# Evaluation of soil modification Feldspar, Compost and Biochar on cultivating cowpea (*Vigna unguiculata* ssp. *unguiculata*) plant and soil sandy clay loam properties.

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**Abstract:** The crop production in Egypt relies completely on imports to meets its annual requirement of potash fertilizers besides; the high cost of conventional, water soluble K fertilizers constrains their use by most of the farmers in the country. This work was conducted cowpea (*Vigna unguiculata* ssp. *unguiculata*) plants cv. Dokki 126 at Ismailia Research Station, Agricultural Research Center (A.R.C), Egypt, during the two summer seasons of 2020 and 2021 to study the effect of some treatments as potassium feldspar, biochar and compost on soil sandy clay loam properties and the physical and chemical contents of cowpea. A randomized complete block design was used. The results show that the potassium feldspar + biochar + Compost significantly increased the vegetative growth expressed as plant length, number of leaves, number of branches, pod length, Pod diameter, Pod fresh weight, Pod dry weight, Plant fresh weight, Plant dry weight. Also the results indicated that soil pH and EC was not significantly affected in the soil treated with potassium feldspar + biochar + compost. There are positive significant effects on nutrient availability (NPK) in both seasons by using potassium feldspar + biochar + compost in soil. The application of OMW can improve soil quality indices (nutrients (N, P, and K), organic matter, pH, total porosity, bulk density.

**Key words**: Cowpea, Vigna unguiculata, plant length, vegetative growth, potassium feldspar, biochar, compost, sandy soil, organic matter, bulk density, total porosity.

## Introduction

Cowpea (*Vigna unguiculata ssp. unguiculata*) has been introduced to the Egyptian agriculture as a promising field crop. It is a short duration legume crop with low water requirements, with high nutritive value and known in both southern parts of Asia and Africa for human consumption. Cowpea as a summer crop will compete with other summer dominant crops in Egypt. Another usage of cowpea it could be employed as vegetable crop for its green pods which could be cooked, however cowpea cultivation as a vegetable crop haven't a role in the Egyptian crop structure and untraditional practices like intercropping could be used for such purpose. (Abd El Lateef, et al., 2020). Due to intensified agricultural mechanization, soils are exposed to increased levels of degradation. Soil compaction is the beginning of this degradation which further proceeds to decrease organic matter content of soils. Among the various methods applied to solve these problems, the addition of organic and non-organic matter to the soil has an important place. In Egypt, it should be used large amount of K chemical fertilizers to maximize crop yield per unit area and to compensate K-decreases in soils due to crop uptake, runoff, leaching and soil erosion (Shams and Fekry, 2014). Also, the high price of these fertilizers is responsible for

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increasing production cost and environmental pollution. The use of natural potassium fertilizer and/or bio-fertilizer is low cost resources for providing plants with K which could alternate the expensive applied K-chemical fertilizers (Manning, 2010 and Labib et al., 2012). The main natural sources of K come from the weathering of minerals (K-feldspar, leuctie, K-mica and illite (Hellal et al., 2009). Many authors reported that K-feldspar may be valuable as a low releasing K and cheaper source of potassium (Shafeek et al., 2005; Abou-el-Seoud and Abdel-Mageed, 2012). Compost, which originates from the decomposition of plant material or organic wastes, is considered as amid fertilizer (Aggelides and Londra, 2000).

The application of composted organic bio-wastes as organic fertilizers is still popular, and agricultural use of compost is found to have a definite advantage to the soil quality improvement. Infusion of compost into the soil increases soil nutrients and organic matter, thus positively affecting the physical, chemical and biological properties of the soil. (Hargreaves, et al., 2008). In recent years, biochar, which is a solid product of biomass pyrolysis, is considered an evidenced soil amendment because it is attributed to soil carbon pool and can remain intact in the soil. Biochar, which is recognized as a valuable soil ameliorant, can offset the effects of climate change because it has a definite capability of retaining too much carbon (Peake et al., 2014). An sample number of evidence shows that it affects soil physical, chemical and biological properties by acting as soil amendment (Głąb et al., 2018; Lehmann et al., 2011; Li et al., 2018; Mukherjee and Lal 2013; Wang et al., 2018). Furthermore, the effects of biochar application on other soil physical properties, such as PR, hydraulic conductivity, bulk density, and soil structure have not been fully evaluated in the field conditions (Asai et al., 2009; Busscher et al., 2010; Chan et al., 2007; Glaser et al 2002; Laird et al., 2010; Masulili, et al 2010; Peng et al., 2011). In this study, we hypothesized that the concurrent application of feldspar, compost and biochar influences the soil compaction, yet this influence can be modified by adjusting compost components and application rates. The objective of this study was to determine the effect of different compost and biochar rates on physical and chemical characteristics loam soil of sandy clay, as well as the effect of this productivity of cowpeas plants.

## Materials and Methods

A field experiment was conducted at Ismailia Research Station, Agricultural Research Center (A.R.C), Egypt during two successive seasons of summer 2020 and 2021 to study the effect some treatments on the physical and chemical contents of cowpea (*Vigna unguiculata* ssp. *unguiculata*) cv. Dokki 126 variety. The first treatment was control (without treatment). The soil samples were taken at depth 0-30 cm before cultivation and after harvesting to determine physical and chemical characteristics of the investigated soil according to Page et al. (1982) as shown in Table (1). Some properties of the used feldspar, compost and biochar were carried out as described by Brunner and Wasmer (1978) as illustrated in Table 2.

The investigation was conducted to evaluate the effect of feldspar, compost and biochar on soil properties, and productivity of plant cowpea grown in sandy loam clay soil. The initial soil was analyzed and showed in Table 1 soil analysis showed that soil was sandy texture and low fertility for available macronutrients. feldspar, compost and biochar analysis were showed in Table 2. The applied biochar to this experiment made of different types of citrus trees it was produced using pyrolysis at a final temperature of 500 $^{\circ}$C with a retention time of 2 h. Biochar samples were ground and sieved at $<0.5$ mm diameter. Biochar was applied to the soil at 4 ton/fed rate while, was applied to the soil. Before planting, cowpea seeds were inoculated with the specific rhizobium (Rhizobium radiobactersp strain) using gum media. The inoculants was prepared by the Soil Microbilology Dept., Soil, Water and Environment Res. Inst., Agricultural Research Center (ARC), Egypt. Seeds of cowpea were sown in the first week of May in the two growing seasons. Also, before sowing the soil was prepared using agricultural gypsum (CaSO4 .2H2 O) at a rate of 1190 kg/fed. Potassium sulphate (41.5 % K) at a rate of 119 kg/fed was applied in two equal portions. The first half was added at sowing and the second one was added after 30 days.

Superphosphate was applied during soil preparation. Ammonium nitrate was added at four split equal doses after 2, 4, 6 and 8 weeks from sowing. Potassium fertilizers were divided into two equal doses, the first was added at sowing after 31 days and the second was added after 55 days from sowing. At harvesting, ten plants from each plot were taken randomly, and threshed. Grain and straw were dried using an electrical oven on $75^{\circ}$ C until constant weight obtained. Then weighted to obtain their dry weight and transferred to seed yield. The grain and straw were ground 0.5 g powder and digested by concentrated digestion mixture of $H_2SO_4$ + $HClO_4$ acids according to Sommers and Nelson (1972). Nitrogen was determined by micro Keldahl, according toPhosphorus was determined by spectrophotometric ally using ammonium moly date stannous chloride method according to Chapman and Pratt (1978). Potassium was determined by a flame photometer, according to Page *et al.* (1982). Available P and K were extracted by Ammonium-Bicarbonate- according to Soltanpour (1985). Field capacity was determined according to USDA (1962). Soil bulk density, total porosity and saturation percent were determined according to Black *et al.* (1965).

At harvest, Sample of vegetative growth were taken after 85 days from sowing.

**Determine the yield components as follows:**

1- Plant length cm. 2- Leaf number/plant. 3- No. of branches/plant. 4- Pod length cm. 5- Pod diameter cm. 6- Pod fresh weight g. 7- Pod dry weight (g) was determined by drying 100 g in an oven at 70 ºC till constant weight was reached 8- Plant fresh weight g. 9- Plant dry weight (g) was determined by drying 100g in an oven at 70 ºC till constant weight was reached 10- Chlorophyll a, b and carotenoids contents in the leaves were determined according Robblen, (1975)11- total Carbohydrates contents were determined in dry seeds according Herbert et. al., (1971) 12- Nitrogen content was determined as g/100 g dry weight according to the micro-kjeldahl method (A.O.A.C., 1990). 13- Phosphorus content was determined calorimetrically as g/100 g dry weight using the hydroquinonoe and sodium sulphite method (A.O.A.C., 1990). 14- Potassium contents were determined as g/100g dry weight using flam photometer according to Dewis and Freitas (1970).

**Table (1): Some physical and chemical properties of the investigated surface layer of soil (0-30 cm).**

| Chemical properties | | | | | | |
|---|---|---|---|---|---|---|
| pH | EC** dS\m | Soluble cations**(meq.\L) | | | | |
| | | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | |
| 7.59 | 1.31 | 5.51 | 2.75 | 10.69 | 1.03 | |
| SAR | ESP | Soluble anions**(meq.\I) | | | | |
| | | $Co_3^{--}$ | $Hco_3^{-}$ | $CI^{-}$ | $SO_4^{=}$ | |
| 1.64 | 3.34 | 7.70 | 3.20 | 14.80 | 2.91 | |
| SP | $CaCO_3$ % | O.M% | Available (mg kg-1) | | | |
| | | | N | P | K | |
| 21.23 | 5.95 | 0.41 | 44.2 | 4.99 | 171.0 | |
| physical properties | | | | | | |
| Particle size distribution (%) | | | | | | Texture class |
| Coarse sand | Fine | Total fined | Silt | Clay | sand | Sandy clay loam |
| 18.69 | 34.06 | 44.89 | 9.00 | 27.31 | 63.69 | |
| Hydraulic conductivity ($cmhr^{-1}$) | 8.40 | Available water % | | | 7.20 | |
| Field capacity % v/v | 9.13 | Total porosity % | | | 47.5 | |
| Wilting point % v/v | 1.90 | Bulk density ( $Mg\ m^{-3}$) | | | 1.62 | |
| pH *: in suspension 1:2.5<br>EC**(ds/m) , soluble cations ** and anions (meq.\I) :in saturated past extract | | | | | | |

The used compost was analyzed for some physical and chemical properties and its content of some essential plant nutrients according to the methods described by Page et al. (1982) and the obtained data are recorded in Table 2. Some physical and chemical properties of biochar in table (3) . This experiment included 8 treatments, which were the combinations between three soil amendment with rate biochar (7.350 $m^3$ /fed.), compost (15.750 $m^3$ /fed.) and feldspar applications of potassium feldspar with soil inoculation of both phosphate and potassium dissolving bacteria (3.150 $m^3$ /fed.)

1- Control treatment without any addition with supplying the full recommended dose of phosphorus (200 kg/ fed. of supper phosphate, 15.5 % P2O5), The full dose of potassium (50 kg/fed. of potassium sulphate, 48 % K2O) and nitrogen (150 kg/fed. of ammonium nitrate, 33 % N) for all experimental plots
2- potassium feldspar
3- Biochar
4- Compost
5- potassium feldspar + Biochar+ Compost
6- potassium feldspar + Biochar
7- potassium feldspar + Compost
8- Biochar+ Compost

**Table (2): Some physical and chemical properties of tested compost.**

| Chemical properties | | | Total nutrient (%) | | |
|---|---|---|---|---|---|
| pHSus.1:10dS m$^{-}$ | EC dSm$^{-1}$ 1:10 Extract | Organic matter | N | P | K |
| 2.27 | 7.47 | 38.17 | 1.06 | 0.94 | 1.27 |
| Available nutrients concentration mg kg$^{-1}$ | | | | | |
| Macronutrients | | | Micronutrients | | |
| N | P | K | Fe | Mn | Zn |
| 442 | 237 | 673 | 283 | 0.98 | 0.82 |
| physical properties | | | | | |
| Bulk density kg m$^{3}$ | | Moisture content % | | Water holding capacity % | |
| 500 | | 25.72 | | 310 | |

**Table (3): Some physical and chemical properties of biochar.**

| | | | |
|---|---|---|---|
| Organic carbon% | 26.91 | Total K % | 8.11 |
| Organic matter% | 46.39 | CEC (cmol / kg) | 32.15 |
| Ash (g kg$^{-1}$) | 3.2 | Moisture (g kg$^{-1}$) | 60 |
| Fixed (g kg$^{-1}$) | 60 | Volatiles (g kg$^{-1}$) | 233 |
| EC (dSm$^{-1}$) (1:10 bio char water suspension) dS/m | 1.4 | pH | 6.87 |
| Total N % | 1.55 | Bulk density (g/cm$^{3}$) | 0.16 |
| Total P % | 0.65 | | |

## Results and Discussion

**Effect of potassium feldspar, biochar and compost on the physical properties of soil.**

**Bulk density, total porosity and hydraulic conductivity:**

Data presented in Table 4 showed that application of feldspar + biochar + compost improved bulk density (BD) values, total porosity (TP) and hydraulic conductivity ($K_{sat}$) in two seasons compared with control. The best value of bulk density, total porosity and hydraulic conductivity were 1.28 (Mg m$^{-3}$), 39.3 (%) and 8.17 (cm/h) respectively, in the second season with treatment by potassium feldspar + biochar + compost was more than the other treatments. Application of biochar + compost reduced bulk density and hydraulic conductivity values by percentage 22.42 and 9.3% respectively, compared with control, while total porosity values was increased by percentage 10.3 % compared with control. These results were agreement with biochar could also reduce bulk density in the long term by interacting with soil particles and improving aggregation and porosity. The latter requires the monitoring of changes in bulk density, total porosity and hydraulic conductivity through extended periods of time (Lucia et al., 2020) (Vitková, and Šurda 2019). Compost application to agricultural lands has been recognized as a reliable way to improve the physical properties of most soils, especially soils changes in physical properties in compost-amended urban soils have included bulk density, infiltration rate, hydraulic conductivity, water content, aggregate stability and porosity. (Somerville et al., 2018; Usowicz et al., 2021). These results were in harmony with El-Shony et al. (2019), who mentioned that the combined application of biochar and compost improved the porosity and bulk density of the soil compared with the sole application of biochar.

**Table (4): Effect of olive mill waste water and boichar combined with different NPK rate on soil bulk density (BD), total porosity (TP) and hydraulic conductivity ($K_{sat}$) in two seasons.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | BD (g/cm3) | TP % | Ksat (cm/h) | BD ($g/cm^3$) | TP% | $K_{sat}$ (cm/h) |
| Control | 1.62g | 47.5g | 8.40f | 1.65g | 47.8f | 8.38f |
| potassium feldspar | 1.43d | 44.1f | 8.31e | 1.41e | 42.1e | 8.27c |
| Biochar | 1.46e | 41.3c | 8.23bc | 1.42e | 41.3c | 8.211b |
| Compost | 1.49f | 40.7b | 8.22ab | 1.46f | 40.7b | 8.20b |
| potassium feldspar+ Biochar+ Compost | 1.33a | 40.3a | 8.21a | 1.28a | 39.3a | 8.17a |
| potassium feldspar + Biochar | 1.37c | 42.5d | 8.35c | 1.37c | 41.6c | 8.33e |
| potassium feldspar+ Compost | 1.34b | 42.6d | 8.34cd | 1.32b | 42.1d | 8.31d |
| Biochar+ Compost | 1.34b | 42.70e | 8.33c | 1.33b | 41.40b | 8.31d |
| LSD. at 0.05 Treatment | 0.39 | 2.19 | 1.57 | 0.32 | 2.13 | 0.31 |



### Field capacity, wilting point and available water

Data presented in Table (5) showed the application effect of the feldspar + biochar + compost on soil field capacity (FC), wilting point (WP) and the content of available water (AW) in the studied sandy clay loam soil. The values of FC, WP and AW in testing soils positively affected responded to the application of different treatments as comparatively observed with the control treatment. Whereas, the values of FC, WP and AW values increased from 11.16, 2.14 and 9.02% in the control treatment to (13.88, 6.33 and 7.55) under potassium feldspar + biochar + compost addition, 13.98, 6.44and 7.45 under potassium feldspar + Biochar + Compost addition, first and second season respectively. The highest increase percentages of retained at field capacity, wilting point and available water were noticed in treatment with feldspar + biochar + compost and biochar + compost. Application of biochar + compost. Caused raised of water retained at either field capacity or wilting point. These results are in similar with these obtained by (Jennifer et al., 2020). The increase in water availability could be ascribed to the beneficial effect of such materials on soil aggregation. On the other hand, the lowest values of field capacity, wilting point and available water were recorded in feldspar, biochar, compost mix together when compared by control and the other treatment . Also, these results may be attributed to the addition of soil organic conditioners either addition increased

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the specific surface area and the water holding pores area which increased water field capacity, wilting point and available water (Christina et al., 2020). Similar finding was observed by (Schmid et al., 2017) and (Sax et al., 2017). Also this can be attributed to the inferiority in the composition and stability of soil aggregates, (Bashir et al., 2020). The increases in available water, hence, lead to a feasible route conditions and plant growth. In general, the aforementioned sequence illustrates the superiority of compost and biochar at its higher which is a logic result because of its relatively which indicates that decomposition of the compost and biochar would take longer time than the other used composites and hence its conditioning effect would still remain for longer periods.

**Table (5): Effect of potassium feldspar + biochar + compost on soil physical properties on field capacity (FC), wilting point (WP) and available water (AW) in two seasons.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | FC % | WP/ % | AW % | FC % | WP /% | AW% |
| Control | 11.16g | 2.14g | 9.02f | 11.66g | 2.24e | 9.42g |
| potassium feldspar | 13.01e | 5.56c | 7.45a | 13.33d | 5.60b | 7.73d |
| Biochar | 13.22b | 5.61b | 7.61c | 13.62b | 5.68b | 7.94f |
| Compost | 13.11c | 5.58c | 7.53b | 13.47c | 5.64b | 7.83e |
| potassium feldspar+ Biochar+ Compost | 13.88a | 6.33a | 7.55b | 13.98a | 6.44a | 7.54b |
| potassium feldspar+ Biochar | 13.09d | 5.15d | 7.93d | 13.33d | 5.32c | 7.89c |
| potassium feldspar+ Compost | 12.15c | 4.5f | 7.65c | 12.20e | 5.01d | 7.19a |
| Biochar+ Compost | 12.98f | 4.79e | 8.19e | 13.03f | 5.32c | 7.71d |
| LSD. at 0.05 Treatment | 2.72 | 3.93 | 1.57 | 2.32 | 4.23 | 2.34 |



**Effect of the feldspar + biochar + compost on soil chemical properties.**

**Soil pH**

Data presented in Table (6) indicated that, the values of soil pH were slightly decreased with addition the different soil amendments feldspar + biochar + compost compared to the control. But the other hand, the effects of the different soil amendments showed non-significant effect on soil pH. These results may be due to contain low plant residual which base forming cautions so cause decreasing pH. In the same trend with feldspar agreement by (Davide and Thomas, 2019) and might be attributed to organic acids produced during the decomposition of the organic fraction of the soil organic conditioner's production of organic acids, which formed as a result of organic matter decomposition from compost (Jeffery et al., 2017). Also who found that the biochar combined with feldspar was slightly reduced the pH by 0.22 than biochar alone. Albert and Kwame (2018) suggested that the added

Biochar as soil amended level reduce pH. Reduction in soil pH may be related to the residual organic matter after different biochemical and chemical changes.

**EC**

Data in Table (6) showed that the electric conductivity (EC) values were affected with addition of feldspar, biochar, and compost with non-significant differences between all the experimental treatments in both season. The low EC value was (1.091) ($dS/m^{-1}$) at second season compared with other treatments. The decrease in EC may be related to the salt leaching of salts outside the root zone (Lehrsch et al., 1993). These results agree with Jones et al. (2011) who reported that the applying of biochar together with N fertilizer led to decrease soil salinity (EC). These results may be due to that biochar application has reduced soil bulk density and improved soil aggregate structure, which led to increase total porosity in soil and increase in macro pores and in turn to increased water content at low suction pressures led to movement of leaching water that enhance progressive removal for Na-salts (Lei & Zhang, 2013). Also (Ghanema et al., 2021) confirmed the average of electrical conductivity of soil during both season were decreased by increasing the amount of organic fertilizers applied. This may be due to increasing water holding capacity. This led to a decrease in the rate of evaporation from the soil surface, and thus a decrease in the concentration and accumulation of salts in the soil. "EC" were decreased by increasing the volume of applied water where as a result, the process of leaching of salts repeated with full irrigation outside the root spread area by deep percolation. The same trend in decrease the electric conductivity (EC) because that the dominant conduction mechanism in dry K-feldspar at high temperature is ionic conduction, and potassium as the major charge carriers migrates in the crystal lattice by the interstitial hopping mechanism in sandy soil (Hu et al., 2014b ).

**OM**

Table (6) indicated that, the values of the percentage of soil organic matter content during both season were significantly increased by addition of feldspar, biochar, and compost applied mix together .The percentage value of increase organic matter of feldspar, biochar, and compost mix in first season was 32.5 % and 37.2 %. The increase in organic matter following biochar application could be due to high carbon (C) associated with biochar (Abdulaziz, 2018). While several studies showed an increase in organic matter content, total N and C/N ratio following irrigation with biochar and may have a beneficial effect on soil fertility (Mekki et al., 2006; Brunetti et al., 2007; Mekki et al., 2013). Improved sandy loam soils by compost application to sustain crop production. All compost types significantly increased soil total carbon (Mahmoud et al., 2021). They added that compost has a positive effect on overcoming the depressive effect of water stress (Kusparwanti et al., 2020). This increase of organic matter could attributed to the activity of micro organisms for bio-fertilizer which enhanced the hydrolysis of applied compost and consequently the soil organic matter concentration increased, (Alshankiti and Gill 2016 & Chapman, 1965). Application of different K sources to tomato plants led to varying amounts of organic C and available NPK in the soil after harvest (Badr, 2006). Organic C and available N content increased appreciably by the application of all organic sources, while mineral sources (feldspar and potassium sulphate) had no or little impact on fertility build up (Badr, 2006).

**Table (6): Effect of potassium feldspar + biochar + compost on soil pH, EC and OM of two seasons in tested soil.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | pH | EC | OM | pH | EC | OM |
| **Control** | **7.80e** | **1.29d** | **0.50e** | **7.81f** | **1.31e** | **0.53f** |
| **potassium feldspar** | **7.71c** | **1.15b** | **0.56d** | **7.67c** | **1.13b** | **0.59e** |
| **Biochar** | **7.73d** | **1.18c** | **0.60c** | **7.70e** | **1.15c** | **0.66d** |
| **Compost** | **7.72c** | **1.16c** | **063b** | **7.71e** | **1.14b** | **0683c** |
| **potassium feldspar + Biochar + Compost** | **7.61a** | **1.11a** | **0.66a** | **7.59a** | **1.09a** | **0.71a** |
| **potassium feldspar + Biochar** | **7.71c** | **1.17c** | **0.62b** | **7.69d** | **1.16d** | **0.70b** |
| **potassium feldspar+ Compost** | **7.63b** | **1.16b** | **0.61c** | **7.61b** | **1.15c** | **0.67d** |
| **Biochar+ Compost** | **7.64b** | **1.15b** | **0.64b** | **7.60b** | **1.14b** | **0.68c** |
| **LSD. at 0.05 Treatment** | **0.04** | **0.14** | **0.08** | **0.05** | **0.18** | **0.09** |

**NPK**

Generally, data showed Table 7 that the available N, P, and K in soil were significantly enhanced by using treatments feldspar alone or mix with other treatment biochar and compost, compared with control. The highest values of N, P and K contents in soil were 48.1, 562 and 185.0 mg/kg soil respectively, at first season and 49.1, 6. 62 and 187 mg/kg soil respectively, at second season for soil treated by feldspar + biochar + compost than other treatments. These results are in agreement with those reported by (Shimaa and Ragab, 2020) the use of natural potassium fertilizer as feldspar rock is low cost resources for providing plants with K which could alternates the expensive applied K-chemical fertilizers. Also, it can able to solubilize rock – K powder, such as feldspar through plant production and excretion of soil organic acids or chelate silicon ions to bring K into solution (Labib. et al., 2012 and Bennett et al., 1998). (Habibi et al 2011) strongly suggested that using biofertilizers plus half dose of feldspar and chemical fertilizers have resulted in the greatest yield. They revealed that 50 % of required potassium fertilizer could be replaced by bio and feldspar fertilizers, because bio and feldspar fertilizers improved the efficiency use of recommended potassium fertilizer and reduced the cost of chemical fertilizer also reduced the environment pollution from extensive application of chemical fertilizer.

**Table (7): Effect of potassium feldspar + biochar + compost on NPK of two seasons in tested soil.**

| Treatments | First season (mg $Kg^{-1}$soil) | | | Second season (mg $Kg^{-1}$soil) | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| Control | 39.20e | 4.99e | 171.00d | 45.10 | 5.09g | 166.00e |
| Potassium feldspar | 44.50d | 5.19d | 175.00c | 47.20b | 5.819e | 183.00b |
| Biochar | 45.90c | 4.61b | 179.00b | 46.90c | 6. 48c | 171.00d |
| Compost | 45.10c | 4.60b | 183.00a | 46.10c | 5. 57f | 179.00c |
| potassium feldspar+ Biochar+ Compost | 48.10a | 5.62a | 185.00a | 49.10a | 6. 62a | 187.0a |
| potassium feldspar+ Biochar | 46.90b | 5.56c | 181.00b | 47.19b | 6. 56b | 183.00b |
| potassium feldspar+ Compost | 46.10c | 5.45c | 184.10a | 46.80c | 6.55b | 185.10b |
| Biochar+ Compost | 47.10b | 5.61b | 182.00a | 47.10b | 6.12d | 183.00b |
| LSD. at 0.05 Treatment | 2.6 | 0.77 | 3.33 | 2.34 | 0.75 | 2.3 |

**NPK Contents in seeds of cowpea.**

Data presented in Table 8 that the concentration of macronutrients i.e., N, P and K in the studied seed under the effect of different treatments. Data show that the increasing of available N, P, and K concentrations in seed as significantly by using treatments mix feldspar, biochar and compost, with two seasons compared with control. The highest values of N, P and K contents in seeds were 4.90, 0.58 and 1.01 % seed at first season and 5.09, 0.678 and 1.21 (mg $plant^{-1}$) seed at second season for plant treated than other treatments. These results are in agreement with those reported by (Sarhan and Abd El-Gayed, 2016) reveal that feldspar application had a positive effect on the studied seed chemical contents from NPK on growth of cotton and its development as well as K %, chlorophyll A and/or B only by increasing the solubility of rock feldspar, consequently released available K to plants. These results are agreement with those obtained by (Shafeek et al., 2005 & Abdel-Hak et al., 2012 & Ismail et al., 2014 & Merwad, 2016). Data reveled that application of compost to sandy soil significantly increased seed contents (%) of N, P and K that result reveled by Abou Hussien et al., (2019) reported that compost application to soil increased soil content of available macro and micro nutrients as well as nutrients uptake by growing plants. Increased uptake of nutrients upon application of compost is mainly due to effect of compost on soil physical, chemical and biological properties which increase nutrients availability and finally their uptake by plants (Wardah et al., 2014 and Emam, 2018). Also, biochar for good soil fertility and nutrient use efficiency of crops it becomes imperative that addition of a fast releasing nutrient source to biochar be sought, These results are in agreement with those reported by Aruna et al., (2020) who showed biochar (4 ton/fed) was responsible improve nutrient status content in plant. Therefore, N and P availability could be expected to increase with biochar application rather than responsible improve crop growth and nutrient status.

**Table (8): Effect of potassium feldspar + biochar + compost on NPK contents in seeds of cowpea .**

| Treatments | First season (g plant$^{-1}$) | | | Second season (g plant$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| Control | 3.77f | 0.30f | 0.45e | 3.97g | 0.37g | 0.55e |
| potassium feldspar | 4.86c | 0.51c | 0.94d | 4.98c | 0.59b | 1.14b |
| Biochar | 4.89b | 0.54b | 0.96c | 4.93d | 0.54d | 1.06c |
| Compost | 4.86c | 0.52c | 0.95d | 4.91e | 0.57c | 1.07c |
| potassium feldspar+ Biochar+ Compost | 4.90a | 0.58a | 1.01a | 5.09a | 0.678a | 1.21a |
| potassium feldspar+ Biochar | 4.22d | 0.36e | 0.940d | 4.29e | 0.41e | 1.04c |
| potassium feldspar+ Compost | 4.85c | 0.52c | 0.991b | 5.05b | 0.57c | 1.011d |
| Biochar+ Compost | 4.15e | 0.34e | 0.951c | 4.25f | 0.39f | 1.03c |
| LSD. at 0.05 Treatment | 1.58 | 0.25 | 0.476 | 1.87 | 0.21 | 0.671 |



**Plant growth**

Results in Tables 9 & 10, revealed that there are significant effect by the using treatments mix feldspar, biochar and compost on all studied traits of plant growth in both seasons compared with control. The maximum values of plant length (cm), number of leaves, number of branches/plant was 305.00 and 278.80 cm, 84.67 and 82.00, 5.33 and 5.67 respectively, also pod length cm, pod diameter, cm Pod fresh weight g was 23.83 and 24.23, 0.82 and 0.85, 13.23 and 12.33 in the first and second seasons. In the tables (11 & 12) the same trend, pod dry weight, plant fresh weight (g/fed), Plant dry weight (g /fed), Carbohydrates g/100 g D.W. was 422.14 (g/fed), 114.90 (g/fed) in the first and second season were achieved with mix feldspar, biochar and compost, application than other treatments at first and second seasons. These results are agreement with the application of biochar helps in improving of soil physiochemical properties, which leads in the increase of grain yield (Muhammad, et al., 2021) and sufficient amount of soil nitrogen availability lead to increase in plant growth and yield (Farooq et al. 2019) and also the increase of 43–68 % in grain yield is due to nitrogen application (Farooq et al. 2020 a, b). Also, the addition of compost stimulates plant root growth and increases root system that makes a plant more drought resistant due to its ability to absorb more water from the 17 soil. The increased root system also helps the plant to increase its nutrient uptake. Leaching is reduced drastically because of increased water and nutrient retention capacities of the soil as a result of increased organic matter provided by the compost (Graves and Hattemer, 2000). Compost improve soil fertility and plant water availability to plant. (Curtis and Claassen, 2005 & Farrell and Jones, 2009). (Labib et al., 2012) reported that the positive influence of the fine grains of the K mineral bearing rocks is improving the poor structure of loose sandy soil, consequently the water and nutrient capacities of this soil will be enhanced and increase their ability to cowpea plant uptake. Sugumaran (2007) pointed to the feldspar bearing rocks are quite resistant to weathering and supply relatively small quantities of K during given growing season. In the meantime their cumulative release of K over several years is of some importance. This release is enhanced by the solvent action of carbonate and organic acids.

The correlation analysis revealed that plant length, number of leaves, effective nodule, and chlorophyll content had positive correlation to growth and yield production in cowpea. This is an indication that the taller the plant the more likely it is to have more leaves and greater the opportunity for more chlorophyll content in leaves and the greater the chance for photosynthesis to occur leading to vegetative growth. This agrees with report by (Brhgth, 2017) that tall plants are likely to have more green areas for more photosynthetic activities that facilitate increase in growth and grain yield of crops.

**Table (9): Effect of potassium feldspar + biochar + compost on plant length, No. of leaves and No. of branches/plant in cowpea plant.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | Plant length (cm) | Number of leaves | No. of branches / plant | Plant length (cm) | Number of leaves | No. of branches / plant |
| Control | 144.30 f | 42.67 e | 3.67 bc | 127.00 f | 49.33 g | 3.33 b |
| potassium feldspar | 199.90 e | 52.33 de | 3.33 c | 185.78 e | 61.67 e | 3.67 b |
| Biochar | 224.70 d | 56.33 cd | 4.33 abc | 214.43 d | 56.00 f | 4.00 b |
| Compost | 191.87 e | 71.33 b | 3.33 c | 180.18 e | 52.00 g | 3.33 b |
| potassium feldspar+ Biochar+ Compost | 305.00 a | 84.67 a | 5.00 ab | 278.80 a | 82.00 a | 5.67 a |
| potassium feldspar+ Biochar | 265.93 b | 72.00 b | 5.33 a | 258.43 b | 74.33 b | 4.33 b |
| potassium feldspar+ Compost | 259.77 b | 66.00 bc | 4.33 abc | 249.43 b | 70.00 c | 4.00 b |
| Biochar+ Compost | 250.23 c | 59.00bcd | 4.00 abc | 237.17 c | 65.33 d | 3.67 b |
| LSD. at 0.05 | 9.52 | 12.28 | 1.223 | 9.63 | 3.43 | 1.059 |

**Table (10): Effect of potassium feldspar + biochar + compost on pod length, Pod diameter and Pod fresh weight in cowpea plant.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | Pod length cm | Pod diameter cm | Pod fresh weight g | Pod length cm | Pod diameter cm | Pod fresh weight g |
| Control | 18.17 f | 0.58 d | 8.35 f | 17.70 f | 0.60 g | 7.85 g |
| potassium feldspar | 20.67 e | 0.70 c | 9.84 e | 20.10 d | 0.69 e | 8.85 e |
| Biochar | 21.40 d | 0.72 c | 10.69 d | 20.53 d | 0.72 d | 9.19 d |
| Compost | 20.23 e | 0.57 d | 8.89 f | 19.03 e | 0.65 f | 8.45 f |
| potassium feldspar+ Biochar+ Compost | 23.83 a | 0.82 a | 13.23 a | 24.23 a | 0.85 a | 12.33 a |
| potassium feldspar+ Biochar | 22.93 b | 0.80 a | 12.53 b | 23.30 b | 0.82 b | 12.08 a |
| potassium feldspar+ Compost | 22.63 bc | 0.77 ab | 11.85 c | 22.87 b | 0.78 c | 11.53 b |
| Biochar+ Compost | 22.13 c | 0.74 bc | 11.35 c | 21.77 c | 0.73 d | 10.32 c |
| LSD. at 0.05 | 0.59 | 0.046 | 0.58 | 0.92 | 0.028 | 0.32 |

**Table (11): Effect of potassium feldspar + biochar + compost on pod dry weight, plant fresh weight and plant dry weight in cowpea plant.**

| Treatments | First season | | | Second season | | |
|---|---|---|---|---|---|---|
| | Plant fresh weight g | Pod dry weight g | Plant dry weight g | Plant fresh weight g | Pod dry weight g | Plant dry weight g |
| Control | 358.74 h | 2.60 f | 92.50 f | 353.28 h | 2.64 e | 98.53 g |
| potassium feldspar | 372.75 f | 3.36 d | 98.07 e | 369.03 f | 3.20 d | 106.48 e |
| Biochar | 378.17 e | 3.59 d | 102.59 d | 377.91 e | 3.14 d | 109.22 d |
| Compost | 366.05 g | 3.07 e | 95.29 ef | 360.32 g | 3.04 d | 102.49 f |
| potassium feldspar+ Biochar+ Compost | 421.90 a | 5.07 a | 118.78 a | 441.25 a | 4.59 a | 121.33 a |
| potassium feldspar + Biochar | 397.46 b | 4.52 b | 111.76 b | 412.54 b | 4.22 b | 116.83 b |
| potassium feldspar + Compost | 390.28 c | 4.14 c | 106.32 c | 401.91 c | 4.14 b | 112.22 c |
| Biochar+ Compost | Plant fresh weight g | 3.96 c | 104.08 cd | 392.34 d | 3.78 c | 108.68 d |
| LSD. at 0.05 | 358.74 h | 0.27 | 2.93 | 6.53 | 0.15 | 1.74 |

**Table (12): Effect of potassium feldspar + biochar + compost on carbohydrates and chlorophyll contents of cowpea plant in two seasons.**

| Treatments | First season | | Second season | |
|---|---|---|---|---|
| | Carbohydrates g/100 g D.W. | Chlorophyll A mg/100g F.W. | Carbohydrates g/100 g D.W. | Chlorophyll A mg/100g F.W. |
| Control | 59.81 e | 16.27 h | 59.99 g | 13.10 e |
| potassium feldspar | 60.39 d | 18.60 f | 61.38 e | 14.75 d |
| Biochar | 60.89 c | 21.62 e | 61.92 de | 16.15 c |
| Compost | 58.06 f | 17.73 g | 60.74 f | 13.86 de |
| potassium feldspar+ Biochar+ Compost | 63.23 a | 26.07 a | 64.80 a | 20.86 a |
| potassium feldspar+ Biochar | 62.89 a | 24.68 b | 63.59 b | 19.97 a |
| potassium feldspar+ Compost | 61.80 b | 23.73 c | 62.69 c | 18.55 b |
| Biochar+ Compost | 61.27 c | 22.68 d | 62.01 d | 16.88 c |
| LSD. at 0.05 | 0.447 | 0.77 | 0.579 | 1.00 |

**Table (13): Effect of potassium feldspar + biochar + compost on chlorophyll b and carotenoids contents in leaves of cowpea plant in two seasons.**

| Treatments | First season | | Second season | |
|---|---|---|---|---|
| | Chlorophyll B mg/100g F.W. | Carotenoids mg/100g F.W. | Chlorophyll B mg/100g F.W. | Carotenoids mg/100g F.W. |
| Control | 9.16 h | 3.59 g | 5.57 f | 3.59 g |
| potassium feldspar | 11.29 f | 5.04 ef | 6.52 de | 5.04 ef |
| Biochar | 12.09 e | 5.45 de | 6.95 cd | 5.45 de |
| Compost | 10.43 g | 4.50 f | 7.42 c | 4.50 f |
| potassium feldspar+ Biochar+ Compost | 16.13 a | 8.45 a | 9.89 a | 8.45 a |
| potassium feldspar+ Biochar | 14.83 b | 7.28 b | 9.38 a | 7.28 b |
| potassium feldspar+ Compost | 14.05 c | 6.55 c | 8.44 b | 6.55 c |
| Biochar+ Compost | 12.903 d | 5.96 cd | 7.42 c | 5.96 cd |
| LSD. at 0.05 | 0.67 | 0.70 | 0.52 | 0.35 |

**CONCLUSION**: Based on the above discussion, it can be concluded that we can achieve increasing soil water and nutrient retention of low fertility soil by applying organic amendments like biochar, compost and potassium feldspar. Moreover, biochar, compost and potassium feldspar as slow-release fertilizers improved soil's physical and chemical properties and enhanced plant growth and yield parameters of cowpea crop. Concerning the application method, the mixed application of two organic amendments and one inorganic, especially at mix treatment together superiority in soil properties and yield productivity as compared with sole application of biochar alone or compost alone or potassium feldspar. The beneficial effect of biochar compost and potassium feldspar mix could be due to the organic acids released from the mixture, which positively reflected the availability of nutrients and their concentration in different plant parts of cowpea plants.

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