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Sudan University of Science and Technology

College of Graduate Studies

Effect of Some Fertilizers on Growth and Forage Yield of Guar (*Cyamopisis tetragonoloba L*)

أثر أنواع من الأسمدة على نمو وإنتاجية علف القوار

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الآيــة

قال تعالي:

﴿...لأَزْوَاجَ كُلَّهَا مِمَّا تُنْبِتُ الأَرْضُ وَمِنْ أَنفُسِهِمْ وَمِمَّا

لا يَعْلَمُونَ ﴿36﴾.

صدق الله العظيم

سورة يس الآية (36)

DEDICATION

To my late mother who kept burn her fingers to shining my way (God mercy her)

Special thanks to my father

To my brothers, sisters, friends and for all who helped me

ACKNOWLEDGEMENT

First praise to Allah, for given me strength and patience to complete this work successfully.

I would like to express my sincere thanks to my supervisor Prof. Yassin Mohamed Ibrahim Dagash for his continual support, stimulating suggestion, instructive advice and encouragement that help me during this work.

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Abstract

Pots experiment was carried out in july (2016) at the Demonstration Farm of the College of Agricultural Studies, Sudan University of Sciences and Technology, Shambat to study the effect of different types of fertilizers and their combination on growth and forage yield of guar (*Cyamopsis tetragonoloba L*). The treatments consisted of phosphorus, potassium, phosphorus with humic acid, potassium with humic acid and phosphorus with potassium and humic acid and control. The experimental design was randomized complete block. With five replications. Data on various guar growth and forage yield were collected and analyzed.

Results showed highly significant differences ($p \leq 0.05$) among the treatmentS for all the studied growth and yield parameters except stem thickness. The results also demonstrated that the combined effect of phosphorus, potassium and humic acid treatment recorded the highest guar growth (except the number of branches/ plant) and forage yield attributes. The highest number of branches/ plant was achieved by the control. While, phosphorus and humic acid produced the lowest guar forage fresh and dry yields.

المستخلص

أجريت هذه التجربة التجربة في أصص في يولو 2016 بمزرعة كلية الدراسات الزراعية، جامعة السودان للعلوم والتكنولوجيا، شمبات لدراسة تأثير عدة أنواع من الأسمدة و مزيجها علي نمو وإنتاجية علف القوار . المعاملات شملت فوسفور، بوتاسيوم، فوسفور مع هيومك اسيد، بوتاسيوم مع هيومك اسيد، فوسفور مع بوتاسيوم وهيومك اسيد و الكنترول. صممت التجربة بنظام القطاعات العشوائية الكامله في خمس مكررات. تم جمع البيانات للنمو والإنتاجية لعلف القوار وتم تحليلها, أظهرت نتائج التحليل فروق معنوية عالية في المعاملات المدروسة التي قيست ماعدا سمك الساق.

أظهرت النتائج أيضا ان مزيج الأسمدة (فوسفور مع بوتاسيوم وهيوميك اسيد) سجل أفضل النتائج بالنسبة لنمو القوار (ماعدا عدد الأفرع للنبات الواحد) وكذلك الإنتاجية . اعلي عدد للأفرع بالنسبة للنبات الواحد حققه الكنترول ،وأيضا كان مزيج الأسمدة الأفضل من حيث إنتاجية القوار للوزن الرطب والجاف.

CHAPTER ONE

INTRODUCTION

The estimated livestock number in Sudan was about 168 million heads (40 million cattle, 49 million sheep, 42 million goats and 37 million camel) (FMAR, 2005). Due to degradation and desertification of rangelands in Sudan, the annual total dry matter production from natural rangelands vegetation, crop residues, green forage and concentrrates feed was estimated to amount only for 104.80 million, while the annual total dry matter required to support the livestock feeding was estimated about 213.20 million ton. The gap in livestock feeding was therefore, about 108.40 million ton, which represents around 50% of the total requirement of livestock feed (Abu-suwar and Drrag, 2002).

To cope with increase in livestock number and the shortage in forage production in natural rangeland, expansion and improvement of irrigated forage became a necessity. The irrigated forges in Sudan contribute about 4% of the total forage production (Abu-Suwar, 2004). They are mainly produced in the Northern State (0.5 million) as well as Khartoum and Eastern States (one million). Abu-Suwar (2004) mentioned that alfalfa (*Medicago sativa* L.) or Lucerne as it is called in many European countries is considered the top ranking among irrigated forage crops (94% of the total cultivated forage crops) and “Abusabeen” (*sorghum bicolor*) is the second (5%) forage crop in the country. The other leguminous forages constitute only about 1%.

Guar or cluster bean (*Cyamopsis tetragonoloba*) is a drought tolerant annual legume crop, grown widely in the semiarid tropics of India and Pakistan, mainly as a green manure, animal feed and as a vegetable and grain for human consumption (Whistler and Hymowitz,1979). The three major components of guar seed are the seed coat (14-17%), endosperm (35-42%) and germ (43-47%) (Golstein and alter 1959). The germ contains most of the protein in the seed while the endosperm contains the galactomanan gum. Guar was introduced in the United States from India in 1903, the commercial production began in mid-1940. The commercial and industrial importance of this crop is based on the fact that, the seed is an important source of galactomannan gum. This gum has a number of useful properties, including high viscosities, which lead to wide range of industrial and food processing use (Alexander *et al.*, 1988). Guar like other legumes containing phosphorus, potassium and calcium contributing in formation of bones dry forage guar content 25.2% protein, 13.8%fiber, 16.5 ash, 43.6 NFE, while fresh forage content 6.6 protein, 40.7 sugar (Abu suwar, 2004).

Guar was introduce into Sudan from United States in early 1930 for assessment as fodder legume in the Gezira, which on the other hand an important bearing on the soil as a nitrogen fixing crop (Flowerman, 1987). Several trials were conducted on heavy clay under high soil moisture regimes. In1965 guar trials were extended to Hudeiba Research Station due to the more favorable soil conditions where good yield (one t/ha) (Mahmoud, 1996). Was obtained In 1990 Gum Arabic Company together with El-sheikh Mustafa EL-Amin Agricultural Company began seed production and consequently, the Sudanese Gum company LTD constructed a factory for guar gum in Singa, Sinnar State in 1992. So far, only four varieties (HFG 53, HFG 75, HFG 408 and HFG 9065) were recommended to be grown by the Sudanese Guar company.

In Sudan guar is increasingly being grown in rain feed area and other marginal areas, like Northern Kordufan and Northern Darfur States, where the average annual rainfall is less than 400mm. However, Yousif (1984) in a field study at Shambat Research Station, Sudan, reported that guar required 400-

500mm annual rainfall. Under such conditions there is a high probability of water deficits developing during any stage along the life cycle of the crop (Flowerman.1987).

At present, most of guar production in Sudan is by rains. Production is mainly in the mechanized sector in the Blue Nile, Gadarif and Northern Kordofan States (Gumma, 2001). In spite of its importance as an industrial and export crop, guar has received little attention in the Sudan (Sabah- Elkhir, 1999).

The objective of this study was:-

1) To investigate the effect of different fertilizer types on growth and yield of guar forage.

CHAPTER TWO

LITERATURE REVIEW

2.1 Botanical description:

Gua (*Cyamopsis tetragonoloba L*) is a member of the family *Fabaceae*. Its common names include guar, cluster bean, siambean, gwarar, guaru and gavar. Guar is bushy branching annual plant, usually ranging from 0.5-3.0m in height, numerous strong branches arising from basal nodes. The root system consists of a long tab root and well developed lateral roots having large light colored nodules. Guar is self-polinated and the amount of out crossing under field condition varies from 1-9% depending on genotype and environment. Pod setting start just above the ground to the top of the plant. Pods normally contain 5-12 ovals or cube shaped seed of variable size with white, grey or blanch color.Guar seeds do not shatter but pods can break off quite easily when over dry (Duke, 1981).

2.2 Uses of guar:

Guar is a multipurpose crop and is used as vegetable for human consumption and for cattle and also used as green manure crop (Abdalla. 2007). It has the capacity to improve the soil fertility through nitrogen fixation. Its seed are also source of galactomannan gums which is used in the food industry as a thickening agent, paper manufacturing, textile industries printing and in pharmaceutical industries for lotions and creams, and in the mining industry for purification of potash, or building materials, tobacco curing, petroleum flotation, and water proofing of explosives. Nevertheless, the best known use of this gum is a friction- reducing additive in drilling mud for the petroleum industry (Alexander *et al*., 1988).

In the Indo Pakistan immature pods are dried, salted, and preserved for future use. Also immature pods are dried like potato chips, or cooked like fresh bean. Mature seeds are used as emergency cattle feed. Also, plants are cut and fed as green forage. In some cases, Guar plants are ashed then mixed with oil and used as emergence on cattle feed. Leaves are eaten as a cure of night blindness. Guar seed was also found to contain 27-37.2% protein of nutritional quality(Ibrahim, 2011).

2.3 Climatic requirement of guar:

Guar is a drought-resistant, warm-weather, summer growing annual legume. It grows well under a wide range of soil, but performs better on fertile and well drained sub soil. Although guar grows well on a variety of soil, it thrives best in sandy, sandy loam and coarse textured alluvial soils. It does not grow well in heavy black soil. Soil with a pH rang of 7.5-8.0 are better suited for guar production than are acidic soils (Fletcher and Murphy, 1998).

Guar is a drought-resistant crop with a deep tap root and cannot withstand excess moisture or water logging during the growing season. it is grown without irrigation in area with 250-1000 mm of annual rainfall , Excessive rain or humidity after maturity causes the seeds to turn black and shrivel, reducing their quality and marketability (Duke *et al*., 1991). Guar is a salt-tolerant crop that can survive at a fairly high level of soil salinity. Guar is photoperiod sensitive plant and is classified as a short-day plant. Guar can tolerate a wide range of temperatures but maximum growth occurs at high temperatures (21-30°C) (Tyagi *et al*., 1982).

2.4 Irrigation:

Guar needs plenty of water at planting time and at development (Duke, 1981). Yousif (1984) suggested that guar should receive no more than three to four irrigations when grown in a pre-irrigation seed bed, and the first irrigation should take place within a month after planting. In some areas in India the first irrigation of guar grown for fodder production is given within 15-20 days after sowing with subsequent irrigation at interval of 7-10 days.

2.5 Inoculation and nitrogen fixation:

Inoculation of seed of many leguminous plants with rhizobia is important to increase nodulation and thus nitrogen fixation (Kannaian, *et al.*, 1992). Inoculation of legumes with rhizobium strains was observed to increase nodulation and seed yield (El-shaikh, 1999). The symbiotic relationship between rhizobium bacteria are selective in terms of which crop species they inoculate. Furthermore, cross-inoculation groups has been developed to account for these differences within a culture of right kind of bacterial strains. Inoculation of guar with rhizobium *Japonicum* increased seed yields compared with untreated control (Singh and Singh, 1989).

Inoculation was also reported to increase the number of nodules, nodules fresh weight, plant dry weight, nitrogen fixation and total nitrogen content of guar crop (Mand *et al.*, 1991; Suman *et al.*, 1995). Plants grow from inoculated seed were slightly taller with more nodes on the main stem and weighted more than plants grown from non-inoculated seed (Stafford *et al.*, 1980). Nodulation was significantly correlated with shoot growth; however nitrogenase active level per plant declined significantly with plant maturity (Lynd *et al.*, 1989). In Sudan, El-shaikh and Ibrahim (1999), found that most of the Bradyrhizobium strains they tested (two indigenous and two imported strains) significantly increased guar yield, protein, fiber and mineral content. The local strains were more effective in this respect than introduced strains. Guar response to inoculation was found to vary with soil type as has been reported by Mand *et al.* (1991) who observed better response to inoculation in form of nodulation and growth in loamy sands than in sandy loams in India. Starter (booster) doses of nitrogen (20 kg N/ha) were reported to enhance the guar response to inoculation with root nodule bacteria (Singh and Singh, 1990).

Guar is a legume that is well known for improvement of soil fertility and is usually incorporated in crop rotation as "soil building crop" (Undersander *et al.*, 1991). However, for this benefit to be achieved plant have to be well nodulated. Stafford and Lewis (1980) found that guar plants raised from inoculated seeds were taller, had more nodules and weighed more than plants raised from un-inoculated seeds. Researchers (Badawy *et al.*, 1996; Bell *et al.*, 1990; Garg, 2005;Mahmoud *et al.* 1996) found that inoculation resulted in significant improvement of all nodulation parameters of guar, yield as well as plant N and P contents. Ghalab *et al.*, (2000) reported that guar inoculation with a mixture of three Bradyrhizobium strains in Egypt resulted in significant increases in nodule dry weights and shoot nitrogen contents. Variation in efficiencies of Bradyrhizobium strains in improving guar growth and nodulation was also noticed by the same authors. Inoculation of guar seeds with Bradyrhizobium produced higher forage yield than nitrogen or phosphorus application.

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inoculation resulted in significant improvement of all nodulation parameters of guar, yield as well as plant N and P contents. Ghalab *et al*., (2000) reported that guar inoculation with a mixture of three Bradyrhizobium strains in Egypt resulted in significant increases in nodule dry weights and shoot nitrogen contents. Variation in efficiencies of Bradyrhizobium strains in improving guar growth and nodulation was also noticed by the same authors. Inoculation of guar seeds with Bradyrhizobium produced higher forage yield than nitrogen or phosphorus application.

2.6 Weed control:

Guar is not a good competitor with weed during establishment. (Matlock and Aepli,1984). Weed competition can reduce the yield substantially. Early preparation of land cultivations during the growing season will be helpful. Matlock and Aepli (1984) recognized that there was a close relationship between degree of weed infestation and final harvested yields of guar seed.

2.6 Irrigation:

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2.7 Fertilization:

Fertilization of guar crop based on soil test is not a common practice. However, an annual application of phosphorus at a rate of 15-17 kg p_2o_5/ha is recommended depending on fertility status of the soil (oke,1969). The fertilizer should be ploughed down or covered well into the root zone (Whistler and Hymowitz, 1979). Phosphorus application in combination with nitrogen, potassium, or sulfur significantly increased the yield and nitrogen content of guar compared to the control. Singh and Singh (1989) reported that phosphorus and nitrogen treatments increased nodulation, root dry weight, gum content and 1000-seed weight. Application of phosphorus fertilizer is also important for effective nodulation and contributes to yield (Hossain, 2007).

2.7.1 Nitrogen:

Guar is a leguminous crop and if inoculated properly will supply nitrogen, so nitrogen fertilizers are generally not required. In condition of extremely low soil nitrogen (for example if double-cropping guar into high levels of cereal stubble), low nitrogen application rates (5-10 kg N/ha) as starter fertilizer may assist early growth. The application of nitrogen in small doses improved nodulation, growth and nitrogen fixation in guar (Hago *et al*., 2001). In poorer soils a small dose of nitrogen fertilizer in the range of 10-15 kg N/ha is thought to be beneficial for forage production (Faroda, 1986).

Nitrogen application alone or in combination with phosphorus, potassium or sulfur, significantly increased the yield and nitrogen content of guar forage compared with the control (Sidhu *et al*., 1985). Singh *et al.* (1989) found that nitrogen application and inoculation increased the seed yield of guar compared with untreated control. The researchers also reported that inoculation and/or nitrogen and phosphorus treatments increase nodulation, root dry weight, seed protein and gum content.

2.7.2 Phosphorus:

It is reported that phosphorus application and Rhizobium inoculation enhance growth and yield of leguminous crops and nodulation can significantly be improved (El Hassan *et al*., 2010). However, little attention has been paid to the effect of phosphorus on guar forage production. Phosphorus application in combination with nitrogen, potassium or sulfur, significantly increased the yield and nitrogen content of guar plants compared to control. Abdalmalik (2004) and Henry *et al*. (2003), Shukla (1997) observed that optimal levels of phosphorus increase improve plant height. Singh and Singh (1989) reported that phosphorus and nitrogen treatments increased nodulation, root dry weight, seed protein and gum content. Application of phosphorus fertilizer also important for effective nodulation and contributes to increase seed yield. This information varies with different varieties of guar (Idris *et al*., 2001;Tiwana, 1994). Further, studies have shown that similar crops like *Dolichos leblab* L can positively respond to the application of phosphorous fertilizers. For example, Parasad *et al*., (1988) found that an application of 40kg P_2O_5/ha increased seed yield of *Dolichos leblab* L.

Gill and Singh (1981) stated that application of 30kg $P_2 O_5$/ha proved to be the best dose for increased seed yield of guar and above this level the yield can considerably be decreased. Hango and Gumma (2001) reported that guar responded to phosphorus up to the rate of 50kg $P_2 O_5$/ha. On the other hand, Omar *et al*. (1993) noted that the plant weight and yield per plant were slightly increased by applying 60kg $P_2 O_5$/fed . These results are not in disagreement with those obtained by Razin *et al*., (1980).

2.7.3 Potassium:

Potassium is one of the major elements taken by plant in amount that exceeds most of other elements, except nitrogen and perhaps calcium. Jones (1982) reported that soil potassium can be grouped into three main categories namely, relatively unavailable, slowly available and readily available forms. The availability of potassium is affected by many factors including the type of soil colloids, temperature and soil pH. These various forms of soil potassium exist equilibrium with one another and the depletion of one form is replenished by the other forms (Verma and Sexena ,1995). Potassium is very essential to all higher and lower plants and found to serve vital role in photosynthesis, increasing growth and leaf area index. Potassium is also required to activate many enzymes and neutralize the anion. Potassium specific role is in the mechanism of opening and closing stomata. The combine application of P and K increased the weight of individual nodule in clover up to 4 times (Broude and Gasman, 1990).

In Pakistan, eight different combination between P and K on guar 0-0, 25-0, 25-25, 40-40, 55-55, 70-70-85-85 and 100-100 kg/ha were used. The results revealed that above ground biomass like plant height, stem diameter, number of branches and leaf area/plant affected by the above mentioned P and K doses. The application of at the rate of 70-70 kg/ha registered the highest value for plant and stem diameter,whereas the maximum number of branches and leaf are/plant, fresh and dry matter yield was achieved with 85-85kg/ha (Ayub *et al.*, 2012). The stem diameter reached at its maximum value with 55-55kg/ha and further increase in P and K rates did not account. These findings were consistent with those of Youssef *et al.* (2002) and Singh *et al.,* (2002). The increase in number of leaves/plant, stem diameter, plant high and number of branches/plant due to the application of P and K led to improved green forage yield (Sokrab, 1983).

2.7.4 Humic acid (HA):

Humic acid is a commercial production fertilizer contains many elements which improve soil physical properties and increase the available soil nutrients and consequently enhance crops growth and yield (Abd *et al.*, 2005). In specific, it is found that humic acid application led to a significant increase in soil organic matter which improves plant height and crop production (Magdi et. al., 2011).

As a suspension, potassium hamates can be applied successfully in many areas of plant production as a plant growth stimulant or soil conditioner (Scheuerell and Mahaffe, 2006). It can be sprayed on the plant foliage as liquid or in the soil in the form of granules alone or as a fertilizer mixture. Humic acid is one of the major components of humus. Humates are natural organic substances, high in humic acid and contain most of the known trace minerals necessary to the growth and development of plants(McDonnell *et al*, 2001). Humic substances provide stable fraction of carbon and improve soil water holding capacity and pH buffering (Yildirim, 2007).

2.8 Forage production:

The literature concerning the use of guar as a forage source is meager. However, some studies have shown that producing guar as a forage crop in a mono-cropping system seemed more profitable than growing it as mixture with other crops like pearl millet (Fletcher, 1998). Concern has been expressed about the use of guar as a forge crop because guar immature beans contain hydrocyanic acid; a toxic substance to cattle. Immature guar beans contain about 40-70 mg hydrocyanic acid /100g dry matter; while the fully dry guar beans has only traces of the toxic substance.

The cultural practices of guar as a fodder crop is slightly different from their counterparts when the crop is gown for grains production. For example, guar forage crop is occasionally grown under irrigation during the summer months of March through June (Whister and Hymowitz, 1979) . It is recommended that the crop be irrigated at an interval of 8-10 days. It is also noted that guar is broadcasted under irrigation conditions and drilled under dry land conditions (rain-fed systems) (Whister and Hymowitz, 1979). For the broadcasting sowing method, a seeding rate of 30-40 kg/ha is recommended. On the other hand, fertilizes application of 30-15kg P_2 O_5/ha and 10-15kg of K_2O per ha are recommended. Under suboptimal soil conditions, a small dose of nitrogen fertilizer in the range of 10-15kg/ha is thought to be beneficial for guar forage production(Whister and Hymowitz, 1979). The crop is ready to be cut 10-12 weeks after sowing when the plants are in full bloom and pod formation has stared. Yields ranging from 8000-12000 kg of green forage per ha can be expected from dry land plantings (rain-fed systems), while yield of 16000-20000 kg of green forage per ha can be obtained under irrigation conditions (Whister and Hymowitz, 1979).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental site:

Pots experiments was conducted on the 14 March 2016 at the experimental farm of the Collage of Agricultural Studies, Sudan University of Science and Technology (latitude 15-40 N, longitude 30-32 E, Elevation is 380 m above sea level). The experimental site is located in semi-desert and tropical zone, with low relative humidity. The daily maximum temperature was 12°C in January. The annual rain fall was 100-250 mm (Adam, 2002).

3.2 Experiment treatments:

In this study, three types of fertilizers and their combinations were tested. The fertilizers were applied at the sowing. Urea (46% N) was applied to all experimental units (pots) at a rate of 4gm urea/pot as a basal dose.

Table (1): treatments used in the experiment:

P	10 gm/pot
K	15gm/pot
P+Humic acid (HA)	5gm+1 ml /pot
K+Humic acid (HA)	7.5gm+1ml /pot
P+K+Humic acid	3.5gm+5gm+1ml /pot
Control	0

3.3 Experimental design:

The treatments were arranged in a Randomized Complete Block Design (RCBD) with five replications.

3.4 Source of seeds:

Seed of guar line L18 was obtained from the Department of Agronomy, Faculty of Agriculture, University of Khartoum.

3.5 Cultural practices:

The soil mixture consisted of clay and sand (2:1) in plastic pots. Pot area was 1.4 m^2 and each pot contained 10 kg soil. Soil sub samples were taken before sowing and analyzed for electric conductivity (EC), pH, soluble salts, P (ppm), N (%), O.C (%), soil particles distribution (%) and textural class (Appendix 1). Before sowing the seeds were treated by thiram (as pesticide and fungicide) at a dose of 0.12 mg thiram per 24 gm seeds. The seeding rate was 15 seeds/ pot. Plants were thinned to 2 plant/hole 21 days after sowing.Weeds were removed manually every three weeks after sowing and continued till two month from sowing. There was no damage from pest or diseases observed during the experimental period.

3.6 Data collection:

Four plants were randomly selected from each pot and tagged and following observations were recorded:

3.6.1 Plant height (cm):

The height of the four tagged plants were measured from soil surface to the uppermost leaf of the stem. Then the average plant height was measured.

3.6.2 Stem thickness (cm):

Stem thickness for each of the four selected plants was estimated and the average was recorded for each treatment.

3.6.3 Number of branches /plant:

The average number of branches per plant was counted from the four tagged plants from each treatment.

3.6.4 Number of leaves /plant:

From the same four tagged plants, average number of leaves per plant for each treatment was counted.

3.6.5 Fresh weight (gm/ plant):

Average fresh weight was determined from the four tagged plants for each treatment.

3.6.6 Dry weight (gm/ plant):

The average dry weight was measured from the four tagged plants for each treatment. The plants were oven dried for about 24 hours at 80°C.

Forage fresh and dry weight (kg/ hectare) were calculated as follows:

$$\frac{\text{Area in hectare } (10000\ m^2) \times \text{forage weight per pot (gm)}}{\text{Pot area } (1.4\ m^2)}$$

3.7 Statistical analysis:

Analysis of variance (ANOVA) was performed for all collected data according to RCBD using MSTAT-package. Means were then compared using the Least Significant Difference (L.S.D) test (Gomez and Gomez, 1984).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Vegetative attributes:

4.1.1 Plant height (cm):

The results showed significant ($p \leq 0.05$) differences for mean plant height between the three types of fertilizers and their combinations (Table 2). Phosphorus and the combined three fertilizers (phosphorus, potassium and humic acid) recorded significantly taller plants (33.69 cm) compared to all other treatments (Table 3); while the control recorded the shortest mean plant height (20.24cm) (Table 3). This is due to the fact that phosphorus plays an important role in improving plant growth and the deficiency in this nutrient can lead to weak plant growth. These results are in an agreement with those of Henry *et al.* (2003) who noted an increase in plant height when phosphorus was applied.

4.1.2 Stem thickness (cm):

Analsis of variance test showed no significant ($p \geq 0.05$) effect of fertilizer types and their combinations on mean stem thickness (Table 2). That means guar did not benefit from these fertilizers. That might imply that guar stem thickness could be more controlled by genetic facters than the chemical or organic fertilizers. Notwithstanding, Abd *et al*. (2005) observed that humic acid can improve soil organic matter witch improve plant growth and crop production.

4.1.3 Number of branches / plant:

Table (2) shows that there were significant ($p \leq 0.05$) differences among the different treatments. However, when the mean treatment were compared, control treatment had the highest mean number of branches/ plant (3.00) compared to other treatments (Table 3). It was reborted that the increase level of phosphorus could decrease number of branches/ plant (Abdalmalik, 2004).on the other hand, Magdi *et al.* (2011) reported that combination of chemical fertilizers with application of humic acid may improve plant growth.

4.1.4 Number of leaves / plant:

Mean number of leaves /plant was significantly ($p \leq 0.05$) affected by the types of fertilizers and their combination (Table 2). Significanty higher number of leaves / plant (68.20) was recorded when a combined dose of the three types of fertilizers (phosphorus, potassium and humic acid) was applied. On the other hand, the lowest number of leaves/ plant (52.20) was recorded at combination of only two fertilizers (phosphorus with humic acid) (Table 3). These findings indicate that the number of leaves/ plant was affected by the combined effect of the chemical fertilizers together with the humic acid which led to enhanced plant growth. Similar result was obtained by Hafez (2003) who reported that humic acid with chemical fertilizer improved plant growth. In contrast, Lemaire *et al.* (1991) noted that insufficient phosphorus and potassium content in the plant can decrease number of leaves/ plant.

4.2 Yield attributes:

4.2.1 Fresh weight (kg/ha):

Analysis of variance result showed that the effect of fertilizer types and their combination on guar fresh weight was significant ($p \leq 0.05$) (Table 2). The highest fresh weight (416 kg/ha) was obtained when the three fertilizers (phosphorus, potassium and humic acid) were applayed (Table 3). The lowest fresh weight (192.8 kg/ha) was recorded with combination of phosphorus with humic acid fertilizers (Table 3). This result implies that guar forage fresh yield can significantly be improved by applying the combination of three studied fertilizers. The combination of the three fertilizers enhance soil chemical and physical properties and therefore improve plant growth which is a proxy of good forage production. Similarly, Haden *et al.* (2007) found that optimal fertilizers application, specifically phosphorus can lead to high fresh yield.

4.2.2 Dry weight (kg/ha):

fertilizers types and their combination had significant ($p \leq 0.05$) effect on guar dry weight (kg/ha) (Table 2). The maximum dry weight of (149.2 kg/ha) (Table 3) was obtained when the crop was treated by the three fertilizers (phosphorus, potassium and humic acid). Likewise, the minimum guar dry weight of (92.80 kg/ha) was recorded from the combination of the phosphorus with humic asid fertilizers (Table 3). This result indicated that guar was significantly responded to the combination of the three fertilizer compared to a single fertilizer or when only two fertilizers were combined. This result was supported by Magdi *et al*., (2011) who noted that a combined chemical fertilizers and humic acid application can improve plant production.

4.3 Growth of plant height with time at different fertilizer types:

Figure (1) shows the plant height mean at different days after sowing (DAS) (30, 45, 60, 75, and 90) as effected under different fertilizer treatments to study the effect of fertilizers on plant height with time. Plant growth (that is plant height) of guar in each treatment increased with time. It is observed that the combined fertilizers treatment was involved in enhancing guar plant height during interal (Figure 1).The highest plant height was recorded at 90 (DAS) by the phosphorus and combined fertilizers treatments. Likewise, the phosphorus and combined fertilizers treatments exhibited the highest plant height at75 days from planting. On the other hand, potassium and combined fertilizers treatments recorded the highest plant height at 45 and 60 (DAS) from planting. At 30 days, only the combined fertilizers treatment showed the highest plant height. The lowest guar plant height was obtained by the control during all ocation (Figure 1). It is also observed that plant height of all treatments followed the exponential shape of the relative growth rate. These results reinforce the importance of combined fertilizers treatment in enhancing guar growth. This could be due to the fact that combined fertilizers treatment enhances the availability of most of the essential nutrients needed for guar growth. This result agreement with Hartz *et al*, (2010).

Table (2): F – values of guar growth parameters (ANOVA) for different studied guar growth and yield parameters

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	4	2.70	1.29	0.03	2.12	1.39	0.76
Fertilizers	5	5.51**	0.27^{NS}	26.16**	13.12**	91.04**	143.01**
Error	20	-	-	-	-	-	-
Total	29	-	-	-	-	-	-
Error Mean Square (EMS)	-	21.37	0.004	0.05	15.72	331.63	15.93
Coefficient of variance (C.V. %)	-	15.83	11.98	11.54	6.73	6.52	3.61
Standard error (SE ±)	-	2.06	0.02	0.10	1.77	8.14	1.78

NS= no significant, **= statistically significant difference at $p \leq 0.05$

Table (3): Means of different studied guar parameters under different types of fertilizers and their combination

Treatments	plant height (cm)	number of branches per plant	number of leaves per plant	fresh weight (kg/ha)	dry weight (kg/ha)
Control	20.24^{C}	3.00^{A}	60.60^{C}	285.80^{C}	99.20^{D}
P	33.69^{A}	1.82^{C}	55.20^{D}	298.40^{D}	98.60^{D}
K	29.51^{B}	1.66^{D}	53.20^{E}	229.80^{E}	107.20^{C}
P + HA	29.56^{B}	1.60^{D}	52.20^{E}	192.80^{F}	92.80^{E}
K + HA	28.94^{B}	2.00^{B}	64.00^{B}	303.40^{B}	117.20^{B}
P + K + HA	33.32^{A}	1.80^{C}	68.20^{A}	416.00^{A}	149.20^{A}
L.S.D at 5%	2.06	0.12	0.10	9.81	2.15

Means followed by the same letters in each column are not significantly different from each others using L.S.D. test at 0.05 level of significance.

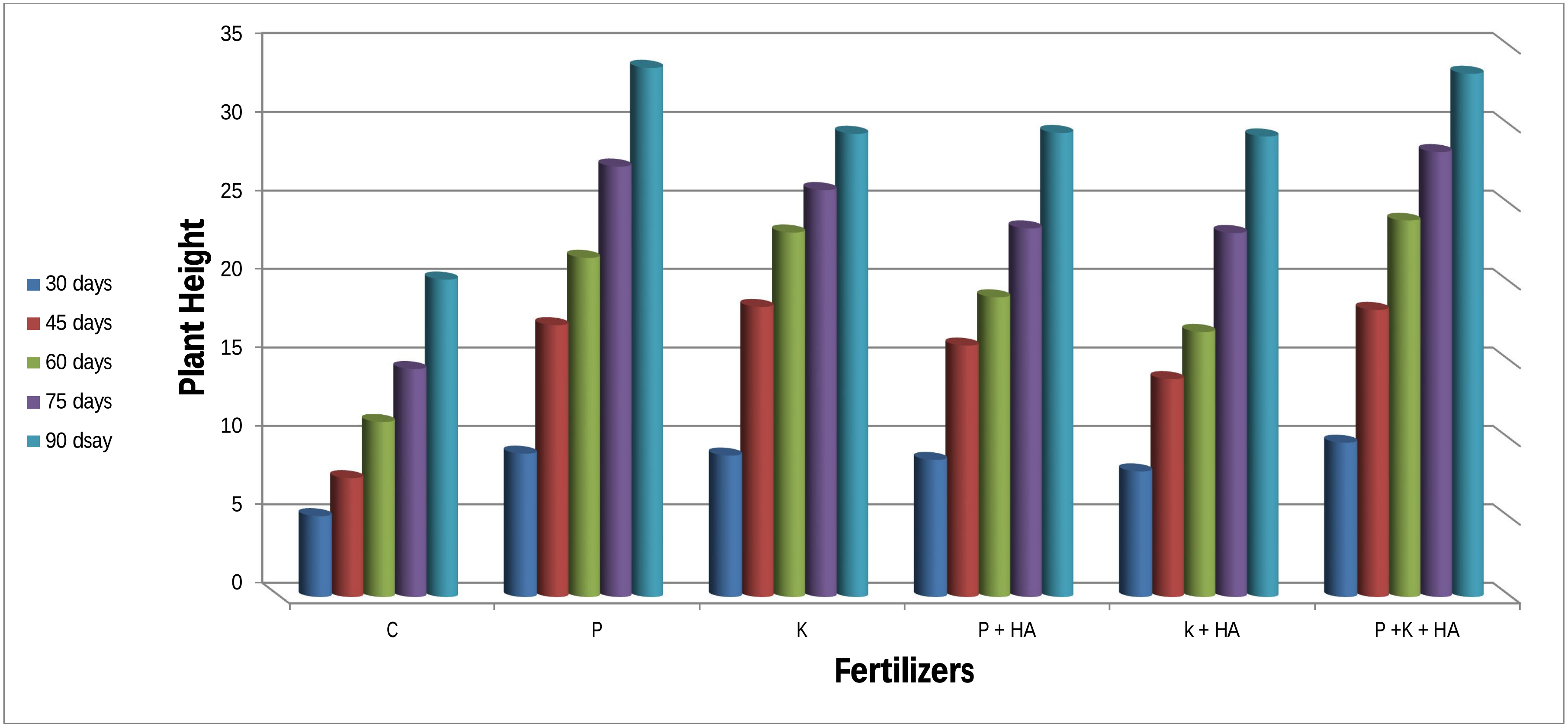

Fig. 1: Growth of guar plant high with time at different fertilizer types and their combination

- C= control, P= phosphorus, K= potassium, P+HA= phosphorus with humic acid, K+HA= potassium with humic acid, P+k+HA= phosphorus with potassium and humic acid.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

The objective of this research was to study the effect of different types of fertilizers on growth and forage yield of guar. The experiment was conducted at Shambat during sumer 2016. Data were collected on plant height, stem thickness, number of branches/ plant, number of leaves/ plant, fresh weight, and dry weight. The results showed that the combined fertilizers treatment improved most of the studied growth and yield attributes. However, stem thickness and number of branches/ plant were not affected by any of the treatments.

Conclusions:

From the results of this study, it could be concluded that:

1-The fertilizers used in this study showed significant effects on growth attributes (plant height per plant, number of branches per plant, number of leaves per plant) and forage yield attributes (fresh and dry weights).

2- The combination of the three fertilizers (phosphorus, potassium and humic acid) recorded the highest guar forage fresh and dry matter yields.

3-The fertilizers had no effect on the stem thickness.

4- Combined phosphorus and humic acid did produced the lowest guar forage fresh and dry matter yields.

5-This work should be repeated for another season to confirm the results.

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APPENDICES

Appendix (1): Soil analysis for soil samples collected before sowing. The analysis was conducted at the soil and water science laboratory, University of Sudan Sciences and Technology

Soil property									
pH Paste	ECe (dS/m)	Soluble Cations (Meq/l)			Soluble Anions (Meq/l)				SAR
		Na	K	Ca+Mg	CO_3	HCO_3	Cl	SO_4	
7.7	1.4	12	0.3	7.5	0.0	3.4	0.08	16.4	6

P (ppm)	N (%)	O.C (%)	C/N	Soil particles distribution (%)			Textural class
				Sand	Silt	Clay	
2.7	0.04	0.7	18	11	34	55	Clay soil

Appendix (2): Analysis of variance (ANOVA) for all studied gaur growth and yield parameters:

(A) Plant height (cm)

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F–value
Replication	4	230.890	57.723	2.700
Fertilizers	5	589.075	117.518	5.512**
Error	20	427.486	21.374	
Total	29	1247.454		

C.V. %= 15.83

SE± for means group = 2.067

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ = 2.49

(B)Stem thickness (cm)

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F–value
Replication	4	0.021	0.005	1.290
Fertilizers	5	0.006	0.001	0.274^{NS}
Error	20	0.083	0.004	
Total	29	0.110		

C.V. %= 11.98

SE± for means group = 0.028

NS= no significantat alpha = 0.05

(C) Number of branches / plant

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F–value
Replication	4	0.131	0.033	0.638
Fertilizers	5	6.728	1.346	26.162**
Error	20	1.029	0.051	
Total	29	7.888		

C.V. %= 11.54

SE± for means group = 0.101

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ =0.12

(D) Number of leaves / plant

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F–value
Replication	4	133.867	33.467	2.128
Fertilizers	5	1032.300	206.460	13.128**
Error	20	314.533	15.727	
Total	29	1480.700		

C.V. %= 6.73

SE± for means group = 1.77

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ =2.14

(E) Fresh forage yield (kg/ha)

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F–value
Replication	4	1845.133	461283	1.391
Fertilizers	5	150986.167	30497.233	91.042**
Error	20	6633.667	331.683	
Total	29	159464.967		

C.V. %= 6.52

SE± for means group = 8.14

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ = 9.81

(F) Dry weight (kg/ha)

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F–value
Replication	4	48.467	12.117	0.760
Fertilizers	5	10679.100	2135.820	134.019**
Error	20	318.733	15.937	
Total	29	11046.300		

C.V. %= 3.61

SE± for means group = 1.78

**= high statistically significant difference at alpha = 0.05

$LSD_{0.05}$ = 2.15