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Research Article

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Response of Sugar Beet (*Beta vulgaris* L.) Growth, Yield and Yield Components to Compost and Phosphorus Fertilizers

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Abstract

Sugar beet is one of the sugar crops which widely grown in different regions of the world due to its advantages over Sugarcane. Several studies were conducted in Sudan to assess its adaptation and economic value. However, the aim of this experiment was to study the effect of application of compost and different levels of phosphorus fertilizer and their combination on Sugar beet (*Beta vulgaris*) growth attributes, yield and yield components. The study was conducted during the winter season 2018 –2019 at the farm of the College of Agriculture, University of Bahri, Alkadaro-Khartoum State, Sudan. The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications and six treatments, namely the Compost (5t./ha.), Phosphorous (P_2O_5) (88kg./ha.), P_2O_5 (176 kg./ha.), Compost (5t./ha.)+P_2O_5 (88kg./ha.), Compost (5t./ha.)+ P_2O_5 (176Kg./ha.) and the Control (C) respectively. All cultural practices were carried out timely according to the recommendations of the Agricultural Research Centre in Sudan. Then the data pertaining the following agronomic traits were recorded, the leaf number; leaf dry weight (g), leaf area index (LAI) (cm), root diameter (RD) (cm) and root fresh weight (RFW) (g). The results of statistical analysis revealed the application of compost in combination with phosphorus displayed significant increase at 5% level for the leaf number (22.75), leaf area index (5.23), leaf dry weight(36.78), root diameter(69.67) and root fresh weight (422.68), followed by the application of compost alone compared to the control and other treatments. The study concludes that the combination of compost and mineral

fertilizer (P_2O_5) proved to increase all Sugar beet growth and yield parameters.

Introduction

Sugar beet (*Beta vulgaris* L.) is one of the main raw materials for sugar production in many countries. It is considered to be the second most important crop in the world, after sugarcane for sucrose production. This crop can be grown in a variety of climatic conditions, but it is primarily grown in the temperate latitudes between 30-60^{0}C N[1]. It can be grown successfully on a range of soil types. On a textural classification, in all types of clay, silt, sand and organic soils, but the production may be limited to soils with excessive wetness in spring and autumn [2].

Despite the importance of sugar beet as an industrial cash crop, its productivity remains low because many farmers luck the technical knowhow of its production; and therefore, it became necessary to pay great attention to this point and look for naturally safe stimulating growth substances which can markedly influence plant growth and yield parameters[3]. However, the application of nitrogen fertilizer is considered as an important practice that determines sugar beet growth and production[4]. But, compost appears to be less understood as a contributor to soil organic matter and overall soil ecology and management. Nevertheless, it supposed to become another tool which can be used along with the cover crops, animal manure and other management strategies[5]. However, in this regard, the most important point to be considered is the decomposition of Phosphorous which depends on many variables. The active composting process leading to a stable product can be completed in a matter of days, weeks or months, and then followed by a maturation phase which may take weeks to months to results in finished mature compost [6].

Studies showed that compost contains important elements such as nitrogen 0.3% – 1.5% (3g to 15g per kg of compost), phosphorus 0.1% – 1.0% (1g to 10g per kg of compost); and potassium 0.3% – 1.0% (3g to 10g per kg of compost)[7]. Therefore, it improves the status of the mineral nutrients in plants, particularly the nitrogen, phosphate and potassium[8]. Generally, the application of organic fertilizers is one of the important practical measures to improve soil fertility, providing the necessary nutrients for crops, improving soil physico-chemical properties, and organic matter[9].

It is very important to understand the problem of phosphorus in agriculture, particularly its various forms in the soils, transformation, mobilization, and the conditions for the most effective use of phosphorus [10, 11]

There are a lot of information on the various forms of various phosphates and their quantitative content in different soils. The accumulation of mobile phosphates and phosphates of loose-bound and the different-base fractions in the soil are the basis for increasing sugar beet yields. The actual concentration of soluble phosphorous in most soils is relatively low—on the order of 1μM—because of several factors, among these the propensity of phosphorous to form insoluble complexes[11]. Generally, a wide variety of interacting factors such as soil formation, climatic conditions, and the several processes like weathering, mineralization, desorption, immobilization, adsorption, precipitation, runoff, erosion, organic matter, clay content, soil mineralogy and soil pH etc. determine the availability of phosphorus in the soils[3].

In plants, phosphorous is found largely as phosphate esters-including the sugar-phosphates, which play such an important role in photosynthesis, intermediary metabolism and energy metabolism of cells[12]. The optimal level of mobile phosphorus content in the soil is found to be about 30–45 mg·kg^{-1} with the sum of loose-bound and different-base 385–445 mg·kg^{-1} of soil[13,14]. It is found that nitrogen and phosphorous application led to an increase in leaf area and biomass. On the other hand, the application of nitrogen increases the total dry weight of the plants and reaching to the maximum total dry weight. Moreover, addition of phosphorus and potassium triggers microorganisms' activities to improve the compost quality, but the soil enrichment with phosphorus over the optimal level leads to unproductive costs and low availability of soil phosphorus[15]. Furthermore, the application of FYM + NPK increases the content of organic carbon in the soil, the total content of nitrogen, P and K concentrations[16].

It worth mentioning that most of the studies on sugar beet crops concentrated on how to increase the root and sugar productivity. Therefore, many researchers have studied the effects of different fertilization levels and/or different growth regulators. This experiment aimed to study the response of sugar beet growth parameters, yield and yield components to the application of compost and phosphorus fertilizes under saline soil conditions.

Materials and Methods

The experiment was conducted during the winter season of 2016–2017 in the demonstration farm of the College of Agriculture, University of Bahri, Khartoum North, Alkadaro, Sudan (Latitudes 15^0.44'-15^0.45' N, Longitudes 32^0 35' 32^0 39' E. and Altitudes 398m above the sea level). The area is located in semi-arid zone, characterized by long period of dry season, hot climate in summer with mean daily maximum temperature between 30 -45°C, and cool in winter, with temperature between 25-10°C. Usually it rains in summer and the annual average rainfall ranges between 0 - 100mm, and the relative humidity between16% - 50%. The soil is moderate to strong alkaline, with pH 7.5-8; EC 1.1-8.3 dSm^{-1} [17].

This study adopted the Randomized Complete Block (RCBD) experimental design with three replications and six treatments; compost 5t/ha, phosphorus 88Kg P_2O_5/ha, phosphorus 176 Kg P_2O_5/ha, compost 5t/ha + phosphorus 88Kg P_2O_5/ha, compost 5t/ ha + phosphorus 176Kg P_2O_5/ha and control which referred to (O, P_1, P_2, P_1O, P_2O and C) respectively. Soil was prepared by disk plough, harrowed, leveled, and ridged. Plot size was 5x4 m; spacing between ridges was 70 cm and 15 cm between plants. Seeds were manually planted on 13/12/2016 by placing two seeds /hole and thinned to one plant/hole. Frequent irrigation was carried out every 7-10 days. Harvesting was done on 7/5/2017. Data were collected by taking three plants at random from the two outer rows of each plot after 7, 10, 13, and 16 weeks after sowing (WAS). The following parameters were studied, the Leaves number, Leaf dry weight (g), Leaf Area Index, Root diameter (cm), Root fresh weight (g), Yield and yield components. The data were analyzed, using Statistic 8 software Program.

Results and Discussion

Table 1. Effect of compost and phosphorus fertilizers and their combinations on leaves No. of sugar beet (ALkadaro-Sudan, 2016/2017).

Time Treatment.	7WAS	10 WAS	13 WAS	16 WAS
Control	8.22 bc	17.89 ab	25.67 ab	31.89 bc
O	9.33 ab	20.22 a	26.89 a	34.89 ab
P_1	7.67 c	16.55 b	22.67 b	27.89 d
P_2	8.33 bc	21.00 a	25.45 ab	28.89 cd
P_1 + O	9.89 a	19.67 ab	26.00 ab	33.89 ab
P_2 + O	9.56 ab	20.31 a	24.78 ab	36.33 a
SE±	0.673	1.563	1.583	1.514
C.V	9.33	9.93	7.68	5.74

WAS: Weeks after sowing. Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 2. Effect of compost and phosphorus fertilizers and their combinations on Leaf Area Index of sugar beet (ALkadaro-Sudan, 2016/2017).

Time Treatment	7WAS	10 WAS	13 WAS	16 WAS
Control	0.71 c	2.60 ab	2.45 b	09.60 bc
O	1.03 ab	3.23 ab	5.38 a	10.45 ab
P_1	0.71 c	2.10 b	4.10 ab	08.43 c
P_2	0.69 c	3.36 a	5.05 a	09.01 bc
P_1 + O	0.78 bc	3.52 a	5.89 a	10.73 ab
P_2 + O	1.13 a	2.63 ab	4.86 a	11.53 a
SE±	0.129	0.509	0.918	0.834
C.V	18.77	21.46	24.33	10.27

WAS: Weeks after sowing. Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 3. Effect of compost and phosphorus fertilizers and their combinations on leaves dry weight (g) sugar beet (ALkadaro-Sudan, 2016/2017).

Time Treatment.	7WAS	10 WAS	13 WAS	16 WAS
Control	7.27 c	23.32 c	32.61 cd	42.70 d
O	7.90 bc	28.79 a	35.22 c	44.94 c
P_1	7.21 c	27.08 b	32.01 d	44.68 cd
P_2	8.02 abc	25.98 bc	34.56 cd	46.18 c
P_1 + O	9.05 a	35.63 a	46.30 a	56.12 a
P_2 + O	8.54 ab	34.40 a	41.15 b	52.63 b
SE±	0.510	1.362	1.283	0.969
C.V	7.82	5.71	4.25	2.48

WAS: Weeks after sowing. Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 4. Effect of compost and phosphorus fertilizers and their combinations on root diameter (mm) of sugar beet (ALkadaro-Sudan, 2016/2017).

Time Treatment	7WAS	10 WAS	13 WAS	16 WAS
Control	21.41 [c]	37.04 [b]	55.37 [d]	82.47 [c]
O	28.10 [a]	58.15 [a]	84.53 [a]	107.90 [a]
P_1	23.24 [bc]	35.98 [b]	59.77 [cd]	86.37 [c]
P_2	23.27 [bc]	39.61 [b]	61.68 [c]	96.24 [b]
P_1 + O	26.74 [ab]	55.44 [a]	68.16 [b]	106.45 [a]
P_2 + O	28.14 [a]	55.64 [a]	67.89 [b]	99.33 [b]
SE±	1.605	2.074	2.404	3.025
C.V	7.82	5.41	4.45	3.84

WAS: Weeks after sowing. Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 5. Effect of compost and phosphorus fertilizers and their combinations on root fresh weight (g) of sugar beet (ALkadaro-Sudan, 2016/2017).

Time Treatment.	7WAS	10 WAS	13 WAS	16 WAS
Control	34.777[b]	153.77[c]	429.20[ab]	569.01[c]
O	45.600[a]	206.87[b]	457.63[a]	777.33[ab]
P_1	37.167[b]	125.33[d]	345.11[c]	688.12[bc]
P_2	34.537[b]	147.01[cd]	380.58[bc]	666.27[bc]
P_1 + O	45.303[a]	258.99[a]	452.16[a]	934.25[a]
P_2 + O	45.320[a]	258.56[a]	466.74[a]	705.69[bc]
SE±	1.6088	11.125	25.778	76.952
C.V	4.87	7.11	7.48	13.03

WAS: Weeks after sowing. Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Table 6. Effect of compost and phosphorus fertilizers and their combinations on yield and yield components of sugar beet (ALkadaro-Sudan, 2016/2017).

Time Treatment.	pol%	Brix %	Root Yield t/ha	White Sugar t/ha
Control	14.36[a]	16.63[a]	41.94[b]	6.02[b]
O	15.41[a]	19.10[a]	43.71[b]	6.58[ab]
P_1	14.23[a]	17.18[a]	44.28[b]	6.35[ab]
P_2	15.79[a]	20.13[a]	40.00[b]	6.32[ab]
P_1 + O	15.97[a]	18.97[a]	53.83[a]	8.68[a]
P_2 + O	14.21[a]	17.38[a]	44.28[b]	6.36[ab]
SE±	1.641	1.922	4.124	1.120
C.V	13.40	12.91	11.31	20.41

Means followed by the same latter(s) within a column are not significantly different at the 5% level according to (LSD).

Results in table (1) showed significant differences in the leaf number of sugar beet as influenced by different treatments of compost and phosphorus. The highest leaf number was obtained in treatment (P2+O) followed by treatment (P1+O), whereas the lowest one was recorded in treatment (P1)[17]. The increase of leaf number may be due to nutrients availability which released during the decomposition of compost, especially the nitrogen which plays a vital role in plant growth. The available nitrogen that released in the soil from the compost mineralization process increases the shoot/root ratio of sugar beet. Also the solubility of phosphorus in soil can be increased due to the presence of compost and phosphate which provide the plant with energy. This result was in confirmative with the result obtained by Nshimiyimana[18] who stated that when sugar beet was evaluated by using cow dung as organic manure and NPK as mineral fertilizer; the differences among treatments were significant and high leaf number after four weeks was observed. Michel, et. Al.; [19] suggested that the organic manure can benefit crops in various ways through the provision of nitrogen in the early season and more slowly during the remaining growing period.

The results of data analysis (table 4) showed the study displayed the different treatments of compost, phosphorus and their combinations had significant effects on Leaf Area Index (L.A.I) of sugar beet table (2). When the treatment (P2+O) 16 days after sowing (DAS) recorded the highest L.A.I, followed by treatment (O), while the treatment (P1) recorded the lowest one. These results indicated increase of that LAI due to the interaction between compost and phosphorus rather than the application of compost or phosphorus alone. The slowly release of nitrogen and phosphorus from compost during the growing season had increased the shoot of sugar beet and as a result LAI increased too. Several researchers reported the increase of leaf area of sugar beet with the application of optimum compost throughout the development stages. However, the mixture of organic and inorganic fertilizers had tremendously influenced the growth of sugar beets more than any other treatments [18, 19].

Leaves dry weight (LDW) (g) of sugar beet; 16 DAS was significantly affected by the different treatments of compost, phosphorus and their combinations (table 3). The highest leaf dry weight was obtained from the treatment (P1+O); followed by (P2+O), whereas the control recorded the lowest one. The increase of leaf dry weight may be depending on the optimum nutrients which released from compost and their uptake by plant, specially the nitrogen during the growing season. This result confirmed with the result found by Michel, et. Al.;.[19] who found that compost has significantly increased the biomass of sugar beet at different growth stages as well as the dry weight.

Data analysis in table (4) showed the different treatments of compost, phosphorus and their combinations had significant differences on root diameter (mm) of sugar beet. The higher records of root diameter were observed in treatment (O) followed by (P1+O) 16 DAS, while the lower one was recorded in the control. This result may be due to the increase of leaf number and L.A.I. which enhanced the photosynthesis process and accumulation of more assimilate. The quantity of nitrogen and available phosphorus released from the decomposition of compost had positive effect on root diameter. Similar result was confirmed by Michel, et. Al.; [19]. They found that the application of compost, animal manure and chemical fertilizer had increased the roots and sugar yield compared with control. However, application of 40 Mg/ha compost along with 50% chemical fertilizer had produced higher yield than chemical fertilizer alone.

Results in table (5) 16 DAS, revealed that root fresh weight (g) of sugar beet was significantly affected by different treatments of compost, phosphorus and their combination; while the treatment (P1+O) recorded the highest root fresh weight followed by treatment (O), while the control (C) recorded the lowest one.

Considering the table 6, the different treatments of compost, phosphorus and their combinations had non-significant effects on pol% and Brix%, but had significant differences on root yield t/ha and white sugar t/. The highest pol% was observed in treatment (P1+O) followed by (P2) treatment while the lowest percentage was recorded in treatment (P2+O). Treatment (P2) recorded the highest Brix% followed by the treatment (O), whereas the control recorded the lowest percentage. Nevertheless, treatment (P1+O) recorded the highest root yield followed by (P2+O) and (P1), whereas the control recorded the lowest root yield. Treatment (P1+O) followed by treatment (O) recorded the highest white sugar t/ha, while the control recorded the lowest weight. These results indicated that, the application of compost in combination with adequate rate of phosphorus fertilizer Produced better yield of beet roots and white sugar. This result is in confirmative with the results found by Michel, et. Al.;[19] who stated that, the application of compost and chemical fertilizer increase the root and sugar yield compared to control. The application of 40 Mg/ha compost along with 50% chemical fertilizer produced higher yield than the application of chemical fertilizer alone.

Conclusion and Recommendations

This study demonstrated that application of compost had enhanced the mineral nutrition and fertility of soil by slow releasing of nutrients during the growing season. The combination of compost and phosphorus raised the content of nitrogen and soluble phosphate in the soil which led to an increase of vegetative growth and assimilate production. The application of compost and phosphorus combinations had positive effects on vegetative growth, yield and yield components of sugar beet than single application. It is recommended that this study to be replicated in Alkadaro and other locations under different climatic conditions and soils.

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