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Effect of soil application of ag-zyme liquid organic fertilizer on growth and yield of soybean (*Glycine max* L.)

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Abstract

The aim of this study was to evaluate the effect of Ag-zyme liquid organic fertilizer on growth and yield of soybean (*Glycine max* L.). The experiment was carried out at the Teaching and Research Farm of Faculty of Agriculture and Veterinary Medicine. The experimental was the Randomized Complete Block Design (RCBD) with five treatments and four replications. The treatments are 0 ml(T_1), 50 ml(T_2), 100 ml(T_3), 150 ml (T_4) and 200 ml (T_5) of Ag-zyme liquid organic fertilizer. The results obtained showed that soil application of Ag-zyme liquid organic fertilizer at different rates significantly ($P<0.05$) influenced the vegetative and yield parameters of soybean evaluated. The application of moderate levels of (T_2 and T_3) Ag-zyme liquid fertilizers markedly increased the yields (35.595 kg/ha and 29.583 kg/ha respectively) compared to other levels and control. The result showed that the increase in vegetative, parameters, yield and yield components were correlated to mitigation effect of application of Ag-zyme liquid organic fertilizer during late planting in relation to harsh environmental condition.

Keywords: Ag-Zyme; Liquid Organic Fertilizer; Soybean; Macro Element; Uptake

1. Introduction

Liquid organic fertilizers are made with different organic waste materials including either plant or animal based crop residues, green manures, animal manures, household waste and food waste [1], and provide soluble and easily available nutrients to the crops.

Organic fertilizers are effective in promoting environmental sustainability and plant growth after long-term use, but previous studies have focused primarily on the conventional solid organic fertilizer product, such as straw and manure [2.3]. Specialized horticultural production has fostered the emergence of new liquid organic fertilizers [4], which have usually been derived from natural products and their biological activities occur at limited doses. Compared with conventional organic fertilizer, the abundant organic matter and soluble nutrients in the liquid organic fertilizers could maintain soil sustainability and plant health [5, 6].

In addition, the integration of watering and fertilization patterns could improve the nutrient use efficiency and decrease the risk of nutrient loss [7, 8]. Moreover, the special compounds in liquid organic fertilizers, such as chitin, humic and fulvic acids, and other biopolymers, can be biostimulants to plants

Most Nigerian soils have low nitrogen and the low nitrogen status is usually supplemented with N fertilizer, and the importance of this source has increased over the year. However, the problem with the usage of chemical fertilizer is that

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while it can lead to high crop yield, it results into pollution of ground water after crop harvest [9,10]. Another major limitation to the usage of chemical fertilizers is due to the adverse effects they have on plant quality and disease susceptibility. A continual dependence on chemical fertilizers may be accompanied by a fall in organic matter content, increased soil acidity, degradation of soil physical properties and increased rate of erosion due to instability of soil aggregates [11,10]. One of the ways to maintain or improve the soil fertility is by maintaining its organic matter; this is possible through the use of liquid organic sources of fertilizer.High levels of nitrate accumulation in plants are harmful to both human health and to plant growth [12,13,14].

[15], reported that either an animal or plant-based liquid organic fertilizer produced a higher total biomass of citrus trees than mineral fertilizers because of the more profuse development of new organs under the organic treatments.[16] , has suggested that shrimp liquid fertilizer had a positive effect on seedling growth, leaf chlorophyll concentrations, photosynthetic activities, and nutrient uptake efficiency. The addition of shrimp liquidmay promote root growth and ecological adaptability and reduce the occurrence of plant diseases and insect pests, thereby improving chrysanthemum growth [16] . The addition of organic fertilizers efficiently ensures high production and continuous crops by improving soil properties and increase roots development and soil microorganism's activity [17.18]. Some researchers reported that spraying with humic acid improve plant growth and yield [19].Liquid organic fertilizers produced from agricultural residues and industrial wastes are becoming increasingly popular among farmers and reseachers. This study is to examine the effect of liquid organic fertilizer on vegetative growth parameters and yield of soybean.

2. Material and methods

2.1. Location

This study was carried out in the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri. Owerri lies between the latitudes 5°10'N and 6°0'N and longitudes 6°35'E and 7°0'E with an altitude of 91.0m within the Southeast rain forest agricultural zone of Nigeria. The area maintains an average annual rainfall of 2,500 mm, mean minimum and maximum temperature of 23.5°C and 32.1°C respectively, with relative humidity ranging from 70-85% and the annual evapotranspiration is 1450 mm9[20].

2.2. Source of Materials

Soybean seeds that were used in this study were collected from Imo State Agricultural Programme, Owerri. Agro-enzyme Liquid organic fertilizer was source from scientific (Right Time Family Limited) suppliers here in Owerri.

2.3. Experiment Design

The experiment was laid out in Randomized Block Design with four treatments including, Control (T_1), 50 ml (T_2). 100 ml (T_3) 150 ml (T_4) and 200 ml (T_5) (soil application) and five replicates. All the treatments were given through sprayer at the base of stem. The first spray was applied after two weeks of sowing, followed by the second and the third, after an interval of two weeks, respectively. The initial data on plant height and other parameters were taken before spraying

2.4. Land Preparation and Experimental Layout

The land was cleared, ploughed and harrowed by tractor before planting. The experimental area used was 7 x 6 m (42m) with 1m x 1m bed.

2.5. Method of Planting

The seeds were pre-soaked in water one hour before sowing to identify the viable seeds and hasten germination. Three seeds were sow per hole and after 7 days of emergence, the germinated soybean was thinned to a stand per hole.

2.6. Preparation of Ag-Zymes as Fertilizer

When using Ag-zymes as fertilizer,a combination of 1 bottle of Ag-Zyme soil conditioner and 1 bottle of Ag-Zyme NPK fertilizer was diluted into 50 litres of water and apply directly to the soil around the roots of the cropsand Apply approximately 100ml solution to one crop stand Repeat after two weeks.

2.7. Weed Control

Weeding was done manually with the use of hoe three weeks after planting and subsequent weeding was done at five weeks.

2.8. Data Collection

Plant samples were collected at two weeks interval to monitor growth of plant days from sowing.

2.8.1. Plant Height

This is the distance from the ground level of the plant to the Apex of the plant. It was measured using ruler (graduated in centimetre).

2.8.2. Number Leaves

Virtual counting of leaves was done.

2.8.3. Leaf area

The leaf area was taken using this formular; L x W x 0.75

2.8.4. Leaf Area Index per Plant

This was obtained by a simple

formular, leaf area index per plant

LA/ area of land cover by the canopy

2.8.5. Yield (Kg/ha)

The yield which is the major criteria was

taken into consideration to evaluate this effect. The yield of soybean was done by picking-up the fruits every two to three days. The weight of the collected fruits in each plot was recorded.

The fruit yield was weighed and calculated using the formula [21].

$$\frac{\text{Fresh Weight}}{\text{Land Area}} \text{X} \frac{10{,}000}{1}$$

2.9. Statistical analysis

Analysis of the variance and the schemas related to them was done by MS-Excel Ver.11, SAS and The mean treatment values was compared using LSD test at the 5% probability level.

3. Results

3.1. Effect of Treatments on Plant Heights (cm) of Soybean

From the results obtained from the plant height analysis the Ag-Zyme soil application improved the plant heights as week's increases. At 2WAP T_4 recorded the highest plant height (8.375cm) which was significantly different ($P<0.05$) from the lowest (5.625cm) recorded from T_3. This was by T_2 with 8.325cm plant height, T_1 (7.325cm) and T_5 (6.525cm). At 4WAP, T_5 recorded slightly higher plant height (13.550) than T_2 with 13.200cm and T_1 (13.050) though statistically they are similar. Lowest was T_4 with 11.625cm plant height which was not significantly different from T_3 (12.95cm). At 6WAP, 8WAP and 10WAP T_3 recorded significantly highest plant height (29.8cm, 38.75cm and 38.75cm) compare to the lowest (20.27cm, 25.125cm and 31.530cm) obtained from the control. It was observed that 10WAP, there was no significant different among different levels of application as shown in Table 1.

Table 1 Effect of Treatments on Plant Heights (cm) of Soybean

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T_1	7.3250^{ab}	13.050^{a}	20.275^{b}	25.125^{b}	31.550^{a}
T_2	8.3250^{a}	13.200^{a}	22.025^{b}	26.250^{b}	31.825^{a}
T_3	5.6250^{c}	12.950^{a}	29.800^{a}	38.750^{a}	41.450^{a}
T_4	8.3750^{a}	11.625^{a}	25.375^{ab}	33.500^{ab}	31.825^{a}
T_5	6.5250^{bc}	13.550^{a}	23.050^{ab}	26.750^{b}	30.575^{a}

Mean in the column, having the same letter(s) are not significantly different at P≤0.05, according to Least Significant Difference (LSD) method.

3.2. Effect of Treatments on Number of Leaves

The response of leave production on the application of Ag-Zyme liquid fertilizer is presented in Table 2. At 2 and 4WAP, T_1e recorded the maximum number of leaves (8.25 and 13.75 respectively) which was significant at 2WAP and not significant at 4WAP when compared with the lowest 5.25 and 11.500 respectively recorded from T_3 and T_5 as shown in Table 2. Result obtained at 6WAP, showed that there was no significant difference (P<0.05) among the treatments, T_3 was seen to have recorded maximum leaf production (36.750) compare to the lowest 27.5 obtained in T_5. Also control gave highest number of leaves (29.25) than T_2 (28), T_3 and T_4 were observed to have performed better than the rest treatments levels. At maturity stage (8 and 10WAP) T_3 gave the highest number of leaves (46.5 and 75.5 respectively) which was significantly different (P<0.05) from the lowest (28.750 and 45.5) recorded from control and T_5 respectively. T_3 performed better than all other treatments towards the end of the study (8 and 10 WAP).

Table 2 Effect of Treatments on Number of Leaves

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T_1	8.250^{a}	13.750^{a}	29.250^{a}	28.750^{b}	70.500^{a}
T_2	6.500^{ab}	11.750^{a}	28.000^{a}	35.000^{ab}	67.750^{a}
T_3	5.250^{b}	12.500^{a}	36.750^{a}	46.500^{a}	75.500^{a}
T_4	8.000^{a}	12.000^{a}	30.500^{a}	38.500^{ab}	60.000^{ab}
T_5	6.000^{ab}	11.500^{a}	27.500^{a}	31.250^{b}	45.500^{b}

Mean in the column, having the same letter(s) are not significantly different at P≤0.05, according to Least Significant Difference (LSD) method.

3.3. Effect of Treatment on Number of Branches

Table 3 Effect of Treatment on Number of Branches

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T_1	2.7500^{ab}	7.000^{a}	8.500^{a}	15.250^{a}	30.000^{c}
T_2	3.0000^{a}	7.000^{a}	10.750^{a}	14.500^{a}	40.500^{ab}
T_3	2.0000^{b}	6.250^{a}	8.000^{a}	19.000^{a}	44.500^{a}
T_4	3.2500^{a}	7.000^{a}	7.750^{a}	16.250^{a}	35.500^{bc}
T_5	2.5000^{ab}	5.000^{a}	10.000^{a}	14.750^{a}	29.250^{c}

Mean in the column, having the same letter(s) are not significantly different at P≤0.05, according to Least Significant Difference (LSD) method.

The response of Number of Branches of soybean as influenced by soil application of liquid fertilizer rates at 2, 4, 6, 8 and 10WAP variety (Table 3). The results shows that T_4 recorded highest number of branches (3.25) which was significantly different (P<0.05) from the lowest (2) obtained from T_3. However, the result was not significantly different from T_5 (2.5), T_1 (2.75), and T_2 (3). At 4WAP, T_1, T_2 and T_4 were at par with each other (7 branches each) which was statistically similar. Also, the lowest recorded from T_5 (5) was not significantly different (P<0.05) from other intermediate levels and control. At 6WAP, there was no significant difference among the treatment levels, T_2 recorded

highest number of branches (10.75) compare to lowest (7.75) recorded from T_4, while at 8 and 10WAP, T_3 produced maximum number of branches (19 and 445 respectively) compare to other treatments. At 10WAP, the lowest was T_5 (29.250) which is significantly different ($P<0.05$) from the highest (44.5) obtained from T_3 and other treatment levels including control as shown in Table 3.

3.4. Effect of treatments on Leaf Area (cm^2) of Soybean

Application rates of Ag-Zyme liquid fertilizer significantly improved leaf area of soybean at 2, 6 and 10WAP as shown in Table 4. At 2 WAP T_2 obtained maximum leaf area of 8.975cm^2 which was significantly different ($P<0.05$) from the lowest (4.2cm) recorded from T_3. There was no significant different in leaf area obtained from control (7.4cm^2), T_4 (7.875cm^2) and T_5 (6.28cm^2). At 4WAP there was no significant different ($P<0.05$) among the treatment levels, although, T_2 recorded higher leaf area (13.875cm^2), in that order. While at 6 and 8WAP T_3 significantly recorded higher leaf area of 37.175cm^2 and 51.825cm^2 respectively compared to the lowest 25$cm^2$and 41.625cm^2 obtained in control. However, at 10WAP, it was observed that T_2 gave maximum leaf area of 51.75cm^2 which was significantly different ($P<0.05$) from T_5 (31.825cm^2).

Table 4 Effect of treatments on Leaf Area (cm^2) of Soybean

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T_1	7.400^{ab}	12.075^{a}	25.000^{b}	41.625^{a}	42.125^{ab}
T_2	8.975^{a}	13.875^{a}	30.525^{ab}	49.950^{a}	51.750^{a}
T_3	4.200^{b}	10.575^{a}	37.175^{a}	51.825^{a}	49.600^{ab}
T_4	7.875^{ab}	12.075^{a}	30.450^{ab}	42.150^{a}	38.650^{ab}
T_5	6.280^{ab}	9.650^{a}	26.350^{ab}	46.000^{a}	31.825^{b}

Mean in the column, having the same letter(s) are not significantly different at P≤0.05, according to Least Significant Difference (LSD) method.

3.5. Effect of Treatments in Leaf Area Index

The result of leaf area index is presented in Table 5. There was no particular tread in the treatments level that enhance leaf area index, however, there was significant different ($P<0.05$) on impact of liquid fertilizer on leaf area index. At 2WAP, T_2 recorded maximum (0.17425) leaf area index which was not significantly different ($P<0.05$) from the lowest (0.091) obtained in T_3. Other treatments were statistically similar while at 4WAP. T_3 gave maximum leaf area index (0.20225) which was significantly different ($P<0.05$) from the lowest (0.05850) recorded in T_2. At 6WAP, control gave the maximum leaf area index (0.07325) which was significantly difference from the lowest (0.044250) obtained from T_5. Whereas at 8WAP, T_3 gave maximum leaf area index (0.10550) which was significantly different from the lowest (0.0355) obtained in T_4. Other intermediate levels were not significant. At 10WAP, there was decrease in the leave area index as shown 5. However, control recorded the highest leaf area (0.034250) which was significantly different ($P<0.05$) from the lowest (0.15250) recorded from T_5. The values of leaf area index in T_2, T_3 and T_4 are found to be statistically different.

Table 5 Effect of Treatments in Leaf Area Index

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T_1	0.14875^{a}	0.09100^{ab}	0.073250^{a}	0.05375^{ab}	0.034250^{a}
T_2	0.17425^{a}	0.05850^{b}	0.050500^{b}	0.07500^{ab}	0.029000^{ab}
T_3	0.09100^{a}	0.20225^{a}	0.048750^{b}	0.10550^{a}	0.027250^{ab}
T_4	0.12300^{a}	0.06525^{b}	0.059500^{ab}	0.03500^{b}	0.024250^{ab}
T_5	0.15150	0.09525^{ab}	0.044250^{b}	0.07575	0.015250^{b}

Mean in the column, having the same letter(s) are not significantly different at P≤0.05, according to Least Significant Difference (LSD) method.

3.6. Effect of Treatments on Leaf Canopy Area (cm^2)

Table 6 shows the effect of rates of liquid fertilizers on leaf canopy area of soybean at 2, 4, 6, 8 and 10WAP. At 2WAP, there was no significant different among the treated plots and control. T_4 gave the highest (63.35cm^2) canopy area whereas the lowest (42.88cm^2) was obtained in T_3. There was significant different ($P<0.05$) on leaf canopy area in response to liquid fertilizer application at 2, 4, 6, 8 and 10WAP. It was observed that at 4 and 6 WAP T_2 recorded the maximum leaf canopy areas (263.77cm^2 and 613.64cm^2 respectively) which was significantly different ($P<0.05$) from lowest (108.63cm^2 and 341.94cm^2 respectively) obtained in T_2 and T_1 respectively as shown in Table 6 while At 8WAP T_4 gave highest leaf canopy area (1286.7cm^2) which was significantly different ($P<0.05$) from the values (702.4cm^2 in T_2, 773.9cm^2 in T_3, 778.7cm^2 in T_1 and 807.7cm^2 in T_5. However, at 10WAP, T_5 gave the maximum leaf canopy area of 2093.1cm^2 compare to the minimum in T_1 (1291.1cm^2). This was followed by T_3, T_2 and T_4 in that other.

Table 6 Effect of Treatments on Leaf Canopy Area (cm^2)

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T_1	53.79^a	160.92^{ab}	341.94^b	778.7^b	1291.1^b
T_2	54.95^a	263.77^a	613.64^a	702.4^b	1890.2^a
T_3	42.88^a	124.47^{ab}	589.1^a	773.90^b	1946.4^a
T_4	63.85^a	216.43^{ab}	520.46^a	1286.7^a	1713.2^{ab}
T_5	44.36^a	108.63^b	580.46^a	807.7^{ab}	2093.1^a

Mean in the column, having the same letter(s) are not significantly different at P≤0.05, according to Least Significant Difference (LSD) method.

3.7. Effect of Treatment on Yield and Yield Components

The response of yield and yield components to soil application of Ag-zyme liquid fertilizer is presented in Figure 1. Number of pods, weight of 100 seeds and yield were significantly varied among the various treatment levels.

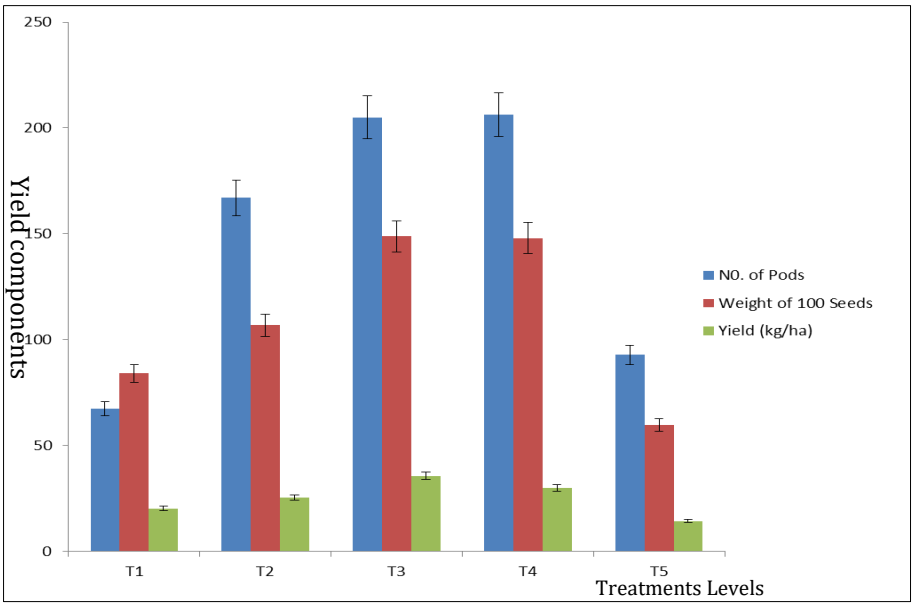

Figure 1 Effect of treatment on yield and yield components

Data analysis showed that T_4 recorded significantly highest number of pods (206.25) compares to the lowest (67.25) obtained in control. However, it was observed that T_5 recorded the lowest (92.75) mean number of pods among the treated plots.

T_3 was found to produce higher number of pods (205) than T_2 with 167 pods and T_5 with 92.75 pods.

Result on weight of 100 seeds revealed that T_5 have the lowest weight of 59.73g which was significantly different from the highest (148.78g) recorded in T_5. The weight 147.97g obtained in T_4 was statistically similar to the weight (106.75g) obtained in T_2 and 84.09g of seed weight recorded in control.

Data on yield showed that control had higher yield (20.178kg/ha) than T_5 with yield of 14.238 though statistically there was no significant different, however, T_3 recorded the highest yield of 35.595kg/ha which was significantly different ($P<0.05$) compare to the lowest (14.238kg/ha) obtained in T_5 plots, but statistically similar to intermediates yields (25.415kg/ha, and 29.415kg/ha) obtained T_2 and T_4.

4. Discussion

This study have revealed that soil application of Ag-zyme liquid fertilizer significantly improve the growth parameters vis plant height, number of branches, number of leaves, leaf area, leaf area index and leaf area canopy. The improvement in vegetative traits evaluated could be due to rapid absorption of nutrient already in solution form that are readily available for growth and reproduction of soybean. This finding is in conformity with findings of [16], who reported that shrimp liquid fertilizer had a positive effect on seedling growth, leaf chlorophyll concentrations, photosynthetic activities, and nutrient uptake efficiency. Also, some of the organic substances releases during the mineralization of soil conditioner may act as chelates that help in absorption of essential ions and other micro nutrients thus enhancing the release of nutrients to plant in soil would improve the beneficial effect of liquid organic fertilizers or bio-fertilizers as well as micronutrient [22]. Similarly, [19], reported that spraying with humic acid improve plant growth and yield.

The increase in the plant heights could be that the liquid organic fertilizer (Ag-zyme fertilizer) contain enough N.P and K that increase cell division and cell elongation that lead to improvement in the plant height of soybean crop. This is in line with observation by [23], who remark that treatment with liquid organic fertilizer showed improvement and development in plant height. Also [24], reported that liquid organic fertilizer contains all macro and micro nutrients for plants that have important role on plant growth and improving quantity and quality of crop production.

. The enhanced improvement in all the vegetative parameters measured could be as a result of readily available forms of N, P, K and Ca in rhizosphere of soybean due to application of liquid fertilizer resulting in synthesis of growth promoting physiological processes in plant. In this study the Ag-zyme organic liquid fertilizer contained the required balance nutrients necessary for growth, reproduction and development of soybean.[25.26], observed that the quality of crops given organic liquid fertilization depend on the nutrient composition and concentration in the fertilizer, crop species, type of growing medium used and root zone conditions.In addition, [27], reported that liquid fertilizer treatment had a positive effect on shoot height, which may be due to the modified availability of resources and significantly enhanced leaf growth of chrysanthemum, which contributed towards and advanced photosynthetic efficiency.

The higher number of pods, weight of 100 seeds and yield observed in T_2, T_3 and T_4 could be attributed to better supply of nutrient to the plant by application of Ag-zyme liquid fertilizer. In other hand, the increased in yield, number of pods and weight of hundred seeds could be attributed to enhance leaf production, branches leaf area, number of root, root length and uptake of macro element observed in the treated plots. Increase in the leaf area and leaf area canopy could have reflected increased the net photo assimilate production and thus increase in yield and seeds obtained in plots applied with 100ml (T_3) and 150 ml (T_4) of Ag-zyme liquid organic fertilizers. This assertion is in conformity with the work of [28], who reported that highest yield of lettuce was obtained in treatments of liquid organic fertilizer. In addition, increase number of pods and weight of seeds is in line with work of [23], who observed that the treatment with liquid organic fertilizer significantly improved number of pods per plant; weight of seeds per plant, and weight of 100 seeds, flowering and harvest age. Similarly [19], reported that spraying with humic acid improve plant growth and yield. Also exogenous application of seaweed liquid extract has already been shown to enhance plant growth, yield and its quality according to[29].

In this study, it would be deduce that supply of liquid organic fertilizer could have help to mitigate the effect of climatic weather such as temperature and poor soil moisture content due to late planting. It has been shown that planting date, temperature and poor soil water content could adversely affect soybean production irrespective of variety in use. This agreed with [30], who concluded that planting date, along with environmental conditions and the cultivars genetic potential did affect the growth development, yield of soybeans. The slightly poor vegetative growth and yield recorded during September – November planting could be due to effect of environmental conditions prevalent at that period. This is in conformity with works of [31,32], that yield trends of soybean across planting dates show progressively greater yield decline will occur in soybean production with delay in planting.

5. Conclusion

In this study the soil application of Ag-zyme liquid organic fertilizer during late planting of soybean has effectively mitigated the adverse effect of environmental factors by enhancing, plant height, leaf area, leaf area canopy subsequently increased yield compare to control. Also 100 ml and 150 ml of this Ag-zyme have been shown to perform better than other levels of treatment. We recommend the use of this Ag-zyme liquid organic fertilizer because it is cheaper; easier to use and apply, finally it is eco-friendly.

Compliance with ethical standards

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Disclosure of conflict of interest

Author declares no conflict of interest.

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