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Impact of applying organic fertilizers activated by doses of NPK the new reclaimed soil and wheat productivity

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Abstract

A field trial was carried out at the experimental farm in the El Qusiyah district, Assiut governorate, which is located at 325 km south of Cairo, Egypt at latitude (27°29'2.58" N and longitude 30°39'3.23"E) during the winter growth season of (2019-2020) to investigate the impact of different doses (1, 2 and 3) of two compound fertilizers (19:19:19 and 15:5:5) with different application rates plus organic fertilizer (compost) at the rate (10 ton/feddan) (feddan = 4200 m² = 0.420 hectares = 1.037 acres) to assess their effects on some soil properties and wheat crop production. The results indicated that increasing of NPK nutrient by 78.06, 67.62 and 70.64% respectively above of control under treatment. Wheat crop treatment significantly increased weight of 1000 grain, straw yield, and grain yield by 45.92, 46.91 and 41.18% respectively in comparison to control. 19:19:19 treatment, at all tested doses, was the best agriculture practice that produces higher wheat yield as well as increased of available nutrient.

Keywords: wheat, soil, chlorophyll, compost, applied doses, chemical fertilizer.

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1. Introduction

The population of Egypt is increasing constantly and rapidly which requires an increase in food production, to meet the growing consumption of food. The area of Egypt is 1.0 million km^2, but more than 95% of it is arid desert. Cultivation of grain crops in some desert land may help in solving part of the problem of food shortage in Egypt (Abdel-Gawad and Morsy, 2020). Wheat (*Triticum aestivum* L.) is one of the most important food grain crops grown in the world and in Egypt on account of its wide adaptability to different agro climatic conditions and different soils (Mohamed *et al*., 2021). Wheat ranks first among main cereals in terms of worldwide area and production, and it provides more calories and proteins to the world's human diet than any other cereal (Rekaby *et al*., 2016). In Egypt, wheat is cultivated on the area of 1.343 million hectares yearly with an annual production of 8.800 million tonnes and an average yield of 6.55 tons/ha (FAO, 2020). Wheat contains high levels of carbohydrates and significant amounts of vitamins B and C and several minerals (Eissa *et al*., 2018). Fertilization is one of the main factors that affect the yield and quality of wheat. Growing wheat requires high amounts of both nitrogen and organic fertilizers for optimum growth, grain production and seed quality. Application of nitrogen fertilizers results in larger biomass grain yield and protein content.

To achieve the maximum benefit from added nitrogen fertilizer, it must be divided and added at different doses throughout the plant growth period, because excessive fertilizer leads to groundwater pollution (Hu *et al*., 2021). Generally, the reclaimed sandy soils in Egypt contain relatively low amounts of available nitrogen, phosphorus potassium and organic matter. Hence the ordinary demanded for N, P and K fertilizers may be high under such conditions. The addition of organic fertilizers to the soil improves soil fertility and increases agricultural (Abd Elgalil and Abdel-Gawad, 2020). Furthermore, composted organic matter has a high nutritional value, with high concentrations of some nutrients such as nitrogen, phosphorus and potassium. Compost is known for its high organic content, which increases enzymatic and microbiological activity in the soil (Al-Sayed *et al*., 2019; Yousaf *et al*., 2022). Integration of organic and inorganic fertilizers improves soil fertility, and this led to increase the production of crop yield (Abdel-Gawad and Morsy, 2017). Therefore, the main of objective of the study was to identify the best managements and combination of NPK plus compost and number of doses of chemical fertilizer for sustainable soil properties and wheat production with maximum nutritional and quality values.

2. Materials and methods

2.1 Experimental site

A field experiment was carried out in the winter season of (2019-2020) at El Qusiyah district, Assiut governorate, Egypt located at latitude of 27°29'2.58" N; and longitude 30°39'3.23"E).The climate is cold in winter, dry and very hot in summer with average temperatures between 11.9 and 30.7 °C with mean of

21.3°C, very low rainfall (2.9 mm/year) and high evapotranspiration (2000 mm/year), the average relative humidity varied between 50% and 58%, with the lowest value of 35.8% recorded at June and the highest value was recorded at January (Figure 1) according to Egyptian Meteorological Authority (2017).

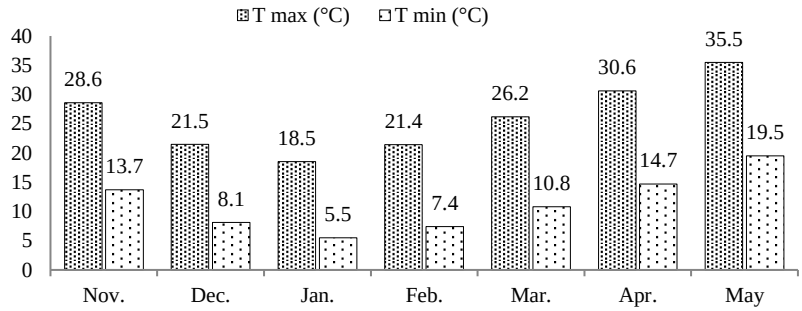

Figure (1): Average weather conditions during the growing periods of wheat cultivation (2019-2020).

Soil sample was collected before planting to determine some soil physical and chemical properties according to the methods of Page *et al*. (1982) and result to are presented in Table (1).

2.2 Experimental design and treatments

The experiment was designed in a randomized complete block design with four replications in growth season. The treatments enclouded T1=control without fertilizer, T2= ten tons of organic compost activated by 15 Kg of chemical compound fertilizer such as 15:5:5 and 19:19:19. The 15 Kg of each type was divided in the three doses: 15 kg T3= 7.5 then 7.5 Kg and T4= 5:5:5 Kg. Also, the T5= 15 Kg of 19:19:19 wase divided in two 15 Kg. T6= 7.5 then 7.5 Kg and T7= 5:5:5 Kg. making a total number of 7 treatments as shown in Table (2).

Table (1): Weather data recorded during the study period.

Property	Value	Property	Value
pH (1:2.5 suspension)	8.33	Total N (mg kg^{-1})	350
EC (1:1) (dS m^{-1})	0.45	Total P (mg kg^{-1})	250
SP (%)	30	Total K (mg kg^{-1})	320
Organic matter (g kg^{-1})	2.9	Available N (mg kg^{-1})	36
Sand (%)	90.3	Available P (mg kg^{-1})	1.6
Silt (%)	6.5	Available K (mg kg^{-1})	130
Clay (%)	3.2	Soluble cations	
Texture	Sandy	*Ca (meq/L)	0.15
$CaCO_3$ (%)	4.1	*Mg (meq/L)	0.2
Soluble anions		*Na (meq/L)	1.01
CO^{3-} + HCO^{3-} (meq/L)	1.85	*K (meq/L)	0.74
Cl (meq/L)	1.21		

Each value represents the mean of three replications. * = soluble cations.

Table (2): Code of treatments and amounts of combined chemical fertilizers applied per filed.

Compost rates	Chemical compound fertilizer doses	Treatment code	Amount per dose
Compost (0 ton/feddan)	Without	T1	0 Kg/feddan
Compost (10 ton/feddan)	Compound fertilizer (15: 5: 5) at one dose (2.25 Kg.N)	T2	15 kg/feddan
	Compound fertilizer (15: 5: 5) at two doses (1. 125Kg.N)	T3	15 kg/feddan
	Compound fertilizer (15: 5: 5) at three doses (0 .75 Kg.N)	T4	15 kg/feddan
	Compound fertilizer (19:19:19) at one dose (3. 85Kg.N)	T5	15 kg/feddan
	Compound fertilizer (19:19:19) at two doses (1. 92Kg.N)	T6	15 kg/feddan
	Compound fertilizer (19:19:19) at three doses (1. 28Kg.N)	T7	15 kg/feddan

The organic compost was added before cultivation and the activating. Doses were added after 20 days from planting. Also, the second and third doses were applied after 20 days (Table 2). The size of each plot was 100 m^2 (10 × 10 m^2). Each plot represents one replicate of each treatment, which means four plots for each treatment, making a total number of 28 plots. Wheat (*Triticum aestivum* L.) grains were sown at rate of 60 kg $feddan^{-1}$ (feddan = 4200 m^2 = 0.420 hectares = 1.037 acres) on 20th November during (2019-2020) season. No insecticide or fungicide was applied as there was no serious incidence of insect pests or diseases. Using sprinkler irrigation system was a solid set a spacing of 10 × 10 m between laterals and between sprinklers. Harvesting was done in the 10 May 2020 after170 days. The compost was obtained from the Egyptian company for compost production of 50:50% waste plants: animal (ECARU), Minya, Egypt. The compost was mixed with the topsoil layer (0–30 cm) before plant cultivation and during the preparation of soil the properties of compost and presents in Table (3). All plots received equal amount of (10 ton/feddan) compost that were added during soil preparation before blowing.

Table (3): Some chemical characteristics of tested compost.

Properties	Compost	Properties	Compost
pH (1:5 suspension)	8.5	Total P (%)	0.6
EC (1:5) (dS m^{-1})	5.2	Total K (%)	0.9
Organic matter (%)	35	C/N ratio	1:16
Total N (%)	1.7	Organic-C (%)	20.30

Each value represents the mean of three replications.

2.3 Soil and plant sampling and analysis

2.3.1 Soil sampling

The physical and chemical properties of the studied soil were determined according to Burt (2004). Soil mechanical analysis and texture was determined by using the pipette method the pH of soil was measured in 1:2.5 (soil: water) suspension and the electrical conductivity (EC) was measured in 1:2.5 and 1:5 extract according to Burt (2004). Soil organic matter was determined by wet oxidation method by $K_2Cr_2O_7$ and H_2SO_4

(Walkley and Black, 1934). Total carbonates in the soil were estimated using the calciminer method and calculated as $CaCO_3$ according to Burt (2004). Total N was determined by the Kjeldhal method (Burt, 2004). The total K contents were determined with a flame photometer (Burt, 2004). The total P was estimated by a spectrophotometer as described by Burt (2004).

2.3.2 Plant sampling

At the end of the experiment, the plant samples were collected at harvesting and washed twice by deionized water. Then, the plant samples were distilled water. After air drying, plant samples were oven-dried 70°C to a constant weight and then were ground. The dried ground plant samples were digested in H_2SO_4 and H_2O_2 as described by Parkinson and Allen (1975). Then, the digested plant sample were analyzed for N, P and K according to the standards methods described by Burt (2004). Crop yield measurements plant samples were collected from 1 m^2 from the middle of each experimental unit. Plant height was measured from the surface soil to the top of the plant. At harvest time, plant height (cm), 1000 grain weight (g), grain yield (ton/feddan), straw yield (ton/feddan) and biological yield (ton/feddan). A dry weight of the plant was weighed using an electronic balance (0.01 g) and thousands of grains were also weighed after the harvest dry. Total chlorophyll in fresh plant leaves (Spad-502-m Konica Minolta, Inc., Tokyo, Japan) at a green stage after the spikes were expelled.

2.4 Statistical Analysis

All data collected were subjected to one-way analysis of variance (ANOVA) using Costat software (Steel and Torrie 1996).

3. Results and Discussion

3.1 Changes of some chemical properties of the soil

The combined applications of the chemical compounds fertilizers doses with organic fertilization were beneficial for the physical and chemical properties of soil and were important for the quality and productivity of the soil. The results showed that the entire soil parameters (available of nitrogen, phosphorous, potassium, electrical conductivity and organic matter) increased significantly under (T2 to T7) doses treatments.

3.1.1 Soil reaction (pH)

The results indicated that a significant decrease in the soil pH values as compared with the control. But there is no significant difference between the treatments of F15, due to the buffering action of soils, and also in treatments of F19, but there is a significant difference between the treatments of commercial fertilizers F15 and F19, and this because the F15 fertilizer has an acidic effect, while F19 fertilizer has a neutral effect.

Also, several investigators studied the ammonium-based nitrogen fertilizers are over-applied to reimburse for the nitrate leached, therefore soil pH is decreased over time, (Iqbal, 2020) so we should be application the level and rates of chemical fertilizer.

3.1.2 Electrical conductivity (EC)

The data showed that there is an increase in soil salinity (EC) which received in all fertilizer treatments compared to the control, as well as an increase in F19 compared to F15 treatments, due to the increase in the concentration of units' fertilizer (F19). The highest increase in soil salinity was recorded in T7 in season as compared to the control. Such increase did not reach the hazardous effect and might be due to the non-high salt content of the soil and compost. Also, similar results were obtained by Dar *et al*. (2021) electrical conductivity increased when rates of chemical fertilizers were added to the soil, large number of salts and nutrients were added in soil when application of rates of chemical fertilizer were added, an increase in sales increases salinity that ultimately results in increased electrical conductivity. Chang *et al*. (2007) showed that electrical conductivity in soil treated by compost was generally higher than those received chemical fertilizer treatment.

3.1.3 Organic matter (OM)

The data indicated that the application of compound minerals fertilizers NPK (F15 and F19) had significant effect on organic matter content during the two growth seasons as shown in Table (4). This can be explained that the rate of adding the organic matter was stable in all treatments compared to the control. Baloch *et al.* (2015) found that compost in combination with small inorganic fertilizer applications improved the soil as opposed to heavy fertilizer doses alone or mere application of crop residues. Magda *et al.* (2015) also obtained significant increase in crop yields when a combination of organic and mineral fertilizers was applied compared with sole application of organic or mineral fertilizer.

Table (4): Influence of chemical compound fertilizers doses under organic fertilization on soil properties.

Treatments	pH (Susp.1:2.5)	EC (dSm^{-1})	OM ($g\ kg^{-1}$)
T1	8.31^{a}	0.35^{e}	3.08^{c}
T2	7.80^{bc}	0.51^{cd}	8.05^{ab}
T3	7.78^{bc}	0.53^{c}	8.29^{a}
T4	7.72^{c}	0.52^{cd}	6.62^{a}
T5	7.81^{bc}	0.54^{b}	6.89^{ab}
T6	7.85^{bc}	0.54^{b}	7.47^{ab}
T7	7.95^{b}	0.55^{a}	7.95^{a}

* Each value in this table is the mean of 3 replicates. ** Numbers with same letters in the same column means there no significant between them following Duncan's multiple range test at ($p \leq 0.05$).

3.1.3.1 Available nutrients

Data in Table (5) showed that the high concentration of available nutrients in the soil from (T2 to T7) due to the addition of amounts of (organic and inorganic fertilizer) in all treatments compared to the control, similar result was obtained by Ali *et al*. (2021). Liu *et al*. (2021) showed that the compost application at rate (1 and 2%) increased the available N by 14 and 26%, respectively, compared with the control. Rana and Bharti (2021) reported that the effect on available NPK and organic carbon in soil incorporation of organic manures and chemical fertilizers various treatments showed available N, P and K increased in soil with the application of different rates nutrient management treatments during years.

Table (5): Influence of chemical compound fertilizers doses under organic fertilization on nutrient availability (ppm).

Treatments	N (ppm)	P(ppm)	K (ppm)
T1	34^{c}	1.59^{e}	123^{d}
T2	139^{ab}	3.62^{bcd}	316^{abc}
T3	146^{ab}	3.82^{abc}	335^{abc}
T4	147^{ab}	4.22^{ab}	354^{abc}
Mean	144	3.88	335
T5	117^{ab}	3.62^{bcd}	273^{c}
T6	145^{ab}	4.27^{ab}	406^{ab}
T7	155^{a}	4.91^{a}	419^{a}
Mean	139	4.26	366

* Each value in this table is the mean of 3 replicates. ** Numbers with same letters in the same column means there no significant between them following Duncan's multiple range test at ($p \leq 0.05$).

3.2 Effect of chemical compound fertilizer doses with organic fertilizer on growth parameters of wheat plants

In the present study, the plant height was significantly affected by doses of chemical fertilizer was observed in T7 andT4 does treatments by 58.48 and 13.60% respectively above of control. Data in Figure (2) show the effect of doses of chemical compound fertilizer on the photosynthetic pigments. The chemical compound fertilizer significantly ($p<0.05$) increased the total chlorophyll in T7 and T4 by 27.37 and 9.25% compared to the control. Also, the effects of NPK three does under treatments T7 and T4 on growth variables may have been due to the extent to which plants benefit from doses in different stages of growth instead of one or two doses of NPK which helped in the nutrient uptake by the plant (Subhan *et al*., 2017). This result is in agreement with Okunlola and Adeona (2016) and Ali *et al*. (2021) who observed an increase in the growth parameters with applied fertilizer types, which might be due to the effective use of applied fertilizer at this rate by the plants. The rates of chemical fertilizers are amendments comprising of nutrients needed for plant growth it is given in time for the growth of the crop and in a limited

quantity increasing the growth and yield of the plants (Šiaudinis *et al.*, 2021; Sugiono *et al*., 2021). Rana and Bharti (2021) studied the effect of addition of 100% NPK and the recorded significantly higher value of yield and yield attributes in terms of spikelet's spike^{-1}, spike length (cm), 1000 grain weight (g) at recommended dose of fertilizer *i.e*., 120, 60, 40 kg NPK ha^{-1}.

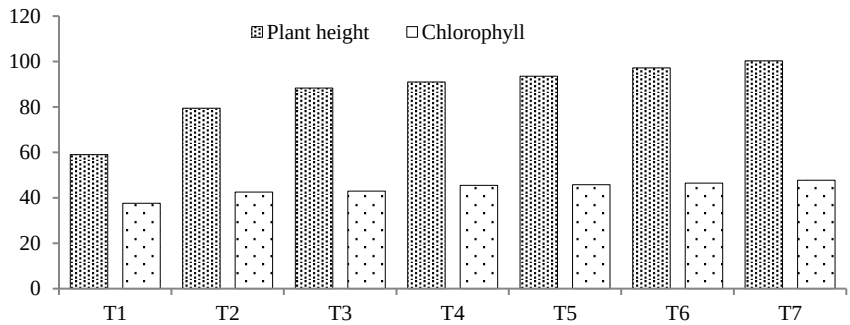

Figure (2): Influence of chemical compound fertilizers doses with organic fertilization on wheat plants. Plant height (cm), chlorophyll (SPAD unit).

The biological yield of wheat plants improved increased with increasing the doses of chemical fertilizers. The increases in weight of 1000 grain, straw yield, and grain yield might be due to the increase of compound chemical fertilizers' content of essential nutrients (Amin and Eissa, 2017; Tartoura and Youssef, 2011). A significant increase in the biological yield of wheat plants occurred with increasing the addition doses chemical fertilizers of compared to the un-amended soil. Nitrogen fertilization showed a significant increase in the fruit yield (Mohammad, 2004). Additions of the compost to the soil gave an increase in the total yield. This result agreements' with (Rekaby *et al*., 2016; Hammad *et al*., 2020). The chlorophyll contents of wheat leaves were significantly increased at treatments T7 doses and T4. This may be attributed to the increase in absorption of nutrients by plant, improvement of soil characteristics besides the increase in doses nitrogen (Al-Sayed *et al*., 2020; Esmailpour *et al*., 2013). All measured growth characters and photosynthetic pigments were positively affected by the more doses of nitrogen.

3.2.1 Wheat growth parameters

3.2.1.1 Plant height (cm)

Different fertilizers affected significantly plant height on the plant. Data in Figure (2) showed that plant height was increased through the growth period in treatments T4 and T7 by 94 and 101 cm, respectively compared to the control. The increase in plant height with increasing chemical fertilizers and organic might be due to

balanced nutrient provision from compost, when improved soil properties and N availability to crop. This might result in rapid cell production and enlargement which resulted in taller plants (Boomsma *et al*., 2009). The results of this study are in accordance with Khan *et al*. (2016) they reported that a maximum plant height of wheat from combined application of compost and inorganic fertilizer.

3.2.1.2 Total chlorophyll

Data in Figure (2) showed the effect of number of doses of chemical compound fertilizer on the photosynthetic pigments. The chemical compound fertilizer significantly ($p<0.05$) increased the total chlorophyll in T4 and T7 by 27.37 and 9.25% and that due to the high percentage of nitrogen in chemical fertilizers F15 and F19 by 15 N and 19 N unit, respectively and in organic fertilizer (compost) compared to the control.

3.2.2 Yield attributes

3.2.2.1 1000-grain weight

All doses of chemical treatments significantly increased weight of 1000 grain, of wheat compared to the control, The results showed that application of T7 significantly increased weight of 1000 grain, straw yield, and grain yield by 70, 88 and 85% respectively in comparison to control, whereas the T7 recorded the highest value in 1000 grain (51 g) compared to the control, on the other hand (T2) recorded the less value in 1000 grain (42 g) in seasons. The increase of 1000-grain weight depends on the status of soil fertility, water availability, crop management, agronomic practices, environmental factors, and plant genetic characteristics. Yield improvement under this treatment might be due to enhanced use of N, water and other associated soil improving benefits of organic sources, which made plants more efficient in photosynthetic activity. The current results are similar with the findings of Baloch *et al.* (2015), they found that increase in 1000-grain weight was mainly due to the balanced supply of nitrogen in combination with P and K and maximum N use efficiency from both inorganic and organic sources during the grain filling development and growth stages.

3.2.2.2 Straw and grain yield

Influence of chemical compound fertilizers doses under organic fertilization on wheat plants. Wheat straw yield increased as nitrogen fertilization doses increased. All doses of chemical treatments significantly increased straw yield of wheat compared to control (Table 5). The results showed that application of (T7) significantly increased weight of straw yield by (87.79%) in comparison to control.

3.2.2.3 Grain yield (ton/feddan)

Influence of chemical compound fertilizers doses under organic

fertilization on wheat plants. Wheat grain yield increased as nitrogen fertilization doses increased. All doses of chemical treatments significantly increased grain yield of wheat compared to control (Table 6). The results showed that application of (T7) significantly increased weight of straw yield by 84.67% in comparison to control. This may be attributed to the increase in absorption of nutrients by plant, improvement of soil characteristics besides the increase in doses nitrogen (Al-Sayed *et al*., 2020). It is clear that all measured growth characters and photosynthetic pigments were positively affected by the more doses of nitrogen.

Table (6): Influence of chemical compound fertilizers doses under organic fertilization on wheat grain yield.

Treatments	Wight of 1000 grain (g)	Straw yield (ton/feddan)	Grin yield (ton/feddan)	Total biomass
T1	30^{c}	1.46^{e}	1.79^{f}	3.25^{e}
T2	42^{b}	1.85^{d}	2.00^{ef}	3.85^{d}
T3	45^{ab}	2.17^{cd}	2.58^{cd}	4.75^{cd}
T4	49^{ab}	2.16^{cd}	2.69^{cd}	4.85^{c}
Mean	45.33	2.06	2.42	4.48
T5	49^{ab}	2.23^{c}	2.60^{cd}	4.83^{c}
T6	49^{ab}	2.62^{ab}	3.16^{ab}	5.78^{ab}
T7	51^{a}	2.75^{a}	3.31^{a}	6.06^{a}
Mean	49.66	2.53	3.02	5.55

* Each value in this table is the mean of three replicates. ** Numbers with same letters in the same column means there no significant between them following Duncan's multiple range test at ($p \leq 0.05$).

3.3 Effect of chemical compound fertilizer doses with organic manor on content nutrients (NPK) in grain at wheat plants

The results of analysis of variance indicated that doses of chemical fertilizer had a significant effect on all measured traits. Chemical fertilizer under compost had a significant effect on concentration of NPK on grain yield (Table 7). The highest values were obtained in the T4 and T7 treatment, due to the third dose, which leads to maximizing the utilization of the fertilizer. The concentration of NPK was obtained in the control decrease with increasing doses and rate of nitrogen level. The increases in concentration of NPK at treatments (T7) were 111.89, 178.82 and 74.06% respectively above the control, while the treatment (T4) doses increase by 18.38, 178.82 and 13.35% respectively above the control. This result is in agreement with Okunlola and Adeona (2016) and Ali *et al*. (2021) who observed an increase in the growth parameters with applied fertilizer types, which might be due to the effective use of applied fertilizer at this rate by the plants.

Table (7): Influence of chemical compound fertilizers doses under organic fertilization on wheat plants.

Treatments	N-content (g kg^{-1})	P-content (g kg^{-1})	K-content (g kg^{-1})
T1	23.46_{e}	6.47^{c}	14.77^{e}
T2	32.20_{cd}	13.74^{b}	18.42^{cd}
T3	33.90_{cd}	14.99^{ab}	19.12^{cd}
T4	36.16_{cd}	15.83^{ab}	20.07^{cd}
Mean	34.08	14.85	19.20
T5	38.12_{bc}	15.89^{ab}	20.88^{bc}
T6	46.46_{a}	16.10^{ab}	24.36^{a}
T7	49.70_{a}	18.04^{a}	25.71^{a}
Mean	44.76	16.67	23.65

* Each value in this table is the mean of three replicates. ** Numbers with same letters in the same column means there no significant between them following Duncan's multiple range test at ($p \leq 0.05$).

The rates of chemical fertilizers are amendments comprising of nutrients needed for plant growth it is given in time for the growth of the crop and in a limited quantity increasing the growth and yield of the plants (Šiaudinis *et al*., 2021; Sugiono, 2021). Al-Sayed *et al*. (2019) showed that the application of organic and inorganic fertilizers with regular doses will be able to increase the content of NPK in the plants.

4. Conclusion

Organic fertilizers play a significant role in improving soil physical and chemical pro properties, and inorganic fertilizers are important due to their ability to provide essential nutrients, this study sought, specifically, to obtain new insights into the interactive chemical compound doses. According to the presented data, the wheat plant increased number of doses of the same amount of in organic fertilizer. The study inferred that growth wheat give the highest productivity on (T7). The recommended application of organic fertilizer is 10 ton/fed. combined with (CF19 Chemical fertilizer 19:19:19) at three doses.

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