EFFECTS OF LIME, NITROGEN AND PHOSPHORUS ON GROWTH, YIELD AND YIELD COMPONENTS OF COWPEA (*Vigna unguiculata* (L.) Walp).

BY

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A theis submitted to the Postgraduate School, Ahmadu Bello University, Zaria in partial fulfillment of the requirements of the Degreee of Master of Science (M.Sc) in Agronomy.

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OCTOBER, 1999

DECLARATION

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

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CERTIFICATION

This thesis titled: "Effects of lime, nitrogen and phosphorus on growth, yield and yield components of cowpea (Vigna unguiculata (L.) Walp) by Ka'ankuk'a Cornelius Nenkop meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To my wife Regina

and our

Sons

Jurbe and Nathan.

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ABSTRACT

Field experiments were conducted at Samaru during the 1995 and 1996 wet sesons to study the effects of lime, nitrogen and phosphorus on growth, yield and yield components of cowpea (Vigna unguiculata (L.) Walp).

The experiment consisted of 27 treatments, replicated three times and laid out in a split-plot design.

The effect of lime on growth parameters was significant during growth. At 12 WAS, number of primary branches per plant, leaf area index, number of leaves per plant, leaf dry weight, stem dry weight and plant height responded to lime significantly upto the highest rate of l000kg/ha.

Plant height, stem dry weight, root dry weight, leaf dry weight, number of leaves per plant, number of primary branches per plant, leaf area index and total dry matter per plant at harvest were all significantly increased with the application of nitrogen and phosphorus. Leaf area index, number of primary branches per plant, leaf dry weight per plant at 12 WAS and total dry matter per plant at harvest did not respond to nitrogen above the N-rate of 20kg/ha and the phosphorus of 15kg/ha.

Lime and nitrogen did not significantly increase grain yield , but the interaction between nitrogen and phosphorus significantly increased grain yield. Grain yield, number of pods per plant and days to 50% flowering were significantly increased by phosphorus application to cowpea upto the highest P-rate of 30kg/ha while P-rate of 15kg/ha was enough for the number of seeds per pod.

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CHAPTER ONE

1.0 INTRODUCTION

Cowpea (Vigna unguiculata (L.) Walp) is an important food crop which contains 17 to 40 percent protein (Bressani and Elías, 1980). In some parts of the semi-humid tropics, cowpea provides more than half of the protein of the diets (Rachie, 1985). The advantages of cowpea over other plant protein sources are associated with the ease of preparation and diversity of dishes made from it, either as pulse or green (Chiezey et al; 1990).

1.2 Origin of cowpea

The cowpea also known as southern pea, black eye pea, beans, lubia, niebe, coupe or frijole is one of the most ancient food crops of man and because of lack of Archaeological evidence the centre of origin is disputable and uncertain. Some early workers on crop evolution suggested that cowpea originated from the Indian subcontinent. Vavilov (1950) suggested that cowpea originated from India with Ethiopia and China as secondary centres of origin. However, field and botanical evidences and presence of progenitors proved cowpea to be of African origin (Faris, 1965).

Faris (1965) and Steele et al; (1972) concluded that the wild Vigna unguiculata probably subspecies of dekindtiana of the African Savannah zone was the progenitor since no other Vigna species produce fertile progeny when crossed with other cultivars. This belief was strengthened by the studies of Rawal (1975), who demonstrated that introgression between wild and cultivated cowpea took place in West Africa where many forms of wild, weedy and

cultivated cowpea are grown. This was earlier observed by Rachie and Robert (1974), who noted that cowpea originated in West Africa, very likely in Nigeria where a profusion of wild and weedy species abound in both savannah and forest zones.

1.3 Distribution

There is more uncertainty in the distribution of cowpea. It is believed to have reached South West Asia at about 2,300 BC and was grown early enough in Europe where the Romans and Greeks called it by the names Phaseolas, phaseolos, Phaselus (Burkill, 1953, Purseglove, 1976). Cowpea probably reached India earlier than two thousand years ago from East Africa through the Sabarrean Ach, along with other food crops (Steele, 1970) and reached the new world and West Indies in the late 17th century through the Spaniards along with slaves from West Africa. Cowpea reached Southern United States of America in the early 19th century (Wight, 1907). The crop is grown extensively throughout the low land tropics of Africa in a broad belt along the Southern fringe of the Sahara and in Eastern Africa from Ethiopia to South Africa. Production is confined to the hot semi-arid to subhumid areas with significant production in Nigeria, Niger, Burkina Faso, Uganda and Senegal (Rachie and Roberts, 1974).

1.4 Cowpea Morphology

Cowpea is an annual herbaceous legume which belongs to the family of Papilionaceae and the genus Vigna (Cobley, 1956 and Martin and Leonard, 1956). Cowpea may be prostrate, semi-viny or bunched depending on the variety. The stems are generally weak and

green throughout growth. Most Nigerian cowpeas are prostrate, indeterminate and produce flowers and fruits only when day length drops below 12 hours (Njoku, 1958). The leaves are normally trifoliate and borne on a long petiole, (Cobley, 1956). The leaves are glabrous and become brittle with age and terminal leaflet is bigger, larger and more symetrical than lateral leaflets. The flowers vary in colour from white to purple. All the flowers produced by a plant are of the same colour and are crowded together at the end of floral peduncles. Flowers are normally self fertilized but natural crossing may occur in the field (Martin and Leonard, 1965).

Cowpea produces a well developed rooting system in which the primary root reaches a depth of 30-45cm in the soil and the smaller secondary roots ramify the immediate surroundings (Cobley, 1956). Cowpea roots produce nodules in which symbiotic nitrogen fixing bacteria are housed.

1.5 Ecological Requirements

Cowpea is a short day, warm-weather crop. It can tolerate hot and dry conditions and can be grown with little rainfall of about 430-890mm annually and is sensitive to cold and susceptible to frost. Most cultivars do not tolerate waterlogging. Severe drought however generally prevents formation of seeds in cultivars (John et al; (1975). Cowpeas are adapted to a wide range of soil and can be grown on light sands to heavy clays but prefers a fairly well drained soil (Smart, 1977). Soils with a pH range of 5.3 to 6.0 are desirable for optimum yields (Martin and Leonard, 1956).

A temperature range of 20-35$_0$C is desirable for cowpea in semi-arid regions (Daisy, 1979).

1.6 Production of Cowpea

Worldwide cowpea production in 1981 was estimated at 2.27 million tonnes from 7.7 million hectares (Rachie, 1985), grown extensively in 16 countries of Africa which produced two-thirds of the world total. Nigeria and Niger produced 850,000 tonnes and 271,000 tones respectively annually or 49.3% of the world crop. The second highest producing country is Brazil where 600,000 tones of dry seeds or 26.4% of the world was produced in 1981. Other major producers in Africa include Burkina Faso (95,000t), Ghana (57,000t), Kenya (48,000t), Uganda (42,000t), Malawi (42,000t), Tanzania Senegal and Togo each produced annually 20,000 tonnes respectively (Rachie, 1985).

1.7 Production in Nigeria

Although Nigeria is the leading producer of cowpea in the world, the average grain yield of about 189kg/ha is low as compared with those from other countries (Anon, 1975). In Nigeria research has shown that fertilizer use accompanied by adequate crop protection measures could result in tremendous yield of cowpea (Anon; 1982). Grain yield of 2,768kg/ha were obtained at Yandev in Benue State and 2,879kg/ha at Tumu in Bauchi State. Grain yield from farmers fields are much lower because they lack adequate inputs such as crop protection chemicals and fertilizer.

Hartmans (1983) reported that average grain yield in Nigeria was 250kg/ha as compared to 3,457kg/ha, 3,106kg/ha, 3,103kg/ha and

651kg/ha in Madagascar, Egypt, Trinidad and Malawi respectively. However, recent estimated grain yield of cowpea from farmers fields in Nigeria has been on the increase. Grain yield of 320kg/ha, 420kg/ha, 460kg/ha, 480kg/ha and 450kg/ha have been estimated for the years 1993 to 1997 respectively (Anon. 1998).

1.8 Economic Importance of Cowpea

1.8.1 Food

Cowpea as a food is eaten in the form of dry seeds, green pods are collected and eaten or are frozen and canned in some countries like the United States (Purseglove, 1968). Young leaves and shoots serve as spinach and pot-herbs for humans or as green fodder, hay, silage or pasture for livestock. The dry seeds are of major importance commercially or in subsistence farming.

1.8.2 Other uses

On account of its ability to fix nitrogen efficiently up to 240kg/ha, cowpea provides a high proportion of its own nitrogen requirement, besides leaving a fixed deposit in the soil of upto 60-70kgN/ha for the succeeding crop (Rachie, 1985). As a result of this, cowpea is grown in rotation or mixed with many cereal and tuber food crops. Cowpea can be used as a green manure or as cover crop in checking crosion.

1.9 Problems Associated with Cowpea Production

Cowpea yields are low especially in West Africa where the bulk of the crop is produced due to low population density. This is because cowpea is mostly grown in mixtures with other crops (Yayock & Asenime 1977). Other factors contributing to low yield are

problems of low soil pH, high Aluminium concentration, low soil fertility, excessively high temperature and drought (Rachie, 1985). Cowpeas are also very susceptible to insects attack. This is because cowpea provide food for a large number of insects and all parts of the plant are susceptible to attack (Onwueme et al; 1991).

1.10 Objectives of the Study

Savannah soils are reported to be generally low in total nitrogen(Jones et al; 1975). Amount of available N varies from 0.008 to 0.29 percent with an average of 0.051 percent (Jones 1973). Phosphate deficiency occurs widely in the savannah and in some soils, deficiency is so acute that seedling growth virtually stops as soon as the seed reserve of phosphate have been exhausted (Jones et al; 1975). Planting of shallow rooted crops have been observed to make savannah soils more acidic under continuous cultivation whether acidifying fertilizers are used or not. (Fauck et al; 1969, Charreau and Fauck, 1970). Cowpea yield has been reported to increase considerably when the soil is limed to between pH 5.5 and 6.5 (Anon, 1964).

Liming is reported to neutralize Aluminium toxicity increase pH thereby increasing P availability resulting in increased uptake of phosphorus by cowpea (Munns, 1965, Kamprath, 1970, Reeve and Sumner, 1970, Brauner et al; 1976, and Naidu et al; 1991), but only a little work like those of Uzo (1976) and Yayock and Asenime

(1977) have been carried out in the Nigerian Savannah. Therefore, this research was designed to achieve the following objectives:

Determine the effects of lime, nitrogen and phosphorus application and their interaction on growth, yield and yield components of cowpea.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effects of Lime on Cowpea Production

Soil acidity limit root growth and exploitation of water and nutrients (Adams et al; 1967; Bouldin, 1979). To derive satisfactory result in crop production on such acidic soils they need to be limed. Liming is an important practice in soil management. Too frequently, soil fertility is regarded chiefly as a matter of supply of nitrogen, phosphorus and potassium. Insufficient emphasis is placed on calcium, which perform many functions in plant growth and modification of soil conditions (Miller et al; 1959) and liming of acid soils should be seen as fundamental and essential practice. It is frequently referred to as the "backbone" of permanent agriculture in the humid regions.

Agriculturally, lime maybe said to be any compound of calcium or of calcium and magnesium capable of counteracting the harmful effects of an acid soil. In humid regions, the ions of calcium and magnesium are predominating cations in soils and it is natural that an attempt should be made to restore the supply when depleted (Miller et al; 1959). Apart from neutralizing acidity, increasing Mg and Ca ions concentration, liming also play a great role in reducing aluminium toxicity and increasing availability of phosphorus in acid soils (Sanchez, 1976). Lime application on the soil for the purposes of reducing soil acidity for improved cowpea production has been carried out by many agricultural scientists

around the world with varying results. Many soils in the warm humid tropics are acidic, phosphorus deficient and approaches to liming soils in the humid tropics have varied from neutralizing of exchangeable alluminum to pH control (Pearson, 1975).

Liming highly weathered acid soils can increase (Griffin, 1971), reduce (Naidu et al; 1987), or not affect (Martini et al; 1974) the amount of P that can be extracted from acid soils. Ezedinma (1961) observed that liming appeared unnecessary and may be harmful to cowpea when the soil pH is about 6.5. However,the positive response of cowpea grown on humid soils that have been limed may indicate that most soils in the tropics have pH lower than 6.5.

It has also been observed that phosphorus availability in limed soils is as a result of reduction of alluminum toxicity (Munns, 1965; Kamprath, 1970; Reeve and Sumner, 1970; and Naidu et al; 1991) and liming reduced P sorption and Al toxicity by reducing the concentration of soluble Al which could otherwise interact with fertilizer P.

2.2 Effects of Levels of Lime on Yield and Yield Components of Cowpea

Kang (1978), in Southern Nigeria using 0 to 5t/ha $CaCO_3$ observed that plants grown without liming were chlorotic and showed Ca-deficiency during early growth. Similarly, Edwawrd et al; (1981), observed a significant yield response to lime application of 0.5t/ha and maximum yields were obtained with the application of 1.6 to 2.5t/ha to cowpea cultivars. They also reported that the first lime application enable excellent nodulation to be achieved

in all cultivars and that visual symptoms of nitrogen deficiency was observed in those grown on unlimed soils. Mahler (1986), also observed that the application of 2.2 to 4.4t/ha of lime resulted in 22 to 23% yield increase of lentil.

2.3 Nitrogen Requirement of Cowpea

Nitrogen is one of the essential mineral element that is utilized for growth by plants. Application of nitrogen to the soil and its subsequent absorption by plants aids in the synthesis of amino acids which in turn aid plant growth. The growth of a plant is associated with the amount of nitrogen taken up (Gasser and Williams, 1963). As a legume, cowpea fixes substantial amount of its nitrogen requirement (Oke, 1966; Agboola and Fayemi, 1972), hence inorganic fertilization is generally not recommended. The ability to fix atmospheric nitrogen by means of rhizobia living in symnbiosis in its nodules improved soil fertilization for the succeeding crops. Nnadi et al; (1981), found no justification for giving starter nitrogen to cowpea and other leguminous crops. However, Remison, et al; (1980), stated that cowpea needs a supply of nitrogen for early stages of growth and root nodules formation. Similarly, Agboola (1977) reported some beneficial effects of starter nitrogen in soils having less than 2.0% organic matter and further showed that nitrogen should be applied not later than two weeks after sowing. He concluded that time of application affects nodulation and nitrogen fixation.

Ezedinma (1965), Aryectecy (1971), Osiname (1978), Srinivas et al; (1988) and Shebayan (1989) observed increased in cowpea growth,

plant height, number of leaves per plant with the application of 20kgN/ha. However, as earlier reported, Nnadi (1981) failed to obtain any significant response to starter nitrogen even in soil with 0.4% organic matter in the northern Nigeria savannah. It is however generally agreed that liberal supply of nitrogen to legume depresses nitrogen fixation (Agboola, 1977). Similarly, Samuel (1980) reported that excessive supply of nitrogen to plants causes unusual tall growth or promotes excessive plant height, heavy foliage and succulent stem and hence susceptible to disease and attractive to insects damage. Applying nitrogen at first flowering tend to reduce nodule dry weight, promote vegetative dry weight due especially to increase in dry matter (Eriksen and Whiteney, 1984). Studies elsewhere showed that cowpea respond to inorganic nitrogen source (Wilkes and Scansbrick, 1974 and Edje et al; 1975). Westerman et al; (1981) justified the need for nitrogen fertilization of cowpea seed production especially in soils where the initial amount of nitrate is less than 50kg/ha. Thus, response indicates that cowpea crop does not fix enough nitrogen for maximum yield.

Information available indicates that about 40kgN/ha is fixed by cowpea compared to 100kgN/ha by soybeans. Edje et al; (1975), stated that cowpea are poor nitrogen fixers, and so for them, nitrogen fertilization is essential. It appears that there is some justification for use of nitrogen fertilizer in cowpea production in the savannah. This is because Agboola (1978), Osiname (1978) and Chiezey et al; (1992), observed positive response of cowpea to

nitrogen on acid and highly leached soils low in organic matter.

2.4 Effects of Levels of Nitrogen on Cowpea Production

The amount of nitrogen to be applied is as varied and controversial as whether to apply nitrogen to cowpea at all as earlier discussed. Many workers suggesting different levels. Among many factors that can contribute to improving seed yields in grain legumes, increasing the availability of nitrogen at critical stages of growth is of great importance, Nerves et al; (1981). Newton and Robertson (1982), reported increase in seed yield from 2.4t/ha to 3.16t/ha when the level of nitrogen was raised from 20kgN/ha to 40kgN/ha. Agboola (1978), in a pot experiment observed that top growth and number of nodule per plant was highest when 33.6kgN/ha was applied at sowing. Hague and Gbla (1978), obtained the highest yield of cowpea by applying 80kgN/ha in two splits.

Kurdikeri et al; (1973), Srinivas (1988), observed increase in the number of pods per plant, seed weight per plant with the application of 20kgN/ha to 160kgN/ha.

2.5 Effects of Phosphorus on Cowpea Production

Phosphorus plays a vital role in the growth and yield of cowpea. It has been reported to cause robust over all development of cowpea and generally increased the crop yield (Yayock, 1975); Kungju et al; 1976; Garg et al; 1977 and Remison et al; 1980). Cowpea is known to respond positively to phosphorus application and its requirement is generally low. Rhodes (1980) observed improved nodulation and seed yield of cowpea with phosphorus application. The need for phosphorus in the vigorous growth of cowpea is evident

from the various characteristics development that are common with cowpea growing under low or non-availability of phosphorus. Cowpea plant grown in soils low in phosphorus have been reported to be stunted, chlorotic and had smaller leaves with reduction in the protein N-content in all parts of the plant (Pavely, 1968); Kang and Nangju, 1983). It is not surprising, therefore, that the low phosphorus content of the semi-arid soils has been shown to be a great limiting factor to the growth and yield of cowpea (Anon, 1983). Despite the reports of positive response of cowpea to phosphorus, some workers reported low, neutral or no significant effects on cowpea (Johnson and Evans, 1975). Phosphorus was observed to have no effect on grain yield and yield components of cowpea in the growing season of 1983 in trial at Samaru, Zaria, Nigeria (Anon, 1984). Since these workers did not indicate the initial phosphorus status of the soils before their studies, the negative and lack of response obtained might have been due to the phosphorus status of the soil used. This is especially so, since it is known that crop yield usually increased curvilinearly with increasing amounts of the nutrients in the soil which is deficient. An optimum is usually attained which cannot be increased and may even reduce with additional nutrients (Doyle, 1966). However, reports indicate the positive response of cowpea to applied phosphorus. Yayock (1975), after many fertilizer trials in northern parts of Nigeria reported that phosphorus was found to be unquestionably the most important element in cowpea seed production. Research findings at the Institute for Agricultural

Research, Samaru-Zaria, Nigeria have also shown significant yield increase in cowpea due to phosphorus fertilizer application (Anon, 1977).

Phosphorus does not only increase the yields of cowpea but also improve the quality of the crop. Omueti and Oyenuga (1970), and Kurdikeri et al; (1983) reported that phosphorus fertilization increased the protein content of cowpea significantly. The quality of fodder from phosphorus fertilized cowpea was reported to be a rich forage material for livestock, Kang and Nangju (1983). They also reported that such crops are often found to be rich in many other nutrients such as N, K, Ca and Mn.

Phosphorus exerts favourable and positive contributing effects on yield components of cowpea as shown by significant effects it has on the final yield of the crop. Singh and Jain (1966) reported that application of phosphorus increased the number of nodules per plant of cowpea. It increased number of leaves per plant, leaf area per plant, number of flowers per plant, number of fruits per plant as well as earliness of flowering and generally increased yields (Kurdikeri, et al, 1977; Tarila et al, 1977).

Tarila, et al, (1977) also reported that the total number of pods per plant, number of seeds per plant and seed weight per plant were all increased as a result of increasing phosphorus contents of the soil. Jarayam and Ramia (1980) observed that phosphorus fertilization reduced flower shedding significantly in cowpea and Laskar and Dadhwal (1981) observed that as P-fertilization was increased, pod abscision was reduced in cowpea in addition to

increment in the vegetative and reproductive parts. These results indicated that much of the energy conserved by the crop would result in increased harvestable yields.

2.6 The Effects of Levels of Phosphorus on Growth and Yield of Cowpea

It is fairly established that certain minimum amount of phosphorus is required for effective performance in cowpea. In relatively low P-containing soils, several workers have reported significant increase in the growth and yield of cowpea with increasing P-levels (Yayock, 1975; Kungju et al; 1976; Remison et al ; 1980). Several others have also reported various optimal levels of P for attaining maximum growth and yield in cowpea. Garg et al; (1970), after studying the effects of different rates of phosphorus on cowpea reported that green fodder yield of the crop was significantly increased by a rate of 37kgP/ha and not by higher rates. Agboola and Obigbesan (1979) observed that highest grain yield was obtained at 30kgP/ha from four different phosphatic fertilizers (Rock phosphate, Basic Slag, converted bone and superphosphate).

In trials conducted at various locations in the savannah ecological zone of Nigeria for years, it was found that a rate of 16kgP/ha is optimal for seed yield in cowpea production in the savannah region of Nigeria (Anon, 1979). Okelana and Adedipe (1981), while working on four levels of P on cowpea in the forest ecological zone of Nigeria, however, found that a phosphorus dressing of 40kgP/ha proved to be the nearest optimum P level for seed production in New Era variety of cowpea. Also, Kang and Nangju

(1983) reported an optimal level of 13kgP/ha for cowpea in forest zone of Nigeria.

With these conflicting findings, it is worthy to note, however that the effectiveness of any P level applied to cowpea depends on the properties of the soil, fertilizer type and variety (Terman, 1974; Anon, 1977). This may explain the variation in the responses of cope to P in various studies cited.

2.7 Nitrogen and Phosphorus Interaction on Cowpea Production

In an experiment with 3 - levels of phosphorus, (0, 13 and 26kgP/ha and 4-levels of nitrogen (0, 20, 40, 60kgN/ha), the interaction of the treatments had no significant effect on grain yield of cowpea (Anon, 1983). Tewari (1964), in an experiment with N and P, observed that combination of low phosphorus (18kg/haP_2O_5) and zero nitrogen produced the highest total number of nodules effective and in effective, while high phosphate (36kg/ha P_2O_5) plus zero nitrogen produced the highest number of effective nodules. Medium phosphate (27kg/haP_2O_5) plus zero nitrogen appear to be the most economic rate. In an experiment in a Northern Guinea savannah environment of Nigeria, Katung et al; (1993), observed increase in grain yield of cowpea due to the interaction between nitrogen and phosphorus.

2.8 Interaction Between Lime, Nitrogen and Phosphorus on Yield and Yield Components of Cowpea

Literature on liming and fertilization with nitrogen and phosphorus is scanty. However, Kang (1978), working with nitrogen on a limed soil observed that plant grown without liming were chlorotic and showed Ca-deficiency during early growth. He also

observed that without liming N-application corrected N-deficiency and partially corrected Ca-deficiency during early growth. Liming improved nodulation and corrected N-deficiency. Large responses to liming were observed with rates between 0.25 to 1.0t/ha while high lime rate of 5.0t/ha reduced nodulation, nodule dry weight, Mg, Zn and Mn concentration in plant tops. In Hawaii, Fox et al; (1964) observed that small addition of lime to acid latosols greatly increased the uptake of fertilizers and liming soils to pH 7, drastically reduced P uptake from acid aluminous latosols. Woodruff and Kamprath (1965) observed that neutralization of exchangeable Al reduced by 50% the fertilizer required for optimum growth on North Carolina soils.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Experimental Sites

Field experiments were conducted during the wet seasons of 1995 and 1996 on the Research Farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru-Zaria, located on latitude $11^0 11'$N and longitude $07^0 38'$E on elevation of 686 meter above sea level. Samaru which is located within the northern Guinea Savanna Ecologial zone of Nigeria is characterized by an average rainfall of about 1100mm mostly distributed between the months of May and October. Mean monthly minimum and maximum temperature of about 20^0C and 30^0C respectively. The soil is classified as Alfisols characterised by accumulation of clay in the B horizon due to intensive leaching (Moberg and Esu, 1989). Climatological data collected during the 1995 and 1996 growing seasons are presented in Appendices 1 and 2. The physico chemical properties of the soils of the two sites used for the experiments are presented in Appendix 3.

3.2 Experiment Treatments and Experimental Designs

Treatments consisted of 3 levels of lime ($CaCO_3$) 0, 500 and 1000kg/ha), 3 levels of nitrogen using Urea (0, 20 and 40kgN/ha) and 3 levels of phosphorus using single superphosphate (SSP) (0, 15 and 30kgP/ha). The experimental design used was a split-plot with nitrogen and phosphorus combination in the main plots and the lime in the sub-plots with factorial arrangement. The experiments were

replicated 3-times with 27 treatments in each replicate making a total of 81 plots in all. The gross plots were 22.5m^2 made up of 6 ridges of 5m length and the net plot of 15m^2 made up of 4 inner ridges, that is discarding one ridge on either side of the gross plot.

5.3 Soil Sampling and Analysis

Soil samples were collected from randomly selected points from the research fields. Samples were taken at two depths (0-15cm and 15-30cm) using a tubular auger and bulked. The soil samples were analysed for phsico-chemical properties such as percent clay, silt and sand. Percentage organic carbon, total nitrogen, available P, exchangeable bases, cation Exchange capacity(CEC) and soil pH. The particle size analysis of the soil was carried out using hydrometer method as described by Day (1965), soil pH in H_2O and 0.01m $CaCl_2$ using a pH meter. (Black, 1965), total nitrogen by Kjedahl method. (Bremner, 1965 and IITA, 1975). Available phosphorus by Bray I method (Bray et al; 196B). Exchangeable bases by ammonium acetate saturation and cation exchange capacity by ammonium acetate and extraction and distribution method (Black, 1965).

3.4 Land Preparation

The land was prepared by ploughing once and harrowing twice and ridged at 75cm apart.

3.5 Planting and Planting Materials

Three to four seeds were sown 30cm apart within the ridges spaced 75cm apart first week of August in each case which were later

thinned to two plants per stand giving a plant population of 88,888 plants per hectare. The planting material used was cowpea variety sampea 7.

Sampea 7 is a product of a cross between Ife brown as female parent and a local large white, spreading and photosensitive variety from Institute for Agricultural Research (IAR) collection designated as 2479. Sampea -7 is semi-upright, and day neutral. Its maturity period varies from 65 to 90 days from planting to harvest. It cooks quickly and tastes very good and hence it is readily acceptable with protein content of about 26% (Anon. 1985).

3.6 Lime and Fertilizer Application

Lime was worked into one side of the ridges and the nitrogen and phosphorus band placed at sowing.

3.7 Weeds, Pest and Disease Control

The crops were hoe weeded at 3 and 6 weeks after sowing. Diseases (fungal) were controlled by the use of Benomyl as Benlate and Mancozeb as Dithane M45 at the product rate of 0.60kg + 2.5kg/ha respectively in 400 litres of water beginning at 3 weeks after sowing and continued at 3 weekly intervals until flowering. Insect pests were controlled by applying a tank mixture of cypermethrine as cymbush 10EC and dimethoate as Rogor at the product rate of 0.75 litres/ha first to control leaf eating beetles like Ootheca mutabilis and later to control flower and pod sucking insects such as Clavigralla tomentosicolis and aphids (Aphis caraccivora).

3.8.0 Data collection

Assessment of parameters such as the number of branches per plant, number of leaves per plant, leaf area index, plant height, dry weights of stem, leaves and roots, number of root nodules per plant began at 4 weeks after sowing and continued at two weekly intervals till the 12th week after sowing, that is, data were collected at 4,6,8,10 and 12 weeks after sowing.

Data on days to 50% flowering were also collected. Five plants were sampled per plot for the parameters observed.

3.8.1 Number of primary branches per plant:

The number of primary branches in all the sampled plants were counted and the mean recorded.

3.8.2 Number of leaves per plant

The number of functional leaves were counted from each of the 5 sampled plants and the mean calculated and recorded.

3.8.3 Plant height per plant

The height of each of the sampled plants were taken by measuring the stem from the soil base to apex.

3.8.4 Leaf area per plant:

The leaf area was determined by measuring the areas of the middle leaflets and multiplying it by a constant factor of 2.7 as described by Nangju and Wanki (1979).

3.8.5 Roots, stems and leaf dry weights per plant:

Samples were separated into roots, stems and leaves and oven dried to constant weight at 70^0C for 48 hours and the weights recorded.

3.8.6 Days to 50% flowering:

The length of time (days) from planting to when half the plants in the plot have flowered was determined and recorded.

3.8.7 Leaf area index

This was determined by dividing the total leaf area per plant by the area supporting the plant.

3.8.8 Number of root nodules per plant:

This was carried out by carefully uprooting 5 plants with their roots and washing the soil through a sieve and the nodules were collected and counted thereafter.

3.8.9 Tissue analysis

Plant samples were collected from each plot and the stems and leaves were oven dried and bulked at 8 WAS. The combination of the stems and leaves were analysed for the concentration of nitrogen using the micro Kjedahl method (A.O.A.C., 1975). Spectronic 20 440mm was used to determine phosphorus concentration while calcium and magnesium concentrations were determined by flamesphotometer.

3.8.10 Harvesting

Mature pods were harvested by removing them by hand. This was between 13-15 weeks after sowing.

3.9.0 Assessment of post-harvest parameters:

3.9.1 Grain yield per plot

Grain yield per plot was determined by weighing the grains after shelling and winnowing the pods harvested from each plot. The grain yield per plot was expressed in kg/ha by multiplying the grain weight from each plot by a factor of 666.67.

3.9.2 Number of pods per plant:

The number of pods per plant was determined by counting the pods from the five sampled plants and dividing by the number of plants.

3.9.3 Number of seeds per pod

The number of seeds per pod was determined by counting the seeds from the counted pods of the five sampled plants and dividing the total by the number of pods.

3.9.4 100 seed weight

The hundred seed weight was determined by randomly counting 100 seeds from the grains from each plot and the weight taken.

3.9.5 Shelling percentage

The shelling percentage was determined by dividing the weight of the grains per plot by the weight of the unshelled per plot multiplied by 100.

3.9.6 Harvest-index (%): was expressed as:

$$\frac{\text{Grain weight/plant}}{\text{Total dry matter per plant}} \times 100$$

3.9.7 Analysis of data:

Analysis of variance was carried out as described by Snedecor and Cochram (1967). The multiple comparison procedure of the Duncan mulitple range (DMRT) (Duncan, 1955) was used to compared means of lime, nitrogen and phosphorus levels and their interactions. Also, a combined analysis for the two year data was

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carried out to see the mean effects. Studies of correlation and regression coefficients between growth characters, yield components and grain yields of cowpea were also carried out to determine their associations.

CHAPTER FOUR

4.0 RESULTS

4.1 Effects of Levels of Lime, Nitrogen and Phosphorus Fertilizers on Growth, Yield and Yield Components of Cowpea

4.1.1 Plant height

The effects of lime on plant height was not consistent. Lime application significantly influenced plant height only at 8 WAS in 1995 and at 10 and 12 WAS in 1996 (Fig. 1). The mean shows that lime significantly increased plant height only at 10 and 12 WAS with the highest lime levels of 1000kg/ha in both years.

Application of nitrogen to cowpea significantly increased plant height (Fig.2). In 1995, application of nitrogen significantly increased plant height except at 12 WAS. However, in 1996 nitrogen significantly increased plant height. At 12 WAS, averaged over the two years shows that nitrogen application of 20kg/ha increased plant height significantly by 14% when compared with the control. There was no further significant increase in plant height when the nitrogen rate was increased to 40kg/ha.

Phosphorus application significantly influenced plant height in both years at each sample interval (Fig. 3). At 12 WAS, applying 15kgP/ha significantly increased plant height by 20.5% when compared with the control but there was no further significant increase in plant height when the phosphorus rate was increased to 30kg/ha.

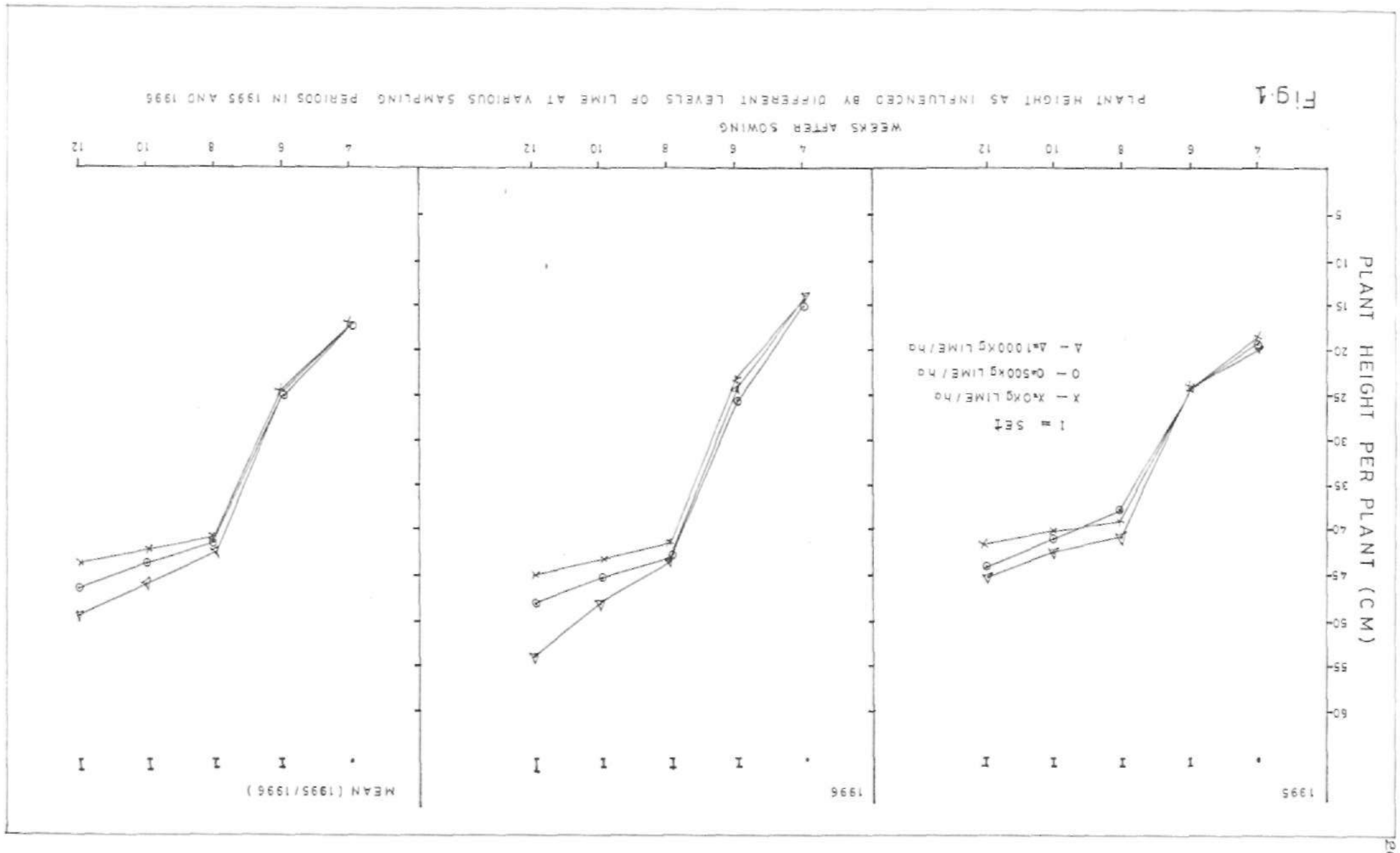

PLANT HEIGHT AS INFLUENCED BY DIFFERENT LEVELS OF LIME AT VARIOUS SAMPLING PERIODS IN 1995 AND 1996
WEEKS AFTER SOWING
PLANT HEIGHT PER PLANT (CM)
1 = SET
X – X0Kg LIME/ha
O – O500Kg LIME/ha
Δ – Δ1000Kg LIME/ha
1995
1996
MEAN (1995/1996)

Fig.4

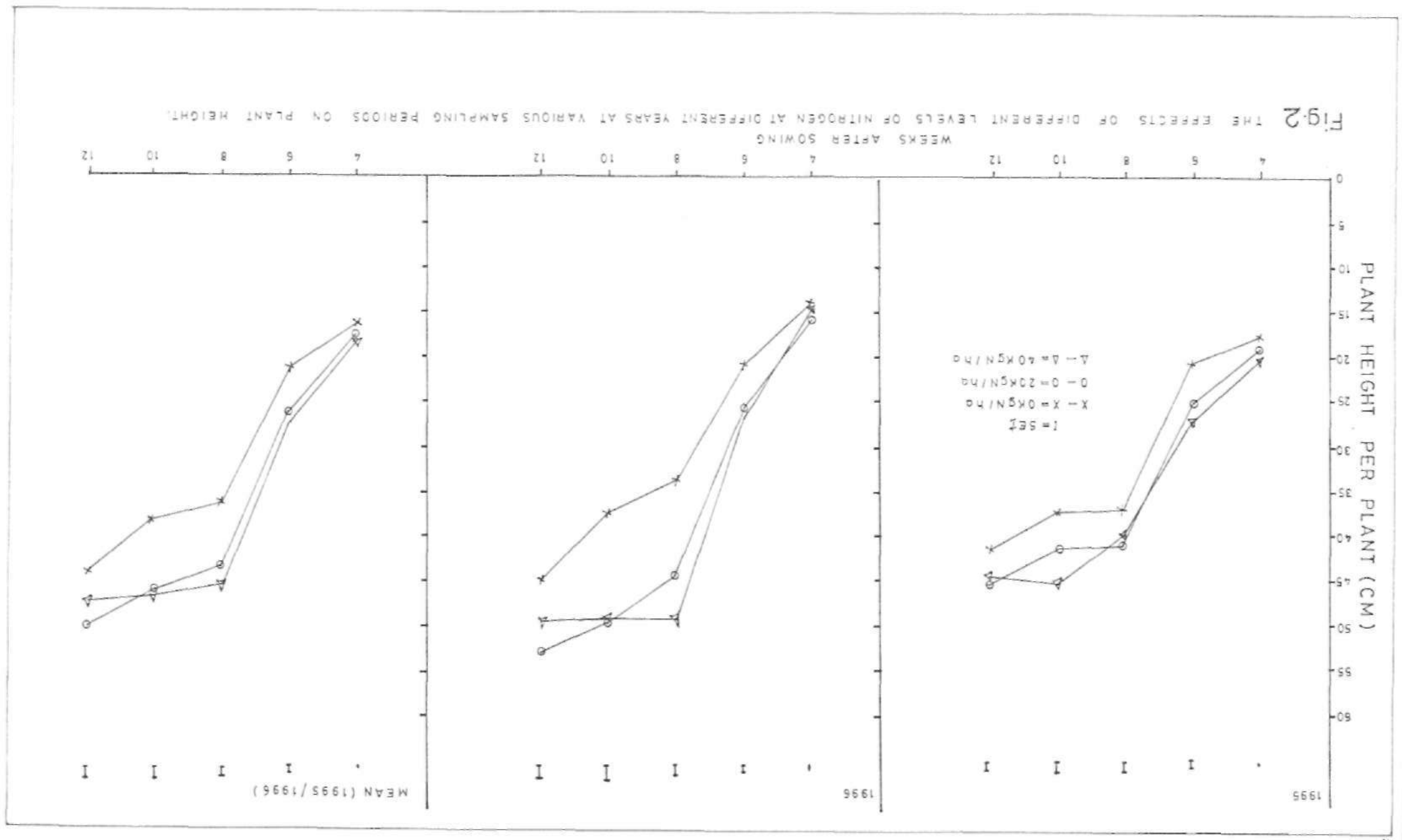


Fig.2 THE EFFECTS OF DIFFERENT LEVELS OF NITROGEN AT DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS ON PLANT HEIGHT.

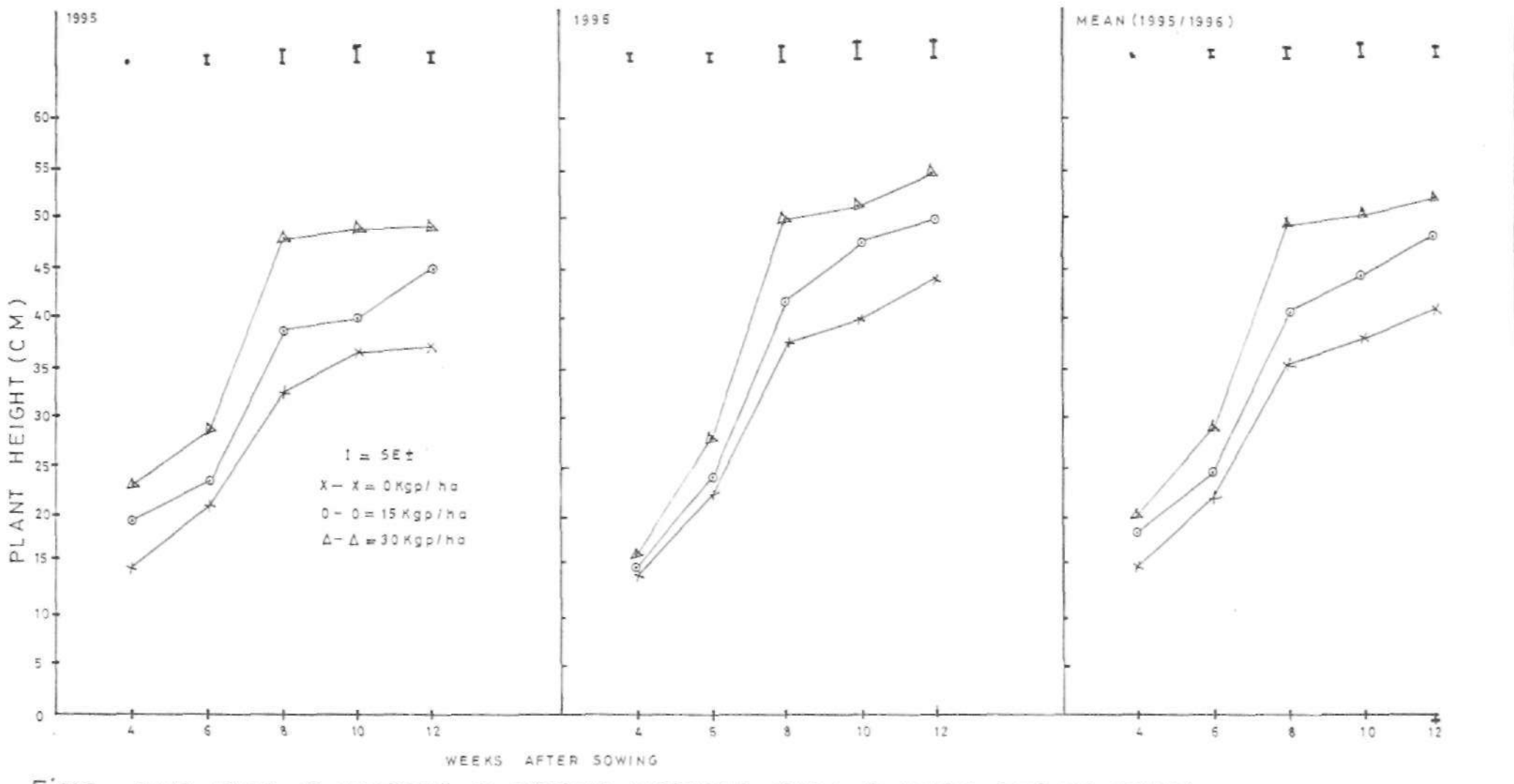


Fig 3 PLANT HEIGHT AS INFLUENCED BY DIFFERENT PHOSPHORUS LEVELS AT VARIOUS SAMPLING PERIODS.

Table 1: Interaction between nitrogen and phosphorus on plant height at 10 weeks after sowing (cm).

Treatments	1995 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	37.42cd	31.18d	38.97cd
15	31.18d	48.67a	39.26c
30	38.23cd	40.28bc	47.78ab
SE +	2.33		

	1996 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	40.18bc	33.18c	40.60bc
15	33.18a	50.54a	41.26abc
30	35.00c	41.83abc	47.09ab
SE +	2.72		

	1995/96 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	38.80cd	32.18d	39.78bcd
15	32.18d	49.51a	40.26bcd
30	34.12cd	41.06bc	47.43ab
SE +	2.50		

Means followed by the same letter(s) are not significantly different at 5%.

Table 2: Interaction between lime, nitrogen and phosphorus on plant height as 10 WAS (cm

	Phosphorus (kgP/ha) 1995								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	40.27b-e	32.27c-g	43.87a-c	21.00g	40.83b-d	49.50ab	23.00e-f	33.50e-f	44.00a-c
500	54.33c-f	22.50fg	35.77c-e	33.77c-g	49.17ab	29.27d-g	40.00b-c	37.67b-e	43.83a-c
100	37.67b-c	38.77b-e	37.27c-e	38.77b-e	56.00a	39.00b-e	31.70c-g	49.67ab	55.50a
SE +					3.64				

	Phosphorus (kgP/ha) 1996								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	42.27c-e	34.27d-g	44.77b-d	23.00g	41.77c-e	51.50a-c	30.00e-g	34.50d-g	45.00b-d
500	36.00d-f	24.50fg	37.77de	35.77d-g	51.27a-c	31.27e-g	42.00c-e	39.50c-e	40.50c-e
100	42.27c-e	40.77c-e	39.27c-e	40.77c-e	58.00a	41.00c-e	33.00d-g	51.50a-c	55.77bc
SE +					3.72				

	Phosphorus (kgP/ha) 1995/1996								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	41.27c-e	33.27c-h	44.32b-d	22.00i	41.50b-e	50.50ab	29.00g-i	34.00d-g	44.50b-d
500	35.17d-g	23.50hi	36.77d-g	34.77d-g	50.22a-c	30.27f-i	41.00b-e	38.58d-g	42.17b-e
100	39.97b-f	39.77d-f	38.27d-g	39.77c-f	57.00a	40.00b-e	35.00e-i	50.58ab	55.63a
SE +					3.68				

Means followed by the same letter(s) are not significantly different at 5%.

The interaction between nitrogen and phosphorus was significant on plant height at 10 WAS (Table 1). Averaged over both years, combination of 20kgN/ha and 15kgP/ha produced the tallest plants of 50cm. Similarly, the interaction between lime,nitrogen and phosphorus was also significant at 10 WAS where the combination of the highest lime rate of 1000kg/ha, 20kgN/ha and 15kgP/ha, produced the tallest plants of 57cm. (Table 2).

4.1.2 Number of leaves per plant

Maximum number of leaves was obtained at 12 WAS (Fig. 4, 5, 6). The effect of lime on the number of leaves per plant was significant at 10 WAS in 1995 and at 10 and 12 WAS in 1996. Across the years there was significant effect of lime on the number of leaves per plant at 10 and 12 WAS where the highest number of leaves at 12 WAS of 56 was produced by the highest lime rate of 1000kg/ha but the lower lime rate of 500kg/ha was not significantly different from the control. (Fig.4).

Application of nitrogen to cowpea significantly increased the number of leaves per plant throughout growth in 1995 and 1996, except at 4 WAS in 1995 and at 12 WAS in 1996, (Fig. 5). Average over the 2 years, application of 40kgN/ha increased leaf number by 20% at 12 WAS. Number of leaves per plant was significantly influenced by the application of phosphorus. In 1995, there was significant effect of phosphorus on the number of leaves throughout the sampling period while in 1996, the effect was also significant except at 10 and 12 WAS (Fig. 6). Average over both years, shows that application of 30kgP/ha increased leaf number by 17% at 12 WAS.

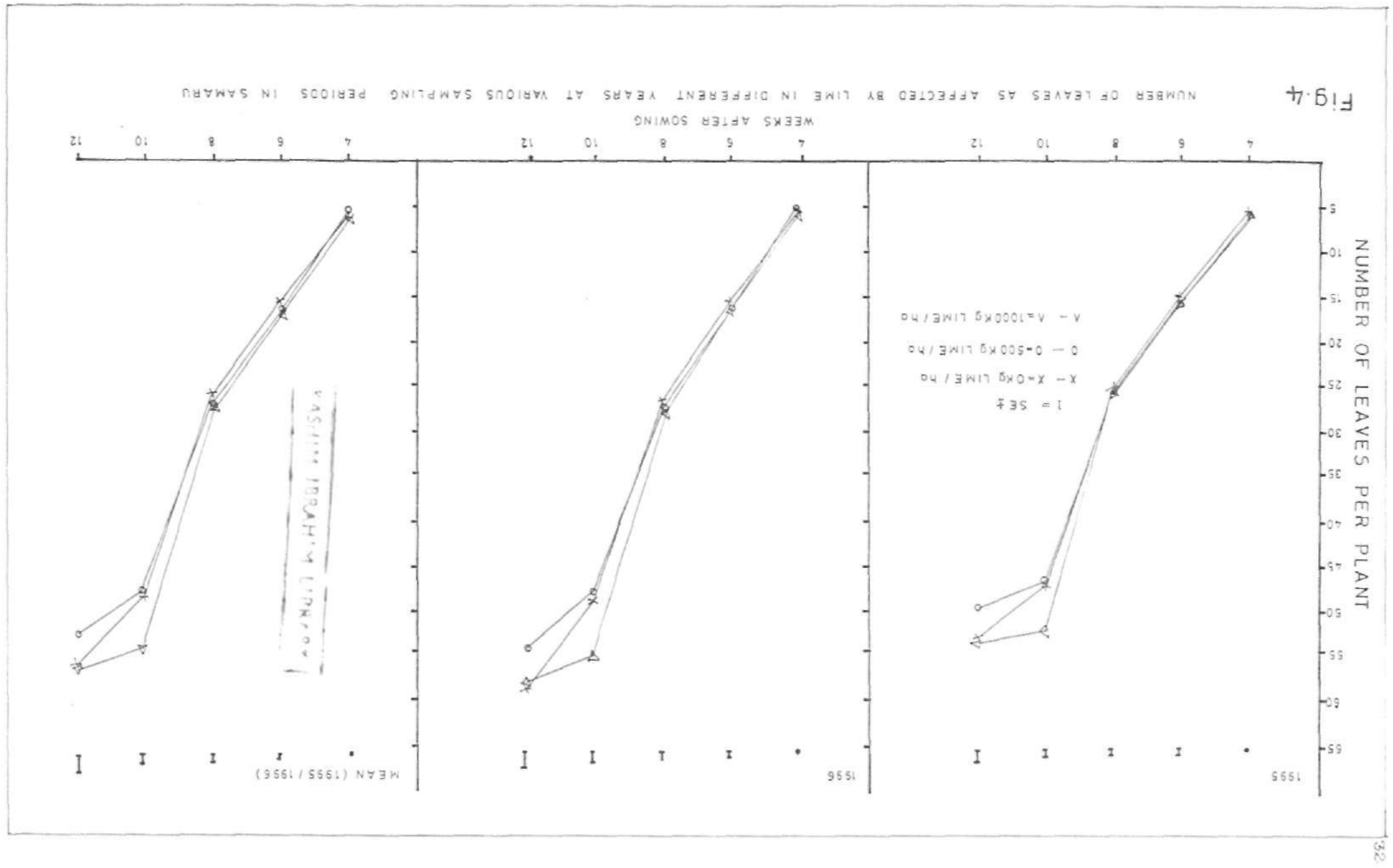


Fig.4 NUMBER OF LEAVES AS AFFECTED BY LIME IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS IN SAMARU

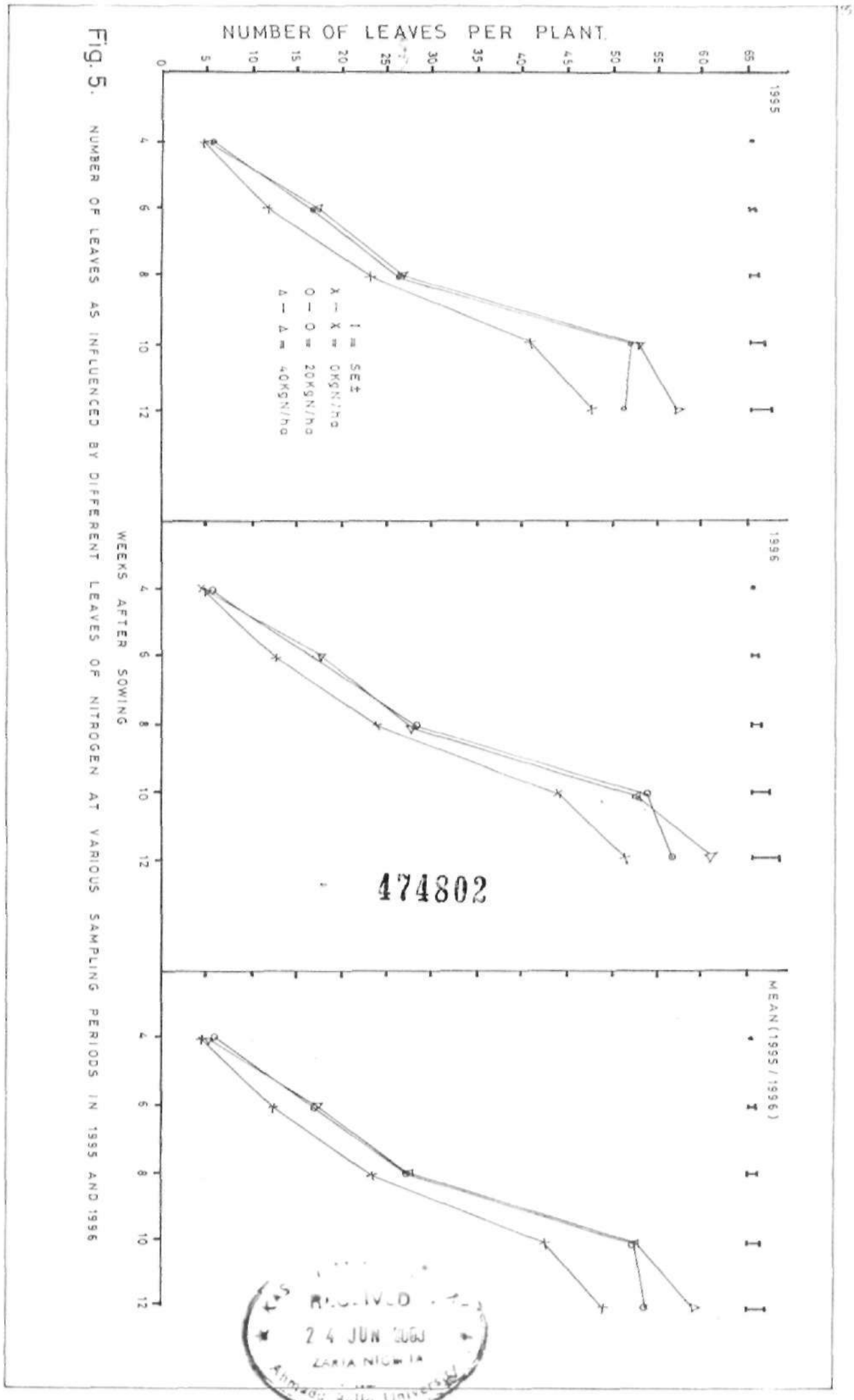


Fig. 5. NUMBER OF LEAVES AS INFLUENCED BY DIFFERENT LEAVES OF NITROGEN AT VARIOUS SAMPLING PERIODS IN 1995 AND 1996

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Fig.6 NUMBER OF LEAVES AS AFFECTED BY DIFFERENT LEVELS OF PHOSPHORUS IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS

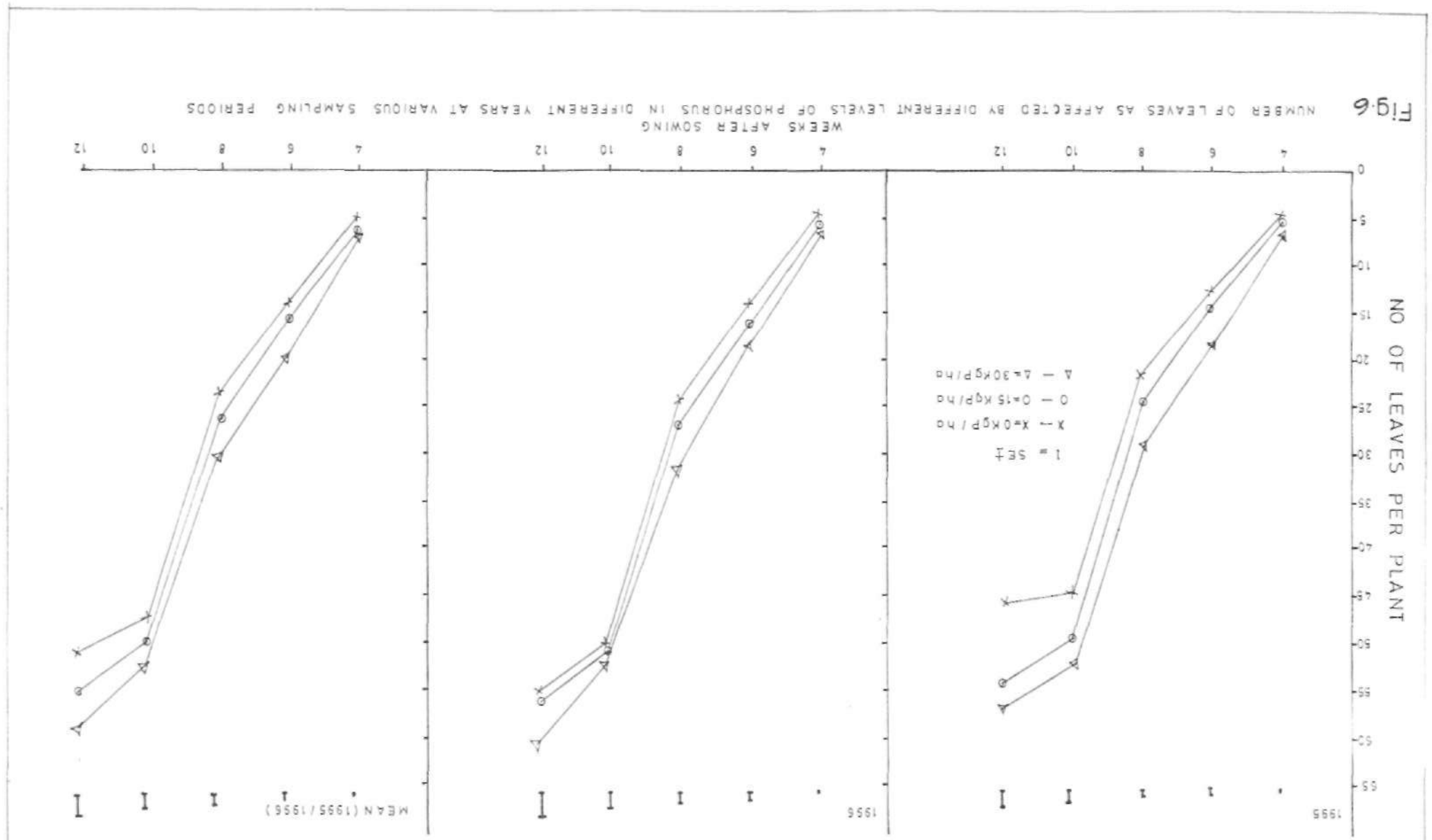


Table 3: Interaction between lime, nitrogen and phosphorus on the number of leaves per plant at 12 WA.

	Phosphorus (kgP/ha) 1995								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	36.40i	41/67h-j	48.60d-j	64.00a-e	41.90g-i	69.00ab	53.00a-j	59.60a-g	59.30a-i
500	38.37ij	41.63h-j	55.27a-i	43.33f-j	52.53b-j	49.00d-j	47.53e-j	66.27a-d	52.70a-j
100	38.97ij	35.83j	70.57a	48.57d-j	67.00abc	50.00c-j	56.07a-i	53.53a-j	60.40a-f
SE ±					5.17				

	Phosphorus (kgP/ha) 1996								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	37.00g	67.50b-d	57.30c-g	62.30b-f	43.30d-g	78.30ab	64.50b-e	66.50b-d	51.50c-g
500	45.50d-g	53.00c-g	56.80b-g	44.00d-g	58.30d-g	49.00c-g	53.50b-g	72.50a-c	47.50d-g
100	39.30fge	40.30e-g	93.50a	56.00b-g	67.00b-d	41.80e-g	59.30b-g	45.80d-g	79.30ab
SE ±					7.04				

	Phosphorus (kgP/ha) 1995/1996								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	36.70i	54.58c-h	52.93c-i	63.13b-c	42.58f-i	73.63ab	53.20c-i	63.05b-e	55.40c-h
500	41.95f-i	47.32c-i	56.02c-g	43.67f-i	55.40c-h	49.00e-i	50.52d-i	69.38a-c	50.10d-i
100	39.12g-i	38.05hi	82.03a	52.28c-i	67.25a-c	45.88e-i	57.67b-f	49.65b-f	69.83a-c
SE ±					7.18				

Means followed by the same letter(s) are not significantly different at 5%.

The interaction among lime, nitrogen and phosphorus was significant on the number of leaves per plant at 12 WAS where the highest number of leaves per plant of 82 was produced by a combination of the highest lime rate of 1000kg/ha and the highest N-rate of 40kg/ha with zero P.(Table 3).

4.1.3 Number of primary branches per plant

Significant response of cowpea regarding the number of primary branches per plant due to lime application was inconsistent throughout growth (Fig. 7). Significant response in 1995 was only at 4 and 8 WAS while the response was significant only at 4 and 12 WAS in 1996. The mean for the two years shows that the lime had significant effect on the number of primary branches at 4, 8 and 12 WAS.

Nitrogen application to cowpea increased the number of primary branches per plant at all stages in 1995 except at 8 WAS and throughout the sampling period in 1996 (Fig. 8). At 12 WAS, the average over the two years shows that nitrogen nutrition of cowpea significantly affected the number of primary branches by 15, 16 and 16% in 1995, 1996 and the mean respectively when 20kg/ha was applied. Further increase in N-rate to 40kg/ha did not confer significant effect or the number of primary branches per plant.

Phosphorus application to cowpea significantly increased the number of primary branches per plant in both years (Fig. 9). The effect was significant at all stages of sampling in 1995 except at 10 WAS and at 4, 6 and 12 WAS in 1996. The mean shows significant response except at 10 WAS. At 12 WAS, the mean shows that P-rate

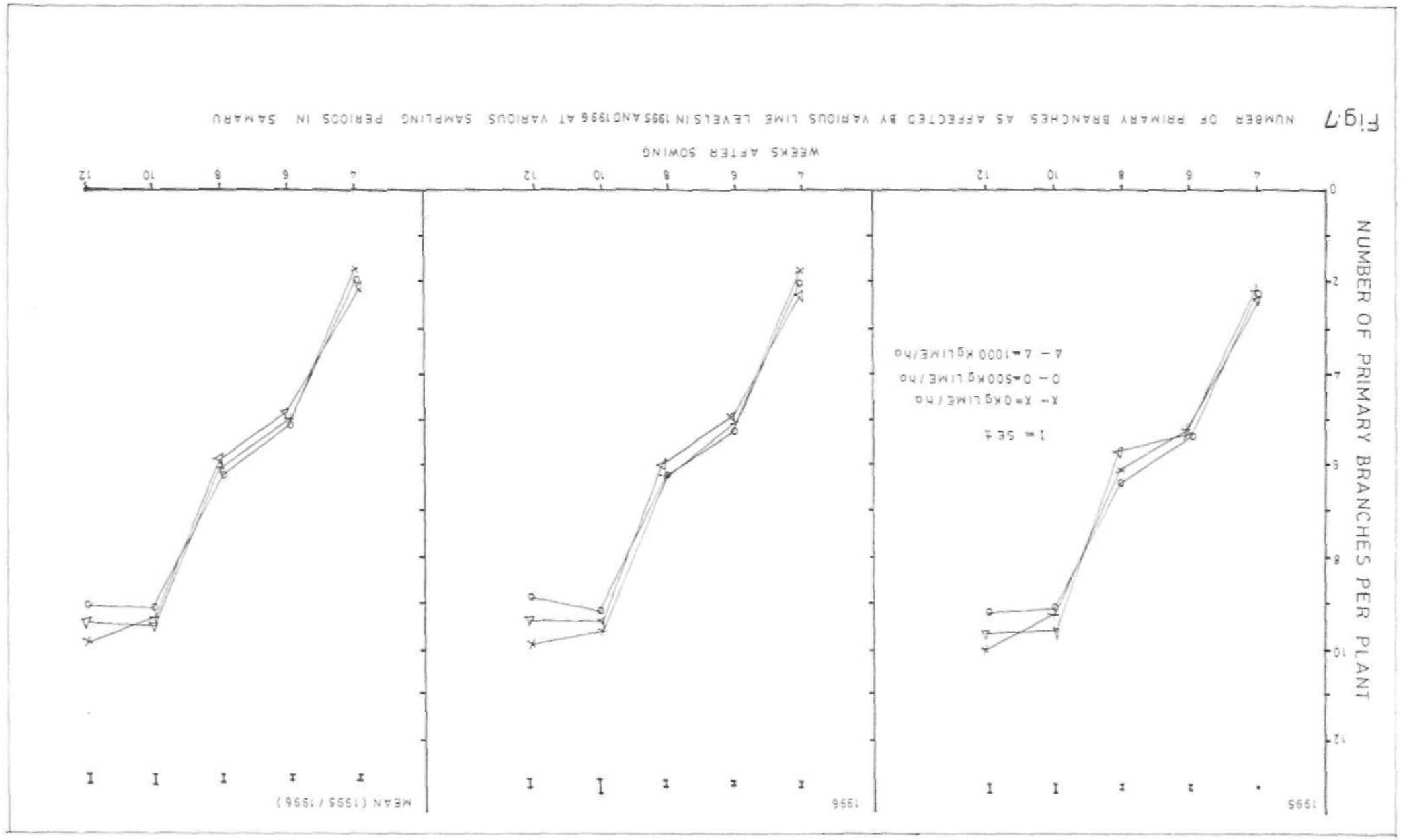


Fig.7 NUMBER OF PRIMARY BRANCHES AS AFFECTED BY VARIOUS LIME LEVELS IN 1995 AND 1996 AT VARIOUS SAMPLING PERIODS IN SAMARU

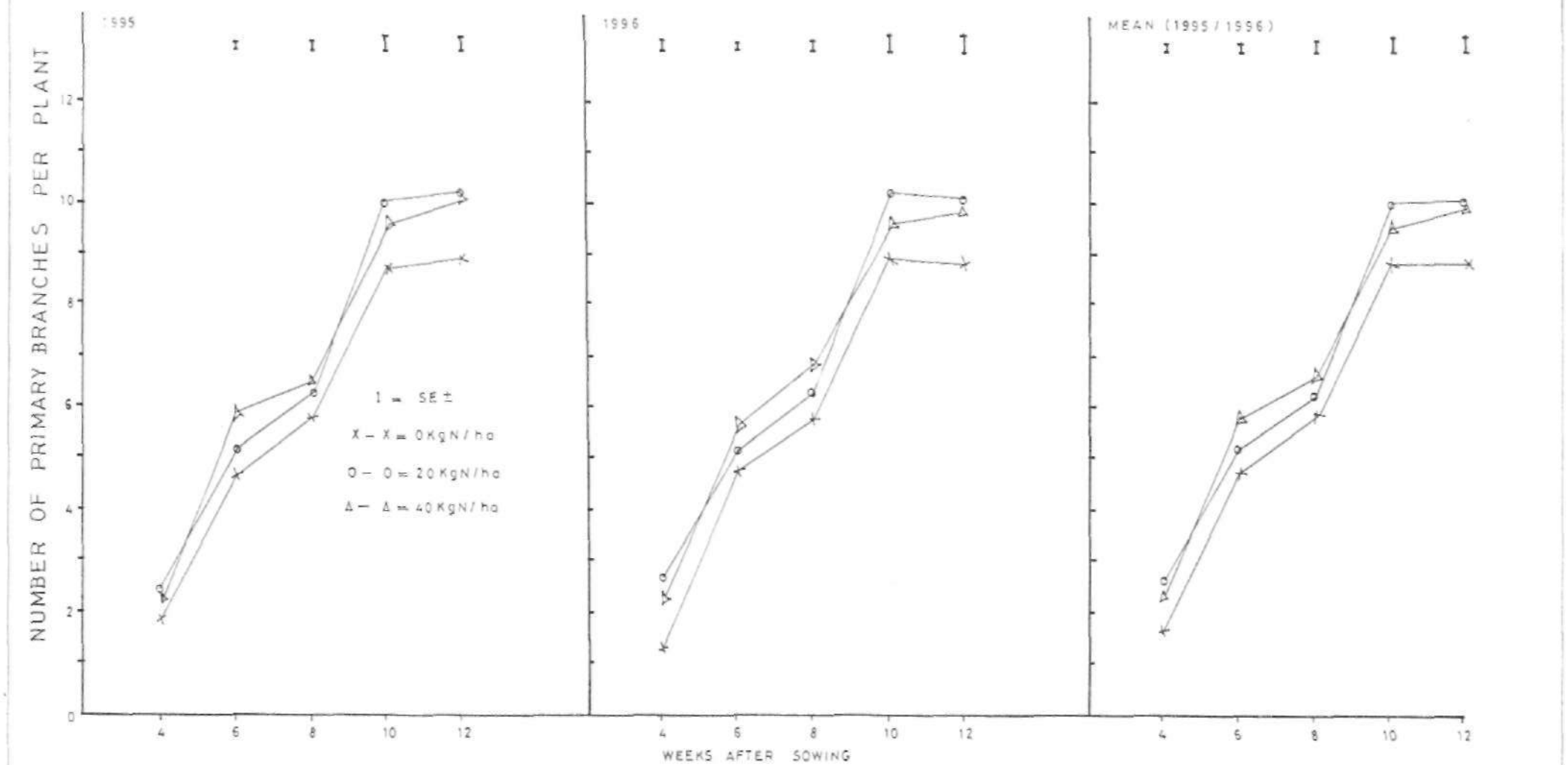


Fig.8. NUMBER OF PRIMARY BRANCHES AS INFLUENCED BY VARIOUS LEVELS OF NITROGEN IN DIFFERENT YEARS.

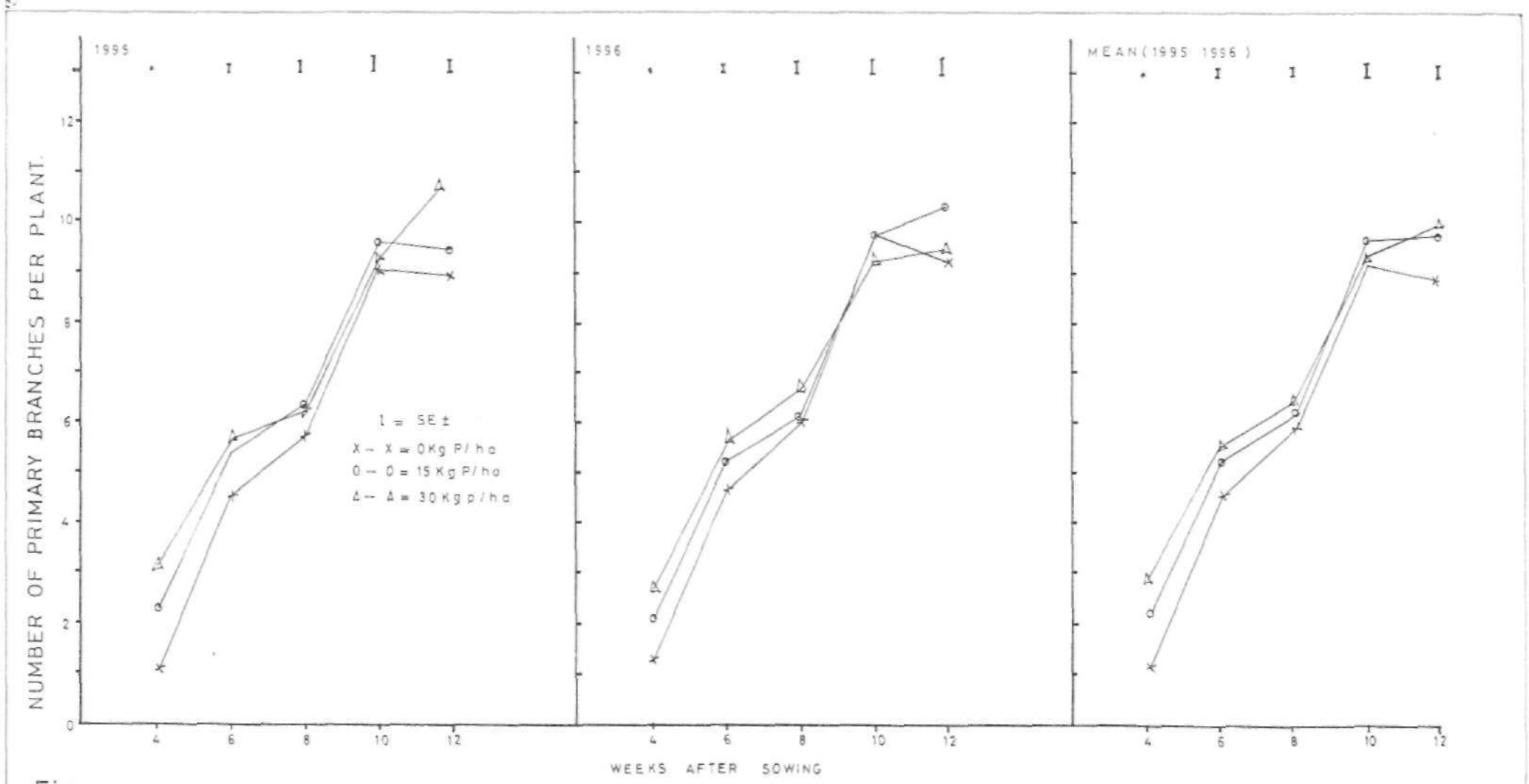


Fig.9 THE EFFECTS OF DIFFERENT LEVELS OF PHOSPHORUS ON THE NUMBER OF PRIMARY BRANCHES IN 1995 AND 1996 AT VARIOUS SAMPLING PERIODS

Table 4: Interaction between lime and phosphorus on the number of primary branches per plant at 8 weeks after sowing

Treatments	1995 Lime (kgN/ha)		
	0	20	40
0	5.27d	5.82cd	5.98c
15	6.33bc	7.50a	5.98c
30	6.96b	5.99c	6.09c
SE +	0.29		

	1996 Lime (kgN/ha)		
	0	20	40
0	6.15	5.97	5.96
15	6.38	6.32	5.67
30	6.63	6.82	6.67
SE +	0.36		

	1995/96 Lime (kgN/ha)		
	0	20	40
0	5.71de	5.89cd	5.97c
15	6.36b	6.91a	5.49c
30	6.69a	6.40b	6.38b
SE +	0.25		

Means followed by the same letter(s) are not significantly different at 5%.

of 15kgP/ha significantly increased the number of primary branches by 11% and there was no further significant effect above this rate.

The interaction between lime and phosphorus was significant on the number of primary branches per plant in 1995 but the effect was no significant in 1996 at 8 WAS (Table 4). However the mean for the two years was significant where the highest number of primary branches (7) was produced by a combination of 500kg/ha of lime and 15kgP/ha.

4.1.4 Leaf dry weight per plant

Lime application had inconsistent effect on leaf dry weight (Fig. 10). The increase in the leaf dry weight was significant at 4 and 6 WAS in 1995 and at 4, 10 and 12 WAS in 1996. Average for the two years shows that lime significantly affected leaf dry weight at 4, 10 and 12 WAS. Across the years applying 1000kg/ha of lime significantly increased leaf dry weight by 18% but there was no significant difference in leaf dry weight compared with the control when the lower lime rate of 500kg/ha was used.

Application of nitrogen increased leaf dry weight of cowpea (Fig.11). This increase was significant throughout the sampling period in 1995, but in 1996 it was only significant at 4, 6 and 8 WAS. However, the mean shows that nitrogen has significant effect on leaf dry weight throughout the sampling period. At 12 WAS, application of 20kgN/ha increased leaf dry weight by 31% and 25% in 1995 and the mean respectively. In both cases there was no significant effect of nitrogen on leaf dry weight above 20kgN/ha.

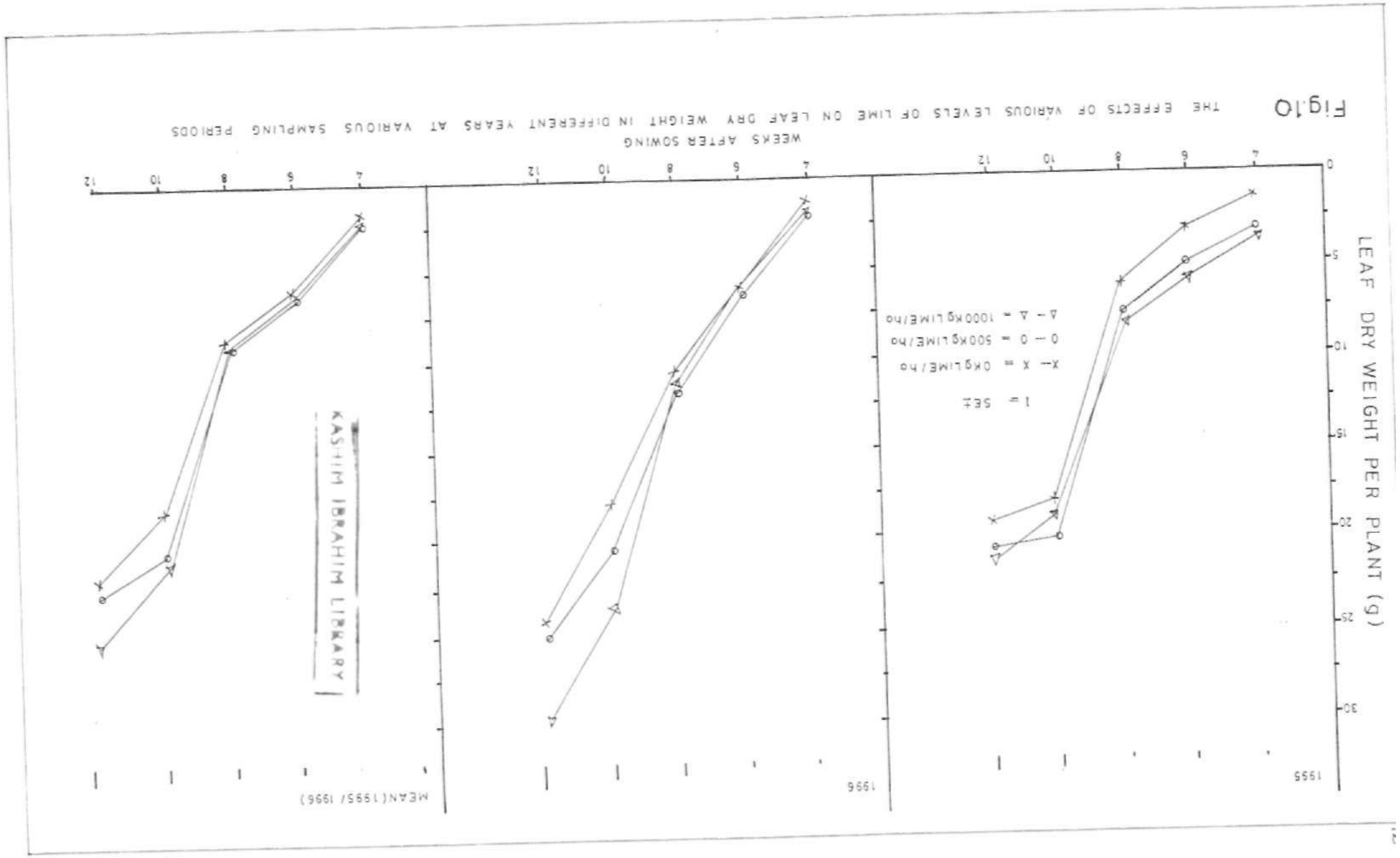


Fig.10 THE EFFECTS OF VARIOUS LEVELS OF LIME ON LEAF DRY WEIGHT IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS

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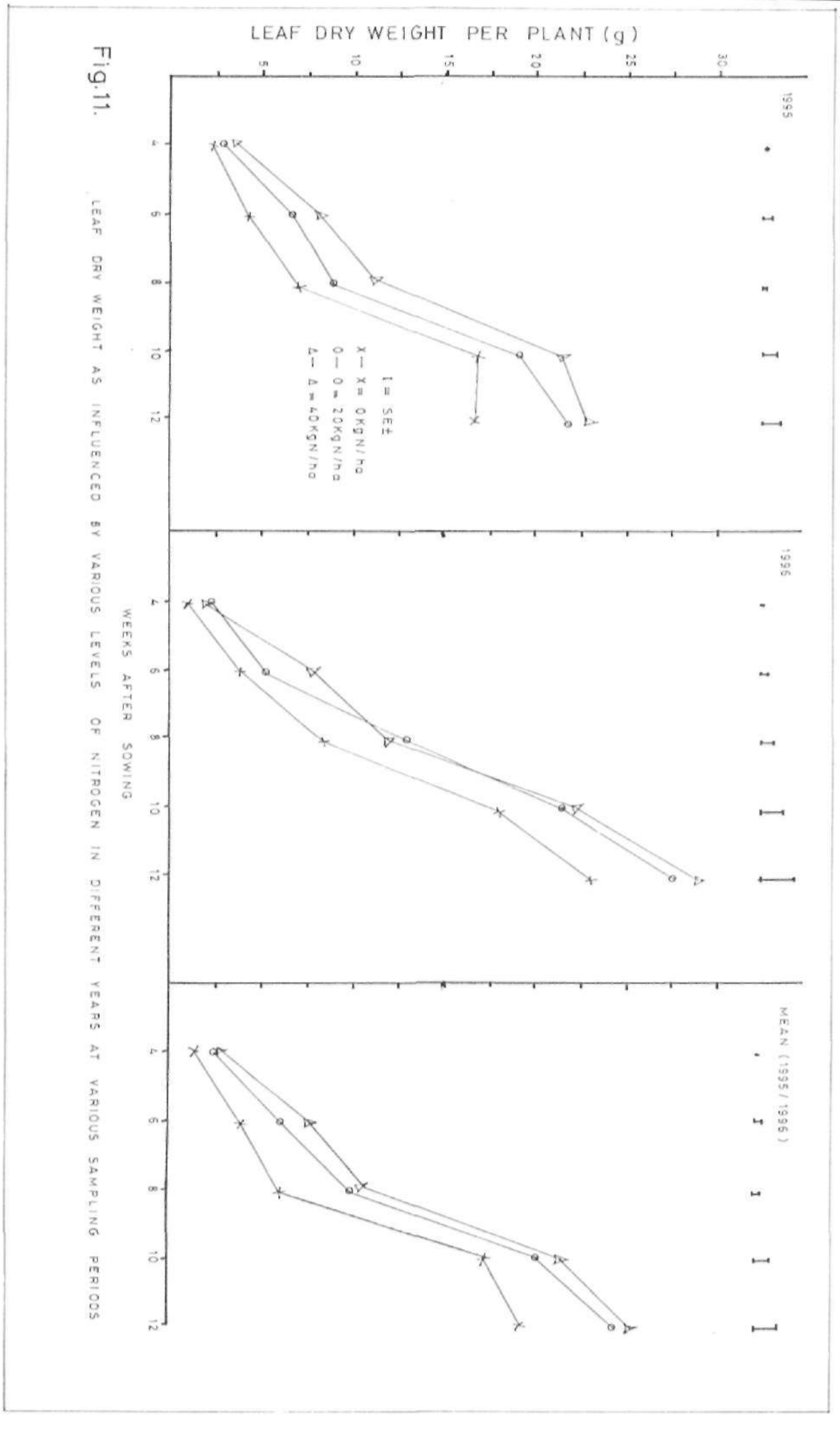


Fig.11. LEAF DRY WEIGHT AS INFLUENCED BY VARIOUS LEVELS OF NITROGEN IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS

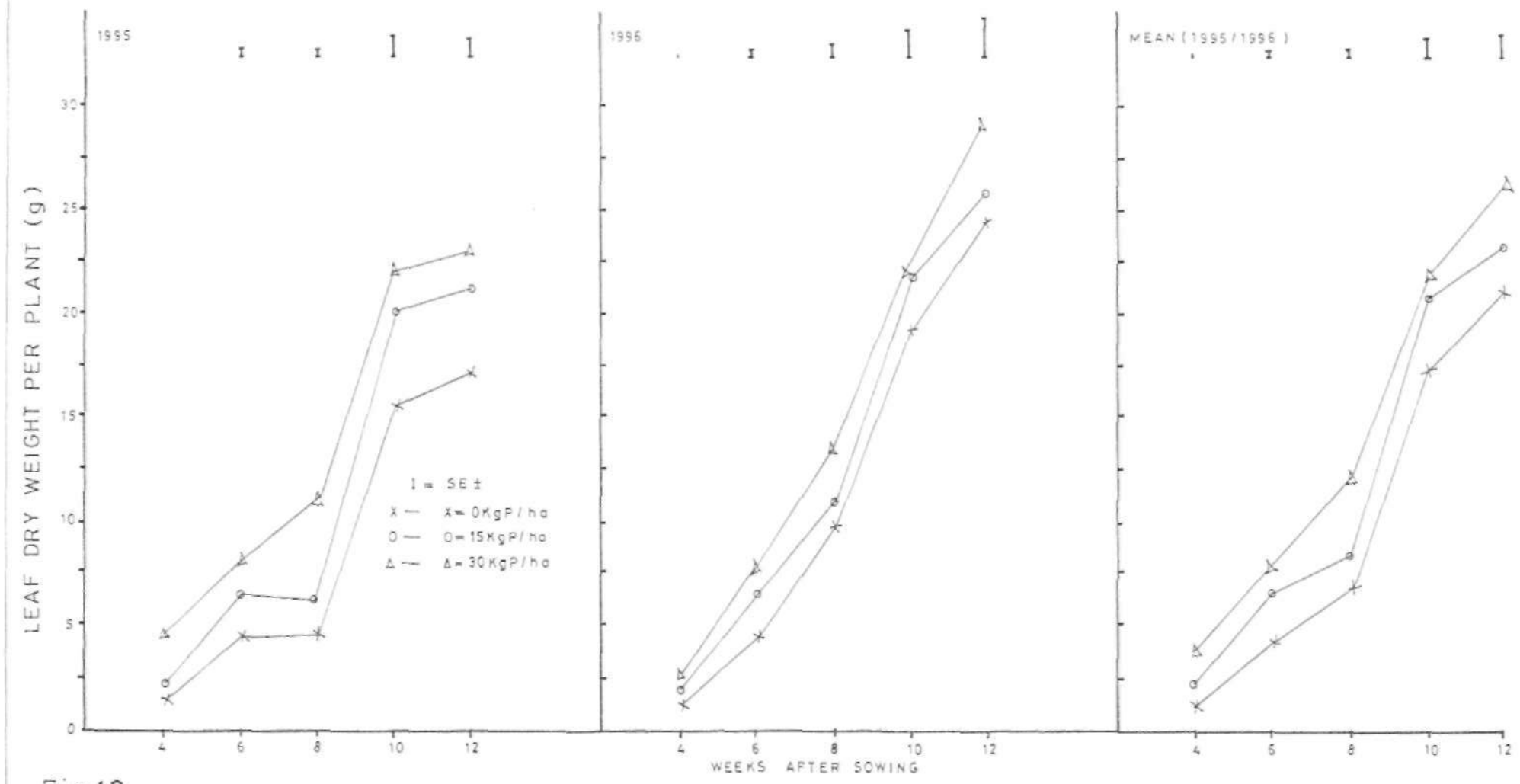


Fig.12. LEAF DRY WEIGHT AS INFLUENCED BY VARIOUS LEVELS OF PHOSPHORUS IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS

Table 5: Interaction between nitrogen and phosphorus on leaf dry weight(g) per plant at 10 weeks after sowing.

Treatments	1995 Nitrogen (KgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	11.17c	14.59bc	21.32a
15	20.00a	21.34a	19.61ab
30	19.88a	22.76a	23.40a
SE +	1.51		

	1996 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	14.19c	17.41bc	25.99a
15	19.31abc	26.49a	19.91abc
30	21.74abc	22.11ab	21.98ab
SE +	2.24		

	1995/96 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	12.68c	16.00bc	23.66a
15	19.66ab	23.92a	19.76ab
30	20.81ab	22.43a	22.69a
SE +	1.55		

Means followed by the same letters) are not significantly different at 5%.

Leaf dry weight was affected by phosphorus application to cowpea (Fig.12). Significant effects were observed at all sampling periods in 1995 and at 4, 6 and 8 WAS in 1996. The average of the two years shows that leaf dry weight of cowpea was significantly affected throughout the sampling period. At 12 WAS application of 15kg/ha significantly increased leaf dry weight by 22% in 1995 and there was no significant response above this P-rate. However, across the years increases in leaf dry weight was significant upto the highest P-rate of 30kg/ha. Application of 30kgp/ha increase leaf dry weight by 15% when compared with the control but the increase was not significantly different from the lower P-rate of 15kg/ha.

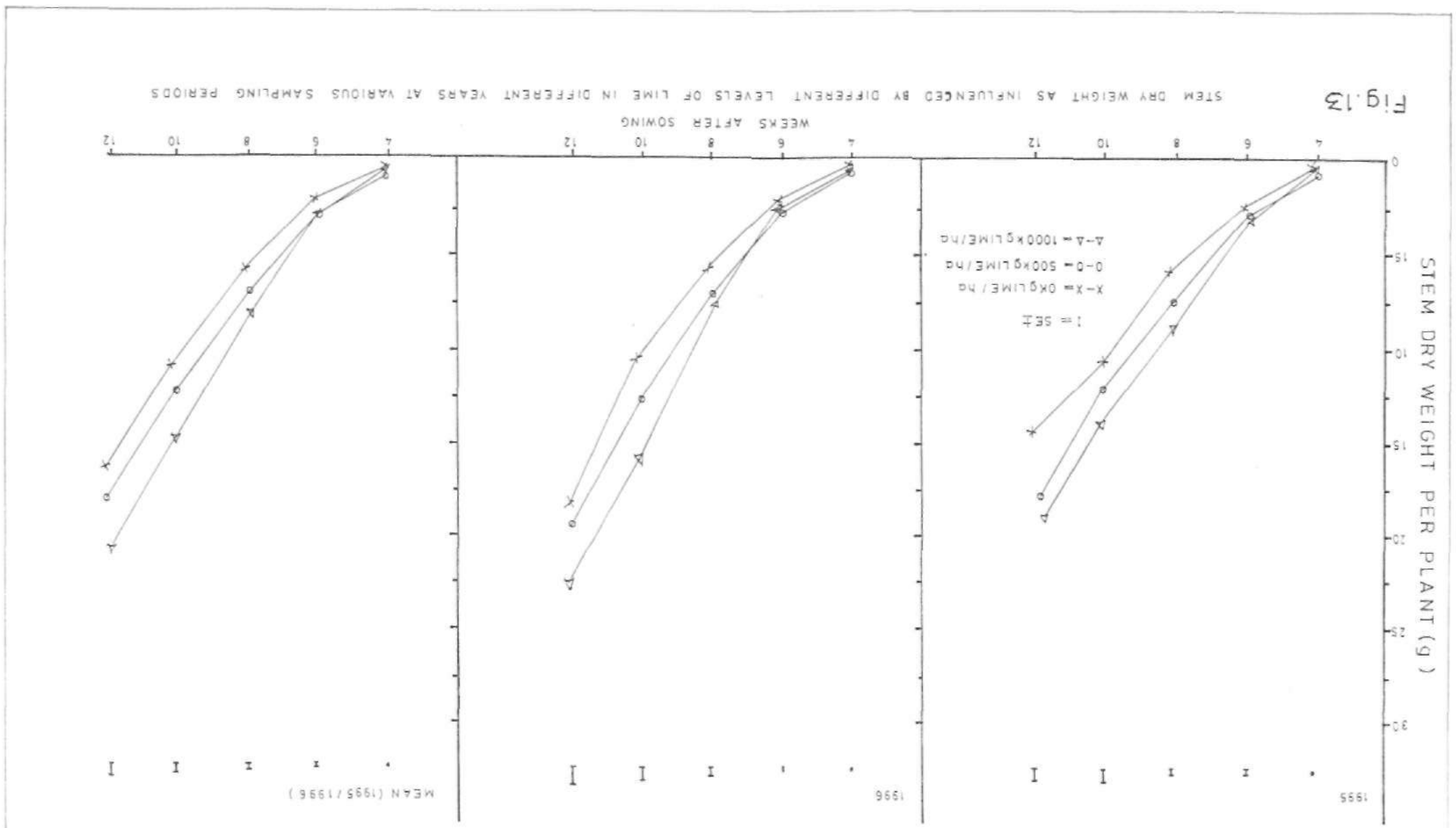
The interaction between nitrogen and phosphorus on leaf dry weight per plant at 10 WAS was significant in 1995 and 1996. The combined analysis shows that the highest leaf dry weight of 24g was produced by a combination of 15kgP/ha and N-rate of 20kgN/ha (Table 5).

4.1.5 Stem dry weight per plant

Maximum stem dry weight was attained at 12 WAS (Figs. 13, 14 and 15). Lime significantly increased stem dry weight. The significant effects were at 8, 10 and 12 WAS in 1995 and at 4, 6, 10 and 12 WAS in 1996 (Fig.13). At 12 WAS, averaged over both years, application of 500 and 1000kg/ha significantly increased stem dry weight by 14% and 27% respectively over the control.

Nitrogen application significantly influenced stem dry weight in 1995 and 1996. (Fig. 14). The mean for the two years shows that nitrogen nutrition of cowpea significantly increased stem dry

Fig.13 STEM DRY WEIGHT AS INFLUENCED BY DIFFERENT LEVELS OF LIME IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS



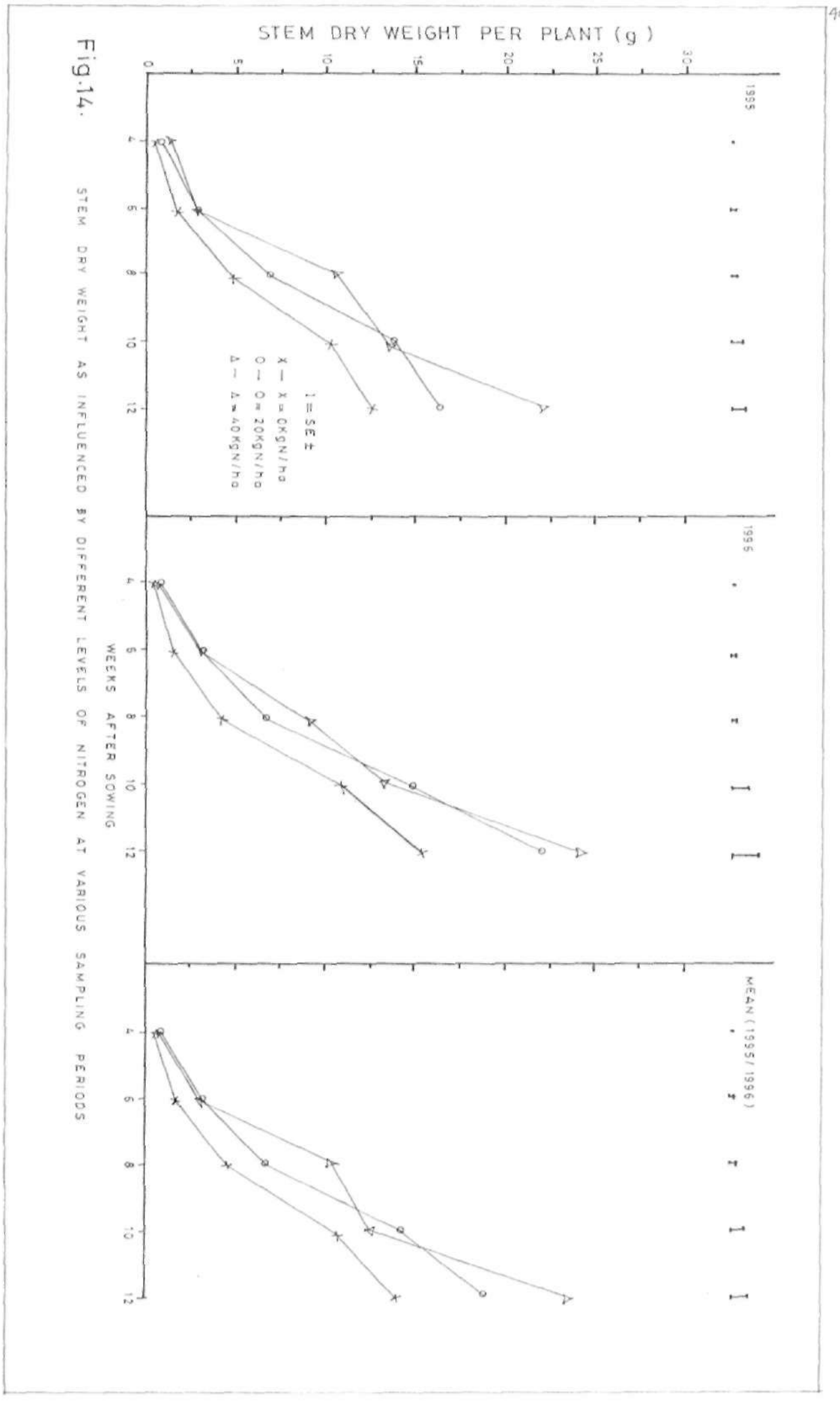


Fig.14. STEM DRY WEIGHT AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN AT VARIOUS SAMPLING PERIODS

Fig.15 THE EFFECTS OF DIFFERENT LEVELS OF PHOSPHORUS ON STEM DRY WEIGHT AT VARIOUS SAMPLING PERIODS AT SAMARU

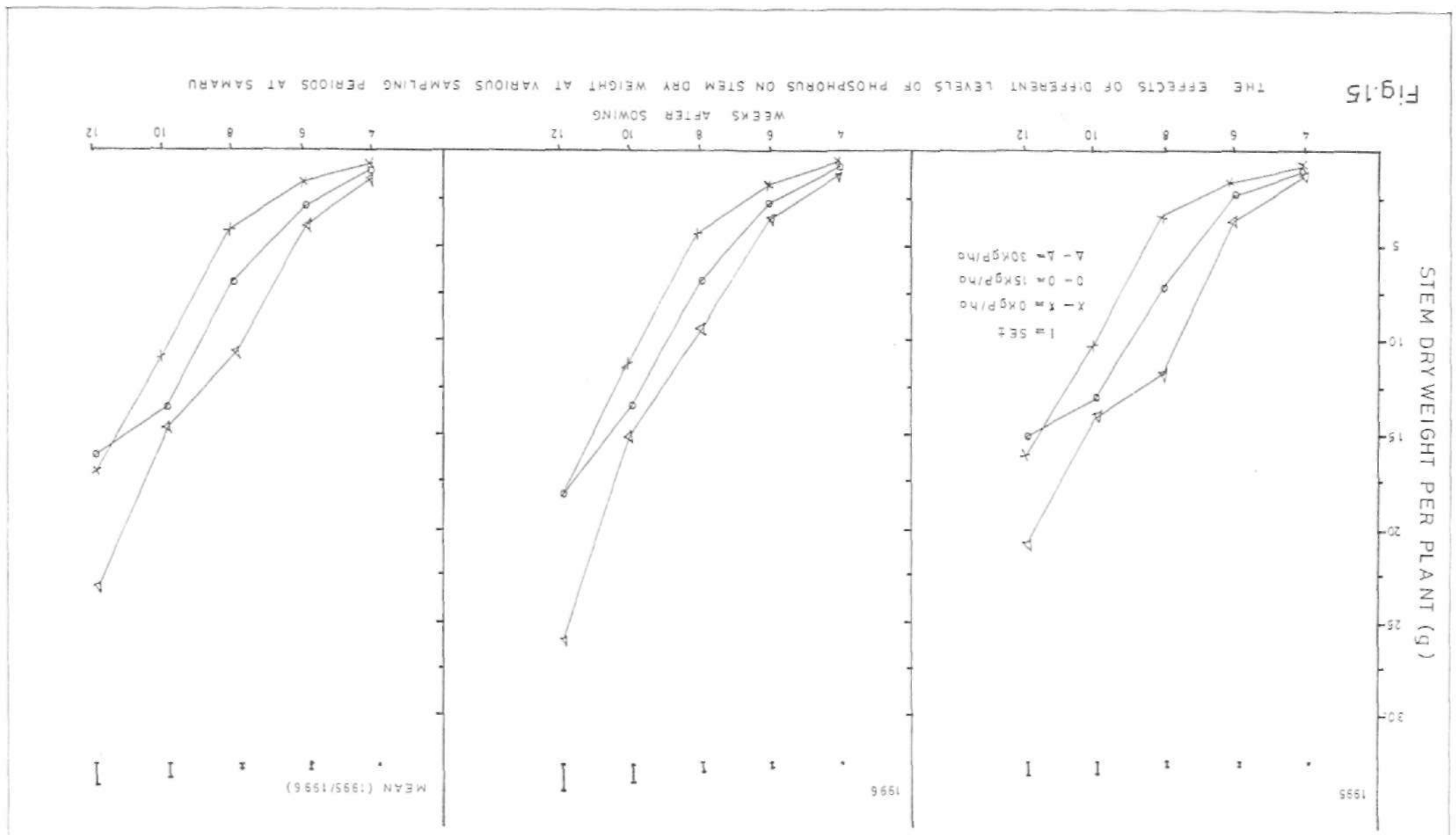


Table 6: Interaction between nitrogen and phosphorus on stem dry weight(g) per plant at 8 weeks after sowing.

1995			
Treatments	Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	2.28e	3.97d	3.98a
15	4.49d	6.17c	10.58b
30	7.42c	11.60b	16.80a
SE +	0.37		

1996			
	Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	3.18c	4.61ba	4.88bc
15	4.06bc	5.91b	10.38a
30	5.71b	10.22e	11.06a
SE +	0.62		

1995/96			
	Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	2.88e	4.29de	4.43d
15	4.27de	6.04c	10.48b
30	6.57c	10.91b	13.93a
SE +	0.43		

Means followed by the same letter(s) are not significantly different at 5%.

weight of cowpea throughout growth. At 12 WAS, the mean show that applying 20kgN/ha increased stem dry weight significantly by 39% and doubling the N-rate to 40kg/ha further significantly increased stem dry weight by 65%.

Stem dry weight was significantly increased by the application of phosphorus (Fig.15). Phosphorus increased stem dry weight significantly throughout growth in 1995 and in 1996, it was only at 10 WAS that the increase in stem dry weight was not significant. Across the years the stem dry weight of cowpea was significantly increased throughout the sampling period and at 12 WAS, application of 30kgP/ha significantly increased stem dry weight by 37% over the control and the lower P-rate of 15kg/ha.

The interaction between nitrogen and phosphorus was significant on stem dry weight (Table 6), in both years. The means shows that a combination of the highest N-rate of 40kg/ha and the highest P-rate of 30kg/ha produced the highest stem dry weight of 14g at 8 WAS.

4.1.5 Root dry weight per plant

Lime positively influenced root dry weight (Fig. 16). The effect of lime on root dry weight was significant at 4, 6, 10 and 12 WAS. Averaged over the years, at 12 WAS, lime rate of 500kg/ha significantly increased root dry weight by 13%. There was no

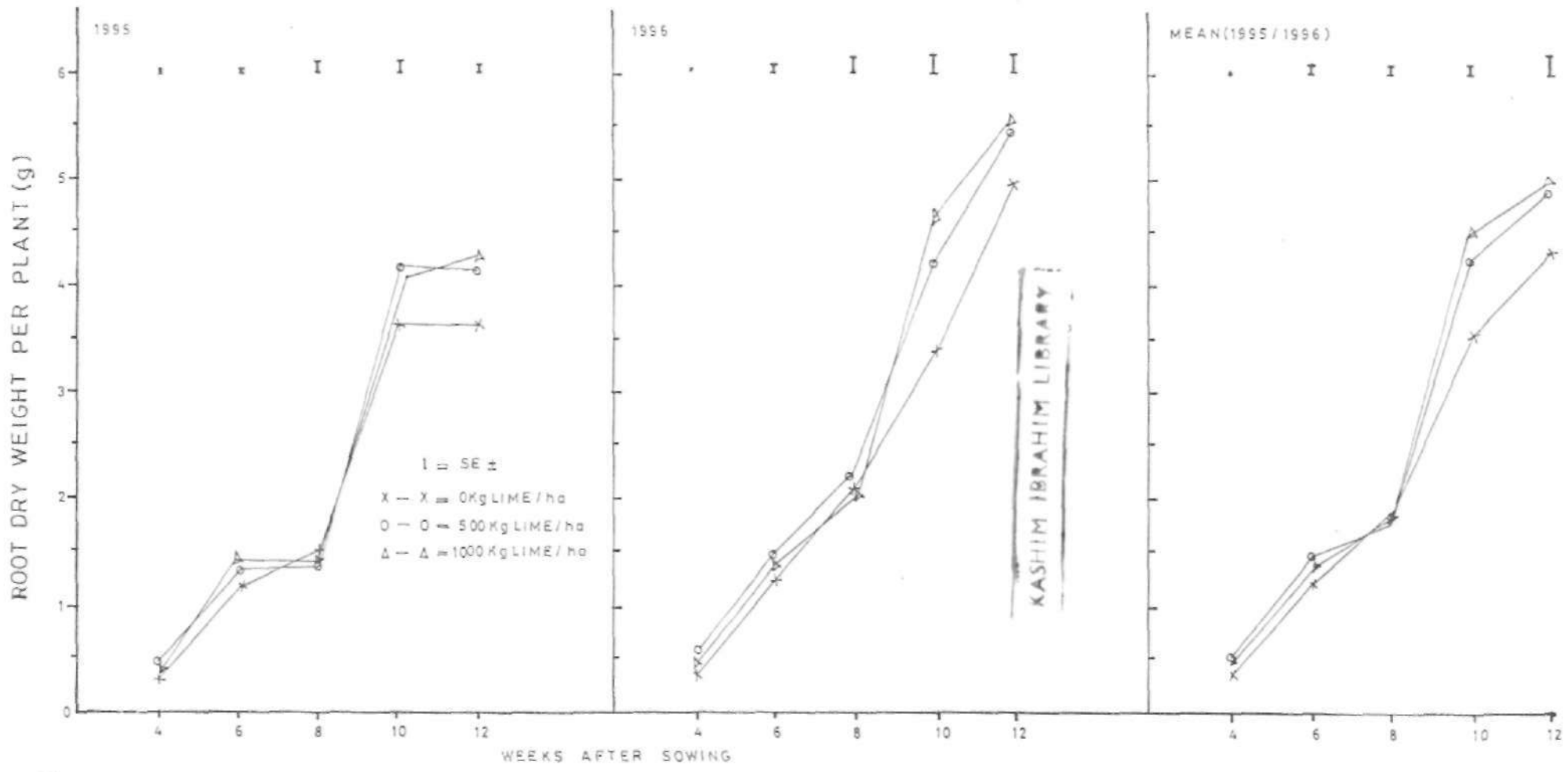


Fig.16 THE EFFECTS OF DIFFERENT LEVELS OF LIME ON ROOT DRY WEIGHT IN DIFFERENT YEARS

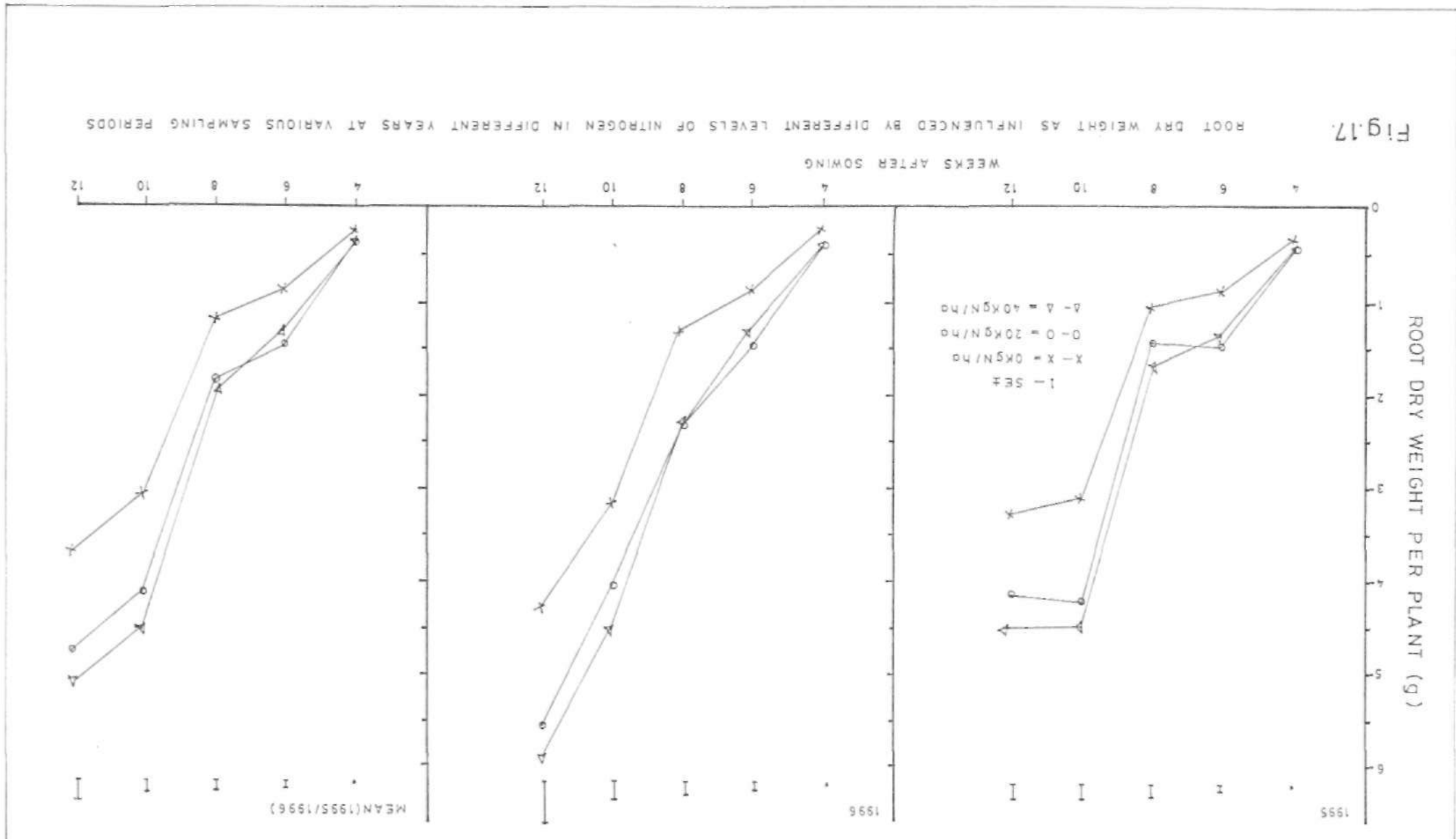


Fig.17. ROOT DRY WEIGHT AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS

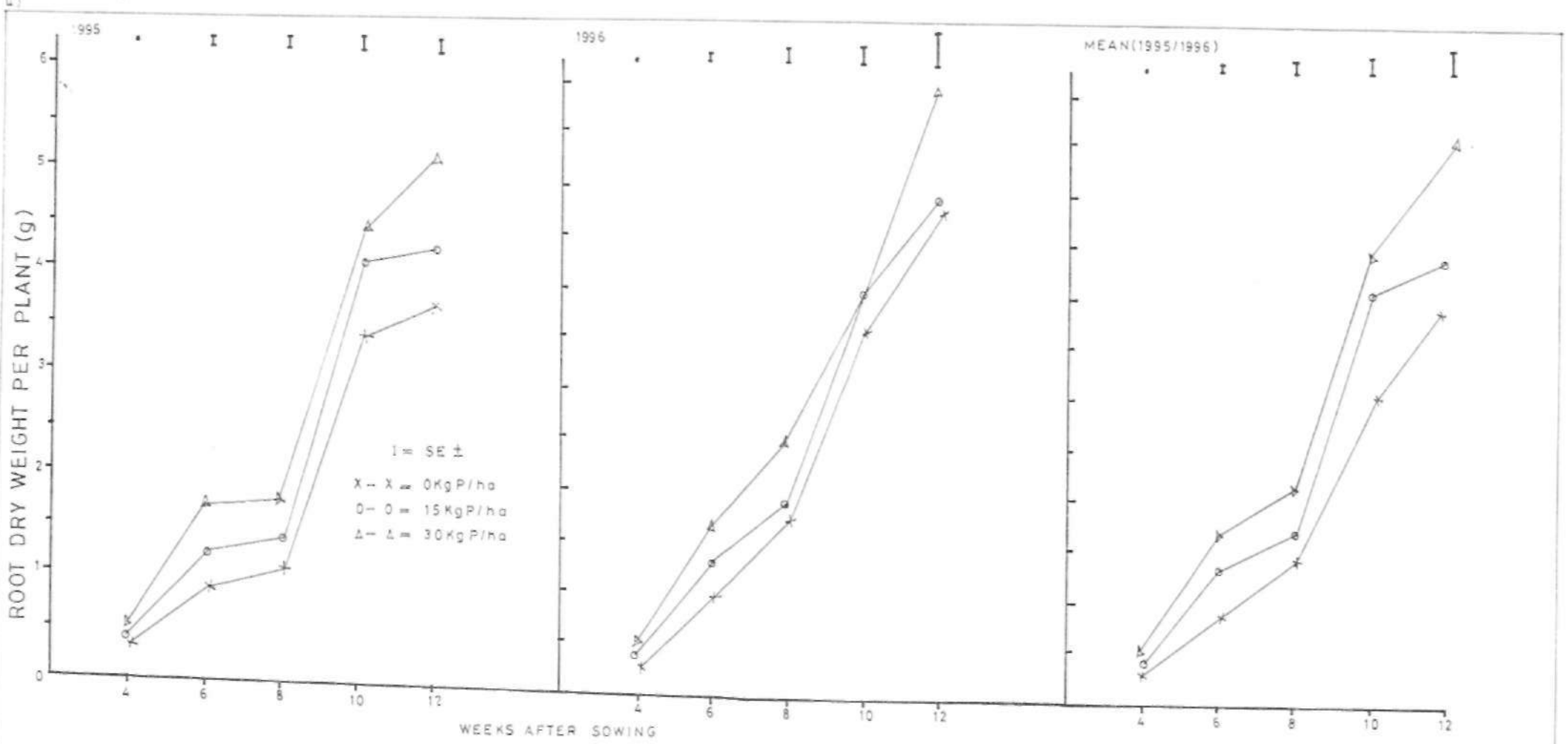


Fig.18 THE EFFECTS OF DIFFERENT LEVELS OF PHOSPHORUS ON ROOT DRY WEIGHT IN DIFFERENT YEARS AT VARIOUS SAMPLING PERIODS

significant effect of lime on root dry weight above 500kg/ha.

Similarly, the application of nitrogen to cowpea increased the root dry weight significantly throughout growth in both years (Fig.17). At 12 WAS, the mean shows that N-rate of 20kg/ha significantly increase root dry weight by 28.5%. There was no further significant increase above this rate.

Phosphorus application to cowpea significantly increased root dry weight in both years (Fig. 18). Average over both years, phosphorus positively and significantly increased root dry weight throughout growth. At 12 WAS, P-rate of 15kg/ha and 30kg/ha increased root dry weight significantly by 23.5% and 67% respectively when compared with the control in 1995 but the effect was not significant in 1996. The mean shows that there was no significant difference in root dry weight when the cowpea was given 15kgP/ha and the control. However, doubling the P-rate to 30kg/ha significantly increased root dry weight by 42% over the control.

4.1.7 Number of nodules per plant

The number of root nodules per plant was highest at 8 WAS (Fig.19). The effect of lime on the number of root nodules was not consistent, though lime tended to increase the number of root nodules only at 6 WAS in 1995 and at 6, 8 and 10 WAS in 1996. Averaged over the two years, at 8 WAS, increasing the lime rate from zero to 500kg/ha increase root nodule number by 10.8% but the increase was not significantly different from the control. However, increasing lime rate from 500kg/ha to 1000kg/ha reduced the number of root nodules, though the reduction was not significant when compared with the control.

Nitrogen application reduced nodule number in both years (Fig.19). Application of 20kgN/ha reduced nodule number by 50% and 39% in 1995 and 1996 respectively at 8 WAS. Averaged of both years, application of 20kgN/ha reduced nodule number by 31%. In both years, there was no further significant decrease in the number of root nodules when the N-rate was doubled. Application of phosphorus fertilizer increased the number of root nodules significantly in both years. Increasing P-level from zero to 15kgP/ha increased root nodule number significantly by 25%. However, further increase in P-level to 30kgP/ha reduced nodule number significantly when compared with the control.

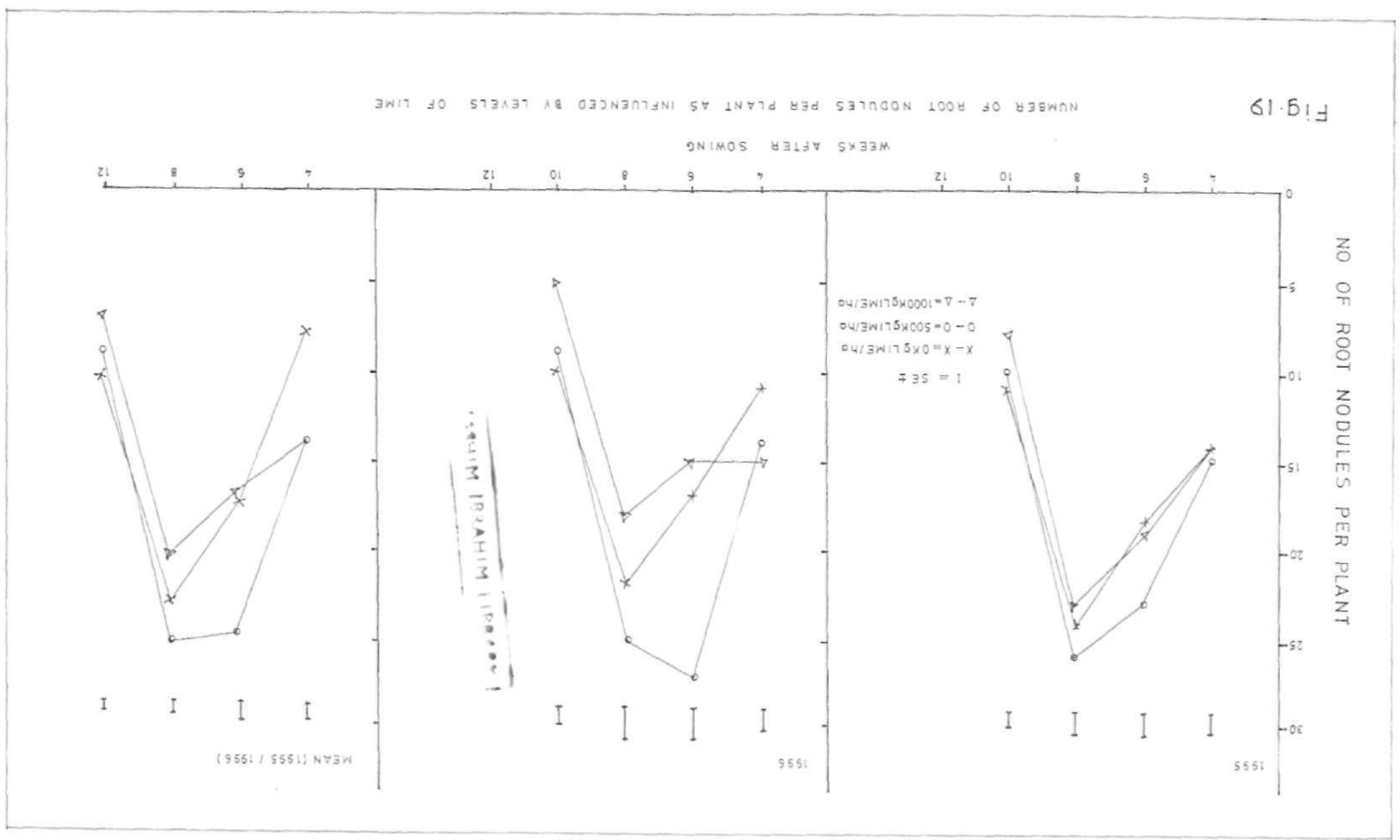
4.1.8 Leaf area index (LAI)

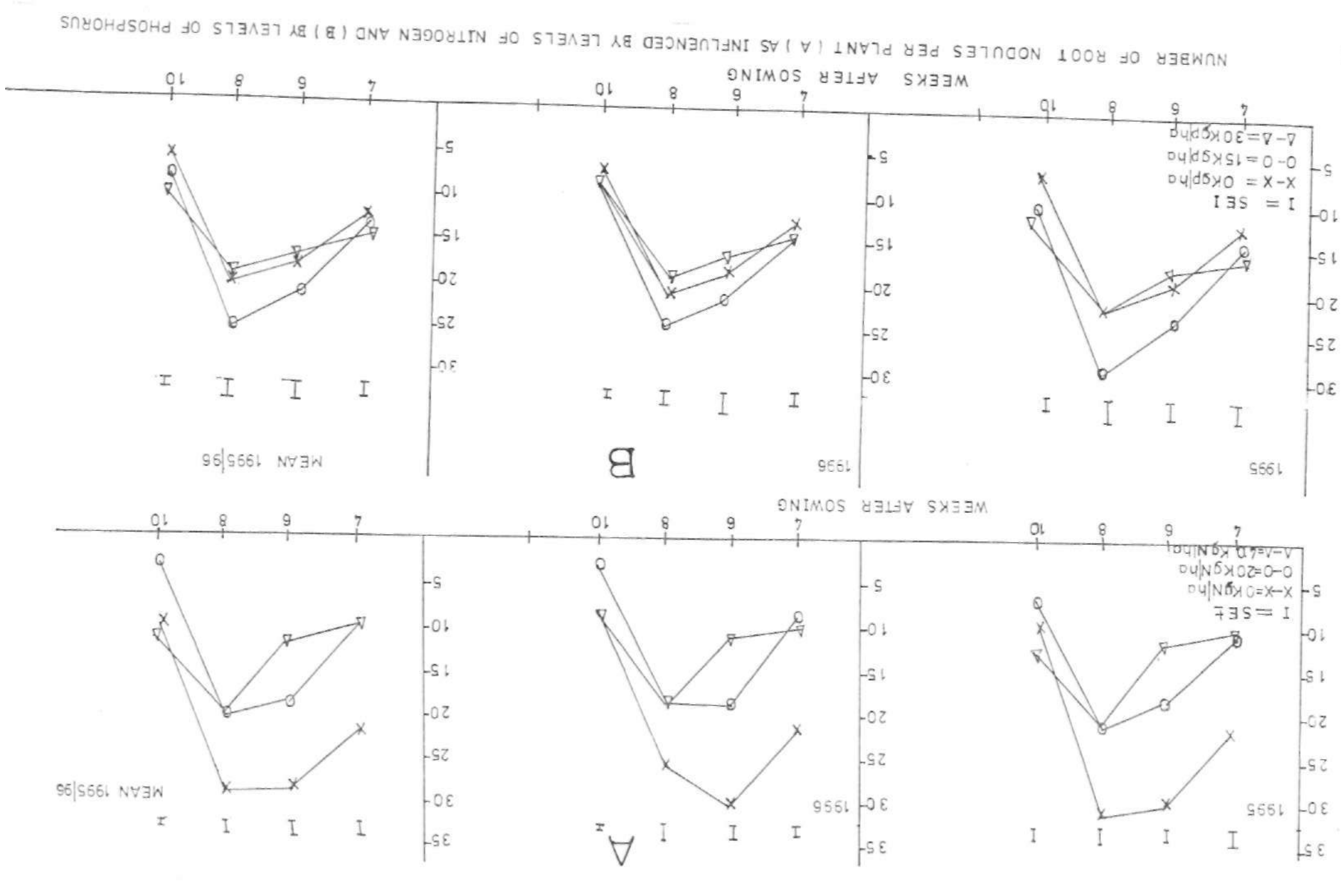
Leaf area index (LAI) increased linearly from 4 WAS, peaked at 10 WAS and thereafter declined (Figs. 21, 22, 23). Liming the soil increased LAI in both years (fig. 21). Across the years, application of 1000kg/ha of lime increased LAI by 25.6% over the control at 10 WAS, but there was no significant difference between the control and the lower lime rate of 500kg/ha.

Application of nitrogen increased leaf area index in both years (fig.22). Nitrogen rate of 20kg/ha increased leaf area index by 7.5 and 24% in 1995 and 1996 respectively. Across the years, 20kgN/ha increased LAI by 45% compared with the control without nitrogen at 10 WAS, but increasing the N-rate to 40kg/ha confered no further increased in LAI.

Application of 15kgP/ha increased LAI by 31% in 1995 when compared with the control and there was no further significant

Fig.19


NUMBER OF ROOT NODULES PER PLANT AS INFLUENCED BY LEVELS OF LIME
WEEKS AFTER SOWING
NO OF ROOT NODULES PER PLANT
1 = SE ±
X – X = 0KG LIME/ha
O – O = 500KG LIME/ha
Δ – Δ = 1000KG LIME/ha
1955
1956
MEAN (1955 / 1956)


NUMBER OF ROOT NODULES PER PLANT (A) AS INFLUENCED BY LEVELS OF NITROGEN AND (B) BY LEVELS OF PHOSPHORUS
WEEKS AFTER SOWING
1 = SE I
X-X = 0Kgp/ha
O-O = 15KgP/ha
Δ-Δ = 30KgP/ha
1995
1996
MEAN 1995/96
A
B
1 = SE I
X-X = 0 KgN/ha
O-O = 20KgN/ha
Δ-Δ = 40 KgN/ha

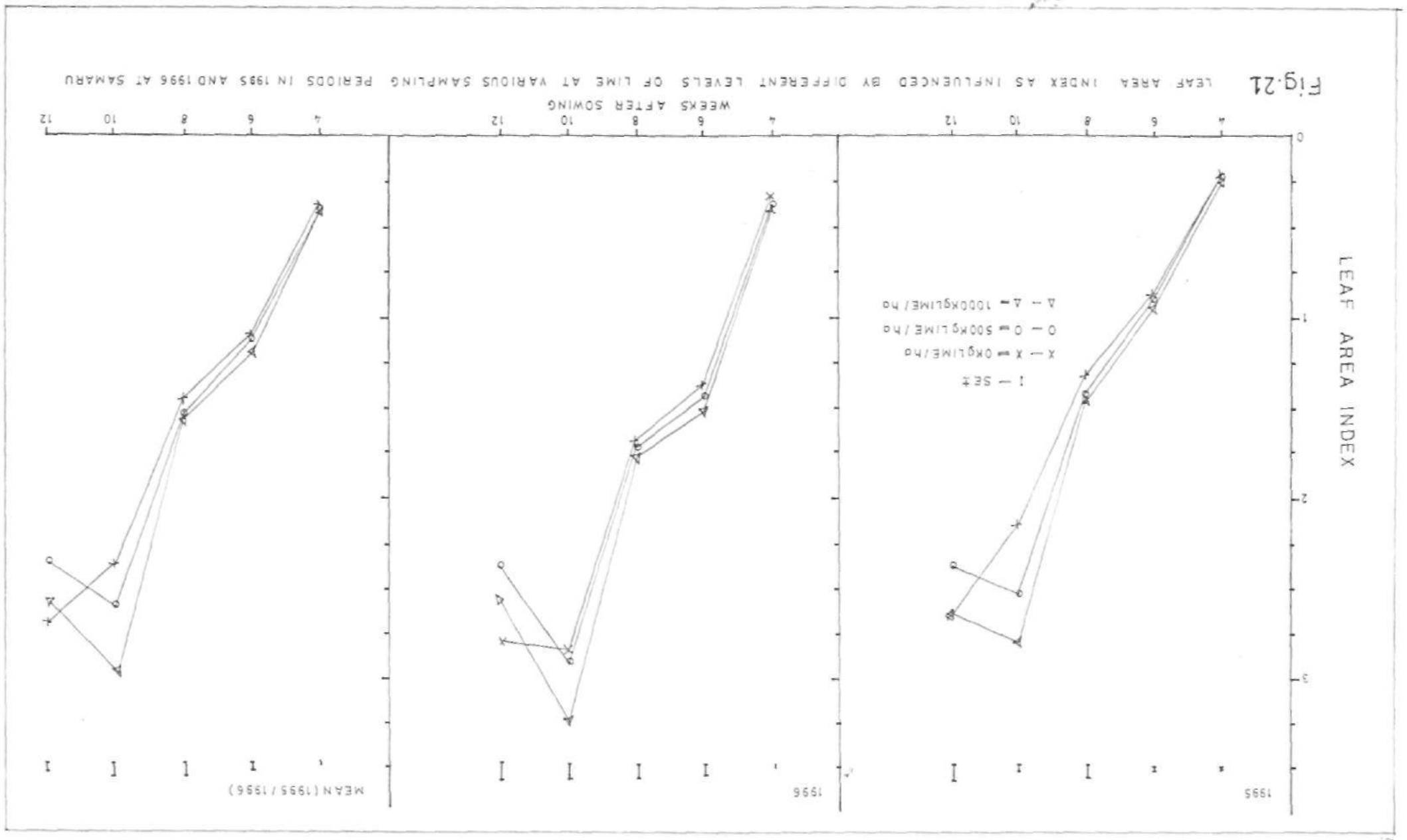


Fig.21 LEAF AREA INDEX AS INFLUENCED BY DIFFERENT LEVELS OF LIME AT VARIOUS SAMPLING PERIODS IN 1995 AND 1996 AT SAMARU

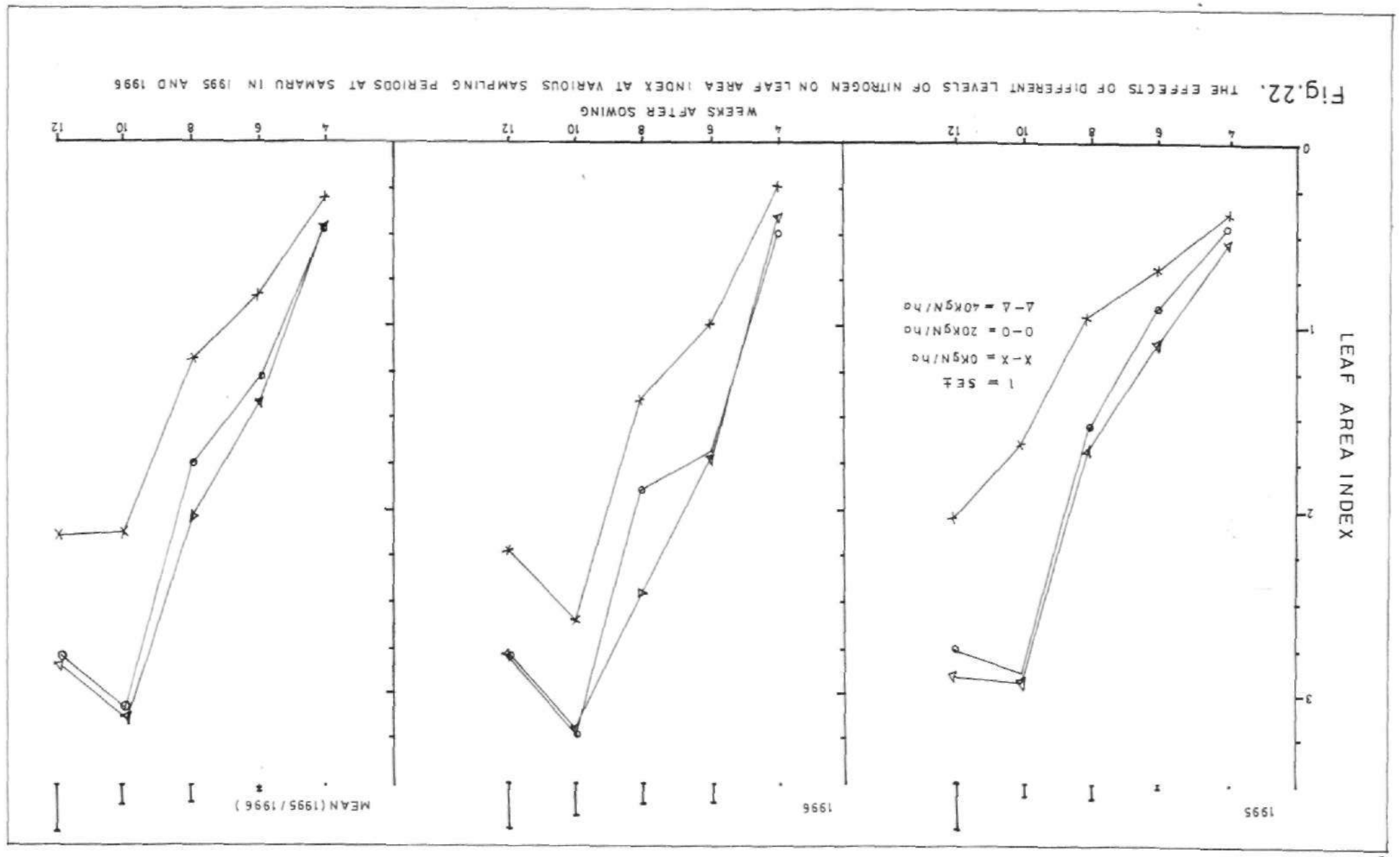


Fig.22. THE EFFECTS OF DIFFERENT LEVELS OF NITROGEN ON LEAF AREA INDEX AT VARIOUS SAMPLING PERIODS AT SAMARU IN 1995 AND 1996

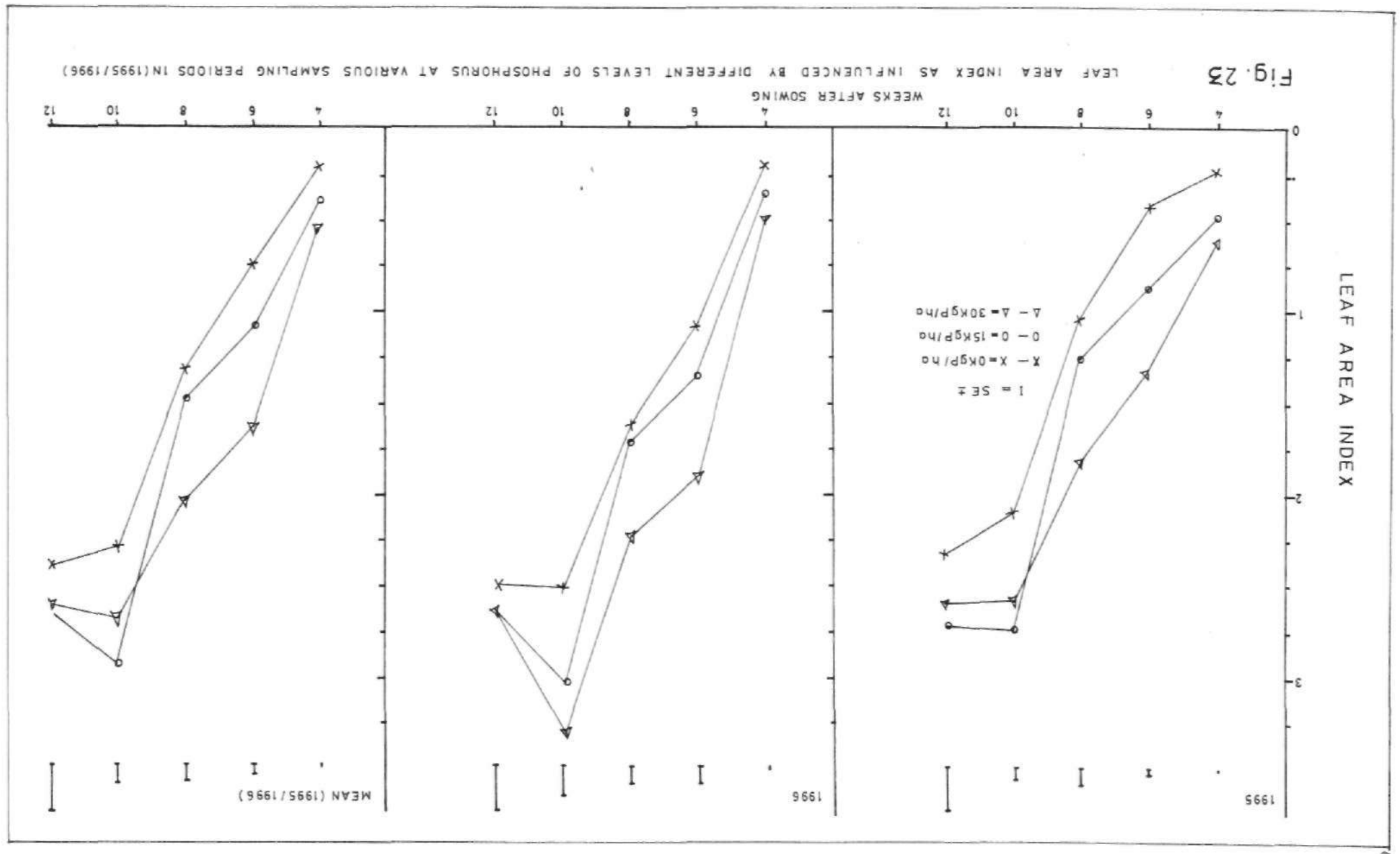


Fig. 23 LEAF AREA INDEX AS INFLUENCED BY DIFFERENT LEVELS OF PHOSPHORUS AT VARIOUS SAMPLING PERIODS IN(1995/1996)

response above this rate. In 1996, significant response was observed only at the highest P-rate of 30kgP/ha which increased LAI by 32% over the control. Averaged over the years 15kgP/ha increased LAI by 24% compared with the control without P. There was no significant difference in LAI between 15kgP/ha and 30kgP/ha.

4.1.9 Total dry matter per plant at harvest:

Total dry matter (TDM) was significantly increased by lime in 1996 only, where 1000kg/ha increased TDM by 14% but there was no significant difference in TDM between the control and 500kg/ha. The mean shows that lime significantly increased TDM where lime rate of 500kg/ha increased TDM by 19% (Table 7).

Similarly, application of nitrogen significantly increased TDM in both years. In 1995, the application of 20kgN/ha and 40kgN/ha significantly increased TDM by 13.4 and 48% respectively over the control. However, in 1996 and across both years, the nitrogen rate of 20kg/ha produced plants whose dry weights were significantly heavier than the control by 26% and 21.4% respectively but there was no further significant response above 20kgN/ha).

Total dry matter per plant at harvest was significantly increased by the application of phosphorus in 1995 but not in 1996. Across the years, 15kgP/ha significantly increased TDM by 40% but there was no further increase above this rate.

Total dry matter was significantly influenced by the interaction between nitrogen and phosphorus (Table 8). The mean for both years shows that the highest TDM of 53g was produced by the combination of the highest N-rate of 40kg/ha and the highest P-rate of 30kg/ha.

Table 7: Effects of lime, nitrogen and phosphorus on Total dry matter (TDM) per plant (g).

Lime (kg/ha)	1995	1996	1995/96
0	29.28	45.83b	35.55b
500	31.00	49.31ab	42.15a
1000	30.96	52.14a	41.55a
SE ±	0.60	1.63	1.12
Nitrogen (kgN/ha)			
0	25.27c	41.33b	33.30b
20	28.64b	50.21a	40.42a
40	67.34a	53.74a	45.54a
SE +	0.84	3.57	2.07
Phosphorus (kgP/ha)			
0	22.63c	44.20	30.67b
15	28.06b	49.27	41.67a
30	40.55a	53.80	47.18a
SE +	0.84	3.57	2.07

Means followed by the same letter(s) within a treatment are not significantly different at 5%.

NS - Not significant at 5%.

Table 8: Interaction between nitrogen and phosphorus on the total dry matter per plant at harvest (g).

Treatments	1995 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	23.66de	21.97e	22.27e
15	20.28e	28.09cd	35.82b
30	31.87bc	35.86b	53.92a
SE ±	1.47		

	1996 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	38.50b	49.07ab	63.04a
15	37.28b	46.48ab	46.06ab
30	48.21ab	61.09a	52.11ab
SE ±	6.18		

	1995/96 combined Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	31.08cd	35.52cd	42.66abc
15	28.78d	37.28bcd	40.94bc
30	40.09bcd	48.47ab	53.02a
SE ±	3.59		

Means followed by the same letters) are not significantly different at 5%.

4.2 Yield and Yield Components

4.2.1 Grain yield (kg/ha)

In both years liming did not affect grain yield significantly.(Table 9).

Nitrogen application increased grain yield significantly in 1995. Application of 20kgN/ha increased grain yield by 17% and doubling the N-rate to 40kg/ha increased grain yield by 25% although the increase in 1996 was not significant. When the mean for the two years was computed, the result shows that nitrogen did not significantly increase cowpea grain yield in this study.

Phosphorus application to cowpea significantly increased cowpea grain yield in both years. In 1995, increasing rate of phosphorus from 15kgP/ha to 30kgP/ha resulted in significant grain yield increase but in 1996 the grain yield stopped responding at the phosphorus rate of 15kg/ha. The mean of the two years shows that phosphorus rate of 15kg/ha increased grain yield by 53% compared with the control and doubling the P-rate to 30kg/ha increased grain yield by 83% when compared with the control.

The interaction between nitrogen and phosphorus was significant on grain yield (Table 10). The highest grain yield of 1060kg/ha was produced by the application of 40kgN/ha and 30kgP/ha respectively.

4.2.2 Number of pods per plant at harvest.

Lime significantly influencd the number of pods per plant in 1995 but the increase in 1996 was not significant (Table 9). The mean for the two years shows that the highest lime rate of

1000kg/ha significantly increased the number of pods per plant by 11%.

Nitrogen significantly increased the number of pods per plant in 1995 but not in 1996. Average over the two years showed a significant effect of nitrogen on the number of pods per plant where N-rate of 20kg/ha increased the number of pods significantly by 16.5% over the control but doubling the N-rate did not result into further significant increase in the number of pods per plant.

Similarly, the number of pods per plant at harvest was increased significantly by 69% by the application of 15kgP/ha in 1995 but the increase in 1996 was not significant. The mean shows that application of 15kg/ha and 30kgP/ha increased the number of pods per plant significantly by 20% and 36% respectively when compared with the control.

4.2.3 Shelling percentage (%)

Neither lime, nitrogen nor phosphorus application to cowpea significantly affect shelling percent (Table 11).

4.2.4 Harvest Index (%)

Lime and nitrogen did not significantly affect harvest index (Table 11). Harvest index was significantly influenced by phosphorus application to cowpea. In 1995, P-rate of 15kg/ha increased harvest index by 5% which was not significantly different from the control. However, the higher P-rate of 30kg/ha significantly depressed harvest index by 12% which was not statistically different from the control. Similarly, in 1996, application of 15kgP/ha resulted into no significant difference in

Table 9: Grain yield (kg/ha) and the number of pods/plant at harvest as influenced by lime nitrogen and phosphorus at Samaru.

	Grain yield (kg/ha			No of pods/plant at harvest		
	1995	1996	1995/96	1995	1996	1995/96
Lime (kg/ha)						
0	763	735	749.0	17.59b	16.08	16.84b
500	822	697	759.0	18.74ab	16.73	16.74b
1000	806	767	787.0	19.99a	17.33	18.66a
SE ±	26.73	44.77	27.30	0.60	0.60	0.47
Sign.	NS	NS	NS		NS	
Nitrogen (kgN/ha)						
0	699c	771	735	15.77b	14.72	15.24b
20	819b	771	765	19.68a	15.85	17.76a
40	873a	717	795	20.87a	17.58	19.22a
SE ±	34.37	40.66	30.34	0.93	0.85	0.72
		NS	NS		NS	
Phosphorus (kgP/ha)						
0	493c	576b	535c	12.26b	16.51	14.29c
15	885b	749a	817b	20.64a	14.50	17.57b
30	1013a	873a	943a	22.80a	17.13	19.97a
SE ±	34.37	40.66	30.34	0.93	0.85	0.72
Sign.					NS	

Means followed by the same letter(s) within a treatment are not significant at 5%.
NS = Not significant at 5%.

Table 10 Interaction between nitrogen and phosphorus on grain yield in (kg/ha).

Treatments	1995 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	241.00d	294.0d	342.0d
15	583.00c	895.0b	1179.0a
30	1198.00a	1192.0a	1248.0a
SE ±	59.48		

	1996 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	534b	523b	671ab
15	795a	695ab	758ab
30	904a	843a	872a
SE ±	70.4		

	1995/96 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	388c	409c	507c
15	689b	795b	968a
30	1051a	1018a	1060a
SE ±	52.6		

Means followed by the same letter(s) are not significantly different at 5%.

harvest index when compared with the control. The average for the two years reveals that P-rate of 15kg/ha increased harvest index but the increase was not significantly different from the control. Further increase in P-rate to 30kg/ha significantly depressed harvest index by 16.4%.

4.2.5 Number of seeds per pod

Neither lime nor nitrogen affected the number of seeds per pod in this study, (Table 12).

The number of seeds per pod was significantly increased by phosphorus in 1995 but not in 1996. The mean of the two years shows that 15kgP/ha increased the number of seeds/pod by 15% and there was no further response above 15kgP/ha.

4.2.6 One hundred (100) seed weight.

Application of lime, nitrogen and phosphorus did not significantly affect 100 seed weight (Table 12).

4.2.7 Days to 50% flowering.

Lime did not significantly influence days to 50% flowering in 1995 but the effect was significant in 1996 (Table 13). The mean for the two years shows that lime rate of 500kg/ha delayed the attainment of 50% flowering by 0.04 days which was not significantly different from the control but doubling the lime rate significantly delayed 50% flowering by 0.6 day.

Similarly, 50% flowering was also delayed significantly by the application of nitrogen to cowpea in both years. The mean shows a

Table 11: Effects of lime, nitrogen and phosphoruson shelling percentage and harvest index of cowpea at Samaru.

	Shelling percentage (%)			Harvest index (%)		
	1995	1996	1995/96	1995	1996	1995/96
Lime (kg/ha)						
0	74.86	75.07	74.96	41.66	46.04	43.85
500	75.07	74.42	74.75	42.17	41.59	41.88
1000	75.33	72.49	73.91	44.15	44.2	44.24
SE ±	0.82	1.32	0.72	1.27	1.54	1.10
Sign.	NS	NS	NS		NS	NS
Nitrogen (kgN/ha)						
0	74.74	73.59	74.16	45.53	46.08	45.40
20	75.58	75.41	75.49	41.19	45.81	43.50
40	74.95	72.97	73.96	41.27	40.06	40.66
SE ±	0.91	1.29	1.00	1.93	2.07	1.57
	NS	NS	NS	NS	NS	NS
Phosphorus (kgP/ha)						
0	74.66	74.41	74.56	43.56ab	47.89a	45.73a
15	75.48	74.68	75.08	45.84a	46.13ab	45.99a
30	75.13	72.89	74.01	38.57b	37.9ab	38.35b
SE ±	0.94	1.29	1.00	1.93	2.07	1.57
	NS	NS	NS			

Means followed by the same letter(s) within a treatment are not significant at 5%.

NS = Not significant at 5%.

Table 12: Number of seeds/pod, 100 seed weight(g) as affected by Lime, Nitrogen and phosphorus.

	No. of seeds/pod.			100 sed weight.		
	1995	1996	1995/96	1995	1996	1995/96
Lime (kg/ha)						
0	9.48	8.24	8.86	16.35	17.73	17.04
500	9.80	7.88	8.84	16.18	17.50	16.84
1000	10.05	8.34	9.19	16.11	17.44	16.78
SE ±	0.19	0.05	0.18	0.11	0.25	0.14
Sign.	NS	NS	NS	NS	NS	NS
Nitrogen (kgN/ha)						
0	9.41	8.29	8.85	16.02	17.21	16.61
20	10.27	8.13	9.20	16.30	17.16	17.03
40	9.64	8.03	8.84	16.32	17.70	17.01
SE ±	0.28	0.33	0.24	0.11	0.35	0.18
	NS	NS	NS	NS	NS	NS
Phosphorus (kgP/ha)						
0	8.24b	8.24	8.24b	16.35	17.74	17.04
15	10.71a	8.23	9.47a	16.10	17.45	16.78
30	10.37a	8.98	9.18a	16.19	17.49	16.84
SE ±	0.28	0.38	0.24	0.11	0.35	0.8
		NS		NS	NS	NS

Means followed by the same letter(s) within a treatment are not significant at 5%.
NS = Not significant at 5%.

significant delay of 1.8 days with the application of 20kgN/ha. There was a further delay in 50% flowering by 3.5 days when the nitrogen rate was doubled.

Application of phosphorus to cowpea significantly delayed the attainment of 50% flowering in both years. The mean shows that P-rate of 15kg/ha delayed attainment of 50% flowering significantly by 1.7 days compared with the control. Further increased delayed 50% flowering by 4.7 days which was significant when compared with the control.

4.3.0 Concentration of Nutrients in Plant

4.3.1 Nitrogen concentration

Lime applictiondid not affect the concentrationn of nitrogen in plant tissues significantly. (Table 14).

Nitrogen nutrition of cowpea significantly depressed N-concentration in plant tissues in 1995 but not in 1996. However, the average for the two years shows that N-rate of 20kg/ha significantly depressed N-concentration in plant tissues but doubling the N-rate to 40kg/ha increased N-concentration but the increase was statistically the same with the control.

Application of phosphorus increased plant tissue concentration of nitrogen significantly in both years. The result in both years shows that the concentration of N-rate when P-rate is 15kg/ha is not significantly different from the control but N-concentration increased significantly by 4% and 6% in 1995 and 1996 respectively when P-rate was doubled.

Nitrogen concentration in plant tissues was significantly affected by the interaction between lime and phosphorus. (Table 15). The mean shows that the highest nitrogen concentration of 3.47% was produced by the application of 1000kg/ha of lime and 15kgP/ha. There was also a significant interaction between lime, nitrogen and phosphorus on nitrogen concentration in plant tissues, (Table 16). Averaged over the two years shows that the highest nitrogen concentration of 3.69% was produced by the combination of 1000kg/ha, 40kgN/ha and 15kgP/ha.

4.3.2 Phosphorus concentration

Phosphorus concentration in plant tissues was not significantly affected by the application of lime (Table 14).

Nitrogen nutrition of cowpea depressed phosphorus concentration in both years. N-rate of 20kg/ha depressed P-concentration significantly but further increase in N-rate to 40kg/ha did not result into further significant depression.

Though not significantly, phosphorus concentration in plant tissues was depressed by the application of fertilizer phosphorus in both years. Application of phosphorus did not have significant affect on plant tissues concentration of phosphorus.

Table 13 Days to 50% flowering as affected by lime, nitrogen and phosphorus.

Lime (kg/ha)	1995	1996	1995/96
0	53.07	52.22b	52.65b
500	52.81	52.56a	52.69b
1000	53.44	53.00a	53.22a
SE ±	0.21	0.14	0.15
	NS		
Nitrogen (kgN/ha)			
0	51.63c	50.52c	51.07c
20	52.93b	52.89b	52.91b
40	54.78a	54.37a	54.57a
SE +	0.30	0.29	0.21
Phosphorus (kgP/ha)			
0	31.20c	50.15c	50.72c
15	53.04b	51.32b	52.43b
30	55.00a	55.82a	55.41a
SE +	0.30	0.29	0.21

Means followed by the same letter(s) within a treatment are not significantly different at 5%.

NS - Not significant at 5%.

Table 14: Percentage concentration of Nitrogen and phosphorus in plant tissues as influenced by lime, Nitrogen and phosphorus.

	Nitrogen concentrations (%)			Prosphorus concentrations (%)		
	1995	1996	1995/96	1995	1996	1995/96
Lime (kg/ha)						
0	3.33	3.29	3.31	0.38	0.40	0.39
500	3.28	3.24	3.26	0.40	0.38	0.39
1000	3.38	3.38	3.38	0.37	0.38	0.38
SE ±	0.04	0.06	0.04	0.01	0.01	0.01
Sign.	NS	NS	NS	NS	NS	NS
Nitrogen (kgN/ha)						
0	3.40a	3.33	3.36a	0.41a	0.43a	0.42a
20	3.23b	3.24	2.23b	0.27b	0.37b	0.37b
40	3.37b	3.38	3.36a	0.36b	0.37b	0.37b
SE ±	0.03	0.05	0.04	0.01	0.01	0.01
		NS				
Phosphorus (kgP/ha)						
0	3.26b	3.20b	3.23b	0.40	0.39	0.40
15	3.34b	3.33b	3.34b	0.38	0.40	0.39
30	3.39a	3.39a	3.39a	0.37	0.37	0.37
SE ±	0.03	0.05	0.04	0.01	0.01	0.01
Sign.				NS	NS	NS

Means followed by the same letter(s) within a treatment are not significant at 5%.
NS = Not significant at 5%.

Table 15: Interaction between nitrogen and phosphorus on percentage concentration of Nitrogen in plant tissues (%).

Treatments	1995 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	3.38bc	3.44ab	3.35bc
15	3.45ab	3.03c	3.54a
30	3.16de	3.35bc	3.26cd
SE ±	0.15		

	1996 Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	3.32	3.27	3.34
15	3.40	3.20	3.41
30	3.15	3.27	3.40
SE ±	0.10		

	1995/96 combined Nitrogen (kgN/ha)		
Phosphorus (kgP/ha)	0	20	40
0	3.35ab	3.35ab	3.34ab
15	3.42a	3.11c	3.47a
30	3.15bc	3.31abc	3.33ab
SE ±	0.06		

Means followed by the same letters) are not significantly different at 5%.

Table 16: Interaction between lime, nitrogen and phosphorus on nitrogen concentration in plant tissues

	Phosphorus (kgP/ha) 1995								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	3.28d-h	3.43a-g	3.44a-g	3.34b-h	3.51a-f	3.49a-g	3.74ab	2.58i	3.17e-h
500	3.27e-h	3.70a-d	3.36b-h	3.11f-h	3.07gh	3.92hi	3.50a-f	3.22eh	3.33b-f
100	3.31c-h	3.52a-f	3.21e-h	3.72a-c	3.05gh	3.84a	3.30c-h	2.94hi	3.55a-f
SE ±					0.12				

	Phosphorus (kgP/ha) 1996								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	3.49	3.23	3.24	3.06	3.62	3.51	3.48	2.74	3.21
500	3.23	3.38	3.22	3.21	3.33	3.04	3.41	3.04	3.35
100	3.59	3.21	3.58	3.12	3.53	3.33	3.08	3.08	3.78
SE ±					0.17				

	Phosphorus (kgP/ha) 1995/1996								
	0			15			30		
Nitrogen (kgN/ha)									
Lime kg/ha	0	20	40	0	20	40	0	20	40
0	3.38a-i	3.33b-j	3.34a-j	3.20e-j	3.57a-e	3.50a-e	3.61a-d	2.66k	3.19e-j
500	3.23e-j	3.54a-f	3.29d-j	3.16g-j	3.20e-j	3.00jk	3.46a-h	3.13h-j	3.34a-j
100	3.26d-j	3.56a-f	3.21e-j	3.65a-c	3.09ij	3.69a	3.30e-j	3.0ijk	3.67ab
SE ±					0.1				

Means followed by the same letter(s) are not significantly different at 5%.

4.3.3 Calcium concentration

Lime and nitrogen did not have significant effect on the concentration of calcium in cowpea tissues in this study. (Table 17).

Calcium concentration in plant tissues was significantly increased by the application at phosphorus in 1995 when the highest P-rate of 30kg/ha increased calcium concentration in plant tissues by 29% but the increased was not significant.

4.3.4 Magnesium concentration

Lime did not significantly influenced the concentration of Mg in plant tissues. (Table 17).

Nitrogen nutrition increased concentration of magnesium in both years. The significant response was only at the highest N-rate of 40kg/ha where magnesium concentration was increased significantly by 21% and 12% in 1995 and 1996 respectively.

Similarly, magnesium concentration in plant tissues was increased by the application of phosphorus. The highest P-rate of 30kg/ha increased Mg concentration significantly by 19% and 30% in 1995 and 1996 respectively but not the lower rate which was statistically not different from the control.

Table 17: Percentage concentration of calcium (Ca) and Magnesium (Mg) in plant tissues as influenced by lime, nitrogen and phosphorus.

	% Calcium			% Magneium		
Levels of Lime (kg/ha)	1995	1996	1995/96	1995	1996	1995/96
0	1.00	0.99	1.00	0.47	0.46	0.46
500	1.00	0.97	1.03	0.49	0.40	0.44
1000	0.98	1.01	1.00	0.43	0.41	0.42
SE +	0.06	0.03	0.03	0.02	0.02	0.02
	NS	NS	NS	NS	NS	NS
Levels of Nitrogen(kgN/ha)						
0	1.05	0.93	0.99	0.44b	0.42b	0.43b
20	0.97	1.03	1.00	0.42b	0.39b	0.40b
40	1.05	1.01	1.03	0.53a	0.47a	0.50a
SE ±	0.07	0.07	0.07	0.02	0.02	0.02
		NS	NS			
Levels of Phosphorus (kgP/ha)						
0	0.92b	0.95	0.04	0.43b	0.37b	0.40b
15	0.96b	0.96	0.96	0.45b	0.43b	0.44b
30	1.19a	1.06	1.12	0.51a	0.48a	0.49a
SE ±	0.07	0.07	0.07	0.02	0.02	0.02
Sign.				NS	NS	NS

Means followed by the same letter(s) within a treatment are not significant at 5%.
NS = Not significant at 5%.

4.4.0 Correlation and Regression:

Simple correlation analyses of grain yield and important plant characters were made and the results presented in (Table 18, 19 and 20 respectively. The correlation shows that there was a positive and highly significant correlation between grain yield and the number of pods per plant, number of seeds per pod, total dry matter per plant at harvest, number of primary branches per plant at 12 WAS, plant height at 12 WAS, number of leaves per plant at 12 WAS in 1995. In 1996, the result was similar, positive and highly significant correlation wsith grain yield was between number of pods per plant, number of primary branches per plant and the number of leaves per plant at 12 WAS.

The mean for the two years shows that there was a positive and highly significant correlation between grain yield and number of pods/plant at harvest, number of seeds/pod, total dry mater/plant at harvest, number of primary branches per plant at 12 WAS, plant height at 12 WAS and number of leaves per plant at 12 WAS. The seed weight, leaf areas index (LAI) were significantly correlated with grain yield in 1995, 1996 and the mean. Number of seeds per pod was positively and significantly correlated to grain yield in 1996.

Regression Studies

Subjecting the yield data to regression model, the response was best described by a guadratic function, each model was described by the following equation.

1995	Y	=	493+48.4p -	0.60p2 (R^2 = 78%)
1996	Y	=	576+13.2p -	0.18p2 (R^2 = 23%)
1995/96	Y	=	535+30.8p -	0.40p2 (R^2 = 50%)

From these equations, the optimum P-rate was calculated to be 38.7kgp/ha.

Table 18: Correlation (Matrix) (r) between grain yield and other plant characters of cowpea 1995

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Grain Yield (kg/ha	1.00											
2.	Number of pods/plant at harvest	0.61**	1.00										
3.	Number of seeds/pods at harvest	0.61**	0.51**	-1.00									
4.	100 seed weight	0.23*	0.07	0.10	1.00								
5.	Total dry matter/plant at harvest	0.72**	0.63**	0.27**	0.10	1.00							
6.	Shelling percentage (%)	0.03	0.13	0.18	-0.13	-0.07	1.00						
7.	Harvest Index (%)	0.09	0.13	0.01	-0.05	-0.37**	0.26	1.00					
8.	Number of primary branches/plant at 12 WAS	0.42**	0.15	0.19	0.08	0.36**	0.03	0.20	1.00				
9.	Plant height at 12 WAS	0.56**	0.43**	0.45**	0.08	0.36**	0.01	0.09	0.21	1.00			
10.	Number of leaves/plant at 12 WAS	0.42**	0.49**	0.37**	0.02	0.30**	0.35**	0.03	0.44**	0.14	1.00		
11.	Leaf Area Index at 10 WAS	0.22*	0.35**	0.32**	0.23*	0.17	0.07	0.15	0.18	0.05	0.57**	1.00	
12.	Days to 50% flowering	0.17	0.58**	0.40**	0.03	0.58**	0.11	0.24*	0.43**	0.19	0.43**	0.39**	1.00

** Significant at 5% level of significant. = Significat at 1% level of significant. WAS = Weeks after sowing.

Table 19: Correlation (Matrix) (r) between grain yield and other plant characters of cowpea 1996

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Grain Yield (kg/ha	1.00											
2.	Number of pods/plant at harvest	0.42**	1.00										
3.	Number of seeds/pods at harvest	0.22*	0.24*	1.00									
4.	100 seed weight	0.22*	0.21	−0.19	1.00								
5.	Total dry matter/plant at harvest	0.23*	0.64**	0.35**	0.06	1.00							
6.	Shelling percentage (%)	0.08	0.11	0.02	0.02	0.05	1.00						
7.	Harvest Index (%)	0.18	0.17	0.20	0.04	0.59**	0.45	1.00					
8.	Number of primary branches/plant at 12 WAS	0.35**	0.19	−0.04	0.03	0.36**	0.14	0.09	1.00				
9.	Plant height at 12 WAS	0.27**	0.24*	0.22*	−0.06	0.32**	−0.12	0.27**	0.11	1.00			
10.	Number of leaves/plant at 12 WAS	0.59**	0.41**	0.23*	−0.10	0.60**	−0.07	0.28**	0.35**	0.08	1.00		
11.	Leaf Area Index at 10 WAS	0.22*	0.16	0.15	0.17	0.46**	−0.12	0.18	−0.04	0.14	0.75**	1.00	
12.	Days to 50% flowering	0.19	0.16	0.16**	0.12	0.27**	0.09	0.44**	0.18**	0.38**	0.24**	0.15	1.00

** Significant at 5% level of significant. = Significat at 1% level of significant. WAS = Weeks after sowing.

Table 20: Correlation (Matrix) (r) between grain yield and plant characters of cowpea 1995/1996

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Grain Yield (kg/ha	1.00											
2.	Number of pods/plant at harvest	0.46**	1.00										
3.	Number of seeds/pods at harvest	0.41**	0.39**	1.00									
4.	100 seed weight	0.22*	0.15	0.02	1.00								
5.	Total dry matter/plant at harvest	0.47**	0.63**	0.31**	0.04	1.00							
6.	Shelling percentage (%)	0.02	0.14	0.18	0.01	0.09	1.00						
7.	Harvest Index (%)	0.12	0.16	0.06	0.15	0.35**	0.28*	1.00					
8.	Number of primary branches/plant at 12 WAS	0.40**	-0.12	-0.05	0.12	0.37**	0.07	0.20	1.00				
9.	Plant height at 12 WAS	0.29**	0.35**	0.34**	-0.07	0.25*	-0.13	-0.05**	0.11	1.00			
10.	Number of leaves/plant at 12 WAS	0.48**	0.44**	0.24*	-0.10	0.40**	0.18	-0.29**	0.36**	0.07	1.00		
11.	Leaf Area Index at 10 WAS	0.24*	0.26*	0.24*	0.18	0.33**	-0.09	-0.17	0.14	0.15	0.43**	1.00	
12.	Days to 50% flowering	0.24	0.26**	0.24*	0.08	0.38**	0.10	-0.32**	0.32**	0.20**	0.63**	0.22	1.00

** Significant at 5% level of significant. = Significat at 1% level of significant. WAS = Weeks after sowing.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Vegetative growth

The effect of lime on the vegetative growth of cowpea in Samaru was not consistent except on root dry weight. Even the optimum rate for these parameters was also not consistent. This may be due to the fact that the effect of lime on the soil was not immediate. At peak vegetative growth (12 WAS), the mean reveals that plant height per plant, number of leaves per plant, leaf dry weight per plant and leaf area index were significantly increased by lime rate of 1000kg/ha. This may be due to the eventual enhancement of soil pH and increased availability of phosphorus, Kang (1982). Emil, (1953), earlier reported that rational liming of acid soils promote the availability of their phosphorus whether native or added.

Nitrogen nutrition of cowpea positively and significantly influenced vegetative growth. Number of primary branches per plant, leaf dry weight/plant, stem dry weight/plant, root dry weight/plant, TDM, plant height, number of leaves per plant and leaf area index (LAI) were significantly increased. This is because nitrogen is one of the most essential mineral element utilized by plants. Nitrogen aids in the synthesis of protein amino acids in plants which in turn aid plant growth as observed by Gasser and Williams (1963) who stated that the growth of plants is associated with the amount of nitrogen taken up.

At peak vegetative growth (12 WAS) significant response did not exceed 20kgN/ha for root dry weight, leaf dry weight, number of leaves per plant, number of primary branches/plant and leaf area index, suggesting that 20kgN/ha was enough for growth. This observation is similar to that observed by prassad (1985) in India. Plant height, number of leaves per plant, number of primary branches per plant, leaf dry weight per plant, stem dry weight per plant, root dry weight per plant, total dry matter at harvest and leaf area index were all increased with increasing levels of phosphorus. Cowpea plants that received phosphorus were generally more robust in growth and produced significantly higher vegetative growth characters than those without P. The general effect of phosphorus on cowpea may be due to its ability to promote crop growth and development and consequently enhanced nutrient uptake. Many scientists have reported the positive and significant effect of phosphorus on cowpea growth. Ezedinma, (1965). Singh and Jain, (1966), Yayock, 1975, Kungju et al; (1976), Remison et al;(1980) and Garg et al; (1982).

Parameters such as leaf dry weight per plant, leaf area index and number of primary branches per plant at peak vegetative growth (12 WAS) were not significantly increased above the P-rate of 15kg/ha. This infers that this rate was enough for those parameters.

5.1.1 Interactions Nitrogen Levels x Phosphorus Levels Nitrogen x Phosphorus.

Significant nitrogen x phosphorus interactions were observed in this study. The mean for the two years shows that applying the highest N-rate of 40kg/ha and the highest P-rate of 30kg/ha produced the highest stem dry weight per plant and total dry matter per plant at harvest. This may be due to the fact that both nitrogen and phosphorus are involved in the vigorous growth in the vigorous growth of plants. Similar favorable interaction between nitrogen and phosphorus have been reported by Kumar and Pillai, (1979). The maximum plant height and leaf dry weight per plant were produced by the combination of 20kgN/ha and 15kgP/ha. This may be due to the better balancing ratio between these lower rates which supply enough nitrogen and phosphorus for the enhanced performance of these parameters.

Lime x phosphorus.

The highest number of primary branches per plant was achieved with the combination of 500kg/ha of lime and 15kgP/ha. This could be that the P-rate of 15kg/ha plus the soil P. made more easily available to the plants by the lower lime rate was enough for this parameter.

Lime x nitrogen x phosphorus

Significant interaction between lime, nitrogen and phosphorus was observed in this study. The mean for the two years shows that the highest plant height was produced by a combination of 1000kg/ha of lime, 20kgN/ha and 15kgP/ha. This may be due to the fact that the lower rates of nitrogen and phosphorus were complemented by the

effect on the soil of the highest lime rate which might have enhanced soil pH and increased the availability of both applied and soil phosphorus.

5.1.2 Days to 50% flowering.

Days to 50% flowering was reduced by the application of lime, nitrogen and phosphorus to cowpea in Samaru. Kang and Nangju, (1983), reported a similar finding where they stated that cowpea plants from low P-plots bloomed and mature earlier than those from high P-plots. This may be due to the fact that phosphorus encouraged growth and development especially the roots which enhanced higher absorption of nutrients from the soil. Chiezey et al; (1990), reported delay in the attainment of 50% flowering in soybean by the application of phosphorus. Also nitrogen is known to enhance growth, longer retention of leaves and delay of flower initiation and lime could have created a favourable soil pH for the maximum availability of soil nutrients especially phosphorus.

5.2 Nodulation

Result shows that lime generally tend to increased the number of root nodules in cowpea. Lime rate of 500kg/ha increased root nodule number per plant but was depressed by the higher rates of 1000kg/ha. Kang, (1982) reported that liming improved nodulation and stated that large response to liming were observed with lime rates of 250kg/ha to 1000kg/ha but that higher rates reduced nodulation. This may be because excess lime may tie up phosphorus.

Nitrogen significantly depressed nodule formation. This may be as a result of the inhibitory effect of nitrogen on nodule

formation. This result in similar to what was observed by Agboola, (1977) and Rhodes et al; 1987.

Phosphorus application increased the number of root nodules per plant in Samaru but at a higher rate, root nodule formation was depressed. This indicates that 15kgP/ha was enough for beneficial formation of root nodules in cowpea at Samaru as higher rate significantly depressed nodule formation. Singh and Jain (1966), reported increased nodulation as a result of fertilization of cowpea with phosphorus. However, cowpea is reported to have an optimum phosphorus requirement above which the effect may be detrimental (Doyle, 1966).

5.3 Yield and Yield Components

Lime had significant effect only on the number of pods per plant at harvest though it did not significantly affect the over all grain yield. This may be that it was not all the pods that produced seeds. Nnohan (1986) in Southern Nigeria reported a similar result where liming has no significant effect on yield and yield components.

Nitrogen did not have significant effect on grain yield in the study. Yield was significantly increased in 1995 but the effect of nitrogen on grain yield in 1996 was not significant. Grain yield responded to nitrogen in 1995 probably due to the lower N-content of the soil used (Appendix 3). Nnadi et al; (1981), failed to obtained any significant response to starter nitrogen in Northern Nigeria savannah. However, the number of pods per plant was significantly increased among all the yield parameters. The fact

that it did not result into increase grain yield means that not all the pods produced seeds. Kurdikeri et al; (1973) Srinivas (1988), observed increased in the number of pods per plant with the application of nitrogen.

Grain yield of copwea was significantly increased by phosphorus nutrition. However, the response was more dramatic in 1995. This may be due to the lower P-content of the soil used. Other yield parameters such as the number of pods per plant, number of seeds per pod were also significantly increased by phosphorus. Grain yield per hectare and the number of pods per plant were higher when given the highest P-rate of 30kg/ha while the number of seeds per pod stopped responding to P-after the P-rate of 15kg/ha. The significant effect phosphorus has on cowpea grain yield may be due to the very important roles phosphorus play in being a component of DNA, its involvement in numerous metabolic processes with satisfactory growth and maturation. Similar significant effects of phosphorus on grain yield have been reported by many scientists (Yayock, 1975, Anon, 1977, Tarila, 1977, Katung et al; 1993). These significant increase in grain yield were obtained from different locations in the savannah ecological zone in which 16kgP/ha was observed as optimum P-rate for grain yield (Anon. 1977, Yusuf, 1987). Katung et al; 1993, observed 20kgP/ha as the optimum P-rate for cowpea grain yield. However, in this study, yield was significant even at P-rate of 30kg/ha. This may be due to the relatively low P-content of the soil used, especially in

1995 (Appendix 3). Agboola and Obigbesan (1979), observed that the highest grain yield was obtained at 30kgP/ha (69kgP_2O_5/ha).

5.3.1 Interactions Nitrogen x Phosphorus

Significant nitrogen and phosphorus interaction on grain yield was observed in this study. The mean for the two years shows that applying the highest N-rate of 40kg/ha and the highest P-rate of 30kg/ha gave the highest grain yield of 1060kg/ha. Similar favourable interaction between nitrogen and phosphorus on grain yield have been reported by Katung et al; (1993).

5.4 Harvest index

Neither lime nor nitrogen significantly affected harvest index. This infers that increasing lime and N-rate increased both grain yield and total dry matter by the same magnitude (Chiezey et al; 1990).

Harvest index was significantly depressed by P-rate of 30kgP/ha applied to cowpea. This means that vegetative parts were produced in greater proportion to the seeds. Anon, (1989), reported that high P-rate did not increased seed weight but that biggest seeds were produced when no P was applied at all. This may be due to the fact that the P-rate produce more pods per plant and more but smaller seeds per pod.

5.5 Nutrients concentration in plant tissues

Lime did not affect the concentrations of nitrogen, phosphorus, calcium and magnesium significantly. The lack of significant response means that the plant had enough of these nutrients from the soil even without the moderating effect of lime.

Application of nitrogen reduced N-concentration. This may be due to dilution effect. The bigger the plant caused by N-application, the lower the N-concentration. It may also be due to the significant reduction the application of nitrogen had on the number of root nodules per plant. Agbenin et al; (1990) reported that nitrogen application had no effect on the N-content of cowpea leaves while Willie et al;(1985) reported a decrease in the N-content of leaves with increasing level of nitrogen.

Application of phosphorus significantly increased the concentration of nitrogen in plant tissues in both years. This may be due to the fact that phosphorus help in root development and enhanced nutrient exploitation from the soil. Kang and Nangju (1983) reported that cowpea plants fertilized with phosphorus were found to be rich in many other nutrients such as N,K,Ca, Mn.

Application of nitrogen depressed P-concentration in plant tissues. This may be due to dilution effect. The bigger the plant caused by N-application, the lower the P-concentration. Similar findings have been reported by Willie et al; (1985), who reported decreased in the leaf concentration of N, P and K with increasing rate of nitrogen. The application of phosphorus, although the differences were not significant, tended to depressed the concentration of phosphorus in plant tissues. Osiname (1978), observed a similar result in the leaves of cowpea.

Mg concentration in plant tissues was significantly increased as a result of the application of nitrogen and phosphorus. This could be because both N and P stimulated vigorous growth and

nutrient absorption from the soil including Mg. Kang and Nangju (1983) reported that crops fertilized with P-are rich in N, K, Ca and Mn. However, application of nitrogen and phosphorus did not significantly affect the concentration of calcium in plant tissues. This could be that the absorption of calcium was not significantly higher because of the presence of N and P in the soil.

3.3.1 Interactions

Lime x phosphorus:

Interaction between lime and phosphorus on tissue concentration of nitrogen was significant. The highest N-concentration was produced by the combination of the highest lime rate of 1000kg/ha and P-rate of 15kg/ha. This could be that the highest lime rate improved soil condition for easy availability of more phosphorus and other nutrients for absorption.

Lime x nitrogen x phosphorus

Significant interaction between lime, nitrogen and phosphorus on nitrogen concentration in plant tissues were produced with a combination of 1000kg/ha of lime, 20kgN/ha and 15kgP/ha. This maybe due to the fact that the lower rates of N and P were complemented by the effect on the soil of the highest lime rate which might have enhanced soil pH and increased the availability of both applied and soil phosphorus which in turn stimulated growth especially the roots for general enhancement of nutrients uptake.

5.6 Correlation.

The significant and positive correlations observed between grain yield of cowpea and growth parameters such as total dry

matter per plant, number of primary branches at 12 WAS, plant height at 12 WAS, number of leaves per plant at 12 WAS and leaf area index may be attributed to the fact that these vegetative characters directly determine how much of photosynthate is available for growth and grain production. Efficient vegetative growth enhance photosynthetic activities of the crop. Plant height was significantly and positively correlated to grain yield probably because taller plants were more exposed to light for photosynthesis. Singh et al; (1982) reported a highly significant and positive correlation between plant height and grain yield. LAI, number of primary branches per plant and number of leaves per plant are determinants of photosynthesis.

A highly significant and positive correlation between grain yield and number of pods/plant, number of seeds/pod and positive and significant correlation of 100 seed weight with grain yield shows these components as important yield determinants. These results are in agreement with the findings of Singh et al; (1982), Oliveira et al; (1982), Arytecy and Laing (1983).

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Field experiments were conducted at the Institute for Agricultural Research Farm in Samaru, Nigeria during the wet seasons of 1995 and 1996 to asses the effect of lime, nitrogen and phosphorus on growth, yield and yield components of cowpea. (Vigna unguiculata (L) Walp).

The experiment consisted of 27 treatments replicated three times and laid out in a split-plot design. The effect of lime on growth parameters was significant but inconsistent during growth. At 12 WAS, plant height, number of leaves per plant, and stem dry weight responded to lime significantly upto the highest rate of 1000kg/ha.

Plant height, number of leaves per plant, number of primary branches per plant, LAI, leaf dry weight, stem dry weight and total dry matter per plant at harvest were all significantly increased by the application of nitrogen and phosphorus. The lower rates of nitrogen (20kg/ha) and phosphorus (15kg/ha) were enough for the following growth parameters, number of primary branches per plant, LAI, leaf dry weight at 12 WAS and total dry matter per plant at harvest.

Lime did not significantly affect grain yield but the number of pods/plant and days to 50% flowering were significantly increased by lime rate of 1000kg/ha.

Nitrogen did not significantly increased grain yield. However, number of pods/plant was significantly increased by 20kgN/ha and days to 50% flowering.

Grain yield, number of pods/plant and days to 50% flowering were significantly increased by phosphorus application to cowpea of 30kgP/ha while 15kgP/ha was enough for the number of seeds per pod. The interaction between nitrogen (40kgN/ha) and phosphorus (30kgP/ha) on grain yield was also significant on grain yield.

In conclusion, since lime significantly increased only the number of pods/plant and days to 50% flowering at 1000kg/ha but not grain yield, it may not be advisable economically to apply lime to cowpea except where the soil pH is lower than those of the soils used in this experiment.

Nitrogen may be used where the N-content of the soil is low. This is because cowpea responded to nitrogen in N-deficient soils (Chiezey et al; 1990) and the grain yield of the first year of this research in 1995 probably due to the lower N-content of the soil.

Since phosphorus significantly increased all growth parameters, yield and most yield attributes with a calculated optimum rate of 38.7kgP/ha for optimum grain yield, cowpea grown in this ecological zone should always be given P-fertilizer. Though for optimum vegetative growth (TDM), low P-rate was optimum, a higher rate of 38.7kgP/ha is recommended for grain production.

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Appendix 1: Total rainfall, maximum and minimum temperature, relative humidity and sunshine hours at ten days interval during the experimental period at Samaru in 1995.

Months	Days	Rain-fall (mm)	Max. temp. A.M.	Min. temp. P.M.	Rel. humid. (%)	Sunshine (hours)
June	11-20	66.4	32	18	87	52
	21-30	19.62	30	19	79	54
	1-10	36.8	29	22	80	60
July	11-20	52.3	30	23	79	70
	21-31	67.8	30	21	82	73
	1 -10	86.3	29	20	82	74
August	11-20	73.6	28	20	82	73
	21-31	96.7	28	21	79	81
	1-10	39.3	30	22	82	79
September	11-20	80.3	29	19	82	69
	21-30	39.3	28	21	81	63
	1-10	32.5	31	20	78	69
Oct.	11-20	Nil	33	19	71	44
	21-31	Nil	32	18	53	73

Appendix 2: Total rainfall, maximum and minimum temperature, relative humidity and sunshine hours at ten days interval during the experimental period at Samaru in 1996.

Months	Days	Rain-fall (mm)	Max. temp. A.M.	Min. temp. P.M.	Rel. humid. (%)	Sunshine (hours)
June	11-20	38.8	31	20	77	66
	21-30	11.82	30	20	80	60
	1-10	36.7	28	19	78	56
July	11-20	47.4	28	18	82	57
	21-31	72.6	27	17	77	68
	1 -10	40.6	28	20	80	70.6
August	11-20	77.1	27	20	84	77
	21-31	53.4	28	20	81	70
	1-10	76.6	30	21	83	70
September	11-20	37.8	30	19	82	69
	21-30	22.6	30	20	80	76
	1-10	19.5	32	20	80	60
Oct.	11-20	31.7	32	20	77	74
	21-31	Nil	28	17	43	42

Appendix 3: Physico-chemical properties of top soil (0-30cm) of the experimental fields at Samaru.

Physical characteristics	1994	1996
Clay (%)	24	14
Silt (%)	44	36
Sand (%)	32	50
Textural class:	Loam	Loam
Chemical characteristics.		
pH (H_2O)	5.5	5.1
pH 0.01m ($Cacl_2$)	4.9	4.4
Organic carbon (%)	0.32	0.32
Available P (ppm).	3.48 ppm	8.87 ppm
Total N (%)	0.03	0.09
Exchangeable bases (Meq/100g of soil).		
Ca	4.00	3.28
Mg	1.17	3.28
K	0.21	0.35
Na	0.26	0.17
CEC	8.30	5.2

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BIOGRAPHY

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DATE OF BIRTH - 15th Feb. 1962

PLACE OF BIRTH - Vel-Pankshin.

L.G.A. AND STATE - Pankshin - Plateau State

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PREVIOUS QUALIFICTIONS

Institutions attended	From	To	Certificates/Diploma/Degrees
Holy Cross Pri. Sch.Pkn	1971	77	F.S.L.C.
St. Joseph's Collage Vom	1977	82	O.L. GCE Certificate
Sch. of Preliminary Studies, Keffi	1982	84	IJMB Exams. Cert.
Ahmadu Bello University, Zaria.	1984	88	B.Sc. Agric.

POST(s) HELD SINCE THE AWARD OF THE FIRST DEGREE.

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	Organization	From	To	Position
a.	DFFRI, FARM, IKONO L.G.A. AKWAIBON STATE (NYSC)	1988	89	Agric. Officer
b.	St. Joseph's College Vom-Plateau State.	1989	1991	Agric. Science Teacher.
c.	C.O.E. AKWANGA Nasarawa State.	1991	97	Lecturer Agric. Education.
d.	C.O.E. Gindiri	1997	date	Lecturer Agric. Education.

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