EFFECT OF PHOSPHORUS AND PLANT DENSITY ON THE GROWTH, YIELD AND PROTEIN CONTENT OF GREEN GRAM (*Vigna* radiata (L) Wilczek)

BY

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DECLARATION

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

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CERTIFICATION

This dissertation entitled "THE EFFECT OF PHOSPHORUS AND PLANT DENSITY ON THE GROWTH, YIELD AND PROTEIN CONTENT OF GREEN GRAM (Vigna radiata (L) Wilczek)". by Mukhtari Mahmud meets the regulations governing the degree of Doctor of philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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TO ABD-AS-SHAKUUR. M. MAHMUD,

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In the name of Allah, most beneficient, most merciful. All praise be to Him.

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ABSTRACT

Investigations to study the effect of phosphorus and plant density on the growth, yield and protein content of green gram (Vigna radiata (L) Wilczek) were curried out at the Institute for Agricultural Research farm, Samaru (1111 N ;07′38^{N} E, 686m above sea level) Zaria during the rainy season of 1993 to 1995. The treatments consisted of five green gram varieties (Galadima, VC 2768A, VC1178A, VC2778A and VC 1973A); three plant densities (200,000; 400,000 and 600,000 plants/ha) and three levels of phosphorus (0.25 and 50kgP/ha) arranged in a split plot design in which varieties and plant densities well assigned to the main plot and phosphorus levels were placed in subplot. The treatments were replicated three times.

The results showed that variety Galadima was superior to all other varieties for the growth characters studied, while variety VC 1178A was superior to other varieties in terms of yield character investigated with the exception of numbers of days to 50% flowering, pod length, pod width, number of pods/plant and number of seeds/plant. Variety VC 2778A had higher grain crude protein than other varieties.

Increasing plant density from 200,000 to 600,000 plants/ha decreased most of the parameters except LAI, NAR, RGR, pod weight/ha and grain yield/ha which were increased. The grain crude protein content was reduced with increased density up to 400,000 plants/ha.

Growth characters as well as yield characters and grain crude

protein contents were significantly increased with increasing phosphorus rates from 0 to 50kgP/ha.

Correlation analysis showed positive and significant associations between yield and most of the parameters studied. Indirect contribution of most characters was greatest through total dry matters and 1000-grain weight. Plant height and 1000-grain weight make the highest individual contributions to yield; while the combinations of plant height and total dry matter; and number of seed/pod and 1000-grain weight were the highest contributors to yield.

Polynomial responses of grain yield to density and phosphorus were linear and guadratic respectively. Using the regression constant, optimum level of phosphorus was found to be 23.43kgP/ha.

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ABBREVATIONS AND SYMBOLS

g ---------- Gram

kg ---------- Kilogram

mg ---------- Milligram

ml ---------- Millilitre

l ---------- Litre

Meq ---------- Milliequivalent

m ---------- Metre

m^2 ---------- Metre square

cm ---------- Centimeter

cm^2 ---------- Centimeter square

mm ---------- Millimetre

ha ---------- Hectare

% ---------- Percentage

C.E.C ---------- Cation exchange capacity

N ---------- Nitrogen

P ---------- phosphorus

K ---------- Potassium

Ca ---------- Calcium

Mg ---------- Magnessium

H ---------- Hydrogen

Al ---------- Aluminium

Na ---------- Sodium

H_2O ---------- Water

AM ---------- Ante meridian

PM ---------- Post meridian

Min ---------- Minimum

Max ---------- Maximum

* ---------- Significant difference at 5% level

** ---------- Significant difference at 1% level

NS ---------- Non Significant

°C ---------- Degree celsius

Lat ---------- Latitude

/ ---------- Per

SE ---------- Standard error

± ---------- Plus or minus

CHAPTER ONE

INTRODUCTION.

Green gram (Vigna radiata (L.) Wilczek) is a member of the family Leguminosae and sub family Papillionoidae. The distribution of this crop is confined to plains or low elevation between latitude 30°N and 30°S. It is believed to be of ancient cultivation in India. It is probably derived from P. radiatus (L) which occurs in wild throughout Indo-china and Java (Pulseglove 1980). It was introduced in comparatively recent time in the west indies, the United state and Africa. In Nigeria, small scale cultivation is practiced in Plateau state (Nimzing and Falaki 1987) and Oyo state in experimental plots (Leakey and Wills 1977).

The estimated annual world production of green gram in 1986 was 1.9 million tonnes, with India producing the bulk (1.154 million tonnes) (Anon. 1987). Although a large percentage of this crop is utilized domestically, considerable quantities enter international trade. Unfortunately, statistical data are extremely fragmented. Thailand and Burma are the leading exporting countries. Japan is the major import market; Phillipines, Malaysia, Taiwan and Hongkong also import significant quantities of green gram from Thailand (Daisy 1979).

Green gram is a rich source of protein, vitamin and minerals. The protein is rich in leucine, arginine, isoleucine, valine and lysine amino acids. Although, the quality of grain protein like other legumes, is limited by low sulphur content containing amino acids like cystine and methionine, both of these amino acids are comparatively greater in green gram than in other food legumes

(Engel 1978). The vitamin contained in green gram includes vitamin A,B,B_1,B_2 and C and niacin. The following gives the chemical composition of the crop:

Dry matter	88.38
Calories / 100g	363.96
protein	22.96%
fats	2.0%
water	11 %
fibre	4.2%
carbohydrate	0.4%
Ash	3.4%

Source; Sinha 1978.

Green gram is frequently used for feeding children, invalids and gastritis in times of famine because of its high digestibility and relative freedom from antinutritional factors such as flatulences - inducing substances (Rachie and Robert 1974). The seeds may be eaten whole after boiling or split and made into dhal, used in various fried and spiced dishes such as noodles, cake and "moimoi." After the removal of the seed coat and parching, the seeds may be ground into nutritious flour, or used as a source of starch. The flour is widely used as an ingredient for various bakery products and snack food. In East Africa, South East Asia and United states, bean sprout are prepared from the seeds and could be utilized as a source of L- aspargine (Daisy 1979).

The dry seed is sometimes used for animal feed especially poultry. The immature seed-pods are occasionally picked and eaten

as vegetable, green gram is used in smothering weeds (Mahmud et al 1990). The leaves and stalk left after the pods have been harvested, and husk and split remaining after the preparation of dhal can be utilized for animal feed. The green gram flour is reported to be used occasionally in parts of South East Asia as a soap substitute (Daisy 1979).

In many third world countries including Nigeria, where population is ever on the increase and the majority of the populace are poor and therefore cannot afford to include animal protein in their diets due to high cost. Green gram is a potentially important alternative source of protein, more so as the costs of other vegetable protein sources especially cowpea are generally getting out of reach of the poor. Although soyabean is also a very good source of protein especiaally in the quantity of amino acid, it can not be used directly by the consumer.

Green gram being a leguminous crop does not need large quantity of applied nitrogen. However, its requirement of phosphorus is important. The fertility of savanna soil is generally low especially with respect to phosphorus (Sanchez, 1976) but crops respond well to fertilization because of its favourable base exchange properties (Mokwunye 1979). The demand for a reasonably correct evaluation of the effects, beneficial or otherwise of phosphorus in green gram is rapidly increasing, thus emphasizing the need for a well established production function model. Also this therefore calls for intensive investigation on the effect of phosphorus fertilization in relation to green gram productivity in

this zone.

Plant density is another important determinant of crop yield with most field crops, the need for maintaining high plant density has been found necessary with better fertilization, soil management and adequate supply of moisture for green gram, there is an optimum plant density which produces the maximum yield; when plant population falls below this optimum level, all other factors of production fail to produce any appreciable effects on yield.

Reasearch eforts at the Institute for Agricultural Research Samaru and similar research institutions in Nigeria, have concentrated more on other leguminous crops, especially cowpea which needs high protection measures when compared to green gram. There is therefore a need to investigate the potentialities of green gram in Nigerian savanna region. To this end, investigations were conducted with the following objectives:-

a. To study the effect of phosphorus and plant density on the growth and yield of green gram.
b. To examine the effect of phosphorus and density on protein content of green gram.

CHAPTER TWO

LITERATURE REVIEW.

Agronomic research on green gram has been reported from various parts of the world, notably India,Pakistan and Thailand. Some of the findings occassionally contradict one another even within the same environment. There is therefore the need to review published work related to green gram management and production.

2.1 PHOSPHORUS NUTRITION IN GREEN GRAM.

Phosphorus is one of the limiting nutrients in most agricultural soils. Deficiency of phosphorus is particularly common in the savanna soils with low organic matter content (Bache and Roger, 1970, and Mokwunye, 1974). In savanna soils total phosphorus ranges from a mean of less than 100ppm to more than 400ppm and most crops especially legumes will produce only meagre yield in the absence of phosphate fertilizer (Udo and Ogunwale, 1977. and Mokwunye, 1979). The effect of phosphorus on crop growth is usually seen in earliness to maturity and enhanced root system. Phosphorus is required for photosynthesis, respiration and energy storage. Nutrient absorption and metabolism is also phophorus dependent. It is also a constitutent of cell nuclei and is essential for cell division and enlargement (Brady, 1978 and Mengel and Kirkby, 1982).

The response of green gram to phosphatic fertilizer depends on the amount of available phosphorus in the soil. Dhillon et al. (1988) reported that green gram grown in India, responded significantly to phosphorus application only on soils low in

available phosphorus and the increase in yield was significant up to 11kgP/ha. The response decreased markedly with increasing soil phosphorus. Reports from Bangladesh, show that application of up to 26kgP/ha significantly and progressively increased the growth, pod number per plant, grain yield and straw (Ahmed et al. 1986). Duraiswamy et al. (1979) and Reddy and Palaniapan (1979) observed that application of 4 to 18 kgP/ha in soils of medium phosphorus content had a significant effect on yield and yield component of green gram at Madras. However, Balaguraviah et al. (1989) reported that in a trial at 3 sites representing low, medium and high available phosphorus content, significant response was observed up to phosphate equivalent of 26kgP/ha in all the sites.

The response of green gram to phosphorus is dependent on the type of soil in which it is grown. On an acidic lateritic soils with high phosphorus fixation capacity, Moolani and Jana (1965) reported a significant yield response up to 44kgP/ha. Patel et al. (1988) observed that application of 9kgP/ha increased growth and 1000-grain weight and gave average seed yield of 0.75t/ha. compared with 0.57t without phosphorus. Yields were not further increased with 18 - 26kgP/ha in loamy sand soil. On a clayey soil, application of 18kgP/ha significantly increased the seed yield, further increase in phosphorus rate from 18 to 35kgP/ha was not economical. The effect of phosphorus on fodder yield was not significant, whereas increasing phosphorus rates increased the number of pods per plant and 1000 - grain weight (Patel et al., 1984). Patel and Patel (1991) reported that in sandy soil

increasing phosphorus from 0 to 26kgP/ha gave higher seed yield, number of pods per plant, pod length and number of seeds per plant. Further more, Mahmud (1991) reported that application of phosphorus up to 26kgP/ha increase yield and yield component of green gram on sandy loam soil at Samaru.

The rate or level at which phosphorus is applied to a given soil is important. Ravankar et al. (1973) noted that application of 35kgP/ha was optimum for increase growth, nodulation, nitrogen fixation and seed yield. Reports from South East Asia showed that green gram supplied with phosphorus at rates ranging from 0 to 33kgP/ha, gave highest yield with 22kgP/ha (Tej et al. 1975; Panwar et al. 1976; Panwar et al. 1978; Vasimar and Subramanian, 1980; Singh, 1984; Kamat et al. 1986; Arya and Kalra, 1988; Balajuraviah et al. 1989 and Singh 1990). Singh and Hiremath (1990) reported that appling 9 or 22kgP/ha increased number of leaves per plant, number of branches per plant, C.G.R, R.G.R, unit leaf rate, L.A.I and nodulation. Increasing level of phosphorus from 9 to 26kgP/ha resulted in significant increase in grain and number of pods per plant, number of grains per pod, C.G.R, unit rate, LAI, LAR, Specific leaf weight and 1000 - grain weight (Shrivastava and Verma, 1981). However, Jain et al. (1987) observed that application of phosphorus did not show any significant effect on height, number of leaves and branches, fresh and dry weights per plant, indicating that, it did not play any direct role in growth and development, but increased phosphorus level showed significant effect on number of pods, grain yield per plant, number of grains per pod, grain per

hectare and 1000-grain weight.

Application of phosphatic fertilizer increases the protein content of green gram. Panwar and Singh (1975) noted that seed protein content of green gram increased from 18.38 to 19.74% with increasing phosphorus rate from 0 to 26kgP/ha. Phosphorus application also significantly increased seed protein and methionine content, but decreased tryptopan content (Kushwaha and Srivastava, 1978). Higher protein yield was also reported by Patel and Patel (1991) with increasing phosphorus level from 0 to 26kgP/ha. Tej et al. (1975) reported an increase in protein content with increasing phosphorus rates from 0 to 33 kgP/ha, while Reddy et al. (1990) observed an increase in protein content up to 22kgP/ha. However Arya and Kalra (1988) reported that application of phosphorus up to 33kgP/ha increased protein yield, but seed protein content was not affected.

2.2 PLANT DENSITY IN GREEN GRAM.

The optimum plant density that gives maximum yield differs between crop species and varieties under different climatic and adaptive conditions, resource availability and management practices. There is a general increase in grain yield of green gram as plant population density increased from 100,000 to 600,000 plants /ha (Maheshwari et al. 1978; Sabbarayalu et al. 1988; Neciosup and Vista, 1981; Singh and Singh, 1988 and Baghel et al. 1989).

Singh and Malavia (1981) reported that green gram grown at 10 to 40 plants /m^2 gave the highest seed yield of 1.5t/ha with 20

plants/m^2. Increasing the number of plants per unit area increased plant height and reduced the number of primary branches per plant, 1000-grain weight and percentage light transmission. In Thailand, Lochaiyukul et al. (1970) observed that green gram sown at 416,000 plants/ha gave the highest yield, also increase in plant population per unit area increased LAI, total dry matter and growth component at all stages of growth. When the performance of Mung bean was compared over a range of 12 plant densities from 100,000 to 800,000 plants/ha, increasing plant density was positively related with significant reduction in flowering, yield per plant, and plant branching (Mackenzie et al. 1975).

Huesca and Oria (1981) reported that plants were taller with dense stand (25 plants/m^2) and pod set greatest at this density. Seed yield per unit area were greatest at the density of 10 plants/m^2. In a trial on green gram sown at 15 and 30 plants/m^2; yield per hectare and number of seeds per pod on branches increased with increasing plant density, whereas yield per plant, pods per plant and pods per branch decreased. The number of pods per plant was the most sensitive yield component to high density (Panwar and Sirohi, 1987). Trung and Yoshida (1985) observed that increasing plant density from 8 - 18 plant/m^2 increase dry matter production per unit area, LAI and seed yield and pod number per unit area, but had little effect on average number(8.2 - 8.6) or weight (0.39 - 0.40g) or seed per pod of 1000 - grain weight (42.6 - 47.1g).

Seed protein content of green gram is reported to decrease with increasing plant density. Safar and Al-Falahi (1977) observed

that protein yield was highest with sowing rate of 40kg/ha. Jain et al. (1988) reported an increase in protein content of green gram from 17.6 to 21.8 and 22.3 percent when spacing between plants were increased from 15 to 22.5 and 37.5cm. Furthermore, Jain and Chauhan (1988) observed higher protein content in wider rows than in narrow rows, However, little effect was observed by Trung and Yoshida (1985) on seed crude protein with increasing plant density.

2.3 **VARIETAL DIFFERENCES IN GREEN GRAM.**

A large number of green gram varieties are grown world wide. The varieties vary in some morphological, anatomical and physological characteristics. While some are determinate and end their vegetative phase at full flowering, others are indeterminate in which case growth continues even at flowering. The consequence of determinate types is that plants are short, photoperiod insensitive, pods borne above the canopy and improved tolerance to lodging and pod shattering (Fernandez and Shanmugasundaram 1987). The indeterminate types are photoperiod sensitive, late and non-synchrorous maturity, susceptibility of lodging and pod shatering (lin and cheng 1987). The growth of different green gram varieties vary; Najhaman and Chandra (1980) observed that Asia vegetable Research Development centre varieties have higher value of leaf area duration, leaf area index, net assimilation rate, relative growth rate and plant height at one or other phase of growth than indigenous varieties. The yield of different varieties also differs. Ko (1977) and Ling et al. (1988) reported that most of AVRDC varieties mature earlier, have larger and heavier seed and

produce higher yield than indigenous varieties. Trung and Yoshida (1982) also reported a variation in protein content of different varieties of green gram. He observed an efficiencies for seed protein production in AVRDC varieties than indigneous varieties.

2.4 INTERACTION BETWEEN DENSITY AND PHOSPHORUS LEVELS ON GROWTH, YIELD AND PROTEIN CONTENT OF GREEN GRAM.

Thakuria and Saharia (1990) reported that in A trial in Jorhat (India), green gram grown at 222,000 or 333,000 plants/ha gave average seed yield of 619 and 680kg/ha respectively. Yields were increased from 518 to 720kg/ha by applying 9kgP/ha, Thus the plant density of 333,000 in combination with 9kgP/ha was found to be optimum. In a spacing fertilizer trial, the highest seed yield was obtained by applying 22kgP/ha and sowing at 50 plants/m^2 (Srinivasan and Kandaswamy 1977). Rao and Rajan (1984) observed the best economic results of green gram at 10 x 25cm spacing and 18kgP/ha. Venkateswarlu et al. (1976) reported that an intra-row spacing of 10cm in combination with 11kgP/ha was found to be optimum under rainfed condition on sandy loam soil of Madras. Reports from America indicated that seed yield decrease from 676 to 604 kg/ha with increase intra-row spacing from 20 to 40cm. Yield increased from 583 to 632 and 779kg/ha by increasing phosphorus rates from 0 to 9 and 18kgP/ha. Therefore for optimum yield, 20cm intra-row spacing in combination with 18kgP/ha is recommended (Huesca and Oria 1981).

2.5 CORRELATION STUDIES.

Correlation deals with the association between a pair of variables independant of other variables under consideration and are of great value in determining the association of quantitative characters with yield for selecting characters that play an important role in influencing yield. Ko and Chang, (1975) observed high correlation between yield and stem length, stem diameter, numbers of branches, number of pods and number of seeds, but no correlation was found between yield and 1000-grain weight in their trial at South Korea. Reports from India indicated that seed yields were positively correlated with plant height, stem diameter, days of maturity, pod number per plant, seed number per pod and 1000-grain weight (Joshi and Kabaria, 1973; Sandhu et al. 1980 and Salyan et al. 1989). Yohe and Poehlman (1973) also observed positive correlation between seed yield and number of pods, number of seeds per pod, 1000 - grain weight and plant height. However, a negative correlation was observed between yield and number of leaves per plant and days to flowering (Singh et al. 1976) and between yield and pod length and number of branches (Sandhu et al. 1980).

2.6 PATH COEFFICIENT STUDIES.

Path-coefficient analysis measures the direct and indirect influence of each of yield contribution variables on yield (Wright, 1921). Tomar et al. (1973) reported that pod number per plant, pod length and seed size were important yield components, whereas, seed number per pod was less important. Reports of path-coefficient

analysis on green gram showed that number of clusters per plant, pod length, pods per plant, seeds per pod and 1000-grain weight were the major determinants of yield (Malhotra et al. 1974; Pokle and Patil, 1975; Rathnaswamy et al. 1978 and Saraswathy et al. 1979). In another report Upadhaya and Singh (1981) observed that days to maturity had significant direct and indirect effect on yield, but number of pods per plant had the greatest influence on yield.

CHAPTER THREE

MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE.

Investigations were carried out between 1993 and 1995 at Samaru (11°11'N, 07°38'E; 686 metres above sea level) to test the effect of phosphorus and plant density on the growth, yield and protein content of green gram (Vigna radiata (L) Wilczek). Samaru is located in the Northern Guinea Savanna zone with a long term (1928 - 1993) mean annual rainfall of 1054.8mm, concentrated in the months of May to September. The mean monthly minimum and maximum temperatures during the rainy season is 12 - 18 and 28 - 35°C, respectively. The mean relative humidity is 48.9%. Meteorological data at Samaru during the period of the experiments are shown in appendices I to III. Soil analysis of the experimental site indicates a sandy loam soil, describe as well drained leached Alfisol (Klinkenberg and Higgins 1968). It is characterised by low pH, Organic Carbon and cation exchange capacity. Physico-chemical analysis of the soil is contained in appendix IV. And meteorological records for the period of the trial is presented in appendices I to III

3.2 TREATMENT AND EXPERIMENTAL DESIGN.

Treatments consist of five green gram varieties (Galadima, VC 2768A, VC1178A, VC2778A and VC1973A) and three plant densities (200,000, 400,000 and 600,000 plants/ha) as the main plot treatments. Three phosphorus levels, (0, 25 and 50kgP/ha) were each allocated as sub-plot treatments. The experiment was replicated

three times in a split plot design (Cochran and Cox 1964). Each gross plot was 2.4 metre wide and consisted of 4 rows of 4 metre length, while the net plot consisted of 2inner row of 4 metres length.

3.3 **CROP VARIETAL DESCRIPTIONS**.

3.3.1 GALADIMA

This variety was obtained locally from plateau state of Nigeria. It has large size foliage, small sized seeds and pods, and relatively low yielder (30 - 40g/1000 seeds). The mature pods are prone to shattering and bear pods very close to the leaf canopy.

3.3.2 VC 2768A

This variety was obtained from Asian Vegetable Research and Development Centre (AVRDC). A cross between VC 1482A and VC 1628A (Quyen 1987). It is a moderate yielder (55 to 69g/1000 seeds), early maturing, moderately seeded and moderately resistant to powdery mildew and Cercospora leaf spot.

3.3.3 VC 1178A

This variety is a cross between V 1944 and V 2273 (Chainuvati et al. 1987) and was obtained from Asian Vegetable Research and Development Centre (AVRDC). It is a short stemed, early maturing, sparse canopy, large seeded, high yielder (70 -75g/1000 seeds). A uniform maturing veriety, and is moderately resistant to powdery mildew and Cercospora leaf spot. It also has its pod extruded high above the canopy.

3.3.4 VC 2778A

It is a cross between V 1560C and V 1628A (He et al. 1987).

This variety was obtained from the Asian Vegetable Research and Development Centre (AVRDC) It is a short stature, large seeded moderate yielder (61g/1000 seeds), uniform maturing variety that has its leaves still green and fresh in later stage. Therefore considered suitable for both feed and manure purposes.

3.3.5 VC 1973A

The variety is a cross between VC 3476 and V 1400 (Malik et al 1987; Lin and Cheng, 1989). It is a high yielder (70g/1000 seeds) with large seeds. A uniform and early maturing variety that has an erect stem and non - shattering pods. It is also moderately resistant to powdery mildew and Cercospora leaf spot.

3.4 **CULTURAL PRACTICES**.

3.4.1 LAND PREPARATION.

The experimental sites which differed in each year, were prepared by disc ploygh ing and harrowing twice in order to achieve a good tilth. Thereafter, ridges were constructed at 60cm apart. Land preparation was carried out as soon as the rains were established in the month of August.

3.4.2 SOWING.

Immediately after the land was prepared, four Seeds were sown by hand at 8.3, 4.2 and 2.8cm intra row spacing along the ridges and thiured to 1 plant per hole at 12 day after sowingto achieve a density of 200,000, 400,000 and 600,000 plants per hectare, respectively.

3.4.3 FERTILIZER APPLICATION.

Nitrogen at the rate of 20kg N/ha as Calcium ammonuim nitrate

(CAN 26%N) was uniformly applied to all plots and incorporated in to the soil. Phosphorus at the rate of 0, 25.0 and 50kgP/ha depending on the treatment was applied using single super phosphate (8%P) as the carrier. The phosphorus was placed in bands 6 cm to the side and 4 cm below the seeds on the same day the seeds were planted.

3.4.4 WEED CONTROL.

Weeds were controlled by pre-emergence application of a preparatory mixture of Metolachlor plus Metobromuron in the ratio of 1:1 at 2.25kg a.i./ha immediatly after planting. A supplementary hoe weeding was carried out at 4 WAS to control the late emerging weeds.

3.4.5 DISEASES AND PEST CONTROL.

Tank mixture of benomyl as Benlate and mancozeb as Dithane M 45 was used at the product rate of 0.6kg + 2.5kg/ha in 400 litres of water to control various fungal diseases.

Insect pest were controlled by applying a tank mixture of Cypermethrin as Cymbush 10EC and Dimethoate as Rogor 40EC at the product rate of 0.75 litres/ha from 5 WAS to harvest at weekly interval.

3.4.6 HARVESTING AND THRESHING.

Harvesting was carried out when pods were mature as indicated by their turning black. The pods were hand picked regularly as they mature and stored indoors to dry. On drying, the pods were threshed and winnowed.

3.5 DETERMINATION OF SOIL NUTRIENT STATUS.

Soil samples were taken to a depth of 30cm before fertilizer application and analysed for the following physical and chemical properties:

3.5.1 SOIL TEXTURE.

The texture was analysed by hydrometer method (Boyoucos 1951) and textural class determined by the soil texture triangle.

3.5.2 TOTAL NITROGEN.

Total nitrogen was determined by the macro-kjeldahl procedure (Bremmer, 1965, IITA, 1975).

3.5.3 AVAILABLE PHOSPHORUS.

Available phosphorus was determined by the method described by Trough (1930). The extractable phosphorus was determined by the molybdate blue colours (Bray and Kurtz, 1945).

3.5.4 EXCHANGEABLE CATIONS.

Exchangeable cations were determined by the acetic acid method (Reith, 1967). Magnesium, Calcium and potassium concentrations were determined by the atomic absorption spectro-photometry using perkin Elmers Model 403.

3.5.5 pH AND ORGANIC CARBON.

pH and organic carbon were determined using the standard procedures described by Black (1965).

3.6 OBSERVATIONS TAKEN.

Five plants were randomly sampled at three week intervals, until harvest to determine the following characters:

3.6.1 PLANT HEIGHT.

Height was measured from ground level to the tip of the plant in cm.

3.6.2 NUMBER OF BRANCHES PER PLANT.

The number of branches were counted and average worked out to give numbers per plant.

3.6.3 NUMBER OF LEAVES PER PLANT.

The number of leaves on the plants were counted and average per plant was determined.

3.6.4 LEAF, STEM AND TOTAL DRY MATTER PRODUCTION.

Three plants were cut from the bases according to the recommendation of Hughes and Freeman (1967), Radford (1967). The leaves, stems and other plant parts (Flowers, buds, pods) were separated and oven dried at 70°C. The data was subsequently used for growth analysis.

3.6.5 NUMBER OF DAYS TO 50 PERCENT FLOWERING.

Days to 50 percent flowering were recorded from the time of sowing to when at least 50% of the plants in each plot had flowered.

3.6.6 POD LENGTH.

Length was measured from the proximal to distal end of 10 randomly selected pods.

3.6.7 POD WIDTH.

Width of 10 randomly selected pods at its maximum end were measured using vernier calipers.

3.6.8 PODS AND GRAIN YIELD.

The number and weight of pods borne on each plant were recorded at harvest. The pods were hand threshed, the grains counted and weighed to determine grain yield per plant.

Total grain yield per hectare was determined by threshing the entire pods from the net plots. The grain yield was then determined by weighing the threshed grain.

3.6.9 1000-GRAIN WEIGHT.

This was worked out by counting 1000 seeds from each plot and weighing with the Mettler scale model 1210.

3.6.10 CRUDE PROTEIN CONTENT OF SEEDS.

The nitrogen content of the seed was determined by the standard micro-Kjeldahl procedure (A.O.A.C 1975). The method involved oven-drying of samples at 70°C for 24 hours and grinding to pass through 1mm sieve. From the sieve sample, 1g was digested with Sulphuric acid, using copper sulphate and sodium sulphate as catalyst. The solution was distilled in to boric acid and the distillate titrated against standard hydrochloric acid and percentage nitrogen determined from the titre. The crude protein content was then determined by multiplying the nitrogen content by factor 6.25 (Sankaram, 1966).

3.6.11 OTHER VARIABLE COMPUTED.

The following variables were derived from computation as described below.

3.6.11.1 LEAF AREA INDEX.

Leaf area index (LAI) was calculated as determined by Watson

(1947 and 1952), as the leaf area A (or other wise define as the assimilatory surface) over certain ground area P

$$L = A/P$$

where L = leaf area index

A = leaf area (cm^2)

P = ground area (cm^2)

3.6.11.2 RELATIVE GROWTH RATE.

The relative growth rate (RGR) was computed from the equation

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

W_2 and W_1 represent dry matter at times t_2 and t_1 respectively.

3.6.11.3 NET ASSIMILATION RATE.

The net assimilation rate (NAR) was calculated as described by Gregory (1926) from the equation

$$NAR = \frac{(\log_e l_2 - \log_e l_1)}{(l_2 - l_1)} \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

W_2 and W_1 are dry matter of plants at times t_2 and t_1 when correponding leaf area were l_2 and l_1 respectively.

3.6.11.4 SHELLING PERCENTAGE.

The ratio of grain yield to pod yield was calculated from the equation.

$$S\% = \frac{\text{grain yield}}{\text{pod yield}} \times 100$$

3.6.11.5 HARVEST INDEX.

The ratio of grain yield to the total dry matter was calculated from the equation.

$$K\% = \frac{\text{Grain yield from Ykg of TDM}}{} \times 100$$

Y kg of TDM.

where

K% = Harvest index

Y = grain yield

TDM = Total dry matter.

3.6.11.6 OPTIMUM LEVELS OF PHOSPHORUS.

Using the formula of Garg and Bansal (1972) and Little and Hills (1978), The optimum levels of phosphorus was calculated viz;

$$Xop = \frac{-b}{2c}$$

where Xop = Optimum level of phosphorus (P)

b and c = regression constants.

3.7 **STATISTICAL ANALYSIS OF DATA.**

The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran (1967) and significant differences among the treatment means were evaluated using Duncan Multiple Range Test (Duncan 1955). The type and magnitude of relationship between the variables were assessed through simple correlation analysis and the polynomial responses of grain yield to density and phosphorus were worked out by the procedure described by Little and Hills (1978). The regression analysis was also carried out to determined the optimum levels of the factor in accordance with Steel and Torrie (1984). The direct and indirect contributions of the yield component to grain yield were partitioned (Path - coefficient analysis) using the method described by Dewey and Lu (1959) and percentage contribution of each character was partitioned in accordance with Ajala et al.(1996).

CHAPTER FOUR

RESULTS

4.1 Plant height, 1993.

Mean plant height (cm) at the four sampling periods as affected by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 1.

The data showed that mean difference due to variety was significant at 3 and 9 WAS, highly significant at 6 WAS and non-significant at 12 WAS. Variety VC 2778A had significantly shorter plants than other varieties at 3 WAS. The height of other varieties were statistically at per. At 6 WAS, variety Galadima produced signifi-
cantly taller plants, this was followed by VC 2768A, which was statistically taller than other varieties. At 9 WAS, variety Galadima had taller plant, but was statistically at par with VC 2768A and VC 1178A. Variety VC 2778A had the shortest plants, but was statistically at par with VC 1973A.

Differences due to plant density were significant at 3,6 and 9 WAS and highly significant at 12 WAS. Increased density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha had no influence on plant height at 3 WAS, however green gram sown at 600,000 plants/ha gave taller plants. At 6 and 9 WAS, increased density from 200,000 to 400,000 plants/ha resulted in statistically the same height; but further increase in density to 600,000 plants/ha resulted in taller plants. At 12 WAS, plants sown at 200,000 plants/ha had significantly shorter plants when compared

Table 1: Plant height (cm) as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatment	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	14.1a	33.1a	46.2a	51.7
VC 2768A	14.1a	31.1b	45.2a	50.4
VC 1178A	13.8a	30.0c	45.1ab	50.0
VC 2778A	13.2b	29.1c	43.2c	47.8
VC 1973A	13.3a	29.3c	43.2bc	49.3
SE ±	0.11	0.29	0.45	1.56
Significance	*	**	*	NS
Density (Plants/ha)				
200,000	13.6b	30.2b	44.4b	46.9b
400,000	13.7ab	30.2b	44.4b	53.5b
600,000	13.9a	31.1a	45.6a	55.1a
SE ±	0.08	0.22	0.35	1.21
Significance	*	**	*	**
Phosphorus (kgP/ha)				
0	12.4c	26.7c	38.5c	42.4c
25	13.9b	30.5b	45.3b	50.3b
50	14.9a	34.3a	50.8a	56.8a
SE ±	0.07	0.13	0.24	1.78
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

with other densities ; further increase in density up to 600,000plants/ha did not influenced plant height.

The differences due to phosphorus was highly significant at the four sampling periods. Each level of phosphorus application increased the plant height significantly.

None of the first or second order of interactions was significant.

4.2 **Plant height, 1994.**

Mean plant height (cm) as affected by variety, plant density and phosphorus levels during 1994 rainy season is shown in Table 2.

Analysis of the data showed that mean difference due to variety was highly significant at all sampling periods. Variety Galadima had taller plant at 3 WAS; however its height was statistically at par with those of VC 2768A and VC 1178A. These were followed by VC 1973A, which was statistically at par with VC 1178A and VC 2768A. Variety VC 2778A produced the shortest plants. At 6 WAS, variety VC 2778A produced significantly shortest plants. The other varieties had statistically the same height. While at 9 WAS, variety Galadima was statistically taller than other varieties. This was followed by VC 1178A and VC 1973A which were taller than VC 2768A. Variety VC 2778A produced the shortest plants. At 12 WAS, varieties VC 2778A, Galadima and VC 1973A produced taller plants than VC 2768A and VC 1178A. Variety VC 2778A was the shortest of all the varieties.

Difference due to plant density was significant at 3 and 12 WAS, highly significant at 9 WAS and non-significant at 6 WAS.

Table 2: Plant height (cm) as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	11.6a	26.7a	39.1a	43.2a
VC 2768A	11.4ab	26.3a	31.8c	34.5b
VC 1178A	11.3ab	26.7a	33.3b	36.2b
VC 2778A	10.7c	22.9b	28.9d	31.0c
VC 1973A	11.1b	25.7a	33.2b	41.5a
SE ±	0.11	0.33	0.57	0.67
Significance	**	**	**	**
Density (Plants/ha)				
200,000	10.9b	25.5	32.3c	35.8b
400,000	11.3a	25.6	33.8b	37.6a
600,000	11.5a	26.1	35.5a	38.3a
SE ±	0.09	0.26	0.44	0.52
Significance	*	NS	**	*
Phosphorus (kgP/ha)				
0	7.3c	23.1c	29.8c	32.3c
25	8.3b	25.7b	33.6b	36.5b
50	9.1a	28.2a	38.1a	42.9a
SE ±	0.03	0.08	0.16	0.24
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Increasing density from 200,000 to 400,000 plants/ha at 3 and 12 WAS resulted in increases in the height of plants. However further increase in density up to 600,000 plants/ha did not affect the plant height. At 9 WAS, plant height increased significantly with increasing density up to 600,000 plants/ha. The differences due to phosphorus was highly significant at all sampling periods. Increase in phosphorus level either from 0 to 25 or 25 to 50kgP/ha significantly increased the plant height at all sampling period.

None of the interactions was significant.

4.3 **Plant height, 1995.**

Mean plant height as affected by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 3.

Analysed data showed a non-significant difference in means due to variety at 3 and 6 WAS, but a significant difference at 9 and 12 WAS, variety Galadima produced taller plants at 9 WAS when compared to other varieties. While at 12WAS, variety Galadima, VC 2768A and VC 1178A produced the tallest plants. The differences in height of varieties VC 2768A, VC 1178A and VC 1973A were not significant. Variety VC 2778A had the shortest plants, but was statistically at par with VC 1973A.

The difference due to plant density was only significant at 3 WAS. Increasing density either from 200,000 to 400.000 or 400,000 to 600,000 plants did not affect the plant height at 3 WAS.

The difference due to phosphorus was highly significant at all sampling periods. Increasing phosphorus level to 50kgP/ha resulted in significant increased in plant height over 25kgP/ha and control

Table 3: Plant height as (cm) affected by variety, plant density and phosphorus levels in 1995 at Samaru.

Treatment	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	11.1	37.4	44.8a	47.0a
VC 2768A	11.0	36.5	40.3b	44.4ab
VC 1178A	10.4	35.9	38.9b	43.9ab
VC 2778A	10.9	34.6	37.8b	39.7c
VC 1973A	10.9	34.7	38.4b	42.8bc
SE ±	0.26	0.91	1.19	1.28
Significance	NS	NS	*	*
Density (Plants/ha)				
200,000	11.2a	35.4	39.6	43.2
400,000	11.0ab	36.5	39.7	43.2
600,000	10.5b	35.6	40.8	44.3
SE ±	0.20	0.17	0.93	0.93
Significance	*	NS	NS	NS
Phosphorus (kgP/ha)				
0	9.9c	31.3c	35.0c	38.0c
25	10.9b	35.7b	40.1b	43.7b
50	11.9a	40.6a	45.1a	49.1a
SE ±	0.09	0.48	0.54	0.47
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

at the four sampling periods.

None of the interactions was significant.

4.4 **Number of branches per plant, 1993.**

Mean number of branches of green gram as affected by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 4.

Variety had a highly significant effect at 3 WAS, and significant effect at 6,9 and 12 WAS. Variety VC 2778A produced plant with the highest number of branches at 3 WAS, This was followed by VC 1178A. The other three varieties had statistically the same branches. At 6 WAS, variety VC 2768A produced significantly lower number of branches than other varieties which were at par with each other. While at 9 and 12 WAS, variety VC 2778A produced higher number of branches than all varieties except VC 1973A. Variety VC 1178A produced lower number of branches than VC 2778A and VC 1973A; but was statistically at par with VC 2768A and Galadima.

Plant density significantly affected the number of branches at 3, 9 and 12 WAS, and highly significant effect at 6 WAS. An increase in plant density from 200,000 to 400,000 plants/ha decreased the number of branches at 3 WAS, but further increase in density to 600,000 plants/ha did not influence the number of branches. However, at 6 WAS, increasing density from 200,000 to 400,000 plants/ha resulted in statistically the same number of branches, but further increased in density to 600,000 plants/ha decreased the number of branches. While at 9 and 12 WAS, increasing

Table 4: Number of branches per plant as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.30c	1.26a	3.93bc	3.93bc
VC 2768A	0.37c	0.89b	3.85bc	3.85bc
VC 1178A	0.59b	1.20a	3.70c	3.70c
VC 2778A	0.85a	1.22a	4.81a	4.81a
VC 1973A	0.41c	1.30a	4.3ab	4.30ab
SE ±	0.04	0.09	0.16	0.16
Significance	**	*	*	*
Density (Plants/ha)				
200,000	0.60a	1.47a	4.27a	4.27a
400,000	0.47b	1.24a	4.11ab	4.11ab
600,000	0.44b	0.87b	3.88b	3.88b
SE ±	0.03	0.07	0.12	0.12
Significance	*	**	*	*
Phosphorus (kgP/ha)				
0	0.13c	0.49c	1.89c	1.89c
25	0.42b	1.29b	3.82b	3.82b
50	0.96a	1.89a	5.64a	5.64a
SE ±	0.02	0.04	0.08	0.08
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

the density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the number of branches. However, the number of branches/plant at 200,000 plants/ha was higher than that produced at 600,000 plants/ha.

Phosphorus significantly ($P<0.01$) affected the number of branches at all sampling periods. Number of branches increased significantly when phosphorus rate was increased from 0 to 25 or 25 to 50kgP/ha at the four sampling periods.

None of the interactions was significant.

4.5 **Number of branches, 1994.**

Mean number of branches per plant of green gram as influenced by variety, plant density and phosphorus levels during 1994 rainy season is shown in Table 5.

The differences due to variety was significant at the four sampling periods. At 3 WAS, the varieties could be divided into two non-significant group of VC 2768A, VC 1178A and VC 1973A; and VC 1973A, VC 2778A and Galadima. At 6WAS, varieties VC 2768A and VC 1178A produced statistically the same number of branches, but were higher than the other three varieties. However, at 9 and 12 WAS, variety VC 2778A produced higher number of branches than other varieties except Galadima.

Plant density had no significant effect on number of branches at 3 and 6 WAS, but had a significant effect at 9 and 12 WAS. Increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affectthe number of branches. However, crops sown at 200,000 plants/ha had higher number of branches.

Table 5: Number of branches per plant as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatment	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.26b	1.82b	3.15ab	3.15ab
VC 2768A	0.52a	2.52a	2.96b	2.96b
VC 1178A	0.52a	2.30a	3.04b	3.04b
VC 2778A	0.37b	1.85b	3.44a	3.44a
VC 1973A	0.41ab	1.67b	2.84b	2.85b
SE ±	0.04	0.08	0.10	0.10
Significance	*	*	*	*
Density (Plants/ha)				
200,000	0.44	2.09	3.22a	3.22a
400,000	0.42	2.02	3.04ab	3.04ab
600,000	0.38	1.98	3.00b	3.00b
SE ±	0.03	0.06	0.07	0.07
Significance	NS	NS	*	*
Phosphorus (kgP/ha)				
0	0.22c	1.24c	2.22c	2.22c
25	0.42b	1.98b	3.18b	3.18b
50	0.60a	2.87a	3.87a	3.87a
SE ±	0.02	0.02	0.03	0.03
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

The differences due to phosphorus was highly significant at the four sampling periods. Increasing phosphorus level either from 0 to 25 or 25 to 50kgP/ha significantly increased the number of branches.

None of the interactions was significant.

4.6 **Number of branches per plant, 1995.**

Mean number of branches of green gram as affected by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 6.

Except at 6WAS, the differences due to varieties were significant at 3, 9 and 12 WAS. Varieties VC 2778A, VC 1973A and VC 1178A produced similar number of branches, but the number of branches in VC 2778A was significantly higher than VC 2778A and Galadima. While at 9 WAS and 12 WAS, variety VC 2778A produced higher number of branches than VC 1178A. The differences among the other varieties were at par.

Plant density had a significant effect at 9 and 12 WAS only. Increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha at 9 and 12 WAS did not affect the number of branches. However plants sown at 200,000 plants/ha produced the highest number of branches per plant.

Phosphorus had highly significant effect at all sampling periods. Increasing rate of application of phosphorus from 0 to 25kgP/ha increased the number of branches per plant, but further increase in phosphorus level from 25 to 50kgP/ha had no significant effect at 3 WAS. However, at other sampling periods, phosphorus

Table 6: Number of branches per plant as affected by variety, plant density and phosphorus levels in 1995 at Samaru.

Treatment	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.26b	2.07	3.67ab	3.67ab
VC 2768A	0.44b	2.00	3.25ab	3.70ab
VC 1178A	0.56ab	2.07	3.25b	3.25b
VC 2778A	0.78a	2.15	4.30a	4.30a
VC 1973A	0.56ab	2.37	3.89ab	3.89ab
SE ±	0.10	0.30	0.25	0.25
Significance	*	NS	*	*
Density (Plants/ha)				
200,000	0.53	2.38	4.27a	4.27a
400,000	0.60	2.13	3.60ab	3.60ab
600,000	0.42	1.89	3.42b	3.42b
SE ±	0.08	0.23	0.23	0.23
Significance	NS	NS	*	*
Phosphorus (kgP/ha)				
0	0.27b	1.40c	1.96c	1.96c
25	0.62a	2.09b	3.73b	3.73b
50	0.67a	2.91a	5.36a	5.36a
SE ±	0.09	0.09	0.15	0.15
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

application significantly increased the number of branches per plant compared with the control.

None of the orders of interaction was significant.

4.7 **Number of leaves per plant, 1993.**

Mean number of leaves per plant as affected by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 7.

Varieties had a significant effect on number of leaves at 3,9 and 12 WAS and highly significant effect at 6 WAS. At 3 WAS varieties VC 2778A, Galadima and VC 1178A produced greater number of leaves than other varieties. Varieties VC 1973A and VC 2768A produced the same number of leaves. While at 6 WAS variety Galadima produced significantly higher number of leaves than other varieties which were at per. However at 9 WAS, varieties Galadima, VC 1178A and VC 2768A produced greater number of leaves than other varieties The differences in the mean number of branches of varieties VC 1973A and VC 2778A were not significant. At 12 WAS, the number of leaves produced by varieties Galadima and VC 1973A were the same statistically. While the leaves produced by other varieties were at per except those of VC 2778A which was the lowest.

Plant density had a significant effect on number of leaves at 3, and 9 WAS and highly significant effect at 6 and 12 WAS. Increasing density from 200,000 to 400,000 plants/ha had no significant effect on leaves at 3 and 9 WAS. However, when the density was further increased to 600,000 plants/ha, a significant reduction was observed. While at 6 and 12 WAS, increase in density

Table 7: Number of leaves per plant as affect by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	15.93a	31.74a	44.41a	33.22a
VC 2768A	14.67c	20.69b	43.56ab	31.30b
VC 1178A	15.44ab	22.56b	43.81ab	31.22b
VC 2778A	16.04a	22.89b	40.70c	29.04c
VC 1973A	14.96bc	21.89b	42.52bc	31.79ab
SE ±	0.17	0.33	0.57	0.48
Significance	*	**	*	*
Density (Plants/ha)				
200,000	15.80a	26.42a	43.80a	35.29a
400,000	15.44a	24.02b	43.67a	29.40b
600,000	14.98b	23.62b	41.53b	29.24b
SE ±	0.12	0.26	0.44	0.38
Significance	*	**	*	**
Phosphorus (kgP/ha)				
0	13.69c	20.16c	35.98c	26.11c
25	15.40b	24.09b	43.09b	31.33b
50	17.13a	29.82a	49.93a	36.49a
SE ±	0.06	0.17	0.19	0.13
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
PD	NS	NS	NS	NS
PVD	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

from 200,000 to 400,000 plants/ha decreased the number of leaves significantly, but further increased in density to 600,000 plants/ha did not affect the number of leaves.

The differences due to phosphorus was highly significant at all the sampling periods. Each increase in phosphorus level either from 0 to 25 or 25 to 50kgP/ha resulted in significant increase in number of leaves.

None of the interactions was significant statistically.

4.8 **Number of leaves per plant, 1994.**

Mean number of leaves per plant as affected by variety, plant density and phosphorus during 1994 rainy season is shown in Table 8.

The difference due to variety was significant at 3 WAS and highly significant at other sampling periods. Variety VC 1178A had statistically higher number of leaves at 3 WAS than other varieties which were at par. At 6 WAS, varieties Galadima and VC 2768A produced significantly higher number of leaves. They were followed by VC 1973A and VC 1178A. The differences between the leaves number of varieties VC 2778A and VC 1178A were not significant. At 9 and 12 WAS, variety Galadima had significantly higher number of leaves than other varieties. It was followed by VC 2768A and VC 1973A. The number of leaves of VC 1178A and VC 1973A were similar. Variety VC 2778A had the lowest number of leaves.

Plant density had a significant effect on number of leaves at all sampling periods. Increasing density from 200,000 to 400,000 plants/ha had no significant effect on number of leaves at 3 and

Table 8: Number of leaves per plant as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatment	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	13.26b	29.89a	43.78a	38.37a
VC 2768A	13.44b	29.52a	35.85b	31.70b
VC 1178A	14.22a	27.63bc	33.26c	29.52c
VC 2778A	13.33b	26.67c	30.81d	27.44d
VC 1973A	13.44b	28.37b	35.00bc	31.22bc
SE ±	0.14	0.32	0.71	0.57
Significance	*	**	**	**
Density (Plants/ha)				
200,000	13.82a	29.71a	36.51a	32.84a
400,000	13.67a	28.49b	35.96ab	32.47a
600,000	13.13b	28.04b	34.76b	29.64b
SE ±	0.10	0.24	0.55	0.46
Significance	*	*	*	*
Phosphorus (kgP/ha)				
0	12.47c	25.60c	30.64c	27.29c
25	13.47b	28.40b	35.73b	31.69b
50	14.69a	31.24a	40.84a	35.98a
SE ±	0.04	0.07	0.15	0.13
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

12 WAS; Further increase of density to 600,000 plants/ha resulted in reduction in the number of leaves. At 6 WAS, a reduction in number of leaves was observed when density was increased from 200,000 to 400,000 plants/ha, but further increase in density to 600,000 plants/ha did not affect the number of leaves. Increasing density either from 200,000 to 400,000 or from 400,000 to 600,000 plants/ha did not affect the number of leaves; however plants sown at 200,000 plants/ha gave the highest number of leaves.

The differences due to phosphorus were highly significant at the four sampling period. Each increase in phosphorus rate resulted in significant increment in number of leaves.

None of the interactions was significant.

4.9 <u>Number of leaves per plant, 1995.</u>

Mean number of leaves per plant as affect by variety, plant density and phosphorus during 1995 reainy season is shown in Table 9.

Varieties had no significant effect at 3 WAS, but significant at all other sampling periods. Variety Galadima produced higher number of leaves at 6 WAS, but was statistically at par with VC 2768A and VC 1178A. Variety VC 1973A produced the lowest numbers of leaves but was also statistically at par with VC 2778A,VC 1178A and VC 1973A. At 9 and 12 WAS, variety Galadima produced the highest number of leaves, but was statistically the same with VC 2768A and VC 1178A. Varieties VC 1973A and VC 2778A produced statistically the same number of leaves but were statistically at par with VC 1178A and VC 2768A.

Table 9: Number of leaves per plant as affected by variety,plant density and phosphorus levels in 1995 at Samaru.

Treatment	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	11.07	27.11a	41.00a	37.26a
VC 2768A	11.07	27.07ab	37.70ab	34.30ab
VC 1178A	11.48	26.56ab	35.67ab	32.56ab
VC 2778A	11.78	25.93ab	33.89b	31.07b
VC 1973A	11.56	25.37b	34.30b	31.26b
SE ±	0.37	0.55	1.76	1.62
Significance	NS	*	*	*
Density (Plants/ha)				
200,000	11.89	26.29	37.84	34.73
400,000	11.18	27.07	36.09	32.22
600,000	11.09	25.87	35.60	32.91
SE ±	0.29	0.48	1.13	1.05
Significance	NS	NS	NS	NS
Phosphorus (kgP/ha)				
0	9.91c	23.24c	31.24c	28.49c
25	11.20b	26.56b	36.07b	32.87b
50	13.04a	29.42a	42.22a	38.51a
SE ±	0.21	0.30	0.63	0.63
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Plant density had no significant effect on number of leaves at all sampling periods.

The differences due to phosphorus was highly significant at the four periods of sampling. Increase in number of leaves, was observed with every increment in phosphorus level from 0 to 25 to 50kgP/ha at all periods of sampling.

None of the interactions were significant.

4.10 Leaf area index, 1993.

Mean leaf area index (LAI) as influenced by variety,plant density and phosphorus during 1993 rainy season is represented in Table 10.

The differences due to varieties was significant at 3 WAS, highly significant at 6 WAS and non-Significant at 9 and 12 WAS. Variety Galadima had significantly lower LAI at 3 WAS than all other varieties which are statistically similar. While at 6 WAS, varieties VC 2778A and VC 1178A have the greatest LAI, they were followed by Galadima which was statistically greater than both VC 2778A and VC 1973A.

The difference due to plant density was highly significant at the four sampling periods. LAI increased with each increase in density from 200,000 to 600,000 plants/ha at all the growth stages.

The mean LAI due to phosphorus was highly significant at the four sampling periods. Control produced lower LAI, when the phosphorus level was increased to 25 and 50kgP/ha, the LAI significantly increases at each level.

None of the orders of interaction was significant

Table 10: Leaf area index as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.294b	2.52b	2.92	2.24
VC 2768A	0.329a	2.71a	2.86	2.19
VC 1178A	0.340a	2.76a	2.88	2.21
VC 2778A	0.327a	2.45c	2.86	2.19
VC 1973A	0.329a	2.47c	2.94	2.26
SE ±	0.009	0.02	0.04	0.03
Significance	**	**	NS	NS
Density (Plants/ha)				
200,000	0.229c	2.20c	2.37c	1.47c
400,000	0.322b	2.58b	2.70b	2.22b
600,000	0.426a	2.93a	3.61a	2.96a
SE ±	0.007	0.01	0.03	0.03
Significance	**	**	**	**
Phosphorus (kgP/ha)				
0	0.248c	2.23c	2.78c	2.13c
25	0.322b	2.58b	2.88b	2.21b
50	0.402a	2.90a	3.02a	2.31a
SE ±	0.003	0.01	0.02	0.02
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.11 Leaf area index, 1994.

Mean leaf area index (LAI) as affected by variety, plant density and phosphorus during 1994 rainy season is shown in Table 11.

The differences in mean LAI due to variety was significant at 3 and 6 WAS; and highly significant at 9 and 12 WAS. Varieties VC 2778A and VC 1973A had significantly higher LAI than other varieties at 3 WAS. These were followed by VC 1178A and VC 2768A. Variety Galadima had the lowest LAI. At 6 WAS, VC 1178A, VC2768A and Galadima had statistically higher LAI. The difference in LAI between varieties VC 2778A, Galadima and VC 2768A was not significant. Variety VC 1973A had the lowest LAI. While at 9 WAS, Galadima had the highest LAI. It was followed by VC 2778A which was statistically higher than VC 1973A. The difference in LAI of VC 2768A and VC 1973A was not significant. Variety VC 1178A had the lowest LAI, but was statistically at par with VC 2768A. Variety Galadima also had significantly higher LAI at 12 WAS. It was followed by VC 2778A. The other varieties had similar LAI.

Difference due to plant density was highly significant at all sampling periods. The highest density (600,000 plants/ha) gave the highest LAI as compared with medium and lowest densities.

Difference due to phosphorus was also highly significant at the four sampling periods. Increasing phosphorus rate from 0 to 25 and 25 to 50kgP/ha increased the LAI at the four sampling period.

None of the interactions was significant.

Table 11: Leaf area index as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.420c	1.60ab	3.32a	2.86a
VC 2768A	0.443b	1.66ab	2.44cd	1.87c
VC 1178A	0.490b	1.70a	2.36d	1.81c
VC 2778A	0.561a	1.56b	2.85b	2.20b
VC 1973A	0.550a	1.44c	2.61c	1.96c
SE ±	0.017	0.04	0.07	0.06
Significance	*	*	**	**
Density (Plants/ha)				
200,000	0.237c	0.84c	1.39c	1.05c
400,000	0.443b	1.47b	3.03b	2.33b
600,000	0.799a	2.45a	3.73a	2.86a
SE ±	0.013	0.03	0.06	0.04
Significance	**	**	**	**
Phosphorus (kgP/ha)				
0	0.353c	1.13c	2.01c	1.54c
25	0.482b	1.60b	2.69b	2.05b
50	0.643a	2.04a	3.45a	2.65a
SE ±	0.006	0.02	0.03	0.02
Significance	**	**	**	**
Interaction				
VD	**NS**	NS	**NS**	NS
VP	**NS**	NS	**NS**	NS
DP	**NS**	NS	**NS**	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Table 12: Leaf area index as affected by variety, plant density and phosphorus levels in 1995 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.353	1.31	3.34a	2.39a
VC 2768A	0.399	1.44	2.25b	1.61b
VC 1178A	0.360	1.52	2.09b	1.49b
VC 2778A	0.453	1.43	2.77ab	2.02b
VC 1973A	0.410	1.67	2.33b	1.67b
SE ±	0.033	0.11	0.31	0.22
Significance	NS	NS	*	*
Density (Plants/ha)				
200,000	0.193c	0.92b	1.40b	0.99b
400,000	0.326b	1.28b	1.88b	1.35b
600,000	0.666a	2.24a	4.40a	3.17a
SE ±	0.025	0.12	0.21	0.17
Significance	**	**	**	**
Phosphorus (kgP/ha)				
0	0.254c	1.00c	1.81c	1.25c
25	0.387b	1.40b	2.40b	1.73b
50	0.544a	2.03a	3.46a	2.49a
SE ±	0.014	0.07	0.16	0.12
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.12 **Leaf area index, 1995.**

Mean leaf area index (LAI) as affected by variety, plant density and phosphorus rates during 1995 rainy season is presented in Table 12.

Mean difference in LAI due to variety was not significant at 3 and 12 WAS, but significant at 9 and 12 WAS. Varieties Galadima and VC 2778A had higher LAI at 9 and 12 WAS as compared to all other varities which had similar LAI.

The mean difference in LAI due to plant density was highly significant at all the sampling periods. LAI increased with each increase in density from 200,000 to 600,000 plants/ha at 3 WAS. At the other three sampling periods, increasing density from 200,000 to 400,000 plants/ha did not affect the LAI, but further increase in density from 400,000 to 600,000 plants/ha increased the LAI.

The difference in LAI due to phosphorus was highly significant at all the sampling periods. There was an increment in LAI as phosphorus rates were increased from 0 to 25 and 25 to 50kgP/ha at all the sampling periods.

All the interactions were not significant.

4.13 **Leaf dry weight (g/plant), 1993.**

Leaf dry weight (g/plant) of green gram as affected by variety, plant density and phosphorus rates during 1993 rainy season is presented in Table 13.

The mean difference in leaf dry weight due to variety was not significant at 3 WAS, significant at 6 and 12 WAS, and highly significant at 9 WAS. Varieties VC 2778A and VC 1973A had

Table 13: Leaf dry weight (g/plant) as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.327a	5.86a	13.64	10.84a
VC 2768A	0.329a.	5.40bc	14.66	10.33ab
VC 1178A	0.324a	5.50b	15.06	10.49ab
VC 2778A	0.276b	5.07c	15.18	9.33b
VC 1973A	0.284b	5.99a	15.00	10.47ab
SE ±	0.004	0.11	0.48	0.39
Significance	**	*	NS	*
Density (Plants/ha)				
200,000	0.312	6.21a	15.81a	13.62a
400,000	0.209	5.29b	15.40a	9.32b
600,000	0.203	5.19b	12.91b	7.93c
SE ±	0.003	0.09	0.38	0.30
Significance	NS	**	*	**
Phosphorus (kgP/ha)				
0	0.254c	4.06c	9.48c	6.65c
25	0.302b	5.57b	13.86b	9.81b
50	0.368a	7.06a	20.78a	14.41a
SE ±	0.002	0.04	0.22	0.17
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

significantly lower leaf dry weight at 3 WAS than other three varieties which had statistically the same leaf dry weight. At 6 WAS, varieties Galadima and VC 1973A had statistically higher leaf dry weight. They were followed by VC 1178A which was statistically at par with VC 2768A. Similarly VC 2768A was statistically at par with VC 2778A. When the dry weight of the leaves were considered at 12 WAS, variety Galadima had higher leaf dry weight than VC 2778A. The differences in leaf dry weight of other varieties were statistically at par.

The difference due to plant density was not significant at 3 WAS, highly significant at 6 and 12 WAS, and Significant at 9 WAS. Increasing the density from 200,000 to 400,000 plants/ha significantly decreased the leaf dry weight at 6 WAS but further increase in density to 600,000 plants/ha had no significant effect. At 9 WAS, there was no statistical difference in leaf dry weight when plants density was increased from 200,000 to 400,000 plants/ha. However, further increased to 600,000 plants/ha resulted in a significant reduction in leaf dry weight. At 12 WAS, increasing plant density resulted in a progressive decrease leaf dry weight.

The difference in leaf dry weight due to phosphorus rates were significant at all the sampling periods under consideration. Each increase in phosphorus rate from 0 to 25 and 25 to 50kgP/ha resulted in increased leaf dry weight at all the sampling periods.

4.14 **Leaf dry weight (g/plant), 1994.**

Mean leaf dry weight (g/plant) as affected by variety, plant density and phosphorus rates during 1994 rainy season is shown in Table 14.

The difference in leaf dry weight due to variety was highly significant at 3,6 and 9 WAS; and significant at 12 WAS. Varieties Galadima, VC 2768A and VC 1178A produced higher leaf dry weight when compared with VC 1973A which in turn produced higher leaf dry weight than VC 2778A. At 6 and 9 WAS, variety Galadima had statistically heavier leaf dry weight than other varieties. Leaf dry weight of VC 2778A was the lowest. The other three varieties constitute a similar significant group. Variety Galadima had highest leaf dry weight at 12 WAS, but was statistically at par with VC 1178A and VC 1973A. They were followed by VC 2768A which was similar to VC 1178A and VC 1973A. Variety VC 2778A produced the lowest leaf dry weight.

The difference due to plant density on leaf dry weight was highly significant at the four sampling periods. Increasing density from 200,000 to 400,000 plants/ha at 3 and 12 WAS significantly decreased the leaf dry weight; while further increase in density to 600,000 plants/ha did not affect the leaf dry weight. At 6 WAS, increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not influenced the leaf dry weight. However, plants sown at 200,000 plants/ha produced heavier dry leaf. At 9WAS, increasing density from 200,000 to 400,000 plants/ha had no significant effect on leaf dry weight, but further increase in

Table 14: Leaf dry weight (g/plant) as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.480a	5.97a	14.58a	10.26a
VC 2768A	0.458a	5.20b	13.49b	9.55b
VC 1178A	0.468a	5.11b	13.94b	9.79ab
VC 2778A	0.333c	4.52c	12.56c	8.65c
VC 1973A	0.392b	5.12b	13.97b	9.84ab
SE ±	0.012	0.11	0.17	0.15
Significance	**	**	**	*
Density (Plants/ha)				
200,000	0.471a	5.37a	13.99a	10.74a
400,000	0.412b	5.18ab	13.60a	9.68b
600,000	0.391b	5.00b	13.53b.	9.44b
SE ±	0.009	0.08	0.13	0.11
Significance	*	*	*	*
Phosphorus (kgP/ha)				
0	0.322c	4.46c	11.08c	7.93c
25	0.414b	5.10b	13.61b	9.58b
50	0.540a	5.99a	15.72a	11.35a
SE ±	0.003	0.03	0.07	0.06
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

density to 600,000 plants/ha resulted in significant reduction of leaf dry weight.

Differences due to phosphorus on leaf dry weight was highly significant at all the sampling periods. Each increase in phosphorus level from 0 to 50kgP/ha increased the leaf dry weight significantly at all sampling periods.

None of the interactions was significant.

4.15 **Leaf dry weight (g/plant), 1995**.

Leaf dry weight (g/plant) as affected by variety, plant density and phosphorus rates during 1995 rainy season is presented in Table 15.

Mean difference in leaf dry weight due to variety was not significant at the initial stage of sampling, but significant at all other sampling periods. At 6 WAS, variety Galadima had heavier dry leaf than other varieties except VC 1178A. They were followed by VC 2768A which was statistically heavier than VC 1973A. Variety VC 2778A had the lowest leaf dry weight. When leaf dry weight was considered at 9 WAS, Galadima and VC 1178A produced significantly higher leaf dry weight than other varieties which were statistically similar. At 12 WAS, varieties under study constitute two non-significant groups; Galadima -VC 1973A -VC 2768A and VC 2768A - VC 1973A - VC 2778A. The differences within the groups were not significant.

Differences in means due to plant density was not significant at 3 WAS, but significnt at all other sampling periods. Increase in density from 200,000 to 400,000 plants/ha did not affect the weight

Table 15: Leaf dry weight (g/plant) as affected by variety, plant density and phosphorus levels in 1995 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.294	4.91a	15.41a	10.30a
VC 2768A	0.377	4.25b	13.83b	9.19ab
VC 1178A	0.330	4.81a	14.82a	9.90a
VC 2778A	0.372	3.22d	13.04b	8.73b
VC 1973A	0.352	3.75c	13.13b	8.78b
SE ±	0.025	0.14	0.28	0.32
Significance	NS	*	*	*
Density (Plants/ha)				
200,000	0.366	4.35a	14.82a	10.01a
400,000	0.335	4.28a	13.89b	8.95b
600,000	0.366	3.98b	13.40b	9.18b
SE ±	0.020	0.09	0.22	0.25
Significance	NS	*	*	*
Phosphorus (kgP/ha)				
0	0.252c	2.66c	9.17c	6.13c
25	0.335b	3.88b	13.40b	8.95b
50	0.450a	6.03a	19.57a	13.06a
SE ±	0.10	0.05	0.16	0.17
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

of dry leaves at 6 WAS. Further increased in density from 400,000 to 600,000 plants/ha resulted in significant reduction of leaf dry weight. At 9 and 12 WAS, increased density from 200,000 to 400,000 plants/ha resulted in significant reduction of leaf dry weight, but further increase in density to 600,000 plants/ha had no significant effect.

The difference due to phosphorus was highly significant at all sampling periods. The highest leaf dry weight was produced by application of 50kg/ha followed by 25kgP/ha and control in that order at all sampling periods.

None of the interactions was significant.

4.16 **Stem dry weight (g/plant), 1993**.

Stem dry weight (g/plant) as affected by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 16.

Difference due to variety was highly significant at 3 and 12 WAS and significant at 6 and 9 WAS. Both at 3 and 9 WAS, the stem dry weight of Galadima was heavier than all other varieties which were statistically at par with each other. At 6 WAS, variety Galadima, VC 1973A and VC 1178A had heavier stem. The differences between VC 1178A and VC 2768A was not significant, but these two produced heavier stem dry weight than VC 2778A. While at 12 WAS, variety Galadima had statistically heavier dry stem than other varieties. This was followed by VC 2768A which was statistically at par with VC 1973A and VC 1178A. Variety VC 2778A had significantly lower stem dry weight, but was statistically at par with VC 1178A

Table 16: Stem dry weight (g/plant) as affected by variety, plant density and phosphorus levels in 1993, Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.114a	3.66a	9.69a	11.52a
VC 2768A	0.097b	3.40b	8.42b	9.99b
VC 1178A	0.093b	3.61ab	7.78b	9.13bc
VC 2778A	0.094b	2.90c	7.39b	8.62c
VC 1973A	0.086b	3.71a	7.99b	9.41bc
SE ±	0.005	0.08	0.32	0.34
Significance	**	*	*	**
Density (Plants/ha)				
200,000	0.102a	3.91a	8.81a	13.50a
400,000	0.100ab	3.27b	8.54a	9.46b
600,000	0.089b	3.19b	7.41b	7.25c
SE ±	0.004	0.06	0.24	0.27
Significance	*	**	*	**
Phosphorus (kgP/ha)				
0	0.066c	2.49c	6.38c	7.50c
25	0.096b	3.39b	8.03b	9.48b
50	0.128a	4.49a	10.35a	12.21a
SE ±	0.003	0.03	0.11	0.15
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

and VC 1973A.

Effect of plant density was significant at 3 and 9 WAS and highly significant at 6 and 12 WAS. Increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the stem dry weight at 3 WAS; however, the stem dry weight produced by plant sown at 200,000 plants/ha was the highest. At 6 WAS, the stem dry weight decreased when density was increased from 200,000 to 400,000 plants/ha; but further increased in density to 600,000 plants/ha had no effect on stem dry weight. Increasing density from 200,000 to 400,000 plants/ha had no significant effect on stem dry weight at 9 WAS, but further increase in density to 600,000 plants/ha decreased the weight of dry stem. Each increase in density from 200,000 to 400,000 and 400,000 to 600,000 plants/ha decreased the stem dry weight at 12 WAS.

The difference due to phosphorus was highly significant at all the sampling periods. Increasing phosphorus levels from 0 to 25 to 50kgP/ha increased stem dry weight significantly at all growth stages under consideration.

None of the order of interactions was significant.

4.17 **Stem dry weight (g/plant), 1994.**

The effect of variety, plant density and phosphorus levels on stem dry weight during the 1994 rainy season is presented in Table 17

The difference due to variety was highly significant at 3 and 6 WAS, but significant at 9 and 12 WAS. Variety Galadima had heavier dry stem at 3 WAS, but was statistically at par with

VC 2768A. The difference between the stem dry weight of VC 2768A and VC 1973A was not significant. Varieties VC 2778A and VC 1178A have similar stem dry weights. At 6 WAS, variety VC 2778A recorded the lowest stem dry weight and Galadima the highest. The stem dry weight of other varieties were statistically at par. Variety Galadima still maintain the lead at 9 WAS, but was not statistically different from variety VC 2768A. They were followed by variety VC 1178A and VC 1973A which in turn produced high stem dry weight than VC 2778A. At 12 WAS, variety Galadima, VC 1973A and VC 2768A produced heavier dry stem than VC 2778A. The differences between VC 2768A, VC 1973A and VC 1178A were at par.

The mean difference due to plant density was highly significant at 3 WAS, but significant at other sampling periods. Each increase in density from 200,000 to 400,000 and 400,000 to 600,000 plants/ha resulted in a significant increament in stem dry weight at 3 WAS. At 6 and 12 WAS, increasing in density from 200,000 to 400,000 plants/ha had no significant influence on stem dry weight, however further increase in density to 600,000 plants/ha resulted in significant increased stem dry weight. At 9 WAS, stem dry weight at 200,000 plants was found to be heavier than at 400,000 and 600,000 plants/ha.

The influence of phosphorus on stem dry weight was highly significant at all the sampling periods. Increase in phosphorus level either from 0 to 25 and 25 to 50kgP/ha significantly increased the stem dry weight.

None of the interactions was significant.

Table 17: Stem dry weight (g/plant) as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.179a	1.92a	8.24a	10.06a
VC 2768A	0.175ab	1.57b	8.06a	9.88ab
VC 1178A	0.144c	1.53b	7.41b	9.38b
VC 2778A	0.140c	1.03c	6.44c	8.60c
VC 1973A	0.163b	1.48b	7.43b	9.41ab
SE ±	0.004	0.05	0.19	0.21
Significance	**	**	*	*
Density (Plants/ha)				
200,000	0.173a	1.54a	7.55a	9.67a
400,000	0.161b	1.54a	7.53b	9.37a
600,000	0.146c	1.41b	7.07b	9.10b
SE ±	0.003	0.04	0.15	0.17
Significance	**	*	*	*
Phosphorus (kgP/ha)				
0	0.116c	1.17c	5.59c	7.84c
25	0.162b	1.46b	7.26b	9.27b
50	0.204a	1.90a	9.70a	10.28a
SE ±	0.002	0.02	0.06	0.07
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.18 **Stem dry weight (g/plant), 1995.**

Stem dry weight (g/plant) as affected by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 18.

Difference due to variety was not significant at 3 WAS, significant at 6 and 9 WAS and highly significant at 12 WAS. Variety VC 2778A recorded significantly lower stem dry weight than other varieties except VC 1973A at 6 WAS. At 9 WAS, variety Galadima had significant heavier dry stem than at other varieties which were statistically similar. At 12 WAS, variety Galadima produced significantly heavier dry stem. It was followed by VC 2778A which was statistically at par with VC 1178A. The differences in stem dry weight of varieties VC 1973A, VC 2778A and VC 1178A were not significant.

Difference in plant density was not significant at 3,6 and 12 WAS, however it was found to be significant at 12 WAS. Increasing density either from 200,000 to 400,000 or from 400,000 to 600,000 plants/ha did not affect the stem dry weight significantly. However plants sown at 200,000 plants/ha had heaviest dry stem.

The difference in means due to phosphorus was significant at 12 WAS and highly significant at 6,9 and 12 WAS. At 3 WAS, both 25 and 50kgp/ha produced heavier stem dry weight than the control. While at 6,9 and 12 WAS, increase in phosphorus level from 0 to 25 or 25 to 50kgp/ha significantly increased the stem dry weight.

None of the interactions was significant.

Table 18: Stem dry weight (g/plant) as affected by variety, plant density and phosphorus levels in 1995 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.096	1.13a	7.56a	11.74a
VC 2768A	0.106	1.11a	6.88b	9.81b
VC 1178A	0.087	1.12a	6.82b	9.21bc
VC 2778A	0.092	0.82b	6.57b	8.47c
VC 1973A	0.085	0.98ab	6.87b	8.84c
SE ±	0.018	0.09	0.18	0.21
Significance	NS	*	*	**
Density (Plants/ha)				
200,000	0.108	0.97	7.01	9.96a
400,000	0.092	1.06	6.77	9.69ab
600,000	0.080	1.07	6.92	9.22b
SE ±	0.014	0.07	0.15	0.16
Significance	NS	NS	NS	*
Phosphorus (kgP/ha)				
0	0.057b	0.66c	6.01c	6.61c
25	0.096b	1.00b	6.80b	9.20b
50	0.126a	1.44a	7.90a	13.05a
SE ±	0.011	0.04	0.09	0.11
Significance	*	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.19 **Total dry matter (g/plant), 1993.**

Mean total dry matter (g/plant) as influenced by variety, plant density and phosphorus levels during the 1993 rainy season in presented in Table 19.

The mean difference due to variety was significant at 3, 9 and 12 WAS and highly significatnt at 6 WAS. The total dry matter produced by different varieties under trial at 3 WAS constituted three non-significant group of Galadima - VC 2768A; VC 1178A - VC 2778A andVC 2778A - VC 1973A. The differences within the groups were not significant. At 6 WAS, variety Galadima produced the heaviest dry matter. It was followed by VC 1178A, VC 2768A and VC 1973A which were statistically at par. Variety VC 2778A produce lighter dry matter than all other varieties except VC 1973A. While at 9 WAS, variety Galadima has significantly heavier dry matter than other varieties except VC 1973A. The difference among the other varieties were similar statistically. At 12 WAS variety Galadima produced significantly heavier dry matter than VC 2778A. The differences among other varieties in respect to total dry matter were similar.

The difference due to plant density was significant at 3 and 6 WAS, but highly significant at 9 and 12 WAS. Increasing density from 200,000 to 400,000 plants/ha at 3 and 9 WAS did not influenced the total dry matter. Further increase in density from 400,000 to 600,000 plants/ha significantly reduced the total dry matter. At 6 WAS, increasing the density either from 200,000 to 400,000 or 600,000 plants/ha significantly decreased total dry matter. The

Table 19: Total dry matter (g/plant) as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.441a	9.71a	25.08a	36.84a
VC 2768A	0.425ab	9.06b	22.50b	36.04ab
VC 1178A	0.417b	9.11b	22.66b	34.61ab
VC 2778A	0.370c	8.47c	21.40b	34.27b
VC 1973A	0.371c	8.62bc	23.00ab	36.17ab
SE ±	0.060	0.17	0.70	0.97
Significance	*	**	*	**
Density (Plants/ha)				
200,000	0.412a	10.12a	24.40a	38.53a
400,000	0.410a	8.46b	24.16a	32.20b
600,000	0.392b	8.40b	20.23b	26.20c
SE ±	0.004	0.13	0.54	0.73
Significance	*	*	**	**
Phosphorus (kgP/ha)				
0	0.331c	6.54c	15.86c	6.61c
25	0.398b	8.97b	21.85b	9.20b
50	0.496a	11.47a	31.08a	13.05a
SE ±	0.003	0.06	0.28	0.33
Significance	**	**	**	**
Interaction				
VD	NS	NS	*	*
VP	NS	NS	*	**
DP	NS	NS	*	*
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Table 19a: Interaction between variety x density, variety x phosphorus and density x phosphorus at 9 WAS in 1993 for total dry matter.

	Density (Plants/ha)			Phosphorus (kgP/ha)		
	200,000	400,000	600,000	0	25	50
Variety						
Galadima	30.96a	23.44cde	20.85def	17.41fgh	23.33d	34.50a
VC 2768A	29.21ab	22.73def	15.55g	15.87hi	19.97ef	32.14ab
VC 1178A	24.59cd	23.76cd	19.63ef	16.78ghi	22.28de	29.94bc
VC 2778A	22.04def	21.56def	20.61ef	14.51i	19.35fg	30.36bc
VC 1973A	26.85bc	23.19cde	18.96fg	16.78ghi	22.28de	29.94bc
SE ±		1.21			0.87	
Phosphorus (kgP/ha)						
0	22.04de	20.61ef	21.56ef			
25	24.59bc	23.76cd	19.63f			
50	33.59a	33.27a	26.37b			
SE ±		0.67				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

differences between 400,000 and 600,000 plants/ha was not significant. At 12 WAS, total dry matter decreased with increasing density from 200,000 to 400,000 and 400,000 to 600,000 plants/ha.

The difference due to phosphorus was highly significant at all the four sampling periods. Total dry matter was observed to increase with increasing phosphorus rates from either 0 to 25 or 25 to 50kgp/ha at the sampling periods.

The first order of interactions at 9 and 12 WAS were significant except interaction for variety and phosphorus at 12 WAS which was highly significant (Table 19a and b).

At 9 WAS, when the same variety was compared at different densities; increasing density from 200,000 to 400,000 plants/ha did not affect the total dry matter of variety VC 1178A and VC 1973A. Further increase in density to 600,000 plants/ha reduced the total dry matter. In the case of VC 2778A, increasing density from 200,000 to 600,000 plants/ha did not affect the total dry matter. The total dry matter of Galadima was decreased significantly with increasing density up to 400,000 plants/ha. Further increase in density to 600,000 plants/ha did not influence the dry matter production. While in the case of VC 2768A increasing the density from 200,000 to 600,000 plants/ha resulted in increament of total dry matter. When the same density level was studied across the different varieties, it was observed that variety Galadima produced heavier dry matter than all other varieties except VC 2768A at 200,000 plants/ha. The differences between VC 2768A and VC 1973A; VC 1973 and VC 1178; and VC 1178A and VC 2778A were not

Table 19b: Interaction between variety x density, variety x phosphorus and density x phosphorus at 12 WAS in 1993 for total dry matter.

	Density (Plants/ha)			Phosphorus (kgP/ha)		
	200,000	400,000	600,000	0	25	50
Variety						
Galadima	52.19a	31.80cde	26.52f	26.98e	34.70cd	48.83a
VC 2768A	48.04b	30.45de	25.35f	26.75e	33.88cd	47.54a
VC 1178A	46.43b	34.92cd	26.77f	24.29ef	32.30d	47.25a
VC 2778A	47.78b	30.17cd	24.85f	24.03f	36.07cd	42.69b
VC 1973A	48.23b	33.66cd	26.61f	26.92e	35.22cd	46.36a
SE ±		0.97			0.63	
Phosphorus (kgP/ha)						
0	33.26d	25.17f	19.63g			
25	41.88c	31.00e	23.72f			
50	64.46a	47.10b	34.04d			
SE ±		0.63				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

significant. At 400,000 plants/ha, all the varieties produced similar total dry matter. The dry matter produced by VC 2778A at 600,000 plants/ha was lower than other varieties except VC 1973A. The difference between the dry matter produced by other varieties was not significant.

Variety x phosphorus interaction revealed that when the same variety was studied at varying phosphorus rates; it was observed that each increment in phosphorus either from 0 to 25 or 25 to 50kgP/ha increased the total dry matter of all the varieties under consideration. When the same phosphorus rate was examined for various varieties, it revealed that there was no significant difference in total dry matter produce by all the varieties at control. At 25kgP/ha variety Galadima had heavier dry than other varieties except VC 1178A and VC 1973A. While at 50kgP/ha, Galadima produced heavier dry matter than other varieties except VC 2768A which was statistically at par with other varieties.

The density x phosphorus interaction revealed that when the same phosphorus level was considered in respect to varying densities. Density did not affect dry matter production at control. At 25 and 50kgP/ha, there was no significant difference in dry matter production by increasing the density from 200,000 to 400,000 plants/ha, further increase in density to 600,000 plants/ha decreased the total dry matter. When the same density was considered in respect to various phosphorus levels, each increase in phosphorus rate resulted in significant increase in dry matter at all densities except 600,000 plants/ha where increase in

phosphorus rate from 0 to 25kgP/ha did not affect total dry matter significant.

At 12 WAS, the variety x density interaction revealed that increasing density from 200,000 to 600,000 plants/ha resulted in significant reduction in dry matter of all the varieties. When the same density was looked at for various varieties; it was observed that at 200,000 plants/ha, Galadima had significantly heavier dry matter than all other varieties which were at par. At both 400,000 and 600,000 plants/ha the mean dry matter of all the varieties were at par.

The variety x phosphorus interaction indicated that there was a significant increase in dry matter with each increment in phosphorus rate for all the varieties. When the same phosphorus rate was examined in respect to different varieties; it revealed that, variety VC 2778A had the least dry matter, but was statistically at par with VC 1178A at control. The difference between the total dry matter of other varieties were at par. At 25kgP/ha, there was no significant difference between the dry matter of all the varieties under consideration. While at 50kgP/ha, variety VC 2778A produced lighter dry matter than other varieties which had statistically similar total dry matter.

The density x phosphorus interaction revealed that, when individual phosphorus rate was examined in respect to various densities; there was a significant decrease in dry matter as the density was increased from 200,000 to 600,000 plants/ha at all phosphorus rates. When the same density was considered at various

phosphorus rates, there was a significant increase in dry matter as the phosphorus rate was increased from 0 to 25 and 25 to 50kgP/ha at all densities.

4.20 **Total dry matter (g/plant), 1994.**

Mean total dry matter (g/plant) as affected by variety, plant density and phosphorus levels during the 1994 rainy season is presented on Table 20.

The differences due to variety was significant at 3 and 9 WAS and highly significant at 6 and 12 WAS. At 3 WAS, varieties Galadima, VC 2768A,VC 1178A and VC 1973A produced significantly higher total dry matter than other varieties. While at 6 WAS, variety Galadima produced the highest dry matter. It was followed by varieties VC 2768A, VC 1178A and VC 1973A which were at par. Variety VC 2778A had the lowest dry matter. At 9 WAS, variety Galadima had statistically higher dry matter than other varieties. It was followed by varieties VC 2776A and VC 1178A which were at par but were higher than the remaining two varieties. Variety VC 1973A produced higher total dry matter than VC 2778A . At 12 WAS, variety Galadima still maintained the lead. It was followed by VC 2768A which was statistically at par with VC 1178A and VC1973A. The latter two were within the same significant group as VC 2778A.

The different due to plant density was highly significant at 3 WAS, but significant at 6, 9 and 12 WAS. Total dry matter was observed to decrease with increasing density from 200,000 to 400,000 plants/ha at 3 WAS. However, further increase in density to 600,000 plants/ha did not affect the dry matter. At 6 and 12 WAS,

Table 20: Total dry matter (g/plant) as affected by variety, density and phosphorus levels in 1994 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.648a	5.89a	22.81a	40.32a
VC 2768A	0.633a	4.72b	21.63b	34.64b
VC 1178A	0.617a	4.62b	21.39b	34.36bc
VC 2778A	0.486c	3.53c	20.00d	32.88c
VC 1973A	0.555b	4.60b	20.40c	34.20bc
SE ±	0.016	0.15	0.30	0.62
Significance	*	**	*	**
Density (Plants/ha)				
200,000	0.647a	4.91a	21.47a	36.32a
400,000	0.575b	4.68a	21.16ab	36.20a
600,000	0.541b	4.43b	20.74b	33.92b
SE ±	0.012	0.11	0.23	0.48
Significance	**	*	*	*
Phosphorus (kgP/ha)				
0	0.437c	3.60c	17.39c	27.85c
25	0.576b	4.57b	20.89b	34.74b
50	0.751a	5.85a	25.46a	43.85a
SE ±	0.004	0.04	0.11	0.17
Significance	**	**	**	**
Interaction				
VD	NS	NS	*	*
VP	NS	NS	*	*
DP	NS	NS	*	**
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

increasing density from 200,000 to 400,000 plants/ha, did not affect the dry matter, however when the density was further increased to 600,000 plants/ha a significant reduction in dry matter was observed. At 9 WAS increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the total dry matter.

The difference due to phosphorus was highly significant at all sampling periods. Each increase in phosphorus application was found to increase the total dry matter at all stages of growth.

The first order of interactions were significant at 9 and 12 WAS except interaction between phosphorus x density at 12 WAS which was highly significant (Table 20a and b).

Holding the density constant when the different varieties were studied; it was observed that varieties fall into two non-significant groups of Galadima - VC 2768A - VC 1178A and VC 2778A - VC 1973A. The differences within the groups were not significant at 200,000 plants/ha. When the crop was sown at 400,000 plants/ha, variety Galadima had significantly heavier dry matter than other varieties which were statistically at par. At 600,000 plants/ha, varieties Galadima and VC 2768A produced heavier dry matter than other varieties which were statistically similar. When each variety was examined at various densities; there was not signigicant effect on dry matter when the density was increased from 200,000 to 600,000 plants/ha for varieties VC 1178A, VC 2778A and VC 1973A. For variety Galadima increase in density from 200,000 to 400,000 plants/ha did not affect the dry matter, but further increase in

Table 20a: Interaction between variety x density, variety x phosphorus and density x phosphorus at 9 WAS in 1994 for total dry matter.

	Density (Plants/ha)			Phosphorus (kgP/ha)		
	200,000	400,000	600,000	0	25	50
Variety						
Galadima	23.81a	23.32a	21.32bc	18.20h	21.57ef	28.68a
VC 2768A	23.78a	21.26bc	19.78d	17.48hi	21.23ef	26.19b
VC 1178A	22.42ab	21.09bc	20.65cd	17.41hi	21.63e	25.12bc
VC 2778A	21.48bc	20.17cd	19.55d	17.48hi	20.42fg	23.30d
VC 1973A	21.02bcd	21.02bcd	20.55cd	16.38i	19.58g	24.03cd
SE ±		0.52			0.36	
Phosphorus (kgP/ha)						
0	17.46d	17.39d	17.32d			
25	21.00c	20.95c	20.71c			
50	25.94a	25.44ab	25.01b			
SE ±		0.28				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

density to 600,000 plants/ha reduced the total dry matter. In the case of variety VC 2768A, the total dry matter was increased with increasing density from 200,000 to 400,000 plants/ha. Further increase to 600,000 plants/ha did not affect dry matter production.

Variety x phosphorus interaction showed that variety Galadima had higher dry matter at control than VC 1973A. The other varieties had statistically similar dry matter. While at 25kgP/ha, variety vc 1178A had higher dry matter than VC 2778A and VC 1973A. The difference between VC 2778A and VC 1973A was not significant. At 50kgP/ha, the differential response of varieties were as follows; Total dry matters of Galadima was higher than all other varieties. It was followed by VC 2768A which was heavier thn VC 2778A and VC 1973A. The differences between VC 1178A and VC 1973A was insignificant, however VC 1178A has heavier total dry matter than VC 2778A.

The density x phosphorus interaction revealed that, when the same phosphorus rates were examined in repect to densities, there was no significant difference in total dry matter by increasing the density at control and 25kgP/ha. However at 50kgP/ha, increasing density either from 200,000 to 400,000 or from 400,000 to 600,000 plants/ha did not affect the dry matter, but crops sown at 200,000 plants gave higher dry matter. When the same density was considered in respect to various phosphorus, every increase in phosphrous level resulted in significant heavier dry matter at each density.

At 12 WAS, the variety x density interactions revealed that

Table 20b: Interaction between variety x density, variety x phosphorus and density x phosphorus at 12 WAS in 1994 for total dry matter.

	Density (Plants/ha)			Phosphorus (kgP/ha)		
	200,000	400,000	600,000	0	25	50
Variety						
Galadima	45.10a	39.41b	36.10bc	28.43d	34.29c	46.25a
VC 2768A	37.71bc	35.70bc	32.88de	23.98e	30.30d	39.80b
VC 1178A	36.80bc	34.06cd	31.74de	22.77ef	29.57d	38.27b
VC 2778A	36.08bc	32.16de	30.38e	21.63f	29.47d	35.53c
VC 1973A	38.08b	34.52cd	31.32de	22.43ef	30.09d	39.40b
SE ±		1.06			0.69	
Phosphorus (kgP/ha)						
0	28.34e	28.30e	26.90e			
25	36.11c	35.22c	32.91d			
50	45.05a	44.54a	41.96b			
SE ±		0.53				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

increase in density from 200,000 to 400,000 plants/ha resulted in reduction of total dry matter of varieties Galadima, VC 2778A and VC 1973A. Further increase in density from 400,000 to 600,000 plants/ha did not affect the dry matter production. Increase in density of VC 2768A from 200,000 to 400,000 plants/ha did not affect the dry matter production, but further increase in density to 600,000 plants/ha reduced the dry matter. In the case of variety VC 1178A, increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the total dry matter production.

Variety x phosphorus interaction indicated that, there was a significant increase in total dry matter with each increment in phosphorus rates for all varieties. When the same phosphorus rate was examined in respect to various varieties, it was observed that variety Galadima produced significantly heavier dry matter at control. It was followed by VC 2768A, VC 1178A and VC 1973A. Variety VC 2778A produced the lowest dry matter, but was statistically at par with VC1178A and VC 1973A. At 25kgP/ha, variety Galadima produced significantly higher dry matter than other varieties which were statistically similar. At 50kgP/ha, variety VC 2778A produced the least total dry matter, while Galadima produced higher dry matter than other varieties which were at par.

Density x phosphorus interactions showed that, when each phosphorus rate was examined at varying densities; there was no significant differences in dry matter when density was increase at

control. However, at 25 and 50kgP/ha, increasing density from 200,000 to 400,000 plants/ha did not affect the dry matter. While further increase in density to 600,000 plants/ha resulted in significant reduction in dry matter production. When the same density was examined at varying phosphorus rates; there was a significant increase in total dry matter as the phosphorus rate was increased from 0 to 50kgP/ha at all densities.

4.21 **Total dry matter (g/plant), 1995.**

Mean total dry matter (g/plant) as affected by variety, plant density and phosphorus rate during the 1995 rainy season is presented in Table 21.

The differences due to variety was not significant at 3 and 12 WAS, but significant at 6 and 9 WAS. variety VC 2778A and VC 1973A produced significantly lower dry matter at 6 WAS than other varieties which were statistically at par. At 9 WAS, variety Galadima produced the highest dry matter but was statistically at par with those of varieties VC 2768A, VC 1178A and VC 1973A. Variety VC 2778A produced the lowest dry matter but was statistically at par with VC 1973A.

The differences due to plant density was not significant at all the sampling periods.

Phosphorus significantly (P> 0.01) affected the total dry matter at all the four sampling stages. Dry matter was observed to increase with increasing phosphorus level from 0 to 25 and 25 to 50kgP/ha at each sampling period.

Table 21: Total dry matter (g/plant) as affected by variety, plant density and phosphorus levels in 1995 at Samaru.

Treatments	3 WAS	6 WAS	9 WAS	12 WAS
Variety				
Galadima	0.483	6.87a	22.56a	33.28
VC 2768A	0.464	6.85a	21.99a	33.22
VC 1178A	0.442	6.70a	22.08a	33.05
VC 2778A	0.352	5.10b	19.95b	32.33
VC 1973A	0.412	5.24b	21.27ab	32.70
SE ±	0.035	0.18	0.38	0.42
Significance	NS	*	*	NS
Density (Plants/ha)				
200,000	0.457	5.68	21.51	32.86
400,000	0.422	5.62	21.78	33.07
600,000	0.417	5.47	21.39	32.82
SE ±	0.027	0.15	0.30	0.33
Significance	NS	NS	NS	NS
Phosphorus (kgP/ha)				
0	0.304c	4.75c	14.49c	30.29c
25	0.415b	5.45b	20.70b	32.58b
50	0.577a	6.57a	29.49a	35.88a
SE ±	0.020	0.08	0.21	0.24
Significance	**	**	**	**
Interaction				
VD	NS	NS	NS	NS
VP	NS	NS	NS	NS
DP	NS	NS	NS	NS
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

None of the orders of interaction was significant.

4.22 **Relative growth rate (R.G.R), 1993.**

Mean relative growth rate (g/g/wk) as influenced by variety, plant density and phosphorus levels during the 1993 rainy season is shown in Table 22.

The difference due to variety was highly significant at 6 WAS, non-significant at 9 WAS and significant at 12 WAS. A significantly higher RGR was observed on variety Galadima than VC 2778A and VC 2768A at 6 WAS. At 12 WAS varieties Galadima and VC 2768A have higher RGR than VC 1178A which in turn was similar to VC 2778A and VC 1973A.

The difference due to density was significant at 6 and 12 WAS; and non-significant at 9 WAS. Relative growth rate decreased with increasing density from 200,000 to 400,000 plants/ha at 6 WAS but further increased in density to 600,000 plants/ha did not affect the RGR significantly. At 12 WAS, sowing at 400,000 plants/ha gave higher RGR than 600,000 plants/ha which in turn was similar to 200,000 plants/ha.

The difference due to phosphorus was non-significant at 3 and 9 WAS and highly significant at 12 WAS. A significant increase in RGR was observed with each increment in phosphorus level from 0 to 50kgP/ha at 12 WAS.

None of the first or second order of interaction were found to be significant.

4.23 **Relative growth rate (RGR), 1994.**

The effect of variety, plant density and phosphorus levels on

Table 22: Relative growth rate(g/g/wk) as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	6 WAS	9 WAS	12 WAS
Variety			
Galadima	1.19a	0.30	0.17a
VC 2768A	1.07b	0.34	0.17a
VC 1178A	1.12ab	0.32	0.14b
VC 2778A	1.09b	0.33	0.15ab
VC 1973A	1.15ab	0.29	0.16ab
SE ±	0.023	0.025	0.006
Significance	*	NS	*
Density (Plants/ha)			
200,000	1.22a	0.34	0.16ab
400,000	1.06b	0.32	0.17a
600,000	1.09b	0.28	0.15b
SE ±	0.018	0.019	0.004
Significance	*	NS	*
Phosphorus (kgP/ha)			
0	1.13	0.30	0.15c
25	1.13	0.31	0.16b
50	1.11	0.31	0.17a
SE ±	0.012	0.09	0.003
Significance	NS	NS	**
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Table 23: Relative growth rate(g/g/wk) as affected by variety, Plant density and phosphorus levels in 1994 at Samaru.

Treatments	6 WAS	9 WAS	12 WAS
Variety			
Galadima	0.734a	0.42a	0.42a
VC 2768A	0.706ab	0.42a	0.33bc
VC 1178A	0.671bc	0.36ab	0.32bc
VC 2778A	0.645c	0.35b	0.27c
VC 1973A	0.665c	0.36ab	0.31bc
SE ±	0.011	0.020	0.020
Significance	*	*	*
Density (Plants/ha)			
200,000	0.634b	0.35b	0.29b
400,000	0.707a	0.36b	0.32b
600,000	0.712a	0.43a	0.38a
SE ±	0.008	0.020	0.020
Significance	**	*	*
Phosphorus (kgP/ha)			
0	0.676b	0.35b	0.29b
25	0.682b	0.38b	0.31b
50	0.694a	0.42a	0.39a
SE ±	0.003	0.010	0.020
Significance	*	*	*
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

relative growth rate (g/g/wk) during the 1994 rainy season is shown in Table 23.

Difference due to variety was significant at all sampling periods. Galadima had higher RGR at 6 WAS than all other varieties except VC 2778A. Similarly variety VC 2768A also resulted in higher RGR than all other varieties except VC 1178A. The differences among varieties VC 1178A,VC 1973A and VC 2778A were similar statistically At 9 WAS, variety VC 2778A had significantly lower RGR than Galadima and VC 2768A. While at 12 WAS varieties Galadima produced the highest RGR. The other varieties have similar RGR.

Plant density was observed to have highly significant effect on RGR at 6 WAS and significant effect at 9 and 12 WAS. Increased RGR was observed with every increment in density from 200,000 to 400,000 plants/ha at 6 WAS. Further increase in density to 600,000 plants/ha did not affect the RGR. While at 9 and 12 WAS, RGR was not affected at the initial density of 200,000 and 400,000 plants/ha. Further increase in density from 400,000 to 600,000 plants/ha increased the RGR.

The difference due to phosphorus was significant at all sampling period; where increase in phosphorus from 0 to 25kgP/ha did not affect the RGR, but further increase to 50kgP/ha increased the RGR significantly.

None of the first or second order of interactions was significant.

4.24 **Relative growth rate (RGR), 1995.**

The effect of variety, plant density and phosphorus levels on

Table 24: Relative growth rate(g/g/wk) as affected by variety, Plant density and phosphorus levels in 1995 at Samaru.

Treatments	6 WAS	9 WAS	12 WAS
Variety			
Galadima	0.60	0.44a	0.35a
VC 2768A	0.54	0.37ab	0.31ab
VC 1178A	0.63	0.37ab	0.32ab
VC 2778A	0.58	0.28b	0.29b
VC 1973A	0.62	0.31b	0.31ab
SE ±	0.028	0.029	0.013
Significance	NS	**	*
Density (Plants/ha)			
200,000	0.57	0.35	0.29b
400,000	0.61	0.36	0.31b
600,000	0.61	0.34	0.35a
SE ±	0.021	0.024	0.010
Significance	NS	NS	**
Phosphorus (kgP/ha)			
0	0.58	0.34	0.31
25	0.59	0.36	0.31
50	0.61	0.36	0.34
SE ±	0.014	0.019	0.009
Significance	NS	NS	NS
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Relative growth rate (g/g/wk) during 1995 rainy season is shown in Table 24.

Difference due to variety was not significant at 6 WAS, highly significant at 9 WAS and significant at 12 WAS. Variety Galadima had higher RGR at 9 WAS than VC 1973A and VC 2778A. The RGR of other varieties were similar. At 12 WAS, variety Galadima had higher RGR than VC 2778A. The differences among the RGR of other varieties were not significant.

The differences in RGR due to plant density was significant only at 12 WAS. No difference was observed when density was increased from 200,000 to 400,000 plants/ha at 12 WAS, a further increase in density to 600,000 plants/ha, however significantly increased the RGR.

The difference due to phosphorus was not significant at all sampling periods.

None of the first or second order of interactions was significant.

2.25 **Net assimilation rate (NAR), 1993.**

Mean net assimilation rate ($g/cm^2/wk$) as influenced by variety plant density and phosphorus levels during the 1993 rainy season is presented in Table 25.

Difference due to variety was significant only at 12 WAS. Variety Galadima had higher NAR than VC 2778A and VC 1973A. The differences among the other varieties were statistically at par.

The difference due to plant density was significant at all the four sampling periods. At 6 WAS, increasing the density either from

Table 25: Net assimilation rate(g/cm²/wk) as affected by variety, plant density and phosphorus levels in 1993 at Samaru.

Treatments	6 WAS	9 WAS	12 WAS
Variety			
Galadima	0.0100	0.0062	0.0060a
VC 2768A	0.0083	0.0065	0.0053b
VC 1178A	0.0087	0.0061	0.0057ab
VC 2778A	0.0095	0.0054	0.0059ab
VC 1973A	0.0102	0.0063	0.0053b
SE ±	0.0006	0.0004	0.0002
Significance	NS	NS	*
Density (Plants/ha)			
200,000	0.0082b	0.0051b	0.0053b
400,000	0.0096ab	0.0063a	0.0054b
600,000	0.0102a	0.0069a	0.0062a
SE ±	0.0005	0.0003	0.0002
Significance	*	*	*
Phosphorus (kgP/ha)			
0	0.0083c	0.0050c	0.0042c
25	0.0093b	0.0059b	0.0055b
50	0.0104a	0.0074a	0.0072a
SE ±	0.0003	0.0002	0.0001
Significance	**	**	**
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

200,000 to 400,000 or 400,000 to 600,000 plants/ha did not significantly affect NAR; however, green gram sown at 600,000 plants/ha gave the highest NAR. While at 9 WAS, NAR was increased when the density was increase from 200,000 to 400,000 plants/ha, but further increase in density to 600,000 plants/ha did not have any significant effect on NAR. At 12 WAS, increasing density from 200,000 to 400,000 plants/ha did not have significant effect on NAR. Further increase in density to 600,000 plant/ha increased the NAR.

The difference due to phosphorus was highly significant at all the sampling periods considered. Each increment in phosphorus rates from 0 to 25 and 25 to 50kgP/ha significantly increased the NAR.

Both the first and second order of interactions were not significant.

4.26 **Net assimilation rate (NAR), 1994.**

The effect of variety, Plant density and phosphorus levels on Net assimilation rate ($g/cm^2/wk$) during 1994 rainy season is shown in Table 26.

The effect of variety on NAR was significant at the three sampling periods. Variety Galadima had higher NAR than other varieties, except VC 2768A and VC 1178A at 6 WAS. They were followed by variety VC 1973A which was also significantly higher than VC 2778A. While at 9 WAS, variety VC 2778A had lower NAR than other varieties except VC 1973A. At 12 WAS, variety Galadima had higher NAR than other varieties except VC 2768A.

The difference in NAR due to plant density was significant at

Table 26: Net assimilation rate ($g/cm^2/wk$) as affected by variety, plant density and phosphorus levels in 1994 at Samaru.

Treatments	6 WAS	9 WAS	12 WAS
Variety			
Galadima	0.0135a	0.0069a	0.0059a
VC 2768A	0.0109ab	0.0069a	0.0058ab
VC 1178A	0.0116ab	0.0067a	0.0054b
VC 2778A	0.0077c	0.0048b	0.0049b
VC 1973A	0.0090b	0.0061ab	0.0049b
SE ±	0.0009	0.0004	0.0002
Significance	*	*	*
Density (Plants/ha)			
200,000	0.0098	0.0054b	0.0052
400,000	0.0108	0.0059ab	0.0053
600,000	0.0110	0.0069a	0.0056
SE ±	0.0004	0.0003	0.0002
Significance	NS	*	NS
Phosphorus (kgP/ha)			
0	0.0096b	0.0067b	0.0052b
25	0.0107a	0.0068b	0.0053ab
50	0.0113a	0.0084a	0.0056a
SE ±	0.0003	0.0002	0.0001
Significance	*	*	*
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

9 WAS only. Increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the NAR; however, plant sown at 600,000 plants/ha had the highest NAR.

The effect of phosphorus was highly significant at the three sampling periods. At 6 WAS, increasing the rate of phosphorus application from either 0 to 25 or 25 to 50kgP/ha significantly increased the NAR. While at 9 WAS application of phosphorus to the tune of 25kgP/ha did not affect the NAR, but further increase in phosphorus to 50kgP/ha increased the NAR. At 12 WAS, increasing phosphorus rate either from 0 to 25 or 25 to 50kgP/ha did not significantly affect the NAR, but application of 50kgP/ha gave higher NAR than control.

None of the interactions was significant.

4.27 **Net assimilation rate (NAR), 1995.**

Mean net assimilation rate ($g/cm^2/wk$) as influenced by variety, plant density and phosphorus levels during 1995 rainy season is presented in Table 27.

Difference due to variety was significant only at 9 and 12 WAS. Variety VC 2768A had higher NAR at 9 WAS than VC 2778A. The differences among the other varieties were at par. At 12 WAS, varieties Galadima and VC 2778A had significantly lower NAR than other varieties which were statistically at par.

The difference due to plant density was only significant at 12 WAS. Net assimilation rate was increased with each increment in density from 200,000 to 600,000 plants/ha.

The difference due to phosphorus was not significant.

Table 27: Net assimilation rate (g/cm²/wk) as affected by variety, density and phosphorus levels in 1995 at Samaru.

Treatments	6 WAS	9 WAS	12 WAS
Variety			
Galadima	0.0018	0.0019ab	0.0003b
VC 2768A	0.0017	0.0023a	0.0004a
VC 1178A	0.0020	0.0019ab	0.0004a
VC 2778A	0.0014	0.0016b	0.0003b
VC 1973A	0.0020	0.0018ab	0.0004a
SE ±	0.0008	0.0002	0.00003
Significance	NS	*	*
Density (Plants/ha)			
200,000	0.0019	0.0020	0.0003c
400,000	0.0019	0.0019	0.0004b
600,000	0.0019	0.0018	0.0005a
SE ±	0.0006	0.0001	0.00003
Significance	NS	NS	**
Phosphorus (kgP/ha)			
0	0.0018	0.0018	0.0004
25	0.0018	0.0019	0.0004
50	0.0021	0.0020	0.0004
SE ±	0.0003	0.0001	0.00002
Significance	NS	NS	NS
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

None of the interactions was significant.

4.28 **Days to 50% flowering, 1993.**

Mean number of days to 50% flowering of green gram as affected by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 28.

The differences due to variety and phosphorus were highly significant and that due to plant density was significant.

Variety Galadima took significantly longer days to reach 50% flowering than other varieties. It was followed by VC 1973A, VC 2778A, VC 1178A and VC 2768A in that order.

Increasing density from 200,000 to 400,000 plants/ha reduced the number of days to attainment of 50% flowering. However, further increase in density did not affect days to 50% flowering.

Application of phosphorus up to 50kgP/ha reduced the days to 50% flowering.

None of the interactions was significant.

4.29 **Days to 50 percent flowering, 1994.**

Mean number of days to 50% flowering as affected by variety, plant density and phosphorus levels during 1994 rainy season is presented in Table 28.

Analysis of data revealed that mean differences due to variety, plant density and phosphorus were all highly significant.

As in 1993, variety Galadima took longer days to reach 50% flowering. It was followed by varieties VC 1973A and VC 2778A in that order. Varieties VC 2768A and VC 1178A took the shortest days to reach 50% flowering.

Table 28: Day to 50 percent flowering as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	39.15a	43.07a	46.48a
VC 2768A	34.04e	37.10d	40.22b
VC 1178A	34.82d	37.61d	40.26b
VC 2778A	35.67c	38.52c	40.85b
VC 1973A	36.93b	39.15b	40.93b
SE ±	0.16	0.17	0.23
Significance	**	**	**
Density (Plants/ha)			
200,000	36.53a	37.99a	41.73
400,000	36.07b	37.15b	41.89
600,000	35.76b	36.48c	41.62
SE ±	0.13	0.13	0.17
Significance	*	**	NS
Phosphorus (kgP/ha)			
0	37.56a	39.44a	42.99a
25	35.96b	37.40b	41.58b
50	34.84c	35.89c	40.69c
SE ±	0.05	0.06	0.14
Significance	**	**	**
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Days to 50% flowering decreased with each reduction in density from 600,000 to 200,000 plants/ha.

Significant reduction in days to 50% flowering was observed with each increment in phosphorus rates from 0 to 25 and 25 to 50kgP/ha.

None of the first or second order of interaction was significant.

4.30 **Days to 50 percent flowering, 1995.**

Mean number of days to 50% flowering of green gram as affected by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 28.

The data showed that the differences due to variety and phosphorus were highly significant, however the difference due to plant density was not significant.

As in the other two seasons, variety Galadima took significntly longer periods to reach 50% flowering than other varieties which were statistically at par.

Significant reduction in days to 50% flowering was observed with each increment in phosphorus rate from 0 to 50kgP/ha.

None of the first or second order of interaction were significant.

4.31 **Pod length, 1993.**

Mean pod length (cm) as affected by variety, plant density and phosphorus levels during 1993 rainy season is presented in Table 29.

The data showed that differences in means due to variety and

Table 29: Pod length (cm) as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	8.81a	8.79	9.21a
VC 2768A	8.03c	8.99	8.44c
VC 1178A	8.64ab	8.98	9.05ab
VC 2778A	8.77a	9.00	9.00ab
VC 1973A	8.53b	8.95	8.94b
SE ±	0.07	0.08	0.12
Significance	*	NS	**
Density (Plants/ha)			
200,000	8.63	9.12a	9.02
400,000	8.54	8.99a	8.97
600,000	8.50	8.73b	8.80
SE ±	0.06	0.06	0.10
Significance	NS	*	NS
Phosphorus (kgP/ha)			
0	7.44c	8.09c	8.45c
25	8.60b	9.02b	8.94b
50	9.63a	9.72a	9.40a
SE ±	0.03	0.04	0.05
Significance	**	**	**
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

phosphorus were significant at 5% and 1% level respectively; while that due to plant density was not significant.

Varieties Galadima and VC 2778A produced the longest pod, but were statistically at par with variety VC 1178A. There were no significant difference in length of pods of varieties VC 1178A and VC 1973A, but these two produced longer pods than VC 2768A.

Pod length increased with each increment in phosphorus rates from 0 to 50kgP/ha.

None of the interactions was significant.

4.32 **Pod length, 1994.**

The effect of variety, plant density and phosphorus levels on pod length (cm) during the 1994 rainy season is shown in Table 29.

Analysis of the data revealed that difference in means due to variety was not significant, however those due to plant density and phosphorus were significant at 5 and 1% levels respectively.

Increasing plant density from 200,000 to 400,000 plants/ha did not significantly affect pod length, but further increase in density to 600,000 plants/ha significantly reduced the length of pods.

The highest level of phosphorus (50kgP/ha) resulted in longer pods than other two levels. It was followed by 25kgP/ha and control in that order.

Both the first and second order of interactions were not significant.

4.33 **Pod length, 1995.**

Mean pod length as affected by variety, plant density and

phosphorus levels during 1995 rainy season is presented in Table 29.

Analysed data revealed that differences in means due to variety and phosphorus were highly significant at 1% level. While difference due to plant density was not significant.

Variety Galadima produced longer pods than other varieties except VC 1178A and VC 2778A. The difference between the length of pods of varieties VC 1973A, VC 1178A and VC 2778A were not significant. Variety VC 2768A produced the shortest pods.

Pod length increased significantly with each increment in posphorus from 0 to 25 and 25 to 50kgP/ha.

None of the order of interactions was significant.

4.34 **Pod Width, 1993**.

Mean pod width (cm) of green gram as influenced by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 30.

The data revealed that the mean differences in pod width due to variety and plant density were significant at 5% and the difference due to phosphorus was significant at 1 % level.

Varieties fall into two non-significant groups of Galadima -VC 2768A -VC 1178A - VC 2778A and VC 1178A - VC 2778A - VC 1973A. The differences within the groups were not significant, however variety Galadima and VC 2768A produced wider pods than VC 1973A.

Increasing plant density from 200,000 to 400,000 plants/ha did not have any effect on pod width; further increase in density to 600,000 plants/ha resulted in significant reduction in pod width.

Table 30: Pod width (cm) as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	0.53a	0.51b	0.47c
VC 2768A	0.53a	1.22a	0.55a
VC 1178A	0.52ab	0.50b	0.53ab
VC 2778A	0.52ab	0.57b	0.54ab
VC 1973A	0.50b	0.55b	0.51b
SE ±	0.006	0.10	0.11
Significance	*	*	**
Density (Plants/ha)			
200,000	0.53a	0.91a	0.53
400,000	0.52a	0.56b	0.53
600,000	0.50b	0.55b	0.50
SE ±	0.004	0.08	0.009
Significance	*	**	NS
Phosphorus (kgP/ha)			
0	0.43c	0.56c	0.49c
25	0.52b	0.68b	0.52b
50	0.60a	0.77a	0.55a
SE ±	0.003	0.01	0.05
Significance	**	**	**
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Significant increased in pod width was observed with each increment in phosphorus rates from 0 to 25 and 25 to 50kgP/ha.

All the interactions were not significant.

4.35 **Pod width 1994.**

Mean pod width (cm) of green gram as affected by variety, density and phosphorus during 1994 rainy season is shown in Table 30.

Analysed data revealed that, the mean difference due to variety was significant at 5% level. While the differences due to density and phosphorus were significant at 1% level.

Among the varieties, VC 2768A had significantly wider pods, than other varieties which had similar pod width.

Pod width was observed to decreased with every increase in density from 200,000 to 400,000 plants/ha. Further increase in density from 400,000 to 600,000 did not significantly decreased the pod width.

Increase in pod width was observed with each increased phosphorus rate.

All the interactions were not significant.

4.36 **Pod width, 1995.**

Mean pod width (cm) of green gram as influenced by variety, plant density and phosphorus during 1995 rainy season is shown in Table 30.

Differences due to variety and phosphorus were highly significant, while difference due to plant density was not significant.

Variety VC 2778A had greater width, but was statistically at

par width VC 1178A and VC 2778A. The differences between the pod width of varieties VC 1973A, VC 2778A and VC 1178A were not significant. Variety Galadima had the lowest pod width.

Significant increase in pod width was observed with each increment in phosphorus rates from 0 to 25 and 25 to 50kgP/ha. All the interaction were not significant.

4.37 **Number of Pods per Plant, 1993.**

Mean number of pods per plant as influenced by variety, Plant density and phosphorus levels during 1993 rainy season is shown in Table 31.

Analysed data revealed that differences in means of pod number/plant due to variety and density were significant. While difference due to phosphorus was highly significant.

Number of pods per plant of Galadima was found to be higher than VC 2778A. The differences among the other varieties were similar.

Number of pods per plant was observed to decreased with increasing density from 200,000 to 400,000 plants/ha. Further increase in density from 400,000 to 600,000 plants/ha did not significantly affect the pods per plant.

Increased number of pods was observed with every increase in phosphorus rate from 0 to 50kgP/ha.

Interaction between variety and density was significantly at 5% level (Table 31a). At the density of 200,000 and 400,000 plants/ha differences in number of pods/plant were not affected by varieties. However at 600,000 plants/ha VC 1178A produced higher

Table 31: Number of Pods per plant as affected by variety, Plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	28.70a	26.74a	34.04a
VC 2768A	28.67ab	24.70a	31.00ab
VC 1178A	28.67ab	22.07b	26.78bc
VC 2778A	26.11b	21.11b	25.78bc
VC 1973A	27.25ab	22.33b	22.56c
SE ±	0.80	0.56	1.88
Significance	*	**	*
Density (Plants/ha)			
200,000	29.16a	27.16a	29.87
400,000	27.76b	23.04b	27.02
600,000	27.23b	19.73c	27.20
SE ±	0.62	0.51	1.43
Significance	*	**	NS
Phosphorus (kgP/ha)			
0	21.84c	17.22c	20.31c
25	28.04b	21.98b	28.78b
50	33.75a	30.98a	35.00a
SE ±	0.18	0.26	0.67
Significance	**	**	**
Interaction			
VD	*	*	NS
VP	*	*	NS
DP	*	**	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

pods number than Galadima. The differences among the other varieties were statistically at par. When the same variety was examined at varyingdensities, number of pods of Galadima and VC 1178A were not affected. In the case of VC 2778A and VC 1973A, higher number of pods were produced at 200,000 plants/ha when compared to 600,000 plants/ha. Variety VC 2768A produced significantly higher number of pods at 200,000 plants/ha; however the number of pods produced at the other two densities were similar.

The interaction between variety and phosphorus was significant at 5% level (Table 31a). When the same variety was considered in relation to various phosphorus rates; there was a significant increase in number of pods with each increment in phosphorus rate for all the varieties. When the same phosphorus rate was examined with respect to various varieties; at control, all the varieties have similar number of pods. At 25kgP/ha, variety VC 2778A and VC 1973A produced higher number of pods than Galadima. The differences among other varieties were similar statistically. However at 50kgP/ha, variety VC 1178A produced higher number of pods than other varieties except VC 2778A. Variety Galadima produced lower pod number than other varieties except VC 2768A and VC 1973A.

The interaction between density and phosphorus was significant at 5% level (Table 31a). At each density, increasing phosphorus rates increased the number of pods. At the same phosphorus level, there was significantly higher number of pod at 200,000 plants/ha when compared with 600,000 plants/ha at control and 50kgP/ha.

Table 31a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 and 1994 for number of pods per plant.

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	28.00a-d	26.44bcd	23.89d	20.56g	25.22e	32.56c
VC 2768A	30.89a	26.67bcd	24.22c	22.11f	26.11de	33.56bc
VC 1178A	29.33ab	29.33ab	28.78abc	26.44de	26.44de	38.00a
VC 2778A	32.33a	28.56abc	25.11bcd	28.78d	28.78d	35.44ab
VC 1973A	32.00a	28.67abc	25.44bcd	28.67d	28.67d	34.22bc
SE ±		1.38			0.86	
Phosphorus (kgP/ha)						
0	23.33d	21.60de	20.80e			
25	27.67c	26.87c	26.60c			
50	35.73a	35.07ab	33.47b			
SE ±		0.86				
Variety						
1994						
Galadima	33.11a	24.78c	22.33cde	20.00def	25.44c	34.78a
VC 2768A	29.22b	28.00b	16.89fg	16.89fg	21.67de	35.56a
VC 1178A	34.67a	16.78fg	14.78g	18.89e	21.00def	26.33c
VC 2778A	23.22cd	21.22cde	18.89ef	15.33g	20.22def	27.73bc
VC 1973A	23.89cd	22.67cde	20.44def	15.00g	21.56de	30.44b
SE ±		1.14			0.81	
Phosphorus (kgP/ha)						
0	20.40d	17.33e	13.93f			
25	25.60c	21.13d	19.20de			
50	35.47a	30.67b	26.80c			
SE ±		0.63				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

However at 25kgP/ha, the differences were not significant statistically.

4.38 **Number of Pods per plant, 1994.**

Mean number of pods per plant as affected by variety, plant density and phosphorus levels during 1994 rainy season is presented in Table 31.

Analysis of the data showed that all the factors in the trial had significant (1% level) effect on number of pods per plant.

Variety Galadima and VC 2768A produced higher number of pods than other varieties which were statistically similar.

There was a progressive decrease in number of pods as density was increased either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha.

Application of phosphorus was observed to increased the number of pods per plant.

The interaction between variety and density was observed to be significant (Table 31a). At the same density when green gram varieties were examined, a differential response of varieties was found with varying density levels. At 200,000 plants/ha, variety Galadima and VC 1178A produced higher number of pods than other varieties. They were followed by VC 2768A. The remaining two varieties had similar pod number. At 400,000 plants/ha, variety VC 2778A produced higher pods than other varieties. It was followed by Galadima which produced higher pods than VC 1178A. At 600,000 plants/ha, variety VC 1178A produced lower number of pods than all other varieties except VC 2768A. When each variety was examined at

varying desities, number of pods was reduced with increasing density from 200,000 to 400,000 plants/ha for varieties VC 1178A and Galadima. In the case of VC 2768A, increasing the density from 200,000 to 400,000 plants/ha did not affect the number of pods, but further increased density to 600,000 plants/ha resulted in a significant reduction of pods. Increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the pod number produced by variety VC 2778A. In the case of VC 1773A, there was no difference in number of pods.

Interaction between variety and phosphorus was significant (Table 31a). When the same variety was examined in relation to various phosphorus rates, there was a significant increase in number of pods with each increment in phosphorus rates for all the varieties. When the same phosphorus rate was examined with respect to different varieties; at control, variety VC 1178A produced higher pods than other varieties except Galadima. The other varieties produced similar pod number. When 25kgP/ha was applied, variety Galadima produced higher number of pods than other varieties which were at par. While at 50kgP/ha variety VC 2768A produced higher number of pods than others except Galadima, which was followed by varieties VC 1973A and VC 2778A which inturn were higher than VC 1178A.

The interaction between density and phosphorus (Table 31a) was significant. At each density, increased number of pod was observed with every increase in phosphorus rate at all densities. At the same phosphorus rate, when compared at varying densities, th

number of pods decreased with increase density from 200,000 to 600,000 plants/ha at control and 50kgP/ha. At 25kgP/ha increase in density from 200,000 to 400,000 plants/ha reduced the pod number, further increase in density to 600,000 plants/ha did not affect the pod number per plant.

4.39 **Number of Pods per plant 1995.**

Mean number of pods per plant as influenced by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 31.

Analysed data revealed that differences in means due to variety was significant at 5% level; while difference due to plant density was not significant. However difference due to phosphorus was significant.

The number of pod per plant produced by variety Galadima was higher than all other varieties except VC 2768A which also produced higher number of pods than VC 1973A.

Increased number of pods was observed with every increase in phosphorus level from 0 to 25 and 25 to 50kgP/ha.

None of the interaction was significant.

4.40 **Number of seeds per Pod, 1993.**

The influence of variety, plant density and phosphorus levels on number of seeds per pod during the 1993 rainy season is presented in Table 32.

The mean number of seed was significantly effected by varieties and plant density, and highly significantly effected by phosphorus rate.

Table 32: Number of seeds per pod as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	9.11a	9.04c	9.52
VC 2768A	9.11a	9.48b	9.07
VC 1178A	8.56b	9.89a	9.22
VC 2778A	9.26a	9.48b	9.37
VC 1973A	9.04a	9.59ab	9.48
SE ±	0.12	0.11	0.37
Significance	*	*	NS
Density (Plants/ha)			
200,000	9.29a	9.53a	9.31
400,000	9.00b	9.53a	9.61
600,000	8.96b	9.22b	9.02
SE ±	0.09	0.09	0.29
Significance	*	*	NS
Phosphorus (kgP/ha)			
0	8.07c	8.31c	7.98c
25	9.00b	9.51b	9.38b
50	9.98a	10.67a	10.64a
SE ±	0.06	0.04	0.17
Significance	**	**	**
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

Variety VC 1178A produced significantly lower number of seed than other varieties which were similar. Number of seeds per pod was reduced when the density was increased 200,000 to 400,000 or 600,000 plants/ha.

Each increase in phosphorus level increased the number of seed per pod.

No significant difference was observed in the first and second order of interactions.

4.41 **Number of seeds per pod,1994.**

The effect of variety, plant density and phosphorus levels on number of seeds per pod during 1994 rainy season is shown in Table 32.

As in 1993 season, differences due to variety and plant density were significant, and difference due to phosphorus was highly significant.

Variety VC 1178A had the highest number of seeds, but was statistically at par with VC 1973A. They were followed by varieties VC 2768A, VC 2778A and VC 1973A. Variety Galadima had the lowest number of seeds per pod.

Increased density from 200,000 to 400,000 plants/ha did not affect number of seeds, but further increase in density to 600,000 plants/ha decreased the seed number.

Application of phosphorus increased the number of seeds per pod significantly.

None of the order of interactions was significant.

Table 33: Number of seeds per plant as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	195.1b	227.3a	324.1a
VC 2768A	196.6b	220.4a	281.2ab
VC 1178A	197.3b	205.5ab	246.9ab
VC 2778A	196.7b	187.6b	241.6b
VC 1973A	201.5a	195.9b	213.9b
SE ±	0.70	7.17	25.8
Significance	*	*	*
Density (Plants/ha)			
200,000	199.3a	244.9a	278.1
400,000	196.8b	202.5b	259.7
600,000	198.2b	174.6c	245.3
SE +	0.54	5.56	20.33
Significance	*	**	NS
Phosphorus (kgP/ha)			
0	191.0c	137.7c	162.1c
25	197.1b	193.1b	270.0b
50	204.2a	291.1a	372.4a
SE ±	0.22	2.82	10.43
Significance	**	**	**
Interaction			
VD	*	*	NS
VP	*	*	NS
DP	*	**	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.42 **Number of seeds per pod, 1995.**

The effect of variety, plant density and phosphorus levels on number of seeds per pod during 1995 rainy season is shown in Table 32.

Differences due to variety and plant density were not significant; while that due to phosphorus was highly significant.

Each increment in level of phosphorus resulted in significant increase in number of seeds per pod.

None of the interactions was significant.

4.43 **Number of seeds per Plant, 1993.**

Mean of variety, plant density and phosphorus levels as they affect number of seeds per plant is presented in Table 33.

Variety and plant density had significant effect on number of seeds, while phosphorus had highly significant effect.

Variety VC 1973A had statistically higher number of seeds than other varieties which were similar.

Number of seeds per plant decreased with increase in density from 200,000 to 400,000 plants/ha. However, when the density was further increased to 600,000 plants/ha, no significance difference was observed.

Application of phosphorus significantly increased the number of seeds per plant.

Variety x density interaction was significant (Table 33a). When the same density was considered for different varieties, variety VC 1973A had significantly higher number of seeds at 200,000 plants/ha than other varieties except VC 2778A. At 400,000

Table 33a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 and 1994 for number of seeds per plant.

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	129.9bcd	125.8efg	119.7h	120.0e	124.8d	130.6c
VC 2768A	128.8cde	127.1def	123.8fg	119.7e	127.0d	133.0bc
VC 1178A	129.3cd	127.1def	125.1efg	120.0e	126.6d	135.4ab
VC 2778A	131.7abc	126.1d-g	122.2gh	119.8e	125.2d	135.0ab
VC 1973A	134.1a	133.7ab	126.8def	125.7e	132.1c	136.8a
SE ±		1.20			0.80	
Phosphorus (kgP/ha)						
0	122.0e	120.7e	120.3e			
25	129.2c	126.7d	125.5d			
50	136.7a	133.5b	132.3b			
SE ±		0.62				
Variety						
1994						
Galadima	292.4b	211.9de	177.4ef	153.3fg	206.2de	257.0d
VC 2768A	278.7bc	239.4cd	143.1hi	141.3gh	184.0e	335.9a
VC 1178A	337.7a	154.4ghi	124.4i	151.4fg	223.2d	307.1ab
VC 2778A	197.8def	195.7ef	169.3fgh	115.7h	178.0ef	269.1cd
VC 1973A	200.4def	200.2def	186.9efg	126.9gh	174.2ef	286.4bc
SE ±		12.4			8.82	
Phosphorus (kgP/ha)						
0	170.6e	141.5f	101.1g			
25	234.2d	178.8e	166.4e			
50	329.8a	287.3b	256.3c			
SE ±		6.83				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

plants/ha, variety VC 1973A produced significant higher number of seed than other varieties which were statistically similar. Variety Galadima produced lower number of seeds at 600,000 plants/ha than other varieties except VC 2778A. The means of other varieties were statistically of par. When each variety were considered at various densities; in varieties VC 2768A and VC 1178A the number of seed was not affected. In the case of Galadima, increase in density decreased the number of seeds. While increasing density from 200,000 to 400,000 plants/ha increased the number of seeds of variety VC 2778A, further increased density did not affect the seed number. Increasing density from 200,000 to 400,000 plants/ha had no effect on number of seed, but further increase in density to 600,000 plants/ha significant reduced the seed number.

Variety x phosphorus interaction was significant (Table 33a). Examining each variety at varying phosphorus levels revealed that the varieties responded similarly to application of phosphorus. At the same level of phosphorus when the varieties were examined; variety VC 1973A produced higher seeds that all other varieties which constituted the same significant group at control and 25kgP/ha. At 50kgP/ha however, VC 1973A produced higher number of seeds than VC 2768A and Galadima. VC 2778A and VC 1178A also produced higher number of seeds than Galadima.

Density x phosphorus interaction was significant (Table 33a). The means have showed that at the same level of phosphorus when densities were considered; the number of seeds produced by increasing density from 200,000 to 600,000 plants/ha at control was

not significant. However, at 25 and 50kgP/ha, increased density from 200,000 to 400,000 plants/ha decrease the number of seeds per plants, further increased in density to 600,000 plant/ha did not affect the number of seeds. At the same density, when phosphorus levels were examined, the mean number of seeds increases with increased phosphorus rate at all densities.

4.44 **Number of seeds per plant, 1994.**

Mean number of seeds per plant as affected by variety, plant density and phosphorus levels are shown in Table 33.

Analysed data revealed that only means due to variety was significant, the others were highly significant.

Varieties Galadima and VC 2768A had higher number of seeds than VC 2778A and VC 1973A. Other differences were not significant.

Number of seeds per plent decreased with increasing density from 200,000 to 600,000 plants/ha.

Increasing phosphorus rate from 0 to 50kgP/ha increased the number of seeds per plant significantly.

Variety x density interaction was significant at 5% level (Table 33a). When the same density was examined for different varieties, it was observed that at 200,000 plants/ha, variety VC 1178A produced the highest number of seeds. It was follwed by Galadima which was statistically at par with VC 2768A and higher than other varieties. At 400,000 plants/ha, variety VC 2768A produced the highest number of seeds, but was statistically at par with Galadima and VC 1973A. The differences between varieties VC1973A, VC 2778A. and Galadima were not significant. Variety

VC 1178A produced the lowest number of seeds. However at 600,000 plants/ha, variety VC 1178A produced lower number of seeds than other variety except VC 2768A. The other varieties produced statistically similar number of seeds. When the same variety was examined at varying densities, there were no significant differences in number of seed produced by varieties VC 2778A and VC 1973A at all densities. While increased in density from 200,000 to 400,000 plants/ha resulted in reduction of seeds of variety Galadima and VC 1178A, further increase in density did not affect the seed number. The number of seeds was not affected by increasing density from 200,000 to 400,000 plants/ha for variety VC 2768A, but further increase in density to 600,000 plants/ha decreased the seed number significantly.

Variety x phosphorus interaction was significant at 5% level (Table 33a). Examining each variety at varying phosphorus levels revealed that, the number of seed increased with each increment in phosphorus level for all varieties with the exception of Galadima, where increased application of phosphorus from 25 to 50kgP/ha did not have any significant effect. At the same phosphorus level, when the different varieties were examined; variety Galadima produced the highest number of seeds at control, the other differences being no significant. While at 25kgP/ha, variety VC 1178A produced higher number of seeds than all other varieties except Galadima. The differences between the other varieties were no significant. At 50kgP/ha, variety VC 2768A produced higher number of seed than other varieties except VC 1178A.

Density x phosphorus interaction was significant at 1% level. (Table 33a). The means had showed that, at the same level of phosphorus when densities were evaluated; the number of seeds per plant decrease with each increment in density at all phosphorus levels, with the exception of 25kgP/ha where increased in density from 400,000 to 600,000 plants/ha did not have any significant effect. At the same density, when different phosphorus levels were examined, the mean number of seeds increased with increasing phosphorus rate for all varieties.

4.45 **Number of seeds per plant, 1995.**

Differences due to variety, plant density and phosphorus levels as they affect number of seeds per plant were presented in Table 33.

Variety had a significant effect at 5% level, while plant density was not significant; however the effect of phosphorus was significant at 1% level.

Variety Galadima had higher number of seeds than VC 2778A and VC 1973A, other differences equal.

Each increment in phosphorus level significantly increased the number of seeds per plant.

None of the interactions was significant.

4.46 **Pod weight per plant, 1993.**

Mean pod weight (g/plant) as influenced by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 34.

Analysis of the data revealed that the differences in means of

Table 34:Pod weight (g/plant) as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	17.19c	18.23d	18.85b
VC 2768A	19.30a	20.04bc	21.20a
VC 1178A	18.86a	23.70a	21.82a
VC 2778A	18.42b	18.98cd	20.83a
VC 1973A	19.32a	20.55b	20.91a
SE ±	0.25	0.43	0.44
Significance	*	**	*
Density (Plants/ha)			
200,000	20.07a	21.07a	20.89
400,000	19.94a	20.83a	20.73
600,000	15.85b	19.01b	20.54
SE ±	0.20	0.34	0.34
Significance	**	*	NS
Phosphorus (kgP/ha)			
0	15.42c	15.98c	18.98c
25	18.18b	19.71b	20.79b
50	22.25a	25.21a	22.40a
SE ±	0.11	0.16	0.18
Significance	**	**	**
Interaction			
VD	*	*	NS
VP	*	*	NS
DP	**	**	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

the pod weight due to variety was significant; whereas plant density and phosphorus were highly significant.

Variety Galadima recorded the lowest pod weight. Variety VC 2778A also produced lower pod weight than the rest three varieties whose differences were not significant.

Pod weight per plant was not significantly affected by increasing density from 200,000 to 400,000 plants/ha. However further increased in density to 600,000 plants/ha decreased the pod weight.

Application of phosphorus significantly increased the pod weight per plant.

The interaction between variety and density was significant at 5% level (Table 34a). At the same density, when varieties were considered; it was observed that at 200,000 plants/ha, variety VC 1178A produced heavier pods than other varieties except VC 2768A and VC 1973A. Variety Galadima had lower pod weight than other varieties except VC 2778A. While at 400,000 plants/ha, variety VC 2768A produced the heaviest pods. Galadima recorded lower pod weight than all other varieties except VC 2778A. However at 600,000 plants/ha variety VC 1178A produced the lowest pod weight. When the same variety was considered at varying densities, each increment in density resulted in reduction in pod weight of all the varieties with the exception of VC 2768A, where increase density from 200,000 to 400,000 plants/ha did not affect the pod weight and VC 2778A where increase in density from 400,000 to 600,000 plants/ha did not affect the pod weight per plant.

Table 34a: Interaction between variety x density, variety and density x phosphorus during 1993 and 1994 for pod weight (g/plant) plant.

Variety	Year	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
Galadima	1993	13.85cd	12.02ef	10.70fg	9.42f	11.42d	15.73b
VC 2768A		16.36ab	16.19ab	10.35g	10.92d	14.15c	17.84a
VC 1178A		17.41a	15.15bc	9.03h	9.78ef	13.06c	18.75a
VC 2778A		15.09bc	12.49de	12.38de	11.24d	13.29c	15.72b
VC 1973A		16.12ab	15.06bc	11.79efg	10.75de	10.75de	18.22b
SE ±			0.44			0.33	
Phosphorus (kgP/ha)							
0		11.44d	11.22de	8.61f			
25		14.77de	14.24b	10.54e			
50		19.36a	19.00a	13.39c			
SE ±			0.25				
Variety							
Galadima	1994	18.10f-i	17.59ghi	17.01ghi	14.04h	18.00f	22.66d
VC 2768A		23.33b	20.10defg	16.68i	16.20g	19.32ef	24.60bc
VC 1178A		27.82a	22.55bcd	20.73cde	19.34ef	22.82d	28.95a
VC 2778A		20.22cdef	19.05efgh	17.67ghi	14.91gh	18.11f	23.92cd
VC 1973A		22.72bc	19.61efg	19.30efgh	15.39gh	20.30e	25.95b
SE ±			0.75			0.52	
Phosphorus (kgP/ha)							
0		16.56e	16.53e	14.81f			
25		20.49c	20.41c	18.23d			
50		26.15a	25.55a	23.95b			
SE ±			0.40				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

The interaction beween variety and phosphorus (Table 34a) was significant at 5% level. When the same variety was evaluated for various phosphorus rates, there was a significant increase in pod weight with each increment in phosphorus rates for all varieties. When the same phosphorus level was considered for various varieties; at control, Galadima produced lower pod weight than others except VC 1178A. The rest of the three varieties were statistically at par. However at 25kgP/ha, variety Galadima produced significant lower pod weight than other varieties that were similar. At 50kgP/ha, varieties Galadima and VC 2778A produced significantly lower pod weight than other varieties which were statistically at par.

The interaction between density and phosphorus was highly significant (Table 34a). At each density increased pod weight was observed with every increase in phosphorus level. At the same phosphorus level, when compared at verying densities, increase density from 200,000 to 400,000 plants/ha did not affect the pod weight at all levels of phosphorus; further increase in density to 600,000 plants/ha reduced the weight of pods per plant.

4.47 **Pod weight per plant, 1994.**

Mean pod weight (g/plant) as influenced by variety, plant density and phosphorus levels during 1994 rainy season is presented in Table 34.

Analysed data revealed that differences due to variety and phosphorus were highly significant; while difference due to plant density was significantly.

Variety VC 1178A produced significantly higher pod weight than other varieties. It was followed by VC 1973A, which was statistically at par with VC 2768A. The differences between VC 2768A and VC 2778A were not significant. Variety Galadima produced the lowest pod weight, but was statistically at par with VC 2778A.

Increased density from 200,000 to 400,000 plants/ha did not affect the pod weight. Further increase in density to 600,000 plants/ha decreased the pods weight per plant.

Application of phosphorus to the tune of 50kgP/ha significant increased the pod weight per plant.

Variety x density interaction was significant at 5% level (Table 34a). Analysed data showed that, when each variety was evaluated at various densities; varieties VC 2768A, VC 1178A, and VC 1973A had the highest pods weight when density was increased from 200,000 to 400,000 plants. When density was further increased from 400,000 to 600,000 plants/ha, there was decreased pod weight only for VC 2778A. When the same density was looked at across the varieties; at 200,000 plants/ha, variety VC 1178A produced higher pod weight than all others; it was followed by VC 2768A which was higher than other varieties except VC 1973A. At 400,000 plants/ha level, variety VC 1178A was found to be higher than other varieties which were similar. At 600,000 plants/ha, VC 1178A produced heavier pod weight than all other varieties except VC 1973A.

Variety x phosphorus interaction (Table 34a) was significant at 5% level. When the same variety was considered in relation to

various phosphorus rates; a significant increase in pod weight was observed with each increment in phosphorus rate. When the same phosphorus rate was considered in respect to various varieties; it was observed that at control, variety VC 1178A produced heavier pods than other varieties. It was followed by variety VC 2768A which was higher than Galadima. At 25 and 50kgP/ha, Variety VC 1178A produced heavier pods than other varieties. It was followed by variety VC 1973A which was higher than the rest varieties except VC 2768A.

Density x phosphorus interaction was significant at 1% level (Table 34a). At the same phosphorus level, when compared at varying density; increasing density from 200,000 to 400,000 plants/ha did not affect the pod weight at any phosphorus rate. Further increased in density to 600,000 plants/ha reduced the pod weight per plant. At each density, increased pod weight was observed with every increment in phosphorus rates.

4.48 **Pod weight per plant, 1995.**

Mean pod weight (g/plant) as influenced by variety, plant density and phosphorus levels during 1995 rainy season is presented in Table 34.

Analysis of the data revealed that the differences due to variety and phosphorus were significant at 5% and 1 % level respectively; whereas that of plant density was not significant.

Variety Galadima produced significantly heavier pods than other varieties which are statistically similar.

Application of phosphorus to the tune of 50kgP/ha significant

Table 35: Grain yield (g/plant) as affected by variety, plant density and phosphorus levels during 1993-95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	9.80c	12.36b	12.60b
VC 2768A	9.50c	11.23c	15.20a
VC 1178A	12.28a	14.33a	15.48a
VC 2778A	10.67b	10.83c	14.83a
VC 1973A	11.58a	11.10c	14.93a
SE ±	0.25	0.35	0.43
Significance	**	**	**
Density (Plants/ha)			
200,000	11.29a	13.14a	15.15a
400,000	10.98a	11.78b	14.73a
600,000	10.03b	10.98b	13.12b
SE +	0.19	0.27	0.32
Significance	**	**	*
Phosphorus (kgP/ha)			
0	7.07c	8.81c	12.38c
25	11.48b	11.41b	14.73b
50	14.12a	15.68a	16.72a
SE ±	0.11	0.14	0.11
Significance	**	**	**
Interaction			
VD	*	*	NS
VP	*	*	NS
DP	**	**	*
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

increased the pod yield.

None of the interactions was significant.

4.49 **Grain yield per plant, 1993.**

Grain yield (g/plant) as affected by variety, plant density and phosphorus levels during 1993 rainy season is presented in Table 35.

Differences due variety and phosphorus were highly significant; while difference due to plant density was significant.

Varieties VC 1178A and VC 1973A had significantly higher grain yield than other varieties under consideration. They were followed by variety VC 2778A which inturn yielded higher than Galadima and VC 2768A. The yield of the latter two were at par with one another.

Increasing density from 200,000 to 400,000 plants/ha resulted in statistically the same grain yield; however when the density was increased from 400,000 to 600,000 plants/ha, the grain yield was observed to decrease significantly.

Increasing application of phosphorus rates from 0 to 50kgP/ha resulted in significant increased in grain yield per plant.

Variety x density interaction was found to be significant at 5% level (Table 35a). Holding the varieties as constant for the different densities, it was observed that variety VC 1178A, Galadima and VC 2778A produced higher grain yield/plant at 200,000 and 400,000 density than at 600,000 plant/ha. In the case of varity VC 2768A, yield per plant at 200,000 plants/ha was higher than the other two densities. The yield of variety VC 1973A was not affected by varying density. Considering each density for different

Table 35a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 and 1994, and phosphorus x density in 1995 for grain yield (g/plant).

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	8.46bc	7.11cd	4.84f	3.53h	5.96e	10.92b
VC 2768A	8.00bc	5.90def	5.61ef	3.75h	6.64de	9.12c
VC 1178A	11.14a	10.98ac	5.73def	6.10ef	9.04c	12.70a
VC 2778A	8.56b	7.95bc	6.51cde	5.03g	7.19d	10.81b
VC 1973A	8.90b	8.47bc	8.36bc	5.11fg	8.59c	12.04a
SE ±		0.43			0.31	
Phosphorus (kgP/ha)						
0	5.62e	4.42f	4.07f			
25	7.84c	7.77c	6.85d			
50	12.05a	11.48a	9.82b			
SE ±		0.24				
Variety						
1994						
Galadima	15.40a	11.49bcd	10.18cde	8.24e	11.24d	17.19b
VC 2768A	12.71b	12.18bc	8.81e	8.77e	11.19d	13.73c
VC 1178A	15.58a	14.82a	12.59b	10.37d	13.29c	19.36a
VC 2778A	11.42bcd	11.15bcd	9.92de	8.45e	10.37d	13.66c
VC 1973A	11.82bcd	10.89bcd	10.59bcde	8.24e	10.58d	14.48c
SE ±		0.61			0.43	
Phosphorus (kgP/ha)						
0	9.09e	8.99e	8.36e			
25	12.14c	11.78c	10.30d			
50	18.30a	14.47b	14.28b			
SE ±		0.34				
Phosphorus (kgP/ha)						
1995						
0	12.36d	12.20d	11.38d			
25	14.36c	13.77c	13.70c			
50	16.21a	15.87ab	14.72bc			
SE ±		0.34				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

varieties, it was observed that variety VC 1178A had higher grain yield than other varieties at 200,000 plants/ha which were statistically at par. In the case of 400,000 plants/ha, varieties VC 1973A and VC 2778A yielded higher than Galadima and VC 2768A. At the density of 600,000 plants/ha, VC1973A yielded significantly higher than all other varieties except VC 2778A which also yielded higher than Galadima.

Variety x Phosphorus interaction was significant at 5% level (Table 35a). It revealed that, when the same variety was considered in relation to various phosphorus rates, there was a significant increase in grain yield with each increment in phosphorus level for all varieties. When the same phosphorus level was considered for different varieties; variety VC 1178A had higher grain yield than other varieties except VC 1973A at control. The difference between the grain yield of varieties VC 2778A and VC 1973A was not significant, but these two varieties yielded significantly higher than VC 2768A and Galadima. While at 25kgP/ha, varieties VC 1973A and VC 1178A still maintain the lead. They were followed by VC 2778A which was statistically at par with VC 2768A but higher than Galadima. Varieties VC 1178A and VC 1973A produced the highest grain yield at 50kgP/ha. They were follwed by VC 2778A and Galadima which also produced higher yield than VC 2768A.

Density x phosphorus interaction was significant at 1% level (Table 35a). when the same phosphorus rate was considered in respect to varying densities, there was a significant reduction in yield as density was increased from 200,000 to 400,000 plants/ha at

control, but further increase in density to 600,000 plants/ha did not affect the yield. At 25kgP/ha, increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the grain yield; however plant sown at 200,000 plants/ha gave the higher yield than 600,000 plants/ha. While at 50kgP/ha, green gram sown at 200,000 and 400,000 plants/ha gave statistically the same yield; further increased in density to 600,000 plants/ha reduced the yield significantly. When the same density was considered in respect to various phosphorus levels, each increased phosphorus rate resulted in significantly higher grain yield at all densities.

4.50 **Grain yield per plant 1994.**

Mean grain yield (g/plant) as affected by variety, plant density and phosphorus levels during 1994 rainy season is shown in Table 35.

Analysed data showed that the difference due to all the three factors under study were highly significant.

Variety VC 1178A produced significantly higher grain yield than others. It was followed by Galadima which was statistically higher than other three varieties that were statistically at par.

Grain yield decreased with increasing density from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not influenced the yield.

Application of phosphorus significantly increase the grain yield at each level.

As in the case of 1993, interaction between variety and density was significant (Table 35a). At the same density, when

green gram varieties were examined, varieties VC 1178A and Galadima gave the highest grain yield at 200,000 plants/ha; the other varieties had statistically the same yield. At 400,000 plants/ha, variety VC 1178A produced significantly higher grain yield than other varieties which were at par. While at 600,000 plants/ha, VC 2768A had lower yield than VC 1178A. When the same variety was examined for different densities, variety Galadima produced higher yield at 200,000 plants/ha than other densities. Varieties VC 1178A and VC 2768A produced similar yield both at 200,000 and 400,000 plants/ha densities, but a further increase in density to 600,000 plants/ha significantly reduced the yield. In the case of varieties VC 2778A and VC 1973A, increasing density from 200,000 to 600,000 plants/ha did not significantly reduced the yield.

The interaction between variety and phosphorus was significant (Table 35a). When the same variety was considered in relation to various phosphorus levels, there was a significant increase in yield with each increment in phosphorus levels. Evaluating the same phosphorus level for different varieties, it was observed that variety VC 1178A produced significantly higher grain yield than all other varieties at control and 25kgP/ha. At 50kgP/ha variety VC 1178A had higher grain yield than other varieties. It was followed by Galadima which in turn was significantly higher than the other three varieties that are statistically at par.

Interaction of density and phosphorus was highly significant (Table 35a). At each density, increased grain yield was observed with every increment in phosphorus rate. At the same phosphorus

level, when compared at varying densities, there was no significant difference in the means of grain yield as density was increased from 200,000 to 600,000 plants/ha at control. At 25kgP/ha, increased density from 200,000 to 400,000 plants/ha did not affect the grain yield, however further increased density to 600,000 plants/ha decreased the grain yield. At 50kgP/ha, grain yield decrease with increased density from 200,000 to 400,000 plants/ha. Further increase in density to 600,000 plants/ha did not influence the grain yield.

4.51 **Grain yield per plant, 1995.**

Mean grain yield (g/plant) as affected by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 35.

Analysed data showed that the differences due to variety and phosphorus were highly significant; while difference due to plant density was significant.

All the four varieties yielded significantly higher than Galadima.

Increased density from 200,000 to 400,000 plants/ha resulted in statistically the same grain yield; however when the density was increased from 400,000 to 600,000 plants/ha, the grain yield was observed to decline significantly.

Increasing application of phosphorus rates from 0 to 50kgP/ha resulted in significant increase in grain yield per plant.

Plant Density x phosphorus interaction was significant (Table 35a). When the same phosphorus rate was considered in respect to

varying densities; at control and 25kgP/ha, increasing density did not affect the yield per plant. However, at 50kgP/ha, the different between 200,000 and 400,000 or 400,000 and 600,000 plants/ha was not significant. When the same density was considered in respect to various phosphorus levels, each increased phosphorus rate resulted in significantly heavier grain yield at 200,000 and 400,000 plants/ha. However at 600,000 plants/ha increase in phosphorus rate from 0 to 25kgP/ha increased the yield per plant, but further increase in phosphorus rate to 50kgP/ha did not have any significant effect.

4.52 **Pod yield per hectare, 1993.**

Pod yield (kg/ha) as influenced by variety, plant density and phosphorus levels during 1993 rainy season is presented in Table 36.

The data showed that difference due to variety was significant; while those due to plant density and phosphorus were highly significant.

Variety VC 1973A produced significantly heavier pods than Galadima. Other differences were not significant statistically.

Each increase in density from 200,000 to 600,000 plants/ha resulted in heavier pods/ha. Likewise each increase in phosphorus level also significantly increased pod yield.

The variety x density interaction was significant at 5% level (Table 36a). Holding the variety constant for different densities; the pod yield of all the varieties increased with increasing density except VC 2778A where increased density from 200,000 to

Table 36: Pod yield (kg/ha) as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	1282b	1105c	661b
VC 2768A	1455ab	1410a	1659a
VC 1178A	1427ab	1407a	1819a
VC 2778A	1420ab	1252b	1524a
VC 1973A	1503a	1299b	1783a
SE ±	26.9	33.5	134.6
Significance	*	**	**
Density (Plants/ha)			
200,000	1129c	1068c	1108b
400,000	1485b	1234b	1576a
600,000	1639a	1488a	1784a
SE ±	20.8	25.9	104.3
Significance	**	**	**
Phosphorus (kgP/ha)			
0	1079c	986c	1110c
25	1426b	1305b	1463b
50	1747a	1593a	1895a
SE ±	11.7	10.5	50.49
Significance	**	**	**
Interaction			
VD	*	*	NS
VP	*	*	NS
DP	**	**	*
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

400,000 plants/ha had no effect on pod yield. When the same density was examined for different varieties at 200,000 plants/ha, variety VC 2768A produced heavier pod yield than Galadima. At 400,000 plants/ha, higher pods were produced by variety VC 1973A than all other varieties except VC 2768A. The difference between VC 2768A and VC 1178A was not significant; however their pod yield were higher than those of VC 2778A and Galadima. While at 600,000 plants/ha, variety VC 2778A produced higher pod yield than VC 2768A and Galadima. It was followed by VC 1973A which was also higher than Galadima.

The variety x phosphorus interaction was significant at 5% level (Table 36a). When the same variety was examined in relation to various phosphorus rates, there was a significant increase in pod yield with each increment in phosphorus level. When the same phosphorus level was considered for the different varieties; varieties VC 2778A and VC 1973A produced higher pod yield than VC 1178A and Galadima. When 25 and 50kgP/ha were applied, variety Galadima produced significantly lower pod yield than other varieties which were statistically at par.

The density x phosphorus interaction was highly significant at 1% level (Table 36a). When the same phosphorus level was considered in respect to varying densities, there was an increase in pod yield per hectare. The same trend was observed when the same density was evaluated in respect to various phosphorus, where each increased phosphorus rate resulted in significantly higher pod yield at each density.

Table 36a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 and 1994, and density x phosphorus in 1995 for Podyield(kg/ha)

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	1039g	1202f	1605cd	995e	1197d	1654b
VC 2768A	1209f	1520de	1636bcd	1087de	1455c	1823a
VC 1178A	1134fg	1443e	1703abc	999e	1357c	1924a
VC 2778A	1132fg	1273f	1857a	1165d	1411c	1685b
VC 1973A	1129fg	1612cd	1769ab	1150d	1461d	1897a
SE ±		46.6			34.3	
Phosphorus (kgP/ha)						
0	854g	1096f	1287e			
25	1106f	1424d	1599c			
50	1425d	1936b	2029a			
SE ±		26.6				
Variety						
1994						
Galadima	891f	1129de	1296cd	680g	1212e	1426c
VC 2768A	1303c	1330c	1598b	1051f	1387cd	1792a
VC 1178A	1000ef	1328c	1894a	1135ef	1458c	1629b
VC 2778A	972ef	1250cd	1533b	1010f	1259de	1487c
VC 1973A	1120de	1141de	16349b	1055f	1208e	1633b
SE ±		58.0			38.6	
Phosphorus (kgP/ha)						
0	811f	979e	1169d			
25	1087d	1320c	1508b			
50	1287c	1705a	1788a			
SE ±		29.9				
Phosphorus (kgP/ha)	1995					
0	825f	1228de	1278de			
25	1122ef	1545cd	1722bc			
50	1377cde	1954b	2353a			
SE ±		105.3				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.53 **Pod yield per hectare, 1994.**

Mean pod yield (kg/ha) as affected by variety, plant density and phosphorus levels during 1994 rainy season is presented in Table 36.

Analysis of the data revealed that variety, plant density and phosphorus have highly significant effect on pod yield per hectare.

The pod yield produced by varieties VC 2768A and VC 1178A were significantly higher than other varietices. They were followed by VC 1973A and VC 2778A which were significantly higher than Galadima.

Each increase in density increased the pod yield. Likewise each increase in phosphorus rate increased the pod yield.

The variety x density interaction was significant (Table 36a). When each variety was examined at varying densities; there was an increase of pod yield with every increment in density for varieties VC 1178A and VC 2778A. In the case of VC 2768A and VC 1973A, increasing density from 200,000 to 400,000 plants/ha did not increased the pod yield; however, when the density was increased from 400,000 to 600,000 plants/ha, the pod yield increased. In the case of Galadima, the pod yield increased with increasing density from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not affect the pod yield. When the same density was observed in respect to different varieties; at 200,000 plants/ha, variety VC 2768A produced higher pod yield than other varieties which were at par. At 400,000 plants/ha, variety VC 2768A produced higher pod yield than other varieties except VC 1178A and

VC 2778A. The differences between VC 2778A, Galadima, and VC 1973A were not significant. While at 600,000 plants/ha, variety VC 1178A produced significantly higher pod yield than all other varieties, which was followed by VC 1973A, VC 2768A and VC 2778A. The lowest pod yield was produced by variety Galadima.

The variety x phosphorus interaction was significant at 5% level (Table 36a). When the same variety was considered in relation to various phosphorus rates, there was a significant increase in pod yield with each increment in phosphorus. When the same phosphorus rate was considered for different varieties; variety Galadima produced significantly lower pod yield than other varieties which were statistically at par at control. At 25kgP/ha, variety VC 1178A produced higher pod yield than all other variety except VC 2778A. Variety VC 2768A also produced higher pod yield per unit area than the rest of the varieties except VC 2778A. The latter was significantly at par with Galadima and VC 1973A. Variety VC 2768A produced significantly higher pod yield than other varieties at 50kgP/ha. It was followed by varieties VC 1973A and VC 1178A which also produced statistically higher pods yield than varieties VC 2778A and Galadima.

The density x phosphorus interaction was significant at 1% level (Table 36a). Examining the same density at various phosphorus rates, each increased in phosphorus levels resulted in significantly higher pod yield at each density. When the same phosphorus rate was considered in respect to varying densities; there was an increase in pod yield per hectare both at control and

25kgP/ha. In the case of 50kgP/ha, increasing density form 400,000 to 600,000 plants/ha did not increase pod yield per unit area.

4.54 **Pod yield per hectare, 1995.**

Pod yield (kg/ha) as influenced by variety, plant density and phosphorus levels during 1995 rainy season is presented in Table 36.

Analysis of the data revealed that all the factors have highly significantly effect on pod yield.

Variety Galadima produced significantly lower pod yield than all other varieties under trial which were statistically at par.

Increasing density from 200,000 to 400,000 plants/ha increased the pod yield/ha, but further increase in density to 600,000 plants/ha did not affect the pod yield.

Each increase in phosphorus rates from 0 to 50kgP/ha increased the pod yield per hectare.

Density x phosphorus interaction was found to be significant at 5% level (Table 36a). Considering the same density at varying phosphorus rates; it was observed that increase in phosphorus rate from 0 to 25kgP/ha at 200,000 and 400,000 plants/ha did not affect the pod yield, further increase phosphorus to 50kgP/ha result in increased pod yield per hectare. While at 600,000 plants/ha, each increase in phosphorus increased the pod yield significantly.When the same phosphorus rate was examined in respect to varying densities; it was observed that increasing density from 200,000 to 400,000 plants/ha increased the pod yield at control and 25kgP/ha; further increase in density to 600,000 plants/ha did not affect the

pod yield. In the case of 50kgP/ha, each increase in density increased the pod yield per hectare.

4.55 **1000-grain weight, 1993.**

Mean of 1000-grain weight(g) as influenced by variety, plant density and phosphorus levels during 1993 rainy season is presented in Table 37.

Analysed data revealed highly significant differences due to variety, plant density and phosphorus.

Variety VC 1178A had significantly heavier test weight than other varieties. Variety Galadima had significantly lower test weight than VC 1973A. The differences among the other varieties were statistically at par.

1000-grain weight was reduced with each increased density from 200,000 to 600,000 plants/ha. Each increase in phosphorus level resulted in higher test weight.

Interaction between variety and density was significant at 5% level (Table 37a). At the same density, when different varieties were considered; variety VC 1178A had significantly higher 1000-grain weight than all other varieties which were statistically similar at 200,000 and 400,000 plant/ha. While at 600,000 plants/ha, varieties VC 1178A and VC 1973A had higher 1000-grain weight than other varieties which were at par. When each variety was considered at varying densities, increase density from 200,000 to 400,000 plants/ha did not affect the 1000-grain weight of varieties VC 1178A, VC 2778A and Galadima; but further increase in density to 600,000 plants/ha increased the test weight. In the case

Table 37:1000-grain weight (g) as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	53.80c	64.70d	62.82b
VC 2768A	57.90bc	70.99c	77.25a
VC 1178A	79.10a	74.77a	80.24a
VC 2778A	60.30bc	70.92c	76.42a
VC 1973A	63.80b	72.93b	72.71a
SE ±	2.15	0.34	2.32
Significance	**	**	**
Density (Plants/ha)			
200,000	68.50a	71.54a	76.17a
400,000	63.00b	71.34a	75.39ab
600,000	57.50c	69.70b	70.12b
SE ±	1.67	0.29	1.80
Significance	**	*	*
Phosphorus (kgP/ha)			
0	39.90c	67.12c	66.09c
25	60.70c	71.09b	73.14b
50	88.40a	74.37a	82.46a
SE ±	0.77	0.14	1.12
Significance	**	**	**
Interaction			
VD	*	*	NS
VP	**	*	NS
DP	*	*	*
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

of VC 2768A, each increase in density increased its test weight. While increased in density from 200,000 to 600,000 plants/ha did not affect the 1000-grain weight of VC 1973A.

The interaction between variety and phosphorus was highly significant (Table 37a). Considering the same variety in respect to varying phosphorus rates there was a significant increase in 1000-grain weight with each increment in phosphorus level. When the same phosphorus level was considered for different varieties; at control and 25kgP/ha, variety VC 1178A had significantly higher test weight than other varieties. While variety Galadima had lower 1000-grain weight that other varieties which were statistically similar. At 50kgP/ha, variety VC 1178A had significantly heavier test weight than other varieties. Variety VC 2768A had lower test weight than other varieties that are statistically at par.

A significant interaction was noticed between density and phosphorus levels (Table 37a). Examining the same density at varying phosphorus rates, it was noticed that the higher the rate of phosphorus applied, the heavier the 1000-grains. When the same phosphorus level was considered at varying densities; at control, sowing green gram at 200,000 plants/ha gave higher test weight. The differences in test weight of crops sown at 400,000 and 600,000 plants/ha were not significant. At 25kgP/ha, each increment in density resulted in heavier 1000-grains. In the case of 50kgP/ha, both 200,000 and 400,000 plants/ha resulted in heavier test weight than 600,000 plants/ha.

Table 37a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 and 1994, and density x phosphorus in 1995 for 1000-grain weight(g)

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	67.0cd	56.1de	38.3f	29.1h	45.4fg	86.8bc
VC 2768A	73.9bc	53.7de	46.2f	38.1g	57.0de	78.6c
VC 1178A	96.2a	84.2ab	56.9de	50.7ef	81.7bc	105.0a
VC 2778A	67.4cd	65.0cd	48.6ef	41.1g	56.9de	83.0bc
VC 1973A	66.7cd	63.0cd	61.7cd	40.2g	62.7d	88.5b
SE ±		3.73			2.57	
Phosphorus (kgP/ha)						
0	46.2f	37.8g	35.5g			
25	67.7c	60.6d	53.8e			
50	91.5a	90.7a	83.0b			
SE ±		1.99				
Variety						
1994						
Galadima	65.3e	64.9e	63.9e	56.3i	66.0h	71.8ef
VC 2768A	72.6bc	71.6c	68.8d	68.8g	70.8f	73.4cd
VC 1178A	75.8a	74.3ab	74.2ab	72.5de	74.8bc	77.0a
VC 2778A	73.1bc	71.3c	68.4d	67.3gh	70.5f	75.00bc
VC 1973A	73.6abc	73.2bc	71.9c	70.6f	73.5bcd	74.7bc
SE ±		0.65			0.45	
Phosphorus (kgP/ha)						
0	68.3f	67.0g	66.1g			
25	71.8cd	71.4d	70.2d			
50	76.3a	74.0b	72.9c			
SE ±		0.35				
Phosphorus (kgP/ha)						
1995						
0	69.4cd	65.7d	63.2d			
25	76.5bc	74.8bc	69.1cd			
50	88.0a	81.3b	78.1b			
SE ±		2.00				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

4.56 **1000- grain weight, 1994.**

Means of 1000-grain weight (g) as influenced by variety, plant density and phosphorus levels during 1994 rainy season is presentedin Table 37.

Analysed data revealed that the differences due to variety and phosphorus were highly significant and that due to plant density was significant.

Variety VC 1178A had significantly heavier 1000 - grains than other varieties. It was followed by VC 1973A which was also heavier than the rest varieties. Varieties VC 2768A and VC 2778A produced similar test weight, but was significantly higher than Galadima.

1000-grain weight was not influenced by increasing density from 200,000 to 400,000 plants/ha; however when the density was further increased to 600,000 plants/ha, the grain weight was reduced.

Each increase in phosphorus rate from 0 to 50kgP/ha resulted in increased 1000-grain weight.

Interaction between variety and density was significant at 5% level (Table 37a). When the same variety was examined at different densities; it was observed that increased density did not have any effect on varieties Galadima, VC 1178A and VC 1973A. In the case of varieties VC 2768A and VC 2778A increased density from 200,000 to 400,000 plants/ha did not influenced 1000-grain weight, but further increase in density to 600,000 plants/ha significantly decreased the test weight. When the density was considered for different variety. At 200,000 and 400,000 plants/ha variety VC 1178A produced

significantly heavier 1000-grains than other varieties except VC 1973A; variety Galadima produced the lowest grain weight. The differences among other varieties were similar statistically. Also at 600,000 plants/ha, variety VC 1178A produced significantly heavier 1000-grains than other varieties. It was followed by VC 1973A, which was statistically higher than both varieties VC 2768A and VC 2778A. Variety Galadima had the lowest test weight.

The interaction between variety and phosphorus was significant (Table 37a). Examining the same variety at varying phosphorus rates, there was a significant increase in 1000-grain weight of all the varieties with each increment in phosphorus rate with the exception of variety VC 1973A, where increase in phosphorus level from 25 to 50kgP/ha did not affect the test weight. Considering the phosphorus level for different varieties; at control variety VC 1178A produced significantly heavier 1000-grain than other varieties. It was followed by VC 1973A which was heavier than other three varieties. Variety Galadima produced the lowest 1000-grain weight. At 50kgP/ha, variety VC 1178A had statistically heavier 1000-grains than other varieties. The differences between varieties VC 2778A, VC 1973A and VC 2768A were not significant. As in the other cases Galadima had the lowest 1000-grain weight.

A significant interaction was noticed between density and phosphorus levels (Table 37a). When the same density was considered at varying phosphorus levels; it was noticed that the higher the level of fertilizer, the heavier the test weight at all densities. Examining the same level of phosphorus at varying densities; at

control increasing density from 200,000 plants/ha to either 400,000 or 600,000 plants/ha significanly decreased the seed weight. The difference between the latter two was found to be insignificant. While at 25kgP/ha, increase density from 200,000 to 600,000 plants/ha did not affect 1000-grains weight. At 50kgP/ha, each increase in density resulted in a decreased 1000-grain weight.

4.57 **1000-grain weight, 1995.**

Means of 1000-grain weight (g) as influenced by variety, plant density and phosphorus levels during 1995 rainy season is presented in Table 37.

Analysed data revealed a highly significant difference due to variety and phosphorus and a significant difference due to plant density.

Variety Galadima produced grains with significantly higher weights, when compare to all other varieties which were statistically similar.

Increasing the density from either 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the 1000-grain weight. However, green gram sown at 200,000 plants/ha had heavier seed weight than 600,000 plants/ha.

1000-grain weight was increased with each increase in phosphorus rate from 0 to 50kgP/ha.

The density x phosphorus interaction was significant at 5% level (Table 37a). When the same phosphorus rate was examined in relation to various densities; increasing density did not affect the test weight at both control and 25kgP/ha. However, at 50kgP/ha

increase in density from 200,000 to 400,000 plants/ha reduced the 1000-grain weight, further increased density to 600,000 plants/ha did not effect the test weight. Considering the same density at varying phosphorus rates, it was observed that, increase in phosphorus rate from 0 to 25kgP/ha at 200,000 and 600,000 plants/ha did not affect the test weight. Further increase in phosphorus to 50kgP/ha increased the weight of test grains. In the case of 400,000 plants/ha, increasing phosphorus rate from 0 to 25kgP/ha increased the 1000-grain weight; further increase in phosphorus to 50kgP/ha did not affect the test weight.

4.58 **Grain yield per hectare, 1993.**

Mean grain yield (kg/ha) as affected by variety, plant density and phosphorus levels during 1993 rainy season is shown in Table 38.

The difference due to variety was significant at 5% level, while those due to plant density and phosphorus were significant at 1% level.

Varieties VC 1178A and VC 1973A produced significantly higher grain yield per hectare than other varieties which were statistically similar.

Grain yield was found to increased by increasing both the density and phosphorus rates from 200,000 to 600,000 plants/ha and 0 to 50kgP/ha respectively.

Variety x density interaction was significant at 5% level (Table 38a). Considering each variety at varying densities; it was observed that, grain yield of varieties VC 2768A, VC 2778A and

Table 38: Grain yield (kg/ha) as affected by variety, plant density and phosphorus levels during 1993 - 95 and combined analysis at Samaru.

Treatments	1993	1994	1995	Combined
Variety				
Galadima	868b	761d	518b	739b
VC 2768A	859b	956a	1190a	936a
VC 1178A	1017a	1009a	1480a	1019a
VC 2778A	887b	940b	1318a	980a
VC 1973A	995a	837c	1397a	1018a
SE ±	25.3	18.7	101.1	38.2
Significance	*	*	**	**
Density (Plants/ha)				
200,000	681c	702c	908b	688c
400,000	963b	968b	1273a	993b
600,000	1131a	1081a	1361a	1133a
SE ±	19.6	14.5	78.3	29.6
Significance	**	**	**	**
Phosphorus (kgp/ha)				
0	607c	675c	907c	698c
25	1022b	954b	1274b	970b
50	1264a	1113a	1461a	1147a
SE ±	7.9	9.8	33.3	14.5
Significance	**	**	**	**
Interaction				
VD	*	*	NS	NS
VP	**	*	NS	*
DP	**	**	*	**
VDP	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

VC 1973A increased with each increment in density. While in the case of varieties Galadima and VC 1178A, increasing density from 200,000 to 400,000 plants/ha did not affect the yield; further increase in density to 600,000 plants/ha resulted in increased grain yield. At

the same density, when green gram varieties were examined; variety VC 1178A produced higher grain yield than other varieties at 200,000 plants/ha with the exception of VC 1973A. Differences in grain yield of other three varieties were statistically similar. At 400,000 plants/ha, variety VC 1178A produced higher yield than Galadima, differences among the other varieties were not significant. While at 600,000 plants/ha, variety VC 1178A produced higher grain yield than other varieties except VC 1973A. The differences between the grain yield of varieties VC 1973A, VC 2778A and Galadima were not significant. Variety VC 2768A had lower grain yield than other varieties except Galadima.

The variety x phosphorus interaction was significant at 1% level (Table 38a). It revealed a significant increase in grain yield with each increment in phosphorus level from 0 to 50kgP/ha when each variety was examined in relation to varying phosphorus rates. Considering the same phosphorus levels across different varieties; at control, variety VC 1973A produced higher grain yield when compared with other varieties which produced similar yield. While at 25kgP/ha, varieties VC 1178A and VC 1973A produced higher grain yield than other varieties which were statistically similar. At 50kgP/ha variety VC 1178A produced significantly higher yield

Table 38a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 and 1994 for grain yield (kg/ha)

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	671gh	806efg	1125bc	537g	885e	1280b
VC 2768A	599h	969d	1010c	586g	943e	1149d
VC 1178A	824def	1040bcd	1315a	615g	1155cd	1380a
VC 2778A	630h	867de	1163b	566g	942e	1251bc
VC 1973A	683fgh	986cd	1186ab	729f	1098d	1257b
SE ±		43.8			29.1	
Phosphorus (kgP/ha)						
0	410g	680f	730ef			
25	778e	1053c	1193b			
50	966d	1256b	1569a			
SE ±		22.6				
Variety						
1994						
Galadima	691g	747fg	844e	518g	896d	967cd
VC 2768A	896de	908d	1065b	744e	1025bc	1200b
VC 1178A	816e	1018b	1194a	746e	1053b	1330a
VC 2778A	704g	1033b	1082b	738e	940cd	1242b
VC 1973A	734fg	829ef	947bcd	628f	904d	1077c
SE ±		32.4			25.7	
Phosphorus (kgP/ha)						
0	562e	710d	753d			
25	836c	1017b	1037b			
50	1007b	1228a	1254a			
SE ±		0.35				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

than other varieties. It was followed by varieties VC 1973A, Galadima and VC 2778A. Variety VC 2768A produced significantly lower yield than other varieties under trial.

The density x phosphorus interaction was significant at 1% level (Table 38a). When the same phosphorus rate was considered in respect to varying densities; there was an increase in grain yield with each increased density except at control, where the yields were similar when population was raised from 400,000 to 600,000 plants/ha. Examining the same density in respect to various phosphorus rates, each increased phosphorus rate resulted in significantly higher grain yield at each density.

4.59 **Grain yield per hectare, 1994.**

Mean grain yield (kg/ha) as affected by variety, plant density and phosphorus levels during 1994 rainy season is shown in Table 38.

The difference due to variety was significant at 5% level, while those due to plant density and phosphorus were significant at 1% level.

Analysed data revealed that, variety VC 1178A produced higher grain yield than other varieties except VC 2768A. They were followed by VC 2778A and VC 1973A. Galadima had the lowest grain yield.

Grain yield was increased with each increase in density was well as each increase in phosphorus rates.

Variety x density interaction was significant at 5% level (Table 38a). Considering each variety at varying densities; it was

found that, grain yield of variety VC 1178A increased with each increment in density. In the case of varieties Galadima, VC 2768A and VC 1973A increased density from 200,000 to 400,000 plants/ha did not affect the yield, but further increase in density to 600,000 plants/ha resulted in increased yield. Increasing density from 200,000 to 400,000 plants/ha increased the yield of variety VC 2778A; further increase in density to 600,000 plants/ha did not affect the yield. At the same density, when green gram varieties were examined; varieties VC 2768A and VC 1178A produced higher grain yield than all other varieties which are statistically similar at 200,000 plants/ha. However at 400,000 plants/ha varieties VC 1178A and VC 2778A produced higher yields than other varieties. They were followed by VC 2768A which was significantly higher than Galadima and VC 1973A. While at 600,000 plants/ha, variety VC 1178A still maintains its lead. Variety Galadima produced the lowest yield.

The variety x phosphorus interaction was significant at 1% level (Table 38a). There was an increase in grain yield of all the varieties with each increment in phosphorus rates, with the exception of VC 2768A which was not increased when the phosphorus rate was increased from 25 to 50kgP/ha. When the same phosphorus rate was considered for different varieties; it revealed that varieties VC 2768A, VC 1178A and VC 2778A had significantly higher grain yield than other two varieties at control. They were followed by variety VC 1973A which in turn yield higher than Galadima. Variety VC 1178A produced higher yield than all other varieties

except VC 2768A at 25kgP/ha. The other varieties have similar yields. At 50kgP/ha, VC 1178A had significantly higher grain yield than all other varieties. It was followed by varieties VC 2778A and VC 2768A which were statistically higher than VC 1973A and Galadima. The difference between the yield of the VC 1973A and Galadima was not significant.

The density x phosphorus interaction was highly significant (Table 38a). When the same phosphorus rate was examined in respect to varying densities; there was an increase in yield as density was increased from 200,000 to 400,000 plants/ha at all the phosphorus rates. However, further increase in density to 600,000 plants/ha did not affect the yield. Examining the same density for different phosphorus rates; each increase in phosphorus rate resulted in increased yield at all densities.

4.60 **Grain yield per hectare, 1995.**

Mean grain yield (kg/ha) has affected by variety, plant density and phosphorus levels during 1995 rainy season is shown in Table 38.

The difference due to all the factors were significant at 1% level.

Variety Galadima produced significantly lower grain yield per hectare than other varieties which were statistically similar.

Grain yield was increased with increase in density from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not affect the yield.

Grain yield was increased with each increase in phosphorus

Table 38b: Interaction between density x phosphorus in 1995 and variety x phosphorus and density x phosphorus (combined analysis) for grain yield (kg/ha).

Year / Variety / Phosphorus (kgP/ha)	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1995						
0	689f	1025de	1007de			
25	906ef	1258cd	1359bc			
50	1129cde	1538ab	1716a			
SE ±		76.2				
Variety						
Combined						
Galadima				492f	808ef	918cde
VC 2768A				671fg	942cde	1194ab
VC 1178A				753ef	1020bcd	1280a
VC 2778A				832def	1043bc	1181ab
VC 1973A				741ef	1037bc	1159ab
SE ±					46.5	
Phosphorus (kgP/ha)						
0	498e	717d	852d			
25	764c	1022c	1194b			
50	832d	1173b	1394a			
SE ±		36.0				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

rate from 0 to 50kgP/ha.

Density x phosphorus interaction was significant at 5% level (Table 38b). Analysed data revealed that when the same phosphorus level was examined in respect to varying densities; there was an increase in yield with increased density from 200,000 to 400,000 plants/ha at all phosphorus levels.Further increase in density to 600,000 plants/ha did not affect the yield. When the same density was examined in respect to varying phosphorus rates; increasing phosphorus rate from 0 to 25kgP/ha did not affect the yield at 200,000 and 400,000 plants/ha. However, further increase in phosphorus level to 50kgP/ha resulted in higher grain yield. At 600,000 plants/ha each increase in phosphorus rate resulted in higher yield.

4.61 **Grain yield per hectare, combined.**

Mean grain yield (kg/ha) as affected by variety, plant density and phosphorus levels for combined analysis is shown in Table 38. The differences due to all factors were significant at 1% level.

Variety Galadima produced significantly lower grain yield per hectare than all other varieties which were statistically similar.

Grain yield was increased with each increase in density as well as each increase in phosphorus level.

Variety x phosphorus interaction was significant at 5% level (Table 38b). Examining the same variety at different phosphorus rates; each increased phosphorus rate increase the yield of varieties VC 1178A and VC 2768A. In the case of the other three varieties, increase phosphorus level from 0 to 25kgP/ha increased

the yield significantly, but further increase in phosphorus rate to 50kgP/ha did not affect the yield. Considering the same phosphorus rate for different varieties; at control and 25kgP/ha, variety Galadima produced significantly lower yield than other varieties except VC 2768A. The other varieties had similar yields. While at 50kgP/ha, variety Galadima produced significantly lower yield than other varieties which were statistically similar.

The density x phosphorus interaction was significant at 1% level (Table, 38b). When the same phosphorus level was evaluated in respect to varying densities, it was observed that at control, increase in density from 200,000 to 400,000 plants/ha increased the yield, but further increase in density to 600,000 plants/ha did not affect the yield. While at 25 and 50kgP/ha, each increasing density resulted in significant increased yield. When the same density was considered in respect to various phosphorus levels; it was observed that at 200,000 plants/ha, increasing phosphorus level from 0 to 25kgP/ha increased the yield; but further increase in phosphorus rate to 50kgP/ha did not affect the yield. At 400,000 and 600,000 plants/ha each increase in phosphorus rate resulted in increased yield per hectare.

4.62 **Shelling percentage, 1993**.

Mean shelling percentage as affected by variety, plant density and phosphorus levels during 1993 rainy season is presented in Table 39.

The difference due to variety and phosphorus were significant at 1% level, while that due to plant density was significant only

Table 39: Shelling percentage as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	57.44d	62.40b	78.91
VC 2768A	65.46bc	65.40ab	79.61
VC 1178A	71.60a	66.90ab	81.96
VC 2778A	61.13c	69.00a	80.81
VC 1973A	65.91b	61.00b	79.49
SE ±	1.39	1.58	1.76
Significance	**	*	NS
Density (Plants/ha)			
200,000	67.05a	69.50a	77.98
400,000	66.85a	64.20b	81.25
600,000	59.02b	61.10b	81.24
SE ±	1.08	1.22	1.39
Significance	*	*	NS
Phosphorus (kgp/ha)			
0	55.40c	59.50c	78.45b
25	65.51b	62.50b	80.72ab
50	72.01a	72.80a	81.31a
SE ±	0.54	0.73	0.83
Significance	**	**	*
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

at 5% level.

Variety VC 1178A had significantly higher shelling percentage when compared to other varieties. It was followed by VC 1178A. The differences in shelling percentage between varieties VC 2768A and VC 2778A as well as between VC 2778A and VC 1973A were not significant. Variety Galadima had the lowest shelling percentage. The shelling percentage was not affected by increasing density from 200,000 to 400,000 plants/ha, but further increased in density to 600,000 plants/ha significantly reduced the shelling percentage.

The shelling percentage increased with each increment in phosphorus rate from 0 to 50kgP/ha.

The first and second order of interactions were not significant.

4.63 **Shelling percentage, 1994.**

Mean shelling percentage as affected by variety, plant density and phosphorus levels during 1994 rainy season is presented in Table 39.

The differences due to variety and plant density were significant at 5% level, while that due to phosphorus was significant at 1% level.

Variety VC 2778A had higher shelling percentage than Galadima and VC 1973A. The other differences were not significant.

Shelling percentage was decreased when the density was increase from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha, did not affect the shelling percentage.

Each application of phosphorus upto 50kgP/ha was observed to significantly increased the shelling percentage.

None of the order of interactions was significant.

4.64 **Shelling percentage, 1995**.

Mean shelling percentage as affected by variety, plant density and phosphorus levels during 1995 rainy season is presented in Table 39.

The differences due to variety and plant density were not significant, but the different due to phosphorus was significant at 5% level.

Increasing the application of phosphorus either from 0 to 25 or 25 to 50kgP/ha did not affect the shelling percentage, however shelling percentage observed at 50kgP/ha was higher than at control.

None of the first or second order on interactions was significant.

4.65 **Harvest index, 1993**.

Mean harvest index (%) as influenced by variety plant density and phosphorus levels during 1993 rainy season is presented in Table 40.

The differences due to all factors under trial were significant at 1% level.

Variety VC 1178A had significantly higher harvest index than other varieties. It was followed by varieties VC 1973A and VC 2778A which were statistically at par. The lowest harvest index was found in varieties VC 2768A and Galadima which were similar

Table 40: Harvest index (%) as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	25.79d	35.37b	43.88b
VC 2768A	27.19cd	40.02a	47.81a
VC 1178A	35.48a	39.21a	49.76a
VC 2778A	31.11b	35.82a	49.22a
VC 1973A	32.02b	35.82a	50.26a
SE ±	0.56	0.64	1.15
Significance	**	**	**
Density (Plants/ha)			
200,000	38.55a	38.44a	50.11b
400,000	34.10b	36.76b	48.10ab
600,000	23.26c	36.54b	46.34b
SE ±	0.46	0.50	0.91
Significance	**	*	*
Phosphorus (kgp/ha)			
0	29.86b	36.41b	46.33b
25	30.45b	36.44b	48.79a
50	38.35a	38.90a	49.43a
SE ±	0.23	0.37	0.60
Significance	**	**	*
Interaction			
VD	NS	NS	NS
VP	NS	NS	NS
DP	NS	NS	NS
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

statistically.

Harvest index increased with each reduction in density from 600,000 to 200,000 plants/ha.

Increasing phosphorus rate from 0 to 25kgP/ha did not influence the harvest index, but further increase to 50kgP/ha resulted in significantly higher harvest index.

The first and second order of interactions were not significant.

4.66 **Harvest index, 1994.**

Mean harvest index (%) as influenced by variety, plant density and phosphorus levels during 1994 rainy season is presented in Table 40.

The differences due to variety and phosphorus were highly significant; while that due to plant density was significant.

Varieties VC 2768A and VC 1178A had statistically higher harvest index than other varieties which were statistically similar.

Harvest index was decreased with each increase in density from 200,000 to 400,000 plants/ha. Further increase in density to 600,000 plants/ha did not affect the harvest index.

Increasing phosphorus rates from 0 to 25kgP/ha resulted in non-significant increase in harvest index, but further increase from 25 to 50kgP/ha increased the harvest index.

None of the interactions was significant.

4.67 **Harvest index, 1995.**

Mean harvest index (%) as influenced by variety, plant density

and phosphorus levels during 1995 rainy season is presented in Table 40.

The differences due to variety and phosphorus were significant at 1% level, while the difference due to plant density was significant at 5% level.

Variety Galadima had significantly lower harvest index than other variety which were statistically at par.

Increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha did not affect the harvest index; however harvest indices of plants sown at 200,000 plants/ha were higher than 600,000 plants/ha.

Harvest index was significantly increased with increasing phosphorus rate from 0 to 25kgP/ha, but further increase in phosphorus rate to 50kgP/ha had no significant effect.

The first and second order of interactions were not significant.

4.68 **Grain crude protein content, 1993.**

Mean grain crude protein content as influenced by variety, plant density and phosphorus rates is presented in Table 41.

The differences due to all the factors under trial were highly significant.

Variety VC 2778A produced significantly higher crude protein than all other varieties. The next significant group consist of Vc 1178A, VC 1973A and VC 2768A which in turn have significantly higher protein content than Galadima.

The crude protein decreased with increasing density from

Table 41: Grain crude protein content as affected by variety, plant density and phosphorus levels during 1993 - 95 at Samaru.

Treatments	1993	1994	1995
Variety			
Galadima	16.78e	18.86e	16.29c
VC 2768A	18.43d	22.91d	20.67b
VC 1178A	19.64b	25.54a	21.61b
VC 2778A	19.90a	24.65b	24.16a
VC 1973A	18.85c	23.14c	20.77b
SE ±	0.01	0.04	0.33
Significance	**	**	**
Density (Plants/ha)			
200,000	19.01a	22.96a	21.58a
400,000	18.60b	22.44b	20.17b
600,000	18.56b	22.46b	19.16b
SE ±	0.01	0.03	0.26
Significance	**	**	**
Phosphorus (kgp/ha)			
0	16.93c	20.54c	18.49c
25	18.78b	22.70b	20.48b
50	20.45a	24.63a	21.93a
SE ±	0.01	0.01	0.06
Significance	**	**	**
Interaction			
VD	**	**	**
VP	**	**	**
DP	**	**	**
VDP	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

200,000 to 400,000 plants/ha, further increase in density to 600,000 plants/ha did not affect the protein content.

The higher the level of phosphorus applied, the higher the grain protein content.

Variety x density interaction was significant at 1% level (Table 41a). When each variety was examined at varying densities; crude protein of variety VC 1178A decreased with increasing density. While increasing density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha in the case of variety VC 1973A did not affect the grain protein content. However, plants sown at 200,000 plants/ha had higher grain protein than those sown at 600,000 plants/ha. Changes in density did not affect the grain crude protein of VC 2778A and VC 2768A. However for variety Galadima, increasing density from 200,000 to 400,000 plants/ha did not affect the protein content; further increase in density to 600,000 plants/ha significantly reduced the protein content. Considering the same density for different varieties; it was observed that at 200,000 plants/ha, variety VC 2778A produced significantly higher crude protein than all other varieties except VC 1178A. The differences between the protein contents of VC 1973A and VC 2768A were not significant, but higher than Galadima. Variety Galadima produced the lowest crude protein. while at 400,000 plants/ha, variety VC 2778A produced significantly higher crude protein than other varieties except VC 1178A and variety Galadima produced lower protein than other varieties. The protein content of the rest of the varieties were similar. Like at the

Table 41a: Interaction between variety x density, variety x phosphorus and density x phosphorus during 1993 - 95, for grain crude protein content

Year / Variety	Density (Plants/ha) 200,000	400,000	600,000	Phosphorus (kgP/ha) 0	25	50
1993						
Galadima	18.45f	17.56j	14.33m	14.98m	17.21j	18.14h
VC 2768A	18.75e	18.27g	18.27g	16.92k	17.69i	20.69c
VC 1178A	21.33b	21.29b	17.06l	18.83g	19.94e	20.92b
VC 2778A	22.21a	19.31d	17.40k	17.65i	20.00d	21.27a
VC 1973A	20.92c	17.98h	17.67i	16.27e	19.08f	21.21a
SE ±		0.02			0.02	
Phosphorus (kgP/ha)						
0	17.12g	17.10g	16.56h			
25	19.02d	18.85e	18.49f			
50	21.44a	20.20b	19.70c			
SE ±		0.02				
Variety 1994						
Galadima	20.70h	19.72j	16.16k	16.88p	19.34m	20.36l
VC 2768A	23.27e	22.73f	22.72f	21.10k	22.02i	25.60d
VC 1178A	28.72a	25.14c	22.75f	23.06h	26.00c	27.55b
VC 2778A	26.40b	26.29b	21.27g	23.33g	24.72e	29.90a
VC 1973A	24.41d	20.18i	19.84j	18.30n	21.39j	23.73f
SE ±		0.06			0.04	
Phosphorus (kgP/ha)						
0	20.83g	20.64h	20.13i			
25	22.97d	22.78e	22.33f			
50	25.78a	24.35b	23.75c			
SE ±		0.03				
Variety 1995						
Galadima	15.76g	14.97g	12.13h	12.71g	14.67f	19.48d
VC 2768A	21.61bcd	21.03cde	19.39def	19.03de	19.87cd	23.12b
VC 1178A	24.83a	21.54bcd	18.47f	19.85cd	22.43b	22.56b
VC 2778A	25.09a	23.87ab	23.52abc	22.76b	24.46a	25.26a
VC 1973A	22.16bc	21.28cde	18.86ef	18.11e	20.96c	23.23b
SE ±		0.57			0.27	
Phosphorus (kgP/ha)						
0	19.96b	18.60b	16.92c			
25	22.08a	20.02b	19.33b			
50	22.69a	21.88a	21.23ab			
SE ±		0.35				

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level using DMRT.

other densities, variety VC 2778A produced significantly higher crude protein than other varieties at 600,000 plants/ha. The differences in crude protein produced by varieties VC 2768A, VC 2778A and VC 1973A were not significant. Variety Galadima produced the lowest grain crude protein.

The variety x phosphorus interaction was significant at 1% level (Table 41a). when the same variety was examined at different phosphorus rates; there was a significant increase in crude protein as application of phosphorus was increased from 0 to 50kgP/ha for varieties Galadima and VC 1973A. Increasing application of phosphorus from 0 to 25kgP/ha to varieties VC 1178A and VC 2778A increased the protein content, but further increase of phosphorus to 50kgP/ha did not affect the protein content. While in the case of variety VC 2768A, increasing the phosphorus rate from 0 to 25kgP/ha did not affect the protein content, but further increase in phosphorus to 50kgP/ha increase the protein. Considering each phosphorus rate for different varieties; at control, variety VC 2778A had significantly higher protein content than other varieties. The differences between the protein content of varieties VC 2768A and VC 1178A were not significant. The former was also significantly similar to VC 1973A. Galadima recorded the lowest protein content. While at 25kgP/ha variety VC 2778A produced significantly higher protein than other varieties. It was followed by VC 1178A which was significantly higher than VC 2768A and VC 1973A that were similar. Variety Galadima had the least protein content. As in the case of other phosphorus levels, VC 2778A

produced higher protein than other varieties at 50kgP/ha, while Galadima had the lowest protein content. The other three varieties had similar protein content.

The density x phosphorus interaction was significant at 1% level (Table 41a). When the same phosphorus rates was examined in respect to varying densities; it was observed that, at control, increasing density from 200,000 to 400,000 plants/ha did not affect the protein content. Further increase in density to 600,000 plants/ha reduced the crude protein content. At 25kgP/ha, the protein content decline as the density was increased from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not affect the protein content. While at 50kgP/ha, the protein content was not significantly affected by changes in densities. Examining the same density at varying phosphorus rates revealed that, protein content was increased with increasing phosphorus rate from 0 to 25kgP/ha at 200,000 and 600,000 plants/ha; further increase in phosphorus rate to 50kgP/ha did not affect the protein content. At 400,000 plants/ha, increasing phosphorus rates from 0 to 25kgP/ha did not affect the protein content, but further increase in phosphorus rate to 50kgP/ha increased the protein content.

4.69 **Grain crude protein content, 1994.**

Mean grain crude protein content as influenced by variety, plant density and phosphorus rates is presented in Table 41.

Analysed data revealed that the differences due to all factors considered were highly significant.

Variety VC 1178A produced significantly higher protein content than other varieties. It was followed by VC 2778A which was statistically higher than other three varieties. Next comes variety VC 1973A which also contain higher protein than VC 2768A and Galadima. Galadima produced the lowest protein content.

The protein content decreased with increasing density from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not affect the crude protein content.

The higher the level of phosphorus applied, the higher the protein content of the grains.

Variety x density interaction was significant at 1% level (Table 41a). When each variety was considered at varying densities; it was observed that the protein content of varieties Galadima, VC 1178A and VC 1973A decreased with increasing density. While the protein content of VC 2768A decreased with an increase in density from 200,000 to 400,000 plants/ha, further increase in density to 600,000 plants/ha did not affect the protein content. In the case of variety VC 2778A, increasing density from 200,000 to 400,000 plants/ha did not affect the protein; but further increase in density to 600,000 plants/ha significantly reduced the protein content. At the same density, when various varieties were examined; variety VC 1178A produced the highest crude protein at 200,000 plants/ha. It was followed by VC 2778A, VC 1973A, VC 2768A and Galadima in a descending order. However, at 400,000 plants/ha, variety VC 2778A had higher protein than other varieties. It was followed by VC 1178A, VC 2768A, VC 1973A and Galadima in a

descending order. While at 600,000 plants/ha, variety VC 2778A produced significantly higher protein than other varieties. The differences between VC 2768A and VC 1178A was insignificant. Next was variety VC 1973A which was statistically higher than Galadima.

The variety x phosphorus interaction was significant at 1% level (Table 41a). When the same variety was considered in respect to various phosphorus rates; there was a significant increased in crude protein with each increment in phosphorus rate. When the same phosphorus rate was considered for different varieties; variety VC 2778A produced significantly higher protein than other varieties at control and 50kgP/ha. It was followed in a descending order by VC 2778A, VC 2768A, VC 1973A and Galadima. At 25kgP/ha variety VC 1178A had the highest protein content. It was followed by VC 2778A, VC 1973A, VC 2768A and Galadima in a decending order.

The density x phosphorus, interaction was significant 1% level (Table 41a). Examining the same phosphorus rate at varying densities; there was a decrease in protein content as the density was increased from 200,000 to 600,00 plants/ha. When the same density was considered in respect to various phosphorus rates; each increased phosphorus rate resulted in significantly higher crude protein at each all the densities.

4.70 **Grain crude protein content, 1995.**

Mean grain crude protein content of green gram as influenced by variety, plant density and phosphorus rates is presented in Table 41.

The differences due to all the factors under trial were

significant at 1% level.

Variety VC 2778A produced significantly higher protein than other varieties. The next significant group consist of VC 1178A, VC 1973A and VC 2768A which inturn had significantly higher protein content than Galadima.

The crude protein content decreased with increasing density from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not affect the protein content.

Variety x density interaction was significant at 1% level (Table 41a). Examining each variety at varying densities; the protein contents of variety VC 1178A decreased with increasing density. While increasing the density either from 200,000 to 400,000 or 400,000 to 600,000 plants/ha in the case of variety VC 1973A did not affect the protein content. Changes in density did not affect the protein content of VC 2778A and VC 2768A. However for variety Galadima, increasing in density from 200,000 to 400,000 plants/ha did not affect the protein content; further increase in density to 600,000 plants/ha significantly decreased the protein content. At the same density, when the various varieties were examined; variety VC 2778A produced higher protein than other varieties except VC 1178A at 200,000 and 400,000 plants/ha. The differences in crude protein content of VC 1973A and VC 2768A were not significant statistically. Variety Galadima had the lowest protein. Like at the other densities, variety VC 2778A produced significantly higher crude protein than other varieties at 600,000 plants/ha. The differences in crude protein produced by varieties

VC 2768A, VC 2778A and VC 1973A were not significant. Variety Galadima produced the lowest crude protein.

The variety x phosphorus interaction (Table 41a) was significant at 1% level. When the same variety was examined at various phosphorus rates; there was a significant increase in protein content as the application of phosphorus was increased from 0 to 50kgP/ha for varieties Galadima and VC 1973A. However, increase application of phosphorus from 0 to 25kgP/ha to varieties VC 1178A and VC 2778A increased the protein content, but further increase to 50kgP/ha did not affect the protein content. While in the case of variety VC 2768A, increasing the phosphorus rate from 0 to 25kgP/ha did not affect the protein content; but further increase in phosphorus rate to 50kgP/ha increased the protein content. When the same phosphorus rate was considered for different varieties; at control, variety VC 2778A had higher protein than other varieties. There was no significant difference in protein content of VC 2768A and VC 1178A; and VC 2768A and VC 1973A. Variety Galadima had the lowest grain protein. At 25kgP/ha, VC 2778A had higher crude protein content than other varieties; it was followed by VC 1178A. The difference between VC 1973A and VC 2768A was not significant. Variety Galadima had the lowest protein content. In the case of 50kgP/ha, variety VC 2778A maintains the lead. It was followed by VC 1973A, which was statistically similar to VC 2768A and VC 1178A. Variety Galadma had the lowest protein content.

The density x phosphorus interation was significant at 1%

level (Table 41a). When the same phosphorus rate was considered in respect to varying densities; at control, increase in density from 200,000 to 400,000 plants/ha did not affect the protein content. Further increase in density to 600,000 plants/ha significantly decreased the protein content. At 25kgP/ha, the protein content decline as the density was increased from 200,000 to 400,000 plants/ha; further increase in density to 600,000 plants/ha did not have any effect. The protein content was not significantly affected with increased density at 50kgP/ha. When the same density was considered in respect to varying phosphorus rates; it was observed that, at 200,000 plants/ha, increase phosphorus rate from 0 to 25kgP/ha increased the protein content, but further increase in phosphorus rate to 50kgP/ha had no significant effect. While at 600,000 plants/ha, there was no significant difference in protein content by increasing the phosphorus rate from 0 to 25kgP/ha; but further increase to 50kgP/ha increased the protein content. In the case of 600,000 plants/ha, each increase in phosphorus levels increased the crude protein content of the grains.

4.71 **Correlation and path coefficient analysis, 1993.**

The coefficient of correlation between yield and yield characters during 1993 rainy season is given in Table 42.

Grain yield per hectare was postively and significantly (1% level) correlated to plant height, number of branches/plant, number of leaves/plant, LAI, total dry matter/plant, number of pods/plant, number of seeds/pod, number of seeds/plant, pod weight (g/plant), grain yield (g/plant), 1000-grain weight and pod weight (kg/ha).

Table 42: Matrix of correlation coefficient between grain yield (kg/ha) and yield characters in 1993 at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.0000													
2	0.5215**	1.0000												
3	0.4363**	0.5311**	1.0000											
4	0.4483**	0.4474**	0.5050**	1.0000										
5	0.4000**	0.2480**	0.3570**	0.5201**	1.0000									
6	0.4927**	0.4845**	0.5510**	0.6405**	0.4614**	1.0000								
7	-0.2150**	-0.3171**	-0.3440**	-0.2921**	-0.3241**	-0.3190**	1.0000							
8	0.3808**	0.3184**	0.4340**	0.3801**	0.2200*	0.4468**	-0.2039*	1.0000						
9	0.2983**	0.4181**	0.2480**	0.3356**	0.2612**	0.2613**	-0.1670NS	-0.1085NS	1.0000					
10	0.3819**	0.4073**	0.3426**	0.2460*	0.3734**	0.2626**	-0.1235NS	0.5480**	0.1990*	1.0000				
11	0.3932**	0.5139**	0.5200**	0.3225**	-0.0133NS	0.3252**	-0.2029*	0.3083**	0.2440**	0.1767NS	1.0000			
12	0.7234**	0.4342**	0.4830**	0.3921**	0.2280*	0.4103**	-0.1204NS	0.4487**	0.2510**	0.3954**	0.6039**	1.0000		
13	0.8516**	0.4583**	0.4280**	0.3595**	0.2190*	0.3791**	-0.1280NS	0.3644**	0.3000**	0.2483*	0.6111**	0.9068**	1.0000	
14	0.7608**	0.5244**	0.5330**	0.3960**	0.3795**	0.4688**	-0.2563**	0.3242**	0.2500**	0.1095NS	0.6719**	0.5138**	0.5533**	1.0000

1. Grain yield per hectare. 2. Plant height. 3. Number of branches per plant. 4. Number of leaves per plant. 5. Leaf area index. 6. Total dry matter per plant.

7. Days to 50% flowering 8. Number of pods per plant. 9. Number of seeds per pod 10. Number of seeds per plant . 11. Pod weight per plant 12. Grain yield per plant

13. 1000-grain weight. 14. Pod yield per hectare.

A negative and significant (5% level) correlation was observed between grain yield and number of day to 50% flowering. Considering the correlation between the major yield components; it was observed

Fig (i)

Path diagram showing interrelations of grain yield (kg/ha) and some growth characters in 1993 at Samaru.

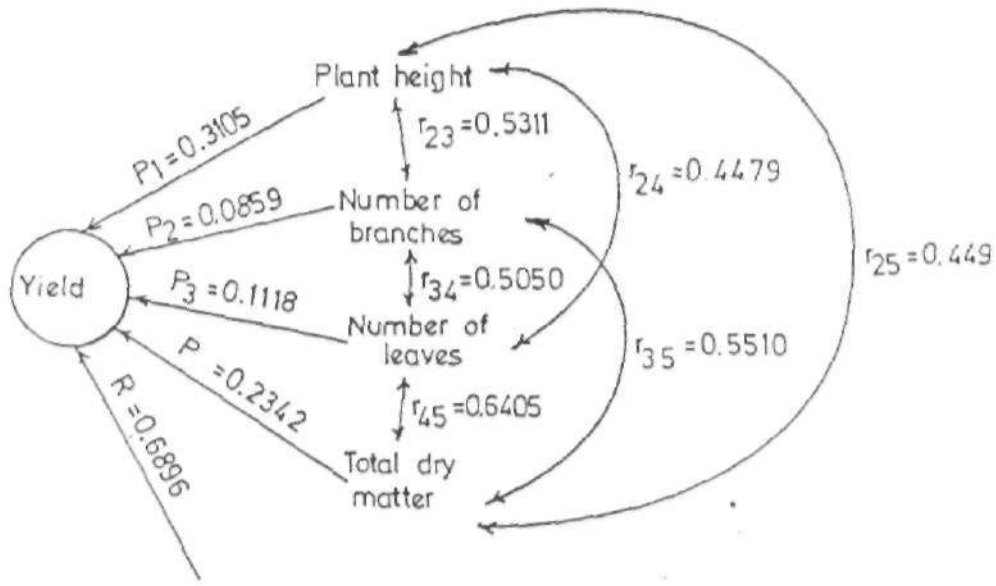


Table 43: The direct and indirect contributions of different growth characters on yield in 1993 at Samaru.

Yield attributes	Effect through.				
	Plant height(cm)	Number of branches	Number of leaves	Total dry matter	Total Correlation
Plant height (cm)	0.3105(a)	0.0456	0.0501	0.1053	0.5115
Number of branches	0.1649	0.0859	0.0565	0.1290	0.4363
Number of leaves	0.1391	0.0434	0.1118	0.1500	0.4443
Total dry matter(g)	0.1396	0.0473	0.0716	0.2342	0.4927

(a) Direct effect underlined.

that the number of pods per plant was positively and highly significantly correlated to 1000-grain weight, but was nagative and not significantly correlated to number of seed per pod. 1000-grain weight was postively and significantly correlated to number of seeds/pod.

The direct and indirect effect of vegetative characters on grain yield is presented in Table 43 and the path coefficient between yield and vegetative character is presented in figure 1. They revealed that plant height contributed 31.05% to the yield. Indirectly, plant height contributed via total dry matter 10.53%. The contribution of plant height via number of branches and number of leaves were low (4.56 and 5.01 percent respectively). Thus the total affect was found to be 51.15%. When the contribution of number of branches/plant was examined for yield, the direct effect was found to be 8.59%. Indirect effect via plant height, number of leaves and total dry matter were found to be 16.49, 5.65 and 12.90 percent repectively. Thus the total effect of number of branches/plant (direct and indirect) was found to be 43.63%. When the number of leaves was investigated for its contribution to the yield; the direct effect was found to be positive and to the tune of 11.18%. Indirectly, number of leaves/plant contributed via plant height, number of branches/plant and total dry matter to the tune of 13.91%, 4.34% and 15.60% respectively. Thus the total direct and indirect effect of number of leaves/plant towards yield was found to be 44.43%. When the contribution of total dry matter (g/plant) to yield was examined; it contributed directly 23.42% to the yield.

Fig (ii)

Path diagram showing interrelations of grain yield (kg/ha) and some yield components in 1993 at Samaru.

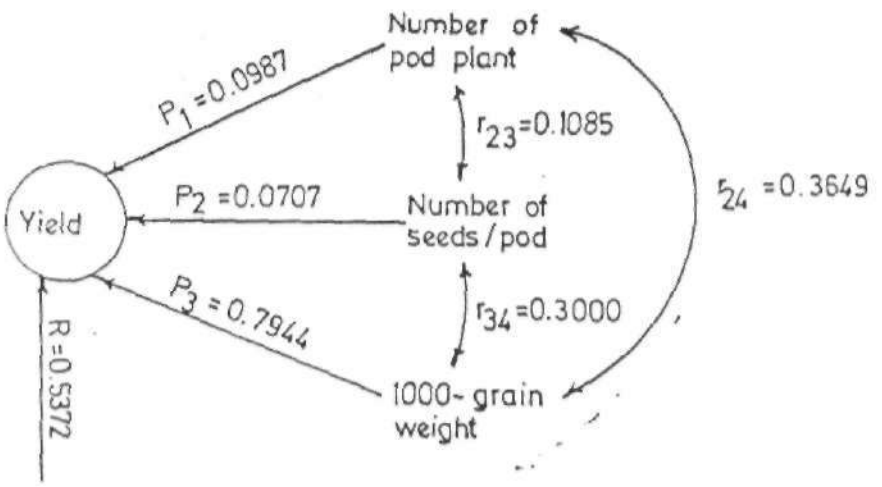


Table 44. The direct and indirect contribution of different yield components on yield in 1993 at Samaru,

Yield attributes	effect through			
	Number of pods/plant	Number of seeds/pod	1000-grain weight (g)	Total Correlation
Number of pods/plant	0.0987(a)	-0.0077	0.2899	0.3808
Number of seeds/pod	0.0107	0.0707	0.2383	0.2983
1000-grain weight (g)	0.0212	0.0360	0.7944	0.8516

(a) Direct effect underlined.

Its indirect effect via number of branches and number of leaves were low (4.73 and 7.16 percent respectively). The contribution of total dry matter through plant height was 13.96 percent, thus the total effect of the total dry matter on yield was found to be 49.27%.

The path coefficient between grain yield and yield characters as well as the direct and indirect contribution of yield characters to yield (Table 44 and figure II) revealed that a 9.87% direct contribution by number of pods/plant on yield. A 28.99% contribution was observed on number of pods/plant via 1000-grain weight. The indirect contribution of number of pods/plant via number of seeds/pod was negative and very small (-0.77%). Thus, the total contribution of number of pods/plant (both direct and indirect effect) on yield was 38.09%. The contribution of number of seeds/pod on grain yield was found to be 7.07% directly and indirectly via 1000-grain weight, 23.83%. The contribution of number of seeds/pod through number of pods/plant was negative (-1.07%). Thus the total contribution of number of seeds/pod both directly and indirectly was 29.83%. The contribution of 1000-grain weight was 79.44% directly and indirectly through number of pods/plant and number of seeds/pod was 2.12% and 3.60% respectively. The total contribution of 1000-grain weight was found to be 85.16 percent.

The percentage contribution of individual growth and yield characters as well as the contribution of various characters to yield is presented in table 45 and 46 respectively.

Table 45: The percentage contributions of different growth characters to yield in 1993 at Samaru.

Yield attributes	Percentage contribution
Individual contributions	
Plant height (cm)	9.52
Number of branches per plant	0.72
Number of leaves per plant	1.24
Total dry matter (g/plant)	5.42
Combined contributions.	
Plant height and number of branches	2.80
Plant height and number of leaves	3.06
Plant height and total dry matter	6.45
Number of branches and number of leaves	0.95
Number of branches and total dry matter	2.20
Number of leaves and total dry matter	4.58
Residual	63.05
Total	100.00

Table 46: The percentage contributions of different yield characters to yield in 1993 at Samaru.

Yield attributes	Percentage contribution
Individual contributions	
Number of pods/plant	0.98
Number of seeds/pods	0.01
1000-grain weight (g)	63.31
Combined contributions.	
Number of pods and number of seeds	-0.15
Number of pods and 1000-grain weight	5.73
Number of seeds and 1000-grain weight	3.37
Residual	26.75
Total	100.00

The percentage contribution of various growth perameters revealed that plant height has the highest contribution of 9.52%. It was followed by Total dry matter (5.42%). Number of leaves and branches contributed 1.24 and 0.72% respectively. The highest combined contribution was made by plant height and total dry matter (6.45%) It was followed by the combinations of number of leaves and total dry matter (4.58%), plant height and number of leaves (3.0%), plant height and number of branches (2.80%); and number of branches and number of leaves (0.95%) in a decending order. The unaccounted residual effect was 63.05%.

When the yield characters were examined individually and collectively for their contribution to yield the highest individual contribution of 63.31% was made by 1000-grain weight. Number of pods/plant and number of seeds/pod contributed 0.98 and 0.01% respectively to yield. When the combined contribution of any two characters were considered, number of pods and 1000-grain weight made the highest contribution of 5.73% to yield, while the lowest contribution of - 0.15% was made by the combination of number of pod/plant and number of seeds/pod. The combination of number of seeds/pod and 1000-grain weight made 3.37% contribution to yield. A residual effect of 26.96% was unaccounted for in the analysis.

4.72 Correlation and path coefficient analysis, 1994.

The coefficient of correlation between yield and yield components and within yields components and thier association with other characters studied in 1994 are shown in Table 47. The analysis revealed that, there was a very strong postive correlation

Table 47: Matrix of correlation coefficient between grain yield (kg/ha) and yield characters in 1994 at Sanaru.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.0000													
2	0.3715**	1.0000												
3	0.4034**	0.3222**	1.0000											
4	0.5626**	0.5172**	0.3347**	1.0000										
5	0.5874**	0.4644**	0.2933**	0.6816**	1.0000									
6	0.5852**	0.3605**	0.6308**	0.4803**	0.4036**	1.0000								
7	-0.2025*	-0.2971**	-0.3044**	-0.2214*	-0.3121**	-0.2029**	1.0000							
8	0.3884**	0.1829*	0.2901**	0.2512**	0.0970NS	0.5420**	-0.2130*	1.0000						
9	0.3512**	0.2093*	0.3294**	0.2816**	0.2858**	0.6497**	-0.1562NS	0.4515**	1.0000					
10	0.4073**	0.1573NS	0.3008**	0.2342*	0.1175NS	0.5770**	-0.0945NS	0.9667**	0.5869**	1.0000				
11	0.3550**	0.2274*	0.3753**	0.1769*	0.1815*	0.5812**	-0.2025*	0.5626**	0.5986**	0.6072**	1.0000			
12	0.4408**	0.1787NS	0.3174**	0.2643**	0.2503**	0.5599**	-0.1335NS	0.5143**	0.5700**	0.5635**	0.7938**	1.0000		
13	0.4724**	0.3577**	0.5296**	0.4605**	0.3940**	0.4551**	-0.1428NS	0.5475**	0.6225**	0.5740**	0.5762**	0.5599**	1.0000	
14	0.6790**	0.3875**	0.3092**	0.4287**	0.6112**	0.5106**	-0.2448*	0.4184**	0.4471**	0.4352**	0.4526**	0.5246**	0.4865**	1.0000

1. Grain yield per hectare. 2. Plant height. 3. Number of branches per plant. 4. Number of leaves per plant. 5. Leaf area index. 6. Total dry matter per plant.

7. Days to 50% flowering 8. Number of pods per plant. 9. Number of seeds per pod 10. Number of seeds per plant . 11. Pod Weight per plant 12. Grain yield per plant

13. 1000-grain weight. 14. Pod yield per hectare.

Fig (iii)

Path diagram showing interrelations of grain yield (kg/ha) and some growth characters in 1994 at Samaru.

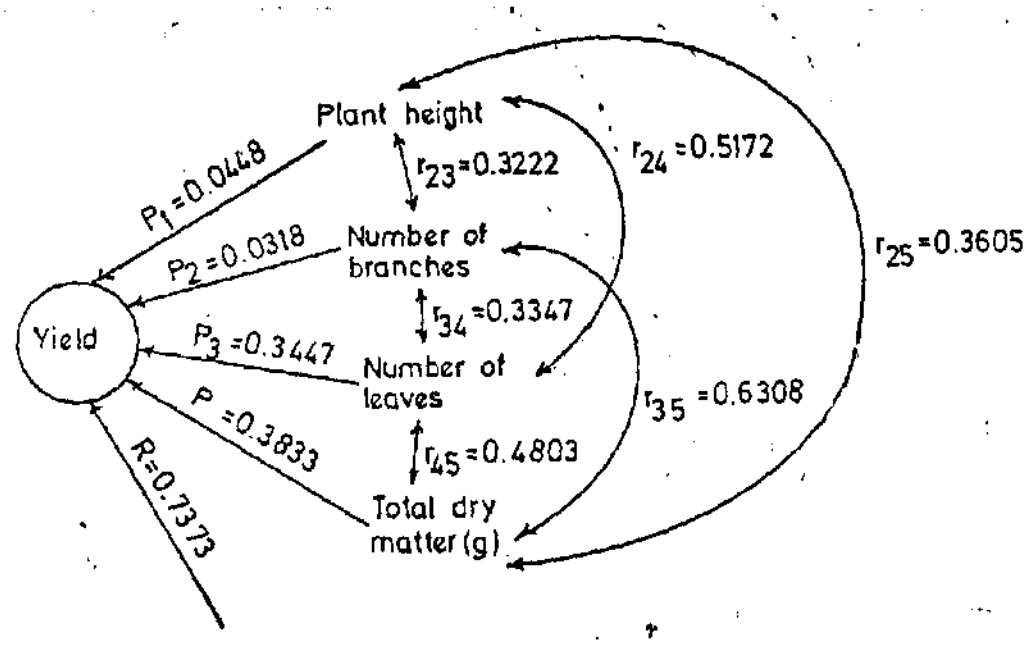


Table 48: The direct and indirect contributions of different growth characters on yield in 1994 at Samaru.

Yield attributes	Effect through.				
	Plant height(cm)	Number of branches	Number of leaves	Total dry matter	Total Correlation
Plant height (cm)	0.0448(a)	0.0102	0.1783	0.1382	0.3715
Number of branches	0.0144	0.0318	0.1154	0.2418	0.4034
Number of leaves	0.0232	0.0106	0.3447	0.1841	0.5626
Total dry matter(g)	0.0162	0.0201	0.1656	0.3833	0.5852

(a) Direct effect underlined.

Fig (iv)

Path diagram showing interrelations of grain yield (kg/ha) and some yield components in 1994 at Samaru.

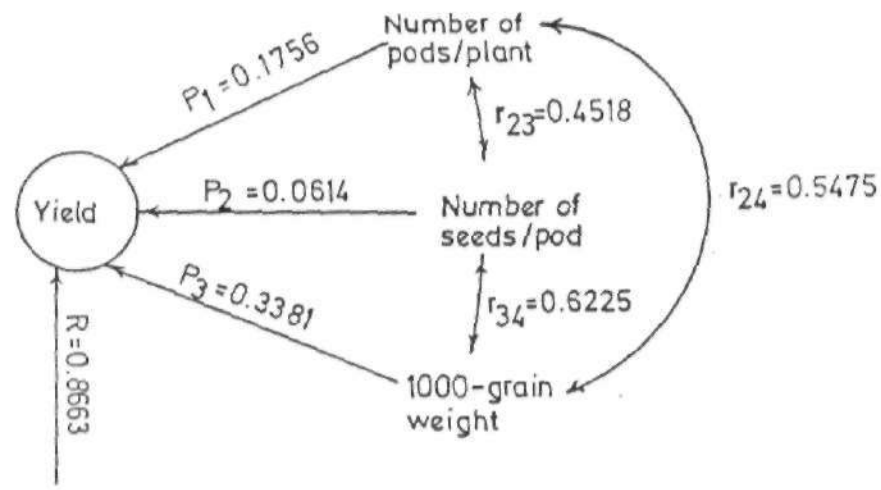


Table 49. The direct and indirect contribution of different yield components on yield in 1994 at Samaru,

Yield attributes	effect through			
	Number of pods/plant	Number of seeds/pod	1000-grain weight (g)	Total Correlation
Number of pods/plant	0.1756(a)	0.0277	0.1851	0.3884
Number of seeds/pod	0.0793	0.0614	0.2105	0.3512
1000-grain weight (g)	0.0961	0.0382	0.3381	0.4724

(a) Direct effect underlined.

at 1% level between grain yield (kg/ha) and plant height, number of branches/plant, number of leaves/plant, LAI, total dry matter (g/Plant), number of pods/plant, number of seeds/pod, number of seeds/plant, pod weight (g/plant), grain weight (g/plant), 1000-grain weight and pod weight (kg/ha). A negative and significant correlation (5% level) existed between grain yield (kg/ha) and days to 50% flowering. When the correlation between various yield component was considered; number of pods per plant was positively and highly correlated to number of seeds/pod and 1000-grain weight. The number of seeds/pod was also strongly and postively correlated to 1000-grain weight.

The direct and indirect effects of vegetative characters with grain yield (Table 48 and figure III) revealed that 4.48% of the grain yield was contributed by plant height. Indirectly it contributed 1.20%, 17.83% and 13.82% via number of branches, number of leaves and total dry matter respectively. The total contribution of plant height to yield was 37.15%. The direct effect of number of branches/plant on grain yield was 3.18%. Number of branches indirectly contributed 1.44% via plant height and 11.54% via number of leaves. The indirect contribution of number of branches via total dry matter was 24.18%. Thus the total contribution by number of branches/plants was 40.34%. The direct effect of number of leaves/plant on grain yield was 34.47 percent. Indirectly, it contributed 2.32, 1.06 and 18.41 percent via plant heigh, number of branches and total dry matter respectively. The total contribution of number of leaves/plant to grain yield was

56.26 percent. The direct effect of total dry matter on grain yield was 38.33 percent and indirect effect via plant height and number of branches were low and 1.62 and 2.01 percent. The indirect effect via number of leaves was 16.56%. Thus the total contribution by total dry matter to yield was 58.52 percent.

The direct and indirect contribution to yield characters on yield is shown in table 49 and figure IV. The number of pods/plant contributed to grain yield 17.56 percent and indirectly, it contributed 2.77 and 18.51 percent via number of seeds/pod and 1000-grain weight respectively. The total direct and indirect effect of number of pods/plant was found to be 38.84 percent. Out of the total contribution of 35.12 percent of number of seeds per pod, the direct effect was small (6.14%) but indirectly it contributed 7.93 and 21.05 percent via number of pods and 1000-grain weight respectively. Most of the effect of 1000-grain weight on yield was direct (33.81%). The indirect effect of 1000-grain weight via number of pods/plant and number of seeds/pod were 9.61 and 3.82 percent respectively.

The percentage individual and collective contribution of growth characters to grain yield (Table 50) showed that, the highest individual contribution was made by total dry matter (14.69%). It was followed by number of leaves/plant (11.87%), plant height (0.20%) and number of branches/plant (0.10%) in a desending order. The combination of number of leaves and total dry matter made the highest contribution (12.69%) towards grain yield. Very small contributions were made by plant height and total dry

Table 50: The percentage contributions of different growth characters to yield in 1994 at Samaru.

Yield attributes	Percentage contribution
Individual contributions	
Plant height (cm)	0.20
Number of branches per plant	0.10
Number of leaves per plant	11.87
Total dry matter (g/plant)	14.69
Combined contributions.	
Plant height and number of branches	0.09
Plant height and number of leaves	1.60
Plant height and total dry matter	1.24
Number of branches and number of leaves	1.54
Number of branches and total dry matter	0.74
Number of leaves and total dry matter	12.69
Residual	55.24
Total	100.00

Table 51: The percentage contributions of different yield characters to yield in 1994 at Samaru.

Yield attributes	Percentage contribution
Individual contributions	
Number of pods/plant	3.08
Number of seeds/pods	0.38
1000-grain weight (g)	11.43
Combined contributions.	
Number of pods and number of seeds	0.97
Number of pods and 1000-grain weight	2.58
Number of seeds and 1000-grain weight	6.50
Residual	75.06
Total	100.00

matter (g/plant); number of branches/plant and total dry matter (g/plant) and plant height and number of leaves/plant which ranges from 1.24 to 1.60. In the case of number of branches and number of leaves (0.74%); and plant height and number of branches (0.09%), their contributions were less than 1%. The unaccounted residual effect was 55.24%.

When the yield characters were examined interms of individual and collective perccentage contribution to grain yield (Table 51); the lowest individual contribution of 0.38% was made by number of seeds/pod. While the highest contribution was by 1000-grain weight (11.43%). Number of pods/plant contributed 3.08% to the grain yield. The combination of numbers of seeds/pod and 1000-grain weight made the highest contribution (6.58%) to yield. While the combination of number of pods/plant and 1000-grain weight and number of pods/plant and number of seeds/plant contributed 2.58 and 0.97% respectively to yield. The unaccounted residual effect was 75.06%.

4.73 <u>Correlation and path coefficient analysis, 1995</u>.

The correlation between grain yield (kg/ha) and yield characters during 1995 rainy season is presented in Table 52. A postive and highly significant linear correlation existed between number of pods/plant, number of seeds/pod, number of seeds/plant, pod weight (g/plant), grain yield (g.plant) 1000-grain weight and pod yield (kg/ha); and grain yield (kg/ha). The relationships between grain yield (kg/ha) and plant height, number of branches/plant, number of leaves/plant and LAI were not

Table 52: Matrix of correlation coefficient between grain yield (kg/ha) and yield characters in 1995 at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.0000													
2	0.2093*	1.0000												
3	0.0711NS	0.4150**	1.0000											
4	0.0131NS	0.6468**	0.1573NS	1.0000										
5	0.1699NS	0.4875**	0.1592NS	0.5360**	1.0000									
6	0.2289*	0.5593**	0.3013**	0.5664**	0.3435**	1.0000								
7	-0.6172**	-0.0214NS	-0.1025NS	-0.0391NS	-0.0972NS	-0.1807NS	1.0000							
8	0.3884**	0.2177*	0.1714NS	0.2950**	0.2710**	0.3671**	-0.3960**	1.0000						
9	0.2542**	0.3309**	0.3562**	0.1768NS	0.2176*	0.3593**	-0.1972*	0.4122**	1.0000					
10	0.4385**	0.2207*	0.1829*	0.2338*	0.2684**	0.3270**	-0.4069**	0.9527**	0.5113**	1.0000				
11	0.4165**	0.2340*	0.1327NS	0.2618**	0.1405NS	0.4068**	-0.4921**	0.8583**	0.4194**	0.8631**	1.0000			
12	0.4780**	0.4092**	0.2921**	0.3632**	0.3574**	0.5403**	-0.3557**	0.3796**	0.4456**	0.4009**	0.4206**	1.0000		
13	0.2324*	0.1338NS	0.2805**	0.1956*	0.0224NS	0.4697**	-0.5195**	0.4314**	0.3263**	0.4295**	0.5927**	0.3997**	1.0000	
14	0.9775**	0.2811**	0.0800NS	0.0431NS	0.2115*	0.2314*	-0.5798**	0.4050**	0.2753**	0.4593**	0.3925**	0.4847**	0.3575**	1.0000

1. Grain yield per hectare. 2. Plant height. 3. Number of branches per plant. 4. Number of leaves per plant. 5. Leaf area index. 6. Total dry matter per plant.

7. Days to 50% flowering 8. Number of pods per plant. 9. Number of seeds per pod 10. Number of seeds per plant . 11. Pod Weight per plant 12. Grain yield per plant

13. 1000-grain weight. 14. Pod yield per hectare.

significant; however a nagative but highly significant association existed between days to 50% flowering and grain yield. The association between grain yield (kg/ha) and total dry matter was positive and significant at 5% level. When the correlation between various major yield contributing characters were examined, it was discovered that 1000-grain weight was highly and positively correlated to number of seeds/pod and number of pods/plant. Similarly, number of pods/plant was also highly and positively correlated to number of seeds/pod.

The direct and indirect effect of vegetative and reproductive characters on grain yield of green gram during 1995 rainy season is shown in Table 53 and 54 respectively. The path diagram on the vegetative and reproductive characters affecting grain yield are presented in figure V and VI respectively. Direct and indirect contribution of vegetative parameters, revealed that plant height directly contributed to yield 30.11%. Indirectly, its contributions via number of branches/plant and number of leaves/plant were negative (-3.5% and -20.71% respectively). The contribution of plant height via total dry matter was 15.03%. Thus plant height contributed 20.93% to yield. The contribution of number of branches/plant to grain yield was found to be -8.43% directly. Indirectly, via plant height, number of leaves/plant and total dry matter, it was 12.50, -5.04 and 8.08% respectively, thus number of branches contributed both directly and indirectly 7.11% to the yield. Number of leaves contributed to grain yield directly -32.02% only. Its effect via plant height and total dry mater were positive

and 19.48 and 15.18% respectively. Number of leaves indirectly contributed via number of branches -1.33%. Thus its total contribution to yield was found to be 1.31%. The direct contribution of total dry matter on grain yield was found to be 26.69%. Its indirect effect via plant height, number of branches, and number of leaves was found to be 16.96%. -2.55% and -18.21 percent respectively. Thus the total contribution of total dry matter was 22.89%.

The direct and indirect effect of yield parameters on grain yield indicated that the number of pods/plant contributed directly 31.99% to yield. Its indirect effect via number of seeds/pod and 1000-grain weight were 4.22% and 2.63% respectively. Thus the total contribution of number of pods/plant on yield was found to be 38.84%. The number of seeds/pod directly contributed 10.24%. Its indirect effects via number of pods/plant and 1000-grain weight were positive and to the tune of 13.19% and 1.99% respectively. The direct effect of 1000-grain weight on grain yield was observed to be 6.10%. Its indirect effect via number of pods/plant and number of seeds/pod were 13.80% and 3.34% respectively.

The percentage contribution of individual growth parameters as well as combination of characters to yield (Table 55) revealed that moderate individual contributions were made by
total dry matter, plant height and number of leave/plant which ranges from 7.12 to 10.25%. The lowest contribution of 0.71% was made by number of branches/plant . The combination of plant height and total dry matter; and number of branches/plant and number of

Fig (v)

Path diagram showing interrelations of grain yield (kg/ha) and some growth characters in 1995 at Samaru.

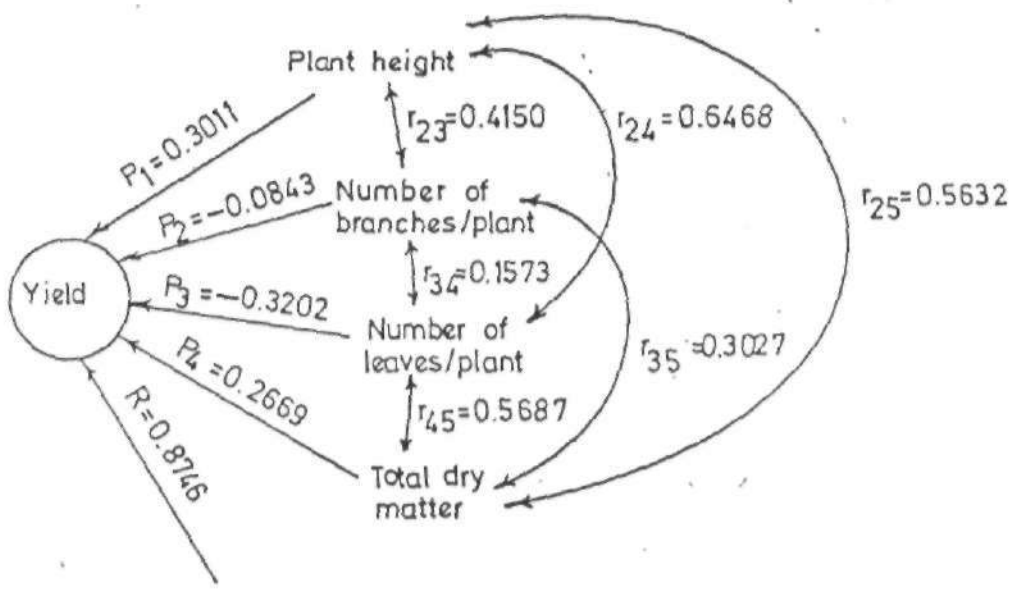


Table 53: The direct and indirect contributions of different growth characters or yield in 1995 at Samaru.

Yield attributes	Effect through.				
	Plant height(cm)	Number of branches	Number of leaves	Total dry matter	Total Correlation
Plant height (cm)	0.3011(a)	-0.0350	-0.2071	0.1503	0.2093
Number of branches	0.1250	-0.0843	-0.050	0.0808	0.0711
Number of leaves	0.1948	-0.0133	-0.3202	0.1518	0.0131
Total dry matter(g)	0.1696	-0.0255	-0.1821	0.2669	0.2289

(a) Direct effect underlined.

Fig (vi)

Path diagram showing interrelations of grain yield (kg/ha) and some yield components in 1995 at Samaru.

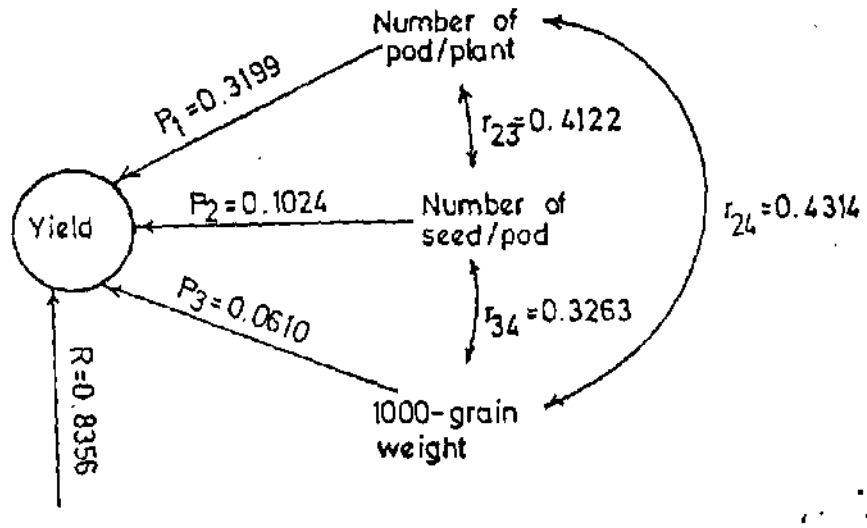


Table 54. The direct and indirect contribution of different yield components on yield in 1995 at Samaru,

Yield attributes	effect through			
	Number of pods/plant	Number of seeds/pod	1000-grain weight (g)	Total Correlation
Number of pods/plant	0.3199(a)	0.0422	0.0263	0.3884
Number of seeds/pod	0.1319	0.1024	0.0199	0.2542
1000-grain weight (g)	0.1380	0.0344	0.0610	0.2324

(a) Direct effect underlined.

Table 55: The percentage contributions of different growth characters to yield in 1995 at Samaru.

Yield attributes	Percentage contribution
Individual contributions	
Plant height (cm)	9.07
Number of branches per plant	0.71
Number of leaves per plant	10.25
Total dry matter (g/plant)	7.12
Combined contributions.	
Plant height and number of branches	-2.11
Plant height and number of leaves	-12.47
Plant height and total dry matter	9.05
Number of branches and number of leaves	0.85
Number of branches and total dry matter	-1.36
Number of leaves and total dry matter	-9.72
Residual	88.61
Total	100.00

Table 56: The percentage contributions of different yield characters to yield in 1995 at Samaru.

Yield attributes	Percentage contribution
Individual contributions	
Number of pods/plant	10.23
Number of seeds/pods	1.05
1000-grain weight (g)	0.37
Combined contributions.	
Number of pods and number of seeds	2.70
Number of pods and 1000-grain weight	1.68
Number of seeds and 1000-grain weight	0.41
Residual	83.56
Total	100.00

leaves/plant contributed 9.05 and 0.85% respectively to the yield. The contribution of the rest combinations were nagative and ranges between -1.36% for number of branches and total dry matter to -12.47% for the combination of plant hieght and number of leaves/plant.

When the percentage contribution of each yield character as well as combination of the characters were examined (Table 56), the highest individual contribution of 10.23% was made by number of pods/plant; while the lowest contribution of 0.37% was made by 1000-grain weight. Number of seeds/pod contributed 1.05% to the grain yield. Combination of number of pods/plant and number of seeds/plant made the highest contribution (2.70%), while the combination of number of pods/plant and 1000-grain weight, and number of seeds/plant and 1000-grain weight contributed 1.68 and 0.41% to grain yield respectively. The remaining unaccounted residual effect was 83.58%.

4.74 Polynomial response of grain yield to plant density and phosphorus levels, 1993.

Deviation between observed and expected yields using the equation developed (Table 57), revealed that all deviation between observed and expected by linear regressions in density were not significant. In the case of Quadratic regressions, deviation from both 200,000 and 400,000 plants/ha were significant.

When the phosphorus levels were considered, all the devation from quadratic response were not significant. The deviation from linerity was highly significant at control, Significant at 25kgP/ha and non - significant at 50kgP/ha.

Table 57: Polynmial response of grain yield to density and phosphorus in 1993 at Samaru.

Treatments	Observed yield (kg/ha)	Expected yield (kg/ha) Linear	χ^2	Quadratic	χ^2
Density (Plants/ha)					
200,000	681	735	4.00NS	577	18.75**
400,000	963	907	3.41NS	1091	15.02**
600,000	1131	1080	2.45NS	1105	0.61NS
Phosphorus (kgP/ha)					
0	604	685	9.58**	606	0.007NS
25	1022	938	7.62*	1017	0.025NS
50	1264	1190	4.60NS	1269	0.020NS

Regression Equations:
Density, YL = 563 + 0.000861x, YQ = 313 + 0.00132x - 0.000000x^2
Phosphorus, YL = 685 + 10.1x, YQ = 606 + 19.6x - 0.127x^2

4.75 **Polynomial response of grain yield to plant density and phosphorus levels, 1994.**

Results of polynomial response in 1994 are presented in Table 58. Deviation from linearity was non-significant at all densities. While the deviation from quadratic was not significant at the lowest density, but highly significant at medium and highest densities. Examining the phosphorus levels; it was observed that neither the deviations from linearity or from quadratic was significant.

4.76 **Polynomial response of grain yield to plant density and phosphorus levels, 1995.**

The polynomial response of grain yield to density and phosphorus in 1995 is presented in Table 59. The deviation from linearity was significant at 200,000plants/ha, highly significant at 400,000 plants/ha and non-significant at 600,000 plants/ha. In the case of quadratic response, the deviation was not significant at both 400,000 and 600,000 plants/ha.

When the phosphorus levels were examined in respect to linear response, the deviation was significant at control, non-significant at 25 and 50kgP/ha. The deviations from quadratic were not significant statistically at all the phosphorus levels.

4.77 **Polynomial response of grain yield to plant density and phosphorus levels, (Combine analysis).**

When combine analysis for three years was examined (Table 60); it was observed that the deviation from linearity was not significant at all the densities. While in the case of quadratic response, the deviation was not significant at 200,000 plants/ha and highly Singnificant at 400,000 and 600,000 plants/ha.

Table 58: Polynmial response of grain yield to density and phosphorus in 1994 at Samaru.

	Observed yield (kg/ha)	Expected yield (kg/ha)			
Treatments		Linear	t^2	Quadratic	t^2
Density (Plants/ha)					
200,000	702	757	4.00NS	758	4.14NS
400,000	968	902	4.86NS	1154	29.98**
600,000	1081	1046	1.17NS	1550	141.91**
Phosphorus (kgP/ha)					
0	675	729	4.00NS	676	0.002NS
25	954	897	3.62NS	948	0.038NS
50	1113	1065	2.16NS	1115	0.004NS

Regression Equations:
Density, YL = 613 + 0.000722x, YQ = 362 + 0.00198x - 0.000000x^2
Phosphorus, YL = 729 + 6.71x, YQ = 676 + 13.0x - 0.0844x^2

Table 59: Polynmial response of grain yield to density and phosphorus in 1995 at Samaru.

	Observed yield (kg/ha)	Expected yield (kg/ha)			
Treatments		Linear	χ^2	Quadratic	χ^2
Density (Plants/ha)					
200,000	908	995	7.61*	996	0.001NS
400,000	1273	1160	11.01**	1534	47.52**
600,000	1361	1324	1.03NS	2072	243.98**
Phosphorus (kgP/ha)					
0	907	986	6.33*	910	0.01NS
25	1274	1190	5.96NS	1267	0.039NS
50	1461	1394	3.22NS	1473	0.098NS

Regression Equations:
Density, YL = 830 + 0.000824x, YQ = 458 + 0.00269x - 0.000000x^2
Phosphorus, YL = 986 + 8.16x, YQ = 910 + 17.3x - 0.121x^2

Table 60: Polynmial response of grain yield to density and phosphorus (Combined analysis) at Samaru.

	Observed yield (kg/ha)	Expected yield (kg/ha)			
Treatments		Linear	t^2	Quadratic	t^2
Density (Plants/ha)					
200,000	688	750	5.13NS	750	5.13NS
400,000	993	921	5.63NS	1206	37.62**
600,000	1133	1091	1.62NS	1662	168.38**
Phosphorus (kgP/ha)					
0	698	743	2.73NS	675	0.78NS
25	970	923	2.39NS	990	0.04NS
50	1147	1103	1.76NS	1215	3.81NS

Regression Equations:
Density, $YL = 580 + 0.000852x$, $YQ = 294 + 0.00228x - 0.000000x^2$
Phosphorus, $YL = 743 + 7.20x$, $YQ = 675 + 14.4x - 0.072x^2$

None of the Chi-square values due to phosphorus was significant.

4.78 **Optimum Levels of Phosphorus.**

When the optimum levels of phosphorus were calculated; the results were 15.46kgP/ha for 1993, 26kgP/ha for 1994, 26.30kgP/ha for 1995 and 23.43kgP/ha for the combined analysis.

CHAPTER FIVE.

DISCUSSION

5.1 EFFECT OF SEASONS.

The higher growth parameters in 1993 season as compared to other seasons was probably due to differences in the seasonal agro-climatic conditions during the growth period of green gram, particularly rainfall and temperatures. The rainfall was 21% higher during the vegetative growth (July/August) as compared to the same period in the other two seasons. The favourable moisture content helps in solublizing and absorption of nutrient which make the plant to grow luxuriantly.

Yield contributors were higher in 1995 as compared to other seasons probably due to the fact that during the reproductive phase (August/October), the rainfall was moderate and green gram being a drought tolerant crop does best when the moisture level is moderate. Further more, the total rainfall during the grain filling period (September/October) was moderate (192.0mm) as compared to high (214mm) in 1993 and low (151.27mm) in 1994. Thus green gram varieties were able to absorb adequate nutrients from the soil in this season as compared to 1993 when leaching and run off were common and 1994, when nutrient absorption was impeded because of low moisture level.

The higher yield contributors in 1995 could also be related to temperature. Green gram is reported to produce good yield when minimum temperature is above 20°C (Sinha, 1977). In 1995 season, the temperature ranges between 23.8 - 24.1°C during the reproductive

phase which is ideal for green gram production as compared to 18.7 - 19.5°C in 1993.

5.2 **EFFECT OF VARIETIES.**

The higher plant height, number of leaves, LAI, stem and leaf dry weights, total dry matter, RGR and NAR exhibited by variety Galadima as compared to other four varieties could be attributed to differences in genetic make up of the individual varieties under trial. Since these characters are mainly genetically controlled, although they may be influenced by environment to certain extent. Variety Galadima is indeterminate in nature and its growth continues even after flowering, thus it is characterized by a large size foliage and attained higher height. This contradicts the findings of Najhman and Chandra (1980) that AVRDC varieties had higher values of LAI, NAR, RGR and plant height than indegenous varieties. Further more, variety Galadima is indigneous and therefore adapted to savannah ecological zone; unlike the other varieties that were exotic and have not yet adapted to the local environmental conditions. Variety Galadima also exhibited higher number of days to 50% flowering, pod length, pod width, number of pods/plant and number of seeds/plant probably due to its genetic make up.

The higher pod weight (g/plant), grain yield (g/plant), 1000 - grain weight, pod weight (kg/ha), grain yield (kg/ha), shelling percentage shown by VC 1178A may be due to its genetic make up, early maturing nature and the fact that it is determinate in growth, in which case the growth ceases after flowering, thus all

the assimilate are translocated to the reproductive parts for grain filling which result in larger and heavier grains. This confirms the observations of Ko (1977) and Ling, et al. (1988) that most AVRDC varieties mature earlier, have larger and heavier grains. Variety VC 1178A also exhibited higher harvest index due to the fact that the nutrient needed for structural development of non-economic parts are proportionately less than that of other varieties. Variety VC 2778A exhibited higher grain crude protein content than other varieties probably because of its efficiency for grain protein production and its genetical composition.

5.3 **EFFECT OF PLANT DENSITY.**

The increase in plant height with increasing density could be ascribed to competition among plants for light as plant density was doubled or tripled. Similar results were reported by Huesca and Oria (1981). The reduction of leaves and branches at higher density is due to competition between and within plants for moisture and nutrient. This results were in agreement with those of Trung and Yoshida (1985) and Singh and Malavia (1981).

Leaf area index increased with increasing density up to the highest density. This could be due to the presence of more plants per unit area, hence more leaves per unit area. Also planting at lower density was characterized by patches at bare ground such that the canopy did not fully cover the ground surface. With such sparce canopy coverage, it was possible that, the incident radiation was not efficiently utilized. This confirms the findings of Lochaiyukul, et al. (1970) who reported an increase in LAI with

increasing density.

The reduction of leaf, stem and total dry weights per plant at higher density could be attributed to the fact that at this density, plants did not have adequate space for growth and development: Thus they were competing for light, moisture and nutrients. Both RGR and NAR were increased with increase plant density. The increase in NAR could be due to its relationship with LAI. Furthermore, denser stands initially have more rapid growth, because they exhibited more photosynthetic surface per unit area, thus synthesize more photosynthates.

The delay in days to 50% flowering recorded at lower density could be attributed to the fact that since the plant were widely spaced, there was a tendency of space, light and moisture being unlimited. This encourages extended vegetative growth period. While the stressed plants tends to flower earlier, because of the inter and intra-plant competition for available resource. Pod length and width were at their maximum at 400,000 plants/ha.

Number of pods/plant, number of seeds/plant, Pod weight/plant and grain yield/plant were higher at lower density. This may be because, the wider the spacing, the more space for any one plant, hence the more soil area for its root system to explore for mineral nutrition and the less the competition for nutrients, moisture and light. This implies that more photosynthate will be produced in the source and translocated to the Sink (yield).

Although growth, pod and seed yield per plant were reduced at higher densities, pod yield and grain yield per hectare were

significantly higher at higher densities compared to lower densities. This could be due to the fact that increased in plant per unit area more than compensated for by the reduction in productivity per plant at high density. Plants sown at higher density display more photosynthetic surface per unit area, thus synthesize more assimilate. Similar results were reported by Singh and Singh (1988), and Baghel et al. (1989). The shelling percentage and harvest index were higher at lower density probably because of the availability of nutrients, moisture and light which make the plant to grow vigorously and produced plump grains.

The higher crude protein content observed at 200,000 plants/ha could be due to the fact that, at sparse density, nutrients especially phosphorus which enhanced nitrogen absorption is present in adequate quantity for higher protein production. Similar result were reported by Nijhawan (1963) who stated that, close spacing decreased the protein content of grains.

5.4 **EFFECT OF PHOSPHORUS.**

Pronounced response of phosphorus to growth characters observed could be as a result of low phosphorus content within the soil (Appendix IV). Plants grown on plots where no phosphorus was applied were thin and spindly, foliage is sparse and restricted, the developments of lateral bud is suppressed, leaves are narrow and turn bluish green with purple anthocyanin pigments. Leaf area index was also low and there was a lower coverage of the ground, therefore radiation was not sufficiently utilised. The increased in RGR and NAR by application of the highest level of phosphorus was

probably due to high leafness and leaf area of plants supplied with this level of phosphorus. Phosphorus plays a fundamental role in a large number of emzymatic reaction that depends on phosphorylation. It is thus essential for cell division and for development of meristematic tissues, thus favouring growth by enhancing efficient root growth and development; and consequently enhancing nutrient uptake for vigorous vegetative growth. Similar results were obtained by Ahmed et al. (1986), Shrirastava and Verma (1991) and Singh and Hiremath (1990).

Application of 50kgP/ha reduced the number of days to 50% flowering more than 0 and 25kgP/ha. Adequate supply of phosphorus encourages earlier crop maturity through enhanced flowering. It also stimulate blooming, fruit setting and grain formation (Black, 1968 and Brady, 1978). Yamashita and Goto (1963) observed differentiation of the first flower clusters at progressively earlier dates as the supply of phosphorus was increased. Due to differences in the rate of development, consequently on application of phosphorus, plant deficent in phosphorus, flower late as compare to those supplied with phosphorus in this experiment.

Supply of phosphorus resulted in the retention of more pods and seeds per plant; heavier pod and grain per plant. The overall effect was a higher 1000-grain weight, grain and pod yield per hectare. This could be attributed to low available phosphorus in the soil of experimental site (Appendix IV). Bache and Roger (1970); and Mokwunye (1974b) observed that deficiency of phosphorus is notably in the savannah areas with low organic matter content;

thus plants were observed to respond favourable to application of phosphorus. Unfertilized crops were competing for limited amount of nutrients in the soil which is not sufficient to sustain higher yield. Phosphorus apart from its significant role in the growth of crop, also plays a key role in the photosynthetic system of the crop. It is important in photophosphorylation of various intermediate in the CO_2 assimilation processes and in the formation of pyro-phosphate bonds which allows energy transfer in plants. It also induce rhizobial activities, nodule formation and thus nitrogen fixation (Mengel and Kirby, 1982). It is therefore expected that adequate supply of phosphorus will result in good crop growth and consequently higher yield. Significant differences in shelling percentage and harvest index with increased phosphorus level could be due to availability of adequate phosphorus for proper pod formation and grain filling; thus higher shelling percentage and harvest index with phosphorus, as compared to plot with no phosphorus where competition for nutrient was intense.

The rise in grain crude protein content with increasing phosphorus level could be due to the role of phosphorus in energy metabolism, thus providing more energy for protein synthesis and it is not unlikely that more phospho-protein are formed. Omneti and Oyenuga (1970) gave similar results.

5.5 INTERACTIONS.

5.5.1 VARIETY X DENSITY INTERACTION.

The higher total dry matter produced by variety Galadima at sparse density may be due to its higher response to lower density,

Where there was little or no competition for nutrients, moisture, space and solar radiation for growth.

Variety VC 1178A exhibited higher number of pods and seeds/plant, pod weight/plant, grain yield/plant and 1000-grain weight at 200,000 plants/ha probably as a result of its genetic make up and its response to lower population. It also had higher pod weight and grain yield/ha at 600,000 plants/ha because of its higher pod weight and yield/plant. The higher protein content exhibited by variety VC 2778A could be due to its genetic make up and it responsiveness to higher population.

5.5.2 **Variety x Phosphorus interaction.**

Variety Galadima, a local variety gave higher total dry matter than other varieties at the highest phosphorus may be because of its large size foliage and stature.

The higher levels of yield contributors exhibited by VC1178A implies that, it respond more to phosphorus than other varieties. It has been reported that improved varieties respond more to phosphorus, thus all AVRDC varieties in these trials responded more than Galadima to phosphorus. The higher grain protein content observed in VC 2778A could be attributed to its response to phosphorus application which is important in protein synthesis.

5.5.3 **Density x Phosphorus Interaction.**

The highest yield contributors exhibited at the lowest density and highest phosphorus level is probably due to availability of adequate nutrient, space and moisture for proper development; thus plants roots are able to explore the soil for nutrient and moisture

that are adequately supplied. Further more, since the plants were mell spaced competition for light is reduced.

The grain yield/ha and pod weight/ha were observed to be higher at highest density and phosphorus levels. This could be because of adequate supply of nutrient to plants and higher numbers of plants/unit area. Similar results were reported by Huesca and Oria (1981) and Rao and Rajan (1984).

5.6 **CORRELATION STUDIES AND PATH - COEFFICIENT ANALYSIS.**

Positive and significant correlation was observed between most of the grain contributors studied, showing an interdependency within the characters.

The nagative association between days to 50% flowering and all other characters and yield, implies that the higher number of days to 50% flowering, the lower will be these characters. This is true, since the longer the vegetative phase, the more assimilates will be used for growth at the expense of reproductive phase.

The positive association between plant height, number of leaves/plant and number of branches/plant and yield is probably due to the fact that, as the plant height increases more nodes are produced at which branches and leaves are differentiated and the more the pod production.

Correlation between yield and yield components revealed that numbers of pods/plant, number of seeds/pod and 1000-grain weight are important yield determinants. This results confirms the findings of Ko and Chang (1975), Yohe and Poehlman (1975) and Sandhu et al. (1980).

The path analysis and percentage contribution showed that most of the growth characters make their greatest contribution to yield through total dry matter and plant height. This could be due to the fact that increased dry matter and plant height are virtually synonymous with increased photosynthetic surface and thus greater photosynthate which translated into higher yield.

Yield components make their greatest contribution through 1000-grain weight. This showed that 1000-grain weight is the greatest determinant of yield. This results confirms the findings of Domar et al. (1973) and Malhota et al. (1974).

5.7 POLYNOMIAL RESPONSE OF GRAIN YIELD TO PLANT DENSITY AND PHOSPHORUS.

When the polynomial response of plant densities were examined using chi-square test for goodness of fit, it was observed that except for 1995 season, the response fitted the first degree of polynomial (Linear). The 1995 data was inconclusive, because both the linear and quadratic responses were significant at one level or the other. However, the chi-square for linearity was lower than the quadratic indicating that linearity is better.

The deviation between observed and predicted yield using chi-square test for phosphorus were found to be non-significant in all the three season and combined analysis for quadratic, indicating that the second degree of polynomial response fitted these data. As regards the linear response which was not significant in 1994 and combined analysis, the chi-squares of quadratic were much lower than linear, which also provided a better fit for quadratic

response.

5.8 OPTIMUM LEVEL OF PHOSPHORUS.

The higher optimum level of phosphorus exhibited by green gram in 1995 as compared to other seasons was probably due to favourable rainfall and temperature during the grain filling stage of the crop. The lowest value of optimum level of phosphorus required to produce optimum yield as observed in 1993 was due to the low moisture level which reduced the absorption of nutrient and low temperature which decrease the growth and yield of the crop; thus the plants in this year use low amount of phosphorus.

Application of phosphorus up to the highest rate of 50kgP/ha resulted in increased values of all growth and yield characters as well as grain crude protein studied.

Significant interaction were recorded on some of the characters such as total dry mater, number of pods/plant, number of seeds/plant, grain yield/plant,pod weight/plant, 1000-grain weight, pod weight/ha and grain yield/ha.

The results of correlation analysis revealed significant association between some of the characters studied. The correlation was also positive for most characters, although days to 50% flowering was negatively correlated with all other characters. Path analysis revealed that indirect contribution of growth characters to yield was highest via total dry matter. Yield characters contributed more via 1000-grain weight.

The percentage contribution of growth characters on yield revealed that plant height make the highest individual contribution to yield, while the combination of plant height and total dry matter make the highest combined contribution to yield. When the percentage contribution of the major yield contributors were examined; 1000-grain weight was observed to contribute the highest percentage to yield, while the combination of number of seeds/pod and 1000-grain weight was the highest contributor to yield.

Polynomial response to density was linear, indicating that grain yield would continue to increase beyond the ranges of the rates tried. With regard to phosphorus, however the response was quadratic.

The study has shown that grain yield was optimum at 23.43kgP/ha. Although most yield component were strongly correlated to grain yield, total dry matter, and 1000-grain weight were observed to be greatly involved in the contribution of the other character to grain yield. Plant height and 1000-grain weight made the heightest percentage individual contribution to yield. Crop improvement programme should be geared towards improving these traits.

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Appendix I

Samaru Meteorological Observations in 1993

Months	Rainfall (mm)	Relative humidity (%)		Air temperature °C		Sunshine (Hrs)
		AM	PM	Min	Max	
January	0.0	23.6	19.2	11.6	26.3	4.0
February	0.0	19.5	23.3	14.6	31.8	NA
March	0.0	31.5	29.7	18.2	34.4	NA
April	8.3	42.7	33.8	23.5	36.5	NA
May	113.6	62.9	46.8	22.0	37.8	8.2
June	155.8	72.7	51.8	20.9	31.7	7.6
July	269.0	78.4	56.7	20.2	29.5	6.6
August	300.0	81.8	62.1	19.5	28.4	5.0
September	181.8	76.7	58.2	19.3	30.2	7.0
October	32.4	63.1	54.0	18.7	34.1	8.4
November	0.0	NA	NA	14.1	33.6	8.6
December	0.0	31.3	25.5	14.1	29.1	6.2
Total	1060.9					
Mean		48.6	38.4	18.1	32.0	5.1

NA: Not available.

Source: Meteorological station at Institute for Agricultural Research, Samaru Zaria.

Appendix II

Samaru Meteorological Observations in 1994

Months	Rainfall (mm)	Relative humidity (%)		Air temperature °C		Sunshine (Hrs)
		AM	PM	Min	Max	
January	0.0	18.7	23.1	16.1	29.6	6.8
February	0.0	12.6	12.8	15.5	31.0	5.9
March	0.0	19.7	25.7	21.0	34.8	6.4
April	0.0	49.0	36.3	24.2	35.8	5.9
May	120.1	71.7	40.8	24.5	35.4	7.0
June	231.9	77.0	52.0	24.1	31.4	3.4
July	169.2	84.3	64.1	24.1	29.3	6.2
August	215.9	85.0	78.0	22.4	25.2	3.8
September	82.5	82.8	75.0	23.0	26.5	5.1
October	69.2	76.4	65.0	24.0	28.2	7.0
November	0.0	35.6	38.0	30.3	20.1	9.2
December	0.0	37.0	26.3	15.2	25.9	6.4
Total	888.8					
Mean		54.2	44.8	22.0	29.4	6.1

NA: Not available.

Source: Meteorological station at Institute for Agricultural Research, Samaru Zaria.

Appendix III

Samaru Meteorological Observations in 1995

Months	Rainfall (mm)	Relative humidity (%)		Air temperature °C		Sunshine (Hrs)
		AM	PM	Min	Max	
January	0.0	31.4	21.2	15.5	27.8	NA
February	0.0	28.5	8.1	16.6	29.8	NA
March	0.0	26.3	29.8	22.1	34.5	NA
April	90.5	41.2	31.0	23.0	35.5	NA
May	45.3	68.0	44.5	24.2	32.9	NA
June	125.4	70.6	51.0	23.9	31.7	NA
July	193.7	79.5	66.7	23.7	28.3	NA
August	258.6	81.8	76.2	23.2	26.8	NA
September	159.1	81.3	69.8	24.1	31.0	NA
October	32.5	74.3	54.6	23.8	30.6	NA
November	0.0	43.7	37.9	21.2	30.7	NA
December	NA	NA	NA	NA	NA	NA
Total	905.1					
Mean		52.2	40.9	20.1	28.3	

NA: Not available.

Source: Meteorological station at Institute for Agricultural Research, Samaru Zaria.

Apendix IV

Physical and chemical propertities of the soil of the experimental plots in Samaru.

Composition	1993	1994	1995
Chemical characteristic			
pH in H_2O (1:2.5)	5.6	5.4	6.0
pH in KC l_2 (1:2.5)	5.0	4.4	5.0
Organic carbon (g/kg)	6.0	4.0	5.0
Total Nitrogen (g/kg)	0.5	0.4	0.4
Available phosphorus (mg/kg)	3.1	2.7	3.2
Exhangeable bases (Cmol/kg)			
Ca	1.2	1.1	1.2
Mg	0.7	0.4	0.5
K	0.3	0.3	0.2
NA	0.12	0.11	0.10
C.E.C	5.6	5.8	5.0
Particle size distribution (g/kg)			
Sand	520.0	540.0	490.0
Silt	360.0	360.0	390.0
Clay	120.0	100.0	120.0
Textural class	Sandy Loam	Sandy Loam	Sandy Loam

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Turaki Primary School, Sokoto.	1969-75	First School Leaving Certificate
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Patigi Secondary School, Patigi.	1979-80	West African School Certificate
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Faculty of Agriculture, Ahmadu Bello University, Zaria	1982-86	B.Sc (Agriculture)
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National Youth Service corp. (Holy Ghost Juniorate,Ihiala)	1986 - 87	Agric. Science Teacher.
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