



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



**Sudan University of Science and Technology
College of Graduate Studies**

**Effects of Organic, Inorganic and Biofertilizers on
Growth and Yield of Faba Bean (*Vicia faba* L.)**

أثر الأسمدة العضوية واللاعضوية والحيوية على نمو وإنتاجية الفول
المصري

*A Thesis submitted in partial fulfillment of the requirements
for the degree of Master Science in (Agronomy)*

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الآية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

(وَأَيُّهُمُ الْمَرِيضُ الْمَيِّتُ أَحْيَيْنَاهَا وَأَخْرَجْنَا مِنْهَا حَبًّا فَمِنْهُ

صَدَقَ اللَّهُ الْعَظِيمُ يَا كُلُونَ)

سورة يس الآية (33)

Dedication

To my darling mother

To my dear father

To my brothers, sisters and all family

To my friends

And all whom help and support me.

Acknowledgement

First of all praise and grateful to Allah, who guided me and gave me strength to finish this work.

Great thanks to Dr. Gafar Ali Farah for his supervision, assistance and guidance during this study.

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ABSTRACT

A Field experiment was conducted at the Demonstration Farm, College of Agricultural Studies, Sudan University of Science & Technology, Shambat during winter season 2017/2018 to study the effects of organic, inorganic and biofertilizers on the growth and yield of faba bean (*Vicia faba* L).

The treatments of experiment were: organic fertilizers (chicken manure 3.6 ton/ha, compost 15 ton/ha), inorganic fertilizer(phosphorus 0.05 ton/ha TSP), biofertilizer (*Rhizobium leguminosarum biovar vicia*) and untreated control. Hudaiba-93 released variety of Faba bean was used in the experiment. The treatments were arranged in Randomized Complete Block Design (RCBD), with four replications. Parameters studied were: plant height (cm), number of leaves/plant, stem diameter (cm), number of nodules, number of pods/plant, seeds number/pod, yield (ton/ha), hundred seed weight (g) and Nutrient use efficiency was calculated. The results showed significant different in plant height (cm) at 30 days, stem diameter at 30 days, number of leaves/plant at two count, number of nodules, number of pods/plant, number of seeds/pod and yield ton/ha, and no significant different in plant height (cm) (at 60,90 days), stem diameter (cm) (at 60 days), and hundred seed weight (g).

Organic fertilizers gave a good results in comparison with the other fertilizers and control.

الخلاصة

أجريت تجربة حقلية بالمزرعة التجريبية بكلية الدراسات الزراعية جامعة السودان للعلوم والتكنولوجيا, شمبات خلال الموسم الشتوي 2017-2018 بغرض دراسة تأثير الأسمدة العضوية والغير عضوية والحيوية على نمو وإنتاجية الفول المصري. استخدمت في هذه التجربة المعاملات الآتية: الأسمدة العضوية (زرق الدواجن 3.6 طن/هكتار, الكمبوست 15 طن/الهكتار), السماد الغير عضوي (الفسفور-سيوبر فوسفات الثلاثي 0.05 طن/الهكتار), السماد الحيوي (بكتيريا الرايزوبيوم) والشاهد, تم استخدام صنف حديدية-93. صممت التجربة بتصميم القطاعات العشوائية الكاملة في 4 مكررات. الصفات التي تمت دراستها هي: طول النبات (سم), عدد الأوراق بالنبات, سمك الساق (سم), عدد العقد الجذرية, عدد القرون في النبات, عدد البذور لكل قرن, الإنتاجية بالطن/هكتار, وزن 100 بذرة وكفاءة استخدام الأسمدة. أوضحت النتائج وجود فروقات معنوية في طول النبات (سم) عند 30 يوم, سمك الساق عند 30 يوم, عدد الأوراق في النبات في القراءتين, عدد العقد, عدد القرون في النبات, عدد البذور لكل قرن والإنتاجية طن/هكتار. ولم توجد فروقات معنوية في طول النبات (سم) عند 60 و90 يوم, سمك الساق عند 60 يوم و وزن الـ100 بذرة بالجرام.

الأسمدة العضوية أعطت أفضل النتائج مقارنة مع بقية الأسمدة والشاهد.

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CHAPTER ONE

INTRODUCTION

Faba bean (*Vicia faba. L*) is one of the most important legume crops used as food for human consumption in developing countries and as animal feed in advanced countries. It is the fourth important pulse crop in the world after dry bean, dry peas and chick peas (Kumarai and Vanleur,2011).

The *Vicia* genus belongs to the Fabaceae family together with lens, pisum and vavilovia (Smykal *et al.*,2015). Faba bean is a winter crop that grows better under cool and moist condition, where as hot and dry weather is unfavorable and could lead to the decrease in the seed yield and quality (Flores *et al.*, 2012). Owing to its numerous uses, great nutritional quality and ability to grow over a broad range of climatic and soil condition, faba bean is appropriate for sustainable agriculture in many marginal areas (Nadal *et al.*, 2003). In Sudan, faba bean is traditionally cultivated in the banks of the Nile River northern of latitude 18-50° N in the Northern and Nile state, where temperature is moderately cooler and winter longer (Salih and Mohammed,1992).

The faba bean world production is approximately 2.4 million metric tons with China being the largest producer with 60% of the total world production (FAO, 2005). In Sudan production of Faba bean was 138 thousand tons in year 2006 (FAO, 2008). Small amount are produced in Khartoum state, Central Sudan and Jebel Mara area in Western Sudan (Salih *et al.*, 1995).

In Sudan, faba bean is one of the primary grown and consumed legume crops, it constitutes to the primary human nutrition, supply high quality proteins essential for a balanced diet for the daily breakfast and dinner of the millions of people who cannot afford meat as source of protein in both rural

and urban areas (Osman *et al.*,2014). Additionally, the crop is an imperative source of income for the farmers in the country (Salih and Mohammed,1992).

Legumes provide nutritionally rich crop residue for animal feed and play a key role in maintaining the soil fertility. They also play a unique role due to their ability of fixing atmospheric nitrogen (Elsheikh ,2011). *Vicia faba* is able to fix nitrogen and it is used in crop rotation. It also increases humus of soil (Peyvast,2002). Depending on the plant density and the field management, this plant is able to fix nitrogen up to 40kg\ha annually (Hashem abadi, 2003).

Faba bean is one of the most efficient nitrogen, fixing legumes and faba bean plants can meet all of their needs through biological nitrogen fixation (BNF) (Herridge *et al.*,2008 and Lindemann, 2016). Nitrogen can be fixed by free living as well as symbiotic and associative microorganisms of all the natural N₂-fixation processes ,the symbiosis between legumes and Rhizobia is by far the most important in terms of quality and also the most energy efficient (TagElsir, 2000).

Biofertilizers inputs containing microorganisms which are capable of mobilizing nutritive elements from non usable form to usable form through biological process. They include mainly the nitrogen fixing, phosphate solubilizing and plant growth, promoting microorganisms (Goel *et al.*,1999) which can fix nitrogen in a symbiotic relationship with legume plant.

Due to the high demand for the crop, new lands of inferior quality are coming into production in these lands (alkaline in reaction) low amount of phosphorus is available to the plant because phosphate ions are almost immobile(Mahdi,1993 and Mirghani,1994).

Phosphate can readily be rendered unavailable to plant roots as it is the most immobile of the major plant nutrients. Its efficiency can be affected by P fertilizer distribution and distance of application from the plant (Eghball Sander,1989). Organic manure has been recognized as effective fertilizer for agricultural production. It improves soil physical chemical and biological properties and released nutrients can be used for growing crops (Risse *et al.*,2001). Among the various natural available sources of organic materials poultry Chicken manure (CM) has long been known the most desirable one because of its high N which is readily available, ranging from 30 to 50% (Nicholson *et al.*, 1996).

The objective of this research is to study the effect of organic, inorganic and biofertilizers on growth and yield of Faba bean under Shambat condition.

CHAPTER TWO

LITRATURE REVIEW

2.1 Background:-

Faba bean (broad bean, horse bean) is a major grain legume widely cultivated in many countries for food and feed purposes (Sillero *et al.*,2010). Its value as a food and feed crop lies in its high lysine –rich protein , vitamin, minerals and carbohydrates (Crepon *et al.*,2010).

The crop is a source of edible protein for food (it is considered as a meat extender or substitute and as a skim -milk substitute), in Asia, Central America and Africa. It is used as a common breakfast food in the Middle East, Mediterranean region, China and Ethiopia (Bond *et al.* ,1985).The crop is also used as feed, worldwide it is third most important feed grain legume after soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) area and production (Mihailovic *et al.*, 2005).

Among the amino acids, the lysine content is high and that of the sulfur amino acids low, compensating in both human and animal diets the opposite values of these amino acids in cereals and explaining the wide use of the mixtures of cereals and legumes in diets from the most remote agricultural times (Bressani and Elias,1988).

The feeding value of faba bean is high, in addition it contributes to soil fertility through biological N₂ –fixation. Interest in faba bean has been reinforced due to the organic farming demand, interest in poultry feed as a replacement for pea in soils infected by *Aphanomyces* (Duc and Marget,2002).

In Sudan, faba bean is grown as an irrigated winter crop in the Northern part of the Sudan (Northern and River Nile states and to limited extent Khartoum), where environmental conditions are suitable for its production than in any other part of the country. Lately, efforts were made to extend its production to nontraditional areas (Gezira, New Halfa, and Rahad) (Stoddard and Bond,1987). Faba bean has been introduced as a cash crop in North Darfur region in the far West, where yields are reasonably high (2.26–3.21 t/ha) (ICARDA 2003).

2.2 Production of faba bean:-

Faba beans are grown in 58 countries. World production of dry faba bean seeds in 1999 to 2003 amounted to 30.90 million tones/year from 20.60 million ha. The main producing country is China (1.9 million tones/year from 1.2 million ha) (FAO,2009).

The world cultivated area in 2007 was 2.5 million ha (Mha) with a total production of about 3.74 million tons (Mt) and an average yield of some 1.5 t/ha, 93% (about 2.3 Mha and 3.6 Mt) being for dry seeds, the rest for vegetable use (FAO,2008).

The annual production in sub-Sahara Africa in 1999 to 2003 was estimated by 510.000 tones, almost entirely from Ethiopia (405.000 tones) and Sudan (100.000 tones) (Mihailovic *et al.*,2005).

In Sudan average faba bean yield is about 1.8 tons/ha with annual fluctuations in different locations and seasons (Stoddard and Bond ,1987). The Northern region of Sudan is considered as one of the main supplier of the crop. The production takes place mainly under farming system of small private pump schemes (Abdalla *et al.*,2015).

2.3 Morphology and description:-

An erect, stiff, glabrous, herbaceous legume reaching 30-80 cm in height, the stem is stout, square and hollow, the plant has a vigorous tap root (FAO,2007). The leaves are alternate, pinnate and consist of 2-6 leaflets each up to 8 cm long, and unlike most other members of the genus, it is without tendrils or with tendrils (Kay,1979, Bond *et al.*,1985).

Flowers are large, white with dark purple markings, borne on short pedicels in clusters of 1-5 on each auxiliary raceme usually between the 5 and 10th, node; 1-4 pods develop from each flower cluster (Bond *et al.*,1985).

2.4 Adaptation and crop ecology:-

Owing to its numerous uses, great nutritional quality and ability to grow over a broad range of climatic and soil conditions, faba bean is appropriate for sustainable agriculture in many marginal areas (Nadal *et al.*,2003).

Singh *et al.*,(2013), stated that as one of the top performing crops under global warming and climate change because of its distinctive capability to excel under most types of climatic situations and broad adaptability to range of soil environments.

Faba bean requires a cool season for best development. It is grown as a winter annual in warm temperate and subtropical areas; hardier cultivars in the Mediterranean region tolerate winter temperatures of -10° c without serious injury whereas the most hardy European cultivars can tolerate up to -15°c , optimum temperatures for production range from 18 to 27°c (Duke,1981).

2.5 Chemical composition of faba bean:-

2.5.1 Proteins:-

The nutritional value of faba bean has been traditionally attributed to high protein content and wide variation of protein content (20-41%) has been reported (Chavan *et al.*,1989). Most of these proteins are globulins(60%), albumins(20%), glutelins (15%), and prolamins (Cubero and Moreno,1983) .

2.5.2 Tannins:-

Tannins were considered to be the main ant nutritional factors reducing faba bean protein digestibility. Zero -tannin genotypes have been reported to be more susceptible to soil –borne diseases (Bond and Duc,1993;Helsper *et al.*,1994).

In general, the whole dried seeds contain (per100g), 344 calories, 10.1% moisture, 1.3 g fat, 59.4 g total carbohydrates, 6.8 g fiber, 3.0 g ash, 104 mg (Ca), 301 mg (P), 6.7 mg (Fe), 8 mg (Na), 1123 mg (K), 0.38 mg thiamine, 0.24 mg riboflavin, 2.1mg niacin, and 162 mg tryptophan (Duke,1981).

2.6 Cultivation of faba bean:-

Even though faba bean has been cultivated in many countries, 60% of total world production comes from China (FAO,1994). In some areas, such as Ethiopia and Sudan , broad bean seeds are broadcast, at seeding time, fields are plowed shallow and seeds are dropped into every second or third furrow, seeds are usually sown 5-10 cm deep in rows 75 cm apart, with seeds 15 cm apart in the rows. Small-seeded cultivars are planted at 90-122 kg\ha, and large-seeded cultivars at 78-90kg \ ha (Duke, 1981).

2.6.1 Harvesting:-

When the crop is meant for dry seed, it is harvested when fully mature, and when grow for consumption as a vegetable, it is harvested green , the

most common harvesting system is to pull and thresh the crop by hand. However, hand harvesting is costly compared to mechanized harvesting (Diekmann and Papazian,1985).

Faba beans are slow to emerge and takes 20 to 25 days, seeds must be in constant contact with moisture until seedlings are well established. The time from seeding to harvest ranges from 80 to 120 days depending upon the cultivars and climatic conditions (Singh *et al.*,2013).

2.7 Fertilization:-

More than half of all African areas are affected by land degradation, making this an urgent development issue for the continent, for example, an estimated US \$ 42 billion in income and 6 million ha of productive land are lost every year due to land degradation and declining agricultural productivity (Bationo *et al.*,2006).

Low soil fertility is considered one of the most important constraints on improved agricultural production (Ayoub,1999). Fertilizers are used to improve fertility and are indispensable for sustained food production. Legumes provide nutritionally rich crop residues for animal feed and play a key role in maintaining the productivity of soil. They also play a unique role due to their ability of fixing atmospheric Nitrogen (Elsheikh,2011). Worldwide, N₂ fixed by nodulated legumes (pulses and oil seeds legumes) is estimated to contribute 21.45 Tg N annually to global agricultural systems (Herridge *et al.*,2008).

Like other legumes, faba bean contributes to sustainable agriculture by fixing atmospheric nitrogen in symbiosis with soil Rhizobia (Van Berkum *et al.*,1995). Globally, the amounts of N₂-fixed by faba bean were estimated in the range from 45 to 300 kg/ha (Smill,1999).

2.7.1 Effect of Rhizobium on faba bean:-

Fixed nitrogen, the conversion of atmospheric nitrogen to ammonium in plant root nodules, is used for plant growth and reproduction as well as chemical and defenses (Arfaoui, 2005& Mishra, 2006). Faba bean commonly establishes effective nitrogen fixation symbiosis with fast-growing Rhizobia of species *Rhizobium leguminosarum* (Allen,1981). Broad bean, roots are one of the most discriminating mutualists, being colonized only by *Rhizobium leguminosarum* *bv. Viciae* Frank (Mutch,2004,Hirsch *et al.*,2001, Ventorino *et al.*,2007).

Biological nitrogen fixation, especially Rhizobia –legumes symbiosis, is one of the alternative solutions and the promising technologies which play an important role in reducing the consumption of chemical N-fertilizers, increasing soil fertility, decreasing the production cost, and eliminating the undesirable pollution impact of chemical fertilizers in the environment (Herridge and Ladha,1995).

Rhizobia are common soil bacteria, but they often fail to produce effective symbiosis with leguminous crops, either because too few are present or because those present are not compatible with the grown legume. In many situations, establishment of effectively nodulated legumes requires the addition of specific Rhizobia in a process known as a Rhizobium inoculation (Mukhtar and Abu Naib,1988, Mahdi,1993). Inoculation of faba bean has been found to increase the shoot and root, dry weight, number of nodules per plant, as well as yield and yield components. It was reported to increase yield and protein content (Babiker *et al.*,1995).

Biofertilizers are very important for countries like Sudan with a predominantly low-inputs agricultural system of production where chemical fertilizers, if available, may not be affordable (Mahdi, 1993).

2.7.2 Effect of phosphorus on faba bean:-

Phosphorus is an essential element for all living organisms, as a component of every living cell, P is indispensable because no other element can replace it in its vital role in many physiological and biochemical processes (FAO, 2008).

Despite its ability in fixing atmospheric nitrogen, an adequate supply of phosphorus early in the life of the plant is important in laying down the reproductive primordia and favor rapid plant growth (Johansen *et al.*, 1991).

Phosphorus is an essential element for plant nutrition; it has to be added to the soil as fertilizer because of its deficiency and low solubility. Phosphorus is found in an insoluble form in soil and hence it is unavailable for plants (Elsheikh, 1993). Phosphate can readily be rendered unavailable to plant roots as it is the most immobile of the major plant nutrients. Its efficiency can be affected by P fertilizer distribution and distance of application from the plant (Eghball Sander, 1989).

Faba bean has the capacity to mobilize soil phosphorus by secretion of acids from its Rhizosphere, and is therefore of important value in low input crop rotation systems (Nuruzzaman *et al.*, 2005). It is known that phosphorus nutrition plays a prime role in growth and development of roots and its role in nodulation, dry matter production, N fixation, and protein synthesis of leguminous crops is vital (Takle, 2015).

Phosphorus is implicated in speeding up maturity and enhancing root-shoot growth ratio, the formation of glycol – phosphate involved in photosynthesis, respiratory metabolism a part from being a part of nucleotides

(RNA,DNA) and phospholipids of membranes and play a role in energy transfer metabolism (ATP, ADP, AMP, pyro- phosphate) (Salisbury, 1992). In Sudan, with the possible exception of nitrogen, no other element has been as critical in crop production as phosphorus (Elsaeed, 1997).

2.7.3 Effect of organic fertilizers on faba bean:-

Chemical and organic fertilizers are an essential process in plant management. Adequate fertilizers led to increase the crop yields, improves the nutrient element concentration in plant tissue and soil macro and micro nutrient status. Chemical fertilizers are expensive and harmful to the environment (Adediran *et al.*, 2004), therefore the addition of organic matter as an alternative to chemical fertilizers is recommended (Oad *et al.*, 2004).

Soil fertility depletion, declining agricultural productivity because of reduction of soil organic matter (SOM), nutrient imbalance, and climate change due to increased greenhouse gases emissions , are major constraints in most tropical agricultural soils (Lai,2015, Pender,2009, Sanchez,2002).

Organic fertilizers coming from fermented and decomposed organic materials are generally nutritious and safe, which play a significant role in plant nutrition as a supplementary and complementary factor for mineral nutrition (Mahajan *et al.*, 2008). Disposal of animal wastes are not regulated with proper guidelines and legislation particularly in developing countries, unlike in the developed world (Westerman and Bicudo, 2005).

The organic matter improves soil structure, reduces soil erosion, helps to store moisture and provides fixation sites for certain plant nutrients. However, unless manure is well stored and composted, much of the initial N content is lost (FAO, 2006).

The positive effects of manures on crop yield have been explained on the basis of Cation exchange between root surfaces and soil colloids (Sharma *et al.*,1990). Continuous and intensive application of organic manure might enhance accumulation of heavy metals in soil particularly: Cu, Zn and Mn along with P and K (Gascho *et al.*, 2001)

2.7.3.1 Effect of Compost:-

Organic manures are composed mainly of waste and residues from plants and animals. They contain much carbon relatively small percentage of plant food, usually those comes from the plant fixed the carbon. In an analysis of organic farming system in Europe, it was found that organic farming increasing microbial biomass by 20-30% (Elawad, 2004).

Compost is highly diverse group of organic soil amendments which provides substantial nutritive fertility to soils , dairy manure compost supplies not only the major nutrients (N, P and K), but also a broad range of secondary nutrients, micronutrients, and organic matter, dairy manure can also improve water and nutrient holding capacity of the soil, reduce erosion, and reduce fluctuation in soil PH. Nutrients in compost products are more stable and are typically released gradually over three or more years, where inorganic fertilizers are generally formulated to released nutrient within a year of application (David *et al.*,2011). Irshad (2002) reported that the application of composted manure fertilizer enhanced plant growth and nutrient uptake compared with non-treated control.

Soil amendment with compost is an agronomical increasing practice as well as an attractive waste management strategy. The addition of mature compost to soil favors plant development and improve soil quality, as well as having a suppressive effect on many soil borne plant pathogens (Erhart *et al* .,1999, Cotxarrera *et al.*,2002, Abdelhamed *et al* 2004).

2.7.3.2 Effect of chicken manure:-

Chicken manure contain as much nitrogen as farm yard manure but richer in Potassium and phosphorus (Cook,1982). Khalil *et al* (2005) reported that addition of chicken manure (CM) into soils had a greater influence on CO_2 - C evolution than the wider C\N ratio organic residues.

According to Elsheikh, (1997), cook ability percentage was only improved by chicken manure. This reflects the role of chicken manure in improving the quality of faba bean seeds.

Forawi *et al.*, (1995) showed that application of chicken manure significantly increased nodulation and dry matter production. Abdelgani *et al.*,(2003) found that the Chicken manure significantly increased yield, shoot and nitrogen content of fenugreek plant (*Trigonella foenumgraecum* L).

The increase is attributable to the role of organic matter in the release of nutrients, notably nitrogen which is necessary for the elongation and cell division and growth and development of plant. The role of organic matter in improving the properties is vital to the soil by increasing number and quality of microbes that increase the readiness of the absorption of most nutrients, which is reflected positively in the general activity of the plant (Sarkar *et al.*, 2004). Therefore fertilizer and plant nutrition research should establish a workable relation between environment preservation and fertilizer (Fageria *et al.*, 2008).

2.8 Nutrient use efficiency (NUE):-

NUE is a critically important concept for evaluating crop production systems and can be greatly impacted by fertilizer management as well as soil – plant and water relationships (Fixen *et al.*,2015). The objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient

losses from the field and supporting agricultural system sustainability through contributions to soil fertility or soil quality components. NUE addresses some but not all aspects of that performance (Mikkelsen *et al.*, 2012).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experiment site:-

The experiment was carried out at the Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, Khartoum North, longitude 32° 32'E, latitude 15° 40'N, and altitude 388m above sea level, during the winter season 2017-2018, to study the effect of organic, inorganic and biofertilizers on growth and yield of faba bean (*Vicia faba*). The treatments were arranged in Randomized Complete Block Design (RCBD).

The climate of this area is described as tropical semiarid, the relative humidity range between 17-27% during dry season and 31-51% during wet season (Adam, 2002). The mean annual rain fall is about 160mm and the mean maximum temperature is more than 40°C in summer and around 20°C in winter (El Nadi and Kher, 1969). The soil type is loamy clay characterized by a deep cracking, and moderately alkaline low permeability and nitrogen content and pH of 7.8-8.5 (Abdel-Hafeez, 2001).

3.2 Materials:-

3.2.1 Plant material:-

The cultivar of Faba bean (*Vicia faba*) used in this experiment was Hudaiba-93 was obtained from Department of Agronomy College of Agricultural studies Sudan University of Science and Technology.

3.2.2 Fertilizers:-

Phosphorus fertilizer as triple super phosphate (TSP), which obtained from Sudan University Of Science and Technology, College of Agricultural

studies, Department of Agronomy. Rhizobium bacteria (*Rhizobium leguminosarum biovarvicea*), was obtained from the National Research Center-Khartoum, as charcoal inoculants.

Organic manure as compost, “Elkhairat” was obtained from Agricultural “Alnuha company” –Bahri, and chicken manure was collected from the poultry farm, Department of Animal production, College of Agricultural studies, Sudan University of Science and Technology.

3.3 Methods:-

3.3.1 Cultural practices:-

The land was ploughed, harrowed, leveled and ridged, then divided to four replicates, each one contain five plots, the plot size was: 9m² (3*3), each plot consists four ridges, 70 cm a part.

The experiment was sown on 26th of November 2017, in holes, manually. The spacing between holes was 20 cm and 3 seeds per hole .Land was irrigated after sowing immediately and then subsequently irrigated every week, hand weeding of the field was carried out after 3 weeks and 5 weeks from sowing. “Aphids” pest appeared after one month from sowing and treated by “Actara” pesticide.

3.3.2 Application of fertilizers:-

All fertilizers were added at 3 days before sowing and after plowing, the fertilizers added on surface and admixed with soil a-good, compost(15ton/ha), chicken manure (3.6 ton/ha), and phosphorus (0.05ton/ha), except Rhizobium inoculant ,which applied at sowing, seeds were mixed with inoculum and few grams of sugar were added to stick the Rhizobium to the seeds and sown immediately. The applied amount of inoculant was estimative depending on number of seeds and method of application, but the adequate amount from Rhizobium inoculant that adding with faba bean in Sudan is (1.2 kg/ha).

3.4 characters studied:-

3.4.1 Growth attributes:-

3.4.1.1 Plant height (cm):-

Six plants were randomly selected from each plot, and plant height (cm), was measured, from the base of the plant on soil surface, to the tip by using Ruler and the mean was achieved.

3.4.1.2 Number of leaves /plant:-

Six plants were selected from each plot and number of leaves per plant was counted and the mean was recorded.

3.4.1.3 Stem thickness (cm):-

Thickness of stem in the same selected plants was measured from each plot, by using String.

3.4.1.4. Nodulation measurement:-

After 11 weeks from sowing, nodulation rate was recorded and number of nodules from 3 plants in each plot was counted randomly.

3.4.2. Reproductive attributes:-

3.4.2.1. Number of pods/plant:-

The total number of pods in the selected plants was counted to determine the mean number of pods per plant after 3 months approximately.

3.4.2.2. Number of seeds/pod:-

Number of seeds were counted after pods desiccated by choosing three pods randomly of each of the selected plant and then the average number was used.

3.4.2.3 100-Seeds weight (g):-

Hundred seeds weigh (g) was estimated from the seed sample, using sensitive balance.

3.4.2.4 Seeds yield/plot (ton/ha):-

One square meter harvested from each plot randomly, then the weight of seeds per gram was obtained using sensitive balance and the yield ton/ha was calculated by converting gram to ton, and meter to hectare.

3.4.2.5 Nutrient use efficiency (NUE):-

Was calculated by using yield and amount of used fertilizers (kg/ha) by this equation:

$$NUE = \frac{Y \text{ kg/ha}}{F \text{ kg/ha}}$$

To evaluate crop production system.

3.5. Statistical analysis:-

Data collected in this study were statistically analyzed using **STATISTiX 8.0** software. The data of each variable were subjected to analysis of variance (**ANOVA**). Least significant different (**L.S.D**) test was used to compare means.

CHAPTER FOUR

RESULTS

4.1 Growth parameters:-

4.1.1 Plant height (cm):-

Statistical analysis showed no significant differences among treatments on plant height counts (60 and 90 days) after sowing, but (Compost) gave the highest plant height compared to the other treatments at (30 days) after sowing (significant increasing), Chicken manure at second count (60 days) and Rhizobium at third count (90 days) from sowing (Table 1).

4.1.2 Number of leaves /plant:-

Analysis of variance showed significant differences among treatments on number of leaves per plant at two sampling occasion (30 days) and (60 days) after sowing, where all fertilizers treatments better than control, which were presented in (Table 2).

4.1.3 Stem Diameter (cm):-

The results of statistical analysis showed no significant differences among fertilizers on stem diameter (cm) at 60 days, however, at 30 days chicken manure increase stem diameter better than control and phosphorus (Table 3).

4.1.4 Number of nodules/plant:-

There were significant differences among treatments on nodules number, phosphorus treatment gave the highest number of nodules than other treatments, lower nodules number were recorded in chicken manure treatment (Table 4).

Table (1): Effects of fertilizers treatments on plant height (cm) of faba bean at different counts:-

Treatment	Plant Height (cm)		
	at 30 days	at 60 days	at 90 days
Compost	33.18 ^a	75.28 ^a	85.21 ^a
Rhizobium	32.06 ^{ab}	74.67 ^a	89.02 ^a
Chicken manure	30.56 ^{ab}	76.28 ^a	87.44 ^a
Control	30.46 ^{ab}	72.75 ^a	84.85 ^a
Phosphorus	29.47 ^b	70.57 ^a	83.47 ^a
L S D	3.52	8.55	7.81
CV%	7.33	7.51	5.90

Means followed by the same letters in the same column are not significantly different at 5% level of LSD.

Table (2): Effect of fertilizers treatments on leaves number of faba bean at two counts:-

Treatment	Number of leaves / plant	
	at 30 Days	at 60 Days
Compost	18.20 ^a	103.86 ^a
Rhizobium	18.11 ^a	97.63 ^{ab}
Chicken manure	17.13 ^{ab}	109.52 ^a
Control	14.85 ^b	88.61 ^b
Phosphorus	17.28 ^a	102.90 ^a
L S D	2.28	13.98
CV%	8.66	9.03

Means followed by the same letters in the same column are not significantly different at 5% level of LSD.

Table (3):Effect of fertilizer treatments on stem diameter (cm) of faba bean at two counts:-

Treatment	Stem Diameter (cm)	
	at 30 days	at 60 days
Compost	0.72 ^{ab}	0.89 ^a
Rhizobium	0.70 ^{ab}	0.90 ^a
Chicken manure	0.74 ^a	0.97 ^a
Control	0.69 _b	0.91 ^a
Phosphorus	0.69 _b	0.89 ^a
L S D	0.04	0.09
CV%	4.07	6.15

Means followed by the same letters in the same column are not significantly different at 5% level of LSD.

Table (4): Effect of fertilizers treatments on nodules number of faba bean:-

Treatment	Number of nodules
Compost	116.05 ^{ab}
Rhizobium	121.05 ^{ab}
Chicken manure	78.80 ^b
Control	115.58 ^{ab}
Phosphorus	141.40 ^a
LSD	61.32
CV%	34.74

Means followed by the same letters in the same column are not significantly different at 5% level of LSD.

4.2 Yield parameters:-

4.2.1 Number of pods/plant:-

Analysis of variance showed that there were significant differences among treatments on number of pods/plant. Chicken manure increased number of pods/plant by (20.5%) compared with control, (Table 5).

4.2.2 Number of seeds/pod:-

Statistical analysis revealed that nutrient treatments had significant effect on number of seeds/pod. Control was gave the highest mean of seeds compare with other treatments (Table 5).

4.2.3 Yield (ton/ ha):-

Significant differences were observed among treatments on yield ton/ha. Faba bean yield increased by (1.54%) at chicken manure treatment when compared with control, the highest mean obtained by Chicken manure was (3.45 ton/ha) while the smallest mean (2.44 ton/ha) was obtained by phosphorus fertilizer (Table 6).

4.2.4 Hundred seed weight:-

Table 6 revealed no significant influence among fertilizers on hundred seed weight (g), so control was showed the highest mean of hundred seed weight than other fertilizers.

4.2.5 Nutrient use efficiency:-

In table 7 calculated (NUE) by using equation:

$$NUE = \frac{Y \text{ kg/ha}}{F \text{ kg/ha}}$$

y: yield (kg/ha), f: fertilizer amount.

Results indicated higher efficiency in phosphorus and less efficiency in compost.

Table (5):Effect of fertilizers treatments on pods number and seeds number per pod of faba bean:-

Treatment	PN	SN/P
Compost	30.56 ^b	3.17 ^{ab}
Rhizobium	33.42 ^{ab}	3.00 ^b
Chicken manure	41.05 ^a	3.28 ^{ab}
Control	27.07 ^b	3.35 ^a
Phosphorus	30.18 ^b	3.18 ^{ab}
LSD	8.32	0.30
CV%	16.65	6.16

Means followed by the same letters in the same column are not significantly different at 5% level of LSD.

Table (6): Effect of fertilizers on yield of faba bean (t/ha) and hundred seed weight:-

Treatment	Yield (t/ha)	100 seed wt(g)
Compost	2.82 ^{ab}	39.38 ^a
Rhizobium	2.82 ^{ab}	38.93 ^a
Chicken manure	3.45 ^a	35.90 ^a
Control	3.34 ^a	39.88 ^a
Phosphorus	2.44 ^b	38.20 ^a
LSD	0.70	6.07
CV%	15.31	10.24

Means followed by the same letters in the same column are not significantly different at 5% level of LSD.

Table (7): Nutrient use efficiency(NUE) of faba bean by (kg/ha):-

Treatment	NUE(kg/ha)
Compost	0.19
Rhizobium	2.35
Chicken manure	0.96
Phosphorus	48.8

CHAPTER FIVE

DISCUSSION

Most significant differences between treatments in faba bean were obtained by Chicken manure treatment, which were detected at second count in number of leaves, first count in stem diameter, number of pods per plant, and yield (ton/ha). Number of leaves/plant and plant height (Cm) at the first count, both were significant increased at compost treatment. Abdelhameed *et al.*,(2004) reported that the application of compost significantly increased faba bean growth and yield.

Chicken manure has the ability to provide a comparatively large amount of nutrients for a long period (El tilip *et al.*,1994). El Sheikh (1997) found that application of chicken manure significantly increased yield and 100-seed weight. The beneficial effect of chicken manure could be due to its positive effect on soil structure, water and root penetration, and their complex properties which prevent penetration and fixation of many plant nutrients (Etilip *et al.*, 1993).

Despite no significant differences between treatments were detected on plant height and stem diameter (at 60 days), but chicken manure treatment-also- gave the highest stem diameter compared to the other treatment at the two readings, and at the second count in plant height. Khalil *et al.*,(2005) reported that addition of chicken manure (CM) into soils had a greater influenced on CO_2 -C evolution than the wider C/N ratio organic residues. El Sheikh *et al.*,(2014) found that organic fertilizers, significantly increased most of their measured parameters for faba bean and groundnut. Chicken manure was also reported to be good source of N and P for the growth, nodulation and yield of some grain legumes, particularly Soybean and Cowpea (Tagoe *et al.*,2010).

"Elkhairat" compost and Rhizobium, increased the plant height of faba bean at the first count (significant) and third counts (no significant), which was agree to El Sheikh *et al* (2014), but his finding that increasing were significantly in both.

The reason for the increase is also due to the role of organic matter in the processing and supply of good nutrient for plants, which appears in the growth characteristics of the crop, and these results are consistent with the findings of many researchers that the addition of organic matter had achieved significant increases in the yield of leguminous crops (Shaaban and Okasha, 2007; El-Desuki *et al.*,2010).

The nodules number of faba bean was not significantly affected by the Rhizobium inoculation, but phosphorus treatment gave the highest number of nodules, compared with other treatments.

Although in legumes, nodulation ability is a genetic character, it is often influenced by crop nutrition, especially of phosphorus which is implicated in better growth and development of root system (Asfaw,2006). Application of phosphorus played a significant role in enhancing the root nodulation of faba bean in comparison with no phosphorus (Takle *et al* .,2016). Faba bean requirement of P is reported to be high due to strong energy expenditure utilized during nodule formation and operation (Kopke, 2010).

Generally in this study phosphorus fertilizer had negative effect in most of parameters, (except number of nodules) and its performance was not efficient, which is due to high pH of study area. In these lands (alkaline in reaction) low phosphate is available to the plant because phosphate ions are almost immobile (Mahdi,1993& Mirgani,1994). Phosphorus is found in an insoluble form in soil and hence it is unavailable for plant (ElSheikh,1993).

The presence of nodules on the roots of uninoculated plants indicated the presence of indigenous Rhizobia that infect faba bean at Shambat area, according to (Tag Elsir,2000). The presence of Rhizobium in Shambat soil was also reported by Mahdi, (1993) and Ahmed and Elsheikh, (1998). Increasing number of root nodules is not considered as a reliable parameter of efficient symbiosis between bacteria and host plant, a Rhizobium strain may form many nodules which are not effective in nitrogen fixation (Ali *et al.*,1997).

There were significant differences between fertilizer treatments on number of seeds/pod and no significant in 100 seed weight, however control was the best one when compare with the fertilizers treatments, and that is due to the fact that faba bean is a legume crop and fixing nitrogen naturally, hence it can gets their nutritionally needs from soil to form seeds, without fertilizers application.

Therefore, organic fertilizers (chicken manure, compost and others) are more efficient than inorganic fertilizers for nutrition of faba bean. In nutrient (fertilizer) use efficiency calculation, the results gave higher efficiency in phosphorus and less efficiency in compost, that is due to the amount of used fertilizer dose, which usually is large in organic fertilizers and little in chemical fertilizers (particularly phosphorus fertilizers).

CHAPTER SIX

SUMMARY & CONCLUSION

6.1 Summary:-

The study aimed to determine the influence of organic, inorganic and biofertilizers on the growth and yield of faba bean (*Vicia faba*). The fertilizers treatments used consisted of: control, Rhizobium, phosphorus, Compost and Chicken manure. The results showed that significant differences in most of parameters (plant height, stem diameter- at 30 days- number of leaves at the two counts- number of nodules, number of pods/plant-number of seeds/pod and yield.ton/ha) obtained often by organic fertilizers, and other parameters are not significantly affected.

6.2 Conclusion:-

According to the results, these conclusions can be drawn:-

1-Chicken manure fertilizer, significantly increased most of parameters, and Compost increased two of parameters (all positive effect in this study obtained by organic fertilizers).

2-Rhizobium inoculation in this area had not affected number of nodules or any other parameters.

3-phosphorus fertilizer in this area is not effective due to its unavailability.

4-The organic fertilizers in this area are recommended to faba bean more than other fertilizers.

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Appendixes

Appendix (1): Mean squares from the analysis of variance for the growth Characters studied of Faba bean:-

Characters		Blocks d.f (3)	Treatments d.f (4)	Error d.f (12)
Plant height (Cm)	At 30 days	21.18	8.58 [*]	5.21
	At 60 days	65.23	20.60 ^{Ns}	30.80
	At 90 days	171.84	19.53 ^{Ns}	25.71
Number of leaves/plant	At 30 days	3.60	7.31 [*]	2.19
	At 60 days	69.64	247.87 [*]	82.28
Stem Diameter(Cm)	At 30 days	.0032	.0018 [*]	.0008
	At 60 days	.0012	.0044 ^{Ns}	.0031
Number of nodules/plant		6512.15	2044.53 [*]	1584.27

* = Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively
Ns = Not significant.

d.f = degree of freedom.

Appendix (2): Mean squares from the analysis of variance for the yield Characters studied of Faba bean:-

Characters	Blocks d.f (3)	Treatments d.f (4)	Error d.f (12)
Number of pods/plant	16.75	112.66*	29.19
Number of seeds/pod	.073	.071*	.039
Yield (ton/ha)	.14	70*	.21
Hundred seed weight	2.08	9.68 ^{Ns}	15.51

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* = Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively

Ns = Not significant.

d.f = degree of freedom.