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Advances in Soil Fertility Research in Sudan

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Abstract: The objective of this article is to review the previous national researches directed to correct soil fertility status. Many field experiments were conducted to detect the responses of different crops to different fertilizers types. As early as 1911, pioneers realized that nitrogen is very low, due to low organic matter, hence, nitrogen was considered as the main yield-limiting factor. Since then, fertilizers research focused on the rate, amount, type and time of application of nitrogen fertilizers. First, nitrogen sources cotton crops was ammonium sulfate but, later, in 1960's replaced by urea for its economical merits. Scientists noted the high correlation between the high response of crops to fertilizers and other agricultural inputs as protection, thinning, irrigation and time of sowing. Wheat yield increased significantly by nitrogen fertilization which was most affecting by time sowing. In rainfed area, sorghum responded well to added nitrogen but this response depends on sorghum variety. In early 1960's, phosphorus fertilizer was introduced in Gezira Scheme in form of Triple Super- Phosphate (TSP). Crops like cotton, wheat, sorghum and sugarcane responded well to phosphorus fertilization. It worth mentioning that many successful attempts were made to substitute imported TSP by local partially acidulated rock phosphate which presents in abundance in Sudan. Early studies showed no response to potassium fertilization to cotton crop but recently many crops such as; potato, sugarcane, sweet potato, and banana were responded well to added potassium. Little data of any, on calcium and magnesium nutrition. Sulphur fertilizer addition in Sudan is low, they received less

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attention. Although microelements contents in Sudanese soil is very low, they received less attention in Sudanese agriculture. Organic soil fertility management was the concern of many scientists. A Number of field experiments were conducted using different manures to increase soil organic matter, biological activity and nutrient availability. It was found that application of sewage sledge and irrigation canal sediment combined with fertilizer nitrogen a useful practice in amelioration of poor-quality arid soils. Incorporation of crop residues was found essential to sustain soil fertility and crop production. The low productivity of salt-affected soils was studies by many researchers. Results of such researches indicated the short irrigation intervals as one of the best measures to increase yield significantly of such marginal soils. Other obtained the highest grain yield of wheat by application of chicken or farm yard manure grown ridges of sodic soil in Gezira. However, the findings of the research trials cited in this article indicated that most crops responded positively to the fertilizer's application, which is evident of poor fertility of Sudan soils. In view of the results of number of field fertilization experiments, it is advisable to adopt the policy of adding both organic and inorganic fertilizers to crop for soil fertility conservation to increase yield and, hence, better sustainable agriculture development.

Key word: Soil fertility, fertilizers, organic fertilizers, Salinity, Sudan soils.

INTRODUCTION

Sudan endowed with many natural resources such as numerous climatic conditions combined with fertile soil and water resources come from rivers and groundwater. Thus, various field crops, vegetables, and fruit can be grown successfully. Sudan lies within the tropical climate and was divided into the following climatic zones: savannah, semi-arid, and arid (Van der Kevie, 1973). Therefore, agriculture is the greatest imperative industry in Sudan. Agriculture is the life force of Sudan's economy, contributing about 40% of the gross domestic product and the job for more than 70% of the Sudanese population (Kavanaughh, 2014).

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Sudan faces a varied set of soil fertility problems that require approaches that go beyond the application of chemical fertilizer or other kind of soil amendments. This problematic such as salinity, erosion, reduction of soil organic matter, deficiency in the essential nutrient and depletion of soil physical properties. These are the major problems that limit economically successful agricultural production worldwide. Therefore, addition of fertilizers is necessary to correct this poor soil fertility. Soils, particularly in the arid and semiarid regions, rarely contain adequate amounts of essential plant nutrients to sustain high yields of crops. This is particularly true for nitrogen (N) and phosphorus (P). Use of chemical fertilizers has been practiced for a long time in modern agriculture to compensate these deficiencies in N and P. Soils of Sudan are inherently deficient in N and of very low P contents. Thus, they are the main limiting factors in production (El Saeed, 1997; Elsheikh,2005; Ahmed *et al*., 2018). Low soil fertility level can be a result of many factors like salinity, which from the agriculture standpoint, such soil contains sufficient neutral soluble salts to adversely affect the growth of most crop plants and ultimately poor yield, the extent depends on the degree of salinity. Other factors that may lead to low soil fertility include loss of nutrients either by leaching or in gaseous forms to atmosphere. Besides, desertification which erodes the fertile topsoil and continuous crop in the same land without replenishing the nutrient. The decline of cropping production and response of crop to fertilizer is the main evidence of land degradation in Sudan.

This article meant to review previous research oriented to evaluate soil fertility status. As defined, soil fertility is the ability of soil to supply plants with essential nutrients in the required form. On the other hand, balanced plant nutrition is the presence of all essential nutrients in the root zone in the right amount and form throughout the growing season, which is almost impossible under field conditions. In view of this, research was directed to correct nutrient deficiencies by fertilization.

INORGANIC FERTILIZERS

Nitrogen fertilizers

Nitrogen is the most plant nutrient required by plants in relatively large amounts. It is the most nutrient prone to loss through leaching and to the

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atmosphere (gaseous). For this, scientists had more attention to N nutrition problems.

For long periods, cotton, as an important agricultural crop, gained the highest research attention among many crops grown in Sudan. Cotton has been extensively grown in the Gezira since the colonial rule as a cash crop. Since that time, cotton was the main foreign exchange earner till the development of a national oil industry. Therefore, initial soil fertility studies were carried out mainly on cotton crop. Studies on soil N level started by pioneers more than hundred years ago. Beam (1911) reported a low N contents in all Gezira soils (0-0.04%N). Later, this was confirmed by Hiepko (1967) who stated that all soil types which are of economic importance are deficient in N as a result of prevailing climatic factors in Sudan. Massey (1923), Walley (1927) and Gregory *et al.*, (1932) studied fertilization of cotton crop in Gezira area. Results of these experiments showed good response of cotton to the applied fertilizer and the response increased with increasing irrigation water. In addition, fertilizer profit increased significantly with increasing rate of N fertilizer from 1N (18kgN/fed) to 3N (54kgN/fed). Green (1932) investigated the agricultural value of different N sources, including sulphates of ammonium, K and iron. He reported that ammonium sulphate was the better and the yield increased significantly with more ammonium sulphate up to 200Ib per feddan. In this context, Johon (1936) pointed that there was no response if a N fertilizer is added at the rate of less than 40 Ib per feddan. With respect to the time of application, Crowther (1941) showed that the best time of application was the first week of June using calcium nitrate and ammonium sulphate as sources of N. This later was confirmed by Gray (1947) who added that application of N fertilizer in autumn season would result in N leaching and he recommended N addition before or after the rainy season. At the same time, Anthony (1947) found that addition of ammonium sulphate in furrow was better than in irrigation water. Research continued by Ferguson and Gray (1949) who compared three N sources, namely, calcium nitrate, ammonium nitrate and ammonium sulfate applied at the time of sowing. The results showed that the higher yield was obtained from calcium nitrate treatments.

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In 1941/42 season, the crop rotation in Gezira Scheme was changed from cotton- dura-fallow-fallow to legume-fallow-cotton-dura and this continued until 1947/48 season. In this period, response to N was high whereas low to P and negative to K. The rate of N in the period from 1941 to 1955 was 1 ½N (60 Ib N/fed). It is worth mentioning that crop rotation in Gezira Scheme was cotton-Fallow to conserve soil fertility status. Later, policy of intensification and diversification introduced in the Scheme. This necessitated more active research on type, amount, time of application and suitability of fertilizers, mainly N.

In 1950's, experiments showed no significant differences between fertilizers applied by broadest or side dressing (Ferguson, 1954). Ammonium sulfate (21%N) was the common fertilizer as a N source to crop but later was replaced by urea (46%N) which became preferable for its economic value as it reduces cost of transportation and storage by almost 50% (Kordfani, 1959). It was pointed out that the loss of ammonia through volatilization from urea was less than that from ammonium sulfate (Rai, 1965). This was later supported by Musa (1966). Burhan (1965) reported that in a crop rotation of Fallow-Fallow-Cotton high productivity of cotton treated with 4N (160 Ib N/fed). Later, Jackson and Burhan (1969) indicated that soil fertility was determined by many factors such as method of fertilizer application, date of sowing, soil management and nutrient requirements.

With respect to amounts of N fertilizer, Musa and Mukhtar (1967) showed that the soil content of nitrate was more in fertilized areas compared with non-fertilized areas. Moreover, soil nitrate content was higher in soils irrigated before urea addition than those areas irrigated after urea addition. On the other hand, Said (1969) noted that N absorption by cotton plant increased with increasing amounts of added urea and also the absorption increased in soils of high cation exchange capacities and high clay contents, like Gezira soils.

Regarding analytical research, it was reported that the loss of N from added urea through the process of volatilization was reduced much when urea was added under soil surface (Crowther, 1946). This was later supported by Musa (1966) who stated that the loss through volatilization from urea was 19% if the fertilizer was applied at the surface of the soil

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and it was reduced to about 0.2% if it was applied one inch under soil surface. Research on fertilizer N efficiency continued by Burhan and Jackson (1969) who showed that there were no significant differences in the production when urea was applied in solid or liquid forms when it is added at six weeks after sowing. In spite of the policy of intensification and diversification increased farmer's income, but, on another hand, it leads to exhaustion of soil nutrients and the soil became more compact. In addition, phenomenon of redness on cotton leaves worried scientists for a while but it was overcome by applying three doses instead of two (one dose= 40 pounds per fed) (Burhan, 1970; Azhari *et al*., 1985). Advance in management of N fertilization continued to reveal that cotton can respond to applied N up the 4N (72kg N/fed). Burhan (1971), from a long term experiments (1964-1970) suggested a mathematical equation to calculate increment in yield from the 1st dose to the 4^{th}:

$$Y = a + 1.37 \times 0.14 \times^2$$

Burhan and Taha (1974) pointed out that it is very important to add the N fertilizer at the right time for more fertilizer efficiency. In this context, many researchers suggested that fertilizer N should be added in two doses, at sowing time and after 6 weeks from swing after thinning process. Later, this was supported by Ishag (1981) who showed that addition of 3N (120 Ib/fed) in number of doses increased yield by 63% for 16 years, and he recorded a fertilizer response of 92% and fertilizer efficiency in the range of 35-55%. Likewise, Hag Abdulla (1986) noted that plant leaf content of N increased with increasing rate of N fertilizer in Gezira cracking clays. He concluded that 4N (160 kg N ha^{-1}) was the best rate below which yield would decrease. He added that leaf P and K contents were not affected by N application. Other experiments showed that foliar application was efficient and gave increment in yield ranged from 15-46% (Lazim, 1993).Later, Ibrahim *et al*., (2010), in a field experiment, studied the response of three newly released cotton varieties to N fertilization at Gezira Research Station. They concluded that cotton growth, seed cotton and lint yield significantly and progressively increased with increasing levels of added N fertilizer.

Due to change in food style and from sorghum to wheat, wheat crop received much attention for its importance as a food crop for a wide sector of population. The yield of wheat was fluctuating in Gezira

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scheme but when diversification and *intensification* policies was adopted in 1959, wheat yield increased significantly. Wheat production in Sudan started on fertile alluvial soils of the Nile in the Northern and Nile River States where winter is relatively longer and cooler. Wheat fertilization started in Hudieba research station by pioneers who reported responses of wheat to N fertilizer (Hiepko, 66). In Gezira, Al-Ahmdi (1967) obtained positive results by addition of urea to wheat at sowing time. This was supported by the findings of Akasha (1968). They recorded a significant increase in wheat grain and dry matter yields by fertilization over the control, with increasing dose of the added fertilizer. In addition, Akasha (1969) indicated that there was no significant difference in wheat yield fertilized with urea in solid form or in liquid form with irrigation water when the rate was 1N (18kgN/fed) but at the rate of 2N (36kgN/fed) solid urea was better. On introduction of certified wheat seeds from Mexico, Ageeb (1974) obtained a high yield of wheat. Ayoub (1973) noted that the main effect of fertilizer N was clearer on yield components where the application was at ploughing process. Research continued by Akasha (1977) who reported that response of wheat to applied N was greatly affected by the time of sowing. He obtained less response to the added urea if the sowing delayed from 3rd Nov, to 15 Dec. Khalifa *et al*. (1977) determined the effects of sowing date and N application on growth and yield of wheat and N –uptake by wheat plants. They reported that benefits from N were greater with early sowing because of higher N-uptake during early vegetative growth. With late sowing N-uptake was much lower during early vegetative growth which diminished response in grain yield to N application. In addition, it was found that N fertilization increased P absorption (Akasha and Ahmed, 1978). Generally, traditional and long staple varieties showed less response to N fertilization compared with short staple Mexican ones. This was attributed to the phenomenon of lodging of long staple varieties as a result of increased vegetative growth due to high doses of applied N fertilizer.

In Sudan, sorghum is the most important cereal crop in terms of total acreage, production and consumption. Sorghum (Dura) is the main grain crop used by Sudanese in their daily diet. It is mainly produced traditionally in rain fed areas and in modern agriculture in central clay plain Gezira. Fertilization of Dura in Gezira scheme showed a high

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response to N fertilizer. The grain yield was doubled on addition of one dose of N (1N=40 Ib/fed) (Anthony, 1947). Similarly, lshag (1972) reported high response of Dura to added N. Besides, he recorded no significant differences between fertilizer N in form of urea or ammonium sulfate added by broadcast or side dress methods. Response of Dura to N fertilizer was supported by many workers (ElRayah, 1978, Frahah, 1987). In Abu Nama, Dura under irrigation responded well to fertilizer N, particularly when added with P fertilizer but no response to K fertilizer (Ali,1974). In Agadi, Ageeb (1974) obtained responses of Dura to added N but the response differed between different Dura verities. Field experiments were carried out at the Demonstration farm of the faculty of Agriculture, University of Gezira to test the effect of N fertilization on growth, yield and yield quality of two sorghum cultivars (Zaid, 2004). The high rate of N (80 IbN/fed) significantly increased forage yield (fresh and dry) and crude fiber percent of a busabin cultivar. In addition, levels of nitrate were below N the toxic level (2, 100 ppm). Prussic acid concentrations declined with crop age. In Gedarif rain fed and eastern Sudan, a field experiment was carried out to investigate the effect of urea on sorghum grain yield and its profitability when practicing sarwala (A local type of zero tillage) with and without urea. Sarwala with urea application increased sorghum grain yield by 73% over sarwala alone (Yousif *et al*., 2008). They concluded that urea application with Sarwala was more profitable as the rate of return ranged from 52.5% to 60.6% compared with farmers practices. Likewise, Ali (2014) studied the effect of applied N and seed rate on growth and yield of sorghum. He showed that all growth attributes increased with increasing doses of N but there were no variations due to seed rate.

Maize (*Zea mays* L.) ranks as one of the world's three most important cereal crops after wheat and rice. It is cultivated in a wide range of agro-ecological environments more than wheat and rice because of its greater adaptability. In Sudan, maize is considered as a minor crop grown on a small scale in different locations under rain-fed, and irrigated conditions**.** The role of N management practices in increasing grain yield of maize (*Zea mays* L.) in Northern Sudan was investigated by Mohamed *et al*. (2008). They conducted a field experiment at Hudeiba research farm to study the effect of rate and time of application on growth and yield of maize. Their results indicated that application of N as a split dose

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resulted in significant increases in plant height. The results also showed that in both August and November sowings, addition of 43kg N/ha increased maize grain yield by 28% to 43%. Further, increase in N rate from 43 to 86kg N/ha resulted in more grain yield increase by 5% to 11%. They concluded that the addition of 43kgN/ha significantly increased maize grain yields in all sowing dates under test.

Arafa *et al*., (2009) investigated the response of water stressed maize to selected N-fertilizers at Gezira Research Station. Their results showed that high N level (86kgN/ha) with normal irrigation resulted in the highest growth rate, irrespective of N source. In conclusion, it was stated that water was found to be the more limiting than N fertilization and the 43kgN/ha is probably adequate for maize production under water stress conditions. The response of maize to N at different irrigation regimes was tested at Gezira Research Station Farm by Arafa *et al*., (2012). They reported a significant effect on maize grain yield by N application during the course of the experiment. The grain yield increased with increasing N rate from 43kgN/ha to 86kgN/ha. Grain yield and N use efficiency of two maize varieties as affected by time and rate of N application was examined by Salih *et al*. (2005). The results showed that the application of 86kgN/ha at sowing or in two equal split doses (43kgN/ha) at sowing and at 3 weeks after emergence gave the highest grain yield, N uptake and N recovery in grains.

Concerning horticultural crops, many experiments were carried out using different fertilizers. For instance, potato crop is one of the most popular and widely grown vegetable in Sudan. The main potato producing garea is Khartoum State. At present, the high demand for potato encouraged more farmers to grow potato as a cash crop (Mohamed, 2004). Therefore, the land is expected to be exhausted, and, thus the addition of fertilizer, is a necessity**.** Response of potato to time of N application was investigated by El khider (2003). Nitrogen as urea, was applied at the rate of 83 kg N/ha to potato cultivars. Application of N was either as a whole dose before planting, whole dose after emergence or doses according to the stage of growth. Application of the whole dose before planting resulted in the highest emergence percentage, most vigorous vegetative growth and the highest tuber yield.

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Regarding Okra (*Abelmoschus esculentus* (L) Moench.), which is the most traditional popular vegetable in Sudan, produced in different parts of the country, growth response and leaf N, P and K contents of Okra to chicken manure and salinity levels were examined by El-Tilib *et al.*, (1994). Results indicated that plant height was increased significantly with increasing rates of chicken manure. Similarly, the number of leaves were significantly increased and decreased by manure and salinity, respectively. Later, Elkashif and Alamri (2013) studied the effect of sowing date and N rate on growth and yield of some okra cultivars in Gezira. They concluded that N rate of 129 kgN/ha resulted in the best vegetative growth and the highest total and exportable yield in all cultivars and sowing dates. Response of cucumber to N fertigation under plastic house conditions was studied under both single and double layer plastic houses with different light intensities (Sidahmed *et al.*, (2004). Results revealed the positive effect of all N treatments, over control, in terms of dry matter, fresh biomass, number of fruits and marketable yield. Moreover, the results reflected the influence of urea as a N source in producing better growth and higher yield.

Concerning fruits trees, similar to vegetable crops, many experiments were carried out on different crops by using different fertilizers types. The Guava fruit is considered as one of the most popular and major fruits of the country coming after dates, citrus, mango and banana. The response of guava to application of various forms of nitrogenous fertilizers was studied under nursery conditions (Eltahir and Hussein, 1997). The results revealed that seedling height, number of leaves and dry and fresh weights of leaves were significantly affected by added N. Leaf-N, P, K, Mn and Cu were significantly higher in treated seedlings, compared with control. Shortly after, Eltahir and Ali (1998) investigated the effect of foliar Bayfolan fertilizer at different concentrations on guava growth and yield. Application of foliar Bayfolan results in a significant increase in yield of guava. The other fruit that received considerable attention to Sudanese scientist is banana fruit. Banana fruits are popular in Sudan and represents one of the most important cash crops. In Sudan, banana is produced commercially in small and medium-scattered orchards along the River Nile and its tributaries banks and in large plantations at Kassala**.** A study was carried out by Eltahir and Elamin (1999) to investigate the effect of foliar application of different

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fertilizers on growth and leaf nutrient contents of banana suckers grown under nursery conditions. Four foliar fertilizers, namely Foliar-X, Wuxal 7, Bayfoan and Nitrofoska were used. The used fertilizers resulted in significantly higher leaf-N, K, Ca, Mg, Mn, Fe, Zn, and Cu contents than control. Also, Eltahir and Bakhiet (1999) conducted an experiment under plantation conditions to study the effect of rates of N and K on growth and yield of banana plants. The results indicated that plants treated with the lowest rate of N and K gave higher increases in all measured growth and yield parameters compared with the control whereas the higher rates resulted in the lowest values. Citrus crop is an important cash crop for growers in many parts of the country. In attempt to investigate the nutritional statues of citrus, a survey was made in Sennar area by Elhassan *et al*., (2005). Results of this survey showed deficiencies of nutrients in the surveyed orchards, particularly N. According to this survey, foster trees were treated with organic and inorganic fertilizers to correct their nutritional status. All treatments significantly increased average yield over control. It was concluded that the most economically feasible fertilizer treatment for best fruit quality and high yield attained by a combination of urea and manure treatment. Later, Elhassan *et al*., (2010) confirmed their previous findings and assured the poor nutritional status of foster grapefruit in Sudan, hence, low yield and poor fruit quality. This was attributed to unsuitable soil conditions and the poor management practices, including lack of fertilizer application.

Regarding rain-fed areas, farmers in the past practiced shifting cultivation in search for more fertile soils. This resulted in much reduction in green belt, causing a negative effect on whole environment. Recently, fertilizer was introduced in these areas but still there are many problems that may strict the wide use of fertilizers. This includes high cost of fertilizers and exact time of application which related to the time and amount of rain which is not known. However, many field fertilization experiments were conduct which gave positive increase in yield of different crops. For instance, Abdalla and El Mahi (1986); Salih (2013) obtained positive response to N and P added to sunflower crop in Blue Nile State. Similarly, a field experiment was conducted at University of Zalengi, Darfur, to study the effect of N and P fertilizers on the chemical composition of pearl miller grains (Hago *et al*., 2004). The results of the experiment showed that added N and P significantly

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increased grain protein and P contents but other grain constituents (K, Ca, Mg) were not affected by any of the treatments. In addition, the results of this experiment showed a rise in grain yield of pearl millet of 32.6%-131.9% and in Stover yield of 69.2%-262.9% over the control. On the other hand, added P had a significant effect on plant height and leaf area index (Eltilib *et al*.,2005; 2006a). Highly significant correlations between added fertilizers (N and P) and yield of millet (grain and Stover) were obtained in both seasons of the experiment. In Sinner area, Faheema *et al.*, (2008) studied the effect of N fertilizer and seed rate on performance of pearl millet. The results showed a considerable increase in fresh matter yield when treated with 40 kg N/ha and 80 kg N/ha over the control. They recommended a seed rate of 4.5-7.2 and 40kg N/ha as an optimal option for growing pearl millet for forage.

In case of sugarcane, as a plant crop with its successive ratoons, is known to be exhaustive to the soil. In Kenanna and Sinar Sugar cane Schemes, P was added at rates of 95 kg P ha^{-} and 54 kg P ha^{-}, respectively. Results showed good responses to the applied P (Isobe and Ali, 1983; Sir Elkhatim, 1985). Later, Awad *et al*., (2004) studied the efficiency of two fertilizer forms namely, ASN and Nitropska compared with standard fertilization practice (4.5N area + the 2P TSP) at El Guneid sugarcane farm. The results revealed that the plant crop responded well to the lower dose (2.25 N) while the ratoon crop responded better to higher dose (4.5N). Based on yield data, the lower dose (2.25 N) was recommended for the plant crop and the high dose (4.5) for the first ratoon. Moreover, A two-year field trial was carried out to investigate the effect of different levels of K and P on the performance of two sugarcane varieties and their fist ratoon grown on three soil series (Hagu, Nasr and Dinder) (Eltilib *et al*., 2004). The results indicated that K application affected plant density and stalk diameter significantly. Yields of cane and sugar on Dinder series were raised significantly in response to K addition in plant cane and ratoon. In plant cane, P addition significantly affected sugar yield on Hagu series whereas added P to ratoon grown on Dinder and Hagu series resulted in significant increases of cane and sugar yields. Afield experiment was carried out at Sennar Sugarcane Company to examine the impact of phosphoric and potassic fertilization on plant cane and its ratoon on level N, P and K contents

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(Eltilib *et al*. 2004). The results showed that the mineral composition of cane plants was significantly affected by treatments. Leaf-N was high early in the season (3.23%) and started to decrease as the growing season proceeded (1.8%). Leaf-N levels were higher in plant cane than those of the ratoon. Nasr soil series gave the highest leaf-N level followed by Dinder and Hago series. Leaf-P and leaf-K in ratoon were higher than those in the plant cane which indicated the residual effect of P and K fertilization. On the other hand, Elamin *et al*., (2007) studied the influenced of P and K fertilization on the quality of sugar of two sugarcane verities. Their results revealed that P treatments significantly affected the sugar content and purity of juice (%). Ratoon plants were slightly affected. Later, Mukhtar (2015) conducted an experiment to examine the effect of urea at different rates (150, 200 and 250 kg urea fed) on yields of cane and sugar at Gunied scheme. The results revealed that there were no significant differences in yield components and total cane yield of the ratoon crop between the rates of N of the first experiments. In the second experiment, yield components and total cane yield increased significantly by the applied urea compared to control. The study recommended 200 kg urea/fed as the dose to be endorsed as an official dose for the ratoon crops in Guneid Sugar Scheme.

Phosphorus fertilizer

Phosphorus is an important element for all living organisms and, second to nitrogen as a limiting factor in plant growth and production (Elsheikh *et al*., 2008).The amount of P in soil is less than that of N and K ranged from 0.1-0.4% in unavailable form. Concentration of P in soil solution only 0.1-0.06 ppm. This small amount of available P is mostly subjected to fixation by soil constituents like calcium and magnesium to produce calcium phosphate, and magnesium phosphate under alkaline condition, thus, becomes unavailable to plants as the case in Gezira soil.Sudan soils, like many agricultural soils worldwide, are generally deficient in available soil P. Fertilizer trials, carried out under Sudan soil conditions, have shown erratic responses of crops to the applied P (Ahmed *et al*., 2018). This absence of response was attributed to the high alkalinity of Gezira soil (pH-8.2) and the slow mobility of phosphate ions, therefore, it was recommended to place phosphate fertilizer near the seeds at sowing.

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Phosphorus fertilization started by application of phosphoric acid but no response was obtained (Walley, 1927). Similarly, Green (1932) and Anthony (1947) did not record any response by addition of triple super phosphate. This was supported by Said (1961) who attributed the lack of response to added P to unfavorable cultural practices which may restrict P absorption by cotton plants. On the other and, Burhan and Mansi (1970) in a long-term experiment, stated a high response to added N, fluctuating response to added P and no response to added K by cotton plants which may be due to the alkalinity of Gezira soils. Later, Hag Abdulla (1991) obtained a good response to added P by cotton plants on application of 36kg P_2O_5/fed. He recorded a significant increase in yield and considered P as an important factor in cotton production. Moreover, he added that the previous less and fluctuating responses to added P may probably due to the placement of P fertilizer on one side of the furrow. Imported P fertilizers are very expensive especially for smallholder farmers. So, its high time to try a local cheaper phosphorus source. To end this, geological administration surveys in Sudan, found the presence of rock phosphate (RP) in considerable amounts in many areas (Saad,1993), which makes it economically attractive to be used as P source for crop fertilization in the agricultural system in Sudan. By treating, PR ore from Jebel Kurun and Uro Hill of western Sudan with different amounts of H_2SO_4 Eltahir (1999) was able to produce an economically low- cost partially acidulated rock phosphate (PAPR) fertilizer, which meets the international measures for a PR to be designated as a P fertilizer. After that, Eltilib, *et al.* (2006b) used sorghum to test the safety levels of radioactivity in the RP for in two types of rock phosphate from two area(Uro Hill and Jebel Kurun), and they stated that such phosphate rocks can be used as P fertilizer without radioactivity hazards. Partially acidulated rock phosphate was tested on many crops and was found useful as P sources to many crops such as and Groundnut (Elsheikh *et al.*,2005; 2006). Abdel-Hafeez *et al.*(2005) studied the impact of (PAPR), Triple superphosphate (TSP) and their combinations on micronutrients uptake by wheat crop. Results indicated that the micronutrient contents in plant receiving local PARP showed an equal and in some cases higher levels of micronutrients than plants treated with TSP. It was also noted that mixing of local PAPR with TSP at relatively low ratios increased its effectiveness on micronutrients uptake, suggesting the possibility of partially replacing the TSP by the

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PAPR. In a field experiment carried out in a desert plain soil at New Hamadab Research Farm in Northern Sudan, Awad ElKarim and Younis (2015) studied the effect of farmyard manure, N and P on wheat growth and yield. The results of the study revealed that the treatment of 5 ton FYM ha^{-1} plus 86 kgN ha^{-1} + 43kg P_2O_5 ha^{-1} was the best for wheat production in such arid areas. In a pot experiment, different rates of rock phosphate were mixed with 33%, 50% or 100% of soil volume. Two soil types of different soil reaction were used in the experiment. Mixing RP with the soil of pH=5.9 gave the highest yield and P concentration of sorghum whereas the sorghum grown on the soil with pH=8.4 was not responsive to rock phosphate application or method of placement (Madibbo, 1998). Field experiments at Rahad Research Station studied the response of sorghum to NP fertilizers (Babiker *et al.*, 1999). They obtained insignificant responses of sorghum to the added P. This was attributed to the sufficient level of available soil P (6-8ppm). Hence, they suggested frequent soil testing to assess how long such an adequate supply of P could be maintained.

Potassium fertilizers

Potassium is an important element for plants and is considered a major nutrient element together with N and P. Early studies in Gezira Research Station revealed that there was no response to added potassium fertilizers by the cotton crop. This lack of response was due to the high content of K in Gezira soils (Walleye, 1927; Snow, 1936 and Fink, 1960). These previous findings, leading scientist to think that Sudanese soil is sufficient in K nutrient (El khider, 2003). However, this may not always be true as soil fertility status is a dynamic process and differs in different soils under different climates. Recently, some researchers found that Sudanese soils respond well to K fertilization by some crops such as Sweet potato (Ali and Bushra,1993), banana (Eltahir and Hussein,1997; Eltahir and Bakhiet,1999; Eltahir and Elamin,1997), Sugarcane (El-Tilib *et al*., 2004; Elamin *et al.*, 2007) and Potato (Babiker *et al.*, 2016).

Sulfur, calcium and magnesium fertilizers

Sudan is one of the developing countries facing the problems of sulfur deficiency. However, little data was available for sulfur status in the soil of Sudan and hence, S fertilizer addition to crop is not common. Only few experiments have been conducted to examine the response of sulfur

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by certain crops in Sudan such as; groundnut (Hago and Salama, 1987), Faba bean (Elamin *et al*., 2004), sorghum (Zaid, 2004) and sugarcane (Hamid and Dagash, 2010). All these trials revealed that the S addition contributed in improving soil chemical properties and increased final yield. With respect to calcium and magnesium fertilizers, no data available, this may be due to the adequate level of this nutrient in the soil of Sudan. Marginal, light textured soil of the country may show some deficiency for these nutrients.

Micronutrient fertilizes

Micronutrients such as; iron, manganese, copper, boron and zinc are indispensable for crop growth, serving as primary and secondary nutrients. Although their requirement is small, they often make a huge variation in yield and quality when they are deficient. The micronutrients have received less attention in Sudanese agriculture. It is narrow to an academic institution and research centers. Generally, they are seldom applied in crop production in most soil. The micronutrient addition may be done in a yield-limiting factor in many agriculture schemes**.** The farming of high yielding varieties of agronomic crop increased the addition of macro fertilizers thus causing micronutrient deficiency as a yield-limiting factor. However, horticultural crops respond positive to application of a foliar of micronutrients, these results show the possible deficiency of micronutrient in Sudanese soil. For instance (Ishag,1992) found that the addition of Fe, Zn, Mn, and B as a foliar application increased cotton yield in very alkaline calcareous soils, Vertisols of the Sudan Gezira. In addition, Abdel Wahab and Abdulmalik (2003) reported that sugarcane at Kenana Sugar Scheme responded well to the addition of Fe, Zn, and Mn. A survey of a number of foster grapefruit orchards grown in Sinnar area revealed that both soil and trees were deficient in zinc element (Elhassan *et al*., 2005). A field experiment was conducted to examine the effect of Zn fertilizer in form of zinc sulfate on yield and its components of *Zea mays* at the Gezira Research Station Farm at three rates (0, 5 and 10kg Zn ha^{-1}) (Abbas *et al.*, 2007). The results indicated that the application of zinc significantly ($P<0.05$) increased the number of cobs ha^{-1}, the number, and weight of grains/cob, 100-grain weight and grain yield. Thus, more studies are needed in order to unravel conditions under which application of micronutrient may pose financial risks.

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ORGANIC FERTILIZERS

Application of organic fertilizers for supplying crop nutrients and improving soil characteristic have been used throughout the world since the ancient history, even so, the use of organic fertilizers is low in Sudan**.** The use of chemical fertilizers in rates more than the recommended has an adverse effect on the environment and may damage soil life in some cases. Therefore, many experiments were conducted to examine the efficiency of organic fertilization in crop production. These experiments showed the possibility of using farm yard manure (FYM) to increase crop yields. Such experiments meant to lessen the use of chemical fertilizers and reduce the purchasing of these imported chemical fertilizers (Al-Gadi, 1995). Based on above, Mubarak and Dawi (2009) monitored the decomposition and nutrient release from residues of mesquite, mahogany and neem fresh leaf litters in a sandy soil of a semi-arid tropics. The study suggested that mesquite and neem constitute a comparatively readily available source of N and they could be suitable for short-term nutrient correction. Mahogany caused noticeable N mineralization which might be used for organic matter build up in arid soils. In line of this, Awadelkarim *et al*., (2011) concluded that adjusting sowing date with manure incorporation in light textured soils might improve yield of sorghum. Similarly, Mubarak *et al*., (2014) suggested the application of 10 ton ha^{-1} of sewage sludge of Hamadab Canal Sediment combined with 2N as a useful practice in amelioration of poor quality Aridisols through improving their physical and chemical properties. Research continued by Salih *et al*., (2012) in a study to examine the effect of crop residues on soil fertility and yield of wheat. Reported results indicated that continuous application of crop residue improved soil fertility and yield of wheat. Decomposition and nutrient release from wheat residues under semiarid conditions was investigated by Rezig *et al*., (2014). They concluded that application of mineral fertilizers or sewage sludge enhances the decomposition of low-quality wheat residues. Therefore, it is essential to apply fertilizer in degraded soil before incorporation of crop residues with high carbon N ratio.

In a field experiment, Abbas *et al*. (2011) investigated the effect of chicken manure on yield and quality of eggplant fruits. Results showed a

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significant increase of eggplant yield and fruit content of total N. Likewise, in Gedarif state, Ibrahim *et al.* (2011) studied the effect of chicken manure and farm yard manure on rain fed sorghum. The results showed that chicken manure treatment surpassed that of farm yard manure. The study recommended the application of chicken manure at 5 tons/ha rate for sorghum production in the Gedarif state. Moreover, the commercial fertilizers (Elkhaseeb) increased the production of groundnut and faba bean grown on three type of Sudanese soils(Mohamed et al., 2014).Desert soils are known of their low fertility and poor productivity. Attempts were made by many researchers to improve their soil properties and increase crop production by organic amendments. For instance, Dawi *et al*. (2017) conducted field trials to examine the effect of some organic amendments (chicken manure, Sewage sludge and Camel manure) on sorghum grain yield. They conduced that incorporation of chicken manure and sewage sludge at rates of 5 and 10 Mg ha^{-1}, respectively, improved soil quality and increased yield and nutrient contents of sorghum. Similarly, Abubaker *et al*. (2017), in a pot experiment, evaluated the effect of digested and non-digested dry matter manures (cattle, poultry and sheep) with urea on wheat yield grown on a desert soil. The results indicated that non-digested sheep and poultry manure yielded higher straws biomass than digested dry manure.

With regards to fertilizer and environment, there is a question as: is high yield production, with its necessary inputs, sustainable from environmental standpoint. It is known that addition of chemical fertilizer in high rates adversely affect environment particularly nitrate which moves with soil water to pollute the underground water.

FERTILITY -SALINITY INTERACTION

Salt-affected soils occur almost under all climatic conditions. The nature and properties of these soils are diverse such that they require specific approaches for their reclamation and management to maintain their long-term productivity. Sudan are affected to some degree, by salinity and sodicity (Mustafa, 1986). The effect of irrigation interval, urea-N and gypsum on salt redistribution in a highly saline-sodic clay soil under forage sorghum was studied by Mustafa and Abdelmagid (1981; 1982).

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Results showed a reduction in ECe and ESP in the top soil but increased in subsoil. Dry matter yields increased significantly by irrigation every 7 days. In addition, plant height and leaf area index increased with N fertilization, with gypsum and with reduction of irrigation interval to 7 days. Abuswar (1994) reported that the application of farmyard manure, alone or with urea to fodder sorghum grown on salt affected soil, significantly increased forage fresh and yield and improved forage quality. Field experiments were carried out on salt-affected soils under semi-arid environment with the objective to examine the response of wheat to irrigation frequency, cattle manure, chicken manure and urea application (Eltilib *et al.*, 1995). The results obtained indicated a significant increase in wheat grain yield by reduction of irrigation interval from 15 to 5 days. Manures treatments were more effective in increasing the grain yield than was urea fertilizer but levels of leaf N, P and K were increased significantly with added fertilizer. Field experiments were conducted in Gezira to study the effect of farm yard manure on wheat yield grown on a heavy sodic clay Vertisol (Ihsan and Fadul, 2013). Addition of farm yard manure improved the physical properties of the soil and significantly increased biomass, grain yield and plant height. The highest grain yield (4.3 t ha^{-}) was obtained from the combination of 20 t ha^{-1} FYM with ridge planting method.

CONCLUSIONS

It is important to consider the high correlation between the response of crops to fertilizers and other cultural practices. Adequate and balanced fertilization certainly has distinct environmental protection benefits because misuse of nutrients can lead to impairment of environment. Best management practices such as soil testing and proper fertilizer placement and application timing are necessary to maximize the benefits and minimize the potential for damage. Accordingly, most studies recommended addition of nitrogen fertilizers in split doses (3-4) to reduce losses to atmosphere and pollution of underground water. Phosphorus fertilizer would be better applied before or at sowing because of its low mobility. Therefore, it is advisable to add phosphorus fertilizer by band placement or side-dress methods. Moreover, it was evident that application of phosphorus fertilizer jointly with fertilizer nitrogen would allow the plant to use nitrogen more efficiently. It was

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indicated that phosphorus increased nitrogen efficiency by about 42%. Consequently, there was much less residual nitrate-N in the soil and less chance of NO_3-N entering ground or surface waters. On the other hand, manures, namely, farm yard manure, chicken manure and sewage sludge were found efficient in increasing yield of crops and improving soil properties of salt-affected and desert soils. However, balanced and appropriate fertilization policy results in a sustainable agriculture development.

REFERTENCES

Abbas, A.E., Hamad, M.E., Babiker, H.M., and Nour, A.E. 2007. Effects of added phosphorus and Zinc on yield of corn. Gezira Journal of Agricultural Science .5(2): 1728-9556.

Abdalla, A.K., and El Mahi, Y.E. 1986. Effect of N, P and P N interactions on some field crops of some soils in the Blue Nile State, Sudan. *University of Khartoum Journal* of *Agricultural Sciences* 13(2): 60-77.

Abdel hafeez, M.E., Abdalla, H.H., and El-Tilib, A.M.A. 2005. The impact of partially acidulated phosphate rock, triple superphosphate and their combinations on micronutrients uptake by wheat crop**.** Journal of Science and Technology6 (1): 214-223.

Abdel Wahab, D., and Abdulmalik, E. 2003. Effects of iron, manganese, zinc and their combinations on growth and yield of sugarcane at Kenana Sugar Scheme. The *University* of *Khartoum Journal* of *Agricultural* Sciences, 11(1): 1-10.

Abubaker, J., Elnesairy, N., and Ahmed, S. 2017. Effects of non-digested and anaerobically digested farm yard manures on wheat crop cultivated in a desert soil. Journal of Arid land Agriculture 3 :1-10.

Abusuwar, A.O. 1994. Effect of seed rates, sowing method and fertilizer application on the performance of fodder sorghum grown on a saline-sodic soil. The *University* of*Khartoum Journal* of *Agricultural Sciences* 2:28-45.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Ageeb, O.A. 1974. Wheat agronomy. Annual Report, Hudeiba Research Station, Sudan.

Ahmed, A.M., Elsheikh, M.A., and El Mahi, Y.E. 2018. Relationship between phosphorus fractions of some selected Sudanese soil orders to phosphate availability. Eurasian Journal of Soil Science 7 (3):224 – 229.

Akasha, M.H.1968. Wheat variety and nitrogen experiment Annual Report, Gezira Research Station, Medani, Sudan

Akasha, M.H. 1969. Wheat variety and nitrogen experiment. Annual Report, Gezira Research Station, Medani, Sudan

Akasha, M.H. 1977. Wheat variety and sowing date experiment. Annual Report, Gezira Research Station, Medani, Sudan

Akasha, M.H., and Ahmed, H.O. 1978. Phosphorus level and Nitrogen on wheat Annual Report, Gezira Research Station, Medani, Sudan.

Al-Ahmdi, A.B.1967.Wheat variety and N experiment. Annual Report, Gezira Research Station, Medani, Sudan

Al-Gadi, S.A.S.I. 2007. The Effect of Organic Manuring and Phosphorus on Growth and Forage Yield of Lablab Bean (Lablab purpureus (L.) Sweet). M. Sc. (Agric.) Thesis, University of Khartoum, Sudan.

Ali, A. M., and Bushra, M. E. E.1993. Effects of Mineral Nutrition on Growth and Yield of Sweet Potato (*Ipomoea batatas*) in Shambat area, Sudan. .University of Khartoum Journal of Agricultural Sciences 1(2): 113-124.

Ali, E. E., Gasima, S. A., and Eltelib, H.A. 2014. Effect of seed rate, phosphorus and nitrogen fertilization on forage yield, leaf to stem ratio and protein content of maize (Zea mays L.) Sudanese Journal of Agricultural Sciences 1: 92–98.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Ali, F. M. 1974. Rotation response of sorghum at Kenana research station 11th research colloquium cereal crop in Sudan.Wad Medani, Sudan.

Anthony, K.R.1947. Annual Report, Gezira Research Station. Wad Medani, Sudan.

Arafa, A.M.; Ali, E.S.; Adam, I.A., and Muawia, E.H. 2009. Response of water stressed maize to selected N. fertilizers. *Sudan Journal of Agricultural Research*. 14: 25-40

Arafa, A.M., Adam, I.A., Ali, E.S., and Muawia, E.H. 2012. Effect of nitrogen rates and irrigation regime at different growth stages on yield of two maize varieties. *Sudan Journal of Agricultural Research*. 20: 1-20.

Awad Elkarim, E.E., and Younis, I.D. 2015. Response of wheat to farm yard manure, nitrogen and phosphorus on a desert plain soil, ElMultaga area, northern Sudan. Journal of Agricultural Research 24: 41-50.

Awadelkarim, A.H., Mubarak, A.R., and Gasim Alsayied, A. G. 2011. Time of sowing sorghum (Sorghum bicolor L.) as affected by nitrogen mineralization from farm yard manure in three soil types Tropentag . University of Bonn, October 5 - 7, 2011 Conference on International Research on Food Security, Natural Resource Management and Rural Development.

Awed, E. M., El. Naiem A. Ali, Abbass E. M.E., and M.A. Abana, 2004. Effect of different fertilizers form on sugar yield at El Guneid Sugar Scheme. Crop husbandry committee. ARC, Wad Medani, Sudan.

Ayoub, A.T. 1973. The effect of N source and time. Annual Report, Hudeiba Research Station, Medani, Sudan.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Azahari, A., Hamadi, A.B., and babiker, E.E. 1985. Redding of cotton Rahad periodical. Mag Pp 5-7.

Babiker, E.A., Salih, A.A., and Mohamed, B.A. 1999. Response of sorghum to N and P fertilizers and cropping sequences or irrigated Vertisols of Rahad Scheme. Sudan Journal of Agricultural Research. 2: 1-8.

Babiker, S.E.O., Elsheikh, M.A., El- Tilib, A.M.A.,and Ali, M.A, 2016. Response of potato (*Solanum tuberosum L.*) to potassium fertilization grown in a Vertisol soil. University of Khartoum journal of Agricultural Sciences 24(2): 245-26.

Beam, W. 1911. Soil of Gezira (preliminary note). Cairo Science Journal 5: 181-189.

Burhan, H.O. 1965. Level of Nitrogen for cotton in Gezira. Annual Report, Gezira Research Station. Medani, Sudan.

Burhan, H.O. 1970. Annual Report, Gezira Research Station. Medani, Sudan.

Burhan, H.O. 1971. Responses of cotton to levels of fertilizer nitrogen in the Sudan. Cotton growing review. 116-127.

Burhan, H.O. and Jackson, T.E. 1969. Effect of Liquid nitrogenous fertilizer and urea applied after thinning on yield of seed cotton. Annual Report, Gezira Research Station, Wad Medani, Sudan.

Burhan, H.O. and Mansi, M.A. 1970. Effect of N, P and K on yield of cotton in Gezira. *Experimental Agriculture*. 6: 279-286.

Burhan, H.O. and Taha, M.A. 1974. Effect on new cotton varieties of sowing date plant population and time fertilizer application grow review 51: 177-186.

Crowther, F.194l. Form *and* Date *of* Nitrogenous. Manuring *of* Cotton in the Sudan Gezira. Imperial Journal Experimental Agriculture .125-136.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Crowther, F. 1946. Studies on nitrogen fertilizer transformation in soil. Annual Report, Gezira Research Station.

Dawi, B.S.I., Mubarak, A.A., Yamanaka, N., El-tilib, A.M.A.,Elhadi, E.A., and Rezig, F.A. M. 2017.Use of Three Organic Amendments for Improvement of Desert Soil Properties and Cultivation of Grain Sorghum (Sorghum bicolor l.). Sudan Journal of Desertification Research 9 (1) :108-141.DOI: 10.18393/ejss.421609.

El khider, A.S.2003. *Response of Potato (Solanum tuberosum L.) to different forms and levels of Urea Fertilizer*. M.Sc. (Agric). Thesis, University of Khartoum.

El Rayah, A.H. 1978. Annual Report, Gezira Research Station. Medani, Sudan.

El Saeed, Y.H. 1997. The Effect of Phosphate Rock, Superphosphate and their Combination on the Performance of Sorghum bicolor var. dura (L.) x Sorghum sudanense (Piper) (Stapf) . M.Sc. (Agric). Thesis,University of Khartoum, Shambat, Sudan.

Elamin, E.A., Ibrahim I.S., and Musa, Z.A., 2004. The Influence of Elemental Sulphur and Phosphorus on the Performance of Faba bean (Vida faba) Grown in Two Alkaline Soils Annals of Arid Zone 43(1): 29-36

Elamin, E.A., Eltilib, A.M.A., Elnasikh, M.H., Ibrahim, H.S., Elsheikh, M.A., and Babiker, E.E. 2007. Influence of phosphorus and potassium fertilization on the quality of sugar of two sugarcane varieties grown on three soil series of Sudan. Journal of Applied Sciences 7 (16): 2345-2350.

Elhassan, A.A.M., Eltilib, A.M.A., Hashim, A.A, Ibrahim, H.S., and Awadelkarim, A.H. 2010. Nutritional Status of Forster grapefruit in Sudan central clay plain. Arab Universities Journal of Agricultural Sciences 18: 181-189.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Elhassan, A.M., Eltilib, A.M.A., Ibrahim. H.S. and Hashim A.A. 2005. Effects of different fertilizers on yield and quality of foster grapefruit. Proceeding. The 37th and 38th Meetings of the National Crop Husbandry Committee. Medani, Sudan.

Elkashif, M.E., and Alamri, K.M.2013. Effect of winter sowing date and nitrogen rate on growth and yield of sown okra cultivars in the Gezira state, State, Sudan. Sudan Journal of Agricultural Research 22: 1-10.

Elsheikh, M. A., Abidin, Z., Matsue, N., and Henmi, T. 2008. Competitive Adsorption of Oxalate and Phosphate on Allophane at Low Concentration. Clay Science 3(6) :181-188

Elsheikh, M.A., El-tilib, A.M.A., and Elsheikh, E.A. 2005. A Note on the Effect of Phosphate Rock, Triple Superphosphate and Their Combination on the available Soil Phosphorus in Shambat clay soil, University of Khartoum journal of Agricultural Sciences 13(3): 488-492.

Elsheikh, M.A., El-tilib, M.A.M., Elsheikh, E.A.E., and Awad Elkarim, A.H. 2006. Effect of phosphate rock and triple superphosphate on growth and leaf N, P and K contents of groundnut (Arachis hypogaea L.) grown on a clay soil. Arab Universities Journal of Agricultural Sciences 14 (2): 873-880.

Eltahir, F.H., and El Amin, M.A. 1999. Response of banana suckers to foliar application of different fertilizers. University of Khartoum Journal of Agricultural Science 7(2): 39-50.

Eltahir, F.H., and Hussein, M.A.1997. Response of Guava (*Psidium guava* L.) Seedlings to Various Nitrogenous Fertilizers, University of Khartoum Journal of Agricultural Sciences 5 (1):64- 79.

Eltahir, F.H., and Ali, I.I. 1998.Response of Guava Trees to Foliar Application of Bayfolan Fertilize. University Khartoum Journal of Agricultural Sciences 6 (2): 16-26.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Eltahir, F.H., and Bakhiet, S.B. 1999. Effects of Nitrogen and Potassium on Growth and Yield of Banana Plants. University Khartoum Journal of Agricultural Sciences 7 (2):26-38.

Eltahir. M. A. (1999). *Evaluation of some Sudanese rock phosphate and production of single superphosphate fertilizer.* M.Sc. (Education) Thesis, University of Khartoum, Sudan.

Eltilib, A.M., Ali, A.M., and Abdallah, A. 1994. Effect of chicken manure and salinity on growth and leaf nitrogen, phosphorus and potassium contents on okra grown in two soil types Khartoum. University Khartoum Journal of Agricultural Sciences I (2):16-36.

El-tilib, A.M.A., Elmahi, Y.E., Abdel Maged, H.M., and Ahmad, B.A.M. 1995. Response of wheat to irrigation frequency and manuring in a salt affected Semi-arid environment. Journal of Agriculture and Environment (13):115-125.

El-tilib, M.A., Elnasikh, M.H., and Elamin, E.A. 2004. Phosphorus and potassium fertilization effects on growth attributes and yield of two sugarcane varieties grown on three soil series. Journal of Plant Nutrition 27:663–699.

El-tilib, A.M.A., Hago, T.E.M., Awad Elkarim, A.H., and Ali, S.A.M. 2005. The response of rain-fed pearl millet to nitrogenous and phosphatic fertilizers grain on sand, loam soil. Annals *of* Agricultural Sciences Journal of Faculty of Agriculture, Ain Shams University 50 (2): 499-511.

El-tilib, A.M.A., Hago, T.E.M, Awadelkarim, A.H.A., and Ali, S.A.M. 2006a. Effect of nitrogenous and phosphatic fertilizers on performance of rain-fed pearl millet grown on clay loam Soil. Arab Universities Journal of Agricultural Sciences, *in Shams University*, Cairo 14 (1): 195-203.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

El-tilib, A.M.A., El Mahi , Y. E. Saad, I.A.A., and Elsheikh, M. A. 2006b. Chemical Composition and the Agronomical Potential of Two Types of Rock Phosphate in Sudan. Journal of King Abdulaziz University: Meteorology, Environment and Arid Land Agriculture Sciences17 (1) :3-13.

Faheema, M.I.; Mohamed, A.M.; Ali, I.A., and Sara, A.B. 2008. Effects of nitrogen and seed rate on performance, forage yield and quality of pear millet. Sudan Journal of Agricultural Research 11: 61-67.

Ferguson, H. 1954. Distribution of ammonium nitrate experiment annual report, Gezira research station. Medani, Sudan.

Ferguson, H., and Gray, S. 1949. manual experiment Annual Report, Gezira research station. Medani, Sudan.

Finck, A. 1960. Long term effect of fertilizer on chemical properties of Gezira soil. Gezira research station. Medani, Sudan. Medani, Sudan.

Frahah, S. M. 1987.Effect of nitrogen yield of hageen dura Annual Report, Gezira Research Station Medani, Sudan.

Gray, S, 1947. Annual report, Gezira research station. Medani, Sudan

Green, H.1932. Soil improves experiment, annual report, Gezira research station. Medani, Sudan

Gregory, F.G., Growther, F., and Lambert, A.R. 1932. The nitrogen of factors controlling the production of cotton under irrigation in Sudan. Journal of Agricultural Science -Cambridge 22: 617-638.

Hag Abdella, H. 1986. Effect of phosphorus fertilizer sources on grain yield of wheat. Annual Report, Gezira Research Station, Medani, Sudan.

Hag Abdulla, H.1991.The response of cotton to phosphorus fertilization unpuplished paper the crop husbandry committee. Agricultural Research Cooperation, Medani, Sudan.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Hago, T. M., and Salama, M. A. 1987. The effects of elemental sulfur on shoot dry weight, nodulation and pod yield of groundnut (*Arachis hypogaea* (L.) under irrigation. Experimental Agriculture 23*(1):*93-97.

Hago, T.E.M., Ali, S.A.M., and Eltilib, A.M.A. 2004. A note of the effect of phosphorus and nitrogen fertilizers on chemical composition of pearl millet grains. University of Khartoum Journal *of* Agricultural Sciences 12 (2): 287-292.

Hamid, A.M.A., and Dagash, Y.M.I. 2014. Effect of sulfur on sugarcane yield and quality at the heavy clay soil “Vertisols” of Sudan. Universal Journal of Applied Science 2: 68–71.

Heipko, G.H.1966., Annual reports, Hudeiba research station.

Ibrahim, E.I., Hassar, A.E., Elasha, E.A., and Elaga, S. 2011. Effect of organic manures on yield and yield components of rain-fed sorghum in the Gedarif state. Journal of science and Technology12 (4).

Ibrahim, M.A.S., Ahrned, K.E., Osman, S. Eltahir S.A., and Hamada, A.A. 2010. Response of new cotton varieties to nitrogen fertilization in Sudan Gezira. African Journal of Agricultural Research 5 (11): 1213-1219.

Ihsan, M.I.A., and Fadul, H.M. 2013. The Effects of Farm Yard Manure on Sodic Soil in Gezira-Sudan (*Triticum aestivum* L.) Production in Gezira-Sudan. Journal of Agricultural and Veterinary Sciences 14(1):11-22.

Isbe,H. M., and Ali, A.O. 1983. Prelaminar assessment of potassium and phosphorus trail at kenana. Annual Report, Kenana Research Station.

Ishag, H.M. 1980. Redding phenomenon in cotton plants agric. bull special annex about the Redding phenomenon in cotton plants

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Gezira scheme administration , Sudan(in Arabic) Sorghum production in Gezira, Sudan-Sudan Agric. J. 1: 5-11.

Ishag, H. M. 1992. Effects of Foliar Micronutrient Fertilizers on the Yield of Irrigated Cotton on the Vertisols of the Sudan Gezira. Experimental agriculture 28 (3): 265-272.

Jackson, T. E., and Burhan, H. O. 1969. Effect of rotation on nitrogen nutrition of cotton, Annual report, Gezira research station. Medani, Sudan

Johon, E.R. 1936. Effect of nitrogen in different doses, irrespective of the form Annual report, Gezira research station. Medani, Sudan.

Kavanaugh D. Sudan and South Sudan: The evolution of Africa's major nations. Simon and Schuster Publisher. ISBN: 9781422294260. 2014;80.

Khalifa, M.A., Akasha, M.H., and Said, M.B. 1977. Growth and N-uptake by wheat as affected by sowing date and nitrogen in irrigated sem-arid conditions. Journal Agricultural Science Cambridge 89: 35-42.

Kordofani, A.Y. 1959. nitrogen trail annual report, Gezira research station. Medani, Sudan.

Lazim, M.E. 1988. Time of nitrogen application. Annual Report, Gezira research station. Medani, Sudan.

Madibbo, G.M. 1998. Sorghum response to phosphate rock as affected by placement, application rate and soil type. Sudan journal of agricultural research 1: 17-19.

Massey, *R.E.1923.* A *Note* on the *Early History of Cotton* 6, 231.

Mohamed, M.A.E. 2004.*Effect of seed source, plant in row spacing, and seed tuber size on growth and yield of potato (Solanum tuberosum) under Khartoum state conditions*. M.Sc. (Agric) Thesis, University of Khartoum.

Create PDF files without this message by purchasing novaPDF printer (http://www.novapdf.com)

Mohamed, A.A., A.E.S. Ibrahim, A.S. Gangi and E.S. Ali. 2008. Effects of rate, way and time of nitrogen application on growth and grain yield of maize (*Zea mays* L.). Gezira Journal of Agriculture Science 6 (1): 71-86.

Mohammed, T.A., Elsheikh, E.A., and Osman, A.G. 2014. Response of groundnut and faba bean to organic chemical and microbial fertilizers in three types of soils in Sudan. International Journal of Sudan Research 4(1): 37-54.

Mubarak, A.A., and Dawi, B.S.2009. Decomposition and nutrient release from various tree litters in a sandy soil of a semi-arid tropics. Sudan-Sudan Journal of Desertification Research 1(1):36–55

Mubarak, A.A., Hassan, A.A., Ahmed, I.A., and El-tilib, A.M.A. 2014. Use of dry sewage sludge and irrigation canal sediment on production of wheat on arid soil, Northern state, Sudan-Sudan Journal of desertification research 6(1): 67-78.

Mukhatar, S.A. 2015. Response of sugarcane ratoons to nitrogen rate and methods of application in Guneid Sugar Seheme, Sudan. Gezira Journal of Agricultural Science 13 (2): 18-34.

Musa, M.M., and Mukhatar, N. O.1967.Nitrogenous fertilizer transformation in Gezira research station. Annual Report, Gezira Research Station, Medani, Sudan.

Musa, M.M. 1966. Studies on nitrogen fertilizer transformation in soils. Annual Report, Gezira Research Station, Medani, Sudan.

Mustafa, M.A. 1986.*Salt affected* soils in the *Sudan*: their *distribution*, properties and management. Reclamation and Revegetation Research 5 (1-3): 115-124.

Mustafa, M. A., and Elamin, A. E. 1981. The effects of irrigation interval, urea-N and gypsum on salt redistribution in a highly

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saline sodic montmorillonitic clay soil under forage sorghum. Soil Science 132(4):308-315.

Mustafa, M. A., and Elamin, A. E. 1982. Interrelationships of irrigation frequency, urea nitrogen and gypsum on forage sorghum growth on a saline sodic clay soil. Agronomy Journal 74(3):447-451.

Rai, K. D. 1965. Annual Report, Gezira Research Station, Medani, Sudan.

Rezig, F.A.M., Elhadi, E.A., and Mubarak, A.R .2014. Decomposition and nutrient release pattern of wheat (*Triticum aestivum*) residues under different treatments in desert field conditions of Sudan. *The* International Journal *of* Recycling *of Organic* Waste *in* Agriculture 3:69. https://doi.org/10.1007/s40093-014-0069-8.

Saad, I. A. A. 1993. I*nvestigation on the Use of Nuba Mountains Phosphate Rocks in Agriculture* M.Sc. (Agric) Thesis, University of Khartoum.

Said, M.B. 1961. Phosphorus uptake by cotton grow in Gezira clay. Annual Report, Gezira Research Station, Medani, Sudan.

Said, M.B. 1969. Adsorption urea and compound by soil. Annual Report, Gezira Research Station, Medani, Sudan.

Salih, M.A., Eltahir, S.A., Elfadil, A.B., and Naiem, A.A. 2005. Grain yield and nitrogen use efficiency of two maize varieties as affected by time of nitrogen application. Sudan Journal of Agricultural Research 5: 21-30.

Salih, M.N.T. 2013. Response of sunflower (*Helianthus annuus* L.) tophosphorus and nitrogen fertilization under rainfed conditions, Blue Nile State,Sudan. Helia 36:101–110.

Salih, N.O.H., Mubarak, A.R., and Hassbo, A.A. 2012. Effect of crop residues on soil fertility and yield of wheat guar crops in dry

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tropics. International Journal of Scientific and Engineering Research 3 (10) 304-307.

Sidahmed, O.A., Elrawahi, M.S., and Raisy, F.S. 2004. Response of encumber to nitrogen fertigation under plastic house conditions. Sudan Journal of Agricultural Research 4: 13-19.

Sirelkhatim, M. E. 1985. *Response of Five Sugarcane Varieties to Phosphorus Fertilization at Two Locations,* University of Khartoum M.Sc. (Agric) Thesis, University of Khartoum.

Snow, O.W. 1936.Soil improvers experiment. Annual Report, Gezira Research Station, Medani, Sudan.

Van der Kevie, W.1973. Climatic Zones in the Sudan. Soil. Survey Department, Wad Medani. Sudan.

Walley, V.D. 1927. Cotton growing at Gezira Research Farm with brief account of some experiment plot S.C. welcome tropical Research Laboratory pep. Meeting: 1-4.

Yousif, L.A., Taha, M.B, Hanan A.S., and Alawi, O.H. 2008. Effect of urea and its time of application with Sarwala on sorghum production in Gedarif rain fed area. Gezira Journal of Agricultural Science. 6 (2):158-170.

Zaid, G.A.A.2004. *Effect of nitrogen and sulfur fertilization on growth, yield, quality, nitrogen and prussic acid content of tow forage sorghum cultivars.* M.Sc. (Agric) Thesis, University of Khartoum.

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تطورات البحوث في خصوبة التربة في السودان

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مستخلص البحث: تهدف هذه المقالة الي إستعراض الأبحاث القومية السابقة الموجهة لتصحيح حالة خصوبة التربة. أجريت العديد من التجارب الحقلية لمعرفة استجابة المحاصيل المتنوعة لمختلف أنواع الأسمدة. وفي وقت مبكر من عام 1911، أدرك الرواد أن النيتروجين منخفض جدًا، بسبب قلة المواد العضوية، وبالتالي، اعتبر النيتروجين العامل المحدد الرئيسي للإنتاج . ومنذ ذلك الحين، ركزت أبحاث الأسمدأولا ً ً على معدل وكمية ونوع ووقت استخدام الأسمدة النيتروجينية. كان مصدر سماد النتروجين لمحصول القطن هوكبريتات الأمونيوم ولكن في وقت لاحق، في عام 1960 تم استبداله باليوريا لمزاياها الاقتصادية. ولاحظ العلماء الترابط الكبير بين استجابة المحاصيل العالية للأسمدة النيتروجينية والمدخلات الزراعية الأخرى مثل الوقاية من الآفات والخف والري ووقت الزراعة. لوحظ أن إضافة السماد النيتروجين يزيد من إنتاج القمح وكان زمن الإضافة هو العامل الأكثر تأثيرًا على الانتاج. في منطقة الزراعة المطرية أستجاب الذرة جيدا للنيتروجين المضاف ولكن هذه الاستجابة تعتمد على صنف الذرة المزروع. في أوائل الستينيات من القرن العشرين، تم إدخال سماد سيوبر الفوسفات الثلاثي كمصدر للفوسفورفي مشروع الجزيرة ووجد التسميد بالفسفور استجابة عالية للمحاصيل مثل القطن والقمح والذرة الرفيعة وقصب السكر. والجدير بالذكر أن العديد من المحاولات الناجحة بذلت لاستبدال الفوسفات المستورد بالفوسفات الصخري المحلي الذي يتوافر بكثرة في السودان. أظهرت الدراسات المبكرة عدم وجود استجابة محصول القطن لسماد البوتاسيوم ولكن في لآونة الأخيرة وجد ان العديد من المحاصيل مثل البطاطس وقصب السكر والبنجر والموز استجابت بشكل جيد لإضافة البوتاسيوم. حظيت دراسة تغذية المحاصيل بعنصري الكالسيوم والمغنيسيوم باهتمام اقل اذ لم تنعدم. أضافة سماد الكبريت قليلة وحظيت باهتمام أقل. على الرغم من أن محتوي التربة السودانية من العناصر الدقيقة منخفض للغاية، إلا أنها حظيت باهتمام أقل في الزراعة السودانية. كانت إدارة خصوبة التربة العضوية مصدر قلق العديد من العلماء. تم إجراء عدد من التجارب الحقلية باستخدام أنواع مختلفة المخلفات العضوية أدت لزيادة المادة العضوية للتربة والنشاط البيولوجي وتوافر المغذيات. وقد وجد أن استخدام مياه الصرف الصحي ورواسب قناة الري مع خلطهما مع سماد النتروجين عملية مفيدة لتحسين التربة القاحلة ذات الجودة الرديئة. وجد أن إضافة بقايا المحاصيل ضروري للحفاظ على خصوبة التربة وإنتاج المحاصيل. تمت دراسة الإنتاجية المنخفضة للتربة المتأثرة بالملوحة من قبل العديد من الباحثين. أشارت نتائج هذه الأبحاث إلى فترات الري القصيرة كأحد أفضل الإجراءات لزيادة الانتاجية بشكل ملحوظ في هذه التربة الهامشية. وحصل البعض الآخرعلى أعلى محصول من القمح بتطبيق مخلفات الدجاج أو مخلفات المزرعة على التلال المزروعة بالتربة الصودية في

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الجزيرة. ومع ذلك، أشارت نتائج التجارب البحثية المذكورة في هذه المقالة إلى أن معظم المحاصيل استجابت بشكل إيجابي لتطبيق السماد، وهو ما يتضح من ضعف خصوبة التربة السودانية. في ضوء نتائج العديد من تجارب الأسمدة الحقلية، من المستحسن اعتماد سياسة إضافة كل من الأسمدة العضوية وغيرالعضوية إلى المحاصيل للحفاظ على خصوبة التربة وزيادة الانتاج، وبالتالي تنمية زراعة مستدامه افضل.
كلمة مفتاحية: الأسمدة وخصوبة التربة والأسمدة العضوية والملوحة والتربة السودانية

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