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The Effect of Organic and Inorganic Sulphur Fertilizers on Growth, Pigments and Carbohydrates of Broccoli (*Brassica Oleracea* L. Varitalica) Plants

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Abstract

The research was undertaken to study the effect of application of different types of organic and inorganic sulfur fertilizers on broccoli. There were three treatments in total consisting of inorganic, organic fertilizers and industrial waste water(WW) .The organic treatment included compost tea(CT) , chicken manure(CKM) and K2SO4 applied with three different concentrations (2.5 , 12 and 50 mg/pot) as well as blank control. Using different types of soil (100 %clay, 1:2, 1:4 clay : sand and 100 % sand) .The use of both organic and inorganic fertilizers and irrigation with industrial waste water led to an increase in height, fresh and dry weights and thickness of stem, number of leaves per plant, also have led to an increase in length , fresh and dry weights of the root system compared with untreated samples (control). The use of WW recorded the highest responses than the other treatments with a special regards at 1:4 soil type .The addition of various fertilizers led to a significant increase in photosynthetic pigments compared to untreated samples. The addition of various fertilizers led to significant changes in carbohydrate content in both shoot and root of treated plants. It has been found that these changes depend on the type of fertilizers and the stage of plant growth.
Keywords: Sulphur; Fertilizers; Growth; Pigments; Carbohydrates; Broccoli.

1. Introduction

Broccoli (*Brassica oleracea* L.var. italica) belongs to family Brassicaceae. It is a fast growing crop and requires high nitrogen input. It is one of the most important crops as it is highly nutritious vegetable with abundant vitamins and minerals such as vitamin A and C, carotenoids, fiber, calcium, and folic acid [1, 2]. Broccoli and other brassica vegetables have high content of glucosinolates [3] which has cancer-fighting properties. Broccoli buds are rich source of minerals especially K, S, P, Mg and micro-elements [4]. Broccoli has become a plant of major agro economic importance known as one of main sources of natural antioxidants as phenolic compounds, and vitamins Finley [5] and Shukry, *et al.* [6]. The diverse variety of organic compounds in vegetables represents the product of primary and secondary plant metabolism [7]**.** Primary metabolites such as carbohydrates and amino acids are involved in growth and development, respiration, photosynthesis, hormone and protein synthesis [8]. Primary metabolites are found in all species within broad phylogenetic groups, and are produced using the same biochemical pathways. Secondary metabolites such as flavonoids, carotenoids, phenolic acids, and glucosinolates among other defects determine the color of vegetables [9]. Carbohydrates in vegetables found as monosaccharides, disaccharides, sugar alcohols, oligosaccharides and polysaccharides. Monosaccharides attached to protein and lipid molecules (glycoproteins and glycolipids) are shared in cell signaling [10]. Suitability of growing broccoli under Egyptian conditions, compared with other vegetables, may be ascribed to its tolerance to harsh environmental influences frequently prevailing in such newly reclaimed soil such as lack of water, salinity and drought [11].

The lack of water is the major restricting factor to cultivation of most crops in arid and semi arid regions. Water deficit occurs whenever the loss of water in transpiration exceeds the rate of absorption. It is characterized by the reduction in water content accompanied with the loss of turgor, closure of stomata and inhibits growth and photosynthesis process [12, 13]. There is critical need to balance water availability, water requirements and water consumption thus water conserving is becoming a decisive consideration for agriculture, particularly in arid and semi-arid regions where water is the main limiting factor for plant growth.

Limitation of water sources has attracted attention of researchers to proper use of unconventional water sources such as brine water and urban and industrial effluents. Due to urban development and increase in water consumption,

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a large volume of water is produced from raw waste water and treated effluents [14]. Under these conditions, usage of low quality water sources is being considered. On the other hand, the urbanized areas produced huge amounts of waste water, the inappropriate disposal of which poses environmental problems to the surrounding areas.

The entire world suffers from food shortage problem as a result of a huge increment of population and the huge loss of agricultural soils due to desertification and erosion problems. Therefore, it is very essential to increase crop productivity by improving the crop ability to mitigate environmental stress conditions including low water availability, soil salinity and nutrients deprivation.

Many agricultural soils of the world are deficient in one or more of the necessary nutrients required for supporting healthy plants. The increase of agricultural food production worldwide over the past four decades has been associated with a remarkable increase in the use of fertilizers [15]. Fertilization is the most important and controllable factor affecting the nutritional value of vegetables. The type and value of fertilizer and the level of application directly influence the level of nutrients available to plants and indirectly influence plant physiology and the biosynthesis of secondary compounds in plants.

Sulfur is an essential element in determining the productivity and quality of agricultural products. It is also an element associated with tolerance to biotic and abiotic stress in plants. In agricultural practice, sulfur has broad use in the form of sulfate fertilizers and, to a lesser extent, as sulfite biostimulants. When used in the form of bulk elemental sulfur, or micro- or nano-sulfur, applied both to the soil and to the canopy, the element undergoes a series of changes in its oxidation state, produced by various intermediaries that apparently act as bio stimulants and promoters of stress tolerance [16]**.** Sulphur is an essential element for plant; it is present in major metabolic compounds such as amino acids, glutathione, proteins, and sulpho-lipids. Therefore, broccoli is particularly sensitive to S deficiency or limitation, which reduces yield. As S is immobile in plants, its deficiency can occur any time during the growing season and severely reduce seed yield, particularly on soil well fertilized with N [17]**.**

The target of this work is to increase the efficiency of growth and some physiological aspects of broccoli (*Brassica oleracea* L. var. italica) plants grown in soil contained different ratios from clay and sand treated with different sulfur organic and inorganic fertilizers as well as using industrial wastewater for irrigation.

2. Materials and Methods

2.1. Plant used and Growth Condition

This investigation was conducted at the green house of Faculty of Science, Mansoura University, Mansoura governorate, Egypt during the winter season (2013- 2014).Pure strain of broccoli (*Brassica oleracea* L. varitalica) seeds was kindly supplied by the agriculture research center, Ministry of agriculture, Giza, Egypt. Seed beds were well prepared watered early in the morning with sprinkler till germination and seedling development. After 45 days, uniform plants were transplanted into plastic pots (35 cm in diameter) arranged in green house and filled with different types of soil. Each pot contains 10 Kg soil as bfollow: a- 100% clay soil, b- 1:2, c- 1:4 (clay: sand) (v/v) soil , d - 100 % sand soil.

The area of the experimental plot was 25 m^2 consisted of many rows, each row consist of 5 pots. The plant distance was 50 cm a part on one side; pots were directly irrigated by normal irrigation system. The following treatment was used as a source of Sulphur fertilization. Industrial waste water as an effluents from El Delta Company for fertilizers of chemical industries (ASMEDA) at the distance of 1.100 Kilometer far away the Factory in Talkha region from El-Dakhlia governorate (19.8 mg sulphate / L) according to Galilah [18] for irrigation. Inorganic fertilizers K_2SO_4 (5, 12.5 and 50 mg/pot) according to Christa, *et al.* [19]**.** Animal organic fertilizers **as** chicken manure **(** CKM) was used at concentration (52.3 gm/10 Kg soil) according to Ouda and Mahadeen [20] and plant organic manure composite tea (CT) at concentration (1 tea: 3 H_2O) according to Hegazi and Algharib [21] and Control (without treatment). Throughout the growth of plants, sampling was carried out at the three different stages of plant growth first, (14 days old), second (63 days old), third (98 days old) from the transplanting date. At the time of sampling, the plant samples were collected from each pot for measurements of major growth parameters (plant height, number of leaves per plant, as well as fresh and dry weight of both shoots and roots) were determined. Moreover the differently treated plants subjected to certain chemical analysis.

2.2. Biochemical Analysis

2.2.1. Estimation of Photosynthetic Pigments

The plant photosynthetic pigment (chlorophyll a, chlorophyll b and carotenoids) were determined at different stages of plant growth using the spectrophotometric method as recommended by Arnon [22] for chlorophylls Horvath, *et al.* [23] for carotenoids and adopted by El-Shahaby, *et al.* [24].

2.2.2. Estimation of Carbohydrates

The method of extraction of different carbohydrate fractions used in this investigation was patterned after those adopted by Yemm and Willis [25]. Total soluble carbohydrates were extracted by overnight submersion of dry tissue in 10 ml of 80% (v/v) ethanol at 25°C with periodic shaking according to the method described by Homme, *et al.* [26].TSS were analyzed by reacting of 0.1 ml of ethanolic extract with 3.0 ml freshly prepared anthirone (150 mg anthrone + 100 ml 72% H_2SO_4) in boiling water bath for ten minutes and reading the cooled samples at 625 nm using Spekol Spectro cololourimeterVEB Carl Zeiss [25]. To determine total carbohydrates, plant tissue (100 mg) was boiled in water bath for three hours with addition of 5 ml of HCl (2.5 N) then cooling and neutralization with Na_2CO_3. Total carbohydrates were analyzed by reacting 1 ml of extract with 4 ml of freshly prepared anthrone in a boiling water bath for 8 minutes and reading the cooled samples at 630 nm using spectrophotometer .The content of polysaccharides was calculated from the difference between total sugar and total soluble sugar.

2.3. Statistical Analysis

The data were statistically analyzed on complete randomized design system according to Snedecor and Cochran [27]. Combined analysis of the two growing seasons was carried out. Means were compared by using least significant difference (LSD) at 5% levels of probability.

3. Results and Discussion

3.1. Effect of Sulfur Treatments on Growth Criteria of Broccoli Plants

Sulfur is considered as a vital element for plant growth because it is present in major metabolic compounds such as amino acids (methionine and cysteine), proteins, and sulfo-lipids. Plants belongs to brassicacea are particularly sensitive to S deficiency or limitation, which reduces growth and in consequences seed quality and yield by 40% [28]. The results in figures 1-4 (a, b) demonstrated the effect of different sulfur treatments either organic (chicken manure; CKM and composite tea; CT) or inorganic fertilizer (K_2SO_4; 2.5, 12 and 50 mg/pot) as well as the waste water irrigation on different growth parameters during different stages of broccoli grown in different types of soils (100 % clay, 1: 2, 1: 4 clay: sand v/v and 100% sand). Data show that all growth criteria (plant height, fresh and dry weight, water content of shoot and root, stem diameter and number of leaves) in addition to relative growth rate (RGR) of broccoli plants were affected in different manner. There is a significant difference in the rate of growth and development of the plant as a result of using dissimilar forms of fertilizers throughout the experimental stages of plant growth and development.

It was obvious that, waste water and different organic fertilizers induced a significant increase in different root parameters except in treatment with CT in root length of plants grown in 100% clay, where a non- significant change was obtained and root dry weight in 1: 4 (clay: sand v/v) soil, where a significant increase was obtained during the first stage. On the other hand, treatment with different concentrations (2.5, 12 and 50 mg/pot) of inorganic fertilizer (K_2SO_4) enhanced a gradual decrease either significant or non-significant during the three stages of growth as shown in figures 1-4 $_{(a).}$

Waste water effluent from factory was collected to investigate its effect on broccoli growth and development. It seems that there are some essential organic and inorganic compounds in waste water which may partially alleviate its negative impacts [29]. According to Panaskar and Pawar [30] polluted water at low concentration enhances the seedling growth and plant development.

It was clear that plants irrigate with factory effluents were found to contain high concentrations of sodium and magnesium than the recommended maximum limit. My obtained results confirm the findings of Charfi, *et al.* [31] who recorded that leaf area as well as weights of fruit and pulp of olive trees irrigated with effluent was higher than those of the control. The greater growth of the olive trees obtained by effluent application may be due to the sufficient availability of essential nutrients in the effluent which might have enhanced growth parameters and did not reach a point causing a decrease in the diffusion pressure gradient between the plant and the medium or ion toxicity and ion imbalance or a combination of any of these adverse effects [32].

The higher values of different root parameters (see figures 1-4 (a, b) were achieved in treatment with organic fertilizer and waste water. Using CKM as fertilizer achieved a higher value of all the studied root parameters than that of CT treatment. Organic manure plays a direct effect in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improves physical and chemical properties of soils [33]. Organic fertilizers has an important influence on slow release of nutrients which support root development leading to higher yield and better quality of broccoli plants [34, 35].

The data herein demonstrated that organic and inorganic fertilizer and irrigation with waste water showed a significant increase in the most shoot parameters. Also, a non- significant change was observed in case of using sandy soil in shoot length and stem diameter during first and second stage, respectively. In addition a non-significant change in treatment with CKM for the number of leaves in (1: 2 clay: sand v/v) soil during the first stage. Wali and Iqbal [36], found that the number of leaves per plant increased with plant age compared with the control. In this respect, in terms of plant growth and soil health, CKM plays an important role in improving soil texture, aeration, soil compaction and thus enhances more water and nutrients uptake by plants from their surrounding areas of root zone [37]. Plant growth and development are strictly dependent on biological fertility factors, more available nutrients and microbial metabolites which released into the soil [38], also, a substantial increase in plant growth and biomass production upon recycled effluent application on several species [39, 40].

The water content (W.C) of both shoot and root follow a different trend of significant increase or decrease (figures (1-4 $_{(c)}$). In this concept, Tuna, *et al.* [41], stated that, water content in leaves is known as an alternative measure of plant water status, reflecting the metabolic activity in tissue. Decrease in water content indicated a loss in turgor that resulted in limited water availability for the cell extension process in plants [41].

The present observed results in figures (1-4 $_{(c)}$) indicated that, RGR recorded higher values in response to treatment with organic fertilizers than in treatment with waste water and inorganic fertilizers. Decrease in RGR of plants during the growth season is due to the increase of structural tissue in comparison with photosynthetic tissues. Sarvari [42], stated that, the application of 80 Kg/ha potassium caused higher growth rate than control treatment in soybean.

The data listed in figures (1-4 $_{(c)}$) indicated that, application of different sulfur sources can improve the sandy soils (1: 4 and 1: 2 clay: sand v/v soil) physical properities and achieved the best results in growth criteria of broccoli compared with inorganic fertilizer. Such observation on amaranth was also obtained by Akanb and Togun [43]. Their results showed that cover area plants increased significantly in response to chicken manure as compared with other treatments and the treatments of the common fertilization program; These results was also in conformity with those obtained by Vimala, *et al.* [44] and Al-Balikh [45]. Organic inputs have a number of effects on nutrients availability and on the amelioration of sandy soil characters. They add new organic matter to the soil and contribute to the maintenance of physical fertility, and result in better soil moisture status. Two main functions of organic manures in soils are the supply of nutrients and increase in the organic matter content of soils. The significance of organic based fertilizers as suppliers of nutrients to plant growth is determined by the rate of nutrient release; the higher the rate of nutrient release the less the soil organic matter [46]. The slow or gradual release of nutrients by organic fertilizers is called the additive effect of organic fertilizers. This is in contrast to inorganic fertilizers that release nutrients rapidly and may fit the plant demand during the crop growth. The organic materials have relatively high pH compared with the soils, hence may raise the pH which increase the availability of most nutrients [47].

Carbon added into the soil in response to organic materials provides substrate for microbial growth as well as microbial activity. The turnover resulting from the decomposition of organic materials improves the nutrient cycling and availability to the plants especially, N and P which improved root development as well as vegetative growth. The same observation was reported by Vanlauwe, *et al.* [48] who found that, microbial pool sizes and activity can be increased by application of organic doses, C and N mineralization rates and enzyme activities; all these affect nutrient cycling.

3.2. Effect of Sulfur Treatments on Chlorophyll Content of Broccoli Plants

Increasing the efficiency of photosynthesis has long been a goal of plant research. Chlorophyll content is well-known as a measurement of plants physiological activities and an index of growth of plant as well as production of organic matter [49] and is important in evaluating chemical and fertilizer application [50]. Generally, in higher plants the main group of photosynthetic pigments is Chlorophylls (a and b), carotenoids and xanthophyll. Chlorophyll *a* is the main photosynthetic pigment and chlorophyll b known as an accessory pigment in plants. Healthy plants with large amount of chlorophyll are expected to have maximum growth Campbell and Reece [51]. In this connection, of most particular importance is chlorophyll a as it plays the primary role in photosynthesis of the higher plants [52]. They also stated that, chlorophyll a appeared to function as photo enzymes; while the other pigments seemed to serve only as physical energy suppliers and so they often called accessory pigments. The chlorophylls are the most active pigments in photosynthesis. The content of chlorophyll a in green plants is twice as that as of chlorophyll b [53]. Leaf chlorophyll content varies within wide limits from (0.05 to 0.30 % of fresh matter). Daughtry, *et al.* [54], demonstrated a positive correlation between leaf photosynthesis rate and chlorophyll content.

The results in figures5 $_{(a\text{-}df)}$ illustrated the effect of different sources of sulfur fertilizer application, throughout the different stages of broccoli growth and development, on photosynthetic pigments (chlorophyll a, chlorophyll b, carotenoids, total chlorophyll and consequently total pigments). Concerning Chl. a, all treatments in different used soils achieved a significant increase except in treatment with a moderate and high concentration of K_2SO_4 at second stage in 1:2 clay: sand v/v soil; the higher concentration of K_2SO_4 of 100% clay at third stage ; CT at second stage in 1:4 clay : sand v/v soil, where a non- significant changes were obtained. The increment in the content of Chl. a was achieved in response to waste water treatment in 1: 4 clay: sand v/v soil than organic fertilizer (CKM > CT).

The observed progressive increases in pigment contents (chl a, chl b, carotenoids and total pigments) of broccoli plant in response to treatment with different sources of sulfur fertilization in good support to the growth rate (Fig. 1-4 $_{(a\text{-}d)}$) as well as to the change in carbohydrate content (Fig. 6 $_{(a\text{-}d)}$). As S is an essential constituent of certain amino acids and proteins, S deficiency results in the inhibition of protein and chlorophyll synthesis [55]. Sulfur plays a role indirectly in the chlorophyll synthesis by enhancing the uptake of N, Fe, Mg and SO_4 [56]. In this respect, sulfur is critical for many physiological functions, including photosynthesis. Sulfur deficiency may negatively affect chloroplast formation and it may eventually leads to chloroplast degradation [57].

The same trend of significant increase in Chl. a was observed in Chl. b and carotenoids as observed in figures $5_{(a\text{-}d)}$ in which all treatments achieved a significant increase in all used soils with some exceptions in K_2SO_4 treatments at different stages and different soils under investigation. Regarding the total content of Chl .a and Chl. b in addition to total pigment content, the waste water treatment achieved the higher content in the used different soils at third stage of experimental period.

Karanatsidis and Berova [58], studied the effect of organic fertilizers on the content of chlorophyll pigments and rate of photosynthesis. They stated that, the application of organic fertilizers can not only enhances the synthesis and amount of chlorophylls but also increases the rate of photosynthesis. Lowest dose of inorganic fertilizer induced the highest leaf chlorophyll content, compared with control. These results agreed with the previous findings obtained on other vegetable crops by Al-Tarawneh [59]. For Chl. a/ Chl. b ratio, the higher values were induced in response to CT treatment in 1:2 (clay: sand v/v) soil and the waste water treatment in 1:4 (clay: sand v/v) soil in addition to application of inorganic fertilizers in other used soils. Abdelrazzag [60], reported that the ratio between chlorophyll a and chlorophyll b in some medicinal plants of Lamiaceae family is rarely 3:1, as stated in classical literature but rather close to 3:2 and more, which makes these species even more medicinal and gives them higher potential anti-oxidant capacity [61].

3.3. Effect of Sulfur Treatment on Carbohydrate Contents of Broccoli Plants

The data herein obtained in figures $6_{(a\text{-}f)}$ clearly demonstrated that , different sulfur treatments resulted in a general significant increase in total carbohydrates (TC), total soluble sugars (TSS) and polysaccharides of shoot and root of broccoli plant growth in different used soils comparing with the control through the three stages of growth. Rosa, *et al.* [62], stated that, the type and concentration of free sugars influence the flavor of Brassica products due to sulfur fertilization. Application of organic fertilizers either CT or CKM or using of waste water in irrigation was achieved the high carbohydrate contents (TC, TSS and polysaccarides) whereas upon using inorganic fertilizer (K_2SO_4), the carbohydrate content was decreased with increasing the concentration. Similar results were obtained by Chinthapalli, *et al.* [63], who demonstrated that, the higher sugar content of bean seedlings was observed at the application of organic fertilizer (cow dung) over the inorganic fertilizers and control. A similar observation was also reported by Vijayakumari, *et al.* [64]**,** from a study on the effect of few eco-friendly manures on the growth and carbohydrate content of carrot. It has been reported that the increase in chlorophyll content was also linked to the increase in total carbohydrate in plant tissues [65]; the same theme was achieved in the present study. Similar correlations also showed in the study of the effect of sulfur on quality parameters and carbohydrates content of spring wheat [65]. The presence or absence of chlorophyll in plant greatly affects the production of secondary metabolites viz., proteins, glycosides, tannins, carotenoids etc. and other essential plant constituents like carbohydrates [63]**.** On the other hand, increased carbohydrates content in growing parts of plant reflects the metabolic regulation associated with enhanced enzyme activity which helps plant to stand environmental conditions and to promote their growth [66]**.**

In the present study, the results in figures $6_{(a-d)}$ show that, the most pronounced values were achieved in soil 1: 4 (clay: sand v/v) comparing with the other used soils. The highest values of TSS were recorded in the used soil 1: 4 (clay : sand v/v) which reveal that , the plants grown in soils with high sand content were exposed to water leaching stress and low water holding capacity. Accumulation of high soluble sugar levels have also been demonstrated in shoots of different plant species under stress conditions [67]. Increased levels of soluble sugars in stressed plants may help in up keeping of cell turgidity and cellular membrane stabilization [68]. This increase of soluble sugars is a response of plants to water leaching stress has been widely reported despite the decrease in net CO_2 assimilation rate [69]**.** In addition soluble sugars may act as ROS (Reactive Oxygen Species) scavengers so improve membrane stabilization [70]**.**

4. Conclusion

From the results obtained it can be concluded that broccoli plant (*Brassica oleracea* L. var. italica) give the best growth when cultivated in the soil which supplemented with organic fertilizers compared with inorganic fertilizers, and with chicken manure than with the compost tea. Also, broccoli can be cultivated in different types of soil irrigated with industrial waste water, where the vigorous growth was obtained in this treatment comparing with the other treatments and with the control. For broccoli plant (*Brassica olereaca* L. var. italica) in general , the best quality of metabolic changes were obtained when *Brassica oleracea* was cultivated in 1:4 (clay:sand v/v) soil and supplemented with industrial waste water in the irrigation than the other treatments.

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Fig-1. (a): Effect of organic and inorganic fertilizer on growth parameters of *Brassica oleracea* cultivated in (100 % clay) soil, where C: control, W.W: waste water, CT: compost tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non- significant change at 5% level.

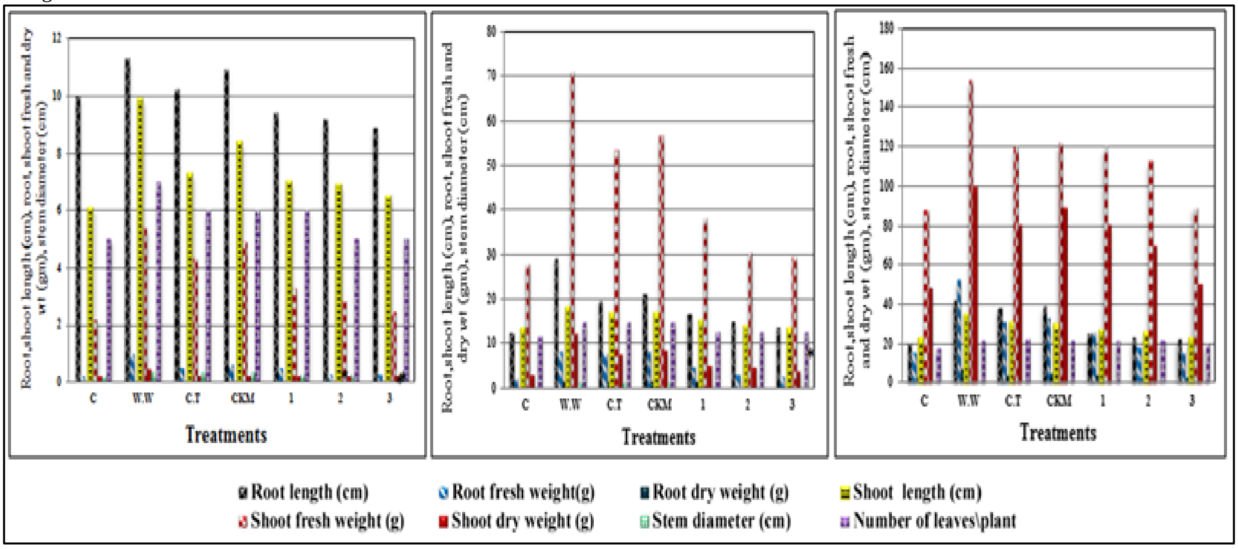

Fig-2. (a): Effect of organic and inorganic fertilizer on growth parameters of *Brassica oleracea* grown in (1:2) (clay: sand v/v) soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non-significant change at 5%.

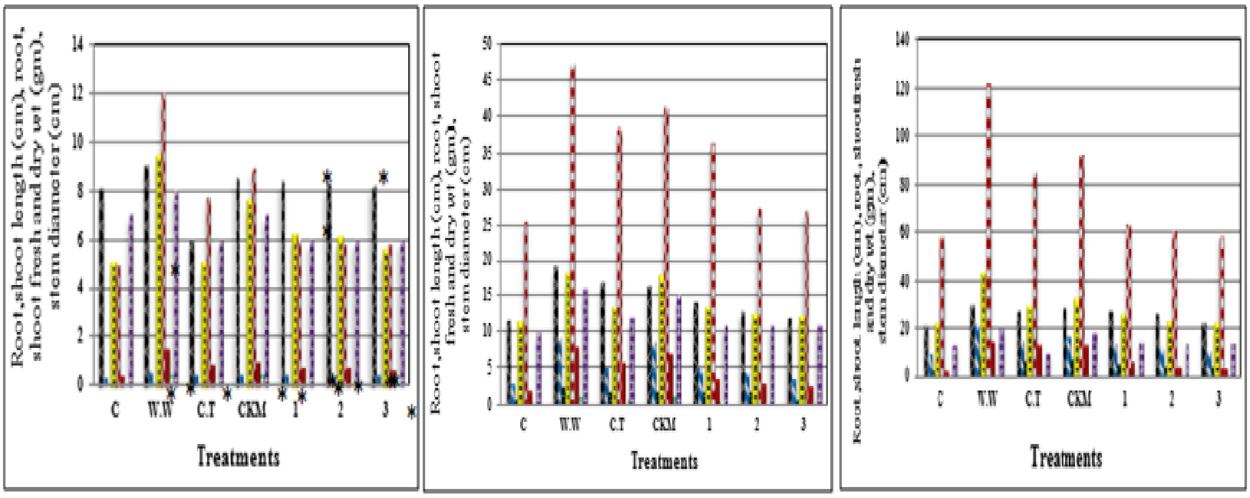

Fig-3. (a): Effect of organic and inorganic fertilizer on growth parameters of *Brassica oleracea* grown in (1:4) (clay: sand v/v) soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non-significant change at 5%.

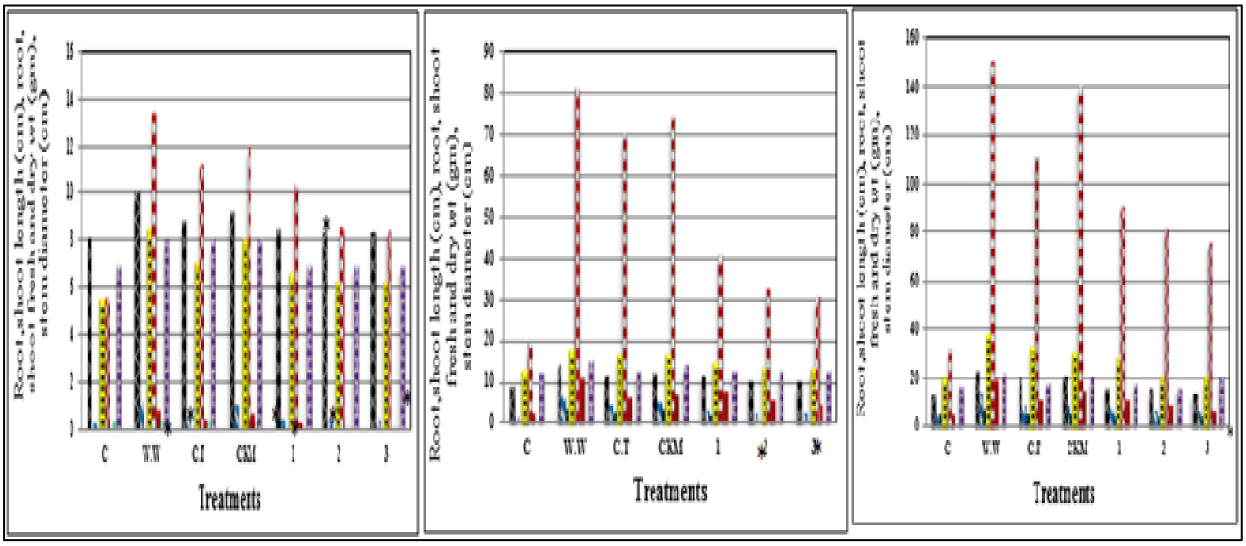

Fig-4. (a): Effect of organic and inorganic fertilizer on growth parameters of *Brassica oleracea* grown in (100 % sand) soil, where C: control, W.W: waste water, CT: compost tea,CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non- significant change at 5%

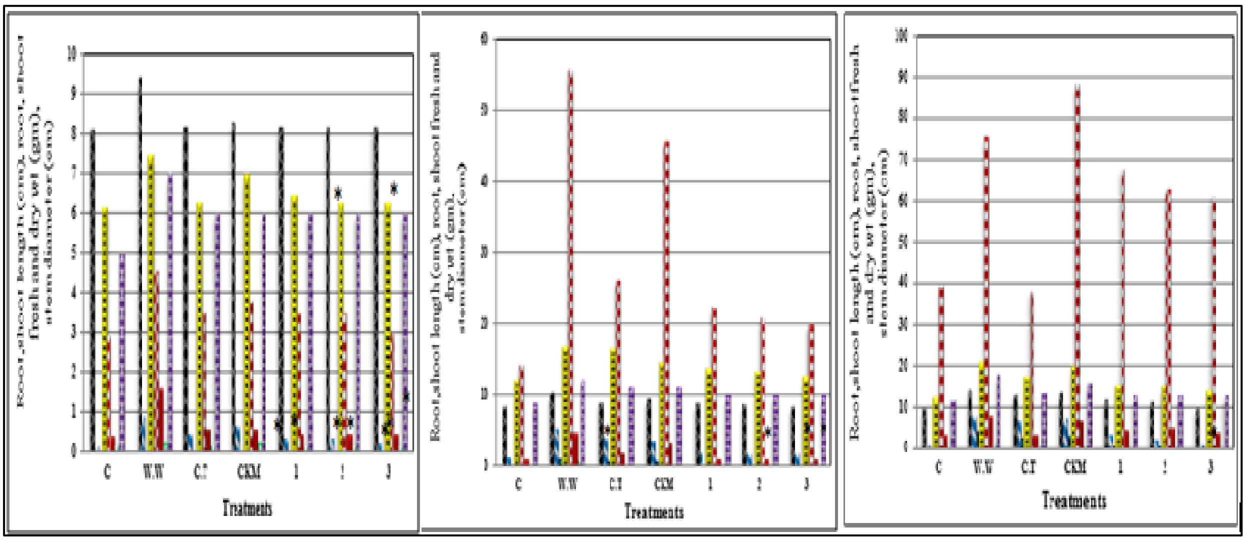

Fig-1(b). Effect of organic and inorganic fertilizer on water content of shoot and root (g) of *Brassica oleracea* grown in (100 % clay) soil, where C: control, W.W: waste water, CT: compost tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non-significant change at 5% level

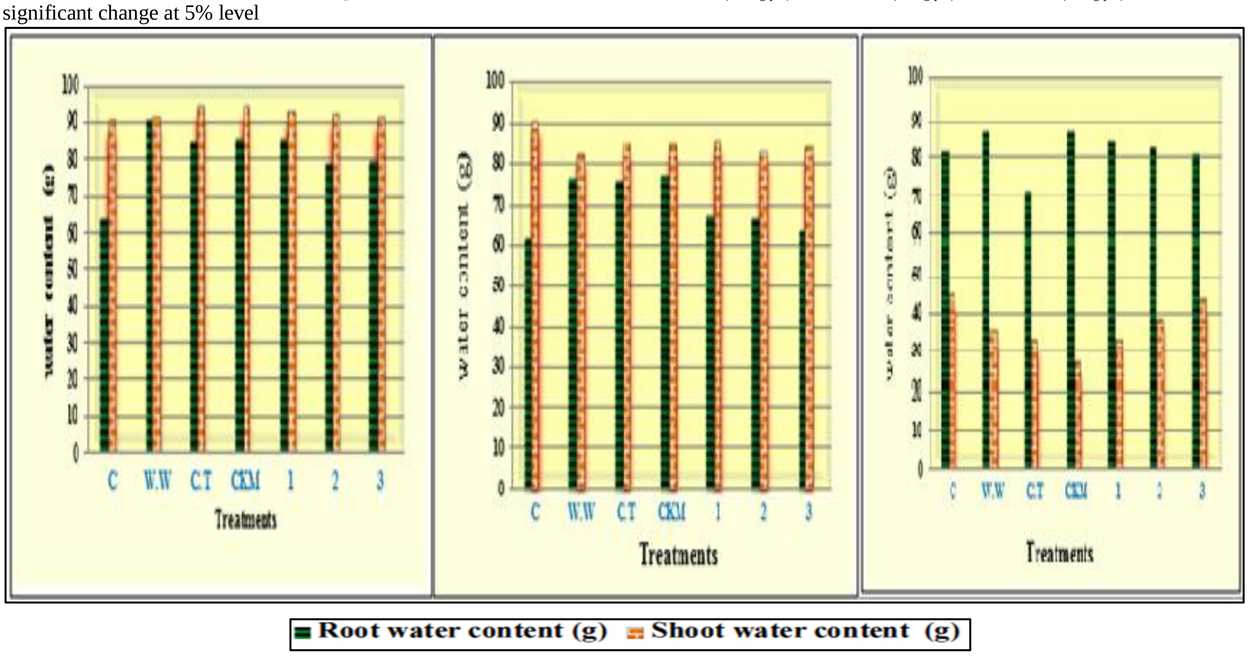

Fig-2. (b): Effect of organic and inorganic fertilizer on water content of shoot and root (g) of *Brassica oleracea* grown in (1:2) (clay: sand v/v) soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non- significant change at 5%

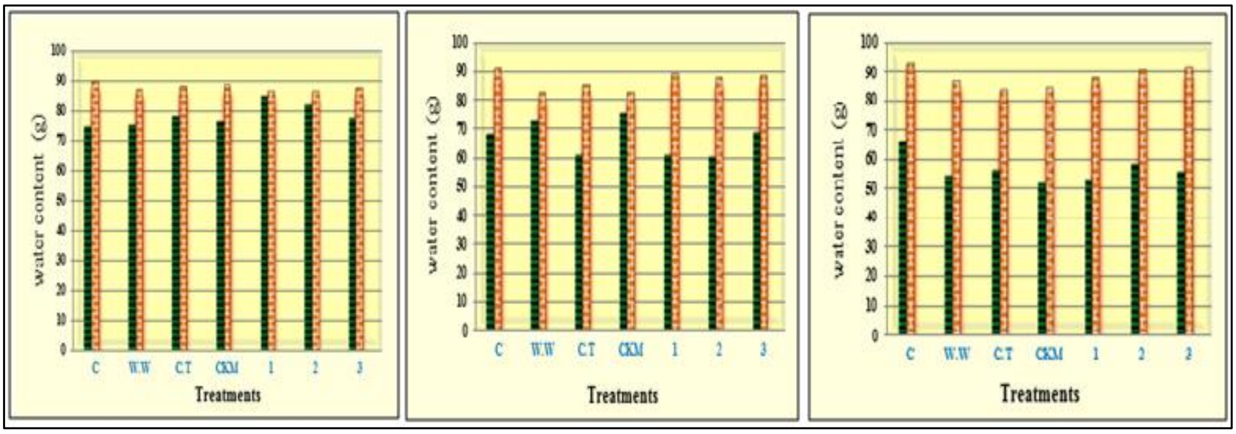

Fig-3. (b): Effect of organic and inorganic fertilizer on water content of shoot and root (g) of *Brassica oleracea* grown in (1:4) (clay: sand v/v) soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 (2.5 mg/pot), (2): K_2SO_4 (12 mg/pot), (3): K_2SO_4 (50 mg/pot). *Non- significant change at 5%

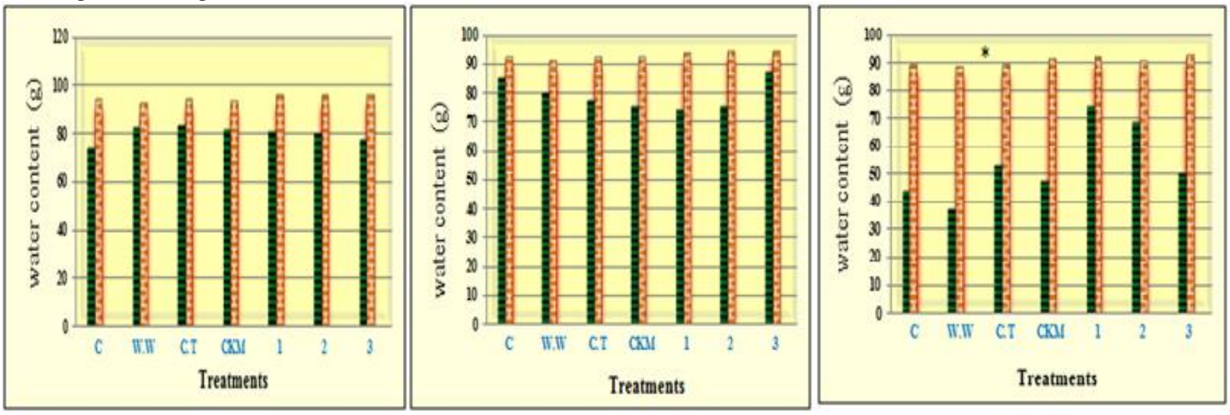

Fig-4. (b): Effect of organic and inorganic fertilizer on water content of shoot and root (g) of *Brassica oleracea* grown in (100 % sand) soil, where C: control, W.W: waste water, CT: compost tea, CKM: chicken manure, (1): K_2SO_4 (2.5 mg/pot), (2): K_2SO_4 (12 mg/pot), (3): K_2SO_4 (50 mg/pot). *Non-significant change at 5%

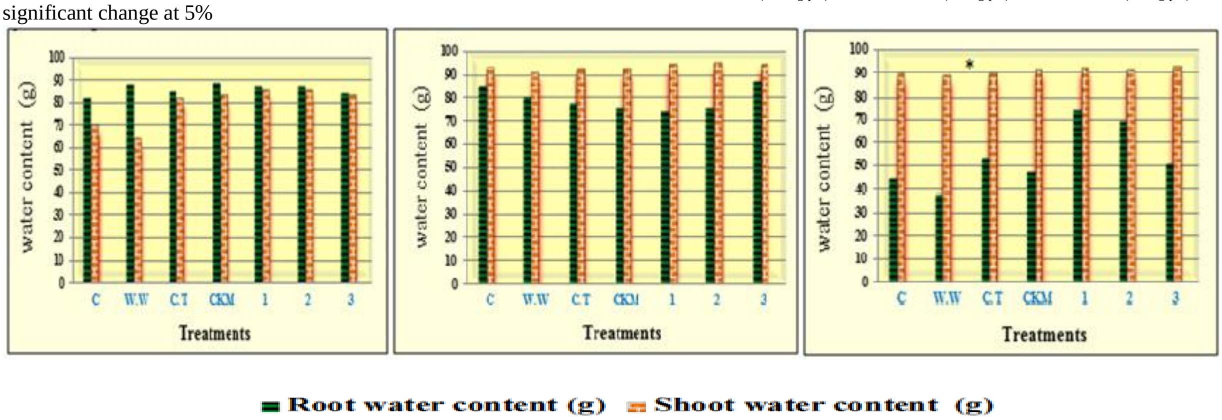

Fig-5. (c): Effect of organic and inorganic fertilizers on relative growth rate (RGR (% day $^{-1}$)) of *Brassica oleracea* in 100% clay soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 (2.5 mg/pot), (2): K_2SO_4 (12 mg/pot), (3) K_2SO_4 (50 mg/pot). *Non significant change at 5% level.

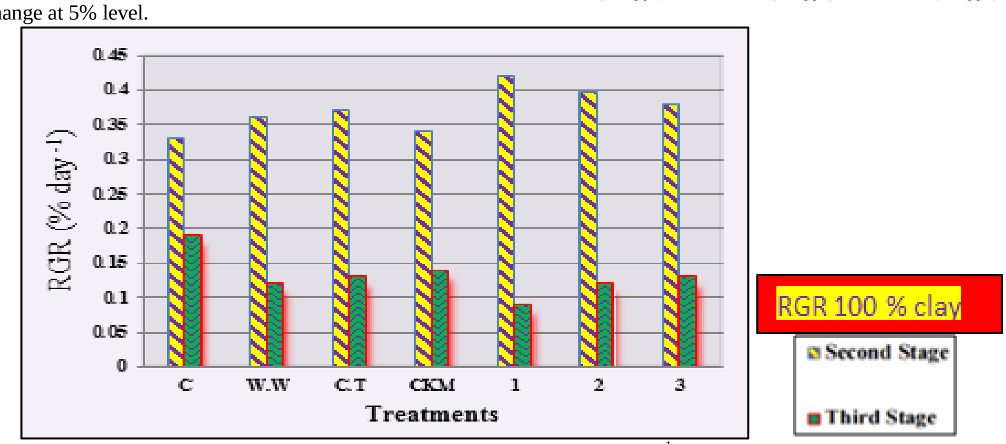

Fig-6. (c): Effect of organic and inorganic fertilizers on relative growth rate(RGR) (% day $^{-1}$) of *Brassica oleracea* grown in (1:2) (clay: sand v/v) soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 (2.5 mg/pot), (2): K_2SO_4 (12 mg/ pot), (3): K_2SO_4 (50 mg/pot). *Non- significant change at 5%.

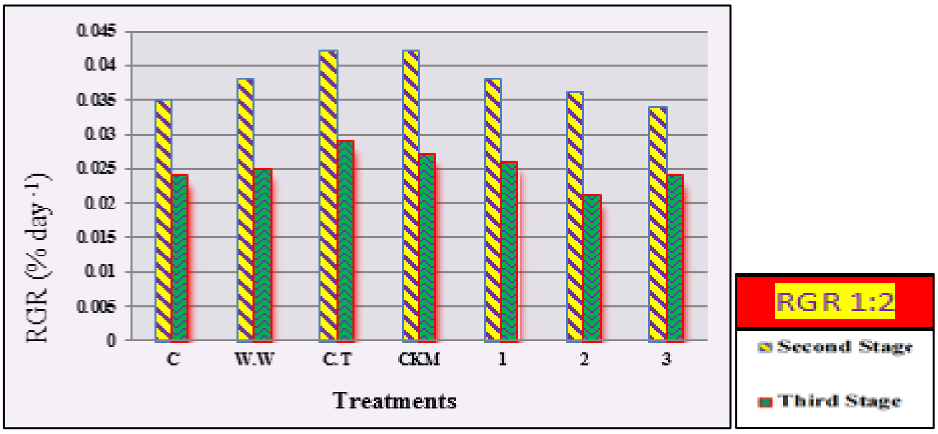

Fig-7. (c): Effect of organic and inorganic fertilizers on relative growth rate(RGR) (% day $^{-1}$) of *Brassica oleracea* grown in (1:4) (clay: sand v/v) soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non- significant change at 5%

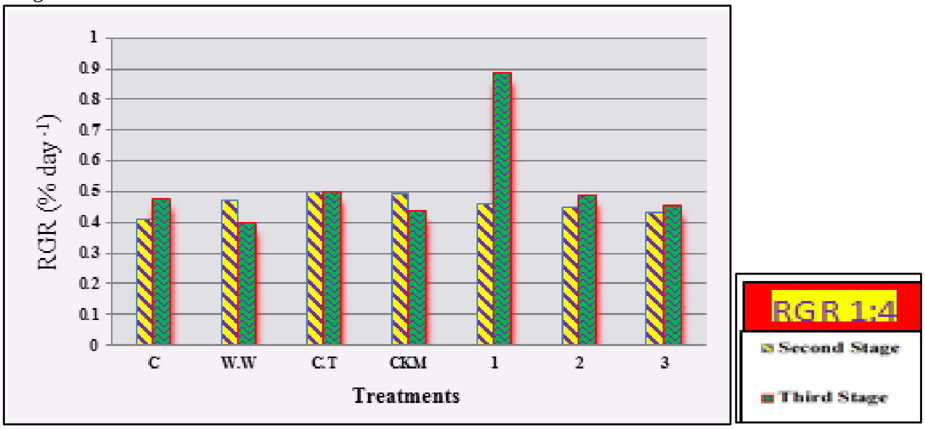

Fig-8. (c): Effect of organic and inorganic fertilizer on relative growth rate (RGR) (% day $^{-1}$) of *Brassica oleracea* grown in 100% sand soil, where C: control, W.W: waste water, CT: composite tea, CKM: chicken manure, (1): K_2SO_4 $_{(2.5\ mg/pot)}$, (2): K_2SO_4 $_{(12\ mg/pot)}$, (3): K_2SO_4 $_{(50\ mg/pot)}$. *Non- significant change at 5%.