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The Influence of Fertilizer Type and Time of application on Growth and Forage Productivity of Mung bean

تاثير نوع السماد و زمن الإضافة علي نمو وإنتاجية علف اللوبيا الذهبية

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الآية

قَالَ تَعَالَىٰ:

﴿ وَءَايَةٌ لَّهُمُ ٱلْأَرْضُ ٱلْمَيْتَةُ أَحْيَيْنَٰهَا وَأَخْرَجْنَا مِنْهَا حَبًّا فَمِنْهُ يَأْكُلُونَ
(٣٣) وَجَعَلْنَا فِيهَا جَنَّٰتٍ مِّن نَّخِيلٍ وَأَعْنَٰبٍ وَفَجَّرْنَا فِيهَا مِنَ ٱلْعُيُونِ (٣٤)
لِيَأْكُلُوا۟ مِن ثَمَرِهِۦ وَمَا عَمِلَتْهُ أَيْدِيهِمْ ۖ أَفَلَا يَشْكُرُونَ (٣٥) ﴾

صدق الله العظيم

سورة يس الايات (33 – 35)

DEDICATION

To dear jannati my mother

To candle brightness my father

To ahbab my heart my brothers and sisters

To my great family my uncles and aunts

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First thank to Allah, the Lord of the Worlds, who gave me strength and patience to finishing this project successfully.

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ARDALSHAM

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Abstract

A field experiment were sown on the 3th of April 2016 at the Demonstration Farm of College of Agricultural Studies, Sudan University of Sciences And Technology, Shambat, to study the effect of some Fertilizers and their time of application on growth and forage productivity of mung bean. The treatments were arranged factorially in split - plot design with four replications. Application Time as the main plot involved three times of application: before sowing, with sowing and after sowing. Types of fertilizers as the sub plot involved four types of fertilizers: without Fertilizer (control), 50 kg /ha (organic manure), 100 kg/ha (diammonium phosphate), and 10 L/ha (humic acid). Different characters were measured include plant height (cm), stem thickness (cm), number of branches/plant, number of leaves/plant, fresh weight /plant (g) as well as dry weight /plant (g). The results revealed that there is a highly significant difference of different application time and types of fertilizers and their interaction on plant height, number of leaves, and fresh forage and dry forage. Highly significant differences ($p \leq 0.01$) were recorded in types of fertilizers and interaction between different application time and types of fertilizers for number of branch and significant difference ($p \leq 0.05$) of application time for number of branch and stem diameter. There was no significant Difference in types of fertilizers for stem diameter. The highest height of the plant (28.78 cm), a maximum stem diameter (6.43 cm), the highest number of branches/plant (9.37), the largest number of leaves/plant (31.69), the best Stover of fresh (815 kg /ha) and dry weight (161 kg / ha) were recorded form 50 kg/ha organic manure applied after sowing.

المستخلص

تمت زراعة تجربة حقلية في الثالث عشر من ابريل 2016م في المزرعة الإيضاحية بكلية الدراسات الزراعية - جامعية السودان للعلوم والتكنولوجيا - شمبات. لدراسة تأثير بعض أنواع الأسمدة و زمن إضافتها على نمو وانتاجية علف اللوبيا الذهبية. أجريت تجربة عاملية مع تصميم القطاعات العشوائية في أربعة مكررات. وقت الإضافة (A) كقطاع رئيسي تضمن ثلاث اوقات من الإضافة : قبل الزراعة، مع الزراعة وبعد الزراعة . الأسمدة (F) كقطاع فرعي شملت أربعة أنواع من الأسمدة مثل بدون سماد (الشاهد)، سماد عضوي ، ثنائي أمونيوم الفوسفات ، وحمض الدبالية .تم قياس صفات مختلفة هي ارتفاع النبات (سم)، قطرالساق (سم) ، وعدد الأفرع / نبات، عدد الأوراق / نبات، الوزن الرطب/ نبات (g) وكذلك الوزن الجاف/ نبات (g) وكشفت النتائج أن هنالك فرق معنوي عالي في إختلاف اوقات الإضافة وانواع الأسمدة وتفاعلهما معاً علي ارتفاع النبات، عدد الأوراق، والوزن الطازج والوزن الجاف فرق كبير عند ($p \geq 0.01$). ايضا يوجد فرق معنوي عالي في أنواع الأسمدة و ($A \times F$) عند ($P \geq 0.01$) لعدد الافرع وفرق معنوي عالي في اوقات الإضافات لعدد الافروع وقطر الساق عند $P \geq 0.05$، فرق كبير في تفاعل ($A \times F$) لقطر الساق عند ($P \geq 0.05$) ولا يوجد فرق معنوي في أنواع الأسمدة عند ($P = 0.05$) لقطر الساق. من وجهة النظر هذه، نجد ان أعلى ارتفاع نبات (28.78 سم)، و أقصى حد لقطر الساق (6.43 سم)، أكبرعدد افرع (9.37)، واكبر عدد من الأوراق (31.69)، وأفضل إنتاج علف طازج 815 كجم / هكتار وعلف الجاف 161 كجم / هكتار تم الحصول عليها عند 50 كجم / هكتار سماد عضوي تم إضافتها بعد الزراعة.

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CHAPTER ONE

INTRODUCTION

Fodders are the very vital resource for the development of agricultural economy of the poor countries for the purpose of livestock raising (Zahid, *et al.,* 2013). Fodder crops are crops that are cultivated primarily for animal feed. All fodder crops wither grasses, legumes and root crops are fed to animals, either as green, hay or silage products (Wanas*, et al.,* 2007). The traditional system for forage production in the Sudan favors high yields at the expense of the nutritive value. This is because fodders were mainly produced as cash crops. Such system requires fast growing, highly productive cultivars to minimize costs of production. These requirements are largely met by Abu Sab'in (Maarouf and Zeinab**,** 2013). The total area of forage production in Sudan is estimated to be about 126,000 ha, with almost half in Khartoum state (Zaroug, *et al.,* 1997). The recent statistics of the ministry of agriculture (2015) showed that the area under forage crops represented 80% of the area cultivated in Khartoum state. This area was almost doubled from 114513in (2006) to 239535 feddans in (2015). 81% of the area under forage production was occupied by Abu Sab'in and alfalfa (Annual statistics, 2015). The system of forage crop production adopted in the Sudan, the green chopping system, does not allow continuous supply of animal feed. According to the recent statistics, 90 % of the animal wealth in the Sudan relay on natural pastures and crop residues **(**N.C.S., 1999).This expansion was due to growing importance forage crops, due to the increased attention given to dairy production, particularly around urban centers and also to satisfy the requirements of increasing animals for meat. The demand is continuously increasing due to normal population growth and mass immigration of rural communities. In addition to this, a remarkable activity of cattle and sheep export has resulted in increasing the area of fodder crops grown primarily under irrigation (Idris*, et al.,* 2013).

Legume fodder is important for livestock production because it is rich in protein, minerals, phosphorus, calcium and vitamins (Bogdan, 1977 and Unkovich, *et al.,* 1997). Dairy animals require a green legume crop to cover up the balance of their protein requirement. Mung bean (*Vigna radiata l*) *wilczek syn.* also called green gram and golden bean is an important summer annual pulse crop, belongs to genus *Vigna* and family Leguminoseae. India is considered its native country, and cultivated in Pakistan, Europe and USA (Imdad, *et al.,* 2012), Philippines, Thailand, Bangladesh, Vietnam, Cambodia and Indonesia (Somashekaraiah, *et al.,* 1992), Uganda (Apioibedo, 2014), Australia and China (Imrie and lawn, 1991) as well as Egypt (Ashour, *et al.,* 1994) and Iran (Paroda *et al.,* 1987). From Asia, it spread into the Middle East, the pacific Islands, East Africa, Australia and the Americas, but Asia continues to be the region of major production (Nassar, 2013).India is the largest producer of mung bean in the world (54%), the average productivity is 550 kg/ha (Anonymous, 2008), and produced higher forage 2.2 ton/ha (Twidwel, *et al.,* 1992). In south Asia, improved varieties of mung bean are planted on an area of 3 million hectares with a total annual production of 3.1 million tones both under rain fed and irrigated conditions (Shanmugasundaram, *et al.,* 2009).In Pakistan, it was planted on an area of 2.5 million hectares with a total annual production of 1.8 million tons with an average yield of 723 kg ha-1. Out of the total area in Pakistan, Khyber Pakhtunkhwa covered an area of 10.1 thousand hectares with the production of 6.4 thousand tons producing an average yield of 634 kg/ha (Minfal, 2008-09) and, the average yield in Pakistan during the year 2009-10 was 709 kg per hectare (Ali *et al.,* 2000) .

In Sudan mung bean is a new crop and it is going to be a commercially promising pulse crop and can be grown as a forage crop. Local production of pulses is not sufficient to meet the increasing demand for human utilization. Therefore, to meet the situation, it is necessary to boost up the production. Inadequate supply of feed in quantity and quality is responsible for the low productivity of animals.

Animal depend entirely on natural pastures for their feed. This source is only adequate for their survival during the wet season but inadequate during the dry season. This has resulted in the characterized limitation posed by non availability of all-year-round feed resources due to prolonged dry season (Oladotun, *et al.,* 2003, Odeyinka and Okunade, 2005). There is the need to improve pasture production through properly planned management and need for better forage cultivars that maintain continuous supply of forages. Such management practices include cutting management, introducing high yielding new crops with short growing season and proper management practices is considered as an effective tool for narrowing the food gap in Sudan as well as cultivation of mung bean and the use of fertilizers. Genetic potential of legume is not obtained at field due to poor soil nutrient status, mineral deficiency (Maskey, *et al.,* 2004) and nodulation is poor on shambat soil. They are worldwide agricultural problems causing yield and quality loss (Liu, 2001). In this context, low cost technique is required to incorporate nutrient (macronutrient and micronutrient) into plant system thus it enhances growth, and boost up crop yield and nutrient status in plant, thus nutrient deficiency can be a remove and higher yield and vigor seedling can be achieved in mung bean, by using the best fertilizers and optimum application time.

The objectives of this study were:-

1) To examine the influence different types of fertilizers on growth and forage productivity of Mung bean (*Vigna radiata l.*).

2) To determine optimum application time of fertilizer to enhance Mung bean forage productivity.

CHAPTER TWO

LITERATURE REVIEW

Adaptation:

Mung bean is a tropical and subtropical pulse crop requires a warm temperature from 30 to 35°c.It is successfully grown on sandy and loamy soils (pH 6.2 to 7.2).It is cultivated in autumn, summer and spring seasons (Bose, 1982 and Kanti, 1998). As an autumn crop, it is sown in June-July while as spring crop it is sown from mid march to April. It is a short duration crop and growth rate is rapid and usually requires 70 to 90 days to mature (Imdad, *et al.,* 2012),So it can be grown twice a year (Hossein, *et al.,* 2011and Kasra, *et al.,* 2011), therefore it has less water requirement as compared to other summer crops. Moreover, it is drought tolerant that can withstand adverse environmental conditions and hence successfully be grown in rain fed areas (Anjum, *et al.,* 2006).

Botanical characteristics:

Mung bean has strong tap root system with nodulation to fix atmospheric nitrogen (Imdad, *et al.,* 2012). By this process atmospheric nitrogen is converted into an available form for plants (Ali, *et al.,* 2010) and thus enhances the soil fertility. It improves the nutrient status of soil (Rahim, *et al.,* 2010), it fixes atmospheric nitrogen at 50-100 kg/ha annually (Phoomthiasong, *et al.,* 2003). It has gains maximum three feet height. It has tripholiate leaves alternate on the stem. It is a self-pollinated crop.

Varieties:

Mung bean varieties based on their seed size can be classified into two groups. One is the bold- seeded varieties 1000 seed weight 50-70g, usually called Philippino types, and is predominantly grown in Southeast Asian countries. They have relatively higher yield potential (1-2 t/ha), large foliage. These varieties usually fail in south Asian countries. The other is the small-seeded varieties 1000 seed weight 20-35 g mainly cultivated in south Asian countries. They have relatively low yield potential (0.5-1.0 t/ha) but are fairly adapted to the local environmental conditions (Sabra, *et al.,* 2012).

Nutritive value of mung bean seeds:

Mung bean is grown principally for its edible seeds (Ashour*, et al.,* 1992, 1993 and 1995). It is a rich source of protein which is nearly three times as much a scereals (Thirumaran, 1988). Generally mung bean seeds contain 25-28% protein, 60-65%carbohydrates, 1-1.5 % fat, 3.5-4.5% fiber and 4.5-5.5% ash (Ibrahim, *et al.,* 2012). Moreover, it is rich in vitamins such A, B, C, niacin, and good source of minerals for pregnanty womenas it contains iron (7.3 mg),calcium (124 mg), zinc (3 mg) and foliate (549 mg) (Chadha, 2010) and also potassium, phosphorus, which are necessary for human body (Rattanawongsa, *et al.,* 1993).

Uses of mung bean:

Seeds are cooked, fermented, roasted, sprouted, or milled. Mung bean seeds, like other pulses, are split and then cooked. It is also used in making noodles and bread. Roasted seeds with spices are also very popular (Malik*, et al.,* 1994). Pods and sprouts of mung bean are also eaten as a vegetable (Zarifinia, *et al.,* 2012). The flour is used for making bread and it is an important source of starch production (Ibrahim, *et al.,* 2012). It is used as an ingredient in both savory and sweet dishes (Somashekaraiah, *et al.,* 1992). Generally, it is used as 'dhal' or vegetable soup and often feed to babies (Salah, *et al.,* 2009).Owing to all these characteristics it is a good substitute of animal protein and forms a balanced diet when it is taken with cereals (Hossein, *et al.,* 2011 and Sharma, *et al.,* 2011). Although mung bean is grown mostly for grain production, it can be used as a dual purpose (forage and seed) crop

(El-karmany, *et al.,* 2005 and El-karamany, 2006). It can be used as green forage for livestock and give farmers a chance to improve the quantity and quality of forage available for clipping or-grazing. A common fashion that leftover leaves, stem and husk of mung bean plants and whole plant can be ploughed and buried as a green manure (Duncan, *et al.,*1995 and Rehman*, et al.,* 2010) for soil improvement in view of different agronomic conditions of cereal crops (Shamsi, *et al.,* 2011, Sleper*, et al.,* 2006). Also, it can be good forage with cowpea under rainfall conditions (Ashour*, et al.,* 1991). Mung bean is considered to be suitable as a catch crop as well as for triple cropping system and could be successfully cultivated in maize wheat rotation without affecting this popular cropping pattern, since after maize harvest and before wheat sowing. Moreover, it breaks insect-pest and disease cycle and thereby enhancing the sustainability of soil health and overall farming system (Hozayn*, et al.,* 2013). It can be used between young trees for four years prior to canopy closure (Milnond*, et al.,* 1999) and can easily fits in different cropping patterns (Kumar, *et al.,* 2010).

Health benefits of mung bean:

1. Can help lower high cholesterol levels and protect against heart disease.
2. Helps lower high blood pressure.
3. Contains antioxidants that fight cancer development.
4. Can help prevent or treat type 2 diabetes.
5. Boosts immunity and protects against infections and viruses.
6. Fights obesity and helps with weight loss.
7. Can help decrease PMS symptoms (Josh, 2016).
8. mung bean protein is easily digestible and does not cause the flatulence as many other legume do (Arif, *et al.,* 2012, Hossein, *et al.,* 2011 and Kasra*, et al.,* 2011) because it has less sulphur containing amino acid with even less methionine than lysine**.**

Fertilization:

The low soil fertility has raised the concerns about the sustainability of agricultural production. Strategies for increasing agricultural productivity focused on efficient utilization of available nutrient and effectively on sustainable basis for maintaining soil health. For sustainable agriculture, integrated management of the nutrients is needed for proper plant growth along with effective use of resources such as crop, water, soil and land management. Secondly owing to the ever increasing cost of inorganic chemical fertilizers, the integration of inorganic fertilizers with organic manures and crop residues has become imperative for sustained crop production and maintenance of soil health (Babulkar, 2000).

Phosphorus:

Phosphorus is the second most important nutrient required by the plants for growth and development. It is the second major essential macronutrient and plays an important role in metabolism of crop plants (Vikram and Hamzehzarghani, 2008). Adequate supply of phosphorus is essential at early stage of crop growth when the limited root system is not yet capable of absorbing the phosphorus reserves of the soil. Increasing levels of phosphorus enhanced the plant growth, yield parameters like, nodules per plant, dry weight of nodules, number of pods per plant, number of grains per pod, 1000-grain weight, straw yield and ultimately final crop yield of mung bean (Muhammad, *et al*., 2014). Abd el- lateef, *et al.,* (1998) stated that increasing phosphorus fertilizer levels from 0 to 15.5 and 31 kg P_2O_5 /fed. Significantly increased number of mature pods/ plant, seed yield /plant (g) and seed yield (kg/ fed) of mung bean. Arya, *et al.*, (1988) described that 25-75 kg phosphorus /ha increased the seed yield and protein content. Ibrahim, *et al.,*(2012) results revealed that increasing period between irrigations from 10 to 20 days caused irrigation intervals of significantly decreased yield and yield components in both seasons and number of seed per pod in the second season only. On the other hand, increasing the rates of phosphorus and potassium led to significant increase in yield and yield components and chemical constituents compared with the other treatments in both seasons. Iqbal, *et al.,* (2012) concluded that the crop growth will not be good due deficiency of phosphorus but appropriate supply of phosphorus increases growth rate. An experiment was conducted to study the effect of varying levels of P application on growth and yield responses of mung bean under different tillage practices. Significant results were obtained in stem diameter, plant height, number of branches per plant, number of seeds per pod and dry matter yield. Also Nazir, *et al.,* (2004) observed that the balanced fertilization and proper tillage practice increased seed yield. Petal *et.al* (1984) observed significant increase in yield if 20 kg nitrogen and 40 kg of P_2O_5 per hectare is applied and reported that as phosphorus dose increase, yield will increase. Whereas, Ghafoor, (1985) found that maximum weight and number of pods is attained when 20 kg nitrogen and 100 kg P_2O_5 ha was applied. Nadeem, *et al.,* (2004) studied the effect of fertilizer on the mung bean and found that almost all the yield parameter were affected positively and ultimately increased the yield significantly when 30 kg/ha of nitrogen and 60 kg/ha of phosphorus was applied. Malik, *et al.,* (2003) found that the plant population was not affected significantly but various growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25-75 kg/ha nitrogen and phosphorus resulted in maximum seed yield (1112.96 kg/ha). Maximum protein content (25.6%) was obtained from plots fertilized with 50-75 kg/ha nitrogen and phosphorus followed by protein content of 25.1% obtained from plots fertilized by 25-75 kg/ha nitrogen and phosphorus. Highest net income, was also obtained by applying nitrogen and phosphorus at 25 and 75 kg/ha nitrogen and phosphorus, respectively. Arshad, (1993) found that plant height, number of plant per unit area and number of branches per plant were not affected by the planting method and level of phosphorus. Different yield components were affected by the phosphorus level significantly but either sowing is done through row sowing or ridge, it has not affected yield significantly. El- sheikh, (1981) concluded that flat planting gives low yield as compared to ridge sowing along with phosphorus application. Beg, *et al.,*(2013) concluded that almost all vegetative and yield characteristics of mung bean were positively enhanced by the phosphorus application. Supply of phosphorus and potassium is necessary in maintaining the crop growth and actualizing the yield potential. El-gharably, *et al.,* (1980) concluded that the concentration of nitrogen, phosphorus and K in plants was increased due to phosphorus application. Same results were obtained by Abdo, *et al.,* (2001), Ramdan and Saad el-din (2002) and Abd el-hay (2008). Bhuiyan, *et al*., (2008) found that the rhizobium inoculation along with phosphorus and Mo significantly increased the growth of plants, as well as grain yield of mung bean compared to un-inoculated control. Combined application of rhizobium inoculate, phosphorus and Mo was considered to be the balanced and suitable combination of fertilizer nutrients for achieving the maximum output through cultivation of mung bean. Arif, *et al.,* (2012) revealed that inoculation with rhizobium has increased nitrogen fixation in mung bean crop. The combination of phosphorus and inoculation showed maximum positive effects on nitrogen and phosphorus concentration and their uptake by plant. Ashraf, *et al.,*(2003) examined the mung bean responses to different doses of NPK and inoculation, plant growth, nodulation, number of pods, seed yield and harvest index were significantly increased and seed inoculated and applying doses of NPK (50+50+0 kg ha-1) gives the highest production. Singh, *et al.,* (2008) suggested that the interaction of phosphorus to mung bean residue incorporation was thus studied in relation to improve crop productivity with balancing fertilizer requirements through an Eco-friendly approach. Sorghum grain yield increased significantly when 60 kg P_2O_5 ha was applied and mung bean residue incorporated. The response was reduced to 30 kg P_2O_5 ha when mung bean residue was not incorporated. The succeeding lentil crop responded up to 60 kg/haP_2O_5only when preceding sorghum crop received 0 or 30 kg/haP_2O_5. Response to applied P_2O_5 to lentil reduced to 30 kg/ha when preceding sorghum crop received 60 kg/ha$P_2O_5$and mung bean residue incorporated. Parvez, *et al.,* (2013) concluded that the mung bean variety binamoog-6 or binamoog-8 can be grown with higher dose of phosphorus (60 kg/haP_2O_5) for higher seed yield. Shakeel, *et al.,* (2015) indicated that cultivar MM-98 treated with 80 kg/ha phosphorus produced maximum nodules per plant, pods per plant, seeds per pod, 1000 grain weight, grain yield and harvest index as compared with other mung bean cultivars.

Organic matter:

Organic matter is an important component of fertile soil. Nusier (2004) reported that organic matter generally increased the ability of the soils to hold water, expand the available water capacity and decreased the modulus of rupture of compacted soils,(i.e. sandy loam, clay loam and clay). Bin Zhang, *et al.,* (2005) mentioned that soil shear strength decreased with a greater peat-amendment rate. They suggested that amending with organic matter will improve recovery from vehicle traffic damage and improve water retention during dry period, providing better conditions for plants and microbes. In another several researches work. Tester, *et al.,* (1990); Carter, *et al.,* (2004) and El-kouny, *et al.,* (2005) pointed out those organic amendments positively affected soil physical properties, penetration resistance and yield of crops. Many different types of organic matter can be used as fertilizers to enhance plant growth, such as manure, compost, etc. The organic fertilizers can increase the quality and improve the output paving the way for sustainable agriculture; they are less expensive, highly biodegradable, non-pollutants to both aquatic and terrestrial ecosystems (Malihe, *et al.,* 2014). Wanas, *et al.,* (2002) reported that applied composts reduced the values of soil bulk density and soil penetration resistance of a clayey soil and the decrease was higher in the surface layer than the subsurface one. He found also that more reduction in soil penetration resistance occurred by increasing rates of added composts, as well as an increase in soil water content. Malihe, *et al.*, (2014) showed a significant effect of irrigation and organic fertilizers on plant height, number of sub branch and number of pods per plant. The results of Singh, (1991) showed that the highest yield was obtained from the application of 25 kg nitrogen, 60 kg phosphorus and 40 kg k/ha with 15 ton /ha of farmyard manure. Singh and Agrawal, (2007)reported that higher availability of nutrients in organic fertilizer was the main factor contributing to higher biomass of plants. Razieh, *et al.,* (2012) results showed that all traits were significantly affected by treatments except the number of second roots. Foliar application of urea and organic manure substantially improved the plant height, leaf area, shoot and root dry weights, root and shoot length, volume and number of roots. Similarly shoot and leave number and nodules root were also improved by the foliar spraying of green humic and amino acid, respectively while the lowest nodules root were observed in plants treated by nutriman N24 and Urea. This improved growth is mainly due to nutrient availability in bio-organic fertilizer and uptake by plants. Irshad, *et al.,* (2002) recorded that maximum plant height was observed in treatment urea followed by amino acid treatment. Foliar application of cattle manure recorded the next highest plant height. Sabra, *et al.,* (2012) observed significant variation among the yield and related traits. Shah, *et al.,* (2007) noticed that manure and urea fertilizer enhanced plant growth and nutrient uptake as compared to control.

Humic acid:

Humic acid is believed to be a good organic fertilizer for certain plants. Humic acid (HA) is a vital constituent and an intimate part of soil organic structure. It has been used by many scientists, agronomists and farmers for improving soil conditions and plant growth (Fagbenro, *et al.,* 1993 and O'donnell, *et al*., 1973). In plants, humic acids have positive effects on enzyme activity, plant nutrients, and growth stimulant and are considered as a "plant food". Humates are most responsive in high carbohydrate crops like potato, carrot, maize, rice, wheat (Fagbenro, *et al.,* 1993 and Lee, *et al.*, 1976). Humic acid contains 51% to 57% C, 4% to 6% N and 0.2% to 1% P and other micronutrients in minute amounts. Application of 1.0 kg.ha−1 to the soil can bring appreciable increase (up to 20%) in yields of groundnut and improvement in soil Physico-chemical conditions (Khattak, *et al.,* 2006 and Sharif, *et al.,* 2003). Application of such minute amounts suggests its enzymatic characteristics. Treating seeds with HA may further increase its beneficial effects to enhance crop yield (Kaya, *et al.,* 2005).The humic substances can improve nutrient uptake, as phosphorous and iron uptake from soils. Nardi, *et al.,* (2000) showed that humic acid increase root length, root number and root branching. Stimulation of root growth is generally more apparent than shoot growth. Muhammad, *et al.,* (2014) found that humic acid application methods significantly affected pods per plant, grains per pod, 1000 grain weights, and grain yield whereas biological yield was not significantly affected by HA application methods. Humic acid application at the rate of 3 kg/ha resulted in higher number of pods per plant, thousand grain weights and grain yield. However it was statistically similar to the treatments where HA was soil applied at rate of 1 and 2 kg/ha, seed priming with 0%

(water soaked), 1%, 2% HA solution and foliar spray with 0.01%, 0.05% and 0.1% of HA solution. It was concluded that HA application in all the three methods significantly enhances grain yield and yield components of mung bean. Sarwar, *et al.,* (2014) results indicated that application of HA at 50 kg/ha along with 45 kg/ha P_2O_5 (75% phosphorus) in presence of PGPR inoculation recorded the highest grain yield (1.96 ton/ha) that is 19% more than the treatment receiving 100% phosphorus application alone (no HA and PGPR). The highest concentration of phosphorus (0.3 %) and N (3.5%) in whole shoot mung bean were observed in the treatment where HA was applied at 50 kg/ha along with 60 kg/ha P_2O_5 (100% phosphorus) and PGPR inoculation. However mung bean yield and phosphorus concentration was statistically at par with the treatment where phosphorus was applied at 75% of recommended rate along with HA and PGPR. Based on findings of this study it can be suggested that HA and PGPR inoculation have significant effect on grain yield and improved phosphorus use efficiency (PUE). It showed that HA and PGRP enhanced phosphorus availability through Chelation and reduce soil phosphorus fixation.

Salah, *et al.,* (2009) results showed that most of the growth and yield component of mung bean. plant height, branch plant, number of nodules plant, total dry matter plant, pods /plant, seed /plant, seed/ pod, weight of 1000-seeds, seed yield and straw yield were significantly influence by the bio-fertilizer (Brady Rhyzobium inoculums) treatment except number of leaves and dry weight of nodule. These are influenced by chemical fertilizer and bio-fertilizer also. Interaction effect of variety and bio-fertilizer (Brady rhyzobium) inoculation was significant of all the parameters. Bari mung 6 with Bradyrhyzobium inoculums produced the highest number of nodule and pod/ plant1. It also showed the highest seed yield, Stover yield and 1000-seed weight. Hossein, *et al.,* (2011) showed that the effect of seed size was significant on germination percentage and seedling dry weight. Hozayn, *et al.,* (2013) conclusion that the most of tested large seed genotypes was gave a reasonable seed, straw and biological yield when sowing lately around mid of August. Zarifinia, *et al.,* (2012) showed that Bartow cultivar and the Indian heap have more adaptability to the harsh environmental conditions of this region. However, these cultivars have formed a vine-type growth habit due to having an unlimited type of growth and more tender stems after flowering and pod-setting stages and thus harvesting them was more difficult than the promising lines which had a limited type of growth, stronger stems and erect growth habit. Mbeyagala, *et al.,* (2015) analyses of variance showed that genotype × environmental interactions (G×E) were significant and therefore could not be ignored. Abd el-salam, *et al.,* (2013) revealed that, the varieties differed significantly from one to another. It could be concluded that the promising multi-cutting mung bean varieties with the high nutritive value could effectively be employed to narrow the summer green forage gap and overcome the critical forage shortage period in Egypt. Mohammad, *et al.,* (2011) stated that regarding the statistic results although these genotypes were advanced lines there was wide genetic diversity among genotypes. In both conditions, seed yield was significantly correlated with yield components and morphological and phonological traits. Nassar, (2013) revealed that foliar application with the relatively low tested concentration of 150 PPM ascorbic acid showed no significant effect on all studied characters of vegetative growth and yield components as well as on photosynthetic pigments and seed quality of mung bean. Singh, *et al.,* (1995) found that seed yield and components traits differ with season where growth, pods/plant, seeds/pod and yield expressed better in autumn season while 100-seed weight expressed better in spring season. Twidwell, *et al.,* (1992) recorded that delayed mung bean planting date from May to July produced forage higher with 2.2 ton/ha.

CHAPTER THREE

MATERIALS AND METHODS

Site of experiment:

The experiment was conducted at the experimental farm in the College of Agricultural Studies –Sudan University of Science and Technology (Shambat), during the period from April to June, 2016. Shambat is located between latitudes (15.40°North and 32.32°East) and altitudes of 380 meters above sea level. The climate is characterized by semi-desert tropic with a low percentage of humidity and average rainfall of 158 mm per annum and temperature of 20.3c° – 36.1c° and clay celtic soil (Khairy, 2010), Soil pH 7.5 – 8.7 (Hamdon, 2001).

Field design:

The treatments were arranged factorially in split – plot design with four replications. The main plot consisted of three application time viz, T1 = before sowing, T2 = with sowing and T3 = after sowing and the sub plot consisted of four fertilizers F0=control (no fertilizer), F1 =diammonium phosphate, F2 =organic manure, F3= humic acid.

Source of seeds:

Mung bean seeds used in the study were obtained from the College of Agricultural Studies, Sudan University of Science and Technology, Shambat.

Cultural Practices:

Preparation of Soil samples:

The soil mixture was consisted of clay and sand percentage (2:1) in plastic pots. Pot area was1.4 M^2 and each pot contained 10 kg soil sample. Sub samples were taken before sowing and analyzed in the soil and water science laboratory at (CAS) in (SUST). EC, pH and soluble salts were determined on paste saturation extract (Ritchard, 1954) using a pH meter (model 3510), EC meter (model M35). Na and K were estimated using direct flame photometry in soil extract (flame photometer (model 410)). $CaCO_3$ was estimated using a calcimeter, Model (Eijkelkamp). Total nitrogen was performed using the Kjeldahl method (Ryan, *et al.,* 2001). Organic carbon was determined by the Walkley and Black method (1934). For available phosphorous, O'lsen (1954) method was using a spectrophotometer model (6305). The amount of exchangeable potassium was estimated by the use of direct flame photometry in soil extract (Ryan, *et al.,* 1996). Soil texture was determined using Particle Size Determination (Pipette Method), and textural classes were defined USDA textural triangle, appendix (1). As activation dose, recommended N (40 kg/ha) by using urea 6 g per pot was applied in each pot before sowing.

Sowing:

30 gm of seeds were mixed thoroughly with 0.15gThiram, at the rate of 10g Thiram /2g seed and immediately sown on the 3^{th} of April 2016 in pots at the rate of 3 seeds per hole.

Irrigation:

The first Irrigation was done immediately after sowing and then when necessary.

Treatment:

Pots were fertilized as per treatments described below. Diammonium phosphate 100 kg/ha (15 g per pot), organic manure 50kg/ha (7.5 g per pot) and humic acid 10 L /ha (1.5 ml per pot). All fertilizers were incorporated into the soil before sowing (15 days), at sowing and after sowing of seeds (15 days).

The treatments were as follows:

a - Application time:

1- 15 days before sowing (B.S).
2- With sowing (W.S).
3- 15 days after sowing (A.S)

b- Fertilizers:

1- Diammonium Phosphate (46% P_2O_5, 18% N) at (100 kg/ha) 15 g per pot.
2- Humic Acid (12% N, 15% Humic Acid, 3% K_2o) at (10 L /ha) 1.5 mL per pot.
3- Organic manure (0.062% O.M, 0.107% O.C, 1.232% N, 61% P, 4.6mL/L K, 40.7mL/L Ca, 119.3mL/L Mg, 32.6mL/L Na, 6.45mL/L Fe, 1.797ml/l Mn, 0.028ml/l Su, 0.108ml/l Co,0.15ml/l Pb, 0.114ml/l Zn, 36.1% m, 58.16% Ash, 1:2 C:N, 6.5 pH, 23.5/D.S.ME.C) at (50kg/ha) 7.5g per pot.

Harvesting:

After75 days from sowing the crop was ready for cut. Removal of the vegetable parts at soil surface was done manually using clipper For Stover production.

Data recorded:

Plant height growth:

After four weeks from sowing (30 days), four plants of mung bean were randomly selected from each pot to determine growth stages and the period between readings was 15 days.

Plant height (cm):

Plant height was measured from the ground level to tip of the stem, from four plants of mung bean randomly selected from each pot, using a measuring tape then the mean plant height was recorded.

Stem thickness (cm):

Four plants of mung bean were randomly selected from each pot and stem diameter was measured for each plant separately at the middle internodes using meter and the average per plant was recorded

Number of branches / plant:

Four plants of mung bean were randomly selected from each pot and number of branches was counted and then the mean per plant was recorded.

Number of leaves / plant:

The number of leaves was counted from four plants of mung bean randomly selected from each pot and then the mean per plant was recorded.

Fresh yield per plant (g):

At harvest (75 DAS) four plants were weighted and the mean fresh yield weight per plant was recorded.

Dry yield per plant (g):

The fresh yield of four plants was oven dried at 80 c$^{\circ}$ for 48 hours to constant weight and the mean dry yield weight per plant was recorded.

The fresh yield and dry yield (kg per hectare) was calculated as follows:

$$= \frac{\text{Area in hectare } (10000\ m^2) \times \text{forage weight per } m^2\ (g)}{\text{Weight unit } (1000)}$$

Statistical analysis:

Data were statistically analyzed according to split – plot design using MSTAT-C package. Means were separated by Least Significant Difference (L.S.D) (Gomez and Gomez, 1984).

CHAPTER FOUR

RESULTS AND DISCUSSION

Plant height (cm):

The analysis of variance showed that a higher significant effect of time of fertilizer application and types of fertilizers as well as their interaction on plant height (Table 1). Tallest plants were recorded at application time after sowing while shorter plants were recorded at application time at sowing (Table 2). The types of fertilizers promoted significantly plant height. The highest plants were observed in organic manure and the shortest plants were recorded in humic acid (Table 3). Plant height ranged from 15.41cm to 28.78 cm. Maximum plant height (28.78 cm) was found with 50 kg organic manure per ha application after sowing which was statistically higher than other treatments. Minimum plant height was observed for organic manure added before sowing (15.41 cm). It was clear that with the fertilizer added after sowing, the plant height was increased with the organic manure (Table 4). These results were in agreement with those of Malihe *et al.,* (2014) whore ported a significant effect of organic fertilizers on plant height and while Bhuiyan, *et al.* (2008), Shukla and Dixit (1996) and Sharma and Singh (1997) reported that application of phosphorus enhanced the plant height significantly.

Stem thickness (cm):

The results showed that the time of fertilizer application and types of fertilizers had higher significant effect on stem thickness per plant, while their interaction had no significant effect on stem thickness per plant (Table 1). Stem thickness was thick at application time before and at sowing and the thin stem thickness was observed at application time after sowing (Table2). Organic manure produced thick stem thickness per plant (5.68 cm), while thin stem thickness per plant (5 cm) was produced by humic acid (Table 3). Interaction between time of fertilizer application and types of fertilizers had also significant effect on stem thickness per plant pots treated with 50 kg/ha organic manure added after sowing produced thick stem thickness (6.43 cm), while thin stem thickness (4.18 cm) were recorded in pots with100kg/ha diammonium phosphate added at sowing (Table 4).These results were not in agreement with those of Iqbal *et.al,* (2012) who showed that significant results were obtained in stem with appropriate supply of phosphorus.

Stem increase with organic manure 50 kg/ha added after sowing was recorded (6.43 cm) (table 4). These results were not in agreement with those of Nemat *et al.,* (2000) who reported that increasing levels of phosphorus lead to increment in stems.

Number of branches / plant:

Number of branches per plant was significantly higher with the time of fertilizer application and types of fertilizers and significantly different with their interaction (Table 1). The lowest number of branches per plant was noticed in application at sowing while higher number of branches per plant was recorded in application after sowing (Table 2). Number of branches was increased with types of fertilizers. The highest number of branches (8.10) was observed with the organic manure application at 50 kg/ha which was statistically higher than other treatments. The lowest values (7.37 and 7.35) were recorded with the diammonium phosphate and control respectively (Table 3). These results were confirmed earlier by Arshad (1993) who showed that the number of branches per plant was not affected by level of phosphorus. In contrast, Muhammad *et al.,* (2014) found that the number of branches per plant was significantly influenced by phosphorus application. The pots treated with 50 kg organic manure per ha added after sowing produced maximum number of branches per plant(9.37), while minimum number of branches per plant (5.12) was recorded with 100 kg/ha diammonium phosphate added at sowing (Table 4). Malihe, *et al.* (2014) stated that the number of branches was not affected by the use of organic fertilizers which did not agree with results in this study.

Number of leaves / plant:

Time of fertilizer application and types of fertilizers as well as their interaction had higher significant effects on number of leaves per plant (Table 1). Number of leaves per plant was influenced significantly by the time of fertilizer application. The highest values of number of leaves were found in after sowing application. While the lowest values of number of leaves were observed with both before sowing and at sowing application (Table 2). Number of leaves was significantly affected by types of fertilizers. The highest number of leaves was recorded with the organic manure application. Number of leaves in pots treatment with humic acid fertilizer was lowest (Table 3). This contradicted with Eldm, (2004) who reported that number leaves per and yield was gradually and significantly increased with the application of humic substances. The interaction between time of fertilizer application and types of fertilizers had higher significant effect on number of leaves per plant, the pots treated with 50 kg organic manure per ha added after sowing produced maximum number of leaves per plant (31.69), while minimum number of leaves per plant (17.88) was recorded in at sowing application by 100 kg/ha diammonium phosphate (Table 4).These results were supported earlier by El-Banna *et al.,* (2006) who found that the increase in leaves number due to the application of organic components had stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis. But this is not line with Bhuiyan, *et al*. (2008) who found that plants produced significantly higher number of leaves with phosphorus and highest number of leaves (22.84) was found with phosphorus added at the rate of 40 kg/ha, which was statistically significant.

Fresh forage yield (kg/ha):

The fresh forage yield as affected by time of fertilizer application and types of fertilizers as well as their interaction (Table1). Time of fertilizer application had high significantly affect the fresh forage yield. The highest fresh forage yield (kg/ha) was recorded from the pots application time after sowing. While the least fresh forage yield (kg/ha) was counted in pots application time at sowing (Table2). 50 kg/ha organic manure performed better than other fertilizers dose. The lowest fresh forage yield was recorded in humic acid fertilizer. Diammonium phosphate increased fresh forage yield significantly over control (Table 3). These results confirm the findings of Bhuiyan, *et al*., (2008) and Manpreet *et al*. (2004) who reported that the effect of phosphorus on Stover yield of mung bean was influenced significantly at harvest. The highest fresh forage yield (815.8 kg/ha) was recorded in 50kg/ha organic manure after sowing application, which was significantly higher than other treatments. At after sowing application humic acid fertilizer and control were statistically similar. The lowest fresh forage yield was146 Kg/ha recorded with 100 Kg/ha added at sowing. There results were in agreement with those of Bhuiyan, *et al*., (2008) who reported with increasing Phosphorus rate, Stover yield decreased significantly.

Dry forage yields (kg/ha):

Dry forage yields of mung bean were influenced significantly by the time of fertilizer application, types of fertilizers and their interaction (Table 1). The highest forage yield106.1 kg/ha was found with application after sowing, which was significantly higher than other treatments. The lowest forage yield was 85.3 kg/ha recorded with application at sowing (Table 2). Again the single effect of types of fertilizers on mung bean forage yields was also significantly influenced. The forage yield with organic manure was significantly higher than the forage yield recorded with humic acid fertilizer (Table 3). Sarwar, *et al.* (2014) showed that the maximum straw yield on mung bean was recorded in the treatment where humic acid was applied at50 kg/ha. Dry forage yield of mung bean were significantly influenced by interaction of time of fertilizer application, types of fertilizers. The maximum forage yield 161 kg/ ha were obtained from pots fertilized by 50 kg organic manure per ha after sowing application. The minimum forage yield 40 kg/ha was obtained from diammonium phosphate application at sowing (Table 4). This result is not in agreement with that of Bhuiyan, *et al.* (2008) who showed the significant effect of phosphorus, on dry weight of mung bean. Singh and Agrawal, (2007) stated that higher availability of nutrients in organic fertilizer was the main factor contributing to higher biomass of plants, which in line with the results of this study.

Plant height growth:

Fig. 1 reveals a significant effect of time of fertilizer application and types of fertilizers and their interaction in early growth stage such as up to 30 days after sowing (days), but at later stage there were higher significant difference among the of time of fertilizer application and types of fertilizers and their interaction. The highest plant height was observed form the diammonium phosphate before sowing application (10.3 cm) at 30 days, diammonium phosphate after sowing application, organic manure and humic acid both application at sowing (11.9 cm) at 45 days, organic manure application at sowing (16.8 cm) at 60 days and organic manure application after sowing (28.7 cm) at 75 days (Fig. 1) while lowest was observed in after sowing control (7 cm) at 30 days, humic acid application before sowing (8 cm) at 45 days, humic acid application before sowing (10.4 cm) at 60 days and organic manure application before sowing (15.4 cm) at 75days (Fig. 1). Similar trend was also found and Thakuni and Saharia (1990) and Salah, *et al.* (2009) showed that in early growth stage such as up to 20 days after sowing (DAS) there was no significant difference among the treatments (Nitrogen, Phosphorus, Potassium and organic fertilizer (Bio fertilizer)) but at later stage the highest plant height was observed form the organic fertilizer (Bio fertilizer) plots (45.93 cm, 60.63 cm and 69.73 cm) at 35 DAS, 50 DAS and 65 DAS respectively (Table 1) while lowest (52.27 cm) was observed with controlat65 DAS.

Table (1):F - value of plant height (cm), plant height (cm),number of branches per plant, number of leaves per plant, fresh weight (kg/ha) and dry weight (kg/ha) of mung bean under time of fertilizer application and types of fertilizers.

source of variation	degree of freedom	F – values					
		plant height (cm)	Stem thickness (cm)	number of branches per plant	number of leaves per plant	fresh weight (kg/ha)	dry weight (kg/ha)
Replication	3	1.62	4.27	0.31	3.35	15.52	7.36
Application Time (A)	2	34.03**	4.69*	9.16*	26.58*	2223.13**	68.22**
Error 1	6	-	-	-	-	-	-
Fertilizers (F)	3	40.39**	1.36^{NS}	14.17**	17.38**	383.98**	34.31**
(A × F)	6	130.99**	3.38*	33.29**	37.64**	954.38**	81.70**
Experimental Error	27	-	-	-	-	-	-
Total	47	-	-	-	-	-	-
Error Mean Square (EMS)	-	0.78	0.74	0.24	2.22	173.90	77.66
Coefficient of Variance (C.V. %)	-	4.10	15.90	6.68	6.03	3.14	9.80
L.S.D at 5%	-	0.369	0.360	0.20	0.62	5.52	3.69
$Se_{\pm}$ (A)	-	0.19	0.14	0.15	0.25	1.96	1.74
$Se_{\pm}$ (F)	-	0.25	0.24	0.14	0.43	3.80	2.54
$Se_{\pm}$ (A×F)	-	0.44	0.43	0.24	0.74	6.59	4.40

NS= no significant, **= statistically significant difference at p = 0.05

Table (2): Mean comparison of parameters studied of mung bean under Time of fertilizer application.

Treatments	Plant height (cm)	Stem thickness (cm)	Number of branches per plant	Number of leaves per plant	Fresh weight (Kg/ha)	Dry weight (Kg/ha)
Before sowing application	20.31^{C}	5.55^{A}	7.28^{B}	24.03^{B}	398^{B}	85.31^{B}
With sowing application	21.71^{B}	5.04^{B}	7.01^{C}	23.89^{B}	339.8^{C}	78.38^{C}
After sowing application	22.62^{A}	5.62^{A}	7.92^{A}	26.20^{A}	521.3^{A}	106.1^{A}

The same letters in each column shows non-significant differences using L.S.D.5%.

Table (3): Mean comparison of parameters studied of mung bean under types of fertilizers.

Treatments	Plant height (cm)	Stem thickness (cm)	Number of branches per plant	Number of leaves per plant	Fresh weight (kg/ha)	Dry weight (kg/ha)
Control	21.48^{C}	5.45^{A}	7.35^{B}	24.94^{B}	388.8^{C}	84.33^{C}
Organic Manure	23.05^{A}	5.68^{A}	8.10^{A}	27.06^{A}	523.8^{A}	109.7^{A}
Diammonium phosphate	22.35^{B}	5.50^{A}	7.37^{B}	24.02^{C}	416.4^{B}	91.42^{B}
Humic acid	19.32^{D}	5^{B}	6.79^{C}	22.81^{D}	349.7^{D}	74.33^{D}

The same letters in each column shows non-significant differences using L.S.D.5%.

Table (4): interaction effects of time of Fertilizer application time and types of Fertilizers of parameters studied of Mung bean.

Treatments	plant height (cm)	stem thickness (cm)	number of branches per plant	number of leaves per plant	fresh weight (kg/ha)	dry weight (kg/ha)
B.S ×C	23.08 D	6 BC	7.85 D	27.31 C	471.8 E	101.8 D
B.S × O.M	15.41 I	4.8 F	6.25 H	20.50 I	218 J	51.50 H
B.S × D.P	24.85 B	6.18 AB	8.37 C	26.63 D	482 D	103.8 D
B.S×H.A	17.92 G	5.25 DE	6.62 G	21.69 H	420.3 F	84.25 E
W.S ×C	23.90 C	5.37 D	7.56 E	25 E	372.8 G	85.25 E
W.S × O.M	24.95 B	5.8 C	8.68 B	29 B	537.5 C	116.5 C
W.S ×D.P	17.17 H	4.18G	5.12 I	17.88 J	146 K	40 I
W.S ×H.A	20.83 E	4.81 F	6.68 G	23.69 F	302.8 I	71.75 F
A.S ×C	17.46 H	5 EF	6.62 G	22.50 G	322 H	66 G
A.S × O.M	28.78 A	6.43 A	9.37 A	31.69 A	815.8 A	161 A
A.S ×D.P	25.04 B	6.12 ABC	8.62 B	27.56 C	621.3 B	130.5 B
A.S ×H.A	19.21 F	4.93 EF	7.06 F	23.06 G	326 H	67 G

B.S: Application fertilizer before sowing, W.S: Application fertilizer with sowing, A.S: Application fertilizer after sowing, C: control, M.O: Manure Organic, D.P: Diammonium Phosphate, H.A: Humic Acid.

The same letters in each column shows non-significant differences using L.S.D. %.

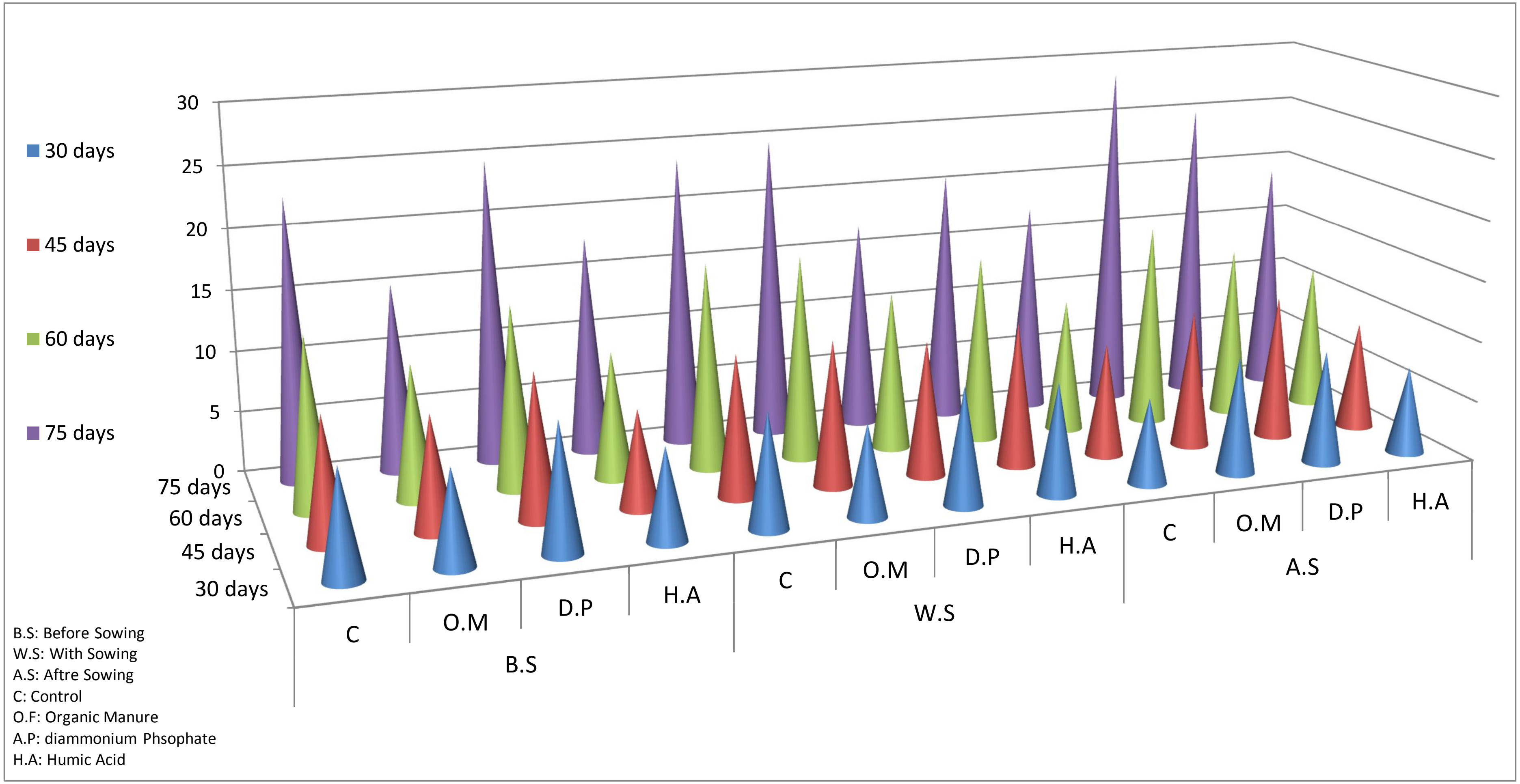

Fig. 1: mean comparison of effect application time and fertilizers and their interaction of plant height Growth on mung bean.

CHAPTER FIVE

SUMMARY AND CONCLUSION

Producing leguminous crops such as mung bean for forage is considered an alternative method to provide supplemental protein. The humic acid, organic manure and diammonium phosphate as fertilizers can increase the quality and improve the output paving the way for sustainable agriculture.

The major targets of this study were to examine the impact of humic acid, organic manure and diammonium phosphate fertilizers on growth and Stover productivity of mung bean and determine optimum application time for enhancing mung bean productivity. To accomplish these objectives, three different applications time and four types of fertilizers were studied using an experimental factorial split plot with random complete blocks designed with four replications. The results obtained from the present research work indicated that highly significant difference of time of fertilizer application and types of fertilizers and their interaction for growth characters of mung bean on plant height, number of leaves per plant, and fresh forage yield and dry forage yield were significantly difference at ($p \leq 0.01$). Highly significant difference of types of fertilizers and interaction between time of fertilizer application and types of fertilizers at ($p \leq 0.01$) for number of branch per plant, significant difference of time of fertilizer application for number of branch per plant and stem thickness at ($p \leq 0.05$), significant difference of interaction between time of fertilizer application for stem thickness at $p \leq 0.05$ and no significant difference of types of fertilizers at ($p = 0.05$) for stem diameter.

The treatment of 50 Kg/ha of organic manure after sowing applications, it gave highest plant height (28.78 cm), thick stem thickness (6.43 cm), optimizes number of branch per plant (9.37), large number of leaves per plant (31.69), best fresh forage yield (815 kg/ ha) and dry forage yield (161 kg / ha) were recorded.

Conclusion:

Based on findings of this study the attributes of mung bean combined application of 50 kg/ha organic manure with application after sowing was considered to be the balanced and suitable combination of fertilizer nutrients for achieving the maximum output of mung bean.

CHAPTER SIX

REFERENCES ANDAPPENDIX

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APPENDIX

Appendix (1): Soil analysis from soil and water science laboratory

Soil sample before the sowing:

<table>
<tr><th colspan="11">Soil property</th></tr>
<tr><th rowspan="2">pH
Paste</th><th rowspan="2">ECe
(dS/m)</th><th colspan="3">Soluble Cations(Meq/l)</th><th colspan="4">Soluble Anions (Meq/l)</th><th rowspan="2">SAR</th></tr>
<tr><th>Na</th><th>K</th><th>Ca+Mg</th><th>CO_3</th><th>HCO_3</th><th>Cl</th><th>SO_4</th></tr>
<tr><td>7.7</td><td>1.4</td><td>12</td><td>0.3</td><td>7.5</td><td>0.0</td><td>3.4</td><td>0.08</td><td>16.4</td><td>6</td></tr>
</table>

<table>
<tr><th rowspan="2">P (ppm)</th><th rowspan="2">N (%)</th><th rowspan="2">O.C (%)</th><th rowspan="2">C/N</th><th colspan="3">Soil particles distribution %</th><th rowspan="2">Textural class</th></tr>
<tr><th>Sand</th><th>Silt</th><th>Clay</th></tr>
<tr><td>2.7</td><td>0.04</td><td>0.7</td><td>18</td><td>11</td><td>34</td><td>55</td><td>Clay soil</td></tr>
</table>

Appendix (2): analysis of variance table:

(A) Plant height (cm)

source of variation	degree of freedom	sum of squares	mean squares	F value
Replication	3	3.102	1.034	1.6277
Application time (A)	2	43.239	21.620	34.0332**
Error 1	6	3.812	0.635	
Fertilizers (F)	3	94.490	31.497	40.3966**
(A × F)	6	612.802	102.134	130.9931**
Experiment al Error	27	21.052	0.780	
Total	47	778.496		

C.V. %= 4.10

$^{s}/_{y}$ for means group addition time (A) = 0.1993

$^{s}/_{y}$ for means group fertilizers (F) = 0.2549

$^{s}/_{y}$ for means group (A × F) = 0.4415

NS= no significant at alpha = 0.05

*= statistically significant at alpha = 0.05

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ =0.3699

(B) Stem thickness (cm)

source of variation	degree of freedom	sum of squares	mean squares	F value
Replication	3	4.409	1.470	4.2270
Application time (A)	2	3.228	1.614	4.6968*
Error 1	6	2.062	0.344	
Fertilizers (F)	3	3.023	1.008	1.3623^{ns}
(A × F)	6	15.019	2.503	3.3844*
Experiment al Error	27	19.969	0.740	
Total	47	47.710		

C.V. %= 19.90

$^{s}/_{y}$ for means group addition time (A) = 0.1466

$^{s}/_{y}$ for means group fertilizers (F) = 0.2483

$^{s}/_{y}$ for means group (A × A) = 0.4300

NS= no significant at alpha = 0.05

*= statistically significant at alpha = 0.05

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$=0.3603

(C)Number of branch / plant

source of variation	degree of freedom	sum of squares	mean squares	F value
Replication	3	0.359	0.120	0.3162
Application time (A)	2	6.945	3.473	9.1649*
Error 1	6	2.273	0.379	
Fertilizers (F)	3	10.422	3.474	14.1747**
(A × F)	6	48.961	8.160	33.2957**
Experimental Error	27	6.617	0.245	
Total	47	75.578		

C.V. %= 6.68

$^{s}/_{y}$ for means group addition time (A) = 0.1539

$^{s}/_{y}$ for means group fertilizers (F) = 0.1429

$^{s}/_{y}$ for means group (A × F) = 0.2475

NS= no significant at alpha = 0.05

*= statistically significant at alpha = 0.05

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ =0.2073

(D)Number of leaves / plant

source of variation	degree of freedom	sum of squares	mean squares	F value
Replication	3	10.188	3.396	3.3565
Application time (A)	2	50.784	26.892	26.5804**
Error 1	6	6.070	1.012	
Fertilizers (F)	3	115.938	38.646	17.3838**
(A × F)	6	502.164	83.694	37.6476**
Experiment al Error	27	60.023	2.223	
Total	47	748.167		

C.V. %= 6.03

$^{s}/_{y}$ for means group addition time (A) = 0.2515

$^{s}/_{y}$ for means group fertilizers (F) = 0.4304

$^{s}/_{y}$ for means group (A× F) = 0.7455

NS= no significant at alpha = 0.05

*= statistically significant at alpha = 0.05

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ =0.6247

(E) Fresh forage yield (kg/ha)

source of variation	degree of freedom	sum of squares	mean squares	F value
Replication	3	2879.167	959.722	15.5281
Application time (A)	2	274804.667	137402.333	2223.1389**
Error 1	6	370.833	61.806	
Fertilizers (F)	3	200335.167	66778.387	383.9882**
(A × F)	6	995847.333	165974.556	954.3846**
Experimental Error	27	4695.500	173.907	
Total	47	1478932.667		

C.V. %= 3.14

$^{s}/_{y}$ for means group addition time (A) = 1.9654

$^{s}/_{y}$ for means group fertilizers (F) = 3.8069

$^{s}/_{y}$ for means group (A× F) = 6.5937

NS= no significant at alpha = 0.05

*= statistically significant at alpha = 0.05

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ = 5.523

(F) Dry forage yield (kg/ha)

source of variation	degree of freedom	sum of squares	mean squares	F value
Replication	3	1080.229	360.076	7.3621
Application time (A)	2	6673.875	3336.938	68.2265**
Error 1	6	293.458	48.910	
Fertilizers (F)	3	7995.896	2665.299	34.3161**
(A × F)	6	38076.292	6346.049	81.7063**
Experiment al Error	27	2097.063	77.669	
Total	47	56216.813		

C.V. %= 9.80

$^{S}/_{y}$ for means group addition time (A) = 1.7484

$^{S}/_{y}$ for means group fertilizers (F) = 2.5441

$^{S}/_{y}$ for means group (A × F) = 4.4065

NS= no significant at alpha = 0.05

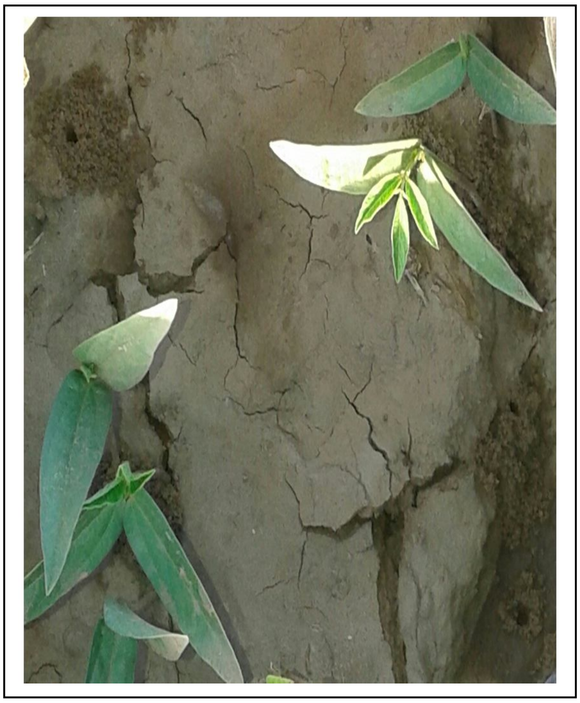
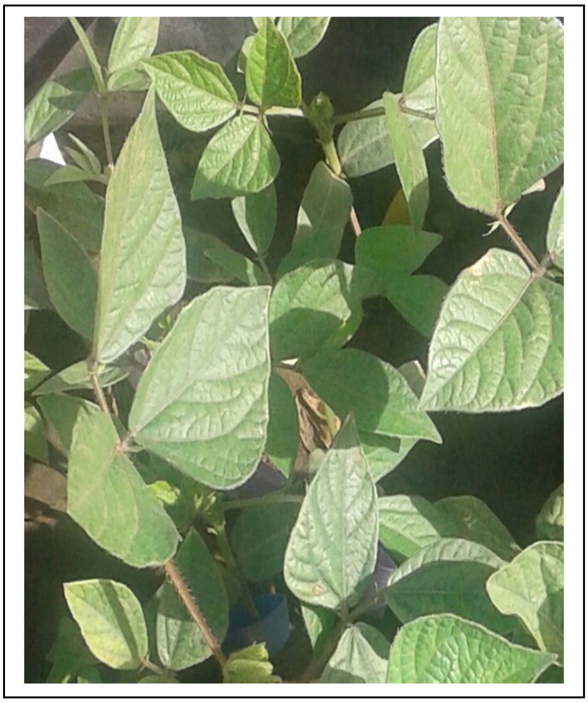
*= statistically significant at alpha = 0.05

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ = 3.697

Appendix (3): some photos

1- Plant Germination


2- Plant Growth Stages

3- Fertilizer application before sowing

4- Fertilizer application with sowing

5- Fertilizer application after sowing

6- Plant at Harvesting