on this parameter.

5.1.3 Effect of Phosphorus

Phosphorus is an important element required by leguminous crops, chickpea inclusive. Saraf (1983) observed that phosphorus deficiency in chickpea appeared to negatively affect growth and development with resultant poor yield. All the growth parameters except number of leaves per plant and crop dry weight were not significantly influenced by phosphorus application throughout the two year trial. This might be explained by the relatively high available phosphorus in the soil of the experimental field (Appendix I) and the crop's ability to absorb and utilise phosphorus in the soil (Prabakhar et al. 1987; ICRISAT 1991). The significant difference observed in number of leaves with increase in phosphorus from 0 to 11 kgP/ha in 1996/97 trial was as a result of the positive effect of phosphorus on root development. Similar observation was made on crop dry weight. Beyond 11 KgP/ha, the effect of phosphorus on these parameters was reduced indicating that 11 kgP/ha might be optimum for chickpea growth and development. This observation is in conformity with the findings of Kalyan et al (1983) who recommended low rate of phosphorus fertilization in chickpea.

5.1.4 Variety x Irrigation interval interaction

Variety and irrigation interval interaction on number of branches per plant was significant at 8 WAS in 1995/96 trial. The

higher number of branches/plant produced by variety C235 at slightly wider irrigation interval (15-day) may be due to its higher tolerance to water stress where there was intense competition for moisture among other growth factors. However, the other two varieties showed higher water use effeciencies than C235 irrespective of irrigation interval.

The significant interaction between variety and irrigation interval on number of leaves in 1995/96 trial indicated that significant varietal differences in moisture utilization existed among the three varieties under study. The interaction showed that C235 was more responsive to irrigation by producing significantly higher number of leaves at 15-day irrigation than other two varieties. Likewise the non-significant difference in leaf number between the three varieties under other intervals indicated that 15-day interval might be the optimum irrigation interval. This result is in line with the findings of Ortega et al. (1996) who reported a significant and positive interaction between variety and irrigation on number of branches and number of leaves of chickpea.

5.1.5 Variety and phosphorus interaction

Variety and phosphorus interaction was significant on number of branches at 10 WAS in 1996/97 trial. The increase in number of branches due to phosphorus application up to 11 KgP/ha indicated the favourable effect of phosphorus fertilization on such growth factors as number of branches per plant. Chickpea being a legume, requires very low levels of phosphorus for proper root development and the decrease in number of branches beyond 11 KgP/ha showed that 11 KgP/ha might be optimum. Mohapatra et al (1995) also reported a

significant response to low levels of phosphorus and attributed it to phosphate build-up in light soils. similar.

Again, variety and phosphorous interaction on number of leaves/plant was significant. The variety ICCV1 gave higher number of leaves than other two varieties at all phosphorous levels probably because it is more responsive to inputs. This observation seems to confirm the earlier description of variety ICCV1 as being input-responsive (ICRISAT, 1984), thus it responded more to phosphorus than K850 and C235. The reduction in number of leaves observed beyond 11 KgP/ha indicated that 11 KgP/ha might be the optimum rate.

5.2 Yield and Yield Components of Chickpea.

5.2.1 Varietal influence

The varieties under study differed significantly with respect to most of the yield attributes studied. Pod diameter, number of seeds per pod, shelling percentage, pod and grain yields, 100-seed weight and grain protein content were all significantly influenced by variety. This indicated that the three varieties responded differently to irrigation and phosphorus treatments in terms of yield attributes.

The varietal difference in relation to number of seed per pod was significant only in 1995/96 trial, when C235 produced more seeds pod than other varieties which had statistically similar number of seeds. This was possibly compensating for the lowest pod diameter and 100-seed weight recorded for C235.

In both trials, K850 recorded significantly larger and heavier seeds with higher shelling percentage (1996/97) than ICCV1 and C235

indicating K850 to either have genetic superiority or responded more favourably to irrigation and phosphorus treatments than the other two varieties. The same K850 produced significantly higher pod and grain yields in the two-year trial as a result of its higher 100-seed weight and shelling percentage than ICCV1 and C235 suggesting K850 to again be genetically superior over other two varieties.

Varietal variation observed on grain protein content (1996/97) indicated that ICCV1 recorded higher protein content than K850 and C235 though statistically similar to that obtained by the latter. This might be due to varietal differences in nitrogen partitioning during fruit development. Khanna-chopra and Singh (1987) observed similar varietal differences in grain protein content.

Based on this study, K850 had consistenly out-performed the other varieties in most of the yield attributes, thus ascertaining its superiority over them. A similar observation was made by Singh and Singh (1988), Yadav et al (1985) and Saxena (1990) who reported greater yield associated with greater yield contributing attributes in some varieties than others.

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5.2.2 Response to Irrigation

Irrigation has been noted to have significant influence on pod and grain yields and shelling percentage only of the three varieties under study. Throughout the two-year trials, irrigation did not significantly affect pod diameter, 100-seed weight, grain protein content and number of seeds per pod suggesting that these characters might be unaffected by environmental factors such as soil moisture regime.

The pod yield and consequently shelling percentage were significantly affected by irrigation, indicating 10-day interval recorded higher values for these parameters than other irrigation intervals. A similar result was obtained on grain yield which showed that 10-day irrigation interval outyielded other intervals. This indicated the effect of moisture regime on the general growth, development and yield of chickpea though the differences were not always significant. The non significant effect of irrigation on chickpea yield and its component obtained in this study might not be unconnected with relatively high water table status reported in many sites of the irrigation project although an area less proned to this problem was chosen for the trial. Khanna-Chopra and Sinha (1987) attributed the differences in yield and its components to moisture supply. Several workers have reported contrasting response of chickpea to irrigation suggesting that most of the important growth and yield attributes of chickpea may or may not be significantly affected by irrigation. This could also probably be due to its tap-rooted nature and drought resistance (ICRISAT, 1983 and Saxena, 1987). While Roy et al (1988) reported no significant response of chickpea due to irrigation, ICRISAT (1981) observed upto 75 percent significant increase in yield of chickpea.

5.2.3 Effect of phosphorus

The overall effect of phosphorus application on yield contributing characters was not significant. Pod diameter, number of seeds per pod; and 100-seed weight, were all not significantly influenced by different phosphorus level throughout the two year study. As earlier noted this might be explained on the basis of the

crop's ability to absorb and utilise phosphorus in the soil (Prabakhar et al 1987). The relatively high available phosphorus (28.67 - 32.38mg/kg) in the soil of the experimental field (Appendix I) could have also contributed to the non-significant response. This result contradicts the findings of Kar et al (1989) who reported that 100-seed seed weight, among other yield characters was significantly influenced by phosphorus application.

However, application of phosphorus resulted in more pod and grain yields though the differences were not significant in 1995/96 trial. The significant effect is expected as phosphorus is important in the photosynthetic system of the crop. It is needed in photophosphorylation of various intermediates in carbon dioxide assimilation process and also in the formation of pyrophosphate bonds which allow energy transfer in plants. As a result, supply of phosphorus will result in good crop growth and consequently high yield. However the low chickpea response to phosphorus in both trials was probably due to the slightly acidic nature and the high phosphate status of the soil of the experimental field (Appendix 1). These results were similar to the findings of Kalyan et al (1998) and Bhuiya et al (1979). Kamprath (1991) also reported that the relatively high yield of chickpea with low phosphorus fertilization might be partially explained by more rapid soil phosphorus uptake characteristics of the crop. Significant difference in shelling percentage with increased phosphorus level could be due to availability of adequate nutrient for proper pod formation and grain-filling, therefore lower shelling percentage

for plots with little or no phosphorus where competition for nutrients was intense.

Throughout the two year trial, grain protein content was not significantly influenced by phosphorus application. This might be because nitrogen which is a primary raw material for protein synthesis has low rate of accumulation and its partitioning declined after fruiting in the crop (Khanna-chopra and Sinha; 1987). This result contradicts the findings of Bhuiya et al (1979) who reported that phosphorus application at rates higher than 8.8kgP/ha increased grain protein content.

5.2.4 Variety x irrigation interval interaction

The interaction between variety and irrigation interval on grain yield (1996/97) showed that K850 outyield other two varieties at all irrigation intervals indicating the superiority of K850 over ICCV1 and C235 with respect to water use efficiency. It was also observed that irrespective of variety, 10-day irrigation out-performed other treatments under consideration, although combination of K850 and 15-day irrigation produced the highest grain yield. The interaction indicated that 10-day irrigation interval is optimum for chickpea grain yield production. This might be attributed to the favourable effect of optimum moisture supply for proper crop development and yield. Singh and Singh (1988) observed K850 to be superior to other varieties in terms of yield while Anonymous (1988) reported that 14-day irrigation interval was optimum for chickpea production.

5.2.5 Variety x phosphorus interaction

The significant variety and phosphorous interaction on grain yield (1996/97) again indicated K850 to have an edge over ICCV1 and C235 at all phosphorus levels. It also responded linearly to increasing levels of phosphorus, and thus recorded the highest grain yield under 22 kgP/ha. However 11 kgP/ha appeared to be optimum irrespective of the variety. The responsiveness of K850 to phosphorus could be attributed to adequate nutrients or genetic superiority coupled with its high water-use efficiency. This implied that phosphorus fertilization is necessary for increased grain yield. This result was similar to the findings of Thakar et al (1989) and Janet and Mali (1992).

5.2.6 Correlation studies.

The significant and positive correlation between chickpea grain yield and growth characters such as plant height, number of branches, number of leaves and crop dry weight revealed that these vegetative characters were important determinants of photosynthetic capacity which enhanced plant growth and ultimately grain yield. It is probably due to the fact that as plant height increases more branches and leaves are differentated and the more pod production. Similar observation was reported by Singh et al (1983). However the correlations between grain yield with pod yield and diameter, shelling percentage and 100-seed weight were negative and significant while the yield was not significantly associated with number of seeds per pod and grain protein content in both trials.

This is in line with what Muehlbauer and Singh (1987) reported that correlations between grain yield and other characters were not always consistent.

Throughout the two- year trial, 100-seed weight and number of seed per pod were negatively but significantly correlated. This is true as number and size are inversely related. The negative effect exerted by 100-seed weight on number of seeds per pod might have explained why grain yield was not significantly correlated with number of seeds per pod in both years. This tallies with the finding of Singh (1982) who reported that number of seeds per pod and 100-seed weight were often positively correlated with grain yield although the correlations were not always significant.

CHAPTER SIX

SUMMARY AND CONCLUSION

The investigation was carried out at the Kadawa Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University (11° 39'N;8° 02"E and 500m above sea level) located in the Sudan savanna ecological zone of northern Nigeria during the 1995/96 and 1996/97 dry seasons. The aim was to study the effect of irrigation interval and phosphorus level on growth and yield of three chickpeea (Cicer arietinum L.) varieties.

The treatments consisted of combinations of three varieties (ICCV1, K850 and C235), four irrgitation intervals (5,10,15 and 20-day) and three phosphorus levels (0,11 and 22 kgP/ha). The experimeent was laid out in a split-plot design with three replications. Combinations of variety and irrigation interval were assigned to the main plot while phosphorus level occupied the subplot.

It was observed that the three varieties differed significantly in most of the growth parameters assessed and K850 proved superior over other two varieties although the differences were not always significant in both trials. Irrigation treatment also significantly influenced all growth parameters except plant height and crop dry weight, while phosphorus application significantly affected number of leaves per plant and crop dry weight only at 8 WAS in 1996-97 trial.

The results also revealed that K850 again significantly outperformed ICCV1 and C235 in all the yield characters studied (mostly in both trials) except number of seeds per pod in 1995/97 trial. Different irrigation intervals resulted in varying *significant effects on shelling percentage, pod and grain yields* in 1996/97 while pod diameter, number of seeds per pod, 100-seed weight and grain protein content were not significaant in both trials. In 1996/97 trial, phosphorus application signicantly influenced shelling percertage, pod and grain yields, while other characters were not significantly affected by phosphorus treatment in the two-year trial.

Significant and positive correlation (P=0.01) was observed between chickpea grain yield and plant height, number of branches per plant, number of leaves per plant and pod yield in 1995-96 trial while shelling percentage and 100-seed weight were also significantly and positively correlated with grain yield in 1996-97 trial. The correlation of grain yield with crop dry weight and pod diameter was positive and significant in both trials. However, there was no significant correlation between grain yield and grain protein content in the two-year trial.

Based on this investigation, the following conclusions were reached:-

1. Chickpea variety K850 was superior to ICCV1 and C235 because *it responded more to irrigation* (with high water use efficiency) and phosphorus application and therefore yielded higher than other two varieties.

2. Irrigation at 10-day interval appeared suitable for chickpea production.
3. Phosphorus fertilization at the rate of 11 kgP/ha was found to be optimum for the crop's growth and yield.

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Appendix I Physical and chemical properties of the soil (upto 30cm depth) of the experimental plot at Kadawa.

Soil characterstic	1995/96	1996/97
pH in water (1:25)	7.6	6.8
pH in 0.1m $Cacl_2$ (1:2.5)	6.2	5.6
Organic carbon (g/kg)	1.04	0.56
Total nitrogen (g/kg)	0.084	0.028
Available phosphorus (mg/kg)	28.67	32.38
Exchangeable bases (Cmol/kg)		
Ca	3.11	2.30
Mg	0.64	0.68
K	0.27	0.24
Na	0.11	0.19
Al	0.10	0.10
CEC	7.0	5.80
Particle size distribution(%)		
Sand	64	66
Silt	22	24
Clay	14	10
Textural class	Sandy loam	Sandy loam

Soil Samples as analysed by Soil Science Department, A.B.U Zaria

Appendix II: Mean maximum and minimum Temperatures (°C) Relative Humidity (%) and Pan Evaporation (mm/day) at 10-day interval during 1995/96 and 1996/97 dry seasons at Kadawa

Month	Temperature (°C)				Relative Humidity (%)		Pan-Evaporation (mm/day)		DAS	
	Max.		Min.							
December	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97	1995/96	1996/97
1st - 10th	34	32	11	12	65	59	6	5	-	-
11th - 20th	33	33	14	11	57	73	6	5	9	-
21st - 31st	30	33	12	11	61	59	6	6	19	-
January										
1st - 10th	31	33	12	11	51	56	7	14	29	-
11th - 20th	31	34	11	11	58	61	6	13	30	-
21st - 31st	32	33	13	11	61	46	6	6	41	11
February										
1st - 10th	34	32	13	10	67	39	7	8	51	21
11th - 20th	33	33	12	11	63	30	6	15	61	31
21st - 28st	33	34	13	12	65	28	6	8	70	39
March										
1st - 10th	36	34	17	12	57	35	7	8	80	49
11th - 20th	37	41	21	12	61	35	6	16	90	59
21st - 31st	35	43	18	21	42	41	8	9	101	70
April										
1st - 10th	37	n.a	18	n.a	64	n.a	7	n.a	*	80
11th - 20th	38	"	21	"	59	"	7	"	-	90
21st - 30th	39	"	21	"	48	"	10	"	-	100
May										
1st - 10th	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	-	*
11th - 20th	"	"	"	"	"	"	"	"	-	-
21st - 31st	"	"	"	"	"	"	"	"	-	-

Key: DAS = Days after sowing; n.a = data not available; * = Harvesting carried out on 17th April, 1996 and 7th May 1997 respectively; Source: IAR Meteorological unit.

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