



Effects of Crop Bio-life on Growth and Yield of Wild Okra (*Corchorus olitorious* L.) in a Sub-tropical Environment

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Authors' contributions

This work was carried out in collaboration among all authors. Author NM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MTM and KAN managed the analyses of the study. Author PKW managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Crop bio-life is used as a foliar spray to enhance the symbiotic effect between roots and soil micro-organisms enabling the plant to better assimilate nutrients essential for growth. The aim of the study was to assess the effect of crop bio-life on growth, yield and quality of wild okra. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The experiment consisted of four treatments. The treatments were different crop bio-life concentrations of 0, 25, 50 and 75 ppm. The highest plant height (103.5 cm) was obtained in plants treated with 25 ppm crop bio-life and the lowest plant height (91.2 cm) was in plants treated with 75 ppm crop bio-life. Plants with the highest chlorophyll content (29.08 $\mu\text{mol per m}^2$) were those treated with 50 ppm crop bio-life while the lowest (18.6 $\mu\text{mol per m}^2$) was 0 ppm treatment. The highest wild okra yield of 22.3 g leaf wet mass was obtained in plants treated with 25 ppm crop bio-life and the lowest yield (12.9 g) obtained from plants applied with 75 ppm crop bio-life. From the results of this study, it was observed that the plants treated with 25 ppm crop bio-life grew better and had a higher yield, therefore, it is the treatment recommended to farmers.

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1. INTRODUCTION

Wild okra (*Corchorus olitorius* L.) is an indigenous leafy vegetable it has been an important vegetable in Egypt since the time of the Pharaohs, and it is from there that it gained its recognition and popularity [1]. Wild okra is an annual herb which belongs to the Tiliaceae family formerly known as *Malvaceae* family [1]. The genus *Corchorus* consists of 40-100 species that vary in many attributes, but all species are apparently highly fibrous. Other species also grown as leafy vegetables are *C. acutangulus* and *C. tridens* [2]. Wild okra is a popular leafy vegetable in West Africa and is thought to have originated in India [2]. It is widely consumed as a vegetable among rural communities in most African countries [3]. In West Africa, it is commonly cultivated and very popular among people of all classes especially in Nigeria [4]. It is also eaten in some parts of Asia [5]. Some of the Southern African countries like Zimbabwe, it is known as *derere* and in Swaziland it is widely known as *ligusha* and the parts which are usually consumed are the tender leaves. It usually grows in summer where there is sufficient rainfall and enough moisture for maximum leaf production. Temperature requirements ranges between 20-30°C [2]. Wild okra is usually regarded as a weed in Eswatini rather than a crop. This vegetable has formed part of food for most people especially in the rural areas and low income earning group in tropical and sub-tropical countries including Eswatini. Indigenous vegetables are important in human diets [6]. They supply the body with minerals, vitamins and certain hormone precursors in addition to protein and energy [6]. Ecologically, wild okra grows more easily in rural subsistence farming systems when compared to exotic species like cabbage and spinach [7].

Crop bio-life is used as a foliar spray to enhance the symbiotic effect between roots and soil micro-organisms enabling the plant to better assimilate nutrients essential for growth while simultaneously providing great carbon transfer to the soil. Crop bio-life by invigorating a plant's health enables plant's own immune system to cope with attacks from fungi, bacteria and environmental stress by the activation of phytoalexins, which is one of the series of plant responses resulting in early detection of lethal invading microorganism [8].

There is a rising need for consumption of indigenous crops due to the rise in numbers of ailing people in Eswatini due to the lack of certain nutrients which are found in large amounts in indigenous crops. This has necessitated a renewed interest of venturing into indigenous crops which have been previously underexploited and regarded as weeds. Wild okra is currently not grown in Eswatini, it grows unattended as a weed resulting in low yields. This study will be done in an attempt to commercialise wild okra production.

Crop bio-life is a revolutionary product that addresses many of the practical and environmental concerns associated with conventional agricultural chemicals. Being non-toxic, it has no withholding period and is safe for human health and the environment. Organic amendments offer a solution to a problem of nutrient loss through leaching and pollution of the environment associated with granular fertilizers. Granular fertilizers are expensive to purchase and are produced at a high cost and are detrimental to the environment. Organic soil amendments are available in most homesteads. At present there is little information on the effects of various organic soil amendments on growth and productivity of wild okra. The main drawback with soil amendments is that the nutrients are subjected to a slow release process. Since crop bio-life is a nutrient synergist, it is anticipated that it would enable a quicker release of nutrients from the soil amendments in a synergistic manner.

The objective of the study was to assess the effect of crop bio-life on growth, yield and quality of wild okra.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out at the Horticulture Department Farm at the University of Swaziland, Luyengo Campus. Luyengo is under the Manzini region, in the Middleveld agro-ecological zone. It is located at 26°34'S and 31°10'E with an average altitude of 750 m above sea level. The mean annual precipitation is 980 mm with most of the rain falling between October and April [9]. Drought hazard is about 40%. Luyengo has an average summer temperature of

about 27°C and winter temperatures of about 15°C. The soil at the experimental site was sandy loam soil [9].

2.2 Plant Materials

Soil was mixed with cattle manure at a rate 40t/ha three weeks before planting of seeds in the field. Wild okra seeds were planted on the 3rd of January 2018 after weeding using a herbicide two weeks before planting. To break seed dormancy the seeds were dipped in boiling water for 10 seconds then dried overnight the day before planting. Other seeds were planted on seed trays in the green house on the same date as on the field. This was done in order to provide backup seedlings in cases of disasters like hailstorms which was experienced a week after planting. Seedlings grown in the greenhouse were used to replant, which was after the seedlings were two weeks old. Crop bio life (Environmental Services Pty Ltd Lic. # 80046, Airport West. VIC, Australia) at different concentrations of 25, 50 and 75 ppm was applied a week after transplanting and thereafter at two week intervals. Manual weeding using hands and a hoe was done to remove weeds once they appeared during the growth of the plant.

2.3 Experimental Layout and Design

The Randomized Complete Block Design (RCBD) was used to conduct the experiment. The design of the experiment involved four treatments including the control and four replications (Table 1). Application of treatments began a week after transplanting (WAT). The treatments were as follows:

- i. Tr1: 0 ppm crop bio-life
- ii. Tr2: 25 ppm crop bio-life
- iii. Tr3: 50 ppm crop bio-life
- iv. Tr4: 75 ppm crop bio-life

Table 1. Field layout of the experiment

Block 1	Block 2	Block 3	Block 4
Tr1	Tr2	Tr3	Tr4
Tr2	Tr3	Tr4	Tr1
Tr3	Tr4	Tr1	Tr2
Tr4	Tr1	Tr2	Tr3

2.4 Data Collection

Three plants from each plot were sampled at random for data collection. Sampling of plants for analysis began 2 weeks after transplanting and continued after every week for four weeks.

Data was collected on the following parameters:

Leaf length, leaf width, roots length and plant height:

A 30 cm ruler was used to measure the length and width of the leaves. The length was measured from the point where the leaf forms an angle to the tip, while the width was measured from the widest part of the leaf. Plant height was measured by the use of 1 m ruler.

2.5 Number of Leaves Per Plant

Leaves of fully expanded wild okra were counted.

2.6 Leaf Area

Leaf area was calculated using the leaf length and leaf width which was collected at a two week interval. Leaf width and length was measured using a 30 cm ruler. Leaf area= leaf length x leaf width x 0.883 [10].

2.7 Leaf Area Index

The leaf area index (LAI) was determined by the leaf area of whole plant to the area occupied by one plant using the base area of plot as area occupied by one plant; LAI= LA/ area occupied by one plant.

2.8 Leaves and Root's Fresh and dry Mass

After completion of growth stage and results taken, three plants were placed in brown one-kg and taken to the laboratory to measure the root and leaf fresh mass. The masses were measured using an electronic scale (balance) which measures up to two decimal places. Thereafter the plant parts were then put in the oven (70°C) and were oven dried for 48 hours [11]. Then they were taken out to be measured for dry mass.

2.9 Soil Analysis

Soil samples were taken from the experimental site using the zigzag method [12]. Soil analysis for major nutrients like nitrogen, potassium and phosphorus were done at Luyengo Campus Chemistry Laboratory. Samples of 10 g of soil were weighed into 50 ml beakers and 20 ml 0.01 M CaCl₂ solution was added into each beaker.

The mixtures were allowed to equilibrate for 30 minutes before pH measurements were taken.

2.10 Data Analysis

Data was analysed using Genstat statistical package developed by a group of scientists under John Nelder at Rothamsted research in 1968 [13]. Data collected were subjected to analysis of variance (ANOVA) in a RCBD to evaluate the differences among treatments. Where significant differences were detected the means were separated using the least significant difference (LSD) test at 5% level of significance [14].

3. RESULTS

3.1 Soil Analysis

The chemical properties of the soil used in this study are shown in Table 2.

3.2 Plant Height

There were no significant ($P>0.05$) differences in the height of the plants sprayed with different crop bio-life concentrations. At 4 WAT, the

highest plant height was recorded from plants applied with 25 ppm crop bio-life and the lowest plant height was recorded from plants supplied with 75 ppm (Fig. 1).

3.3 Number of Leaves

There were significant ($p<0.05$) differences in the number of leaves due to different treatments at 1 and 3 WAT. The highest number of leaves was obtained from wild okra plants applied with 25 ppm of crop bio-life (Fig. 2). The lowest number of leaves was obtained from wild okra plants applied with 75 ppm at 4 WAT (Fig. 2). However, there were no significant ($P>0.05$) differences in the number of leaves of wild okra plants provided with different levels of crop bio-life at 2 and 4 WAT.

3.4 Chlorophyll Content

There were no significant ($P>0.05$) differences in the chlorophyll content in wild okra plants among treatments. At 4 WAT the highest chlorophyll content was obtained in plants sprayed with 50 ppm crop-biolife and the lowest was 0 ppm treatment.

Table 2. Chemical properties of the soil

Parameter	pH (soil)	Available Magnesium (mg/kg)	Available Potassium (mg/kg)	Available Phosphorus (mg/kg)	Available Calcium (mg/kg)
Value	5.37	0.355	0.236	0.070	0.321

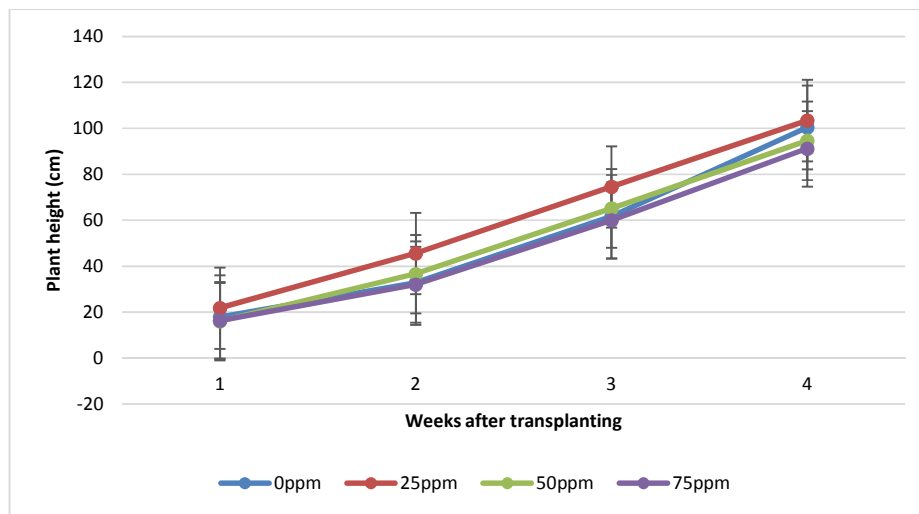


Fig. 1. Effect of crop bio-life on plant height of wild okra. Vertical bars are standard error (SE) bars below and above the mean

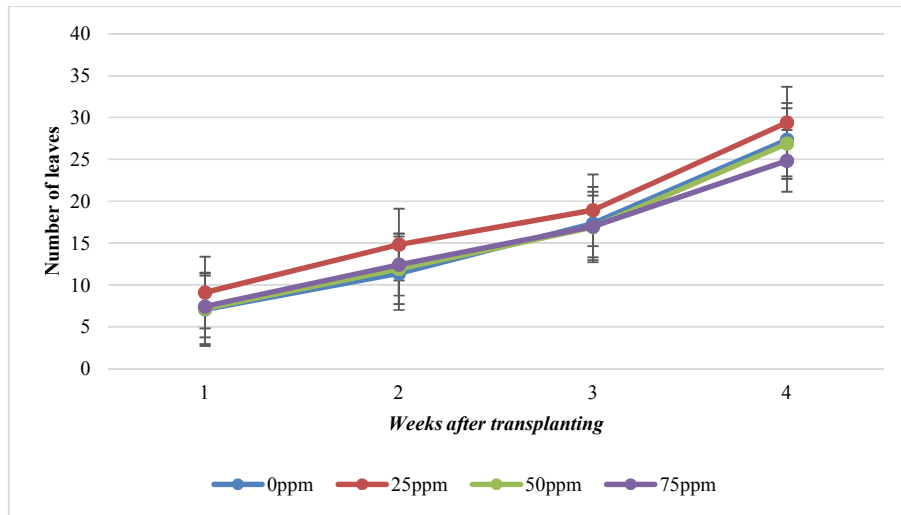


Fig. 2. Effect of crop bio-life on the number of leaves of wild okra. Vertical bars are standard error (SE) bars below and above the mean

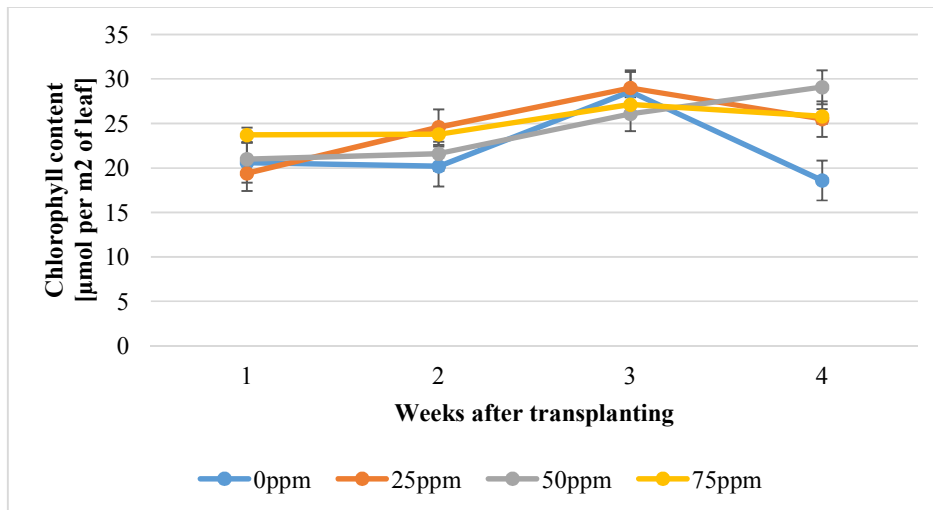


Fig. 3. Effects different crop bio-life on the chlorophyll content of wild okra. Vertical bars are standard error (SE) bars below and above the mean

3.5 Leaf Area

There were no significant ($P > 0.05$) difference in leaf area observed in wild okra plants at 1, 2 and 3 WAT. A significant ($P < 0.05$) difference was observed in plants at 4 WAT. At 4 WAT the highest leaf area was observed in plants treated with 25 ppm crop bio-life and the lowest was obtained from plants with 50 ppm crop bio-life (Fig. 4).

3.6 Leaf Area Index

At 1, 2 and 3 WAT, there were no significant ($P > 0.05$) differences in leaf area indices in wild

okra plants. Significant ($P < 0.05$) difference was observed 4 WAT. At 4 WAT the highest leaf area index (0.05) was observed in plants applied with 25 ppm crop bio-life (Fig. 5). The lowest leaf area index was obtained from plants supplied with 75 ppm of crop bio-life (Fig. 5).

3.7 Root Length

There were no significant ($P > 0.05$) differences in the root length of the plants sprayed the different crop bio-life concentrations. The highest root length was observed from plants treated with 25 ppm crop bio-life while the lowest root length

from those provided with 50 ppm crop bio-life (Fig. 6).

3.8 Leaf Fresh and Dry Mass

There were significant ($P < 0.05$) differences in leaf fresh mass in wild okra plants between the different crop bio-life treatments (Fig. 7). However, there were no significant ($P > 0.05$) differences in leaf dry mass among treatments (Fig. 7). The highest mass was obtained in 25 ppm treatment (22.3 g fresh and 5.38 g dry mass respectively) and the lowest mass was obtained in 75 ppm treatment (12.9 g fresh and 3.18 g dry mass respectively).

3.9 Root Fresh and Dry Mass

There were no significant ($P > 0.05$) differences in the root fresh and dry masses in wild okra

obtained after the different crop bio-life concentrations applied (Fig. 8). The highest root mass was obtained in 25 ppm treatment and the lowest mass was obtained in 75 ppm treatment.

4. DISCUSSION

There were no significant differences in the root length, dry mass and fresh mass. This was due to the fact that crop bio-life promotes leaf growth there by reducing root formation and growth. There results conform to the findings that stated that crop bio-life supports vegetative growth of strawberry [15]. That is why when conducting this study, it was shown that the promotion of vegetative growth occurred at the expense of root growth and development.

The leaf area and leaf area index of the plant showed a significant increase in the fourth week

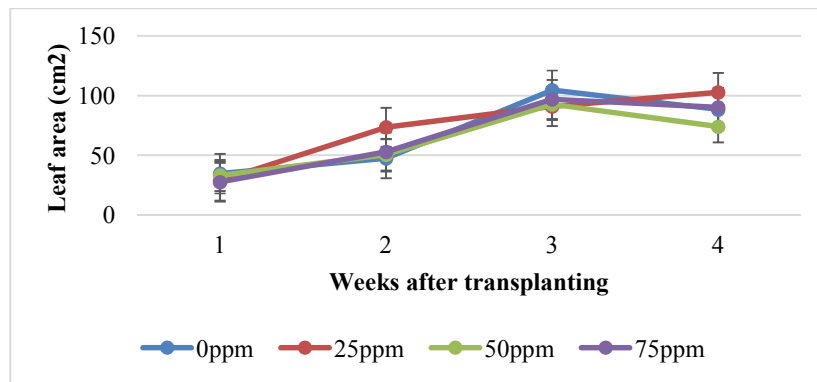


Fig. 4. Effects different crop bio-life on leaf area of wild okra. Vertical bars are standard error (SE) bars below and above the mean

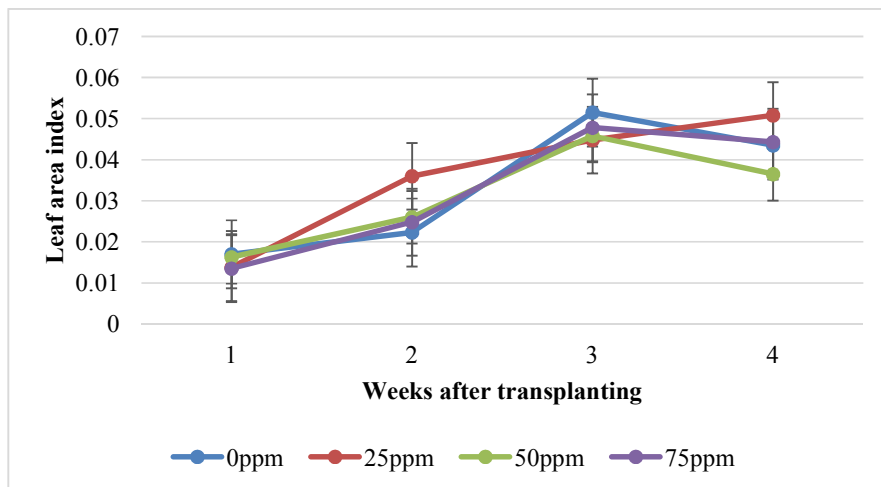


Fig. 5. Effects different crop bio-life on leaf area index of wild okra. Vertical bars are standard error (SE) bars below and above the mean

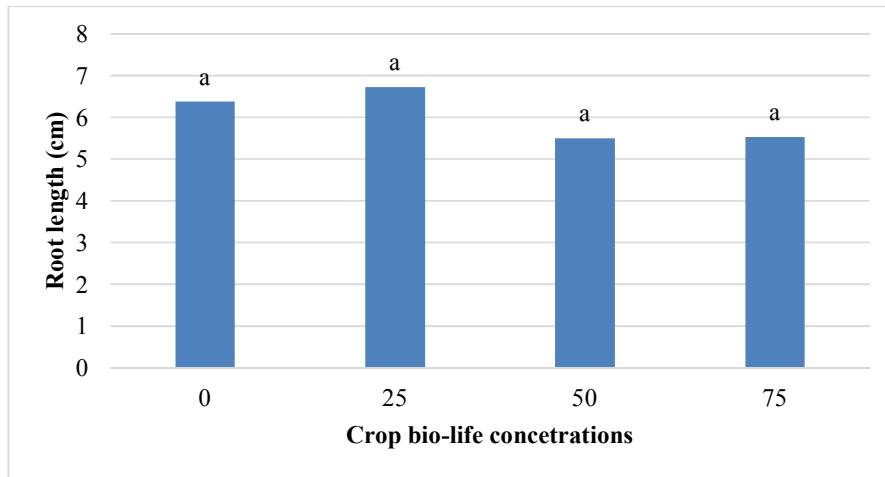


Fig. 6. Effect of crop bio-life on root length of wild okra. Bars with the same letter are not significantly different from each other. Mean separation by LSD at P = 0.05

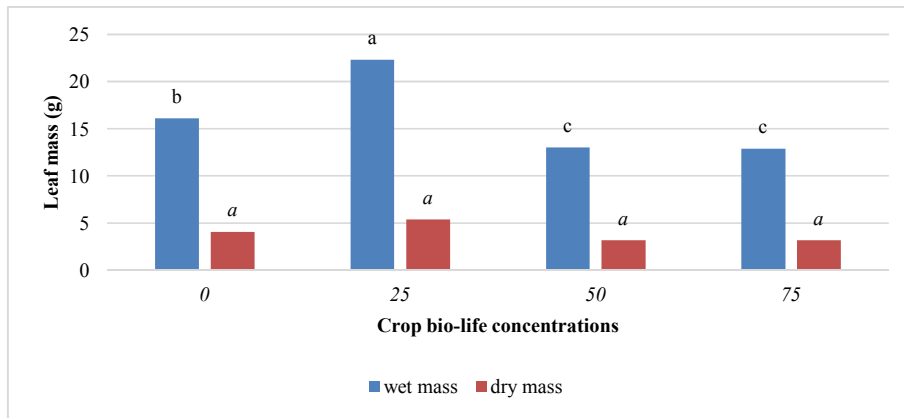


Fig. 7. Effects of crop bio-life on leaf wet and dry mass of wild okra. Bars with the same letter are not significantly different from each other. Mean separation by LSD at P = 0.05

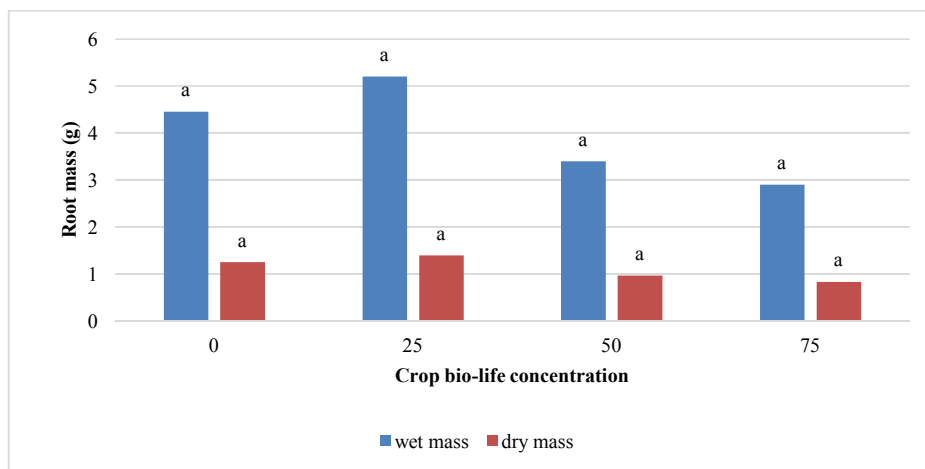


Fig. 8. Effect of crop bio-life on the root wet and dry mass of wild okra. Bars with the same letter are not significantly different from each other. Mean separation by LSD at P = 0.05

of data collection. This collaborated with the results obtained from a research on strawberry [16]. A higher leaf area index means that there would be high light interception that will result in an increase in the rate of photosynthesis for plant growth.

The plants leaf length showed a significant increase when treated with 25 ppm of crop bio-life in the first week. This increase was due to the first application or first introduction of crop bio-life to the plant resulting to an increase in the leaf length of the plants. There were no significant differences in all concentrations in the first three weeks of data collection which was probably as a result of heavy rains that could have reduced the concentrations of the crop bio-life leading to irregular fluctuations thereby causing no significant differences in the results. The increase was a result of an increase in the nitrogen content which led to the formation of nodes and internodes [17]. This also led to an increase in the number of leaves. The highest number of leaves was obtained in 25 ppm treatment which was recorded in week one and three.

There were no significant differences in the chlorophyll content of all the plants treated with different crop bio-life concentrations. This could probably be as a result of environmental factors like a change in soil pH, iron and magnesium deficiencies [18], pathogen invasions since the soil was later discovered to have bacterial wilt pathogen. The chlorophyll meter values are based on light absorption by the leaf chlorophyll at specific spectral bands. Changes in the chlorophyll content reduction can also be caused by environmental stress, exposure to herbicides and exposure to certain light differences as a result of the changing weather [19]. Peng et al. [20] found that most within-species variation in relationships between chlorophyll content could be explained by differences in leaf thickness and how they perceive light.

Leaf width at week 3 and 4 WAT showed significant differences. Crop bio-life increases the vegetative growth of plants which is why the treated plants showed a significant increase in the width of the leaf [17]. The fresh and dry leaf mass had no significant differences. Crop bio-life results in enhanced vegetative growth and dry matter accumulation [21]. This contradicts with the results obtained from this study which had a low dry and fresh leaf mass. Bio-stimulants like crop-bio-life may work up to certain thresholds

beyond which they may start to have inhibitory effects.

5. CONCLUSION AND RECOMMENDATION

Plant bio regulators do have an effect on the production and growth of wild okra. The application of crop bio-life showed a significant difference in the leaf length, leaf width, leaf area and leaf area index and lastly in the number of leaves produced. With an increase in the concentrations of the crop bio-life the plants showed no significant differences.

Farmers are advised to apply 25 ppm treatment of crop bio-life to wild okra in order to produce higher yields. Other studies should be done to confirm this findings which will have crop bio-life concentrations of 5 ppm, 10 ppm, 15 ppm, 20 ppm and 25 ppm treatments. These will prove that wild okra plants perform well in crop bio-life treatments that have low concentration opposed to the higher concentrations. A similar study should be done in the future to test nutrient content and the post-harvest effects of crop bio-life on wild okra.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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