GROWTH AND YIELD OF SOYABEAN (*Glycine max* (L.) Merrill) AS AFFECTED BY NITROGEN AND PHOSPHORUS FERTILIZATION

BY

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D E C L A R A T I O N

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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C E R T I F I C A T I O N

This thesis titled "GROWTH AND YIELD OF SOYABEAN (Glycine max (L.) Merrill) AS AFFECTED BY NITROGEN AND PHOSPHORUS FERTILIZATION" by Thomas Ogon Ojikpong meets regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is therefore approved for its contribution to scientific knowledge and literary presentation.

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D E D I C A T I O N

To my brother, Ben E. Ojikpong, and his late wife, Koko.

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A B S T R A C T

A field experiment was conducted during the 1990 cropping season at Sarnaru, northern Guinea Savana Zone of Nigeria to investigate the response of soyabean (C.V. SAMSOY 2) to different levels of nitrogen and phosphorus fertilizer.

Treatments consisted of factorial combinations of four levels each of nitrogen (O, 20, 40 and 60kg N ha) and phosphorus (O, 17, 35 and 52kg P ha) laid out in a randomized complete block design and replicated four times.

The application of N at the rate of 20kg N ha^{-1} increased nodulation significantly at the initial growth stage. Increasing the level of N above 20kg N ha " resulted in decreased number of nodules. Although N enhanced plant growth, it had no significant effect on grain yield. Nodulation was increased significantly by phosphorus fertilizer application. Similarly P enhanced plant growth up to the highest level of applied P (52kg P ha), but grain yield responded up to 17kg P ha^{-1}.

Grain yield reduction was as much as 54% when no P fertilizer was applied (1325kg ha). The nitrogen concentration in plant decreased with increasing N application while increasing P fertilizer application increased grain nitrogen concentration.

The interaction between N and P was significant on some growth parameters but not on grain yield and yield components.

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CHAPTER ONE

INTRODUCTION

The soyabean, (Glycine max (L.) Merrill) also known as soyabean, Chinese pea and Manchuria bean is an important food and industrial crop in many parts of the world. Although the exact origin of this crop is not known, most of the available evidence suggest that it is a native of East Asia posibly China where it has been under cultivation for more than 5000 years (Hymowitz, 1970). Soyabean was recorded in China as far back as 2838 BC, (Leakey and Wills, 1977). Its introduction into Africa dates back to 1709 when it was introduced into Uganda. Although it was introduced into Nigeria in 1905, it was not established as a crop until the early 1940s (Ezedima, 1964). It is grown rather extensively in various parts of the world, particularly in the temperate zones with the United States of America as the leading world producer.

The world soyabean production in 1986 was put at 95,521 million metric tons, out of which the United States of America accounted for 57.2 per cent (FAO, 1985). Other major soyabean producers include Brazil and China.

Soyabean is one of the most valuable grain legumes that can be cultivated in the tropics. Besides its relatively high grain protein content (about 40%), the grain also contains about 20% high quality unsaturated oil, (Uwala, 1985). Soyabean oil is used in edible products such as margarine, salad and cooking oils, and industrial products such as insecticides, soap, varnishes, printing ink, rubber substitutes, glues and plastics. Soyabean meal is valued as livestock and poultry feeds for its high protein content. Soyabean grits and flour are used in bread and bakery products such as macaroni, spaghetti and baby foods. Soyabean can also be prepared into several local recipes including milk. Soyabean is also a good source of vitamins and minerals.

As a forge crop, the soyabean is preserved as hay or silage or cut and fed green to animals as silage. It is a valuable supplement to corn because of its high protein content.

The crop is also valuable for its high level of atmospheric nitrogen fixation into the soil.

The traditional areas of soyabean cultivation in Nigeria are Benue State and Southern parts of Kaduna State, where it is grown by small scale farmers predominantly in mixtures with cereals (Nyiakura, 1982). According to Olufajo et al. (1984), soyabean is gradually becoming an important crop in Nigeria as evidenced by the fact that its cultivation has spread beyond the traditional areas of production.

Soyabean production in Nigeria has been low and has never exceeded 68,000 metric tonnes per annum (FAO, 1986). Estimates of annual production vary from 15,000 tonnes (Kassam and Kowal, 1978) to 26,000 tonnes (Ashaye et al. 1974). Average yields in the country are encouraging, 1000 - 2000kg/ha (Oyekan, 1987). According to purseglove (1984), the low production figures from Africa including Nigeria could be attributed to such factors as difficulty associated with cooking the beans, flatulence, unpalatability, and availability of other pulses with which the people are more familiar and which better satisfy their dietary needs. Other factors responsible for the low production could be related to the lack of recognition of the potential of the crop (Bichi, 1982), poor seeds viability (Joshua and Ogundipe, 1988), poor relative price hitherto offered by the defunct Marketing Boards (Yuwa, 1983; Emechebe, 1983), and poor agronomic characteristics of the available cultivars.

The local variety of soyabean that has been widely grown in the country (Malayan) from about 1930, has a very high shattering percentage with a resultant huge loss in grain yield (up to 50%).

However, cultivar SAMSOY 2 developed by the Institute for Agricultural Research Samaru, from a cross between the imported Clemson Non-Shattering variety and the local Malayan variety is less susceptible to shattering (less than 5%) and is relatively high yielding.

Recently there has been wide spread interest in soyabean cultivation in Nigeria as a new source of plant protein and oil for manufacturing industries. This renewed interest could be associated with the development of high yielding, shattering tolerant, and resistant cultivars such as SAMSOY 2. Moreover, there has been an increased awareness of the use of the crop. The northern Guinea Savanna ecological zone appears to be the most suitable area for soyabean cultivation in Nigeria due to its unimodel pattern of rainfall. However, most of the soils of this zone are inherently low in native fertility, particularly nitrogen and phosphorus (Heathcote and Stockinger, 1970; Mokwunye, 1979). It is well recognized that low levels of soil phosphorus could limit growth, dinitrogen fixation and yields of legumes (Franco, 1977; Freire, 1984). Phosphorus trials with soyabean in the Guinea Savanna have shown that the application of phosphorus fertilizer is one of the avenues for increasing soyabean grain yield (Kuneman, 1983; pal et al. 1989). However, there is still very scanty information on the interactive effects of nitrogen and phosphorus fertilizers, the two most limiting nutrients, on the productivity of soyabeans in the Savanna.

In the light of the above, this study was conducted with a view to determining the effects of nitrqgen and phosphorus fertilizers on the growth, yield and yield components of soyabean.

CHAPTER TWO

2.0 LITERATURE REVIEW

Agronomic research on soyabean has been reported from various parts of the world and some of the reported findings are conflicting probably due to environmental influences. According to Chiezey (1990) varying results are often obtained even in the same environment.

Soyabean yield response to applied fertilizers especially nitrogen has been erratic while response to direct phosphorus and potassium applications have been consistent (Boswell and Anderson, 1976).

2.1 Nitrogen

Nitrogen is a vital plant nutrient essential for the growth of plants as it is a constituent of proteins and nucleic acids. The optimum growth of a crop plant is achieved when its nutrients requirements are met. Availability of nutrients to a crop can be determined by nitrogen because of its stimulating effect on root activity (Burries, 1959) and rooting pattern of a crop (Bruetsch and Estes, 1976). Nitrogen is one of the most commonly deficient nutrients in the soil. Balasubramanian et al, (1987) reported that the amount of nitrogen required by crops depends upon the initial fertility of the soil and the yield potential of the crop. Nitrogen in excess of the plant requirements leads to vegetative growth. Its deficiency results in the yellowing of foliage and poor yield (Chiezey, 1990).

2.2 Effects of Nitrogen on the Growth and Yield of Soyabean:

Soyabean yield response to applied nitrogen fertilizer has been erratic and has generated a lot of controversy, particularly when Bradyrhizobium inoculum is used.

Soyabean can utilize both soil nitrogen and applied nitrogen as well as symbiotically fixed nitrogen. It is universally accepted that soyabean, like other leguminous plants, fixes its own nitrogen with the aid of Bradyrhizobium Japonicum. However, there is no clear concensus about whether or not the symbiotically fixed nitrogen is sufficient to meet the requirements of the crop. Hanway and Weber (1971) reported that increases in yields of soyabean from nitrogen fertilizer application usually have been small and inconsistent. Allos and Bartholomew (1969) also stated that symbiotic nitrogen fixation in the soyabean must be supplemented with combined nitrogen from the soil or fertilizer for maximum growth and yield. However, when supplied in excess of amounts needed for plant growth, combined nitrogen may prevent symbiotic fixation, the degree of inhibition varying with the form of the nitrogen compound, cultivar, strain of Bradyrhizobium, season, light intensity, temperature and nutritional conditions (Pate and Dart, 1961; Dart and Wilson, 1970; Gibson, 1974 and Pankhurst, 1981). Shibles et al. (1975) pointed out that in any discussion of the nitrogen nutrition of soyabeans, consideration must be given to the two sources of nitrogen, mineral and symbiotically fixed nitrogen. He reported that higher levels of mineral nitrogen retard early nodule development and that plants completely dependent on symbiotic fixation do not receive substantial supplies of nitrogen until four weeks after germination. Mineral nitrogen improved yield when applied from the early stages of plant development through to mid-flowering, but after the time, symbiotic N_2- fixation was adequate to achieve high yields and protein levels. During later stages of development, the two sources of nitrogen have a complementary relationship, an increase in the supply of mineral nitrogen

proportionately retarding symbiotic N_2- fixation (Shibles et al. 1975). On the other hand low levels of nitrogen may stimulate root nodule symbiosis depending on the form of nitrogen, species, cultivars, etc (Pate and Dart, 1961; Gibson, 1974). Thus while it is established that high levels of combined nitrogen inhibit the development and function of the root nodules, the application of low-level "starter doses" of fertilizer nitrogen is sometimes recommended to improve nodulation and nitrogen fixation in the long term. However, the amounts of combined nitrogen which are required to optimize legume symbiosis are poorly defined.

Along with symbiotically fixed nitrogen, soil or fertilizer nitrogen appears to be necessary for high soyabean yields (Bangoo and Albritton, 1972 and Harper, 1974). Lathwell and Evans (1951) observed that yields of soyabeans were closely associated with the amount of nitrogen that accumulated within the plant. Application of nitrogen at bloom stage according to them increased yield by 135kg/ha for every increment of 33.6kg N/ha. The highest rate tested was 100kg N/ha. Response of 130 to 670kg/ha grain yield have been reported from application in the range of 112 - 244kg/ha of nitrogen (De Mooy et al. 1973).

Kang (1975) found that without inoculation, 60kg N/ha was needed to give a significant increase in dry matter yield and nitrogen uptake by soyabean whereas 30kg N/ha was sufficient with inoculation. Hanway and Weber (1971) also observed that application of nitrogen fertilizer greatly increased seed yield of non-nodulated soyabeans. Seed yields were 850, 2040, and 2350kg/ha for 0,224 and 672kg N/ha respectively. The application of nitrogen resulted in increased seed size and number of seeds per pod.

In an experiment conducted over a three year period, Bangoo and Albriton (1972) found that nitrogen resulted in marked yield increases in each of the three years. They observed that when nitrogen was applied as N, NK and NPK, yield increases from nitrogen were 14.0, 8.3 and 10.6 percent respectively. When applied as N, NP and NPK yield increases from nitrogen were 15.0, 13.8 and 10.1 percent respectively. They further observed that yield increases from nitrogen were greater when applied without P and/or K, but that the NPK treatment resulted in overall yield increases each year.

Several workers have reported that symbiotic nitrogen fixation alone could not sustain high yield of soyabean and, therefore, there is a need for supplemental nitrogen (Bangoo and Albriton, 1976; Boswell and Anderson, 1976; Ham et al. 1975; Harper, 1974; Weber, 1966; Kuwahara et al. 1986). On the contrary, numerous studies have shown lack of response of soyabean to nitrogen fertilization. For example, Arnold (1969) and Radley (1971) indicated that symbiotic fixation was sufficient for soyabean yield. Rachie and Sylvestre (1977) also observed that application of nitrogen seldom provided economic yield, provided that the soil is inoculated with an effective strain of Bradyrhizobium. Kalia et al. (1984) in India observed no advantage in grain yield by applying nitrogen to soyabean.

In a study conducted over a period of several years at ten field locations using different rates of nitrogen and methods of application, Welch et al. (1973) observed that yields were significantly increased in only 3 out of the 133 instances, and that these occured at high uneconomic rates of nitrogen fertilization Eaglesham et al. (1983) reported that large amounts of applied nitrogen reduced root hair infection, nodule number, nodule weight, the nitrogen fixing activity of nodulated roots and the total

amount of nitrogen fixed. Weber (1966) also reported that nodule number, weight, and size decreased with increasing levels of fertilizer nitrogen. According to Ohlrogge (1964), a 3363kg/ha soyabean crop requires 314kg of nitrogen. One-third to two-thirds of this requirements may be supplied by nitrogen fixing bacteria and the remainder must come from the soil. Ezedinma (1964) reported that in Nigeria, soyabean is rarely given nitrogen fertilizer because most Nigerian soils contain different strains of Bradyrhizobium that induce nodulation in many legumes.

From the foregoing, it could be concluded that although N fertilizer is not required in large amounts, small initial amount (starter dose) will greatly enhance the performance of the crop.

2.3 Phosphorus:

Phosphorus is a major nutrient element which occurs in most plants in quantities that are much smaller than those of nitrogen and potassium. Phosphorus has for sometime been recognised as a constituent of nucleic acid, phytin, and Phospholipids (Tisdale and Nelson, 1975). Phosphorus is an important plant nutrient for its role in the formation of high energy molecules and synthesis of cell constituents (De Mooy et al. 1973). It also mediates in the transformation and translocation of carbohydrates, fatty acids, and nucleic proteins. Phosphorus has a direct effect on proper growth and development of crops (Balasubramanian et al. 1987).

Phosphorus is also known to influence the availability of nutrients such as nitrogen (Cope and Hunter, 1967). It stimulates root growth and increases the roots efficiency consequently enhancing nutrients absorption for greater growth and development of the entire plant. Poor root development, stunted growth and pronounced signs of phosphorus starvation, such as blueish-green

to purple tints on older leaves, will be apparent if the element is deficient.

2.4 Effects of Phosphorus on Soyabean:

In soil, plant phosphorus uptake and fertilizer phosphorus requirements are dependent on root growth (Khasawneh and Copeland, 1973; Edwards and Barber, 1976). Significant increases in soyabean grain yield with the application of phosphorus have been reported by various workers (Bangoo and Albriton, 1972; Chesney, 1973 and Pal et al. 1989). Chesney (1973) observed that soyabean plants receiving an inadequate supply of phosphorus were of a much smaller stature and matured about two weeks earlier than those receiving an adequate supply of phosphorus. Miller et al. (1961) obtained the greatest yield increase from application of both phosphorus and potassium.

In contrast, some workers reported small and insignificant yield increases from the application of phosphorus on soyabean. For example, Hanway and Weber (1971) and Boswell and Anderson (1976) reported that soyabean yield responses obtained from application of phosphorus and potassium were usually small and not significant. Maples and Koegh (1969) also reported small but insignificant increases in yield from phosphorus application. However, the response of soyabean to phosphorus and potassium applications has been more consistent and is related to cultivars, plant population, and soil fertility levels (Dunphy et al. 1966). With regards to the effect of phosphorus on nodule production, De Mooy and Pesek (1966) reported that maximum nodulation required very high levels of phosphorus and that maximum nodule activity required even higher levels of applied phosphorus.

Investigations on the influence of phosphorus on soyabean in Nigeria have shown that grain yields could be increased by applying phosphorus (Goldsworthy and Heathcote, 1964; Leleji and Adedzwa,

1982). Pal et al. (1989) working in the Guinea Savanna of Nigeria, found that application of only 13.3kg P/ha increased grain yield by more than 50%, thus indicating the need to apply phosphorus. Tewari (1965) also reported that 23kg P/ha produced almost twice as much yield as where no phosphorus was applied in Nigeria. He, however, stated that at the high rate of phosphorus application, the increases in yield over the medium rate was insignificant. Under the traditional farming systems in Nigeria, soyabean rarely exceeds 1,000kg/ha.

2.5 The interaction of Nitrogen and Phosphorus on Soyabean:

While the effects of nitrogen and phosphorus on plant growth is well known, not much is known about the interaction of levels of soil nitrogen and phosphorus on soyabean grain yield. Cassman et al. (1980) reported that soyabean plants supplied with adequate nitrogen had a large and more extensive root system than comparable nitrogen - fixing plants and this difference was greatest at sub-optimal phosphorus levels. The more extensive root system of an N-supplied legume should increase its capacity to absorb phosphorus and lower the requirements for added phosphorus fertilizers. They observed that nitrogen fixing soyabean required 750kg P/ha to obtain a 90% relative yield which was 320kg P/ha more than that required by nitrogen supplied plants to obtain a comparable relative yield. The phosphorus concentration of nitrogen fixing soyabean plants was significantly lower than that of nitrogen supplied plants at all levels of applied phosphorus fertilizer.

Tewari (1965) reported that nitrogen and phosphorus applied at the rate of 45kg N and P/ha gave the highest yields, but observed that nitrogen and phosphorus had significant effects on the grain yield of soyabean as the main treatments but none of the interactions were significantly different.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site:

A field experiment involving soyabean (Glycine max (L.) Merrill) was conducted in the 1990 cropping season at the Agricultural Research farms of the Institute of Agricultural Research (IAR) Ahmadu Bello University, Samaru, Zaria (11^{o} 11'N and 7^{o} 38'E, 650m above mean sea level) to test the response of soyabean to different levels of nitrogen and phosphorus fertilizers.

Samaru lies in the northern Guinea Savanna ecological zone with a mean annual rainfall of about 1100mm, occuring almost entirely during the period May to September.

The soil of the experimental site is a well-drained leached ferruginous tropical sandy loam. Prior to planting soil samples were taken at a dept of 0 - 20cm and were analysed for some chemical and physical properties. Details of the physical and chemical composition of the soil at the experimental site are contained in Table 1 while details of the distribution of rainfall, relative humidity, sunshine and temperature at Samaru during the period of the trial are shown in Table 1.

3.2 Treatments:

Treatments consisted of factorial combinations of four levels of nitrogen (0, 20, 40 and 60kg N ha^{-1}) and four levels of phosphorus (0, 17, 35 and 52kg P ha^{-1}).

3.3 Design and Plot Size:

The experiment was laid out in a randomized complete block design (RCBD) in factorial arrangement with four replications. The gross plot size was $30m^{2}$ (6m x 5m) while the total experimental

Table I: Physio-chemical Analysis of Soil at Experimental Site at Samaru before sowing.

Soil Composition	Soil Dept (0-20cm)
Particle size	
Clay (%)	12.7
Silt (%)	34.8
Sand (%)	52.5
Soil texture class	Sandy loan
Soil pH in water	5.30
Soil pH in 0.01m Cac_{12}	4.75
Organic Carbon (%)	0.90
Available Phosphorus (ppm)	6.80
Total nitrogen (%)	0.09
Exchangeable bases meq/100g of soil	
Sodium (Na)	0.12
Potassium (K)	0.09
Calcium (Ca)	1.20
Magnesium (Mg)	0.60
Cation Exchange Capacity	3.50

area was 2,793m^2 or 0.2793ha (57m x 49m).

Each gross plot contained eight ridges spaced 0.75m apart out of which the two rows bordering the discard rows in each plot were used for sampling while the net plot consisted of 4m length of the four inner rows (12m^2).

3.4 Cultural Practices:

3.4.1 Land Preparation:

The experimental area was disc-ploughed to a depth of about 25cm and harrowed twice to a fine tilth with a notched disc harrow, breaking soil clods and burying plants residues. This operation was followed by ridging at 75cm apart. The field was then marked out into four blocks or replications and further sub-divided into sixteen plots per block. The plots were separated by 1.5m unplanted discards, while the blocks or replications were separated by 1.0m unplanted discards.

3.4.2 Planting and Planting materials:

Sowing was done as soon as the rains established. The soyabean variety used is SAMSOY 2, which is a medium maturing variety (112 - 118 days). The seeds were treated with Fernasan D prior to planting against soil borne diseases. Sowing was done by hand-drilling the seeds on ridges 75cm apart. The plants were later thinned about two weeks after sowing, to maintain an intra-row spacing of 5cm.

3.4.3 Fertilizer Application:

Four levels each of single superphosphate and calcium ammonium nitrate were band applied to rows at about 8.0cm away from the plants at two weeks after sowing. The use of single superphosphate as source of phosphorus enabled the concurrent supply of sulphur and calcium both of which are generally deficient in many tropical soils, while calcium ammonium nitrate was used

as the carrier of fertilizer nitrogen.

3.4.4 Weed Control:

A pre-emergence herbicide, Igran Combi^{R} (Terbutryn) was used to control weeds at the initial stage at the rate of 4.5 litres/ha. Thereafter, mannual weeding was done at the 6th and 10th week after sowing to keep the field weed free. The second weeding done in the 10th week after sowing was necessary so as to keep the plots clean until harvest.

3.5 Observations:

Beginning from the sixth week after sowing (WAS) and at two weekly intervals until the sixteenth week after sowing, five plant samples were taken from each plot to determine the parameters described hereunder. The five plants were dug by means of a garden fork which was driven deep into the soil at about 30cm and 15cm away from the plant. This was to ensure minimal nodules disturbance while removing the plants. The plant samples were taken from the two sampling rows in each plot. The parameters measured are as follows:

3.5.1 Plant height (cm):

The heights of five plants was measured from ground level to the top of the main stem. Average plant height was recorded.

3.5.2 Number of Primary branches per plant:

The number of primary branches per plant was obtained by counting the total number of branches from five plants and the average number of branches was recorded.

3.5.3 Number of nodes per plant:

The number of nodes per plant was obtained by counting the total number of nodes on the five plant sampled and the average number was recorded.

3.5.4 Number of nodules per plant:

The number of nodules per plant was determined by carefully removing five plants with the aid of a garden fork and the nodules carefully detached from the roots, washed and separated from the adhering sand particles. The effective nodules were then counted and the mean number of nodules was recorded.

3.5.5 Nodules dry weight per plant:

The dry weight of nodules was determined by weighing oven-dried nodules (at 70°C) from the five plant sampled using a sensitive melter balance and the mean dry weight of nodules was recorded.

3.5.6 Stem dry Weight per plant:

The stem dry weight per plant was determined by weighing oven-dried stems (at 70°C) with leaves detached from the five plants and the mean weight was recorded.

3.5.7 Leaves dry Weight per plant:

The leaves dry weight per plant was determined by oven-drying the detached leaves from the five plants (at 70°C) sampled and weighing them using a melter balance and the mean weight of the leaves dry matter was recorded.

3.5.8 Leaf area per plant:

The leaf area was determined using the method described by Watson (1958). Leaves from the five plants sampled were detached and about 20 - 30 leaves selected at random and pilled on top of each other according to their sizes. A cork borer of known diameter (1.25cm) was run through the pile of leaves so that leaf discs were formed. The number of complete leaf discs were counted and recorded. The discs, together with the remaining leaves were oven-dried (at 70°C) after which the leaf discs and the remaining

leaves dry matter were weighed separately and their weights recorded. The average disc weight was determined by dividing the total leaf disc weight by the number of leaf discs.

Leaf area of the sample was then calculated using the following equation:

$$LA = \frac{wl + wr}{DA} \times \frac{A}{1}$$

where:

WL = Weight of the leaf discs (g)
WR = Weight of the remaining leaves (g)
DA = Average discs weight (g)
A = Disc area (cm^2)

3.5.9 Leaf area index (LAI):

The leaf area index was determined by dividing the total leaf area (A) of the leaf by the area of ground (P) covered by the leaves.

$$LAI = \frac{A}{P}$$

3.5.10 Number of Days to Maturity:

The number of days to maturity was recorded for each plot from sowing date to when at least 95 percent of the pods had turned brown.

3.5.11 Stand Count at harvest:

Stand count at harvest was done for each net plot. All the plants in each row or ridge were carefully up-rooted by hand and counted.

3.5.12 Number of Pods per plant:

The total number of pods borne on all the five plants sampled were detached from the plants and counted. The mean number of pods per plant was determined by dividing the total number of pods produced by the number of plants.

3.5.13 Pods dry weight per plant (g):

The pods dry weight per plant was determined by detaching the pods from the five sampled plants, oven-dried (at 70°C) and weighed using a metler balance. The mean weight of the pods were recorded.

3.5.14 Number of seeds per pod:

The number of seeds per pod was determined from twenty randomly selected pods from each plot. The pods were hand-threshed, and seeds counted to determine the total number, which was then divided by the total number of pods threshed to obtain the mean number of seeds produced per pod.

3.5.15 Shelling Percentage:

The shelling percentage was determined at harvest by dividing the weight of the shelled grains or seeds by the weight of the unshelled pods obtained from the five samples and the result was multiplied by 100 to convert to percentage.

3.5.16 100-Seed Weight (g):

Hundred seeds from each net plot were randomly selected and weighed using a metler balance model 1210.

3.5.17 Grain Yield (kg/ha):

The total grain yield was determined at harvest by threshing the whole pods harvested from the entire net plot. The grain yield was then determined by weighing the threshed grains using a metler balance - model 1210 and the value obtained was multiplied by a factor of 833.33 to convert the grain yield from grams per net plot to kilogrames per hectre.

3.5.18 Plant Nutrients Analysis:

Plant samples were taken at the 6th, 10th and 14th WAS to determine the N and P concentrations. Oven-dried plant samples (shoot) from each plot were properly ground in a mill to fine

powder for analysis. Total plant nitrogen was determined by the macro-kjeldhal procedure (Bremner, 1965; IITA, 1975). Plant phosphorus content was determined by the molybdenum blue colour method developed, by Bray and Kutz (1945) and modified by Murphy and Riley (1962).

3.6 Data Analysis:

The data collected were subjected to statistical analysis with all the factorial combinations as described by Leclerg et al. (1962). Analysis of Variance was also done to test the treatments effects for significance using 'F' test as described by Snedecor and Cochram (1967).

Significant differences among treatments means were compared using the Least Significant Difference (LSD) as described by Fishers (1970) and the Duncan Multiple Range test (DMRT) as described by Duncan (1955).

Correlation and Regression analysis were also done.

3.7 Meteorological Data:

Temperature, sunshine, rainfall and relative humidity data covering the period of the experiment was obtained from the I.A.R Meteorological Station, Samaru (Appendix I).

CHAPTER FOUR

4.0 R E S U L T S

4.1 Effects of Nitrogen and Phosphorus on Vegetative growth of Soyabean

4.1.1 Plant height:

Plant height increased up to the 16th week after sowing (WAS) as shown in Figure 1. Nitrogen and phosphorus significantly affected plant height throughout the growth period. On all sampling dates, highly significant increases in height was obtained due to nitrogen fertilization up to 60kg N ha^{-1}. Similarly, there were significant increases in plant height with increasing levels of phosphorus up to 52kg P ha^{-1} except in the 6th and 8th week after sowing when the greatest height was obtained at the rate of 35kg P ha^{-1}.

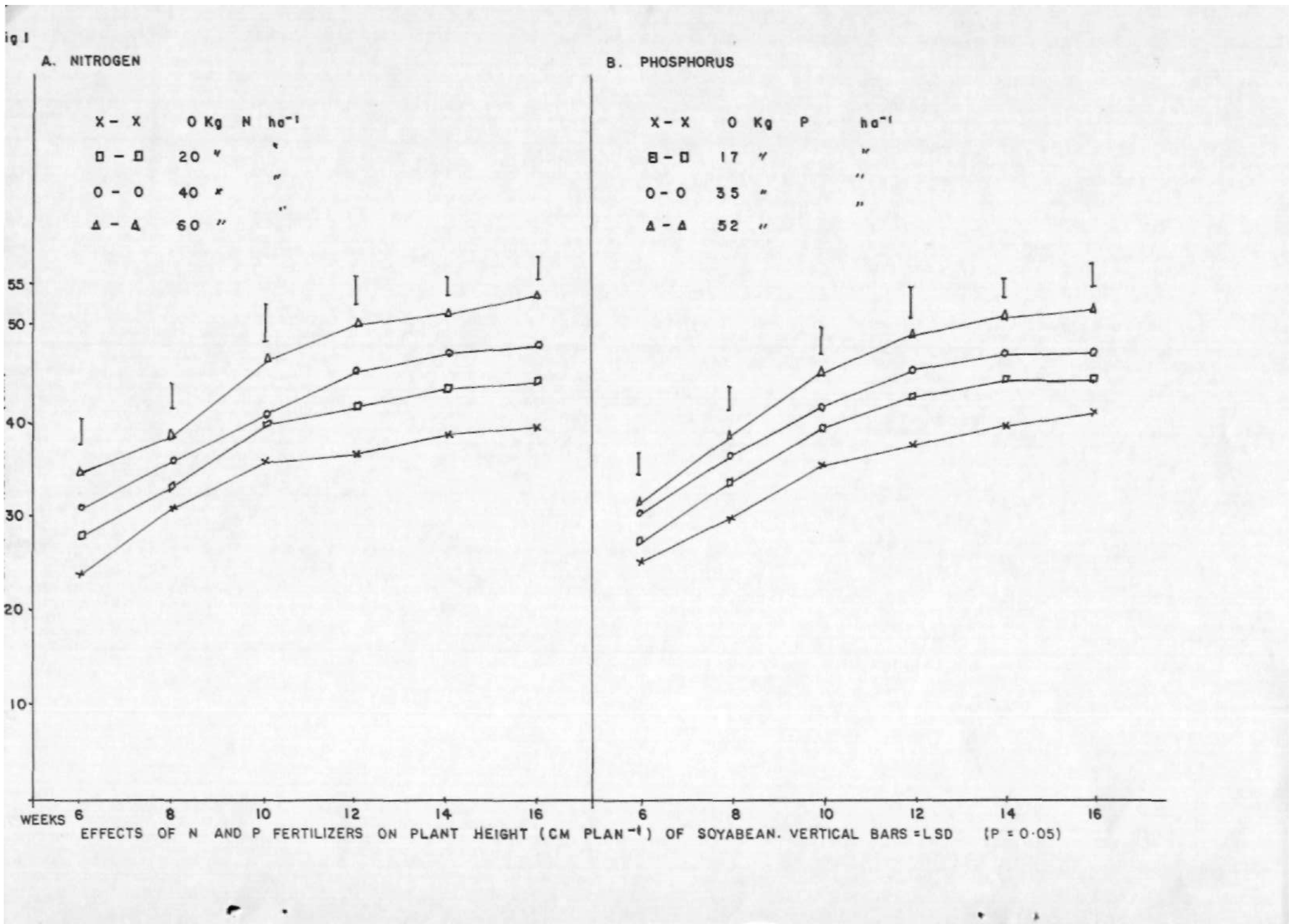
The interaction between N and P on plant height was not significant on all the sampling dates.

4.1.2 Number of Primary branches:

The number of primary branches per plant was significantly affected by N and P fertilizers (Fig.2). Nitrogen significantly increased the number of primary branches produced per plant from the 6th WAS up to the 10th WAS after which there was no response to N.

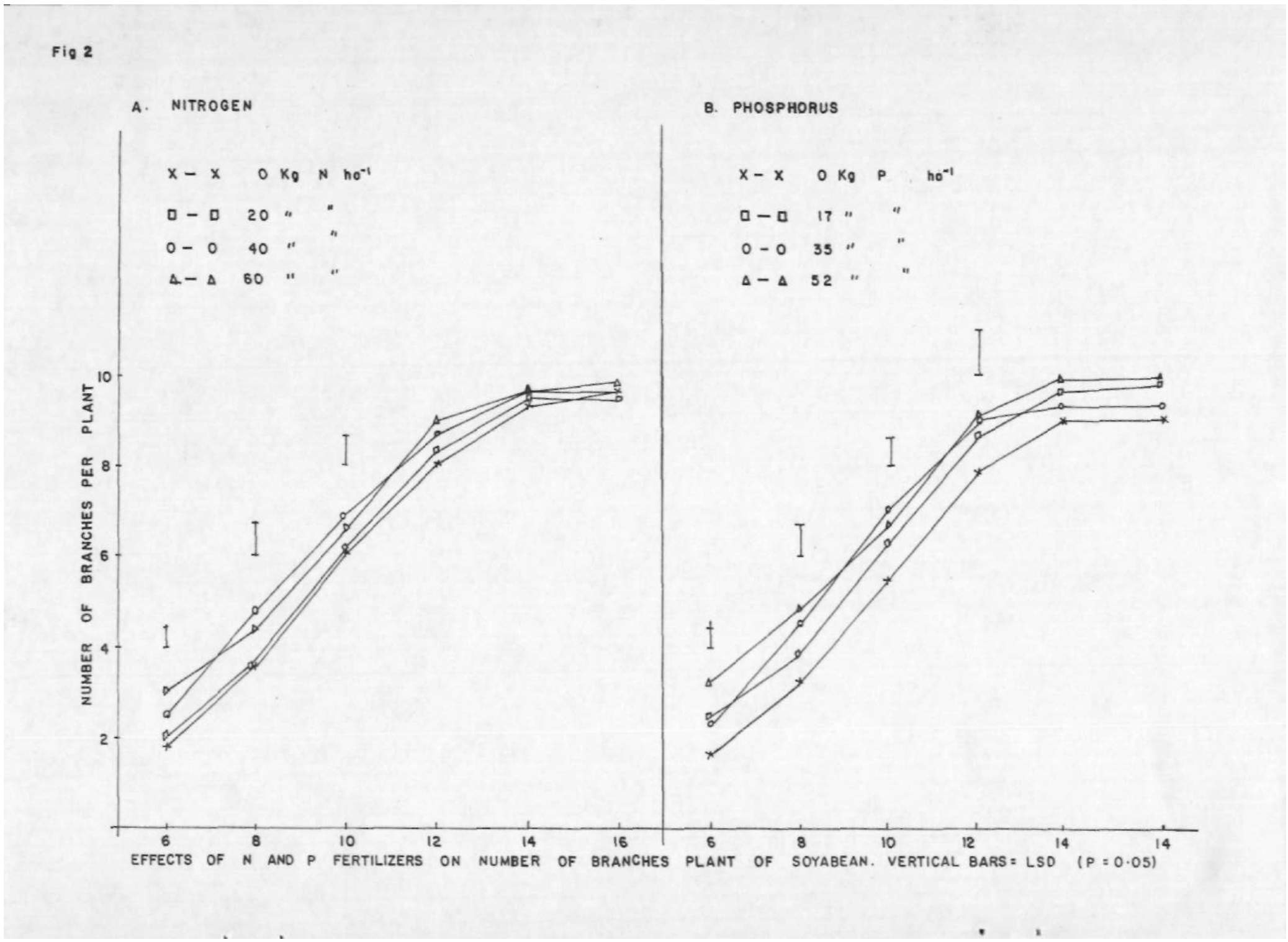
Similarly, phosphorus influenced the number of primary branches on almost all the sampling dates except the last two (i.e 14 and 16 WAS). In all cases the highest number of primary branches was produced at 35kg P ha^{-1} with the exception of 6 WAS when the highest number of branches was produced at 52kg P ha^{-1}.

ig I



EFFECTS OF N AND P FERTILIZERS ON PLANT HEIGHT (CM PLAN^{-1}) OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

Fig 2



EFFECTS OF N AND P FERTILIZERS ON NUMBER OF BRANCHES PLANT OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

The interaction between N and P on number of primary branches was significant at 10 WAS only. In all cases where P was applied N had no effect on the number of branches per plant whereas in the absence of P, N fertilizer increased the number of branches per plant significantly up to 40kg N ha^{-1} (Table 2).

4.1.3 Number of nodes:

The number of nodes per plant increased from the 6th WAS up to the 16th WAS (Fig.3). The number of nodes produced per plant was significantly affected by nitrogen fertilizer on all sampling dates except at 8 WAS. N application increased the number of nodes significantly up to 60kg N ha^{-1} on all sampling dates, except at 6 WAS when the highest number of nodes was obtained using 40kg N ha^{-1} rate. Similarly, phosphorus significantly influenced the number of nodes produced per plant on all the sampling dates except at 12 WAS. The highest number of nodes was obtained at 35kg P ha^{-1} throughout the sampling period.

On all dates, the interaction between N and P on number of nodes per plant was not significant.

4.1.4 Number of nodules:

The number of nodules produced per plant was significantly affected by N and P fertilizers (Fig.4). However, the application of N significantly increased the number of nodules produced at 8 WAS only, when the highest number of nodules was produced at 20kg N ha^{-1}. On the other hand, phosphorus fertilizer significantly increased the number of nodules from the 6th WAS up to the 14th WAS before the nodules finally disintegrated completely in the 16th WAS. The number of nodules was significantly higher at 35kg P ha^{-1} compared with zero and 17kg P ha^{-1} on all sampling dates. The interaction between N and P on number of nodules was not significant on all sampling dates.

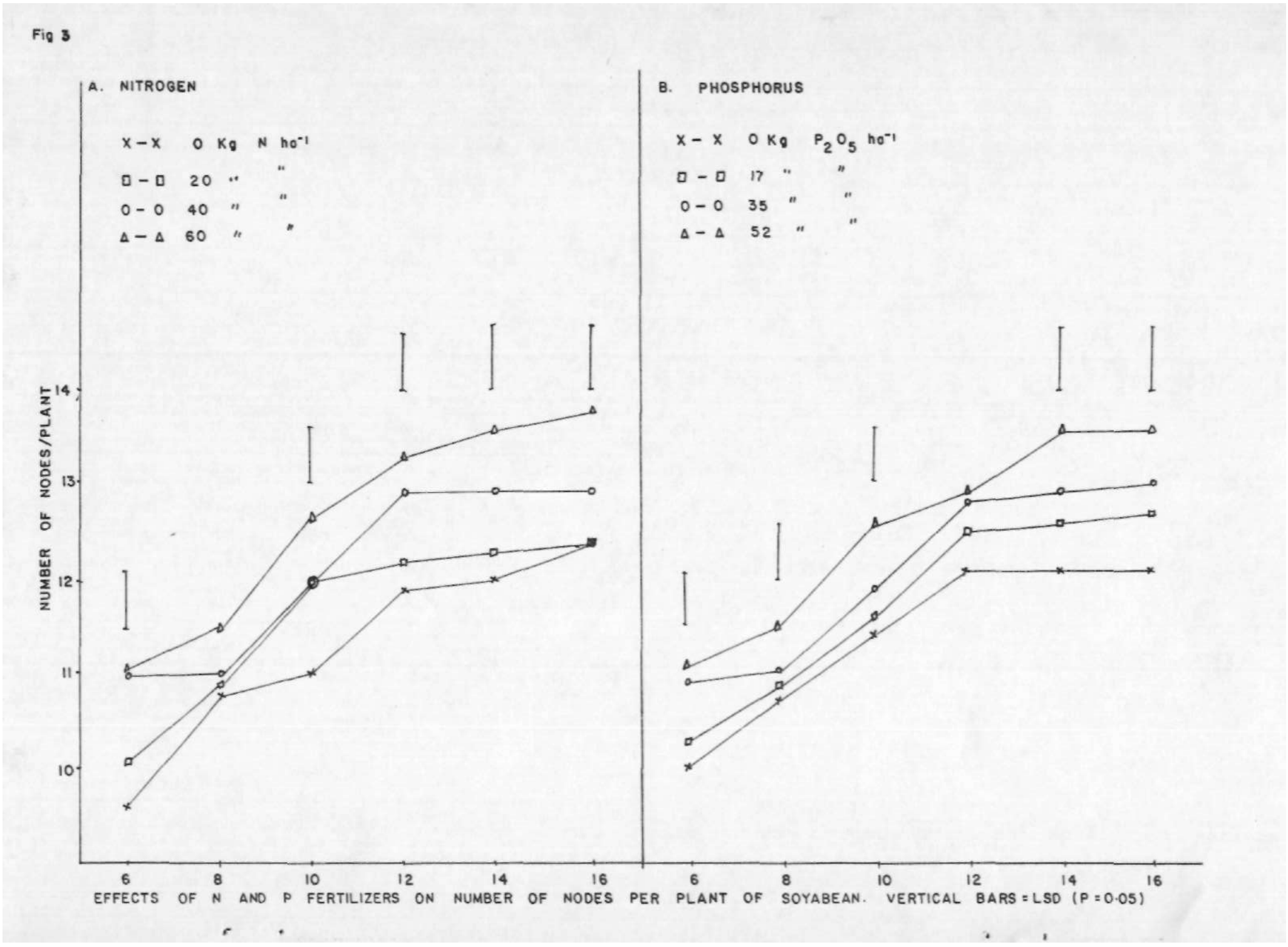
Table 2: Interactive effect of N and P on number of branches produced per soyabean plant.

N rate ($kg\ ha^{-1}$)	P rate ($kg\ ha^{-1}$)			
	0	17	35	52
0	3.8 d	6.8 a	6.8 a	6.7 a
20	4.7 a	6.5 a	6.8 a	6.6 a
40	7.0 a	6.9 a	7.6 a	6.7 a
60	6.2 ab	6.3 a	7.2 a	6.9 a

SE = $\pm$ 0.46

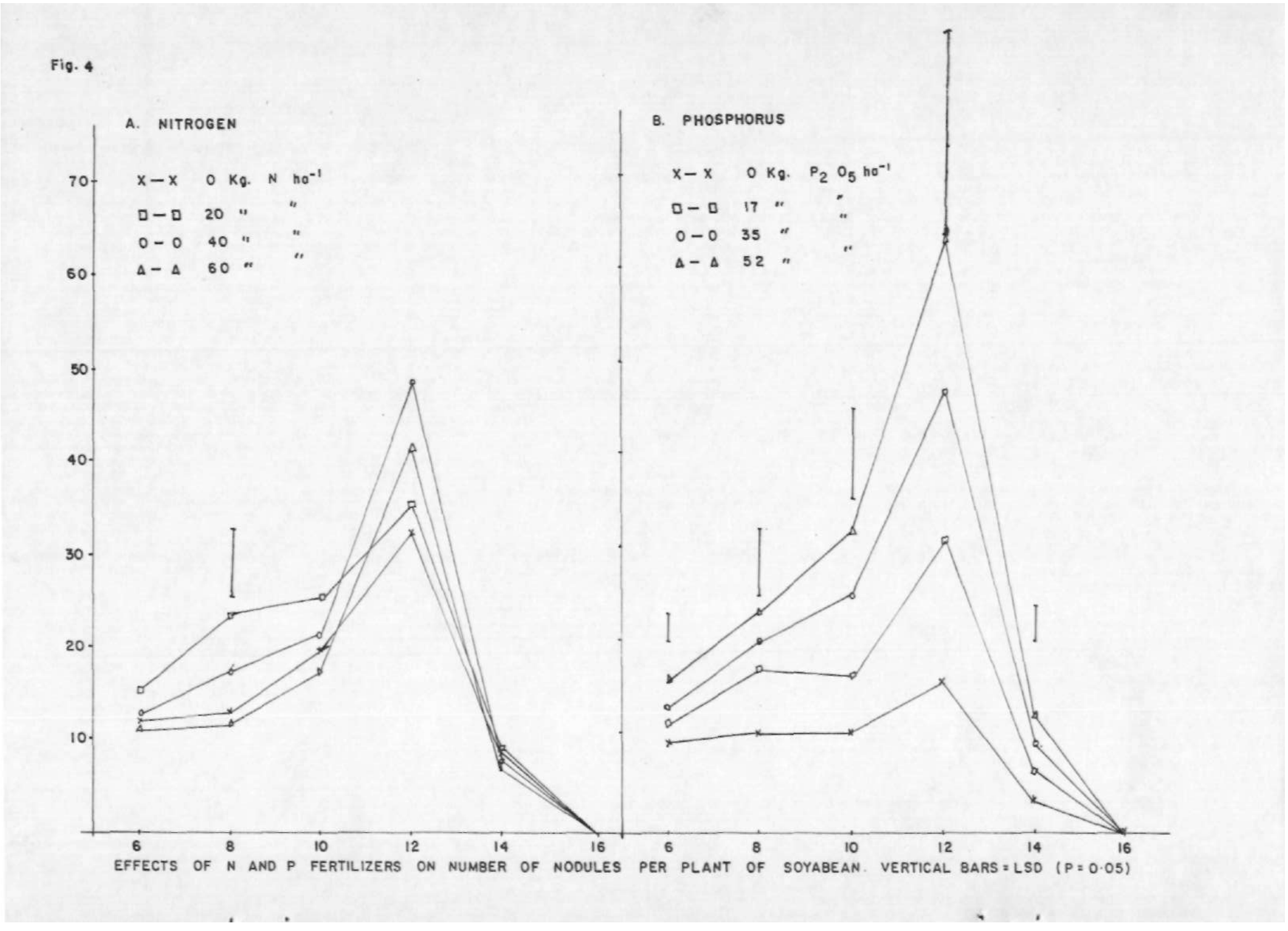
Means followed by the same letter(s) are not significantly different at 5% level using DMRT.

Fig 3



EFFECTS OF N AND P FERTILIZERS ON NUMBER OF NODES PER PLANT OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

Fig. 4



EFFECTS OF N AND P FERTILIZERS ON NUMBER OF NODULES PER PLANT OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

4.1.5 Nodules Dry Weight:

Nitrogen significantly influenced nodules dry weight in the 14th WAS only; coinciding with the peak period of nodule production (Fig. 5). Nodules dry weight was significantly higher at 40kg N ha^{-1} level compared with zero and 20kg N ha^{-1}. Phosphorus also had a significant effect on nodules dry weight on all sampling dates. In general, nodule dry weight increased with increasing P rate. On all sampling dates, the interaction between N and P on nodules dry weight was not significant.

4.1.6 Stem Dry Weight:

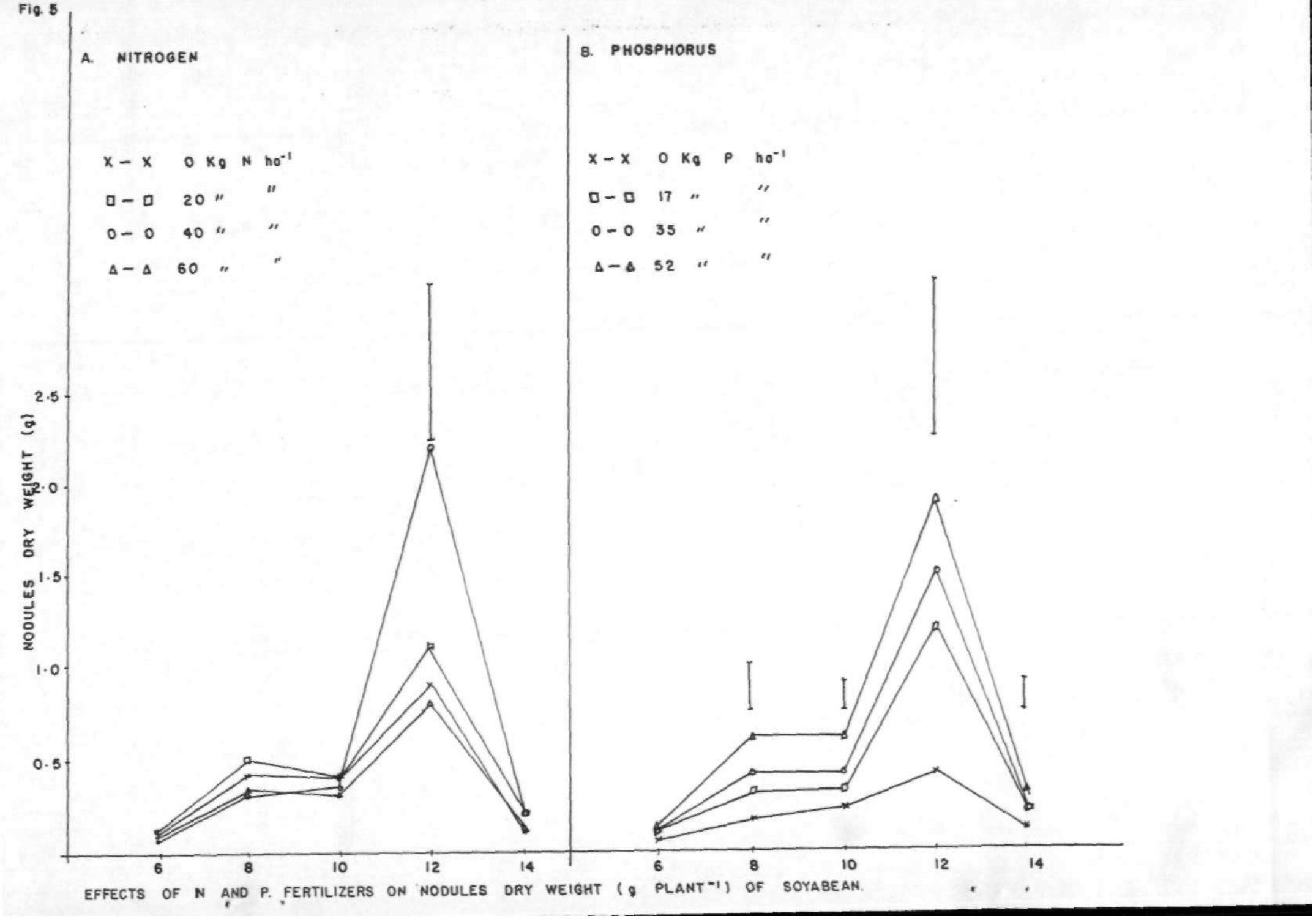
Figure 6 presents the stem dry matter per plant on six sampling dates as affected by N and P fertilizers. The application of nitrogen had a significant effect on stem dry weight in the 8th, 10th and 12th WAS. The dry weight produced per plant was significantly higher at 40kg N ha^{-1} compared with the no - N treatment and 20kg N ha^{-1}. The application of P also significantly increased stem dry weight up to 35kg P ha^{-1} on all sampling dates except 16 WAS.

Stem dry weight was not significantly affected by the interaction between N and P on all sampling dates.

4.1.7 Leaf Dry Weight:

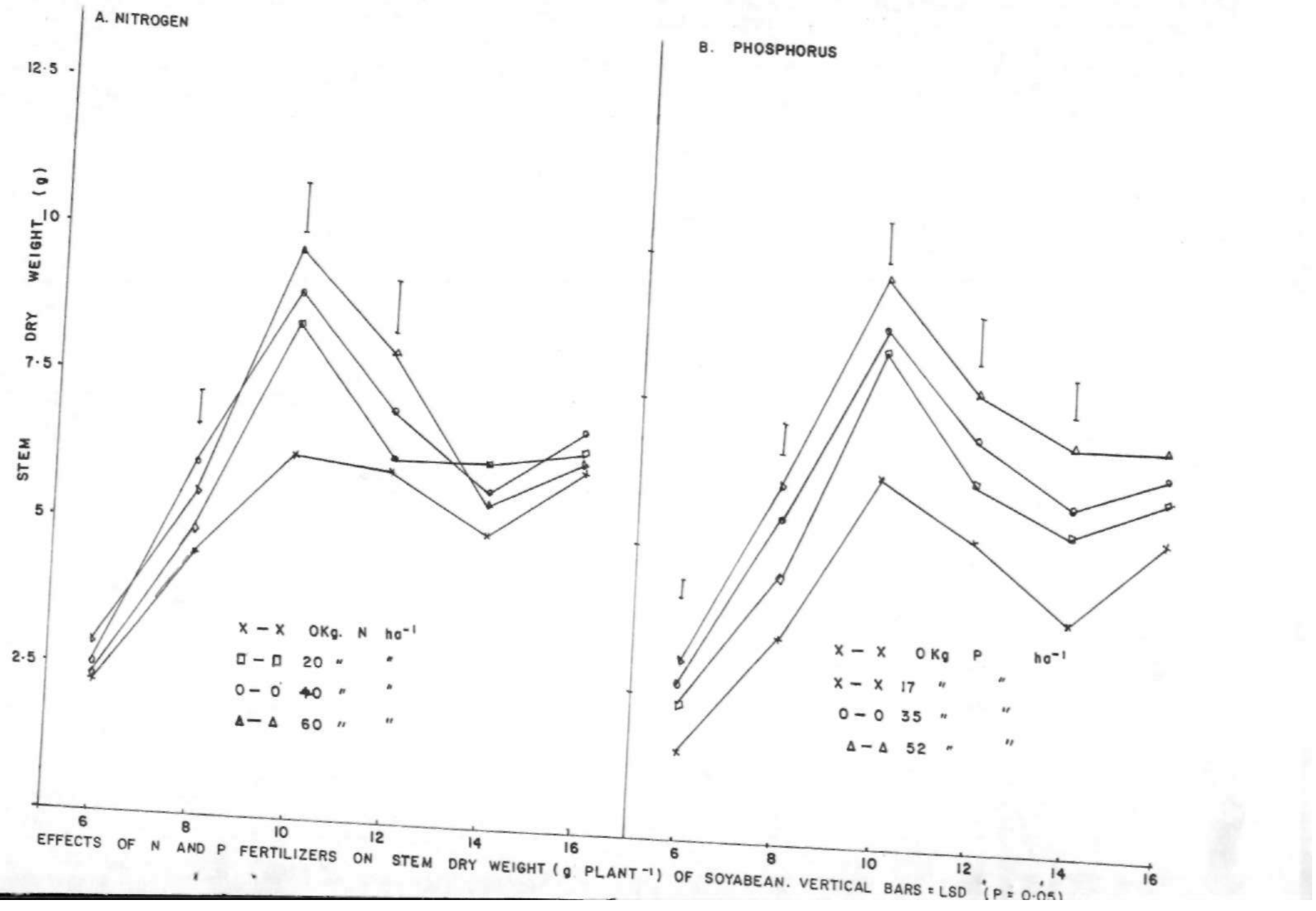
The dry weight of leaves was significantly affected by N and P fertilizers (Fig. 7). Apart from the 16th WAS, N application significantly influenced leaf dry weight on all sampling dates. Leaf dry weight increased significantly with increasing levels of N up to 20kg N ha^{-1}, beyond which, no significant increase was observed.

Fig. 5



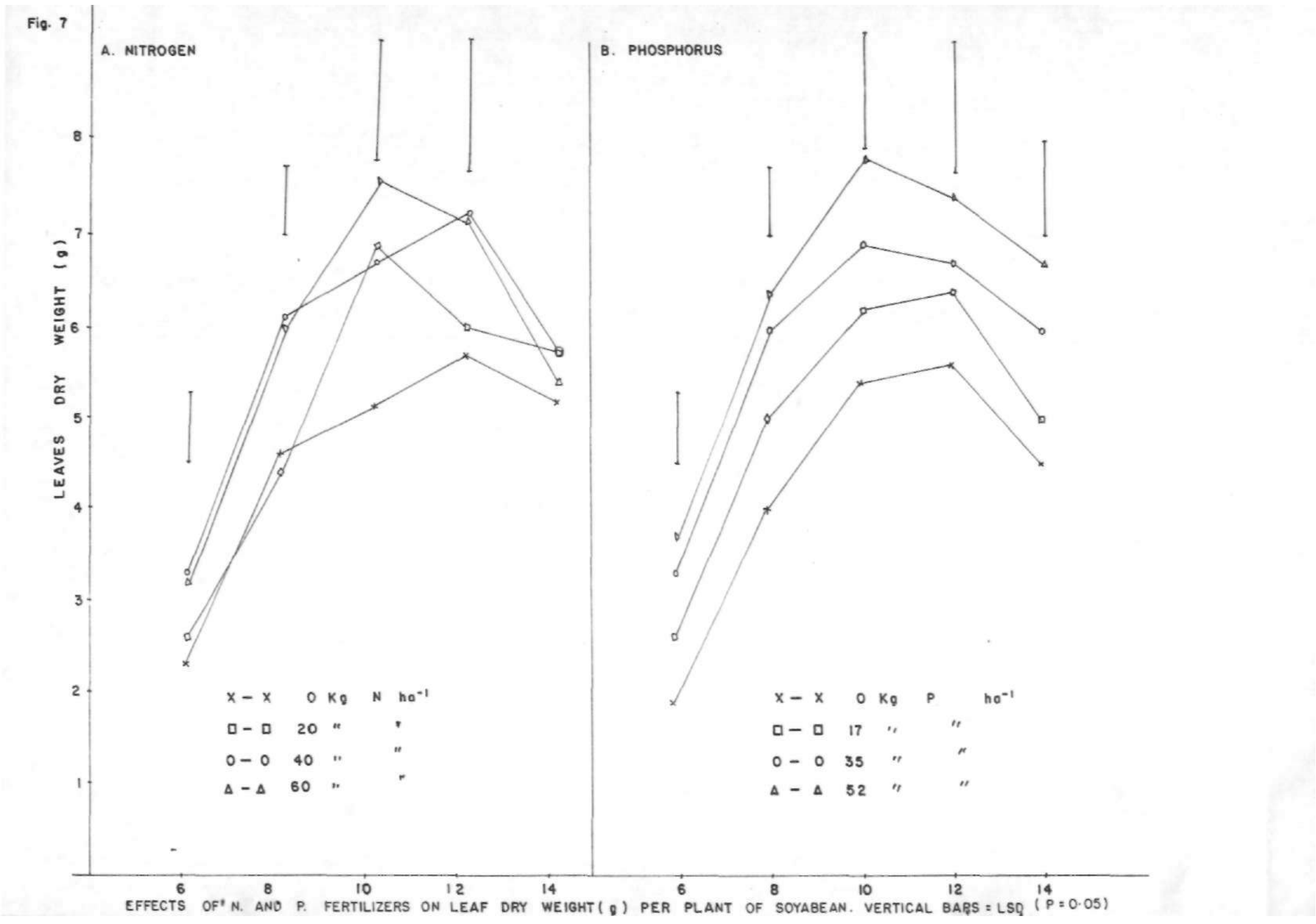
EFFECTS OF N AND P. FERTILIZERS ON NODULES DRY WEIGHT (g PLANT^{-1}) OF SOYABEAN.

Fig. 6 .



EFFECTS OF N AND P FERTILIZERS ON STEM DRY WEIGHT (g PLANT⁻¹) OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

Fig. 7



EFFECTS OF N. AND P. FERTILIZERS ON LEAF DRY WEIGHT (g) PER PLANT OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

Leaf dry weight was also significantly higher with the application of P at the rate of 35kg P ha^{-1} compared with zero and 17kg P ha^{-1} rates on all sampling dates while leaf weights at 35kg P ha^{-1} and 52kg P ha^{-1} were at par.

Leaf dry weight was not significantly influenced by the interaction between N and P on all sampling dates.

4.1.8 Pod dry weight per plant:

Pod dry weight per plant was significantly affected by P fertilizer (Fig. 8) while N fertilization had no effect on pod dry weight throughout the sampling period (ie 10th to 16th WAS). Pod dry weight increased significantly with increasing levels of P fertilization up to 35kg P ha^{-1} at 14 and 16 WAS. Pod weight at 35kg P ha^{-1} did not differ from that at 52kg P ha^{-1} throughout the sampling period.

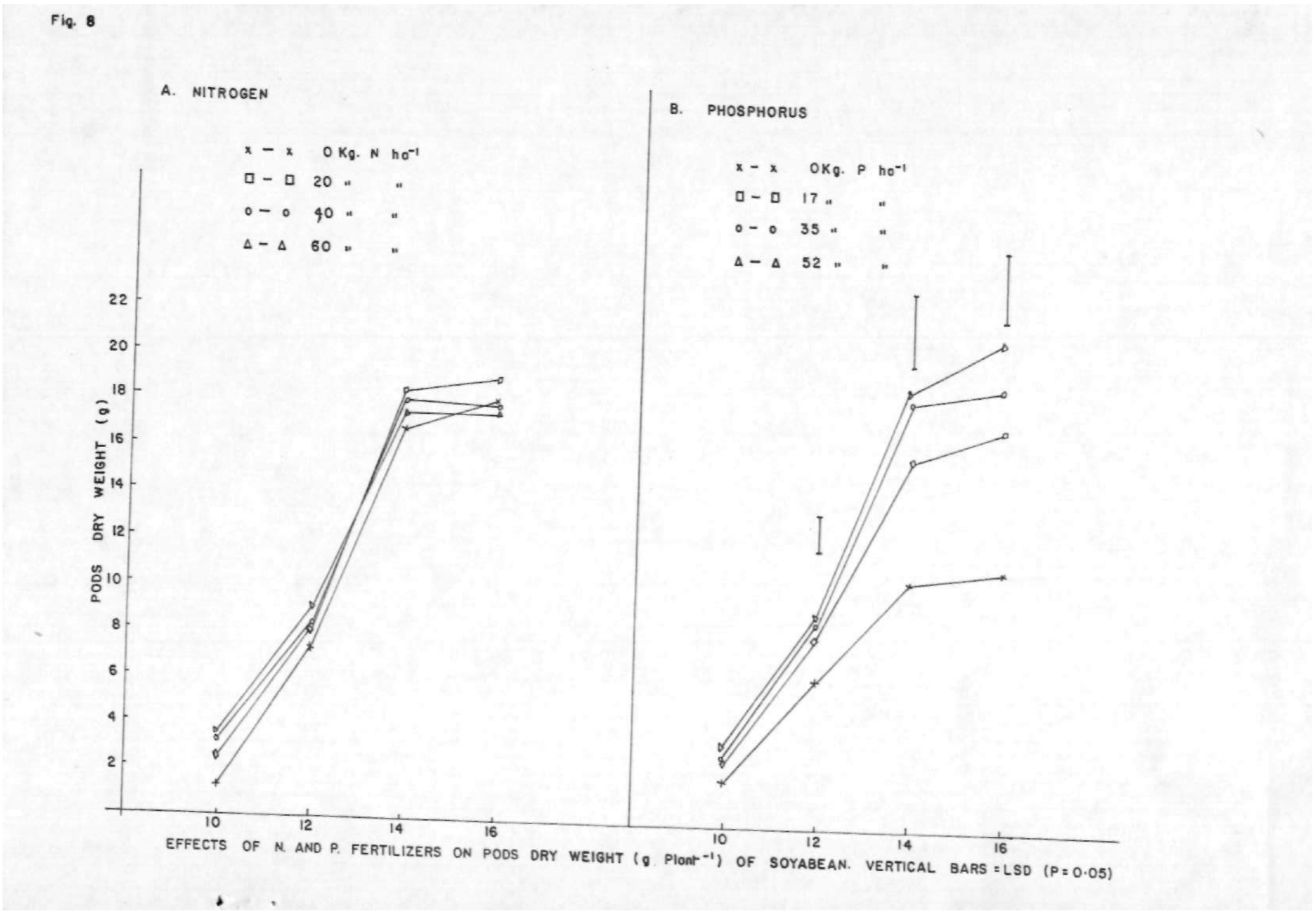
The interaction between N and P on pod dry weight was not significant on all sampling dates.

4.1.9 Leaf area per plant:

The leaf area produced per plant was significantly influenced by N and P fertilizers (Fig. 9). The application of N significantly increased the leaf area up to 60kg N ha^{-1} throughout the sampling period except at 6 WAS when the response was only up to 40kg N ha^{-1}. Leaf area increased significantly with increasing levels of P up to 52kg P ha^{-1}.

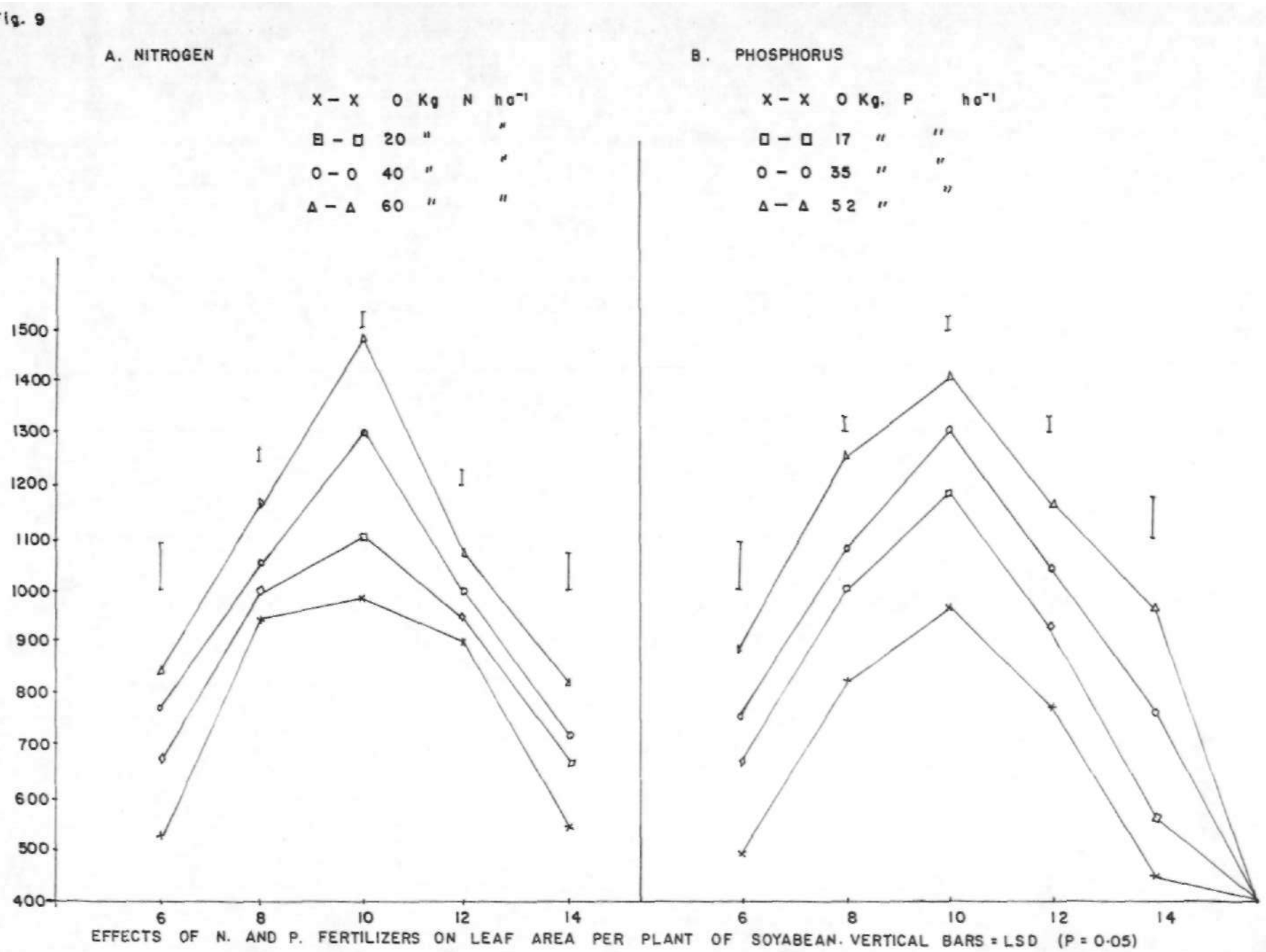
The interaction between N and P on leaf area per plant was significant on all sampling dates except at 6 and 14 WAS. The interaction at 10 WAS (Table 3) shows that when nitrogen was not applied, leaf area increased up to 35kg P/ha whereas in all cases where N was combined with P the leaf area

Fig. 8



EFFECTS OF N. AND P. FERTILIZERS ON PODS DRY WEIGHT (g Plant^{-1}) OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

Fig. 9



EFFECTS OF N. AND P. FERTILIZERS ON LEAF AREA PER PLANT OF SOYABEAN. VERTICAL BARS = LSD (P = 0·05)

Table 3: Interactive effect of N and P on the leaf area (cm^2) of soyabean plant at 10 WAS

N rate ($kg\ ha^{-1}$)	P rate ($kg\ ha^{-1}$)			
	0	17	35	52
0	723	932	1126	1167
20	887	1082	1188	1300
40	1100	1252	1342	1501
60	1223	1496	1558	1652

SE = $\pm$ 17.155

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

increased significatly up to the highest level (52kg P/ha). Similar response was obteained on other sampling dates.

4.1.10 Leaf area index (LAI):

The highest leaf area index occured at 10 WAS when the plants produced full canopy cover (Fig.10). Increasing the levels of N fertilizer resulted in significant increases in the LAI up to 60kg N ha^{-1} on all sampling dates.

Similarly, each increment in P level up to 52kg P ha^{-1} resulted in increases in LAI. With the exception of the 12th and 14th WAS, the interaction between N and P on LAI was significant on all sampling dates. The interaction (Table 4) shows that when phosphorus was applied in the absence of nitrogen, leaf area index (LAI) increased up to 35kg P ha^{-1} whereas when nitrogen was applied in combination with P leaf area index increased significantly up to the highest level of applied phosphorus (52kg P ha^{-1})

4.2 Effects of N and P on yield and yield components of soyabean:

4.2.1 Grain yield:

Grain yield was significantly affected by P whilst N had no effect on yield (Table 5). The application of 17kg P ha^{-1} resulted in a significantly higher grain yield compared with zero P while grain yield at 35kg P ha^{-1} was statistically similar to that at 17kg P ha^{-1} rate. However, grain yields were significantly lower at 17kg P ha^{-1} compared with 52kg P ha^{-1}.

4.2.2 Pods per plant:

The number of pods increased significantly with increasing levels of applied nitrogen up to 40kg N ha^{-1}. Increasing the level of N further to 60kg N ha^{-1} did not produce significant

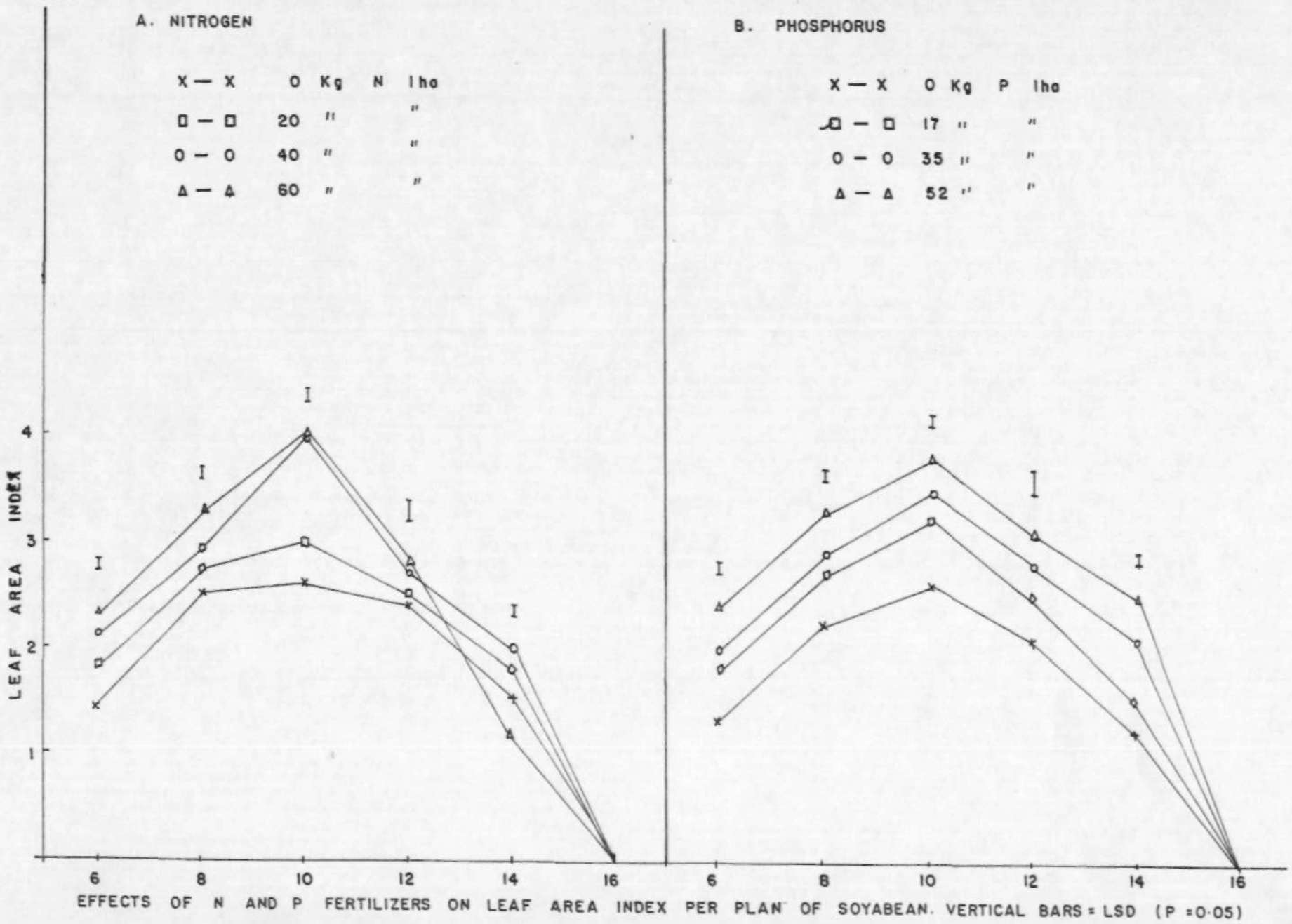
FIG. 10

A. NITROGEN

X — X 0 Kg N lha
□ — □ 20 " "
0 — 0 40 " "
Δ — Δ 60 " "

B. PHOSPHORUS

X — X 0 Kg P lha
□ — □ 17 " "
0 — 0 35 " "
Δ — Δ 52 " "



EFFECTS OF N AND P FERTILIZERS ON LEAF AREA INDEX PER PLAN OF SOYABEAN. VERTICAL BARS = LSD (P =0·05)

Table:4: Interactive effect of N and P on the leaf area index (LAI) produced per soyabean plant at 10 WAS

N rate (kg ha^{-1})	P rate (kg ha^{-1})			
	0	17	35	52
0	1.93e	2.48k	3.00ij	3.11hi
20	2.37k	2.89j	3.17gh	3.47de
40	2.93j	3.34ef	3.58d	4.00c
60	3.26fg	3.99e	4.16b	4.40a

SE = $\pm$ 0.046

Means followed by the same letter(s) not

significantly different at 5% level using DMRT.

Table 5: Effects of nitrogen and phosphorus on the yield, and yield components and some parameters of soyabean at Samaru – 1990.

Treatment	Grain Yield (kg/ha)	Pods Plant-1	Seeds Pod-1	100-seed Weight(g)	Shelling Percentage	Days to Maturity	Stand Count at Harvest/m^2
N rate (kg/ha)							
0	1829	40.9b	2.34b	12.43b	57.0	113.1	25.7b
20	2021	40.1b	2.37	12.97a	59.0	113.0	26.0b
40	2050	48ab	2.37	12.57a	59.8	113.6	26.4ab
60	2135	52.4a	2.34	12.71b	57.6	113.2	26.8a
LSD (P=0.05)	NS	9.0	NS	0.69	NS	NS	1.25
P rate (kg/ha)							
0	1325e	32.7c	2.19b	12.85	55.4	111.4	25.6e
20	2045b	42.0b	2.48a	13.01	57.5	112.3	26.4b
35	2226ab	49.8ab	2.49a	13.02	59.4	113.9	26.4b
52	2440a	56.8a	2.26ab	12.80	60.5	115.3	26.8a
LSD (P=0.05)	297.00	8.95	0.27	NS	3.6	0.98	1.25
INTERACTIONS							
(N X P)	NS	NS	NS	NS	NS	NS	

increase in the number of pods. Similarly number of pods per plant was significantly higher at 17kg P ha^{-1} compared with zero phosphorus level. No further significant increase was observed by increasing the levels of P up to 52kg P ha^{-1}.

The interaction between N and P on the number of pods produced per plant was not significant.

4.2.3 Seeds per pod:

Nitrogen had no significant effect on the number of seeds produced per pod while P had a significant effect (Table 5). The number of seeds produced per pod was significantly higher at 17kg P ha^{-1} compared with no P treatment. No significant increase was observed by increasing P levels up to 52kg P ha^{-1}.

The interaction between N and P on the number of seeds produced per pod was not significant.

4.2.4 100-seed weight:

The 100-seed weight was significantly affected by N only (Table 5). N fertilizer at the rate of 20kg N ha^{-1} gave a significant higher 100-seed weight compared with zero treatment. Increasing the levels of N above 20kg N ha^{-1} did not produce any further significant increase in the 100-seed weight.

The interaction between N and P on 100-seed weight was not significant.

4.2.5 Shelling percentage:

The shelling percentage: was affected by phosphorus only (Table 5). The application of P up to 17kg P ha^{-1} gave significantly higher shelling percentage when compared with zero phosphorus.

Increasing the levels of P beyond 17kg P ha^{-1} did not produce any significant change in the shelling percentage. The interaction between N and P on shelling percentage was not significant.

4.2.6 Days to maturity:

The number of days to maturity was significantly influenced by P only (Table 5). The mean number of days to maturity increased significantly with increasing levels of P up to 52kg P ha^{-1}.

The interaction between N and P on the number of days to maturity was not significant.

4.2.7 Stand count at harvest:

Nitrogen significantly influenced the number of stand at harvest with the highest number of stands obtained at 40kg N ha^{-1} level (Table 5). Stand count also increased significantly with increasing levels of P up to 52kg P ha^{-1}.

The interaction between N and P on the number of stands at harvest was not significant.

4.3 Effects of nitrogen and phosphorus on nutrient concentration:

4.3.1 Nitrogen concentration in soyabean plant:

The N concentration in plants was significantly affected by N and P fertilizers only at 10 and 14 WAS (Table 6).. Values decreased with increasing levels of N up to 60kg N ha^{-1}. Increasing the levels of P fertilizer up to 35kg P ha^{-1} also resulted in a significant decrease in N concentration at 70 and 98 DAS. The interaction effect was not significant.

TABLE 6: Effect of N and P fertilizers on nitrogen concentration (%) in soyabean plant

N rate (kg ha^{-1})	weeks after sowing		
	6	10	14
0	3.54	3.62a	3.96a
20	3.29	3.51ab	3.82a
40	3.22	3.34c	3.83a
60	3.13	3.40bc	3.53b
Mean		3.47	3.78
LSD (P=0.05)	NS	0.145	0.140
P rate (kg ha^{-1})			
0	3.16	3.64a	3.82a
17	3.27	3.53ab	3.77a
35	3.12	3.47b	3.72b
52	3.34	3.24c	3.59b
Mean		3.47	3.72
LSD (P=0.05)	NS	0.145	0.140

NS, not significant at the 5% probability level.

4.3.2 Phosphorus Concentration in plant:

The P concentration in plant at the three growth stages (42, 70 and 98 DAS) was significantly affected by N and P fertilization (Table 7). Increasing the levels of N up to 40kg N ha^{-1} significantly increased the P content in plants at all three stages of growth. At 70 and 98 DAS, increasing the levels of P up to 35kg P ha^{-1} resulted in significant increases in P concentration while beyond this level the differences were not significant. The P content also increased with plant age in all treatments. The interaction effect was not significant.

4.3.3 Phosphorus concentration in grain:

The P concentration in grain was significantly influenced by N and P fertilizers (Table 8). Values increased significantly with increasing levels of N.

Similiarly, the amount of P in grain increased significantly with increasing levels of applied P fertilizer up to 35kg P ha^{-1}, beyond which no significant increase was observed. The interaction was not significant.

4.3.4 Correlation:

Nitrogen and phosphorus significantly affected the correlation between grain yield and some yield components of soyabean (Table 9). Grain yield was found to be highly significant and positively correlated with the number of pods per plant ($r = 0.55$), number of days to maturity ($r = 0.58$), and 100-seed weight ($r = 0.48$). The concentration of N in plants was found to be highly significant and negatively correlated with the grain yield of soyabean.

TABLE 8: Effects of N and P fertilizers on phosphorus concentration (%) in grains of soyabean

nitrogen (kg ha^{-1})	Total phosphorus (%)
0	0.46c
20	0.47bc
40	0.49b
60	0.53a
Mean	0.49
LSD (P=0.05)	0.022
Phosphorus (kg ha^{-1})	
0	0.40c
17	0.49b
35	0.57a
52	0.59a
Mean	0.51
LSD (P=0.05)	0.022

Table 9 : Matrix of Coefficient of Correlation (r) between grain yield, yield components and growth of soyabean (SAMSOY 2) in Samaru - Zaria, 1990.

	1	2	3	4	5	6	7
1.	1.000						
2.	.547**	1					
3.	.553**	.592**	1				
4.	.478**	.280	.373**	1			
5.	.583**	.428**	.313*	.227	1		
6.	.635**	.849**	.549**	.344*	.611**	1	
7.	-.424**	-.549**	-.335*	-.244	-.361*	-.491**	1

NB: *Significant at 5%

**Significant at 1% level of probability

1. Grain Yield
2. Leaf Area
3. No. of Pods/Plant
4. 100-seed ut.
5. No. of days to maturity
6. Conc. of P in Plants at harvest
7. Conc. of N in Plants at harvest

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of N and P fertilizers on yield and yield components of soyabean:

A. Nitrogen:

The grain yield of soyabean was not significantly affected by N rates ranging from zero to 60kg N/ha. The lack of response to applied N conforms with reports by earlier workers (Radley, 1971; Arnold, 1969; Rachie and sylvestre, 1977; Kalia et al. 1984). In the present study, the lack of response of soyabean to N could possibly be attributed to the high initial soil N (0.09%) as shown in Table 1 coupled with the fact that the soyabean cultivar used (SAMSOY 2) has been reported to be promiscously nodulating in that it forms effective symbiosis with indigenous bradyrhizobia (Olufajo et al. 1989). On examination, the nodules were pinkish, an indication that they were fixing atmospheric nitrogen. Thus grain yield was not significantly increased by N application eventhough the number of pods per plant and 100-seed weight were slightly increased by nitrogen.

B. Phosphorus:

Soyabean grain yields were increased by 54%, 68%, and 84% over the no-P control with the application of 17, 35 and 52kg P/ha respectively.

Significant increases in soyabean grain yields with the application of P have been reported by various workers (bangoo and Albriton, 1972; Chesney, 1973 and Pal et al. 1989). Chesney (1973) observed that soyabean plants receiving an inadequate supply of P were of a much smaller stature and matured about two weeks earlier than those receiving an adequate supply of

phosphorus. The advantage of this prolonged period of vegetative growth is in the ability of the plants to develop maximum productive capacity and to accumulate enough assimilates for the eventual translocation to the grains during the grain filling period.

The response of P could also be due to greater nodulation and maximum nodule activity with the application of higher levels of P thereby leading to increased N-fixation which accordi to Shibles et al. (1975) is required to achieve high yields. The use of single superphosphate (SSP) as source of P also enabled the concurrent supply of phosphorus, sulphur and calcium to the soil and thus enhanced the response of soyabean to applied phosphorus.

On the moderately acidic soil used in this study, calcium, as a liming material probably aided in reducing the soil acidity to a more convenient PH level thereby increasing the availability of the phosphorus to the plants.

The application of 17kg P/ha was sufficient to meet the crop's requirements as a further increase in the levels of P did not increase grain yield significantly. This result agrees with the findings by Boswell and Anderson (1976) and Chiezey (1990), that soyabean yield responses obtained from the application of high levels of P were usually small and insignificant. Tewari (1965) also reported that at very high rates of P application, the increases in yield over the medium rates of P application of 32kg P/ha resulted in the retension of more pods per plant, heavier pod weight and higher shelling percentage consequently resulting in enhancement of grain yield.

5.2 Effect of N and P fertilizers on Vegetative growth:

A. Nitrogen:

The application of N resulted in increases in plant height, number of nodes per plant, nodules dry weight, dry matter accumulation, leaf area and leaf area index. The effect of N was more pronounced when plants were given up to 60kg N/ha. This result is in agreement with the findings by Kang (1975) and Kuwahara et al. (1986) who reported that without inoculation 60kg N/ha was needed to give a significant increase in dry matter yield by soyabean plants, whereas 30kg N/ha was sufficient with inoculation.

It was observed in this study that nitrogen increased nodulation significantly only at the initial growth stage, when 20kg N/ha (that is, starter dose) enhanced nodulation. The application of N above 20kg N/ha resulted in a decrease in the number of nodules produced by soyabean plants. This result agrees with the findings by Allos and Bartholomew (1969) and Bangoo and Albriton (1972) that when N is supplied in excess of amounts required for plant growth combined N may prevent symbiotic N fixation and inhibit the production and activities of nodules.

B. Phosphorus:

The application of P resulted in increases in the number of primary branches, number of nodes, number of nodules, nodules dry weight, plant height, dry matter accumulation, leaf area and leaf area index. The overall effect was the establishment of bigger and more vigorous plants from plots that received P fertilizer compared with those that had no P. The effect of P was more pronounced when plants were given up to 52kg P/ha

where plant height, dry matter accumulation, leaf area and leaf area index were maximum. This could perhaps be due to the fact that P stimulates root growth and increases the efficiency of the roots consequently enhancing nutrients absorption for greater growth and development of the entire plants (Cope and Hunter, 1967). The application of P significantly increased the number of nodules produced per plant. De Mooy and Pesek (1966) observed that maximum nodulation required high levels of P application.

Plant height, leaf area and leaf area index increased significantly up to the highest level of P (52kg P/ha) used in this study. Plants grew taller with complete canopy cover at higher levels of applied P probably because the application of P at the rates of 35 and 52kg (P/ha) provided the plants with sufficient nutrients for growth. The application of P at high levels also influenced the number of days to maturity. The delay in maturity recorded in the presence of 35 and 52kg P/ha was probably due to enhanced and prolonged period of vegetative growth similar to the influence of N on cereals (Chesney, 1973).

5.3 Effect of N and P fertilizers on nutrients Concentration in soyabean plant:

The concentration of N in plants decreased with increasing levels of applied N. This result could be attributed to the fact that high rates of N reduced root hair infection, nodule number, the nitrogen fixing activity of nodulated roots and the total amount of N fixed as observed by Eagleasham et al. (1983).

B. Phosphorus:

The application of P increased the amounts of N and P in plants.

In this study, it was observed that the lowest values of P concentration in plants occured at zero phosphorus level.

This was probably due to the relatively low (6.8 ppm) initial value of P in the soil (Table 1). This initial amount of P is considered inadequate to sustain good plant growth and development.

5.4 Interaction of Nitrogen and Phosphorus:

A significant N and P interaction was observed on number of branches, leaf area and leaf area index (LAI). The result indicates that only the vegetative growth was significantly affected by the interactive effects of N and P, while the grain yield was not significantly affected. This result is similar to the findings by Tewari (1965), who observed that N and P had significant effects on grain yield of soyabean as the main treatments but none of the interactions were significantly different. This could probably be due to the fact that soyabean plants supplied with adequate N had a large and more extensive root system than comperable N_2-fixing plants.

Cassman et al. (1980) reported that the more extensive root system of an N-supplied legume should increase its capacity to absorb P and lower the requirements for added P fertilizers.

5.5 Correlation:

The grain yield of soyabean was found to be highly significant and positively correlated with the number of pods per plant, number of days to maturity, and 100-seed weight. These parameters were observed to be important components and determinants of grain yield of soyabean.

Chiezey (1990) in a similar study with soyabean observed that the number of pods per plant and 100-seed weight were the two most important yield components. Almost all the parameters measured were highly significant and positively correlated with grain yield except the concentration of N in plants and in grain which was negatively correlated.

Shibles et al. (1975) attributed this negative behaviour of N to a proportionate retardation of symbiotic N_2- fixation which is required to achieve high yields and protein levels by an increase in mineral or fertilizer nitrogen.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Soyabean (Glycine max (L) Merrill), variety SAMSOY 2 was grown at the Agricultural Research Farm of the Institute for Agricultural Research (I.A.R), Ahmadu Bello University, Samaru - Zaria (11^{o} 11'N and 07^{o} 38'E, 650m above mean sea level) - during the 1990 cropping season to test the response of soyabean to different levels of N and P fertilizers.

Treatments tested consist of four levels each of N (0, 20, 40 and 60kg N ha^{-1}) and P (0, 17, 35, and 52kg P ha^{-1}). They were laid out in a randomised complete block design in factorial combinations and replicated four times.

The results obtained indicates that growth and yield responded differently to nitrogen and phosphorus applications. While soyabean plants required higher rates of N and P for maximum growth, the application of N at all levels did not, however, affect the grain yield of soyabean significantly. Grain yield responded to P application up to 17kg P ha^{-1}. Increasing the levels of P further did not produce any significant increase in yield.

Yield reductions were as high as 54% when no P fertilizer was applied, while a 10% reduction in grain yield was observed when no N fertilizer was applied compared with 20kg N ha^{-1}.

The number of nodules produced and the N concentration in plant decreased with increasing levels of N fertilizer. Thus indicating that N supplied in excessive amounts decreased the nitrogen content of soyabean plants. Phosphorus concentration in plants increased with increasing levels of N and P indicating that N and P stimulated the absorption of P by the soyabean plants

Based on these results, therefore, it could be concluded that the optimum level of phosphorus fertilizer application in this study was 17kg P ha^{-1}.

Nitrogen fertilizer application at all levels did not show any significant effect on the grain yield of soyabean. However, the application of N at the rate of 20kg N ha^{-1} increased nodulation significantly at an earlier growth stage. Thus indicating the need to apply N as a 'stater dose' to enhance early nodulation which eventually plays an important role in symbiotic N_2- fixation that has been found to increase the grain yield of soyabean (Shibles et al. 1975).

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APPENDIX I: Total rainfall, maximum and minimum temperature, Relative humidity, and sunshine hours at 10 - days interval during the period of the experiment at Samaru, 1990.

Month	Days	Total R.F. (mm)	Max T^{O} (0^{C})	Min.T^{O} (0^{C})	R.H.	Sunshine (hours)
	1 - 10	-	--	-	-	-
June	11 - 20	1420	31.1	21.1	19.0	7.64
	21.- 30	732	28.8	19.3	81.2	6.14
	1 - 10	678	29.4	20.9	78.9	6.52
July	11 - 20	846	28.2	21.5	81.2	4.86
	21 - 31	695	28.5	21.9	81.0	7.8
	1 - 10	1032	28.4	19.4	81.9	6.2
August	11 - 20	447	28.4	19.3	84.3	6.6
	21 - 31	1014	29.9	19.8	78.3	7.4
	1 - 10	546	30.0	19.4	78.1	8.4
Sept.	11 - 20	147	30.3	19.7	74.6	6.6
	21 - 30	181	31.4	19.8	75.0	8.1
	1 - 10	-	32.5	20.6	71.7	7.9
Oct.	11 - 20	-	32.5	18.9	59.7	7.0
	21 - 31	-	32.7	17.8	51.0	10.2