RESPONSE OF COMMON BEAN (*Phaseolus vulgaris* L.)
TO ORGANIC MANURES, PHOSPHORUS
AND RHIZOBIUM INOCULATION
UNDER IRRIGATION

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ATHESIS
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DEDICATION

This work is dedicated to my family.
To my kids Hassan.
Rehab.
Maab. with everlasting love.
ACKNOWLEDGEMENT

With great reverence, I thank Allah for getting me alive and giving patience and ability to do my best in conducting this research.

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ABSTRACT

A field experiment was conducted for two consecutive seasons (2004/05-2005/06) to study the response of haricot bean (*Phaseolus vulgaris* L.) to organic fertilization, phosphorus and rhizobium inoculation under irrigation. The experiment was conducted in the Experimental Farm of the Faculty of the Agriculture at Shambat. The experiment was laid out in a factorial randomized complete block design with four replicates. Improved local white seeded cultivar of common bean (RO/21) was used in the experiment. The treatments consisted of two farmyard manure levels: No farmyard manure (FYM0) and 25 tons/ha (FYM1), and two rates of chicken manure, no chicken manure (CM0) and 10 tons/ha (CM1) and two phosphorus levels: No phosphorus (P0) and 50kg P₂O₅ (P1). For the inoculation treatments, seeds will either be inoculated (R1) or un inoculated (R0). Triple super phosphate (48%P₂O₅) was used as source of phosphorus. The inoculant strain USDA/2674 was used in the experiment.

The results showed that, percentage of effective nodules, plant height, number of branches per plant, leaf area index, shoot dry, root dry weight, days to 50% flowering, fruit setting percentage, number of seeds per pod, 100-seed weight, leaf protein content, seed phosphorus content and soil phosphorus content were significantly increased by application of farmyard manure.

Chicken manure application significantly increased the percentage of effective nodules, nodule dry weight, plant height, number of branches per plant, leaf area index, number of nodes per plant, shoot dry weight, root dry weight, days to 50% flowering, number of flowers per plant, days to maturity, number of pods per plant, fruit setting percentage, 100-
seed weight, seed yield, harvest index, seed protein and phosphorus content and soil phosphorus content.

Phosphorus application significantly increased number of nodules per plant, percentage of effective nodules, plant height, number of branches per plant, leaf area index, number of nodes per plant, shoot dry weight, root dry weight, days to 50% flowering, number of flowers per plant, number of pods per plant and fruit setting percentage.

Rhizobium inoculation, significantly increased number of nodules per plant, plant height, number of branches per plant, leaf area index, number of nodes per plant, number of flowers per plant, number of pods per plant, fruit setting percentage and number of seeds per pod. Other parameters such as plant density at harvest, leaf phosphorus content, soil nitrogen content and soil pH were not significantly affected by application of farmyard manure, chicken manure, phosphorus or rhizobium inoculation. In addition there were significant effects of interactions between farmyard manure, chicken manure, phosphorus and rhizobium inoculation on some growth and yield attributes.
خلاصة البحث

أجريت تجربة حقلية لموسمين متتاليين بالمرور التجريبي لكلية الزراعة بشمـبـات (2004/2005 - 2006/2007) لدراسة تأثير الأسمدة العضوية، الفسفور والتفقيد بـبكتريا الرايزوبوم على نمو وتخصيب محصول الفاصوليا الصنف (R/RO) تحت ظروف الري. تمّ إضافة الأسمدة العضوية للترية (السماد البلدى وسماد الدواجن ورري التربة قبل إسبوعين من الزراعة. أضيف الـسماد البلدى على مستويين صـفر (الشاهد) و 25 طن/هكتار، وكذلك أضيف سماـد الدواجن على مستويين صفر (الشاهد) و10 طن/هكتار. أما الفـسفور فقد أضيف في صورة سيرفرومفات ثلاثتي (48% P2O5) على مستويين صفر (الشاهد) و50 كجم فسفور للهكتار كما أجريت معاملتين من التلقيح البكتيري هما بذور مفلفمة وغير مفلفمة وقد لحقت البذور عند الزراعة.

أوضح النتائج أن إضافة الـسماد الـبلدـى أدت إلى فروقات معنوية في نسبة العـدد الجذرـي الفعالـة، طول الـنباتات، عدد الأفرع، دليل مساحة الورقة، الوزن الجاف للمجموع الخضري والجذري، عدد الأيام حتى 50% من الإزهار، عدد الأيام حتى 50% من الزراعة، وزن المانحة بذرة، إنتاجية البذر، دليل الحصاد، محتوى البذرة من البروتين والفسفور، ونسبة الأثمار، ونسبة الإثمار البذر.

وقد بظر التأثير الإيجابي للمعالات على عدد العدد الجذري، نسبة العدد الجذري الفعال، طول الـنباتات، عدد الأفرع، دليل مساحة الورقة، عن عدد الفسفور على عدد العدد الجذري، عدد الأيام حتى 50% من الإزهار، عدد الأزهار، عدد الـقروـن في النباتات، ونسبة الإثمار. أما الأثر الإيجابي المعـنوي للتلقيح البكتيري فقد ظهر على عدد العدد الجذري، طول الـنباتات، عدد الأفرع، دليل مساحة الورقة، عدد الـقيد، عدد الأزهار، عدد الـقرون، نسبة الإثمار، وعدد البذر في الثمرة. وجد أن بعض القياسات مثل الكثافة الـنباتية عند الحصاد، محتوى الورقة من الفسفور، محتوى التربة من النتروجين، ودرجة حموضة التربة لم تتأثر بالـمعالـلات المستخدمة. أظهرت الدراسة أيضا أن التفاعـل بين المعالـلات كان له تأثير معنوي على بعض مظاهر النمو والـإنتاجية.
CHAPTER ONE

INTRODUCTION

In the coming century, food security for a fast growing world population will be the priority in governmental planning all over the world, which will entail tackling the problem of rising cost of factors of production such as fertilizers. Therefore, the role of legumes as soil improving crops and as source of good quality and cheap protein is certain to increase in importance. So many international organizations give great attention to expanding the cultivation of legumes, especially in poor third world countries in Africa and Asia, where animal protein is expensive. Haricot bean is one of the most widely cultivated legumes in temperate regions and is widely distributed in tropical and sub-tropical areas. The crop residue, after harvest, is an excellent animal feed, and is comparable to corn or sorghum fodder in nutritive value.

Common bean (*Phaseolus vulgaris* L.) is an important source of protein and calories in human diets (Laing *et al.*, 1984; Smithon *et al.*, 1993). It requires a warm, frost-free climate, but the plants may drop their flowers or pods during excessively hot temperature or rainy weather. The crop can be grown successfully on most well drained soils ranging from light sands to heavy clays. The soil pH range for growth of haricot bean is 4.2-8.7 with an optimum of 6-6.8 (Ducke, 1981). Lopes (1978) observed considerable increase in percentage of nodulated plants under field conditions due to seed inoculation in soils apparently free of *Rhizobium phaseoli*. However, nodules per plant were low in general and no increase in bean production was observed. Lopes (1978) also reported that it has been observed in Brazil that the lack of response to inoculation and failure of nitrogen fixation were probably related to the presence of indigenous rhizobia.
In the Sudan, haricot bean is grown mainly under irrigation during winter season in the arid part of the Northern and Nile States, particularly in Shendi – Barbar area, where more than 90% of haricot bean area in Sudan is cultivated.

Very little research has been conducted in Sudan to study the many problems facing the production of this crop under field conditions. Some studies on the effect of fertilization and rhizobium inoculation were carried out at Hudeiba Research Station (Ishag, 1970) and then extended to Shendi and Gezira Research Stations.

Although common bean fixes nitrogen symbiotically, nitrogen fertilizer is recommended, because N-fixation doesn’t provide enough nitrogen to meet requirement of this crop (Coelho et al., 1998). In Sudan with the possible exception of nitrogen no other element has been as critical in the growth of plants in the field as phosphorus. A lack of this element is doubly serious since it may prevent other nutrients from being acquired by plants. Unfortunately most of the added phosphorus is made unavailable to plants in alkaline soils. Therefore, much emphasis has been placed upon the processes controlling the level of useful phosphorus in the soil, which affects in the final analysis the productivity of the land. Lynch et al., (1991) reported that leaf area is sensitive to phosphorus supply. Phosphorus deficiency primary reduced leaf area by reducing the number of leaves through the effect on number of nodes and branching. Smithon et al., (1992) observed that nitrogen, phosphorus and potash significantly increased haricot bean plant vigor, plant height and canopy size.

Studies on organic manuring indicated that haricot been showed positive response to such fertilizers. Farmyard manure application significantly increased leaf phosphorus content and soil organic matter. In addition, there were significant effects of the interactions between
phosphorus and farmyard manure on some growth and yield attributes (Sulieman, 2002).

Bio-fertilization is currently gaining increasing importance as an alternative strategy to chemical fertilization particularly in low input agricultural systems. The term bio-fertilization denotes all the nutrients inputs originating from biological sources or due to biological translocation. The term also receives more attention world-wide due to the fact that, they pose a longer lasting effect and if properly managed can out yield the recommended doses of chemical fertilizers (Mahadi, 1993). In Sudan Bio-fertilization receives great attention because of its minimal effects on the environment but low cost input agricultural systems, where chemical fertilizers if available may not be affordable (Elsheikh and Elzindany, 1997).

The contribution made by organic manures to the various systems of agriculture in the Sudan is known to be insignificant (Musa and Fawzi, 1972). This probably arises from factors such as the unilateral development of crop and animal systems of production, lack of appreciation of the value of organic manures in the maintenance of soil fertility, scarcity of manure, and paucity of information on methods of preservation and storage.

In the near future, only agricultural commodities, which are reasonably chemical- free, will have the advantage to compete in local, regional and international markets. Experience has shown that there is a great potential for this approach since there are a number of cases of success demonstrated in some countries. Instead of complete dependence on chemical fertilization of the soil, organic fertilizers will be used to replace the chemical fertilizers. The present study aims at addressing the following objectives:

(1) Effect of organic fertilization, rhizobium inoculation and phosphorus
on growth and yield of haricot bean.

(2) The effect of the above treatments and their interactions on chemical compositions of haricot bean.
CHAPTER TWO

LITERATURE REVIEW

2.1 General:

Common bean (*Phaseolus vulgaris*.L.) is an important source of protein and calories in human diet (Laing *etal.*, 1985; Smithon *etal.*, 1993).

Common bean is a leguminous crop grown for its immature edible pods and for its dry ripe seeds. The crop residue, after harvest constitutes an excellent animal feed. Seeds are rich in protein and make a major contribution to human nutrition. Andrew and Robins (1969) mentioned that, the crude protein in the seeds of common bean ranged between 13.3-26.25% while phosphorus was found to range between 39 - 45% as a percentage of dry matter. Purseglove (1989) stated that, average chemical composition of dried common bean was approximately as follows: 11% water, 22% protein, 1.6%fat, 57.8% carbohydrates, 4% fiber and about 3.6% ash.

Historically common bean (*Phaseolus vulgaris*.L.) originated in the New World and was introduced into Europe in the 16th century and later into Africa and other parts of the World (Heiser,1965; Kaplan,1965; Norman *et al.*,1984).The crop belongs to the family Papilionoidae of which species of the genus Phaseolus are most widely cultivated. Two main kinds of common bean are known, bush cultivars, which comprise the commercial types, and climbing cultivars grown by small farmers in tropical areas.

2.2 Environmental requirements:

2.2.1 Temperature:

The crop can grow at a temperature range of 10º-35ºC, with an optimum temperature of 15.6º-21.1ºC (Duke, 1981). Generally, the growth of the crop is favored by a moderate air temperature (Meinsers
and Elder, 1980). According to Went (1953), the high dry temperature influenced the setting of pods more than any other single factor. According to Holubowics (1992), the optimal temperature over bean vegetation is 23°C, while lower or higher temperature significantly decreases pod and seed yield. High air temperature results in a poor pod setting, and less considerably also in flower abortion.

2.2.2 Moisture:

The growth of common bean is very much affected by the moisture conditions. Wallace (1980) found that, the growth of the crop is favoured by adequate soil temperature and restricted by deficiency or excess of water. Key (1979) found that, common bean would not tolerate wetter weather during the growing season, because it might cause flower drop and increase disease incidence. In this context, Purseglove (1974) and Duke (1981) pointed out the necessity of a distinct dry period during the maturity and harvest time.

2.2.3 Soil:

The crop has the ability to grow at a wide range of soil pH (4.2-8.7) with an optimum soil pH of 6.0-6.8 (Key, 1979; Duke, 1981). Soil crusting has been linked with problems in seedling emergence (Wallace, 1980). The crop can grow on peat soils avoiding high concentration of manganese, aluminum and boron (Duke, 1981). On the other hand, common bean cannot grow well under water logged conditions which may reduce nodule development and hence the efficiency of nitrogen fixation (Sprint, 1976).

2.2.4 Nodulating bacteria:

The root nodule bacteria responsible for nodulating common bean was traditionally classified as *Rhizobium phaseoli*, under cross inoculation grouping system (Fred et al., 1932). The rhizobial classification has been revised since then, and the *Rhizobium species* responsible for
nodulating *Phaseolus vulgaris* has been reclassified as *Rhizobium leguminosarum* biovar phaseoli (Jordan, 1984). It’s a gram-negative, non-sporing, motile rod-shaped bacteria, that is capable of infecting, nodulating and establishing a nitrogen fixing symbiosis with roots of *Phaseolus vulgaris*. These rhizobia are characteristically fast-growing and produce an acid reaction in Yeast Extract Manitol Media (Trinick, 1980; Jordan, 1984). Soil-borne organisms with variable number of *Rizobium phaseoli* in the soil often fail to produce effective nodulation, either because they are too few or they can not work effectively (F.A.O, 1984). They are generally sensitive to low pH levels in the soil (Mangel and Kirkby, 1979).

2.2.5 Organic manure:

Manure is defined as waste plant and animal products, which are recycled by returning them to the soil (Simpson, 1986). Land spreading of animal manure on agricultural land has been a traditional practice. It is known that, the fertility of the soil is directly related to the level of organic matter. Recently, interest has increased in the application of organic manures for many reasons, including supply of nutrients, improving soil condition and energy conservation (Loehr, 1977; Bewick, 1980). Organic matter including manure has a beneficial effect on soil aggregation and hence, it improves tilth and permeability (Magistad and Christiansen, 1944). Moreover, the present emphasis on pollution control has encouraged the use of manure on farms (Abbott and Tucker, 1973).

Organic manures are composed mainly of wastes and residues from plant and animal sources. They contain much carbon and relatively small percentages of plant nutrients.

Manures often improve the structure of soils, they may do this directly through their action as bulky diluents in compacted soils, or indirectly, when the waste products of animals or microorganisms cement
soil particles together. These structural improvements increase the amounts of water useful to crops that soil can hold. They also improve aeration and drainage, and encourage good root growth by providing enough pores of the right sizes and preventing the soil becoming too rigid when dry or completely water-logged and devoid of air when wet (Bardy, 1974). Elamin (1991) reported that, chicken manure, farmyard manure and green manure, whether leguminous or non-leguminous, are utilized extensively in agriculture. Other forms of organic matter such as sewage sludge are also used in agriculture.

The primary source of organic matter in the soil is the plant tissue, while animals are usually considered secondary sources of organic matter as they utilize the plant tissues. Animals contribute waste products and leave their own bodies in and on the soil as their life cycles are ended (Bardy, 1974). Christensen (1987) reported that, nutrients cycling in soil is closely related to organic matter turnover. Carbon metabolism plays a key role in mineralization and immobilization process of plant nutrients. The saprophytic soil organisms, acting as a driving force in nutrient cycling, rely on available organic compounds as source of energy and carbon. Consequently knowledge about the stabilization and decomposability of organic matter in soil is indispensable for understanding the fate of plant nutrients added to soil in fertilizers, crop residues and animal manure.

When manure or crop residues are added to soil, a portion of added organic matter is converted to humus. This represents the principal stage of organic matter transformation, which is also called humification (Kononova, 1968). Broadbent (1962) mentioned that, the major product of aerobic decomposition of organic residues of plant and animal origin are carbon dioxide, water, nitrate, sulfate, phosphate and a number of other anions and cations. The hydrogen bonded to carbon is the fuel that
furnishes the energy for most of the complex and heterogeneous soil flora activities. This energy is generated in a series of steps resulting in hydrogen combining with oxygen to produce water. Energy is released and the release of energy is the principal reason for the decomposition of the organic matter. Incidental to release of energy, certain nutrient elements are converted to inorganic forms.

2.3 Farmyard manure:

Animal manures are excellent sources of plant nutrients. Approximately 70-80% of the nitrogen, 60-85% of the phosphorus and 80-90% of the potassium in feeds is excreted in the manure. The amount of the nutrients available for recycling to plants varies widely, being dependent upon the composition of the feed ration, the amount of bedding and water added or lost, the method of manure collection and storage, the method of land application, and characteristics of the soil, crop and climate. Manure contains all the plant nutrients needed for crop growth including trace elements. The availability or efficiency of manure utilization by crop is determined by the method of application, time of incorporation and the rate of manure decomposition by microorganisms in soil (Stephen, 1998).

Hall (1948) reported that, farmyard manure is a term employed in various parts of the world for the same more or less decomposed mixture of excrete of domestic animals with the straw or litter that is used as a bedding in the yards or stalls to absorb the liquid portions and keep the animals clean. Parasad and Singh (1980) stated that continuous use of farmyard manure for twenty years improved the physical properties of sodic loam soils. Antal (1972) found that, the effect of NPK fertilizer and the manure were similar. Nitta and Mastugushi (1989) found that, farmyard application increased the yield of all crops examined including beans.
Alvarez et al., (2000) found that, the mineralization of multiple crop residues was promoted by incorporating cattle manure at the beginning of the process of rehabilitation of temperate soil (soil of cemented layers or fragipan underlying thin top soil) for agricultural production. The use of vetch as green manure or residues of multiple cropping and cattle manure contributes to this because of its beneficial effects on microbial activity. Saghin (1998) reported that, application of 20 or 40 tones of farmyard manure per hectare increased soil pH by an average of 0.3. Systematic incorporation of both organic and mineral fertilizers, increased mobile phosphorus and potassium accumulation in soil, depending on application rate. NP and NPK fertilizers, as well as farmyard manure increased Vicia faba seed content of total nitrogen, crude protein, phosphorus, potassium, starch and fats. Attia (1990) reported that, increasing farmyard manure rate generally increased the straw and seed yield, nutrient concentrations and total seed nutrient content of faba bean.

Hashimoto and Yamamoto (1973) stated that fertilization of soybean with farmyard manure yielded the greatest seed, leaf and stem weight at maturity. Also farmyard manure produced excellent growth, as shown by the abundance of flowers and good nodulation. Stephen (1998) reported that, manure contains stable and unstable forms of nitrogen. Unstable nitrogen occurs in urine as urea and may account for more than 50% of the total nitrogen in manure, urea changes rapidly to ammonium ions then quickly to ammonia as pH increases and manure begins to dry. Ammonia is extremely volatile resulting in nitrogen loss. Nearly all the ammonium nitrogen can be lost from surface applied manure if it is not incorporated within a few days. For example, 25 tons/acre of dairy manure containing 8Ibs N/ton, applied and incorporated the same day will give approximately 120Ib N/ acre available in the year of application.
Generally, 60% of nitrogen in the manure is available in the first year, with the remainder becoming available in subsequent years from the more stable organic nitrogen fraction. However, if manure incorporation is delayed for 7 days or more only 40 lbs will be available (Stephen, 1998). The above author also stated that, the more stable organic nitrogen occurs in the faeces and is slowly released. Approximately 40-50% of stable organic nitrogen will be available in the first year, 12-15% of the nitrogen remaining in the year after, 5-6% in the third year and lesser amounts in each subsequent year. These figures are approximations and could vary in different locations due to variations in the rate of microorganism breakdown and climate. In addition the author reported that, when manure is applied at sufficient rate to supply the nitrogen need of a crop, the phosphorus and potassium will likely be in excess of the crop requirements. Essentially all of the potassium is available for plant growth in the first year manure is applied. However, some of the phosphorus may be in the form of insoluble inorganic compounds or as organic phosphorus and, like stable organic nitrogen it must be mineralized before it is available to plants.

2.4 Chicken manure:

Poultry manure is quite different in its chemical make-up than other live stock manures, this is because poultry manure contains relatively higher amounts of uric acid and other ureides. As their name implies, these are forms of urea and can be quite toxic to crops both in the soil and on above ground plant tissue. With pre plant application, mixing of the manure and the plow layer of the soil is recommended to avoid planting seeds into concentrated zones of manure. The seeds will either not germinate or they will germinate and the seedlings die due to ammonia toxicity. Composting poultry manure and its bedding or litter is often considered due to the nature of poultry manure (high C: N ratio and
low moisture content). Due to the high labor intensity and mechanization required for composting, it is generally more cost efficient to apply the manure to nearby cropland, as composting the manure makes a product more convenient to handle and apply. The composting process results in carbon dioxide and volatile nitrogen compounds being lost to the atmosphere. So, although the nutrient percentage of compost is higher than the raw manure, there are fewer nutrients in the final product than the initial product (Michael and George, 2002).

As the demand for poultry meat increases, so will the amount of manure produced. Recycling the manure to the soil through a predetermined manure management plan is efficient and practical. This will optimize the nutrient value of the manure while minimizing potential environmental hazards. Manure is valuable resource on a farm and should be treated as an asset (Michael and George, 2002).

Michael and George (2002) reported that, manure management should be a top priority on poultry farms. Mismanagement of manure can have a substantial impact on our water, soil and air resources. When used appropriately, manure has nutritive, and thus economic value. Manure also improves biological activity in the soil, soil tilth and soil chemical properties. According to 1990 Minnesota Agricultural Statistical Service Data, the Minnesota poultry industry generates approximately 2 million tons of manure annually, containing 29,000 tons of nitrogen 24,000 tons of P₂O₅ (Phosphorus fertilizer equivalent) and 14,000 tones of K₂O (Potassium fertilizer equivalent). Fresh poultry droppings contain twice as much nitrogen as farmyard manure, they are much richer in phosphorus and contain about as much potassium as farmyard manure. Composts of droppings and straw are richer than farmyard manure in all three nutrients. On the other hand, in moist soil about half of total nitrogen in droppings and in deep litter is equivalent to inorganic nitrogen fertilizer,
but the proportion that is immediately useful in compost varies with their composition and maturity (Cooke, 1982). The above author also reported that, poultry manure is efficient in terms of total nitrogen as fertilizer and had appreciable residual effect. He also found that, wheat grain yield; grain quality and straw yield were promoted by the rate of chicken manure. The point of profitable grain yield (greatest economic return) corresponded to the manurial rate of 8.25 tons/ha.

Nitrogen and phosphorus uptake as a function of chicken manure application rate, increased progressively with an increasing manurial rate (Magid et al., 1998; Postma et al., 1998 and Hue and Sobieszczyk, 1999).

Chicken manures were effective in increasing soil solution pH and Ca and decreasing soil solution Al and percentage of Al saturation in the sub soil, particularly below the 15 cm depth (Hue and Licudine, 1999). As reviewed by Nose (1998), the nitrogen source to be mixed with composted bark was usually chicken manure, but recently food-processing wastes have been replacing this. Zhao et al.,(1999) showed that, the utilization rate of nitrogen from chemical fertilizer was increased by 25.5% for the first crop with the application of rice straw and by 22.9% and 48.6% for the second crop with the application of rice straw and chicken manure, respectively.

Generally humification percentage was lowered by manure application particularly in sandy soil. However, chicken manure slowed down the decomposition of the soil organic matter (Ismial et al., 1988 and Isermann et al., 1989).

2.5 Rhizobium inoculation:
Bacterial species within the genera Allorhizobium, Azorhizobium, Bradirhizobium, Mesorhizobium, Rhizobium, and Sinorhizobium, (commonly referred to as rhizobia) can infect, nodulate and symbiotically fix nitrogen in legumes. However, legumes express host specificity,
meaning that only certain species or subspecies (i.e., biovar) of rhizobia will infect certain species of legumes. For example, pea is infected by Rhizobium leguminosarum biovar phaseoli. Sometimes different legume crops (e.g., faba bean, Lentil and pea) can be infected by the same species or biovar of rhizobium (cross-inculation group) however, even within these crops often certain strains of rhizobia are more effective in one crop compared to another (Dean and Clark, 1979). Commercial rhizobial inoculants have been available for legume since 1890s (Fred et al., 1932). Currently, a wide variety of commercial legume inoculants are available for use.

Most leguminous crops require inoculation with efficient strains of appropriate root nodule bacteria in order to fix atmospheric nitrogen. Common bean is extensively grown in many parts of the world but in many of these inoculation is not routinely practiced.

Vessey (2004) reported that, inoculation of forage and grain legumes with rhizobia is an important process to maximize biological nitrogen fixation capacity in these crops. The previous author also stated that, inoculation has the potential of increasing dry matter yield, nitrogen yield and residual nitrogen levels. Yield responses to inoculation are dependent upon many factors, but legume species and soil nitrogen levels prior to seeding are two important factors (Vessey, 2004). However, given the modest cost of inoculation compared to the potential agronomic benefits, producers are well advised to seriously consider inoculation of their legume crops in all circumstances. Moreover, The previous author also stated that, inoculation of grain and forage seeds at planting are generally recommended to maximize the potential for nodulation and nitrogen fixation in these crops.

Positive response of common bean to inoculation has been reported by Erdman (1967), Schiffmann and Alper (1968), Date (1970) and
Weiser et al.,(1985). The previous authors also found that, inoculation increased nodule numbers and nodule dry weights. Inoculation also resulted in improved plant nitrogen content and raised the dry matter production. Graham and Rosas (1977), Karrar(1984) and Salih and Salih (1985) observed considerable increase in percentage of nodulated plants under field conditions due to seed inoculation in soils apparently free of Rhizobium phaseoli. However, nodules per plant were low in general and no increase in bean production was observed.

Inoculation of common bean cultivars with the effective strain USDA 2667 and the ineffective local isolate HB of common bean rhizobia improved nodulation. However, significant improvement of shoot nitrogen was rarely observed (Aouani et al.,1998).The previous authors also stated that, native rhizobia were generally more competitive than introduced strains, due to better adaptation to prevailing soil environment.

Producers inoculate their legume crops to increase yield and decrease the input costs of nitrogen fertilizers (Vankessel and Hartley, 2000). In Sudan Habish and Ishag (1974) reported that, inoculation of common bean resulted in enhanced nodulation, plant nitrogen content and plant dry weight. Similar results were recorded by Khairi (1967) and Ishag (1971). Abdel Gabbar (1971) stated that, there was an increase of about 22% in seed yield of common bean due to inoculation and 59% due to application of 80IbN/fed. The plants inoculated with rhizobium showed a greater increase in plant dry weight, especially after 10 weeks from sowing. Application of combined nitrogen at 80lb/fed, gave higher yield than inoculation, and suggests that, the level of nodulation and nitrogen fixation reached was not sufficient to provide the plants with their nitrogen requirements. The use of more effective strains of rhizobia would give a greater response to inoculation. Recently, Ferreira et al.,
(2002) found that, nodulating cultivars with inoculation or even in soil with efficient native population of rhizobia can eliminate the need for nitrogen fertilization with no decrease in yield. In addition (Maingi et al., 2001) found that the inoculated common bean and nitrogen application treatments recorded the largest seed dry weights and subsequently the highest seed yield per hectare. Diouf et al., (1999) reported that, dry matter production and nitrogen accumulation were increased in plants inoculated with rhizobium strain ISRA355 compared to un inoculated plants and in 20kg N/ha, compared to non N-fertilized plants. The amount of fixed nitrogen was increased by the interaction of inoculation with 20kgN/ha. Beside that, nitrogen fixation was inhibited in plants supplied with 80kg N/ha. Thus, 20kg N/ha. should be considered as starting dose in common bean.

Most beans are produced by small farmers who rarely inoculate with rhizobium or apply fertilizers. Bean yields on farmer’s fields in Kenya are usually low, ranging from 0.14 to 0.77 ton/ha. (Kapkiyai et al., 1998), with the national average starting at 0.50 ton/ha. (Ssali, 1988).

For legumes, nodulation and N-fixation are dependent upon an adequate supply of both macro and micronutrients (Munns, 1977; Smith, 1982). These nutrients are not only essential for the symbiotic interaction but also for the host plant and its microbial partner. Russo and Perkins-Veazie (1992) have demonstrated that, fertilizer N, P and K can increase bean yields even when supplied at rates above those recommended. Symbiotic N-fixation begins only after nodule formation, which is preceded by colonization of the rhizosphere and infection of legume roots by rhizobia (Hardy et al., 1971). Nitrogen requirement can be met by both mineral nitrogen fertilization and symbiotic nitrogen fixation (George and Singleton, 1992). The plant nitrogen requirement may not be met during early vegetative and later reproductive phases by N- fixation.
At these critical times, mineral nitrogen becomes the most important source of nitrogen for grain legumes.

Lack of response to rhizobium inoculation has been observed by Montealegre and Graham (1996) who attribute it to the presence of numerous, ineffective indigenous rhizobia. According to Mcloughlin and Duncans (1985), competition between rhizobia strains in the soil is a common phenomenon as the introduced inoculum strains compete with indigenous Rhizobia for nodule sites. Montealegre et al.,(1995) suggested that, cultivars that select strains, rather than nodulate with ineffective indigenous rhizobia, offer one approach to the resolution of lack of response to rhizobium inoculation problem. Moawad et al., (1998) have found evidence of certain rhizobia strains which only improve N-fixation and bean yield in specific cultivars. It is therefore apparent that host rhizobium strain specificity and differences between strains in nitrogen fixing ability contribute significantly to the frequently observed differences in response to inoculation (Graham, 1981).

Response of common bean to inoculation appears to be highly variable in different parts of the world. The factors responsible for this variability in response are many, but Alexander (1977) reported that, lack of response to inoculation is quite common in fields not previously cropped to common bean, and consequently supporting low counts of rhizobia responsible for nodulating this crop. It is believed that, common bean is a poor nitrogen fixer as compared to the other legumes (Date, 1970; Keya, 1975; Alexander, 1977; F.A.O, 1984). These workers attributed, in part, this poor ability to fix nitrogen to partial failure of the crop to establish effective symbiosis in the field, genetic variability and the general growing conditions. Piha and Munns (1987) stated that, failure to establish effective nodulation is often considered the main reason for poor N-fixation by common bean in the field, but the species
may be genetically predisposed to poor fixation because of ineffective symbiosis and the short vegetative fixation period. Failure to respond to inoculation has been reported by EL-Beheidi (1970), Fontes (1972) and Rabih (1999). Lopes (1978), mentioned similar lack of response by common bean in Brazil and he related this to the presence of indigenous rhizobia. Date and Rouphly (1977), reported that, in areas where indigenous strains of *Rhizobium phaseoli* are present, their competition for nodulation sites with more effective inoculant strains may be a major constraint. Moreover, Graham (1981), pointed out that, the failure of applied inoculum to increase seed yield may be due to many causes, such as soil pH, nutritional status and water status which control many nodulation responses. High level of applied or soil nitrogen may completely inhibit nodulation. Pesticides applied to seeds or soils have inhibitory effects on nodulation. Common bean is inferior to other grain legumes in effectiveness nodulation and efficiency of nitrogen fixation, with early flowering cultivars particularly limited in their ability to satisfy their nitrogen needs through fixation (Chaverra and Graham, 1992). The previous authors also concluded that, extending the period of fixation could reduce the dependence of this crop on nitrogen fertilization. Although common bean plants have N-fixation ability by symbiosis with rhizobium, they are recommended to be nitrogen fertilized, because nitrogen fixation does not provide enough nitrogen to meet requirement of this crop (Coelho *et al*., 1998). On the other hand, the reduced nodulation after flowering indicates a process of nodule senescence, noticed in every genotype but at different degrees. With the onset of bean pod filling, competition for photosynthates between nodules and pods becomes important, thus reducing nodule growth and activity (Piha and Munns, 1987). Nodule initiation and complete nodule development can
be restricted in parts of bean root system at pod filling (Vikman and Vessey, 1993).

2.6 Phosphorus:

Phosphorus is an important element that is required for photosynthetic energy production and carbohydrate transport (Alam, 1999; Raghothama, 1999). Lawlor and Cornic (2000) reported that, an inadequate phosphorus supply to the chloroplast can limit ATP synthesis. Phosphorus supply to the chloroplast is crucial for maintaining phosphorylation reactions during CO₂ assimilation, when phosphorus is released from phosphorylated carbohydrates in the cytoplasm as a consequence of sucrose synthesis and export to other tissues (Leegood, 1996).

There are four main sources of phosphorus to plants, namely commercial fertilizers, farmyard manure, plant residues including green manure and native soil components of the element (Buckman and Brady, 1971). The main effect of phosphorus fertilization on leguminous crops is exhibited in increased dry matter production and the level of nitrogen in plant tissue (Andrew, 1977). Availability of phosphorus is very important for root growth in legumes, and its shortage reduced the growth rate and stunted the plant (Abdalla et al., 1984). Generally, the application of phosphorus fertilizers, improved yields of some leguminous crops with or without inoculation (Subba Rao, 1976). In common bean, shoot and root dry weight, root length, phosphorus concentration in the shoot, and phosphorus uptake were significantly affected by soil phosphorus concentration and genotype. However, phosphorus level did not affect root length and genotype had no effect on root dry weight (Fageria et al., 2000). Phosphorus application may increase seed yield of bean on soils that are deficient in available phosphorus (Martin and Leonard, 1967). Robert et al., (1972) reported that, common bean yield increased
when 22kg P_2O_5/ha. were added. In contrast El-Bakry et al., (1980) found that application of phosphorus had no effect on yield and yield components. However, application of both phosphorus and nitrogen might increase seed weight. Garvalho et al.,(1995) stated that, the application of phosphorus significantly increased plant dry weight, seed weight, pod number and seed number. In spite of this, the efficiency of phosphorus uptake was generally low. Verma and Saxena (1995) reported that seed yield of common bean was highest with the addition of 120kg P_2O_5/ha. On the other hand, Sahu et al.,(1994) recorded that, there was no effect on the seed yield of beans with the application of 30 or 60 kgP_2O_5/ha.

Phosphorus has been shown to promote the formation of nodules and pods in legumes (Buttery, 1969; Dadson and Acquaah, 1984). The low nitrogen status of the soil was expected to encourage a positive response to rhizobium inoculation in the presence of applied phosphorus. This observation contradicts the finding of Gobara et al., (1993). The response of applied Phosphorus could be attributed to genotypic characteristics. Yan et al.,(1995) and Ssali and Keya, (1986) observed a close correlation between small seeded bean genotypes and phosphorus use efficiency. Poor nodulation and poor plant vigour have been observed in beans grown in soils low in extractable phosphorus (Amijee and Giller, 1998). Phosphorus fertilizer increases bean yields and causes optimum nodulation earlier during bean growth (Ssali and Keya, 1986). The grain legume project in central Kenya recommended the use of diammonium phosphate fertilizer on beans to supply 36kg N/ha. and 40 kg P_2O_5/ha. (GLP, 1983). Ssali and Keya, (1986) demonstrated that, fertilization of beans promoted good early growth and that the beans fixed substantial amounts of nitrogen. Rabih (1999) reported that, it is unsafe to supply phosphorous fertilizer in the row in contact with seeds of
common bean. Most experimental findings recommended placing the fertilizer in bands about 3 inches to the side and slightly deeper than the seeds. The high concentration of soluble salts resulting from fertilizer placed in contact with the seed delays germination and may kill some of the seedlings. Banding of fertilizers is more efficient than broadcasting since the bean plant does not produce a large root system. On the other hand, Simpson (1986) reported that, application of phosphorus early in the season increased the plant dry matter significantly. Lynch et al., (1991) reported that leaf area was sensitive to phosphorus supply.

Phosphorus deficiency primarily reduced leaf area by reducing the number of leaves through the effects on the number of nodes, branching and relative leaf appearance and secondarily by reducing leaf expansion. Wang et al., (1999) stated that phosphorus deficiency decreased phosphorus uptake and inhibited plant growth. Fageria et al., (1995), found that, fertilization of common bean by application of phosphorus in different acid soils significantly increased dry matter production, grain yield and yield components but the response varied from soil to soil. Fageria and Carvalha (1996) stated that, phosphorus application significantly increased dry weight, seed weight, pod and seed number. Yield and phosphorus uptake were generally greater at the higher phosphorus rate of fertilization (Araujo et al.,2000). Common bean often faces phosphorus deficiency in soils where it is generally grown. Such deficiency is a major limitation to grain yield improvement when common bean relies on Nitrogen fixation (Vadez. et al., 1999). Phosphorus is required in high concentrations in nodules and it is important to their development and function (Graham and Roses, 1979). Gates (1974) demonstrated that the number of nodules and their dry weights were enhanced by phosphorus supply. Moreover, Quispel (1974) found that, the influence of phosphate deficiency was mainly exhibited on
the infection process, nodule initiation and nodule number. It delayed primary infection, initiation of cell division in the cortex or pericycle and reduced number of nodules.

Phosphorus deficiency is considered as the most wide spread soil constraint to agricultural production in tropical America. (Sanchez and Salinas, 1981). Common bean crop exhibits generalized response to phosphorus fertilization, as demonstrated by several trials in Brazil (Oliveira et al., 1982). Maximal economic fertilizer level for bean production was equal to 4 kg/ha, of phosphorus (Barbosa Filho and Silva, 1994).

Most studies on adaptation of beans to low phosphorus availability were carried out under conditions of combined nitrogen, and studies to ensure that tolerance to low phosphorus is compatible with nitrogen fixation are needed, since attempts to select bean genotypes tolerant to low phosphorus are likely to be affected by the symbiosis established with rhizobia (Graham and Rosas, 1979). Genotypic variability in nitrogen fixation at low phosphorus levels indicates that, breeding to enhance these traits simultaneously would be possible (Pereira and Bliss, 1989). The genotypic differences observed in the patterns of root production may be useful for nutritional breeding programs, since growth and phosphorus accumulation in bean in low phosphorus soils were associated with larger root dry weight and root: shoot ratio (Yan et al., 1995). Under low phosphorus supply, roots retained more phosphorus after flowering, whereas the high phosphorus supply stimulated the translocation of phosphorus from roots to shoots, since root phosphorus concentration and content, and also proportion of phosphorous in roots, decreased after flowering. A high proportion of phosphorus in bean plants was initially invested in roots, and this allocation decreased with time, more intensively in plants under high than
under low phosphorus supply (Snapp and Lynch, 1996). In addition, Snapp and Lynch (1996) stated that, the maintenance of phosphorus absorption at late growth stages may be an important factor in establishment of bean crop under low soil fertility. Poor nitrogen fixation after flowering could have limited the expression of the yield potential and the efficiency of phosphorus use, justifying in part the lack of significance of genotype x phosphorus interaction for measured traits. The low number of pods per plant as compared to findings of Youngdahl (1990) also confirmed some restrictions on seed yield.

Leidi and Rodriguez (2000) mentioned that increasing phosphorus nutrition improved symbiotic nitrogen fixation in common bean only at low nitrogen concentration. A decrease in plant phosphorus uptake was observed, as indicated by a low concentration of phosphorus in the xylem sap and shoots, correlated with the amount of nitrogen supplied. Simultaneously with the specific inhibition of nitrogen fixation, high nitrate concentrations might decrease phosphorus availability, thus inhibiting even further the symbiotic association because of the high phosphorus requirement for nodulation and nitrogen fixation. The poor phosphorus status of many tropical soils is offset to some extend by the fact that, many tropical legumes are adapted to such soils and are highly efficient in extracting or mobilizing phosphorus (Andrew and Robins, 1969). Therefore, any test of effectiveness of rhizobium strains should take account of potential phosphorus limitations and ensure that adequate basal phosphorus fertilization is supplied.
CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site:

A field experiment was conducted for two consecutive seasons (2004/05-2005/06) to study the response of haricot bean (*Phaseolus vulgaris* L.) to organic fertilization, phosphorus and rhizobium inoculation under irrigation. The experiment was conducted in the Experimental Farm of the Faculty of the Agriculture at Shambat (Latitude 15º 40` N, Longitude 32º 32` E and Altitude 375 meters above sea level). As described by Oliver (1965), the climate of the locality is semi desert and tropical with low relative humidity. Soil at the site is heavily alkaline clay with pH 8.05 and clay content determined as 40-45% and very low permeability (Saeed, 1968). The data on the mean relative humidity, temperature and rainfall at Shambat during the period of the experiment for the two seasons are shown in Appendix (1).

3.2 Treatments and Layout:

The experiment was laid out in a factorial randomized complete block design with four replicates. Improved local white seeded cultivar of common bean (RO/21) obtained from Hudeiba Research Station was used in the experiment. The treatments consisted of two farmyard manure levels: no farmyard manure (FYM0) and 25 tons/ha (FYM1), and two rates of chicken manure: no chicken manure (CM0) and 10 tons/ha (CM1) and two phosphorus levels: no phosphorus (PO) and 50 kg P₂O₅/ha (P1). For the inoculation treatments, seeds were either inoculated (R1) or un inoculated (R0). Triple super phosphate (48% P₂O₅) was used as source of phosphorus. The farmyard manure and chicken manure were obtained from the Top Farm of the University of Khartoum at Shambat. The inoculant strain USDA/2674...
was obtained from the National Research Center at Khartoum. The chemical composition of the farmyard manure and chicken manure used in the experiment and soil samples are presented in Appendix (2).

3.3 Cultural practices:

The experimental land was disc-ploughed, disc-harrowed, leveled and ridged, then divided into plots. The area of each plot was 5×6m, and ridge spacing was 70 cm. Plant spacing was 30cm. The fertilizers were applied by banding on the side of ridges at 5cm depth and the experimental plots were pre-irrigated 15 days before sowing. The crop was sown on the first week of November in both seasons. Five seeds were sown per hole. The first irrigation was given immediately after sowing, and then the crop was watered every 10-12 days. After the third irrigation, plants were thinned to three plants per hole. Three-hand weedings were carried out in each season.

3.4 Parameters:

3.4.1 Vegetative attributes:

3.4.1.1 Nodulation:

This parameter was determined on five plants taken from the two outer ridges of each plot at two weeks interval, starting from the 4th week until the 10th week after sowing. Plants were dug out after a light irrigation, then the roots were washed gently and nodules separated by forceps. Total number of nodules and percentages of effective nodules were determined. Then nodules were put in an oven at 80°C for 24 hours and nodules dry weight was determined.

3.4.1.2 Plant height (cm):

Plant height was measured once at maturity. Five tagged plants in each plot were used for this purpose.
3.4.1.3 **Number of branches per plant:**

This attribute was also determined once at maturity on the same five tagged plants mentioned above.

3.4.1.4 **Number of nodes per plant:**

This attribute was also determined once at maturity on the same plants used for determining number of branches.

3.4.1.5 **Leaf area index:**

The leaf area index was determined at two weeks interval, starting from the 4th week after sowing until maturity, by using the puncher method (Watson and Watson, 1953) by taking 30 leaf discs from each plot. The leaf area was calculated using the following formula:

\[
\text{Leaf area} = \frac{\text{Total area of leaf discs} \times \text{Total dry weight of leaves}}{\text{Dry weight of leaf discs}}
\]

The leaf area index (LAI) was determined as follows:

\[
\text{Leaf area index (LAI)} = \frac{\text{Leaf area per plant}}{\text{Plant ground area}}
\]

3.4.1.6 **Shoot dry weight (g):**

Shoot dry weight was determined at two weeks interval, starting from the 4th week after sowing until maturity. Five plants were randomly taken from the outer two ridges in each plot and their roots were separated, then the shoots were put in an oven at 80°C for 24 hours and shoot dry weight was determined.

3.4.1.7 **Root dry weight (g):**

Roots separated from the plants mentioned above were put in an oven at 80°C for 24 hours and root dry weight was determined.

3.4.2 **Reproductive attributes:**

3.4.2.1 **Days to 50% flowering:**

Days from sowing until 50% of the plants in each plot flowered were counted and the mean time for each treatment was calculated.
3.4.2.2 Number of flowers per plant:
Total number of flowers per plant was counted when all plants were at the maximum flowering stage. (onset of the first pod). Five tagged plants from each plot were used for this purpose. Mean flowers number per plant was obtained.

3.4.2.3 Days to maturity:
Days from sowing until maturity were counted for each plot. The mean time for each treatment was calculated.

3.4.3 Yield and yield components:
Final seed yield and yield components were determined from an area of 2.1 m\(^2\) in the middle of the central three ridges in each plot.

3.4.3.1 Plant density at harvest:
Number of plants in the yield area (2.1 m\(^2\)) was calculated at harvest. Then the number of plants/ m\(^2\) was obtained.

3.4.3.2 Number of pods per plant:
At maturity, pods of 10 plants randomly taken from the yield area were counted and the mean number of pods per plant was determined.

3.4.3.3 percentages of fruit setting:
Number of flowers and number of pods per plant mentioned above were used to determine the percentage of fruit setting according to the following formula:

\[
\text{Percentage of fruit setting} = \frac{\text{Number of pods per plant}}{\text{Number of flowers per plant}} \times 100
\]

3.4.3.4 Number of seeds per pod:
Fifty pods were selected randomly from each treatment. Total number of seeds was counted, and then the seed number per pod was determined.
3.4.3.5 100-seed weight (g):

A sample of 500 seeds was randomly taken from seed yield of each plot. Sub-samples of 100 seeds were taken from each main sample and their weights determined. Then mean 100-seed weight was determined.

3.4.3.6 Seed yield (t/ha):

The crop was harvested manually when the pods were yellow. All pods in the yield area were picked, dried, threshed, winnowed and weighed. Then seed yield per hectare was estimated.

3.4.3.7 Harvest index (%):

Harvest index was determined according to the following equation:

\[
\text{Harvest index (\%) = } \frac{\text{seed yield (economic yield)}}{\text{seed yield (biological yield)}} \times 100
\]

3.4.4 Chemical composition:

3.4.4.1 Plant analysis:

Chemical analysis was based on a sample of 10 grams of leaves or seeds from each plot and then ground for analysis.

3.4.4.1.1 Protein content:

It was determined by Micro-Kjeldahl method (Appendix 3).

3.4.4.1.2 Phosphorus content:

It was determined by the Stannous Chloride Reduction method (Appendix 4).

3.4.4.2 Soil analysis:

Soil analysis was carried out before sowing and after harvest in both seasons. Soil samples were collected from each plot at two depths 0-30cm and 30-60cm. The soil samples were air-dried and ground.

3.4.4.2.1 Soil nitrogen content:
It was determined by Micro-Kjeldahl method (Appendix 5).

**3.4.4.2 Soil phosphorus content:**
It was determined by Colorimetric Determination Extracts (Ascorbic acid method) (Appendix 6).

**3.4.4.2.3 Soil pH:**
It was measured with pH-meter on a suspension of soil in distilled water with a ratio of 2:5 (10 grams soil in 25ml distilled water) (Appendix 7).

**3.4.5 Statistical analysis:**
Data collected from the experiment were analyzed as factorial randomized complete block design. Analysis of variance (ANOVA) was performed according to the method described by Gomez and Gomez (1984). Means were separated by using Duncan’s Multiple Range Test (DMRT).
CHAPTER FOUR

RESULTS

4.1 Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on nodulation:

4.1.1 Number of nodules per plant:

Farmyard manure and chicken manure significantly decreased number of nodules per plant at 4\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first season. In the second season only chicken manure caused significant decrease in this character at 6\textsuperscript{th} and 8\textsuperscript{th} week from sowing. Moreover, phosphorus significantly decreased nodule number per plant at 6\textsuperscript{th}, 8\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first season, but significantly increased it at 4\textsuperscript{th} week from sowing in the second season. In addition rhizobium inoculation significantly increased nodule number per plant at 10\textsuperscript{th} week from sowing in the second season (Table 1). There was significant interaction between farmyard manure and chicken manure on number of nodules per plant at 4\textsuperscript{th} week from sowing in both seasons (Table 2). Moreover, there was significant interaction between chicken manure and rhizobium inoculation on this character at 4\textsuperscript{th} week from sowing in the first season (Table 3). Tables 4 and 5 show that in the first season, there was significant interaction between chicken manure and phosphorus and between farmyard manure and phosphorus on nodule number per plant at 6\textsuperscript{th} and 8\textsuperscript{th} week respectively. Moreover, there was significant interaction between Farmyard manure and rhizobium inoculation on nodule number per plant at 10\textsuperscript{th} week from sowing in the first season only (Table 6).

4.1.2 Percentages of effective nodules:

Farmyard manure, chicken manure and phosphorus significantly increased the percentages of effective nodules at 10\textsuperscript{th} week from sowing
Table (1):
Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on number of nodules per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall means</td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall means</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.38a</td>
<td>1.31a</td>
<td>1.48a</td>
<td>1.32a</td>
<td>1.37</td>
<td>1.51a</td>
<td>1.64a</td>
<td>1.45a</td>
<td>1.32a</td>
<td>1.4</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.22b</td>
<td>1.32a</td>
<td>1.47a</td>
<td>1.14b</td>
<td>1.29</td>
<td>1.39a</td>
<td>1.57a</td>
<td>1.50a</td>
<td>1.40a</td>
<td>1.4</td>
</tr>
<tr>
<td>CM0</td>
<td>1.38a</td>
<td>1.27a</td>
<td>1.43a</td>
<td>1.35a</td>
<td>1.36</td>
<td>1.46a</td>
<td>1.71a</td>
<td>1.69a</td>
<td>1.40a</td>
<td>1.5</td>
</tr>
<tr>
<td>CM1</td>
<td>1.22b</td>
<td>1.36a</td>
<td>1.52a</td>
<td>1.12b</td>
<td>1.31</td>
<td>1.44a</td>
<td>1.50b</td>
<td>1.26b</td>
<td>1.32a</td>
<td>1.3</td>
</tr>
<tr>
<td>P0</td>
<td>1.32a</td>
<td>1.47a</td>
<td>1.62a</td>
<td>1.33a</td>
<td>1.44</td>
<td>1.34b</td>
<td>1.56a</td>
<td>1.52a</td>
<td>1.35a</td>
<td>1.4</td>
</tr>
<tr>
<td>P1</td>
<td>1.28a</td>
<td>1.17b</td>
<td>1.33b</td>
<td>1.14b</td>
<td>1.23</td>
<td>1.56a</td>
<td>1.65a</td>
<td>1.43a</td>
<td>1.37a</td>
<td>1.5</td>
</tr>
<tr>
<td>R0</td>
<td>1.25a</td>
<td>1.26a</td>
<td>1.42a</td>
<td>1.22a</td>
<td>1.29</td>
<td>1.43a</td>
<td>1.63a</td>
<td>1.46a</td>
<td>1.17b</td>
<td>1.4</td>
</tr>
<tr>
<td>R1</td>
<td>1.35a</td>
<td>1.37a</td>
<td>1.53a</td>
<td>1.25a</td>
<td>1.38</td>
<td>1.48a</td>
<td>1.58a</td>
<td>1.49a</td>
<td>1.56a</td>
<td>1.5</td>
</tr>
<tr>
<td>SE±</td>
<td>0.05</td>
<td>0.05</td>
<td>0.09</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
<td>0.10</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V(%)</td>
<td>23.07</td>
<td>21.43</td>
<td>35.75</td>
<td>18.18</td>
<td>20.68</td>
<td>20.60</td>
<td>38.22</td>
<td>33.69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means within the same factor followed by similar letter(s) in the same column are not significantly different at 0.05 level of probability according to DMRT.
Table (2):

Effect of farmyard manure and chicken manure interactions on number of nodules per plant 4 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYM0</td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
</tr>
<tr>
<td></td>
<td>1.54a</td>
<td>1.23b</td>
<td>1.38a</td>
<td>1.43a</td>
<td>1.57a</td>
<td>1.51a</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.22b</td>
<td>1.22b</td>
<td>1.22b</td>
<td>1.48a</td>
<td>1.30b</td>
<td>1.39a</td>
</tr>
<tr>
<td>Means</td>
<td>1.38a</td>
<td>1.23b</td>
<td>1.46a</td>
<td>1.44a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.05

SE± for FYM x CM = 0.08

C.V(%) 23.07 20.68

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (3):

Effect of chicken manure and rhizobium inoculation interactions on number of nodules per plant 4 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
</tr>
<tr>
<td>CM0</td>
<td>1.42a</td>
<td>1.34a</td>
<td>1.38a</td>
<td>1.45a</td>
</tr>
<tr>
<td>CM1</td>
<td>1.09b</td>
<td>1.35a</td>
<td>1.22b</td>
<td>1.40a</td>
</tr>
<tr>
<td>Means</td>
<td>1.26a</td>
<td>1.35a</td>
<td>1.43a</td>
<td>1.48a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.05

SE± for CM x R = 0.08

C.V(%) 23.07 20.68

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (4):

Effect of chicken manure and phosphorus interactions on number of nodules per plant 6 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>1.31b</td>
<td>1.24b</td>
<td>1.27a</td>
<td>1.64a</td>
</tr>
<tr>
<td>CM1</td>
<td>1.63a</td>
<td>1.09bc</td>
<td>1.36a</td>
<td>1.48a</td>
</tr>
<tr>
<td>Means</td>
<td>1.47a</td>
<td>1.17b</td>
<td>1.56a</td>
<td>1.65a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.05 0.06
SE± for CM x P = 0.07 0.08

C.V(%) 21.43 20.60

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (5):

Effect of farmyard manure and phosphorus interactions on number of nodules per plant 8 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.79a</td>
<td>1.17ab</td>
<td>1.48a</td>
<td>1.54a</td>
<td>1.35a</td>
<td>1.45a</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.45a</td>
<td>1.49a</td>
<td>1.47a</td>
<td>1.49a</td>
<td>1.51a</td>
<td>1.50a</td>
</tr>
<tr>
<td>Means</td>
<td>1.62a</td>
<td>1.33b</td>
<td>1.52a</td>
<td>1.43a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.09
SE± for FYM x P = 0.13
C.V(%) 35.75 38.22

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
**Table (6):**

Effect of farmyard manure and rhizobium inoculation interactions on number of nodules per plant 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.18a</td>
<td>1.46a</td>
<td>1.32a</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.26b</td>
<td>1.03bc</td>
<td>1.14b</td>
</tr>
<tr>
<td>Means</td>
<td>1.22a</td>
<td>1.25a</td>
<td>1.17a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.04 0.08
SE± for FYM x R = 0.06 0.12
C.V(%) = 18.18 33.69

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
in the first season. On the other hand, rhizobium inoculation caused significant decrease in Percentages of effective nodules at 4\textsuperscript{th} week from sowing in the first season (Table 7). The interaction of farmyard manure with chicken manure had significant effect on percentages of effective nodules at 8\textsuperscript{th} week from sowing (Table 8). The highest percentage of effective nodules was given by the combination FYM0 x CM1. The interaction of chicken manure with phosphorus had significant effect on percentage of effective nodules at 8\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first and second seasons respectively (Tables 9 and 11). The highest percentage of effective nodules was given by the combinations CM0 x P1 and CM1 x P1 respectively. Also farmyard manure and rhizobium inoculation showed significant interaction on percentages of effective nodules at 8\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first season (Tables 10 and 12 respectively). The highest percentage of effective nodules was given by the combination FYM0 X R0 and FYM1 X R1 respectively.

### 4.1.3 Nodule dry weight:

Farmyard manure significantly decreased nodule dry weight at 10\textsuperscript{th} week from sowing in the first season and at 6\textsuperscript{th} week from sowing in the second season. Chicken manure had significantly increased nodule dry weight at 4\textsuperscript{th} week from sowing in the first season, but significantly decreased nodule dry weight at 10\textsuperscript{th} week in the first season and at 6\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the second season. Moreover, phosphorus significantly decreased nodule dry weight at 6\textsuperscript{th}, 8\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first season. On the other hand, rhizobium inoculation had no significant effect on this parameter in both seasons (Table 13).

Tables 14 and 16 show significant interactions between farmyard manure and chicken manure on nodule dry weight at 4\textsuperscript{th} and 8\textsuperscript{th} week from sowing in the first and second seasons respectively. Where the highest nodule dry weight was given by the combinations FYM1 X CM1
Table (7):

Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on percentage of effective nodules of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall means</td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
</tr>
<tr>
<td>FYM0</td>
<td>85.5a</td>
<td>88.38a</td>
<td>92.29a</td>
<td>88.76b</td>
<td>88.73</td>
<td>78.47a</td>
<td>76.59a</td>
<td>89.61a</td>
</tr>
<tr>
<td>FYM1</td>
<td>87.13a</td>
<td>91.94a</td>
<td>90.50a</td>
<td>94.27a</td>
<td>90.89</td>
<td>82.29a</td>
<td>81.79a</td>
<td>88.79a</td>
</tr>
<tr>
<td>CM0</td>
<td>83.62a</td>
<td>90.73a</td>
<td>90.42a</td>
<td>88.63b</td>
<td>88.35</td>
<td>79.68a</td>
<td>81.15a</td>
<td>88.27a</td>
</tr>
<tr>
<td>CM1</td>
<td>89.01a</td>
<td>89.28a</td>
<td>92.37a</td>
<td>94.40a</td>
<td>91.27</td>
<td>81.07a</td>
<td>77.23a</td>
<td>90.13a</td>
</tr>
<tr>
<td>P0</td>
<td>83.53a</td>
<td>88.14a</td>
<td>90.28a</td>
<td>88.38b</td>
<td>87.58</td>
<td>81.68a</td>
<td>78.52a</td>
<td>88.49a</td>
</tr>
<tr>
<td>P1</td>
<td>89.11a</td>
<td>91.87a</td>
<td>92.51a</td>
<td>94.64a</td>
<td>92.03</td>
<td>79.08a</td>
<td>79.86a</td>
<td>89.91a</td>
</tr>
<tr>
<td>R0</td>
<td>89.45a</td>
<td>90.35a</td>
<td>91.74a</td>
<td>91.35a</td>
<td>90.72</td>
<td>81.37a</td>
<td>76.53a</td>
<td>86.66a</td>
</tr>
<tr>
<td>R1</td>
<td>83.18b</td>
<td>89.67a</td>
<td>91.05a</td>
<td>91.68a</td>
<td>88.90</td>
<td>79.38a</td>
<td>81.85a</td>
<td>91.74a</td>
</tr>
<tr>
<td>SE±</td>
<td>1.96</td>
<td>2.12</td>
<td>1.50</td>
<td>1.83</td>
<td>2.47</td>
<td>1.96</td>
<td>2.07</td>
<td>2.18</td>
</tr>
<tr>
<td>C.V(%)</td>
<td>12.87</td>
<td>13.29</td>
<td>9.26</td>
<td>11.32</td>
<td>17.37</td>
<td>14.00</td>
<td>13.16</td>
<td>13.36</td>
</tr>
</tbody>
</table>

Means within the same factor followed by similar letter(s) in the same column are not significantly different at 0.05 level of probability according to DMRT.
Table (8):

Effect of farmyard manure and chicken manure interactions on percentage of effective nodules 8 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>88.26ab</td>
<td>96.32a</td>
</tr>
<tr>
<td>FYM1</td>
<td>92.58a</td>
<td>88.43ab</td>
</tr>
<tr>
<td>Means</td>
<td>90.42a</td>
<td>92.37a</td>
</tr>
</tbody>
</table>

SE± for main effect = 1.05 2.07
SE± for FYM x CM = 2.12 2.93
C.V(%) = 9.26 13.16

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (9):

Effect of chicken manure and phosphorus interactions on percentage of effective nodules 8 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>86.41ab</td>
<td>94.43a</td>
<td>90.42a</td>
<td>88.52a</td>
</tr>
<tr>
<td>CM1</td>
<td>94.15a</td>
<td>90.60a</td>
<td>92.37a</td>
<td>88.46a</td>
</tr>
<tr>
<td>Means</td>
<td>90.28a</td>
<td>92.51a</td>
<td>88.49a</td>
<td>88.91a</td>
</tr>
</tbody>
</table>

SE± for main effect = 1.50  
SE± for CM x P = 2.12  
C.V(%) = 19.26  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (10):

Effect of farmyard manure and rhizobium inoculation interactions on percentage of effective nodules 8 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>FYM0</td>
<td>95.87a</td>
<td>88.71ab</td>
<td>92.29a</td>
<td>89.20a</td>
<td>90.03a</td>
</tr>
<tr>
<td>FYM1</td>
<td>87.61ab</td>
<td>93.39a</td>
<td>90.50a</td>
<td>84.12a</td>
<td>93.46a</td>
</tr>
<tr>
<td>Means</td>
<td>91.74a</td>
<td>91.05a</td>
<td>86.66a</td>
<td>91.74a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 1.50
SE± for FYM x R = 2.12
C.V(%) = 19.26

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (11):

Effect of chicken manure and phosphorus interactions on percentage of effective nodules 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>84.82a</td>
<td>92.44a</td>
<td>88.63b</td>
<td>94.56a</td>
</tr>
<tr>
<td>CM1</td>
<td>91.94a</td>
<td>96.85a</td>
<td>94.40a</td>
<td>84.51b</td>
</tr>
<tr>
<td>Means</td>
<td>88.38b</td>
<td>94.64a</td>
<td>89.54a</td>
<td>94.73a</td>
</tr>
</tbody>
</table>

SE± for main effect = 1.83  
SE± for CM x P = 0.06  
C.V (%)  = 11.32  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (12):

Effect of farmyard manure and rhizobium inoculation interactions on percentage of effective nodules per plant 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>FYM0</td>
<td>91.04a</td>
<td>85.86ab</td>
</tr>
<tr>
<td>FYM1</td>
<td>91.66a</td>
<td>97.50a</td>
</tr>
<tr>
<td>Means</td>
<td>91.35a</td>
<td>91.68a</td>
</tr>
</tbody>
</table>

SE± for main effect = 1.83
SE± for FYM x R = 2.59
C.V (%) = 11.32

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (13):

Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on nodule dry weight (mg) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.45a</td>
<td>1.95a</td>
<td>1.91a</td>
<td>1.99a</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.46a</td>
<td>1.74a</td>
<td>1.88a</td>
<td>1.47b</td>
</tr>
<tr>
<td>CM0</td>
<td>1.31b</td>
<td>2.05a</td>
<td>1.95a</td>
<td>1.97a</td>
</tr>
<tr>
<td>CM1</td>
<td>1.60a</td>
<td>1.65a</td>
<td>1.84a</td>
<td>1.50b</td>
</tr>
<tr>
<td>P0</td>
<td>1.45a</td>
<td>2.08a</td>
<td>2.11a</td>
<td>1.99a</td>
</tr>
<tr>
<td>P1</td>
<td>1.46a</td>
<td>1.62b</td>
<td>1.67b</td>
<td>1.48b</td>
</tr>
<tr>
<td>R0</td>
<td>1.38a</td>
<td>1.71a</td>
<td>1.71a</td>
<td>1.68a</td>
</tr>
<tr>
<td>R1</td>
<td>1.53a</td>
<td>1.99a</td>
<td>2.08a</td>
<td>1.79a</td>
</tr>
<tr>
<td>SE±</td>
<td>0.08</td>
<td>0.16</td>
<td>0.14</td>
<td>0.12</td>
</tr>
<tr>
<td>C.V(%)</td>
<td>31.60</td>
<td>48.95</td>
<td>40.42</td>
<td>39.62</td>
</tr>
</tbody>
</table>

Means within the same factor followed by similar letter(s) in the same column are not significantly different at 0.05 level of probability according to DMRT.
Table (14):

Effect of farmyard manure and chicken manure interactions on nodule dry weight (mg) 4 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.46a</td>
<td>1.44ab</td>
<td>1.45a</td>
<td>1.65a</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.17ab</td>
<td>1.76a</td>
<td>1.46a</td>
<td>1.64a</td>
</tr>
<tr>
<td>Means</td>
<td>1.31b</td>
<td>1.60a</td>
<td>1.65a</td>
<td>1.64a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.08                           0.09
SE± for FYM x CM = 0.11                               0.13
C.V(%)                           31.60                                          31.68

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (15):

Effect of chicken manure and phosphorus interactions on nodule dry weight (mg) 6weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM0</td>
<td>1.99a</td>
<td>2.09a</td>
<td>2.05a</td>
<td>2.09a</td>
<td>2.19a</td>
<td>2.14a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM1</td>
<td>2.16a</td>
<td>1.14b</td>
<td>1.65a</td>
<td>1.83a</td>
<td>1.71a</td>
<td>1.77b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>2.08a</td>
<td>1.62b</td>
<td>1.96a</td>
<td>1.95a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.16
SE± for CM x P       = 0.23
C.V(%)               = 48.95

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (16):

Effect of farmyard manure and chicken manure interactions on nodule dry weight (mg) 8weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>2.11a</td>
<td>1.71a</td>
<td>1.91a</td>
<td>1.46b</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.79a</td>
<td>1.98a</td>
<td>1.88a</td>
<td>1.93a</td>
</tr>
<tr>
<td>Means</td>
<td>1.95a</td>
<td>1.84a</td>
<td>1.70a</td>
<td>1.59a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.14 0.11
SE± for FYM x CM = 0.19 0.15
C.V(%) 40.42 37.36

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
and FYM1 X CM0 respectively. The interaction between chicken manure and phosphorus had significant effect on nodule dry weight at 6th and 10th week from sowing in the first and second seasons respectively. (Tables 15 and 17 respectively). The highest nodule dry weight was given by the combinations CM1xP0 and CM0xP1 respectively.

4.2.1 Plant height (cm):

Farmyard manure significantly increased plant height in the second season. In addition chicken manure had significant increase and decrease in plant height in the first and second seasons respectively. The interaction between farmyard manure and chicken manure had significant effect on plant height in both seasons, where the greatest plant height was given by the combination FYM0xCM1 in the first season and FYM1xCM0 in the second season (Table 18).

Phosphorus caused significant increase in plant height in the second season. Moreover, rhizobium inoculation significantly increased plant height in the first season. The interaction between phosphorus and rhizobium inoculation had significant effect on plant height in the second season, where the greatest plant height was given by the combination P1xR0 (Table 19).

4.2.2 Number of branches per plant:

Farmyard manure had significant increase and decrease in number of branches per plant in the first and second seasons respectively. On the other hand, chicken manure significantly increased number of branches per plant in both seasons. The interaction between farmyard manure and chicken manure showed significant effect on number of branches per plant in both seasons, where the highest number of branches was given by the combination FYM0xCM1 in both seasons (Table 20).
Table (17):

Effect of chicken manure and phosphorus interactions on nodule dry weight (mg) 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td></td>
</tr>
<tr>
<td>CM0</td>
<td>2.19a</td>
<td>1.76a</td>
<td>1.97a</td>
<td>1.87b</td>
<td>2.82a</td>
<td>2.35a</td>
</tr>
<tr>
<td>CM1</td>
<td>1.79a</td>
<td>1.20a</td>
<td>1.50b</td>
<td>2.08a</td>
<td>1.37b</td>
<td>1.73b</td>
</tr>
<tr>
<td>Means</td>
<td>1.99a</td>
<td>1.48b</td>
<td>1.98a</td>
<td>2.10a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.12
SE± for CM x P = 0.17
C.V(%) = 39.62

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (18):

Effect of farmyard manure, chicken manure and their interactions on plant height (cm) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>91.73d</td>
<td>100.70a</td>
</tr>
<tr>
<td>FYM1</td>
<td>94.90c</td>
<td>96.03b</td>
</tr>
<tr>
<td>Means</td>
<td>93.31b</td>
<td>98.37a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.52 0.36
SE± for FYM x CM = 0.73 0.50
C.V(%) 3.06 1.58

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (19):

Effect of phosphorus, rhizobium inoculation and their interactions on plant height (cm) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R0</td>
<td>95.48a</td>
<td>94.28a</td>
<td>94.88b</td>
<td>123.91c</td>
<td>131.74a</td>
<td>127.83a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>95.94a</td>
<td>97.68a</td>
<td>96.81a</td>
<td>126.75b</td>
<td>127.10b</td>
<td>126.93a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>95.71a</td>
<td>95.98a</td>
<td></td>
<td>125.33b</td>
<td>129.42a</td>
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</tr>
</tbody>
</table>

SE± for main effect = 0.52  0.36
SE± for P x R = 0.73  0.50
C.V(%) = 3.06  1.58

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (20):

Effect of farmyard manure, chicken manure and their interactions on number of branches per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>7.06b</td>
<td>8.68a</td>
<td>7.87b</td>
<td>5.31c</td>
</tr>
<tr>
<td>FYM1</td>
<td>8.36a</td>
<td>8.35a</td>
<td>8.36a</td>
<td>6.22b</td>
</tr>
<tr>
<td>Means</td>
<td>7.71b</td>
<td>8.52a</td>
<td>5.71b</td>
<td>6.84a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.08  0.06  
SE± for FYM x CM = 0.12  0.08  
C.V(%) 5.91  5.44  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Phosphorus and rhizobium inoculation significantly increased number of branches per plant in both seasons. On the other hand, the interaction between phosphorus and rhizobium inoculation showed significant effect on this character in both seasons, where the highest number of branches was given by the combinations P1xR1 and P0xR1 in the first and second season respectively (Table 21).

4.2.3 Leaf area index:

Farmyard manure caused significant increase in leaf area index at 10th week from sowing in both seasons. Moreover, chicken manure significantly increased leaf area index at 6th, 8th and 10th week, but reduced it at the 4th week in the first season and at 4th, 8th and 10th week from sowing in the second season. In addition phosphorus caused significant increase in leaf area index at 4th, 6th and 8th week from sowing in the first season only. On the other hand, rhizobium inoculation had significant decrease in leaf area index at 4th, 6th week and significant increase at 8th week from sowing in the first season (Table 22).

4.2.4 Number of nodes per plant:

Farmyard manure had no significant effect on number of nodes per plant. On the other hand, chicken manure resulted in significant increase in number of nodes per plant in both seasons. The interaction between farmyard manure and chicken manure showed significant effect on number of nodes per plant in the first season only, where the highest number of nodes was given by the combination FYM0xCM1 (Table 23).

Phosphorus significantly increased number of nodes per plant in the first season, whereas, rhizobium inoculation caused significant increase in number of nodes per plant in both seasons. Moreover, the interaction between phosphorus and rhizobium inoculation had significant effect on number of nodes per plant in the second season,
Table (21):

Effect of phosphorus, rhizobium inoculation and their interactions on number of branches per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>7.31d</td>
<td>7.74a</td>
<td>7.52b</td>
<td>5.31c</td>
</tr>
<tr>
<td>R1</td>
<td>8.14b</td>
<td>9.26a</td>
<td>8.70a</td>
<td>6.07a</td>
</tr>
<tr>
<td>Means</td>
<td>7.37b</td>
<td>8.50a</td>
<td>5.69b</td>
<td>5.91a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.08
SE± for P x R = 0.12
C.V(%) = 5.91

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (22):

Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on leaf area index of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall means</td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall means</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYM0</td>
<td>0.33a</td>
<td>0.84a</td>
<td>1.51a</td>
<td>1.55b</td>
<td>1.06</td>
<td>0.63a</td>
<td>1.62a</td>
<td>2.84a</td>
<td>2.69b</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYM1</td>
<td>0.30a</td>
<td>0.89a</td>
<td>1.51a</td>
<td>1.71a</td>
<td>1.10</td>
<td>0.70a</td>
<td>1.70a</td>
<td>2.81a</td>
<td>3.02a</td>
<td>2.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM0</td>
<td>0.52b</td>
<td>0.77b</td>
<td>1.31b</td>
<td>1.38b</td>
<td>0.93</td>
<td>0.57b</td>
<td>1.61a</td>
<td>2.65b</td>
<td>2.57b</td>
<td>1.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM1</td>
<td>0.38a</td>
<td>0.96a</td>
<td>1.71a</td>
<td>1.88a</td>
<td>1.23</td>
<td>0.75a</td>
<td>1.71a</td>
<td>2.99a</td>
<td>3.15a</td>
<td>2.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>0.29b</td>
<td>0.82b</td>
<td>1.43b</td>
<td>1.61a</td>
<td>1.04</td>
<td>0.65a</td>
<td>1.67a</td>
<td>2.79a</td>
<td>2.86a</td>
<td>1.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>0.34a</td>
<td>0.92a</td>
<td>1.59a</td>
<td>1.66a</td>
<td>1.13</td>
<td>0.67a</td>
<td>1.65a</td>
<td>2.86a</td>
<td>2.86a</td>
<td>2.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R0</td>
<td>0.34a</td>
<td>0.91a</td>
<td>1.44b</td>
<td>1.66a</td>
<td>1.09</td>
<td>0.67a</td>
<td>1.64a</td>
<td>2.87a</td>
<td>2.89a</td>
<td>2.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>0.29b</td>
<td>0.83b</td>
<td>1.58a</td>
<td>1.61a</td>
<td>1.08</td>
<td>0.65a</td>
<td>1.68a</td>
<td>2.78a</td>
<td>2.83a</td>
<td>1.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE±</td>
<td>0.009</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.07</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V(%)</td>
<td>17.12</td>
<td>14.71</td>
<td>10.26</td>
<td>7.25</td>
<td>20.02</td>
<td>12.64</td>
<td>13.36</td>
<td>14.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means within the same factor followed by similar letter(s) in the same column are not significantly different at 0.05 level of probability according to DMRT.
**Table (23):**

Effect of farmyard manure, chicken manure and their interactions on number of nodes per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>37.53cd</td>
<td>45.09a</td>
<td>41.31a</td>
<td>44.04a</td>
</tr>
<tr>
<td>FYM1</td>
<td>40.99bc</td>
<td>41.68b</td>
<td>41.33a</td>
<td>45.34a</td>
</tr>
<tr>
<td>Means</td>
<td>39.26b</td>
<td>43.38a</td>
<td>44.69b</td>
<td>46.73a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.28  
SE± for FYM x CM = 0.39  
C.V (%) 3.80  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
where the highest number of nodes was given by the combination P0x R1 (Table 24).

4.2.5 Shoot dry weight:

Farmyard manure had significant increase in shoot dry weight at 6th week from sowing in the first season, and significant increase at 10th week from sowing in the second season. Moreover, chicken manure significantly increased shoot dry weight at all sampling occasions in both seasons except at 6th week from sowing in the second season. In addition, phosphorus significantly increased shoot dry weight at 4th and 8th week from sowing in the first season and at 8th and 10th week from sowing in the second season. On the other hand, rhizobium inoculation significantly decreased shoot dry weight at 4th, 6th and 10th week from sowing in the first season and at 6th and 8th week from sowing in the second season (Table 25). There was significant interaction between chicken manure and phosphorus on shoot dry weight at 8th week from sowing in the first season and at 10th week from sowing in both seasons, where the highest shoot dry weight was given by the combination CM1xP1 at 8th week and CM1xP0 and CM1xP1 at 10th week (Tables 26 and 28). The interaction between farmyard manure and phosphorus had significant effect on shoot dry weight at 10th week from sowing in the first season, where the highest shoot dry weight was given by the combination FYM0xP0 (Table 27).

There was significant interaction between chicken manure and rhizobium inoculation on shoot dry weight at 10th week from sowing in both seasons. The highest shoot dry weight was given by the combinations CM1xR0 and CM1xR1 in the first and second seasons, respectively (Table 29). Also there was significant interaction between phosphorus and rhizobium inoculation on shoot dry weight at 10th week
Table (24):

Effect of phosphorus, rhizobium inoculation and their interactions on number of nodes per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>38.54a</td>
<td>40.34a</td>
<td>39.44b</td>
<td>42.23c</td>
</tr>
<tr>
<td>R1</td>
<td>42.56a</td>
<td>43.84a</td>
<td>43.20a</td>
<td>49.18a</td>
</tr>
<tr>
<td>Means</td>
<td>40.55b</td>
<td>42.09a</td>
<td>47.70a</td>
<td>45.72a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.28                                          0.47
SE± for P x R         = 0.39                                          0.67
C.V(%)                3.80                                            5.82

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (25):

Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on shoot dry weight (g) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall</td>
<td>W4</td>
<td>W6</td>
<td>W8</td>
<td>W10</td>
<td>Overall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYM0</td>
<td>3.63a</td>
<td>4.47b</td>
<td>12.05a</td>
<td>19.87a</td>
<td>11.01</td>
<td>9.49a</td>
<td>31.11a</td>
<td>62.08a</td>
<td>117.88b</td>
<td>55.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYM1</td>
<td>3.53a</td>
<td>6.48a</td>
<td>11.17a</td>
<td>19.52a</td>
<td>10.13</td>
<td>9.89a</td>
<td>29.92a</td>
<td>61.67a</td>
<td>127.66a</td>
<td>57.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM0</td>
<td>3.02b</td>
<td>6.12b</td>
<td>9.71b</td>
<td>18.54b</td>
<td>9.35</td>
<td>9.09b</td>
<td>28.51a</td>
<td>58.73b</td>
<td>116.31b</td>
<td>53.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM1</td>
<td>3.97a</td>
<td>8.83a</td>
<td>13.51a</td>
<td>20.85a</td>
<td>11.79</td>
<td>10.30a</td>
<td>32.51a</td>
<td>65.01a</td>
<td>129.22a</td>
<td>59.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>3.16b</td>
<td>7.67a</td>
<td>10.81b</td>
<td>19.79a</td>
<td>1.36</td>
<td>9.48a</td>
<td>29.62a</td>
<td>56.84b</td>
<td>108.69b</td>
<td>51.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>3.82a</td>
<td>7.28a</td>
<td>12.41a</td>
<td>19.60a</td>
<td>10.78</td>
<td>9.90a</td>
<td>31.41a</td>
<td>66.90a</td>
<td>136.84a</td>
<td>61.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R0</td>
<td>4.03a</td>
<td>8.21a</td>
<td>10.84b</td>
<td>21.26a</td>
<td>11.09</td>
<td>10.10a</td>
<td>33.23a</td>
<td>67.28a</td>
<td>120.19a</td>
<td>57.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>2.96b</td>
<td>6.74b</td>
<td>12.38a</td>
<td>18.13b</td>
<td>10.05</td>
<td>9.28a</td>
<td>27.79b</td>
<td>56.46b</td>
<td>125.34a</td>
<td>54.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE±</td>
<td>0.15</td>
<td>0.41</td>
<td>0.51</td>
<td>0.38</td>
<td>0.39</td>
<td>1.46</td>
<td>1.86</td>
<td>3.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V(%)</td>
<td>23.80</td>
<td>31.32</td>
<td>25.06</td>
<td>10.96</td>
<td>23.83</td>
<td>27.16</td>
<td>17.04</td>
<td>13.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means within the same factor followed by similar letter(s) in the same column are not significantly different at 0.05 level of probability according to DMRT.
**Table (26):**

Effect of chicken manure and phosphorus interactions on shoot dry weight (g) 8 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>CM0</td>
<td>9.80b</td>
<td>9.62b</td>
<td>9.71b</td>
<td>51.41a</td>
<td>66.05a</td>
<td>58.73b</td>
</tr>
<tr>
<td>CM1</td>
<td>11.82b</td>
<td>15.20a</td>
<td>3.51a</td>
<td>62.28a</td>
<td>67.75a</td>
<td>65.01a</td>
</tr>
<tr>
<td>Means</td>
<td>10.81b</td>
<td>12.41a</td>
<td></td>
<td>56.84b</td>
<td>66.90a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.51

SE± for CM x P = 0.73

C.V(%) | 25.06 | 17.04 |

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (27):

Effect of farmyard manure and phosphorus interactions on shoot dry weight (g) 10weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>FYM0</td>
<td>21.41a</td>
<td>18.33b</td>
</tr>
<tr>
<td>FYM1</td>
<td>18.18b</td>
<td>20.87a</td>
</tr>
<tr>
<td>Means</td>
<td>19.79a</td>
<td>19.60a</td>
</tr>
<tr>
<td>SE± for main effect</td>
<td>= 0.38</td>
<td></td>
</tr>
<tr>
<td>SE± for FYM x P</td>
<td>= 0.54</td>
<td></td>
</tr>
<tr>
<td>C.V(%)</td>
<td>10.96</td>
<td></td>
</tr>
</tbody>
</table>

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
**Table (28):**

Effect of chicken manure and phosphorus interactions on shoot dry weight (g) 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>17.41d</td>
<td>19.67b</td>
<td>18.54b</td>
<td>109.44c</td>
</tr>
<tr>
<td>CM1</td>
<td>22.18a</td>
<td>19.52bc</td>
<td>20.85a</td>
<td>107.94c</td>
</tr>
<tr>
<td>Means</td>
<td>19.79a</td>
<td>19.60a</td>
<td>108.69b</td>
<td>136.84a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.38                                     3.04

SE± for CM x P = 0.54                                      4.29

C.V(%)                                               10.96             13.99

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (29):

Effect of chicken manure and rhizobium inoculation interactions on shoot dry weight (g) 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>R0</th>
<th>R1</th>
<th>Means</th>
<th>R0</th>
<th>R1</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM0</td>
<td>18.96b</td>
<td>18.12b</td>
<td>18.54b</td>
<td>114.38ab</td>
<td>118.25ab</td>
<td>116.44b</td>
</tr>
<tr>
<td>CM1</td>
<td>23.56a</td>
<td>18.15b</td>
<td>20.86a</td>
<td>126.00a</td>
<td>132.44a</td>
<td>129.22a</td>
</tr>
<tr>
<td>Means</td>
<td>21.26a</td>
<td>18.14b</td>
<td></td>
<td>120.19a</td>
<td>125.34a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.38

SE± for CM x R = 0.54

C.V(%) 10.96 13.99

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
from sowing in both seasons. The highest shoot dry weight was given by the combination P1xR0 in both seasons (Table 30).

4.2.6 Root dry weight (g):

Table (31) shows significant increase by farmyard manure in root dry weight at 10\textsuperscript{th} week from sowing in the first season. Chicken manure had significant decrease in root dry weight at 4\textsuperscript{th} week from sowing in the first season, and significant increase at 6\textsuperscript{th}, 8\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first season and at 10\textsuperscript{th} week from sowing in the second season. Moreover, phosphorus showed significant increase in root dry weight at 8\textsuperscript{th} week from sowing in the second season. On the other hand, rhizobium inoculation had significant decrease in root dry weight at 4\textsuperscript{th}, 6\textsuperscript{th} and 10\textsuperscript{th} week from sowing in the first season and at 8\textsuperscript{th} week from sowing in the second season, and had significant increase at 8\textsuperscript{th} week from sowing in the first season.

4.3 Reproductive parameters:

4.3.1 Days to 50\% flowering:

Farmyard manure significantly increased days to 50\% flowering in the first season only, whereas chicken manure showed significant increase in days to 50\% flowering in both seasons. Moreover, the interaction between farmyard manure and chicken manure had significant effect on this character in the second season, where the highest number of days to 50\% flowering was given by the combination FYM0 x CM1 (Table 32). Phosphorus showed significant increase and decrease in days to 50\% flowering in the first and second season respectively. On the other hand, rhizobium inoculation had no significant effect on this parameter in both seasons. The interaction between phosphorus and rhizobium inoculation showed significant effect on days to 50\% flowering in both seasons.
Table (30):

Effect of phosphorus and rhizobium inoculation interactions on shoot dry weight (g) 10 weeks from sowing of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td></td>
</tr>
<tr>
<td>R0</td>
<td>20.38b</td>
<td>22.13a</td>
<td>21.26a</td>
<td>101.00c</td>
<td>139.38a</td>
<td>120.19a</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>19.21b</td>
<td>17.06c</td>
<td>18.13b</td>
<td>116.38b</td>
<td>134.31a</td>
<td>125.34a</td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>19.79a</td>
<td>19.60a</td>
<td>108.69b</td>
<td>136.84a</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.38 3.04
SE± for P x R = 0.54 4.29
C.V(%) = 10.96 13.99

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (31):

Effect of farmyard manure, chicken manure, phosphorus and rhizobium inoculation on root dry weight (g) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th></th>
<th>Overall</th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYM0</td>
<td>0.43a</td>
<td>0.75a</td>
<td>0.81a</td>
<td>1.24b</td>
<td>0.81</td>
<td>0.37a</td>
<td>0.94a</td>
<td>1.77a</td>
<td>2.88a</td>
<td>1.49</td>
</tr>
<tr>
<td>FYM1</td>
<td>0.45a</td>
<td>0.73a</td>
<td>0.82a</td>
<td>1.35a</td>
<td>0.84</td>
<td>0.39a</td>
<td>0.96a</td>
<td>1.79a</td>
<td>2.86a</td>
<td>1.50</td>
</tr>
<tr>
<td>CM0</td>
<td>0.46a</td>
<td>0.67b</td>
<td>0.72b</td>
<td>1.18b</td>
<td>0.76</td>
<td>0.39a</td>
<td>0.95a</td>
<td>1.75a</td>
<td>2.75b</td>
<td>1.46</td>
</tr>
<tr>
<td>CM1</td>
<td>0.42b</td>
<td>0.81a</td>
<td>0.91a</td>
<td>1.41a</td>
<td>0.89</td>
<td>0.37a</td>
<td>0.95a</td>
<td>1.81a</td>
<td>2.99a</td>
<td>1.53</td>
</tr>
<tr>
<td>P0</td>
<td>0.45a</td>
<td>0.77a</td>
<td>0.82a</td>
<td>1.33a</td>
<td>0.84</td>
<td>0.38a</td>
<td>0.95a</td>
<td>1.68b</td>
<td>2.79a</td>
<td>1.45</td>
</tr>
<tr>
<td>P1</td>
<td>0.43a</td>
<td>0.71a</td>
<td>0.81a</td>
<td>1.27a</td>
<td>0.81</td>
<td>0.38a</td>
<td>0.96a</td>
<td>1.88a</td>
<td>2.95a</td>
<td>1.54</td>
</tr>
<tr>
<td>R0</td>
<td>0.48a</td>
<td>0.79a</td>
<td>0.77b</td>
<td>1.35a</td>
<td>0.85</td>
<td>0.40a</td>
<td>0.99a</td>
<td>1.91a</td>
<td>2.85a</td>
<td>1.54</td>
</tr>
<tr>
<td>R1</td>
<td>0.40b</td>
<td>0.70b</td>
<td>0.876a</td>
<td>1.24b</td>
<td>0.80</td>
<td>0.36a</td>
<td>0.91a</td>
<td>1.65b</td>
<td>2.89a</td>
<td>1.45</td>
</tr>
<tr>
<td>SE±</td>
<td>0.014</td>
<td>0.029</td>
<td>0.029</td>
<td>0.027</td>
<td>0.024</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V(%)</td>
<td>17.60</td>
<td>21.79</td>
<td>19.91</td>
<td>11.67</td>
<td>36.27</td>
<td>35.54</td>
<td>11.92</td>
<td>12.71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means within the same factor followed by similar letter(s) in the same column are not significantly different at 0.05 level of probability according to DMRT.
Table (32):

Effect of farmyard manure, chicken manure and their interactions on number of days to 50% flowering of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>45.69a</td>
<td>45.81a</td>
</tr>
<tr>
<td>FYM1</td>
<td>46.00a</td>
<td>46.94a</td>
</tr>
<tr>
<td>Means</td>
<td>45.85b</td>
<td>46.38a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.16

SE± for FYM x CM = 0.23

C.V (%) 1.96 1.21

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
seasons. The highest number of days to 50% flowering was given by the combination P0xR0 in both seasons (Table 33).

4.3.2 Number of flowers per plant:

Farmyard manure showed significant decrease in number of flowers per plant in the first season only, whereas chicken manure significantly increased number of flowers per plant in both seasons. On the other hand, the interaction between farmyard manure and chicken manure had significant effect on number of flowers per plant in the first season only, where the highest number of flowers was given by the combination FYM0xCM1 (Table 34).

Phosphorus and rhizobium inoculation significantly increased number of flowers per plant in both seasons. Moreover, the interaction between phosphorus and rhizobium inoculation showed significant effect on the same parameter in both seasons. The highest number of flowers was given by the combinations P1xR1 and P0xR1 in the first and second season respectively (Table 35).

4.3.3 Days to maturity:

Table (36) shows that farmyard manure had no significant effect on number of days to maturity in both seasons, whereas phosphorus caused significant decrease in days to maturity in the second season only. On the other hand, the interaction between farmyard manure and phosphorus showed significant effect on number of days to maturity in both seasons. The highest number of days to maturity was given by the combinations FYM1xP0 and FYM0xP0 (Table 36).

Chicken manure significantly increased number of days to maturity in the second season, whereas rhizobium inoculation showed significant decrease in number of days to maturity in the second season.
Table (33):

Effect of phosphorus, rhizobium inoculation and their interactions on number of days to 50% flowering of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>R0</td>
<td>46.63a</td>
<td>45.81c</td>
<td>46.22a</td>
<td>47.43a</td>
<td>45.50c</td>
</tr>
<tr>
<td>R1</td>
<td>45.56c</td>
<td>46.44b</td>
<td>46.00a</td>
<td>46.75b</td>
<td>46.93b</td>
</tr>
<tr>
<td>Means</td>
<td>46.09b</td>
<td>46.13a</td>
<td>47.09a</td>
<td>46.72b</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.16  0.10  
SE± for P x R = 0.23  0.14  
C.V (%)  1.96  1.21  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (34):

Effect of farmyard manure, chicken manure and their interactions on number of flowers per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>29.30bc</td>
<td>32.13a</td>
<td>30.58a</td>
<td>35.49a</td>
</tr>
<tr>
<td>FYM1</td>
<td>30.35b</td>
<td>28.96bc</td>
<td>29.66b</td>
<td>36.61a</td>
</tr>
<tr>
<td>Means</td>
<td>29.69b</td>
<td>30.54a</td>
<td>36.05b</td>
<td>39.13a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.21 0.31

SE± for FYM x CM = 0.30 0.43

C.V (%) 3.94 4.61

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (35):

Effect of phosphorus, rhizobium inoculation and their interactions on number of flowers per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>26.29b</td>
<td>31.31a</td>
<td>28.80b</td>
<td>34.01c</td>
</tr>
<tr>
<td>R1</td>
<td>30.90a</td>
<td>31.96a</td>
<td>31.43a</td>
<td>39.62a</td>
</tr>
<tr>
<td>Means</td>
<td>28.59b</td>
<td>31.64a</td>
<td>36.82b</td>
<td>38.36a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.21 0.31
SE± for P x R = 0.30 0.43
C.V (%) 3.94 4.61

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (36):

Effect of farmyard manure, phosphorus and their interactions on number of days to maturity of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>88.38a</td>
<td>89.00a</td>
<td>88.69a</td>
<td>84.50a</td>
<td>83.50c</td>
<td>84.00a</td>
</tr>
<tr>
<td>FYM1</td>
<td>89.00a</td>
<td>87.81ab</td>
<td>88.41a</td>
<td>83.94ab</td>
<td>84.25a</td>
<td>84.09a</td>
</tr>
<tr>
<td>Means</td>
<td>88.69a</td>
<td>88.41a</td>
<td>84.22a</td>
<td>83.88b</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18 0.10
SE± for FYM x P = 0.25 0.14
C.V(%) = 1.14 0.67

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
On the other hand, the interaction between chicken manure and rhizobium inoculation had significant effect on the same character in the second season only, where the highest number of days to maturity was given by the combination CM1xR0 (Table 37).

4.4 Yield and Yield components:

4.4.1 Plant density at harvest:

Tables 38 and 39 show that none of the treatments had significant effect on plant density at harvest.

4.4.2 Number of pods per plant:

Farmyard manure significantly decreased number of pods per plant in the second season only, whereas chicken manure caused significant increase in number of pods per plant in both seasons. On the other hand, the interaction between farmyard manure and chicken manure showed significant effect on number of pods per plant in both seasons. The highest number of pods was given by the combination FYM0xCM1 in both seasons (Table 40).

Phosphorus and rhizobium inoculation caused significant increase in number of pods per plant in both seasons. Moreover, the interaction between phosphorus and rhizobium inoculation had significant effect on the same character in both seasons. The highest number of pods was given by the combination P1xR0 in both seasons (Table 41).

Table (42) shows significant interaction between farmyard manure and phosphorus on number of pods per plant in the first season, where the highest number of pods was given by the combination FYM0xP1.

There was significant interaction between farmyard manure and rhizobium inoculation on number of pods per plant in the first season only, where the highest number of pods was given by the combination FYM1xR1 (Table 43).
Table (37):

Effect of chicken manure, rhizobium inoculation and their interactions on number of days to maturity of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>CM0</td>
<td>88.56a</td>
<td>88.75a</td>
</tr>
<tr>
<td>CM1</td>
<td>88.81a</td>
<td>88.06a</td>
</tr>
<tr>
<td>Means</td>
<td>88.69a</td>
<td>88.41a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18

SE± for CM x R = 0.25

C.V (%) = 1.14

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (38):

Effect of farmyard manure, chicken manure and their interactions on plant density at harvest of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>12.31a</td>
<td>12.44a</td>
</tr>
<tr>
<td>FYM1</td>
<td>12.56a</td>
<td>12.63a</td>
</tr>
<tr>
<td>Means</td>
<td>12.44a</td>
<td>12.53a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.09

SE± for FYM x CM = 0.14

C.V (%) 4.38 4.17

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (39):

Effect of phosphorus, rhizobium inoculation and their interactions on plant density at harvest of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>R0</td>
<td>12.44a</td>
<td>12.56a</td>
<td>12.50a</td>
</tr>
<tr>
<td>R1</td>
<td>12.44a</td>
<td>12.50a</td>
<td>12.47a</td>
</tr>
<tr>
<td>Means</td>
<td>12.44a</td>
<td>12.53a</td>
<td>12.53a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.09
SE± for P x R = 0.14
C.V (%) = 4.38

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (40):

Effect of farmyard manure, chicken manure and their interactions on number of pods per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>18.63c</td>
<td>24.50a</td>
<td>21.56a</td>
<td>31.29c</td>
</tr>
<tr>
<td>FYM1</td>
<td>21.44b</td>
<td>22.16b</td>
<td>21.80a</td>
<td>30.04d</td>
</tr>
<tr>
<td>Means</td>
<td>20.03b</td>
<td>23.33a</td>
<td>30.66b</td>
<td>34.21a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18
SE± for FYM x CM = 0.25
C.V (%) 4.66 3.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (41):

Effect of phosphorus, rhizobium inoculation and their interactions on number of pods per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>R0</td>
<td>19.35c</td>
<td>23.45a</td>
<td>21.40b</td>
<td>26.25c</td>
<td>35.76a</td>
<td>31.03b</td>
</tr>
<tr>
<td>R1</td>
<td>21.00b</td>
<td>22.93a</td>
<td>21.96a</td>
<td>34.03b</td>
<td>33.70b</td>
<td>33.86a</td>
</tr>
<tr>
<td>Means</td>
<td>20.18b</td>
<td>23.19a</td>
<td>30.14b</td>
<td>34.73a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18
SE± for P x R           = 0.25
C.V (%)                        4.66                                             3.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.

Table (42):
Effect of farmyard manure, phosphorus and their interactions on number pods per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>18.75c</td>
<td>24.38a</td>
<td>21.56a</td>
<td>30.95a</td>
<td>35.94a</td>
</tr>
<tr>
<td>FYM1</td>
<td>21.56b</td>
<td>22.00b</td>
<td>21.80a</td>
<td>29.33a</td>
<td>33.53a</td>
</tr>
<tr>
<td>Means</td>
<td>20.18b</td>
<td>23.19a</td>
<td>29.14b</td>
<td>30.14b</td>
<td>34.73a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18 \quad 0.22
SE± for FYM x P = 0.25 \quad 0.31
C.V(%) = 4.66 \quad 3.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (43):

Effect of farmyard manure, rhizobium inoculation and their interactions on number of pods per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>FYM0</td>
<td>22.01b</td>
<td>21.11c</td>
<td>21.56a</td>
<td>32.06a</td>
<td>34.83a</td>
</tr>
<tr>
<td>FYM1</td>
<td>20.79c</td>
<td>22.81a</td>
<td>21.80a</td>
<td>29.95</td>
<td>32.90a</td>
</tr>
<tr>
<td>Means</td>
<td>21.40b</td>
<td>21.96a</td>
<td></td>
<td>31.01b</td>
<td>33.86a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18  0.22
SE± for FYM x R = 0.25  0.31
C.V(%)  4.66  3.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
The interaction between chicken manure and phosphorus showed significant effect on number of pods per plant in the first season, where the highest number of pods was given by the combination CM1xP1 (Table 44).

Chicken manure and rhizobium inoculation interaction had significant effect on number of pods per plant in the second season only, where the highest number of pods was given by the combination CM1xR1 (Table 45).

**4.4.3 Fruit setting (%):**

Farmyard manure and chicken manure resulted in significant increase in fruit setting percentage in both seasons. On the other hand, the interaction between farmyard manure and chicken manure had significant effect on the same parameter in the first season, where the highest percentage of fruit setting was given by the combination FYM1xCM1 (Table 46).

Phosphorus significantly increased percentage of fruit setting in both seasons, whereas rhizobium inoculation showed significant decrease and increase on the same character in the first and second season respectively. Moreover, the interaction between phosphorus and rhizobium inoculation had significant effect on percentage of fruit setting in the second season only, where the highest percentage of fruit setting was given by the combination P1xR0 (Table 47).

**4.4.4 Number of seeds per pod:**

Farmyard manure significantly increased number of seeds per pod in the second season only, whereas chicken manure had no significant effect on this character in both seasons (Table 48).

Phosphorus showed no significant effect on number of seeds per pod in both seasons, but rhizobium inoculation significantly increased this character in the second season only (Table 49).
Table (44):
Effect of chicken manure, phosphorus and their interactions on number of pods per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>CM0</td>
<td>19.29c</td>
<td>20.78b</td>
</tr>
<tr>
<td>CM1</td>
<td>21.60b</td>
<td>25.60a</td>
</tr>
<tr>
<td>Means</td>
<td>20.18b</td>
<td>23.19a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18 0.22
SE± for CM x P = 0.25 0.31
C.V (%) 4.66 3.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (45):

Effect of chicken manure, rhizobium inoculation and their interactions on number of pods per plant of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
</tr>
<tr>
<td>CM0</td>
<td>19.83a</td>
<td>20.24a</td>
<td>20.03b</td>
<td>29.68c</td>
</tr>
<tr>
<td>CM1</td>
<td>22.98a</td>
<td>23.69a</td>
<td>23.33a</td>
<td>32.34b</td>
</tr>
<tr>
<td>Means</td>
<td>21.40b</td>
<td>21.96a</td>
<td>31.01b</td>
<td>33.86a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.18 0.22
SE± for CM x R = 0.25 0.31
C.V (%) 4.66 3.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (46):

Effect of farmyard manure, chicken manure and their interactions on fruit setting (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>64.23c</td>
<td>76.01a</td>
<td>70.12b</td>
<td>87.31a</td>
<td>91.15a</td>
<td>89.23a</td>
</tr>
<tr>
<td>FYM1</td>
<td>71.23b</td>
<td>76.51a</td>
<td>73.87a</td>
<td>81.89a</td>
<td>84.19a</td>
<td>83.04b</td>
</tr>
<tr>
<td>Means</td>
<td>67.73b</td>
<td>76.26a</td>
<td>84.60b</td>
<td>87.67a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.11

SE± for FYM x CM = 0.23

C.V (%)  5.06  5.87

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
**Table (47):**

Effect of phosphorus, rhizobium inoculation and their interactions on fruit setting (％) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>74.09a</td>
<td>74.27a</td>
<td>74.18a</td>
<td>77.69c</td>
</tr>
<tr>
<td>R1</td>
<td>67.89a</td>
<td>71.72a</td>
<td>69.81b</td>
<td>86.35b</td>
</tr>
<tr>
<td>Means</td>
<td>70.99b</td>
<td>72.99a</td>
<td>82.02b</td>
<td>90.26a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.11 0.16
SE± for P x R = 0.23 0.32
C.V (％) 5.06 5.87

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (48):

Effect of farmyard manure, chicken manure and their interactions on number of seeds per pod of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>5.07a</td>
<td>5.2a</td>
<td>5.18a</td>
<td>5.07a</td>
<td>5.05a</td>
<td>5.06b</td>
</tr>
<tr>
<td>FYM1</td>
<td>5.19a</td>
<td>5.17a</td>
<td>5.18a</td>
<td>5.22a</td>
<td>5.23a</td>
<td>5.22a</td>
</tr>
<tr>
<td>Means</td>
<td>5.19a</td>
<td>5.23a</td>
<td>5.14a</td>
<td>5.14a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.06 0.05
SE± for FYM x CM = 0.09 0.07

C.V (%)  6.69  5.15

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (49):

Effect of phosphorus, rhizobium inoculation and their interactions on number of seeds per pod of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>R0</td>
<td>5.14a</td>
<td>5.13a</td>
<td>5.14a</td>
<td>5.03a</td>
<td>5.11a</td>
</tr>
<tr>
<td>R1</td>
<td>5.14a</td>
<td>5.32a</td>
<td>5.23a</td>
<td>5.14a</td>
<td>5.27a</td>
</tr>
<tr>
<td>Means</td>
<td>5.14a</td>
<td>5.23a</td>
<td>5.09a</td>
<td>5.19a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.06  
SE± for P x R = 0.09

C.V (%) 6.69 5.15

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
4.4.5 100-Seed weight:

Farmyard manure had significant increase and decrease in 100-seed weight in the first and second seasons respectively, whereas chicken manure had such increase in the second season only. On the other hand, the interaction between farmyard manure and chicken manure showed significant effect on this parameter in both seasons. The highest 100-seed weight was given by the combination FYM1 x CM1 in both seasons (Table 50).

Rhizobium inoculation showed no significant effect on 100-seed weight in both seasons. On the other hand, the interaction between farmyard manure and rhizobium inoculation had significant effect on this parameter in both seasons. The highest 100-seed weight was given by the combinations FYM1xR0 and FYM0xR1 in the first and second season respectively (Table 51).

Phosphorus showed no significant effect on 100-seed weight in both seasons. On the other hand, the interaction between chicken manure and phosphorus had significant effect on this parameter in both seasons. The highest 100-seed weight was given by the combinations CM0xP0 and CM1xP1 in the first and second season respectively (Table 52).

4.4.6 Seed yield (ton/ha.):

Farmyard manure had no significant effect on seed yield in both seasons, whereas chicken manure caused significant increase in this character in the first season only (Table 53).

Neither phosphorus nor rhizobium inoculation had significant effect on seed yield in both seasons (Table 54).

The interaction between farmyard manure and rhizobium inoculation showed significant effect on seed yield in the second season only, where the highest seed yield was given by the combination FYM0xP1 (Table 55).
Table (50):

Effect of farmyard manure, chicken manure and their interactions on 100-seed weight (g) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
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<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
</tr>
<tr>
<td>FYM0</td>
<td>25.05a</td>
<td>24.47ab</td>
<td>24.76b</td>
<td>24.30a</td>
</tr>
<tr>
<td>FYM1</td>
<td>25.13a</td>
<td>25.64a</td>
<td>25.38a</td>
<td>23.06b</td>
</tr>
<tr>
<td>Means</td>
<td>25.09a</td>
<td>25.05a</td>
<td>23.74b</td>
<td>24.34a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.16 0.19

SE± for FYM x CM = 0.22 0.28

C.V (%) 3.55 4.67

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (51):

Effect of farmyard manure, rhizobium inoculation and their interactions on 100-seed weight (g) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>24.58b</td>
<td>24.94b</td>
<td>24.76b</td>
<td>24.26a</td>
<td>24.50a</td>
<td>24.39a</td>
</tr>
<tr>
<td>FYM1</td>
<td>25.78a</td>
<td>24.99b</td>
<td>25.38a</td>
<td>24.31a</td>
<td>23.07b</td>
<td>23.70b</td>
</tr>
<tr>
<td>Means</td>
<td>25.18a</td>
<td>24.96a</td>
<td>24.29a</td>
<td>23.79a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.16  0.19
SE± for FYM x R = 0.22  0.28
C.V (%)  3.55  4.67

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (52):

Effect of chicken manure, phosphorus and their interactions on 100-seed weight (g) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>25.46a</td>
<td>24.72ab</td>
<td>25.09a</td>
<td>24.18a</td>
</tr>
<tr>
<td>CM1</td>
<td>24.97a</td>
<td>25.13a</td>
<td>25.05a</td>
<td>23.86b</td>
</tr>
<tr>
<td>Means</td>
<td>25.22a</td>
<td>24.93a</td>
<td>24.02a</td>
<td>24.06a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.16 0.19
SE± for CM x P = 0.22 0.28
C.V (%) 3.55 4.67

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (53):

Effect of farmyard manure, chicken manure and their interactions on seed yield (ton/ha) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.48a</td>
<td>1.78a</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.36a</td>
<td>1.82a</td>
</tr>
<tr>
<td>Means</td>
<td>1.42b</td>
<td>1.80a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.07 0.05

SE± for FYM x CM = 0.09 0.08

C.V (%) 23.24 16.13

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (54):

Effect of phosphorus, rhizobium inoculation and their interactions on seed yield (ton/ha) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>1.48a</td>
<td>1.56a</td>
<td>1.52a</td>
<td>1.73a</td>
</tr>
<tr>
<td>R1</td>
<td>1.69a</td>
<td>1.71a</td>
<td>1.70a</td>
<td>1.90a</td>
</tr>
<tr>
<td>Means</td>
<td>1.58a</td>
<td>1.63a</td>
<td>1.82a</td>
<td>1.90a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.07
SE± for P x R         = 0.09
C.V (%)  23.24    16.13

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (55):

Effect of farmyard manure and rhizobium inoculation interactions on seed yield (ton/ha) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
</tr>
<tr>
<td>FYM0</td>
<td>1.53a</td>
<td>1.73a</td>
<td>1.63a</td>
<td>1.74b</td>
</tr>
<tr>
<td>FYM1</td>
<td>1.64a</td>
<td>1.54a</td>
<td>1.59a</td>
<td>1.88a</td>
</tr>
<tr>
<td>Means</td>
<td>1.58a</td>
<td>1.63a</td>
<td>1.82a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.07 0.05
SE± for FYM x R = 0.09 0.08
C.V (%) 23.24 16.13

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (56) shows significant interaction between chicken manure and rhizobium inoculation on seed yield in the first season, where the highest seed yield was given by the combination CM1xR1.

**4.4.7 Harvest index (%):**

Chicken manure caused significant increase in harvest index in the second season only, whereas phosphorus had no significant effect on this character in both seasons. On the other hand, the interaction between chicken manure and phosphorus had significant effect on harvest index in the second season, where the highest harvest index was given by the combination CM1xP1 (Table 57).

Neither farmyard manure nor rhizobium inoculation had significant effect on harvest index in both seasons (Table 58).

**4.5 Chemical composition:**

**4.5.1 Leaf protein content (%):**

Farmyard manure significantly increased leaf protein content in the second season, whereas rhizobium inoculation had no significant effect on this character in both seasons. Moreover, the interaction between farmyard manure and rhizobium inoculation showed significant effect on leaf protein content in both seasons. The highest leaf protein content was given by the combination FYM1 x R0 in both seasons (Table 59).

The results showed no significant effect of chicken manure or phosphorus on leaf protein content in both seasons. However, the interaction between chicken manure and phosphorus showed significant effect on leaf protein content in the first season, where the highest leaf protein content was given by the combination CM1xP0 (Table 60).

**4.5.2 Leaf phosphorus content (%):**

None of the treatments had significant effect on leaf phosphorus content in both seasons (Tables 61 and 62).
Table (56):

Effect of chicken manure and rhizobium inoculation interactions on seed yield (ton/ha) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>CM0</td>
<td>1.41bc</td>
<td>1.42bc</td>
</tr>
<tr>
<td>CM1</td>
<td>1.62b</td>
<td>1.98a</td>
</tr>
<tr>
<td>Means</td>
<td>1.52a</td>
<td>1.70a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.07 0.05
SE± for CM x R = 0.09 0.08
C.V (%) = 23.24 16.13

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (57):
Effect of chicken manure, phosphorus and their interactions on harvest index (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
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<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>150.47a</td>
<td>136.66a</td>
<td>143.56a</td>
<td>75.23b</td>
</tr>
<tr>
<td>CM1</td>
<td>141.50a</td>
<td>140.13a</td>
<td>140.82a</td>
<td>81.08b</td>
</tr>
<tr>
<td>Means</td>
<td>145.98a</td>
<td>138.39a</td>
<td>78.15a</td>
<td>81.63a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.75  1.96
SE± for CM x P = 1.49     2.77
C.V (%)  16.79  13.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (58):

Effect of farmyard manure, rhizobium inoculation and their interactions on harvest index (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/026</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
</tr>
<tr>
<td>FYM0</td>
<td>135.28a</td>
<td>140.08a</td>
<td>137.68a</td>
<td>76.22a</td>
</tr>
<tr>
<td>FYM1</td>
<td>145.29a</td>
<td>148.09a</td>
<td>146.70a</td>
<td>79.60a</td>
</tr>
<tr>
<td>Means</td>
<td>140.29a</td>
<td>144.09a</td>
<td></td>
<td>77.91a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.75 1.96
SE± for FYM x R = 1.49 2.77
C.V (%) 16.79 13.90

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
**Table (59):**

Effect of farmyard manure, rhizobium inoculation and their interactions on leaf protein content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
</tr>
<tr>
<td>FYM0</td>
<td>18.66ab</td>
<td>20.41a</td>
<td>19.54a</td>
<td>11.64ab</td>
</tr>
<tr>
<td>FYM1</td>
<td>21.23a</td>
<td>18.93ab</td>
<td>20.08a</td>
<td>13.20a</td>
</tr>
<tr>
<td>Means</td>
<td>19.95a</td>
<td>19.67a</td>
<td>12.42a</td>
<td>12.20a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.54 0.25
SE± for FYM x R = 0.76 0.35
C.V (%) 13.27 9.91

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (60):

Effect of chicken manure, phosphorus and their interactions on leaf protein content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>18.40ab</td>
<td>20.27a</td>
<td>19.34a</td>
<td>12.37a</td>
</tr>
<tr>
<td>CM1</td>
<td>21.17a</td>
<td>19.39a</td>
<td>20.28a</td>
<td>12.82a</td>
</tr>
<tr>
<td>Means</td>
<td>19.79a</td>
<td>19.83a</td>
<td>12.60a</td>
<td>12.03a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.54  0.25
SE± for CM x P = 0.76  0.35
C.V (%)  13.27  9.91

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (61):

Effect of farmyard manure, chicken manure and their interactions on leaf phosphorus content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
</tr>
<tr>
<td>FYM0</td>
<td>0.37a</td>
<td>0.32a</td>
<td>0.35a</td>
<td>0.13a</td>
<td>0.11a</td>
<td>0.12a</td>
</tr>
<tr>
<td>FYM1</td>
<td>0.28a</td>
<td>0.39a</td>
<td>0.34a</td>
<td>0.13a</td>
<td>0.12a</td>
<td>0.13a</td>
</tr>
<tr>
<td>Means</td>
<td>0.33a</td>
<td>0.36a</td>
<td></td>
<td>0.13a</td>
<td>0.12a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.06
SE± for FYM x CM = 0.08
C.V (%) = 69.20

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (62):

Effect of phosphorus, rhizobium inoculation and their interactions on leaf phosphorus content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>0.34a</td>
<td>0.37a</td>
<td>0.36a</td>
<td>0.12a</td>
</tr>
<tr>
<td>R1</td>
<td>0.32a</td>
<td>0.33a</td>
<td>0.33a</td>
<td>0.11a</td>
</tr>
<tr>
<td>Means</td>
<td>0.33a</td>
<td>0.35a</td>
<td>0.12a</td>
<td>0.13a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.06  0.01
SE± for P x R = 0.08  0.02
C.V (%) 69.20  42.49

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
4.5.3 Seed protein content (%):
Farmyard manure had no significant effect on seed protein content in both seasons, whereas chicken manure significantly increased seed protein content in the second season only (Table 63).

Neither phosphorus nor rhizobium inoculation had significant effect on seed protein content in both seasons (Table 64).

4.5.4 Seed phosphorous content(%):
Farmyard manure and chicken manure caused significant increase in seed phosphorus content in the first season only (Table 65). On the other hand, phosphorus and rhizobium inoculation showed no significant effect on seed phosphorus content in both seasons (Table 66).

4.6 Soil analysis:
4.6.1 Soil nitrogen content (%):
Farmyard manure, chicken manure, phosphorus or rhizobium inoculation showed no significant effect on soil nitrogen content at 0-30 cm and 30-60cm depths in both seasons (Tables 67, 68, 69 and 70).

There was significant interaction between chicken manure and phosphorus on soil nitrogen content at 30-60 cm depth in the first season only, where the highest soil nitrogen content was given by the combination CM1xP0 (Table 68).

Table (69) shows significant interaction between phosphorus and rhizobium inoculation on soil nitrogen content at 0-30 cm depth in the second season only. The highest soil nitrogen content was given by the combination P0xR1.

4.6.2 Soil phosphorus content (ppm):
Farmyard manure and chicken manure caused significant increase in soil phosphorus content at 0-30 cm depth in the first season, whereas phosphorus and rhizobium inoculation showed no significant effect on
Table (63):

Effect of farmyard manure, chicken manure and their interactions on seed protein content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>CM0</th>
<th>CM1</th>
<th>Means</th>
<th>CM0</th>
<th>CM1</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYM0</td>
<td>18.94a</td>
<td>18.36a</td>
<td>18.65a</td>
<td>24.72a</td>
<td>27.05a</td>
<td>25.89a</td>
</tr>
<tr>
<td>FYM1</td>
<td>18.13a</td>
<td>19.37a</td>
<td>18.75a</td>
<td>24.68a</td>
<td>26.80a</td>
<td>25.74a</td>
</tr>
<tr>
<td>Means</td>
<td>18.54a</td>
<td>18.87a</td>
<td>24.70b</td>
<td>26.93a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.37  0.47
SE± for FYM x CM= 0.53  0.66
C.V (%)  9.81  8.89

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (64):

Effect of phosphorus, rhizobium inoculation and their interactions on seed protein content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>18.96a</td>
<td>18.65a</td>
<td>18.81a</td>
<td>25.49a</td>
</tr>
<tr>
<td>R1</td>
<td>17.93a</td>
<td>19.25a</td>
<td>18.59a</td>
<td>26.07a</td>
</tr>
<tr>
<td>Means</td>
<td>18.45a</td>
<td>18.95a</td>
<td>25.78a</td>
<td>25.85a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.37 0.47
SE± for P x R = 0.53 0.66
C.V (%) 9.81 8.89

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
### Table (65):

Effect of farmyard manure, chicken manure and their interactions on seed phosphorus content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>0.43a</td>
<td>0.55a</td>
<td>0.49b</td>
<td>0.42a</td>
<td>0.39a</td>
</tr>
<tr>
<td>FYM1</td>
<td>0.53a</td>
<td>0.66a</td>
<td>0.60a</td>
<td>0.38a</td>
<td>0.42a</td>
</tr>
<tr>
<td>Means</td>
<td>0.48b</td>
<td>0.61a</td>
<td>0.40a</td>
<td>0.41a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.03  
SE± for FYM x CM = 0.04  
C.V (%)  
23.28  
30.62

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (66):

Effect of phosphorus, rhizobium inoculation and their interactions on seed phosphorus content (%) of common bean for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>0.56a</td>
<td>0.51a</td>
<td>0.54a</td>
<td>0.39a</td>
</tr>
<tr>
<td>R1</td>
<td>0.54a</td>
<td>0.57a</td>
<td>0.56a</td>
<td>0.40a</td>
</tr>
<tr>
<td>Means</td>
<td>0.55a</td>
<td>0.54a</td>
<td>0.40a</td>
<td>0.42a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.03  
SE± for P X R = 0.04

C.V (%)  
23.28  
30.62

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (67):

Effect of farmyard manure, chicken manure and their interactions on soil nitrogen content (%) 0-30 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FYM0</td>
<td>FYM1</td>
<td>Means</td>
<td>FYM0</td>
<td>FYM1</td>
<td>Means</td>
</tr>
<tr>
<td>CM0</td>
<td>0.062a</td>
<td>0.067a</td>
<td>0.064a</td>
<td>0.072a</td>
<td>0.075a</td>
<td>0.074a</td>
</tr>
<tr>
<td>CM1</td>
<td>0.063a</td>
<td>0.072a</td>
<td>0.068a</td>
<td>0.088a</td>
<td>0.092a</td>
<td>0.090a</td>
</tr>
<tr>
<td>Means</td>
<td>0.062a</td>
<td>0.069a</td>
<td></td>
<td>0.080a</td>
<td>0.083a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.004  0.007

SE± for FYM x CM = 0.006  0.009

C.V (%) 28.57  41.46

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (68):

Effect of chicken manure, phosphorus and their interactions on soil nitrogen content (%) 30-60 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
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<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>0.074ab</td>
<td>0.083a</td>
<td>0.078a</td>
<td>0.083a</td>
</tr>
<tr>
<td>CM1</td>
<td>0.089a</td>
<td>0.079a</td>
<td>0.084a</td>
<td>0.072a</td>
</tr>
<tr>
<td>Means</td>
<td>0.081a</td>
<td>0.081a</td>
<td>0.078a</td>
<td>0.092a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.003 0.006
SE± for CM x P = 0.004 0.009
C.V (%) 17.68 37.20

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (69):

Effect of phosphorus, rhizobium inoculation and their interactions on soil nitrogen (%) 0-30 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
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<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>R0</td>
<td>0.068a</td>
<td>0.072a</td>
<td>0.070a</td>
<td>0.063b</td>
<td>0.091a</td>
</tr>
<tr>
<td>R1</td>
<td>0.062a</td>
<td>0.062a</td>
<td>0.062a</td>
<td>0.096a</td>
<td>0.075a</td>
</tr>
<tr>
<td>Means</td>
<td>0.065a</td>
<td>0.067a</td>
<td></td>
<td>0.080a</td>
<td>0.083a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.004  
SE± for P x R = 0.006  
C.V (%)  = 28.57  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
**Table (70):**

Effect of farmyard manure, rhizobium inoculation and their interactions on soil nitrogen content (%) 30-60 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>FYM0</td>
<td>0.086a</td>
<td>0.079a</td>
</tr>
<tr>
<td>FYM1</td>
<td>0.079a</td>
<td>0.079a</td>
</tr>
<tr>
<td>Means</td>
<td>0.083a</td>
<td>0.079a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.003 0.006
SE± for FYM x R= 0.004 0.009
C.V (%) 17.68 37.20

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
soil phosphorus content at 0-30 and 30-60 cm depths in both seasons (Tables 71, 72, 73 and 74).

There was significant interaction between chicken manure and phosphorus on soil phosphorus content at 0-30 cm depth in the second season, where the highest soil phosphorus content was given by the combination CM1xP0 (Table 71). Moreover, there was significant interaction between chicken manure and phosphorus on soil phosphorus content at 30-60 cm depth in both seasons. The highest soil phosphorus content was given by the combinations CM0xP1 and CM0xP0 (Table 72).

4.6.3 Soil pH:

Farmyard manure, chicken manure, phosphorus or rhizobium inoculation showed no significant effect on soil pH at 0-30 cm and 30-60 cm depths in both seasons (Tables 75, 76, 77 and 78). On the other hand, the interaction between farmyard manure and chicken manure had significant effect on this parameter at 0-30 cm depth in both seasons. The highest soil pH was given by the combination FYM1xCM0 (Table 75).
Table (71):

Effect of chicken manure, phosphorus and their interactions on soil phosphorus content (ppm) 0-30 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
</tr>
<tr>
<td>CM0</td>
<td>4.63a</td>
<td>4.98a</td>
</tr>
<tr>
<td>CM1</td>
<td>6.68a</td>
<td>5.84a</td>
</tr>
<tr>
<td>Means</td>
<td>5.66a</td>
<td>5.41a</td>
</tr>
</tbody>
</table>

SE± for main effect= 0.30  0.40
SE± for CM x P = 0.42  0.57
C.V (%)  26.62  34.36

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (72):

Effect of chicken manure, phosphorus and their interactions on soil phosphorus content (ppm) 30-60 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>CM0</td>
<td>6.57b</td>
<td>10.05a</td>
<td>8.31a</td>
<td>7.21a</td>
</tr>
<tr>
<td>CM1</td>
<td>8.04b</td>
<td>7.21b</td>
<td>7.63a</td>
<td>4.83b</td>
</tr>
<tr>
<td>Means</td>
<td>7.30a</td>
<td>8.63a</td>
<td>6.02a</td>
<td>5.18a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.67 0.34
SE± for CM x P = 0.95 0.48

C.V (%) 41.75 29.45

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
**Table (73):**

Effect of farmyard manure, rhizobium inoculation and their interactions on soil phosphorus content (ppm) 0-30 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
<td>Means</td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>FYM0</td>
<td>4.58a</td>
<td>5.29a</td>
<td>4.94b</td>
<td>5.87a</td>
<td>5.33a</td>
</tr>
<tr>
<td>FYM1</td>
<td>6.08a</td>
<td>6.15a</td>
<td>6.11a</td>
<td>5.62a</td>
<td>6.11a</td>
</tr>
<tr>
<td>Means</td>
<td>5.33a</td>
<td>5.72a</td>
<td>5.74a</td>
<td>5.72a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.30 0.40
SE± for FYM x R = 0.42 0.57
C.V (%) 26.26 34.36

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (74):

Effect of farmyard manure, rhizobium inoculation and their interactions on phosphorus content (ppm) 30-60 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R0</td>
<td>R1</td>
</tr>
<tr>
<td>FYM0</td>
<td>8.42a</td>
<td>7.58a</td>
</tr>
<tr>
<td>FYM1</td>
<td>8.64a</td>
<td>7.23a</td>
</tr>
<tr>
<td>Means</td>
<td>8.53a</td>
<td>7.40a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.67 0.34
SE± for FYM x R = 0.95 0.48
C.V (%) = 41.75 29.45

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (75):

Effect of farmyard manure, chicken manure and their interactions on soil pH 0-30 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th></th>
<th>2005/06</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
<td>Means</td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>7.97a</td>
<td>8.06a</td>
<td>8.01a</td>
<td>7.97a</td>
<td>8.06a</td>
</tr>
<tr>
<td>FYM1</td>
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<td>7.91ab</td>
<td>8.00a</td>
<td>8.09a</td>
<td>7.90b</td>
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<tr>
<td>Means</td>
<td>8.03a</td>
<td>7.99a</td>
<td>8.03a</td>
<td>7.97a</td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.04
SE± for FYM x CM = 0.06
C.V (%) = 2.41

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (76):  
Effect of farmyard manure, chicken manure and their interactions on soil pH 30-60 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM0</td>
<td>CM1</td>
</tr>
<tr>
<td>FYM0</td>
<td>8.33a</td>
<td>8.38a</td>
</tr>
<tr>
<td>FYM1</td>
<td>8.42a</td>
<td>8.40a</td>
</tr>
<tr>
<td>Means</td>
<td>8.38a</td>
<td>8.39a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.02  0.04  
SE± for FYM x CM = 0.03  0.06  
C.V (%)  1.38  2.36  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (77):

Effect of phosphorus, rhizobium inoculation and their interactions on soil pH 0-30 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
<th>2004/05</th>
<th>2005/06</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
<td>P0</td>
<td>P1</td>
<td>Means</td>
</tr>
<tr>
<td>R0</td>
<td>7.97a</td>
<td>7.99a</td>
<td>7.98a</td>
<td>7.97a</td>
<td>7.99a</td>
<td>7.98a</td>
</tr>
<tr>
<td>R1</td>
<td>8.02a</td>
<td>8.05a</td>
<td>8.04a</td>
<td>8.02a</td>
<td>8.04a</td>
<td>8.03a</td>
</tr>
<tr>
<td>Means</td>
<td>7.99a</td>
<td>8.02a</td>
<td>7.99a</td>
<td>8.02a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SE± for main effect = 0.04

SE± for P  X  R = 0.06

C.V (%) 2.41 2.45

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
Table (78):  
Effect of phosphorus, rhizobium inoculation and their interactions on soil pH 30-60 cm depth for 2004/05 and 2005/06 seasons.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
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<tr>
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<td>Means</td>
<td>P0</td>
</tr>
<tr>
<td>R0</td>
<td>8.44a</td>
<td>8.34a</td>
<td>8.39a</td>
<td>8.16a</td>
</tr>
<tr>
<td>R1</td>
<td>8.40a</td>
<td>8.39a</td>
<td>8.40a</td>
<td>8.31a</td>
</tr>
<tr>
<td>Means</td>
<td>8.42a</td>
<td>8.73a</td>
<td>8.24a</td>
<td>8.26a</td>
</tr>
</tbody>
</table>

SE± for main effect = 0.02 0.04  
SE± for P X R = 0.03 0.06  
C.V (%) 1.38 2.36  

Means followed by similar letter(s) in the same season are not significantly different at 0.05 level of probability according to DMRT.
5.1 Nodulation:

Farmyard manure and chicken manure had significantly decreased number of nodules per plant and increased the percentage of effective nodules. In addition farmyard manure significantly decreased nodule dry weight, whereas chicken manure increased nodule dry weight. Lack of response of nodulation to farmyard manure could be due to unfavorable changes in the soil environment such as increased salinity, pH and/or change in the soil microorganism populations, which could interfere with the infection process. This is supported by the findings of Nitta (1991) who showed that, the diversity of root micro flora was increased by farmyard manure application. Moreover, increase in the soil temperature resulting from decomposition of farmyard manure might have adversely affected the nodulating bacteria.

Phosphorus significantly decreased nodule number in the first season, but significantly increased it in the second season. In addition phosphorus significantly increased percentage of effective nodule at 10th week from sowing in the first season. Also phosphorus significantly decreased nodule dry weight in the first season and showed slight but insignificant effect on nodule dry weight in the second season. Phosphorus has low solubility and thus, its effect will be manifested at later stages of growth. Singh et al., (1989) reported that, nitrogen application and /or inoculation and phosphorus treatments increased nodulation. Phosphorus enhances root development and rhizobium activity by providing biological energy (ATP) and this will enhance nodule formation. Phosphorus has been shown to promote the formation of nodules and pods in legumes (Buttery, 1969; Dadson and Acquaah,
Phosphorus is essential for nodulation and required in high concentration in nodule development and function. The inconsistent effect of phosphorus on nodulation could be attributed to the low phosphorus availability in the alkaline soils at the experimental site. This fact supported the finding of Hendrix (1967) who found that, at pH 4.0 bean plants absorbed phosphate at a 10-fold higher rate than at pH 8.7 and the rate of phosphate uptake declined rapidly with increasing pH. Mengel and Kirkby (1979) reported that, the decrease in phosphorus uptake occurred due to the shift in the $\text{HPO}_4^{2-}/\text{H}_2\text{PO}_4^-$ ratio in the nutrient solution. Graham (1981) showed that, phosphorus is the most important factor limiting $\text{N}_2$ fixation in common bean plants. Poor nodulation and poor plant vigour have been observed in beans grown in soils low in extractable phosphorus (Amijee and Giller, 1998). Wang et al.,(1999) stated that, phosphorus deficiency decreased phosphorus uptake and inhibited plant growth.

Rhizobium inoculation significantly enhanced total number of nodules. Weiser (1984) stated that, nodule number and dry weight of common bean were increased with inoculation. Vessey (2004) found that, inoculation of grain and forage seeds at planting is generally recommended to maximize the potential for nodulation and nitrogen fixation in these crops. Inoculation showed slight but insignificant decrease in percentage of effective nodules and nodule dry weight. The effects of inoculation on nodulation are in agreement with those reported by (Mand et al., 1991; Suman et al., 1995) who stated that, inoculation increased the number of nodules per plant. The response to inoculation in this study was low and this was probably due to existence of indigenous and ineffective rhizobium strains that compete with the inoculant strain. Also unfavorable soil conditions (poor aeration and/or alkaline pH) may have further reduced nodulation. Lack of response to rhizobium
inoculation has been observed by Montalegre and Graham (1996) who attributed it to the presence of numerous, ineffective indigenous rhizobia. According to McLughin and Duncan (1985) competition between rhizobia strains in the soil is a common phenomenon as the introduced inoculum strains compete with the indigenous rhizobia for infection sites. Reduced nodulation after flowering indicates a process of nodule senescence, noticed in every genotype but at different degrees. With the onset of bean pod filling, competition for photosynthates between nodules and pods becomes important, thus reducing nodule growth and activity (Piha and Munns, 1983). Nodule initiation and nodule development can be restricted in parts of bean root system at pod filling (Vikman and Vessey, 1993).

5.2 Vegetative attributes:

Farmyard manure caused significant increase in plant height, number of branches, leaf area index, root dry weight, shoot dry weight at late stages of growth, but insignificant increase in number of nodes per plant in both seasons. Hashimoto and Yamamoto (1973) reported that, fertilization of beans with farmyard manure yielded the greatest seed, leaf and stem weight at maturity. Also farmyard manure produced excellent growth as shown by the abundance of flowers and good nodulation.

Chicken manure significantly increased plant height, number of branches, leaf area index, number of nodes, shoot dry weight and root dry weight. Positive response of the vegetative attributes of the crop to application of chicken manure may be due to the reduction of soil pH, which improved availability of nutrients such as phosphorous to the plant. Nitrogen and phosphorous uptake as a function of chicken manure application rate, increased progressively with increasing manure rate (Magid et al., 1998).
Application of phosphorus significantly increased plant height, number of branches per plant, leaf area index, number of nodes per plant, shoot dry weight and root dry weight. The main effect of phosphorus fertilization on leguminous crops is exhibited in increased dry matter production and the level of nitrogen in plant tissue (Andrew, 1977). These findings are in agreement with those reported by Menon (1973), Anon (1978) and Singh (1978), who stated that, application of phosphorus generally enhanced the growth of plants.

Rhizobium inoculation caused significant increase in plant height, number of branches per plant, number of nodes per plant and leaf area index and significant decrease in shoot and root dry weight. Vessey (2004) reported that, inoculation of forage and grain legumes with rhizobia is an important process to maximize biological nitrogen fixation capacity in these crops. The previous author also stated that, inoculation has the potential of increasing dry matter yield, nitrogen yield and residual nitrogen level. In addition Habish and Ishag (1974) reported that, inoculation of common bean resulted in enhanced nodulation, plant nitrogen content and plant dry weight. Stafford and Lewis (1980) reported that, plants grown from inoculated seeds were slightly taller, with more nodes and weight than plants grown from non-inoculated seeds.

5.3 Reproductive attributes:

Farmyard manure caused significant increase in days to 50% flowering and significant decrease in number of flowers per plant. Saghin (1998) reported that, application of 20 tons of farmyard manure per hectare increased soil pH by an average of 0.30, and this increase in soil pH may affect availability of phosphorus in the soil, which increases flowers abortion and thus, number of flowers per plant. The inconsistent effect of farmyard manure on the reproductive parameters may be
attributed to the fact that, farmyard manure is not a well-balanced fertilizer being rather low in phosphoric acid and relatively high in nitrogen and potash. This result is in agreement with the findings of Anderson (1957) who found that, mixed farmyard manure contains on average about 0.50% N, 0.25% phosphoric acid and 0.50% potash and he stated that, these amounts seem small when manure is compared with high-grade commercial fertilizers. In addition, farmyard manure deteriorates rapidly in nutritive value when not properly managed. On the other hand, farmyard manure had no significant effect on days to maturity, implying that this character is controlled by genetic factors rather than environmental conditions.

Chicken manure had significant increase in number of days to 50% flowering, number of flowers per plant and days to maturity. These results are in agreement with the finding of Magid et al., (1998), Postma et al., (1998) and Hue and Sobieszczyk, (1999) who stated that, nitrogen and phosphorus uptake as a function of chicken manure application rate, increased progressively with an increasing manurial rate.

Phosphorus caused significant increase in days to 50% flowering and number of flowers per plant, but significant decrease in days to maturity. Martin et al., (1976) stated that, adequate amounts of phosphorus in soils favour rapid plant growth and early fruiting or maturity and often improve the quality of vegetation.

Rhizobium inoculation resulted in significant increase in number of flowers per plant and significant decrease in days to maturity. In addition rhizobium inoculation caused slight but insignificant decrease in days to 50% flowering.

5.4 Yield and yield components:

Farmyard manure showed no significant effect on plant density at harvest, seed yield and harvest index. However, number of pods per plant
was significantly decreased in the second season. On the other hand, fruit setting percentage, seed yield and 100-seed weight showed inconsistent response to farmyard manure application. Farmyard manure had a beneficial effect on the phosphorus availability to the plants. The organic matter usually supplies the soil with phosphorus by the process of mineralization. It also acts as a chelating agent, therefore, preventing the formation of insoluble phosphates. Moreover, the acidic compounds that result from the decomposition of organic matter will lower the high pH of the alkaline soil and consequently increase the availability of mineral forms of phosphorus in the soil. This is supported by Meek et al., (1979) who pointed out that, the rapid fixation of phosphorus in calcareous soils can be reduced by applying organic phosphorus sources. Farmyard manure is also a good source of micronutrients, and it improves availability of such nutrients by modifying soil pH or by chelating (Simpson, 1986).

Chicken manure significantly increased number of pods per plant percentage of fruit setting, 100-seed weight, seed yield and harvest index. Positive response of these attributes to chicken manure application may be due to the reduction of soil pH by the manure that makes the nutrient such as phosphorus more available to the plants. Nitrogen and phosphorus uptake as a function of Chicken manure application rate, increased progressively with an increasing manurial rate (Magid et al., 1994). However, some of these parameters such as plant density at harvest and number of seeds per pod were not significantly affected by chicken manure application.

Phosphorous application significantly increased the number of pods per plant and percentage of fruit setting. Seed yield showed slight but insignificant response to phosphorus. Other parameters such as plant density at harvest, number of seeds/pod, 100-seed weight and harvest
index were not significantly affected by phosphorus application. Tiwana et al., (1994) reported that, plant growth and yield components were increased by application of phosphorus. Root systems were elongated and number of seeds per pod and 100-seed weight were increased, but yields were reduced with greater than 40kg $p_2O_5$/ha.

Rhizobium inoculation significantly increased number of pods per plant and number of seeds per pod. In addition rhizobium inoculation also showed slight but insignificant effect on seed yield and harvest index. Other parameters such as plant density at harvest, number of seeds per pod, 100-seed weight showed no significant difference in response to rhizobium inoculation. This lack of response to inoculation could be due to existence of indigenous ineffective rhizobium strains in the soil, that compete with the inoculant strain.

5.5 Chemical composition:

Farmyard manure significantly increased leaf protein content. Hashimoto and Yamamoto (1973) reported that, farmyard manure produced excellent growth as shown by the abundance of flowers and good nodulation. On the other hand, chicken manure, phosphorus or rhizobium inoculation had no significant effects on leaf protein content.

Farmyard manure, chicken manure, phosphorus or rhizobium inoculation had no significant effects on leaf phosphorus content.

Chicken manure significantly increased seed protein content. Nitrogen and phosphorous uptake as a function of chicken manure application rate, increased progressively with an increasing manurial rate (Magid et al.,1994). On the other hand, farmyard manure and rhizobium inoculation had no significant effect on seed protein content.

Farmyard manure and chicken manure caused significant increase in seed phosphorus content. The effect of farmyard manure on seed phosphorus content may be attributed to improved phosphorus
availability and uptake by the plants. Mengel and Kirkby (1979) reported that, organic matter application often improves the status of available phosphorus for plants. Moreover, supporting evidence was also provided by Abbott and Tucker (1973) who stated that, manure is a valuable source of phosphorus and important to the persistence of phosphorus in calcareous soils. On the other hand, phosphorus and rhizobium inoculation had no significant effect on seed phosphorus content.

Farmyard manure, chicken manure phosphorus or rhizobium showed no significant effect on soil nitrogen content at 0-30cm and 30-60cm depths. Although, farmyard manure and chicken manure showed slight but insignificant increase in soil nitrogen content at 0-30cm depths.

Farmyard manure and chicken manure caused significant increase in soil phosphorus content at 0-30 soil phosphorus content at 0-30cm depth in the first season, whereas phosphorus and rhizobium inoculation showed no significant effect on soil phosphorus content at 0-30cm depth in both seasons. Abbott and Tucker (1973) stated that, manure is a valuable source of phosphorus and important to the persistence of phosphorus in calcareous soils.

Farmyard manure, chicken manure, phosphorus or rhizobium showed no significant effect on soil pH at 0-30cm and 30-60cm depths. Although, phosphorus and rhizobium inoculation showed slight but insignificant increase in soil pH at 0-30cm and 30-60cm depths.
Summary and conclusions

1. The results showed that, percentage of effective nodules, plant height, number of branches per plant, leaf area index, shoot dry weight, root dry weight, days to 50% flowering, fruit setting percentage, number of seeds per pod, 100- seed weight, leaf protein content and seed phosphorous content were significantly increased by application of farmyard manure.

2. Chicken manure application significantly increased the percentage of effective nodules, nodule dry weight, plant height, number of branches per plant, leaf area index, number of nodes per plant, shoot dry weight, root dry weight, days to 50% flowering, number of flowers per plant, days to maturity, number of pods per plant, fruit setting percentage, 100- seed weight, seed yield, harvest index, seed protein and phosphorous content.

3. Phosphorus application significantly increased number of nodules per plant, percentage of effective nodules, plant height, number of branches per plant, leaf area index, number of nodes per plant, shoot dry weight, root dry weight, days to 50% flowering, number of flowers per plant, number of pods per plant and fruit setting percentage.

4. Rhizobium inoculation significantly increased number of nodules per plant, plant height, number of branches per plant, leaf area index, number of nodes per plant, number of flowers per plant, number of pods per plant, fruit setting percentage and number of seeds per pod.

5. Some of the attributes such as plant density at harvest, leaf phosphorus content, soil nitrogen content and soil pH showed no significant response to the treatments.
6. There were significant effects of the interactions between treatments on some growth and yield attributes.

7. This study clearly indicated the importance of organic fertilizers and inoculation as a better alternative to inorganic fertilizers.

8. Further studies are needed in order to consolidate this approach, for example carrying such studies under rainfed conditions and marginal areas.
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Appendix (1):

Mean temperature, relative humidity and rainfall from Shambat Observatory Station during the experiment period.

### Season 2004/2005

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>36.1</td>
<td>19.9</td>
<td>32</td>
</tr>
<tr>
<td>December</td>
<td>31.5</td>
<td>15.1</td>
<td>29</td>
</tr>
<tr>
<td>January</td>
<td>29.3</td>
<td>12.1</td>
<td>25</td>
</tr>
<tr>
<td>February</td>
<td>37.0</td>
<td>17.4</td>
<td>24</td>
</tr>
</tbody>
</table>

### Season 2005/2006

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>35.6</td>
<td>19.6</td>
<td>25</td>
</tr>
<tr>
<td>December</td>
<td>34.1</td>
<td>16.8</td>
<td>34</td>
</tr>
<tr>
<td>January</td>
<td>33.6</td>
<td>15.6</td>
<td>28</td>
</tr>
<tr>
<td>February</td>
<td>35.2</td>
<td>16.1</td>
<td>19</td>
</tr>
</tbody>
</table>
Appendix (2):

Chemical composition of farmyard manure and chicken manure used in the experiment for 2004/05 and 2005/06 seasons.

### Season 2004/2005

<table>
<thead>
<tr>
<th>Sample No</th>
<th>N (%)</th>
<th>P (mg/l)</th>
<th>K (mg/l)</th>
<th>Ca (mg/l)</th>
<th>Mg (mg/l)</th>
<th>Na (mg/l)</th>
<th>Cu (mg/l)</th>
<th>Fe (mg/l)</th>
<th>Mn (mg/l)</th>
<th>Zn (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYM</td>
<td>1.89</td>
<td>22.59</td>
<td>559.65</td>
<td>480</td>
<td>230.4</td>
<td>39.79</td>
<td>0.094</td>
<td>0.413</td>
<td>2.225</td>
<td>0.493</td>
</tr>
<tr>
<td>CM</td>
<td>1.75</td>
<td>28.74</td>
<td>239.85</td>
<td>1152</td>
<td>576</td>
<td>119.83</td>
<td>0.045</td>
<td>0.262</td>
<td>1.385</td>
<td>0.238</td>
</tr>
</tbody>
</table>

### Season 2005/2006

<table>
<thead>
<tr>
<th>Sample No</th>
<th>N (%)</th>
<th>P (mg/l)</th>
<th>K (mg/l)</th>
<th>Ca (mg/l)</th>
<th>Mg (mg/l)</th>
<th>Na (mg/l)</th>
<th>Cu (mg/l)</th>
<th>Fe (mg/l)</th>
<th>Mn (mg/l)</th>
<th>Zn (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYM</td>
<td>1.67</td>
<td>18.45</td>
<td>489.25</td>
<td>393.40</td>
<td>315.70</td>
<td>54.30</td>
<td>0.89</td>
<td>0.514</td>
<td>2.175</td>
<td>0.395</td>
</tr>
<tr>
<td>CM</td>
<td>1.58</td>
<td>20.45</td>
<td>233.6</td>
<td>614.5</td>
<td>396.2</td>
<td>87.75</td>
<td>0.056</td>
<td>0.275</td>
<td>1.266</td>
<td>0.301</td>
</tr>
</tbody>
</table>

Chemical composition of Soil samples before sowing.

<table>
<thead>
<tr>
<th>Sample depth(cm)</th>
<th>Sp pH</th>
<th>Ece ds/m</th>
<th>Ca+Mg mmol+/l</th>
<th>Na mmol+/l</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>54.00</td>
<td>8.75</td>
<td>0.60</td>
<td>4.00</td>
<td>3.00</td>
</tr>
<tr>
<td>30-60</td>
<td>64.00</td>
<td>9.00</td>
<td>0.50</td>
<td>4.80</td>
<td>7.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N0</th>
<th>CaCO3 (%)</th>
<th>Particle Clay</th>
<th>Size Distribution</th>
<th>Nitrogen(%)</th>
<th>P(mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>2.83</td>
<td>40.60</td>
<td>33.90</td>
<td>25.50</td>
<td>0.08</td>
</tr>
<tr>
<td>30-60</td>
<td>3.64</td>
<td>48.00</td>
<td>27.90</td>
<td>24.10</td>
<td>0.06</td>
</tr>
</tbody>
</table>
**Appendix (3):** Determination of crude protein using MicroKjeldhal method:

**1-Procedure:**

a- 1.0 gram of the plant sample was weighed and transferred to Kjeldhal flask.

b- To the sample Kjeldhal catalyst mixture and 25 ml of conc. sulpharic acid were added.

c- The sample was digested for about 3 hours at full heat up to the point that the sample solution was clear.

d- The sample solution was cooled, distilled water was added to make 100 ml of solution and then distilled in the distillation unit as follows:

i - 25 ml of 4% boric acid was put in a conical flask and an indicator was added to it (known as receiver). The colour becomes purple.

ii- 5 ml of plant sample was poured gently through the funnel of the distillation unit and about 10 ml of 40% NaOH solution was added slowly. The receiver colour changed to blue.

iii- The receiver content was titrated against 0.02 HCl to the end point, then the amount of HCl was recorded.

**2-Calculation:**

\[
N\% = \text{Dilution factor} \times \text{titration figure} \times \text{Normality of HCl} \times 14 \times \frac{100}{\text{Weighed of plant sample (g)}}
\]

Crude protein = N\% x 6.25.
Appendix (4): Determination of phosphorus content using Stannous Chloride Reduction Method:

1-Reagents:
- Phosphorus standards (KH$_2$PO$_4$ dissolved in water).
- Ammonium molybdate – sulphuric acid reagent.
- Stannous chloride reagent.

2-Procedure:
Prepare the sample solution and dilute. Pipette 0-15 ml of working standard into 50 ml volumetric flask to give standard range aliquot of sample solution into 50 ml volumetric flask. Dilute until the flask is about two-thirds full. Add 2 ml Ammonium molybdate reagent and mix. Add 2 ml stannous chloride reagent, mix, dilute to volume and leave for 30 minutes. Measure the absorbance at 700nm or with a red filter using water as reference. Prepare the calibration curve from the standards and use it to determine mg P in the sample aliquot.

3-Calculation:

\[
P\% = \frac{\text{mg P from the graph} \times \text{solution volume (ml)}}{10 \times \text{aliquot (ml)} \times \text{sample weight}}\]

Appendix (5): Determination of soil nitrogen:
(Bremer’s method to include nitrates, 1965):

1-Reagents:

1- Conc. Sulphuric acid (N-free) containing 5% salicylic acid.
   (50g salicylic acid in 1 litre H₂SO₄ d=1.84).
2- Sodium thiosulphate-Na₂S₂O₃.
3- Selenium (5g)- Sodium sulphate anhydrous (100g) mixture.
4- Sodium hydroxide(30%w/v)
5- 0.01hydrochloric acid.
6- Boric acid (2%)-indicator solution
   - place 80g of pure boric acid(H₃PO₃) in a 5 litre flask marked to indicate a volume of 4 litres.
   - add about 3,800ml of distilled water H₂O and heat and swirl the flask until the H₃BO₃ dissolved.
   - cool the solution.
   - add 8 ml of mixed indicator solution.
   (i.dissolve 0.089g of bromo-cresol green and 0.066g of methyl red in 100 ml ethanol).
   ii-0.25g methylene blue and 0.75g methyl red dissolved in 1 litre of ethyl alcohol (95%)

2-Procedure:

1- Weigh 1.0g soil (ground and passed through 60 mesh sieve) 50ml.
   Kjeldahl flask or a thick walled, rimless test-tube (25x200mm).
2- Add 5ml of Sulphuric-salicylic acid. Shake and allow to stand for 30 mins with frequent shaking.
3- Add 2.5g Sodium thiosulphate and shake.
4- After 15 mins add selenium mixture and digest till the solution turns clear (about 2.5hrs).
5- Filter the digest using whatman’s filter paper no. 2 into a 100ml volumetric flask and add dist. H₂O to make up to 100ml.
6- Take 10ml aliquot and put into distillation flask.
7- Add 10ml 30% NaOH.
8- Distill and collect the ammonia in 10ml boric acid (in a 50 ml Erlenmeyer flask).
9- Titrate the boric acid solution with 0.01 N HCl. The solution will turn from green to red at the endpoint.
10- Do duplicate blanks.

3- Calculation:

Let the concentration of nitrogen in the 100ml of made up digest be x ppm. Then in 100ml there will be 100x ug of N. This has come from Y mg of soil material. Therefore,

\[
N\% = \frac{100x}{10^6} \times \frac{X}{100} = \frac{X}{100Y}
\]
Appendix (6): Determination of total phosphorus in Soil:

1-Reagents:

- Digestion mixture
- Ammonium molybdate solution
- Ascorbic acid solution
- Stock standard P solution (100 ppm)
- Standard solutions of P for calibration curve
- Digestion

Add to 2.0 g of air dry soil (212mu) in a Kjeldhal flask, 6ml of the H$_2$SO$_4$-HClO$_4$ mixture and 2 glass beads. Digest in a heater for 2 hours at moderate heat. Where necessary a further 1 ml of acid mixture is added to wash down the undigested material at the neck of the flask. Cool, transfer into a 100 ml volumetric flask and make up to volume with water. Filter through a whatman,s No. 2 filter paper and collect about 30ml for analysis.

- Determination of P in the digest

Pipette 10ml (or appropriate aliquot) of the digest into a 50ml Volumetric flask. Add 10ml of ammonium molybdate solution followed by

5 ml of ascorbic acid and make up to volume with water.

Mix the solution thoroughly. Allow the blue colour to develop for 5 min before measuring its intensity in an absorptiometer using red filter (660mu) and a 4cm cell).

- P calibration curve

Pipette into 50ml volumetric flasks 10ml of each of the standard p Solution.

Add 10ml of the molybdate solution followed by the ascorbic acid solution and determine the colour intensity as given above.
3- Calculation:

Let the concentration of the extract be $v$ ppm

Total $p$ in soil (ppm) = 50 $v$. 
Appendix (7): Determination of Soil pH:

Soil pH is measured with a pH-meter on a suspension of soil in distilled water with a ratio of 2: 5 or 10g. soil in 25 ml distilled water. Its also measured in electrolyte solution (eg. 1N KcL or 0.01M CaCl2) when required.

Apparatus:

Any pH meter with accuracy of greater than 0.55 units

1-Reagents:
- Buffer solution pH 4.0
- Buffer solution pH 7.0
- IN KcL solution (74.6 Kcl/litre distilled H₂o)
  \[ \text{PH/KCL} = 3.2 \]
  \[ \text{PH/H₂O} = 3.6 \]

2-Procedure:
(a) PH/H₂o and KCl
  i- Weigh 10g of soil into a plastic vail.
  ii- Add 25 ml H₂o/ IN Kcl.
  iii- Shake the suspension and leave for 18 hrs.(Overnight)
  iv- Shake and read the pH with a pH-meter.
  V- Wash the electrodes thoroughly with distilled water between
samples. When not in use leave the electrodes standing in water.
  vi  pH in IN Kcl can be determined 15 minutes after
shaking(not18 hrs)

note:
  pH measurements should be reported to one place of decimal and always state whether pH in water or Kcl (i.e pH/ H₂o or pH/Kcl)
**Appendix (8):** Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interaction number of nodules per plant of common bean in 2005 and 2006 seasons.

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C.V(%)  

23.07 21.43 35.75 18.18 20.68 20.60 38.22 33.69

ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.
Appendix (9): Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interactions on percentage of effective nodules per plant of common bean for 2005 and 2006 seasons.

<table>
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C.V(%) 12.87 13.29 9.26 11.32 20.68 20.60 38.22 33.69

ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.

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C.V (%)  
|          | 31.60 | 48.95 | 40.42 | 39.62 | 31.68 | 26.02 | 37.36 | 55.45 |

ns,*, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.
Appendix (11): Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interactions on shoot dry weight (g) of common bean for 2005 and 2006 seasons.

<table>
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<tr>
<th>Source of variation</th>
<th>d.f</th>
<th>Season 4&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 6&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 8&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 10&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 4&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 6&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 8&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>Season 10&lt;sup&gt;th&lt;/sup&gt;W</th>
</tr>
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<tr>
<td>Rep ss</td>
<td>3</td>
<td>1.2*</td>
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<td>53.96**</td>
<td>8.70ns</td>
<td>17.33*</td>
<td>312.82**</td>
<td>111.72ns</td>
<td>789.06ns</td>
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<tr>
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<td>1</td>
<td>1.25ns</td>
<td>63.92**</td>
<td>12.23ns</td>
<td>1.93ns</td>
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<td>22.67ns</td>
<td>2.64ns</td>
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</tr>
<tr>
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<td>117.45**</td>
<td>231.12**</td>
<td>85.56**</td>
<td>23.43*</td>
<td>256.36ns</td>
<td>631.27*</td>
<td>2665.1**</td>
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<td>2.49ns</td>
<td>41.09*</td>
<td>0.61ns</td>
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<td>51.28ns</td>
<td>1618.1**</td>
<td>12684.4**</td>
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<td>37.88*</td>
<td>156.0**</td>
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<td>472.57*</td>
<td>1872.7**</td>
<td>425.39ns</td>
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<td>1.25ns</td>
<td>1.25ns</td>
<td>5.04ns</td>
<td>5.30ns</td>
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<td>122.96ns</td>
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<td>3.12ns</td>
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<td>9.09ns</td>
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<td>96.83**</td>
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<td>2.37ns</td>
<td>335.81ns</td>
<td>3320.6**</td>
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<td>0.07ns</td>
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<td>118.27ns</td>
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<td>2437.9**</td>
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<td>0.90ns</td>
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<td>763.14*</td>
<td>62.02ns</td>
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<td>682.52*</td>
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<td>31.32</td>
<td>25.06</td>
<td>10.96</td>
<td>23.83</td>
<td>27.16</td>
<td>17.04</td>
<td>13.99</td>
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ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.
Appendix (12): Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium Inoculation and their interactions on root dry weight (g) of common bean for 2005 and 2006 seasons.

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<th>Season 2006</th>
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</tr>
<tr>
<td>CM</td>
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<tr>
<td>P</td>
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</tr>
<tr>
<td>R</td>
<td>1</td>
<td>0.094** 0.122* 0.131* 0.189** 0.025 ns 0.119 ns 1.070** 0.016 ns</td>
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<tr>
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</tr>
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<tr>
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<tr>
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<tr>
<td>C.V(%)</td>
<td></td>
<td>17.60 21.79 19.91 11.67 36.27 35.54 11.92 12.71</td>
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</tbody>
</table>

* ns, ** =not significant and significant at 0.05 and 0.01 level of probability, respectively.

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<th>Source of variation</th>
<th>d.f</th>
<th>4&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>6&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>8&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>10&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>4&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>6&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>8&lt;sup&gt;th&lt;/sup&gt;W</th>
<th>10&lt;sup&gt;th&lt;/sup&gt;W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep ss</td>
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<td>0.062 ns</td>
<td>0.062 ns</td>
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<td>0.451**</td>
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<td>0.007 ns</td>
<td>0.005 ns</td>
<td>0.080 ns</td>
<td>0.001 ns</td>
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<td>1</td>
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<td>0.115*</td>
<td>0.329**</td>
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<td>0.006 ns</td>
<td>0.020 ns</td>
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<td>0.004 ns</td>
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<td>0.149 ns</td>
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<td>1.066*</td>
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<tr>
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<td>0.001 ns</td>
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<td>0.001 ns</td>
<td>0.302 ns</td>
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<td>1.005*</td>
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<td>0.003 ns</td>
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<td>0.018</td>
<td>0.11</td>
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C.V(%) 17.12 14.71 10.26 7.25 20.02 20.60 13.36 14.33

ns,*, ** =not significant and significant at 0.05 and 0.01 level of probability, respectively

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<th>Season 2006</th>
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</tr>
<tr>
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<td>9.61**</td>
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<td>10.56**</td>
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<tr>
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<td>96.53**</td>
<td>3.06**</td>
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<td>1</td>
<td>74.39**</td>
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<td>0.56 ns</td>
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<td>5.91</td>
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ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.
X1=Plant height . X2=Number of branches/plant.
X3=Number of nodes/plant.
**Appendix (15):** Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interactions on reproductive attributes of common bean for 2005 and 2006 seasons.

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<td>X2</td>
<td>X3</td>
<td>X1</td>
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<td>X3</td>
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<td>0.97 ns</td>
<td>4.52*</td>
<td>2.31 ns</td>
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<td>2.18 ns</td>
<td>1.89*</td>
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</table>

ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.
X1 = Days to 50% flowering. X2 = Number of flowers/plant. X3 = Days to maturity.
**Appendix (16):** Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interactions on yield and yield components of common bean for 2005 and 2006 seasons.

<table>
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<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>X5</th>
<th>X6</th>
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<td>1.72 ns</td>
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<td>922.030 ns</td>
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<td>305.77**</td>
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<td>0.50 ns</td>
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<td>0.94 ns</td>
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<td>268.76**</td>
<td>0.01 ns</td>
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<td>0.05 ns</td>
<td>15.920 ns</td>
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*ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.*
## Appendix 16. (cont.)

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<th>X3</th>
<th>X4</th>
<th>X5</th>
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</table>

*ns, ** =not significant and significant at 0.05 and 0.01 level of probability, respectively.*

X1=Plant density. X2=Number of pods/plant. X3=Fruit setting(%).
X4=Number of seeds/pod. X5=100-seed weight. X6=Seed yield. X7=Harvest index.

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<td>1</td>
<td>2.76 ns</td>
<td>1.94 ns</td>
<td>0.001 ns</td>
<td>0.004 ns</td>
<td>2.10 ns</td>
<td>5.67 ns</td>
<td>0.001 ns</td>
<td>0.013 ns</td>
</tr>
<tr>
<td>FYMxPxR</td>
<td>1</td>
<td>4.14 ns</td>
<td>30.85*</td>
<td>0.001 ns</td>
<td>0.082*</td>
<td>0.085 ns</td>
<td>0.350 ns</td>
<td>0.001 ns</td>
<td>0.015 ns</td>
</tr>
<tr>
<td>FYMxCMxPxR</td>
<td>1</td>
<td>29.61*</td>
<td>0.143 ns</td>
<td>0.084 ns</td>
<td>0.024 ns</td>
<td>4.54 ns</td>
<td>0.255 ns</td>
<td>0.003 ns</td>
<td>0.001 ns</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>6.91</td>
<td>5.27</td>
<td>0.092</td>
<td>0.016</td>
<td>1.49</td>
<td>3.37</td>
<td>0.003</td>
<td>0.015</td>
</tr>
<tr>
<td>C.V(%)</td>
<td>13.27</td>
<td>8.98</td>
<td>89.20</td>
<td>23.28</td>
<td>9.91</td>
<td>9.81</td>
<td>421.49</td>
<td>30.62</td>
<td></td>
</tr>
</tbody>
</table>

ns*, ** = not significant and significant at 0.05 and 0.01 level oprobability, respectively. X1=Leaf protein. X2= Seed protein. X3= Leaf phosphorus. X4= Seed phosphorus.
Appendix (18): Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interactions on soil chemical compositions (0-30 cm depth) for 2005 and 2006 seasons.

| Source of variation | d.f | Season 2005 | | Season 2006 | |
|---------------------|-----|-------------|----------------------|-------------|
|                     |     | X1 | X2     | X3 | X1 | X2 | X3 |
| Rep ss              | 2   | 0.0001 ns | 0.87 ns | 0.005 ns | 0.0016 ns | 6.36 ns | 0.0032 ns |
| FYM                 | 1   | 0.0001 ns | 16.57** | 0.002 ns | 0.0032 ns | 0.83 ns | 0.0065 ns |
| CM                  | 1   | 0.0006 ns | 24.94** | 0.021 ns | 0.0001 ns | 0.50 ns | 0.0310 ns |
| P                   | 1   | 0.0001 ns | 0.65 ns | 0.011 ns | 0.0001 ns | 6.09 ns | 0.0052 ns |
| R                   | 1   | 0.0008 ns | 1.84 ns | 0.037 ns | 0.001 ns | 0.005 ns | 0.0300 ns |
| FYMxCM              | 1   | 0.0001 ns | 0.75 ns | 0.2002* | 0.0001 ns | 2.76 ns | 0.2296* |
| FYMxP               | 1   | 0.003 ns | 1.54 ns | 0.049 ns | 0.0013 ns | 5.40 ns | 0.0363 ns |
| FYMxR               | 1   | 0.0001 ns | 1.20 ns | 0.021 ns | 0.0001 ns | 3.15 ns | 0.0154 ns |
| CMxP                | 1   | 0.0001 ns | 3.97 ns | 0.094 ns | 0.0001 ns | 18.13* | 0.0752 ns |
| CMxR                | 1   | 0.0001 ns | 3.00 ns | 0.004 ns | 0.0008 ns | 3.91 ns | 0.0016 ns |
| PxR                 | 1   | 0.0001 ns | 0.61 ns | 0.0001 ns | 0.0072* | 0.18 ns | 0.0001 ns |
| FYMxCMxP            | 1   | 0.0001 ns | 0.12 ns | 0.002 ns | 0.0016 ns | 0.11 ns | 0.0001 ns |
| FYMxCMxR            | 1   | 0.0001 ns | 0.71 ns | 0.023 ns | 0.0001 ns | 8.09 ns | 0.0169 ns |
| CMxPxR              | 1   | 0.0001 ns | 0.0001 ns | 0.057 ns | 0.0003 ns | 5.67 ns | 0.0675 ns |
| FYMxPxR             | 1   | 0.0001 ns | 5.07 ns | 0.034 ns | 0.0013 ns | 0.002 ns | 0.0420 ns |
| FYMxCMxPxR          | 1   | 0.0008 ns | 0.91 ns | 0.080 ns | 0.0024 ns | 16.92* | 0.0919 ns |
| Error               | 30  | 0.0004 ns | 2.11 | 0.037 | 0.0011 ns | 3.88 | 0.0384 |
| C.V(%)              |     | 28.57 | 26.26 | 2.41 | 41.46 | 34.36 | 2.45 |

ns, *, ** = not significant and significant at 0.05 and 0.01 level of probability, respectively.  
X1=Soil nitrogen content.  X2=Soil phosphorus content.  X3=Soil pH.
**Appendix (19):** Means squares for the effect of farmyard manure, chicken manure, phosphorus, rhizobium inoculation and their interactions on soil chemical compositions (30-60 cm depth) for 2005 and 2006 seasons.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f</th>
<th>Season 2005</th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>Season 2006</th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep ss</td>
<td>2</td>
<td>0.0002 ns</td>
<td>2.135 ns</td>
<td>0.146**</td>
<td>0.0004 ns</td>
<td>0.376 ns</td>
<td>0.0099 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYM</td>
<td>1</td>
<td>0.0001 ns</td>
<td>0.041 ns</td>
<td>0.017 ns</td>
<td>0.0010 ns</td>
<td>1.268 ns</td>
<td>0.0213 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM</td>
<td>1</td>
<td>0.0004 ns</td>
<td>5.603 ns</td>
<td>0.001 ns</td>
<td>0.0001 ns</td>
<td>6.453 ns</td>
<td>0.0165 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>1</td>
<td>0.0001 ns</td>
<td>21.068 ns</td>
<td>0.035 ns</td>
<td>0.0024 ns</td>
<td>8.333 ns</td>
<td>0.0068 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>1</td>
<td>0.0001 ns</td>
<td>15.188 ns</td>
<td>0.001 ns</td>
<td>0.0010 ns</td>
<td>0.188 ns</td>
<td>0.0221 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYMxCM</td>
<td>1</td>
<td>0.0001 ns</td>
<td>0.068 ns</td>
<td>0.003 ns</td>
<td>0.0001 ns</td>
<td>0.521 ns</td>
<td>0.0005 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYMxP</td>
<td>1</td>
<td>0.0006 ns</td>
<td>48.000*</td>
<td>0.001 ns</td>
<td>0.0008 ns</td>
<td>7.521 ns</td>
<td>0.0003 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYMxR</td>
<td>1</td>
<td>0.0001 ns</td>
<td>0.963 ns</td>
<td>0.002 ns</td>
<td>0.0001 ns</td>
<td>0.0001 ns</td>
<td>0.0005 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMxP</td>
<td>1</td>
<td>0.0010 ns</td>
<td>55.90*</td>
<td>0.016 ns</td>
<td>0.0013 ns</td>
<td>32.67 **</td>
<td>0.0018 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMxR</td>
<td>1</td>
<td>0.0004 ns</td>
<td>1.401 ns</td>
<td>0.001 ns</td>
<td>0.0001 ns</td>
<td>0.701 ns</td>
<td>0.0050 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PxR</td>
<td>1</td>
<td>0.0001 ns</td>
<td>12.813 ns</td>
<td>0.020 ns</td>
<td>0.0037 ns</td>
<td>0.021 ns</td>
<td>0.1553 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYMxCmxP</td>
<td>1</td>
<td>0.0006 ns</td>
<td>0.0133 ns</td>
<td>0.008 ns</td>
<td>0.0001 ns</td>
<td>0.101 ns</td>
<td>0.0001 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FYMxCmxR</td>
<td>1</td>
<td>0.0001 ns</td>
<td>0.0133 ns</td>
<td>0.001 ns</td>
<td>0.0003 ns</td>
<td>1.080 ns</td>
<td>0.0326 ns</td>
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<td></td>
</tr>
<tr>
<td>CMxPxR</td>
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<td>0.00101 ns</td>
<td>17.041 ns</td>
<td>0.008 ns</td>
<td>0.0013 ns</td>
<td>0.270 ns</td>
<td>0.0035 ns</td>
<td></td>
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</tr>
<tr>
<td>FYMxPxR</td>
<td>1</td>
<td>0.0001 ns</td>
<td>6.601 ns</td>
<td>0.033 ns</td>
<td>0.0013 ns</td>
<td>0.853 ns</td>
<td>0.0002 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>0.0002 ns</td>
<td>10.879 ns</td>
<td>0.013 ns</td>
<td>0.0010 ns</td>
<td>2.719 ns</td>
<td>0.0377</td>
<td></td>
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</tr>
<tr>
<td>C.V(%)</td>
<td></td>
<td>17.86</td>
<td>41.75</td>
<td>1.38</td>
<td>37.20</td>
<td>29.45</td>
<td>3.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ns,*, ** =not significant and significant at 0.05 and 0.01 level of probability, respectively.  
X1=Soil nitrogen content.   X2=Soil phosphorus content.   X3=Soil pH.