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# Study of the Response of Some Soybean Cultivars to Organic Fertilization Treatments Under Greenhouse Conditions

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## ABSTRACT

This study investigated the response of three soybean cultivars (Giza 21, Giza 35, and Giza 111) to various seven of organic fertilization treatments under greenhouse conditions. A 45-day pot experiment was conducted during 2022 at the Department of Plant Pathology ,Faculty of Agriculture, Mansoura University, Egypt. A completely randomized design with three replications was followed. Our results revealed significant variations in performance among the tested soybean cultivars across most measured characteristics. Giza 21 consistently outperformed each of Giza 111 and Giza 35 in root and shoot characters, number of nodules, and both of fresh and dry nodules. While Giza 21 and Giza 111 cultivars were exhibited comparable performance in shoot length, seedling vigor index, and shoot dry weight. Organic fertilization significantly influenced all evaluated parameters, encompassing field emergence, shoot and root growth, fresh and dry biomass, and nodulation. Among the treatments, vermicompost combined with 6-times seaweed generally produced the highest values for these characteristic. Notably, vermicompost + 6 times seaweed and chicken manure + 6 times seaweed treatments were showed no significant difference in field emergence. Furthermore, a significant interaction effect was observed between soybean cultivars and organic fertilization for all examined traits. The most favorable results for root length, nodule number, and root and nodule fresh and dry weights were consistently achieved by combining the Giza 21 cultivar with the vermicompost + seaweed treatment. Finally, it can be recommended that the treatment of soybean cultivars with vermicompost + 6 times adding seaweed treatment had a significant effect in improving the the root and shoot characteristics and growth of bacterial nodules, and then reflected on the increase in the growth and yield of soybean under field conditions .

**Keywords:** Soybean, germination, organic fertilizers, seedling characters, seed viability.

## INTRODUCTION

Soybean (*Glycine max*, L.) is a globally important legume crop. It is considered a primary source of vegetable oil and protein for both human and animal consumption. It is used in a variety of food products as well as industrial products.

It holds the third most significant position among food crops after rice and maize, and the second most important oilseed crop after groundnut (**Sinaga and Marpaung, 2024**).

It is called the "gold of soil" because it improves the soil fertility and productivity of subsequent crops by fixing nitrogen through nodules.

Soybean is an excellent source of low cost protein; it contains 30-45% protein and it contains approximately15-24% oil (**Akram *et al*., 2011**), which is either used directly as edible oil or indirectly in production. It also has a high carbohydrate content of 30% and fiber of 4% (**Sunilkumar *et al*., 2013**).

Soybean protein is rich in the valuable amino acid lysine (5%), which is deficient in most cereals (**Nizkii *et al*., 2022**). Soybean, like other legumes, fixes atmospheric nitrogen ($N_2$) through association with gram negative bacteria species of the genera *Bradyrhizobium* and *Sinorhizobium* (**Sarao *et al*., 2024**).

In Egypt, there is a big problem concerning edible oil production. The local production only satisfies 10% of the total requirements. To increase the total production of edible oil, the area cultivated with oil crops such as soybeans should be increased by expanding into the newly reclaimed soil planting high-potential yield cultivars, and conducting the best agricultural practices, such as using organic fertilizers.

Organic fertilizers are natural materials derived from either plant or animal origin that increase levels of nitrogen, phosphorus in the soil, which leads to improve crop yield (**Liu *et al*., 2013**). Nowadays, organic fertilizers can partially or replace the inorganic fertilization process to mitigate the negative effects of chemical fertilizer misuse, which leads to the degradation of the physical, chemical, and biological properties of the soil, resulting in land productivity degradation and reducing environmental pollution (**Ahmadpour and Armand, 2020**).

Chicken manure is an inexpensive organic fertilizer that is preferre to use compared to other animal wastes because it contains different levels of water, mineral nutrients, and organic matter. So, it improves properties of the soil, which leads to increase in the crop production (**Agbede *et al*., 2008**).

Vermicompost is an organic fertilizer was produced by breeding earthworms on wastes of homes, farms, and markets. It is composed of macro and micronutrients and plant growth promoting substances. It is important in agriculture because it enriches the soil with nutrients necessary for plant growth. It also preserves soil fertility and improves soil physical, chemical, and biological properties, which leads to increase agricultural production (**DeCorato,2020**). Vermicompost was provided similar results to those of chemical fertilizers (**Singh *et al*., 2008; Ghasem *et al*., 2014**), which led to reduce chemical fertilizers usage and caused safe environmental system for sustainable.

However, Seaweeds are adding to chicken manure and vermicompost because they are useful for achieving the highest crop production since the extract contains a variety of macro and micro nutrients, amino acids, vitamins, and numerous growth regulators such as cytokinins, auxins, gibberellins, and abscisic acid (**Shukla *et al*., 2019**). The average cultivated area in the world was about 133 million hectares, total production was about 348.48 million tons and the yield average was about 2.61 tons/ha **(FAOSTAT, 2022)**. In Egypt, the cultivated area of soybeans is being increased and extended to the newly reclaimed areas. The total cultivated area in Egypt during the 2021 season was about 49052 feddan, with an average seed yield of 62.6 thousand tons and a productivity of 1.27 tons/ feddan. **(Statistics, 2021)**. Additionally, seaweed extract aids in the establishment of beneficial soil bacteria, which lead to soil reformation and improve crop growth.

Based on what was previously reviewed above, the present study aims to investigate the early growth, physiological responses, and nodulation characteristics of various soybean cultivars under different organic fertilization regimes in greenhouse conditions.

## Materials and Methods

### 2.1. Plant Material

Three soybean cultivars were selected for the study. These chosen cultivars varied in thier maturity duration and diverse in their genetic backgrounds, as illustrated in Table 1. Seeds of assessed cultivars were obtained from Legume Crops Department, the Field Crops Research Institute (FCRI).

### 2.2. Experimental Site

A pot experiment aim to evaluate the response of three soybean cultivars (Giza 21, Giza 35, and Giza 111) to some organic fertilizers was conducted at the green house for 45 days at the Department of Plant Pathology, Faculty of Agriculture, Mansoura University, Egypt, during the summer season of 2022. A brief description of soybean genotypes is presented in Table 1.

**Table 1: Name, pedigree, maturity group, growth habit, and duration of the assessed soybean cultivars in the current study.**

| No. | Name | Pedigree | Maturity group | Growth habit | Duration |
|---|---|---|---|---|---|
| 1 | Giza 21 | Crawford x Celestiza 21 x Major | IV | Indeterminate | 125-130 days |
| 2 | Giza 35 | Crawford × Celest | III | Indeterminate | 105-110 days |
| 3 | Giza 111 | Crawford × Celest | IV | Indeterminate | 115-120 days |

Plastic pots (15 cm diameter) were used in this experiment, half pots were filled with 3 kg (1 clay: 2 sand) sterilized soil (autoclaved at 121 °C for 30 min).

### 2.3. Physical and Chemical Soil Analysis

Physical and chemical analysis of the soil experimental pots (Table 2) were determined at the General Organization of Agricultural Equilibrium Factor El-Mansoura Laboratory of Soil fertility by the method described by **Page *et al.*, (1982)**.

### 2.4. Experimental Design and Organic Fertilization Treatments.

The pot experiment was conducted in a Factorial Experiment arranged in Completely Randomized Design (CRD) with three replications containing the two factors. The first factor was contained soybean cultivars ( Giza 21, Giza 35, and Giza 111). The second factor included 7 treatment of organic fertilization which were control (without organic), 100% recommended dose fertilizer (RDF) of Chicken manure (3.5 ton/fed) , 100% RDF of Chicken manure + Seaweed algae (3 Times), 100% RDF of Chicken manure + Seaweed algae (6 Times), 100% RDF of Vermicompost( 4 ton/fed) , 100% RDF of Vermicompost + Seaweed algae (3 times) and 100% RDF of Vermicompost + Seaweed algae (6 Times).

The pot experiment contained sixty-three pots, which were divided into three groups, each group containing 21 pots. The first group was filled with sterilized soil and divided into seven subgroups, 3 pots each. The first subgroup (21 pots) was planted with the cultivar Giza 21 and divided into seven organic fertilizer treatments with 3 replicates. The second and third subgroups (21 and 21 pots) were planted with the cultivars Giza 35 and Giza 111 using the same organic fertilizer treatments.

**Table 2. Some physicochemical properties of the soil.**

| Soil properties | The values |
|---|---|
| **1- Mechanical analysis:** | |
| Sand (%) | 77.04 |
| Silt (%) | 12.96 |
| Clay (%) | 10.00 |
| Textural class | Sandy Loam |
| **2- Chemical analysis:** | |
| Organic matter (%) | 0.30 |
| Available nitrogen (ppm) | 65.99 |
| Available phosphorus (ppm) | 22.33 |
| Exchangeable potasium (ppm) | 376.81 |
| EC (dS/$m$) | 1.96 |
| Soil reaction pH | 7.94 |
| C (%) | 1.78 |
| $Caco_3$ | 2.15 |

Ten soybean seeds were sown on the 1st of April 2022 season at 26.1°C and a relative humidity of 60.0%. After ten days, the plants were thinned to leave only five seedlings. Seaweed extract was added to the soil with each irrigation at the rate of 3g/L where the water requirement of soybean (2500 $m^3$/fed, in newly soil) was performed according to **El-Sayed *et al.* (2025).**

Physical and chemical analysis of the chicken manure and vermicompost presented in Table 3. The nitrogen content was determined by the Kjeldahl method according to **Anderson and Ingram (1993)**. The phosphorus content was determined according to the method of **Tandon (2005)**. Brown seaweed algae extract was obtained from the Soil, Water, and Environment Dep. National Research Centre, Egypt, which contains 1% N, 6% P, 18% K, 8.5 pH, and 0.23-0.55 Spec weight.

**Table 3: The physical and Chemical analysis of chicken manure and vermicompost.**

| Parameters | Chicken manure | Vermi compost |
|---|---|---|
| pH | 8.56 | 7.35 |
| E.C (dS/$m$ ) | 5.05 | 1.64 |
| Organic matter (%) | 38.55 | 32.89 |
| Organic carbon (%) | 22.35 | 19.08 |
| C.N ratio (%) | 5.24 | 12.80 |
| Total nitrogen (%) | 1.49 | 4.26 |
| Total phosphorus (%) | 1.66 | 0.43 |
| Total potassium (%) | 0.76 | 1.47 |

**2.5. Measured Traits**

At the end of the experiment (after forty-five days from sowing), the following characteristics were measured:

1- Field emergency (%): It was estimated by counting the germinated plants per pot and expressing it as a percentage of the total sown seeds (10 seeds).

2- Shoot length (cm) :It was measured for each plant of the samples from the soil surface to the back of the head.

3- Length of root (cm): It was measured from the base of the plant to the tip of the main axis of the primary root.

4- Seedling vigor index (SVI): The SVI of soybeans was obtained according to **Abdul-Baki and Anderson (1973).**

SVI= Seedling length × germination percentage (GP).

Where: Seedling length= root length (cm) + shoot length (cm).

5-Shoot fresh weight (g/plant): The fresh weight of the shoot was taken from each plant of the samples for recording.

6- Number of nodules /plant :The nodule count was obtained by uprooting plants carefully at random. Then, the roots were carefully washed with water to avoid losing root nodules, and the nodules from the root of each plant of the samples were separately collected and counted.

7- Root fresh weight (g/plant): The fresh weight of the roots was taken from each plant of the samples for recording.

8- Nodules fresh weight (g/plant): After obtaining the nodules, they were weighed for recording.

9- Shoot dry weight (g/plant): The dry weight of the shoot was taken from each plant of the samples, then the same samples were sun-dried and later dried in a hot air oven for about 48 hours at 70° C until the weight is stable. When it was dried, the weight of the sample was taken for recording.

10- Root dry weight (g/plant): The dry weight of the roots was taken from each plant of the samples, then the same samples were sun-dried and later dried in a hot air oven for about 48 hours at 70ºC until the weight is stable. When it was dried, the weight of the sample was taken for recording.

11- Nodules dry weight (g/plant): The nodules were dried in a hot air oven for about 48 hours at 70 ºC until the weight is stable to remove the moisture content from the nodules, nodules were weighed to obtain the nodule dry weight.

**2.6. Statistical Analysis**

The Factorial Experiment in Completely Randomized Design (RCD) of the subject data was conducted using the analysis of variance (ANOVA) system, as described by **Gomez and Gomez (1984)**. At the 5% level of confidence, differences between treatment means were compared using the LSD method, which was developed by **Snedecor and Cochran (1980)**. Using the RCBD design and the Statistix Analytical software program (version 9.0) was used.

# 3. RESULT AND DISCUSSION

**3. 1.a. Soybean cultivars performance:**

The results of the effects of cultivars and different organic fertilization on field emergence (%) and SVI were presented in Table (4). The analysis was showed significant effects of cultivars and different organic fertilization on SVI while showing non significant effects of cultivars and different organic fertilization on the field emergence (%). Cultivar Giza 21 was produced significantly higher SVI (2839.90), whereas cultivar Giza 35 showed the lowest values of SVI (1817.40).

**3. 2.a. Organic fertilization effect**

The different organic fertilization, and inoculation of vermicompost + 6 times seaweed, were cleared that, significantly effects on all the traits examined, which included the highest field emergence (98.88 %) and SVI (3538.60). Interestingly, chicken manure + 6 times seaweed came in the second rank on values of field emergence and SVI (94.44% and 3099.40, respectively). The other different organic fertilization, *i.e.* chicken manure, chicken manure + 3 times seaweed, vermicompost, and vermicompost + 3 times seaweed, were showed the effects lower than vermicompost + 6 times seaweed, but their effects were higher when compared to the control treatment. Generally, the application of different organic fertilizations showed positive effects on all traits examined, as compared to those without organic fertilization.

These increases in field emergence and SVI may be due to attributed to a common effect. Vermicompost improves soil fertility and nutrient availability because it contains essentialsubstances and helpful microorganisms. Additionally, seaweed extract, which is rich in micronutrients and plant growth hormones, stimulates root development and increases the efficiency of their uptake of nutrients.

This dual action creates an optimal environment for seedling growth, resulting in improved field emergence and SVI. These findings are in harmony with the results were reported by **Sheikh and Dwivedi (2017) and Aritonang and Sidauruk (2020).**

**Table 4: Means of field emergence and seedling vigor index (SVI) of soybean as affected by Soybean Cultivars and Organic fertilization treatments, as well as their interactions during the 2022 season.**

| Characters / Treatments | Field emergence (%) | SVI |
|---|---|---|
| **A. Soybean Cultivars:** | | |
| Giza 21 | 86.19 | 2839.90 |
| Giza 35 | 75.71 | 1817.40 |
| Giza 111 | 81.42 | 2688.50 |
| **F-test** | NS | ** |
| **LSD 5%** | --- | 262.73 |
| **B. Organic Fertilization:** | | |
| Control(without) | 60.00 | 1369.40 |
| Chicken manure | 70.00 | 1850.30 |
| Chicken manure + 3 times seaweed | 80.00 | 2397.9 |
| Chicken manure + 6 times seaweed | 94.44 | 3099.40 |
| Vermicompost | 77.77 | 2176.80 |
| Vermicompost + 3 times seaweed | 86.66 | 2707.90 |
| Vermicompost + 6 times seaweed | 98.88 | 3538.60 |
| **F-test** | ** | ** |
| **LSD 5%** | 7.00 | 203.93 |
| **C – Interactions** | | |
| **A × B** | NS | NS |

**; highly significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.

**3.3.a. Interactions effect**

The result of the interaction between soybean cultivars and different organic fertilization on field emergence and SVI is presented in Table (4). The analysis were showed non-significant effects of the cultivars and the different organic fertilization on field emergence and SVI.

**3. 1.b. Soybean cultivars performance:**

The data obtained demonstrated that all the studied parameters (*i.e.*, root length, root fresh weight, and root dry weight) were significantly impacted by the studied cultivars and different organic fertilizations (Table 5) and (Figure 1, 2 and 3).

Giza 21 cultivar markedly possesses the most marked increase in root length, and fresh and dry weights of root (32.57 cm, 6.51 g/plant, and 2.17 g/plant, respectively), compared with cultivars Giza 111 and Giza 35. Moreover, the Giza 111 cultivar has significantly superior root characters compared with Giza 35. While the Giza 35 cultivar was showed the lowest values for root length, and fresh and dry weights of root. These values were possessed 24.85 cm, 4.97 g/plant, and 1.65 g/plant, respectively. These results were in same line with those reported by **Abo Zahra (2020).**

**3.2.b. Organic fertilization effect**

It was observed that vermicompost + 6 times seaweed resulted in the highest values of root length, and fresh and dry weights of root (42.50 cm, 8.50 g/plant, and 2.83 g/plant, respectively). Additionally, chicken manure + 6 times seaweed ranked second after vermicompost + 6 times seaweed on root length, fresh and dry weights of root with scored 39.00 cm,7.80 g/plant, and 2.60 g/plant, in respectively. On the other hand, the control treatment came in the last place if compared with differentorganic fertilizations and showed the lowest values, which have 21.50 cm, 4.30 g/plant, and 1.43 g/plant, in respectively.

The increasing of root characters may be due to the common effects of vermicompost and seaweed to induce metabolic changes in the root, which caused a decrease in the activity of oxidative enzymes and consequently increase in endogenous IAA and the production of auxins and other plant growth substances. The results were indicated that organic fertilization have positive effects on improving soybean root growth. The present results are in good harmony with those reported by **Sinha *et al*. (2010), Ragagnin *et al.* (2013), Basimfar *et al.* (2015) and Arslanoğlu (2022).**

**3.3.b. Interaction effect:**

The result of the interaction between soybean cultivars and different organic fertilization on root length, and fresh and dry weights of roots are presented in Figure (4). The analysis was showed significant effects of cultivars and different organic fertilization on all the examined traits. Vermicompost + 6 times seaweed treatment was markedly possessing the most significant increases in root length, and fresh and dry weights of root under all soybean cultivars compared with the other organic fertilization. Chicken manure + 6 times seaweed has the second rank in increasing root length and fresh and dry weights of root with all soybean cultivars. The tallest root (49.50, 31.50, and 46.50 cm,respectively), fresh weight of root (9.90, 6.30, and 9.30 g/plant, respectively), and dry weight of root (3.30, 2.10, and 3.10 g/plant, respectively) were recorded by vermicompost + 6 times seaweed treatment in all soybean cultivars. On the other hand, the lowest values of root length (28.50, 21.00, and 15.00 cm, respectively), fresh weight of root (5.70, 4.20, and 3.00 g/plant, respectively), and dry weight of root (1.90, 1.40 and 1.00 g/plant, respectively) were obtained from all soybean cultivars under control treatment which without significant different with the interaction between chicken manure treatment in Giza 21 cultivar and Giza 35 cultivar. These finding was in agreement with these reported by **Abdulqader (2024).**

**3.1.c. Soybean cultivars performance**

The data was obtained demonstrated that, all the studied parameters (*i.e*., nodules number / plant, fresh and dry weight of nodules) were significantly impacted by the studied cultivars and different organic fertilizations (Table 6) and (Figure 1, 2 and 3). Giza 21 cultivar possesses the most marked increased nodules number/ plant, fresh and dry weight of nodules (21.98, 0.40 g/plant and 0.17 g/plant, respectively), compared with cultivars Giza 111 and Giza 35. The Giza 35 cultivar were showed the lowest values of nodules number / plant, fresh and dry weight of nodules (14.91, 0.27 g/plant, and 0.11 g/plant, respectively). Similar results were reported by **Abo Zahra (2020).**

**3.2.c. Organic fertilization effect**

It was observed that vermicompost + 6 times seaweed resulted in the highest of nodules number / plant (25.50), fresh weight of nodules (0.47 g/plant), and dry weight of nodules (0.20 g/plant). Additionally, chicken manure + 6 times seaweed were ranked second after vermicompost + 6 times seaweed on the nodules number / plant, fresh weight of nodules and dry weight of nodules (23.40, 0.43 g/plant and 0.18 g/plant, respectively). Furthermore, the control treatment came in the last place if compared with different organic fertilizations and showed the lowest values.

The increasing in the nodules number, fresh and dry weights of nodules might be attributed to increase soil fertility and microbial activity resulting by using vermicompost and seaweed extract. Vermicompost able to provide a rich source of nutrients and beneficial microorganisms, which create a favorable environment for the growth of nitrogen-fixing bacteria (*Rhizobia*). These bacteria are essential for nodule formation. Seaweed extracts contain plant growth regulators that can promote root development, are leading to a greater surface area for nodule formation. These currunt finding were are in agreement with those reported by each of **Frasetya *et al.* and Gangwar *et al.* (2023).**

**Table 5: Means of root length, fresh and dry weights of the root of soybean as affected by Soybean Cultivars and Organic fertilization treatments as well as their interactions during the 2022 season.**

| Treatments / Characters | Root length (cm) | Root fresh weight (g/plant) | Root dry weight (g/plant) |
|---|---|---|---|
| **A. Soybean Cultivars:** | | | |
| Giza 21 | 36.64 | 7.32 | 2.44 |
| Giza 35 | 24.85 | 4.97 | 1.65 |
| Giza 111 | 32.57 | 6.51 | 2.17 |
| **F-test** | ** | ** | ** |
| **LSD 5%** | 0.75 | 0.14 | 0.04 |
| **B. Organic Fertilization:** | | | |
| Control(without) | 21.50 | 4.30 | 1.43 |
| Chicken manure | 23.50 | 4.70 | 1.56 |
| Chicken manure + 3 times seaweed | 31.00 | 6.20 | 2.06 |
| Chicken manure + 6 times seaweed | 39.00 | 7.80 | 2.60 |
| Vermicompost | 27.00 | 5.40 | 1.80 |
| Vermicompost + 3 times seaweed | 34.99 | 6.99 | 2.33 |
| Vermicompost + 6 times seaweed | 42.50 | 8.50 | 2.83 |
| **F-test** | ** | ** | ** |
| **LSD 5%** | 0.99 | 0.20 | 0.06 |
| **C - Interactions:** | | | |
| **A × B** | ** | ** | ** |

**; highly significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.


**$G_1$: Giza21, $T_1$: Control(without organic), $T_2$: 100%chicken manure, $T_3$: 100% chicken manure + 3 times seaweed, $T_4$: 100% chicken manure + 6 times seaweed, $T_5$: 100%vermicompost, $T_6$: 100% vermicompost + 3 times seaweed, $T_7$: 100% vermicompost + 6 times seaweed.**

**Fig. 1: Effect of organic fertilizers (chicken manure and vermicompost) on shoot and root development of soybean, namely, Giza 21. The plants were grown for 45 days in Sandy Loam**


**pots.**

**$G_2$: Giza 35, $T_1$: Control(without organic), $T_2$: 100%chicken manure, $T_3$: 100% chicken manure + 3 times seaweed, $T_4$: 100% chicken manure + 6 times seaweed, $T_5$: 100%vermicompost, $T_6$: 100% vermicompost + 3 times seaweed, $T_7$: 100% vermicompost + 6 times seaweed.**

**Fig. 2: Effect of organic fertilizers (chicken manure and vermicompost) on shoot and root development of soybean, namely, Giza 35. The plants were grown for 45 days in Sandy Loam**


**pots.**

**$G_3$: Giza 111, $T_1$: Control(without organic), $T_2$: 100%chicken manure, $T_3$: 100% chicken manure + 3 times seaweed, $T_4$: 100% chicken manure + 6 times seaweed, $T_5$: 100%vermicompost, $T_6$: 100% vermicompost + 3 times seaweed, $T_7$: 100% vermicompost + 6 times seaweed.**

**Fig. 3: Effect of organic fertilizers (chicken manure and vermicompost) on shoot and root development of soybean, namely, Giza111. The plants were grown for 45 days in Sandy Loam pots.**

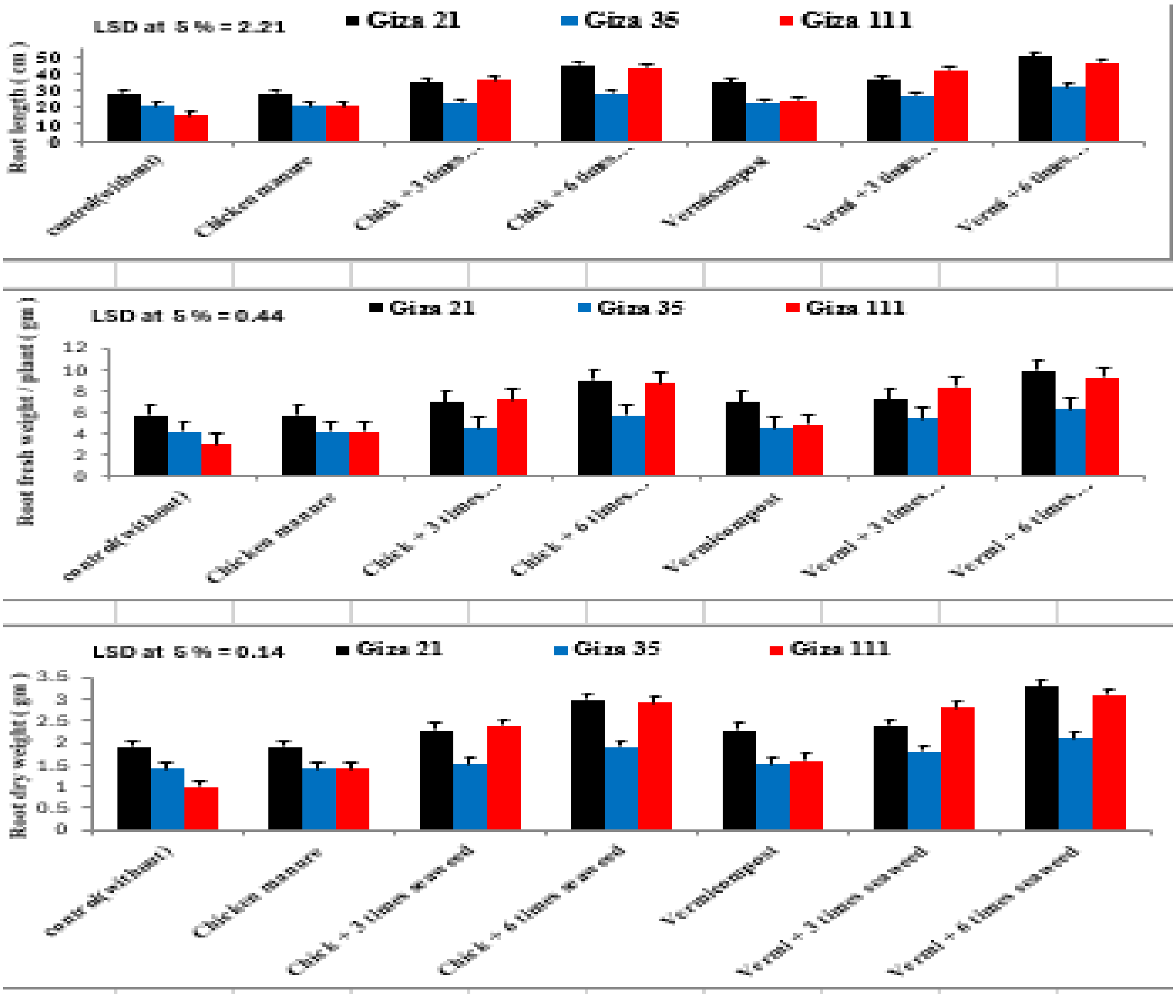


**Figure 4: Impact of different organic fertilization on the root length, fresh and dry weights of the root of three diverse soybean cultivars during the 2022 season.**

### 3.3.c. Interaction effect

Significant effects were observed on the nodules number, fresh and dry weights of nodules as a result of the various interactions between the two factors under study, namely soybean cultivars and organic fertilization, as shown in Figure (5).

The highest values of number of nodules/ plant (29.70, 18.90, 27.90, respectively), nodules fresh weight (0.55, 0.35, 0.52 g/plant, respectively) and nodules dry weight (0.24, 0.15 and 0.22 g/plant, respectively) were obtained by applying vermicompost + 6 times seaweed treatment in all soybean cultivars.

Moreover, there are no significant differences between vermicompost + 6 times seaweed and chicken manure + 6 times seaweed treatments under Giza 35 and Giza 111 cultivars on nodules dry weights. Chicken manure + 6 times seaweed has the second rank in increasing the nodules number/ plant and fresh weight of nodules with all soybean cultivars. All organic fertilization treatments significantly outperformed the control treatment under all soybean cultivars.

Futhermore, the lowest values of the number of nodules/ plant (17.10, 12.60, and 9.00, respectively), nodules fresh weight ( 0.32, 0.23 and 0.17 g/plant, respectively) and nodules dry weight (0.14, 0.10 and 0.07 g/plant, respectively) were obtained from all soybean cultivars under control treatment which without significant different with the interaction between chicken manure treatment in both Giza 21 and Giza 35 cultivars on nodules number / plant and fresh weight of nodules.

### 3. 1.d. Soybean cultivars performance

It is clear from the statistical analysis of the data that was gathered about cultivars and different organic fertilization, that there were significant effects on shoot length, and fresh and dry weights of shoot (Table 7) and (Figure 1, 2 and 3). Giza 21 cultivar markedly increases the shoot length, and fresh and dry weights of shoot increase (31.93 cm, 6.17 g/plant, and 2.45 g/plant, respectively), compared with the other cultivars. Moreover, the Giza 111 cultivar come in the second rank, while the lowest values of shoot length, and fresh and dry weights of shoot (23.10 cm, 3.85 g/plant, and 1.45 g/plant, respectively) produced from Giza 35 cultivar. In this recpect, each of **Dawood (2017) and Soltan *et al.* (2018)** reached to the same results, which reported in the current work.

**Table 6: Means of nodules number/ plant, and weights of nodules of soybean as affected by Cultivars and Organic fertilization treatments as well as their interactions during the 2022 season.**

| Treatments / Characters | Number of nodules /plant | Nodules fresh weight (g/plant) | Nodules dry weight (g/plant) |
|---|---|---|---|
| **A. Soybean Cultivars:** | | | |
| Giza 21 | 21.98 | 0.40 | 0.17 |
| Giza 35 | 14.91 | 0.27 | 0.11 |
| Giza 111 | 19.54 | 0.36 | 0.15 |
| **F-test** | ** | ** | ** |
| **LSD 5%** | 0.45 | 0.01 | 0.004 |
| **B. Organic Fertilization:** | | | |
| Control (without) | 12.89 | 0.24 | 0.10 |
| Chicken manure | 14.10 | 0.26 | 0.11 |
| Chicken manure + 3 times seaweed | 18.60 | 0.34 | 0.14 |
| Chicken manure + 6 times seaweed | 23.40 | 0.43 | 0.18 |
| Vermicompost | 16.20 | 0.30 | 0.12 |
| Vermicompost + 3 times seaweed | 21.00 | 0.38 | 0.16 |
| Vermicompost + 6 times seaweed | 25.50 | 0.47 | 0.20 |
| **F-test** | ** | ** | ** |
| **LSD 5%** | 0.59 | 0.01 | 0.005 |
| **C - Interactions:** | | | |
| A×B | ** | ** | ** |

**; highly significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.

These improvements in shoot length, and fresh and dry weights of the shoot may be due to vermicompost, and seaweed extract were enhanced bioactive compounds and can be used as biostimulants because they contain organisms that are useful to plant growth and development and enable it to produce essential growth substances and increase more available nutrients at fix more nitrogenous components. Many investigators concluded such as **El-Hafez and Abo El-Soud (2007), Sinha *et al*. (2010), Basimfar *et al.* (2015), Frasetya *et al.* (2019), Kiran (2019), Rahayu *et al.* (2021), Aritonang and Sidauruk (2020), Arslanoğlu (2022) and Gangwar *et al.* (2023).**

**3.3.d. Interaction effect**

The weights of the shoots were impacted by interactions between soybean cultivars and organic fertilization (Figure 6). The analysis was showed significant effects of cultivars and different organic fertilization on all the previous traits. Vermicompost + 6 times seaweed treatment was markedly possessing the most significant increase in fresh and dry weights of shoots under all soybean cultivars. Moreover, there are no significant differences between vermicompost + 6 times seaweed and chicken manure + 6 times seaweed treatments under Giza 35 and Giza 111 cultivars on shoot dry weights. Chicken manure + 6 times seaweed has the second rank in the increasing shoot fresh weight with all soybean cultivars. The highest values of shoot fresh weight (7.40, 4.90, and 6.30 g/plant, respectively) and shoot dry weight (3.37, 2.02, and 2.88 g/plant, respectively) were recorded by vermicompost + 6 times seaweed treatment in all soybean cultivars. On the other hand, the lowest values of shoot fresh weight (4.40, 3.20, and 5.00 g/plant, respectively) and shoot dry weight (1.68, 0.89, and 1.43 g/plant, respectively) were obtained from all soybean cultivars under control treatment. A similar finding was reported by **Jawale *et al.* (2020)** and **Abdulqader (2024).**

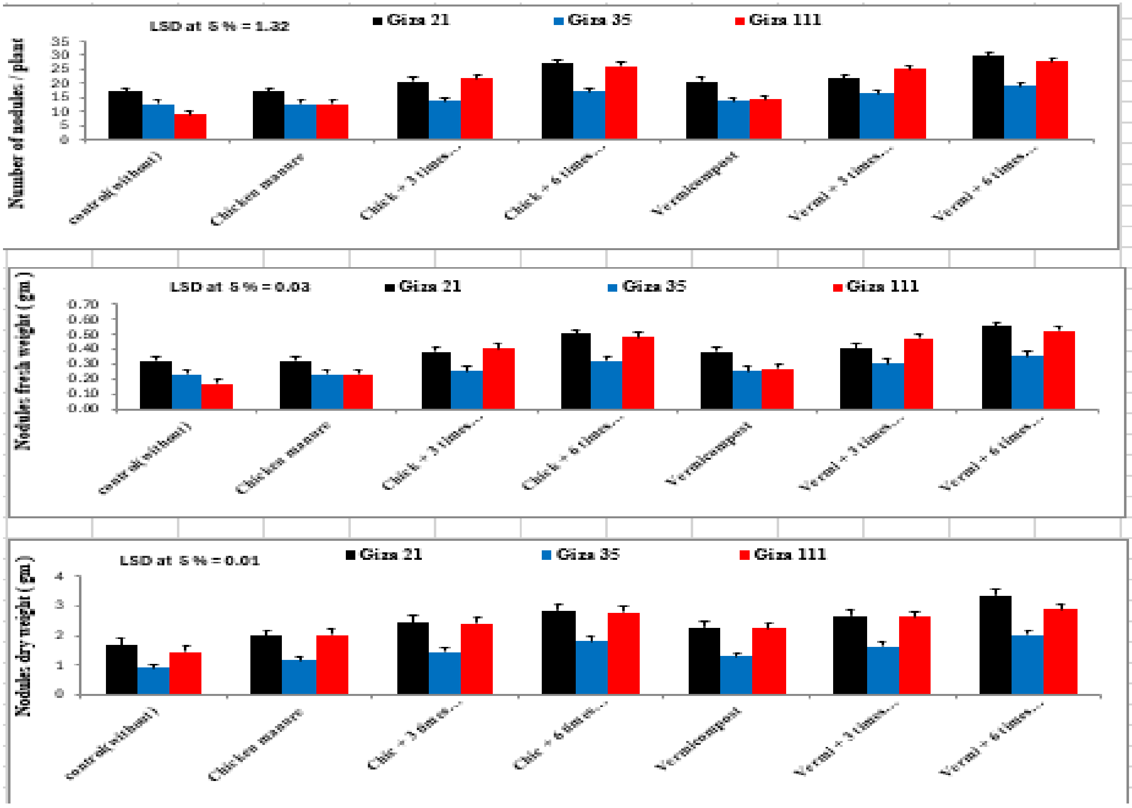


**Figure 5: Impact of different organic fertilizations on the number of nodules per plant, fresh and dry weights of nodules of three diverse soybean cultivars during the 2022 season.**

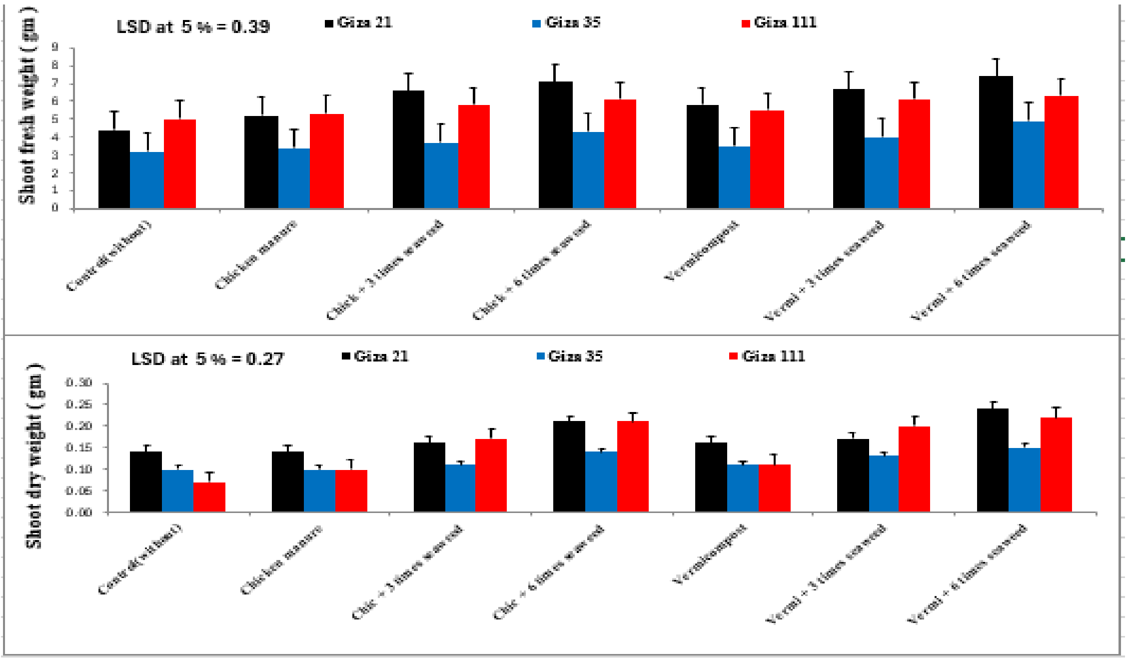


**Figure 6: Impact of different organic fertilization on the fresh and dry weights of the shoot of three diverse soybean cultivars during the 2022 season.**

**Table 7: Means of shoot length, fresh and dry weights of the shoot of soybean as affected by Soybean Cultivars and Organic fertilization treatments as well as their interactions during the 2022 season.**

| Characters<br>Treatments | shoot length (cm) | fresh weight of Shoot (g/plant) | dry weight of Shoot (g/plant) |
|---|---|---|---|
| **A. Soybean Cultivars:** | | | |
| Giza 21 | 31.93 | 6.17 | 2.45 |
| Giza 35 | 23.10 | 3.85 | 1.45 |
| Giza 111 | 31.91 | 5.72 | 2.34 |
| **F-test** | ** | ** | ** |
| **LSD 5%** | 1.50 | 0.15 | 0.23 |
| **B. Organic fertilization:** | | | |
| Control (without) | 22.21 | 4.20 | 1.33 |
| Chicken manure | 25.85 | 4.63 | 1.71 |
| Chicken manure + 3 times seaweed | 29.36 | 5.36 | 2.09 |
| Chicken manure + 6 times seaweed | 32.24 | 5.83 | 2.47 |
| Vermicompost | 27.44 | 4.93 | 1.92 |
| Vermicompost + 3 times seaweed | 30.50 | 5.60 | 2.30 |
| Vermicompost + 6 times seaweed | 35.27 | 6.20 | 2.75 |
| **F-test** | ** | ** | ** |
| **LSD 5%** | 0.78 | 0.21 | 0.15 |
| **C - Interactions:** | | | |
| **A×B** | NS | ** | ** |

**; highly significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.

**3.2.d. Organic fertilization effect**

It was observed that vermicompost + 6 times seaweed gave the tallest shoot, and fresh and dry weights of shoot (35.27 cm, 6.20 and 2.75 g/plant). Chicken manure + 3 times seaweed ranked second on shoot length, fresh and dry weights of the shoot (32.24 cm, 5.83 g/plant, and 2.47g/plant, respectively). The other different organic fertilization, chicken manure, chicken manure + 3 times seaweed, vermicompost, and vermicompost + 3 times seaweed, showed effects lower than vermicompost + 6 times seaweed, but their effects were higher when compared to the control. As well as the control treatment showed the lowest values.

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## CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

## AUTHORS CONTRIBUTION

The authors developed the concept of the manuscript. All authors checked and confirmed the final revised manuscript.

## CONCLUSION

This study clearly demonstrates that soybean cultivars vary significantly in their responses to different organic fertilization sources, highlighting the substantial positive influence of these amendments on plant performance. Our findings showed the marked superiority of the Giza 21 cultivar in key growth and nodulation parameters, and similarly, vermicompost combined with seaweed application proved to be the most effective organic treatment across all assessed characteristics. Crucially, the significant interaction observed indicated that the optimal combination for enhancing root and nodule development was the Giza 21 cultivar paired with vermicompost + 6 seaweed treatment. This synergistic success underscores the potential of this promising approach to boost soybean growth and development, suggesting its value for sustainable agricultural practices. These initial results indicate a strong possibility for integrating this optimized organic fertilization strategy into field conditions to improve soybean productivity.

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## دراسة استجابة بعض أصناف فول الصويا لمعاملات التسميد العضوي تحت ظروف الصوبة

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**الملخص :**

بحثت هذه الدراسة استجابة ثلاثة تراكيب وراثية من فول الصويا (جيزة 21، جيزة 35، جيزة 111) لمعاملات مختلفة من التسميد العضوي تحت ظروف الصوبة. تم إجراء تجربة الأصص لمدة 45 يوما خلال الموسم الصيفي لعام 2022 بكلية الزراعة، جامعة المنصورة، مصر. كما تم استخدام تصميم تام العشوائية ذو ثلاث مكررات. أشارت النتائج الي وجود تباين في أداء أصناف فول الصويا تحت الدراسة بشكل ملحوظ في معظم الصفات المدروسة، حيث تفوق صنف جيزة 21 بشكل ملحوظ على الصنفين جيزة 111 وجيزة 35 في صفات طول الجذر، والوزن الطازج والجاف للمجموع الجذري والخضري. أوضحت النتائج عدم وجود فرق معنوي بين الصنفين جيزة ٢١ وجيزة ١١١ في صفات طول المجموع الخضري، ودليل حيوية البادرات، ووزن المجموع الخضري الجاف. أيضا كان للتسميد العضوي تأثير معنوي على جميع الصفات التي تم تقيمها، بما في ذلك التكشف الحقلي ، صفات نمو المجموع الجذري والخضري، الأوزان الطازجة والجافة، والعقد البكتيرية. كما أشارت النتائج الى أن أعلي قيم للصفات المدروسة نتجت من المعاملة بالسماد الدودي المخلوط بالطحالب البحرية والمضاف 6 مرات. كذلك أظهرت النتائج عدم وجود فرق معنوي بين استخدام السماد الدودي + 6 مرات من إضافة الطحالب البحرية وسماد سبلة الدجاج + 6 مرات من إضافة الطحالب البحرية في صفة النسبة المئوية للتكشف الحقلي. أسفرت النتائج الى أن التفاعل بين الأصناف ومعاملات التسميد العضوي كان له تأثيراً معنوياً على جميع الصفات المدروسة، حيث كانت أعلي قيم لصفات طول الجذر وعدد العقد البكتيرية والوزن الطازج والوزن الجاف للجذر والعقد البكتيرية نتجت من الصنف جيزة 21 عند تطبيق معاملة السماد الدودي + 6 مرات من إضافة الطحالب البحرية. وأخيرا يمكن التوصية بأن معاملة أصناف فول الصويا بالسماد الدودي + 6 مرات من إضافة طحالب بحرية كان لها تأثير كبير في تحسين صفات المجموع الجذري و الخضري ونمو العقد البكتيرية ومن ثم ينعكس ذلك علي زيادة نمو ومحصول فول الصويا تحت ظروف الحقل.