Plant Growth Promotion Potential of Biofertilizer Produced from Microalgae Chlorella Vulgaris in Zea Mays

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Abstract

This study investigates the potential of biofertilizer produced from the microalga *Chlorella vulgaris* to promote maize (Zea mays) growth, as a sustainable alternative to inorganic fertilizers. The research addresses the global challenge of increasing food production on limited arable land while minimizing environmental impact. Microalgae were cultivated using various substrates, including organic waste (poultry droppings and sewage) and inorganic components (NPK fertilizer), and processed into biofertilizer. These biofertilizers were applied to maize crops, and their effects on growth parameters such as plant height, leaf and shoot development, and biomass accumulation were monitored over a 90-day period. Results indicated that maize treated with *C. vulgaris* biofertilizer showed significant improvements in growth indices, comparable or superior to conventional inorganic fertilizer. Notably, organically cultivated maize demonstrated better shoot development and yield, with a 36% increase in plant height relative to controls. The study also highlights *C. vulgaris's* capacity to enhance soil fertility by supplying essential nutrients, reducing pollution, and supporting sustainable agriculture practices. The findings suggest that *Chlorella vulgaris* biofertilizer is a cost-effective, environmentally friendly, and efficient alternative that can contribute to increased crop productivity and soil health, promoting sustainable farming systems.

Keywords: Microalgae, Agricultural Waste, *Chlorella vulgaris* and plant growth.

Introduction

The practice of shifting cultivation as an agricultural process arose as an answer to the problem of reduced subsequent yield of a farm after the first planting and harvesting, but because of limited land mass, this practice was not practicable. With the global increase in population, there's a challenge to produce more food from the highly reduced arable land at a lesser cost. Thus, began the search for a way to maintain or even enhance the yield of a farm. Farmers began to enrich their land with animal dung and sewage, with the advent of science, the knowledge of nitrogen, phosphorous and potassium (NPK) as the key elements of plant nutrition was established.

DOI: https://doi.org/10.5281/zenodo.16677486

Currently, the race towards increased food production is being propelled using chemicals, pesticides and fertilizers. This was widely accepted until studies started showing up some of the implications of the use of chemical substances on crop production. Nature has a way of replenishing the soil after continuous agricultural practice. One of such methods is the activities of leguminous plants in improvement of soil fertility. This process has been utilized even from ancient times although unknowingly and has been very important in biological nitrogen fixation. Thus the need for increased crop production has necessitated the commercial exploitation of this biological process. Nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms are responsible for this fixation through application to seed, soil or composting areas, (Mazid, M., Khan, T.A and Mohammad, F., 2011a).

Majority of known nitrogen fixers are bacteria, current commercial exploitation of these processes using bio-fertilizer are geared towards the use of other organisms other than bacteria. The essence of bio-fertilizer is to offer a safe option to utilize renewable materials to improve the fertility of land using biological wastes with beneficial micro-organisms which impart organic nutrients to the farm produce, (Khan, T.A., Mazid, M. and Mohammad, F., 2011a).

Bio-fertilizers have been defined as biologically active products or microbial inoculants that are formulations containing one or more beneficial bacteria, fungal strains or any other microorganism in easy to use and economical carrier materials which add, conserve and mobilize crop nutrients in the soil, (Mazid and Khan 2014). The term also refers to substances containing living microorganisms which when applied to seeds, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the availability of primary nutrients to the host plant, (Mazid *et al*, 2011a). Bio-fertilizers are organic in nature and increases soil fertility through their decay. The microorganisms, which are used as bio-fertilizers belong to families of bacteria, BGA (blue-green algae) and other algae species and fungi. They are also called bio-inoculants which on supply to plants improve their growth and yield (Khan *et al*, 2011a).

Biofertilizers have important and long term environmental implications, negating the adverse effects of chemicals. Moreover, Biofertilizers can act as a renewable supplement to chemical fertilizers and organic manures. They have the capacity to produce natural resistance in plants against pests and soil borne diseases, because antibodies are produced and beneficial micro-organisms participate in the soil to increase fertility (Board, 2004).

Wrong and untimely application of chemical fertilizers is known to adversely affect the natural balance of the ecosystem and the environment at large and also cause a decline in crop production, (Bohlool *et al*, 1992). Thus there is need to reduce the dependence on chemicals and substitute with economically and environmentally viable option, thus the option of bio-fertilizer.

This study aims at investigating the plant growth promotion potential of the microalgae *Chlorella vulgaris* grown from inexpensive organic materials (poultry droppings and sewage) and inorganic materials, investigate and demonstrate the use of the microalgae as a bio-fertilizer and its impact on growth of *Zea mays* as a test crop.

Materials and Methods

Seeds of *Zea mays var* L used were procured from the seed unit of National Root Crop Research Institute, Umudike, Abia State This research was carried out using a pure culture of *C. vulgaris*. Different substrates; chicken waste, cow dung, NPK fertilizer and microalgal growth medium BG 11 were filtered separately and used to culture *C.*

DOI: https://doi.org/10.5281/zenodo.16677486

vulgaris which was later used as biofertilizer for the growth of *Zea mays*. C. vulgaris culture method was according to, Ukogo, et. al. (2025). Culture system was maintained over a period of 3 weeks (21 days). Biomass produced was harvested on day 8 by allowing the system to sediment without stirring on day 7, then decanted, filtrate was passed through 0.5mm filter and allowed to dry under room temperature. The biomass obtained was crushed to powder using mortar and pestle. A washed, dried and sterilized peat was used as a carrier in the ratio of 2:1 peat/biomass. All supplementation was used 2 times during the course of crop growth in the same quantity of 15g measure of each treatment, giving a total of 30g treatment for each plant throughout the course of the study. This measurement which contains 5g of biofertilizer and 10g of carrier material ensures that each application contains 5g measure of biofertilizer. First 5g treatment was applied 14 days after germination, while the second 5g treatment was followed 14 days after the first treatment. A total of 10 plants per treatment were used as sample. The field experiment was conducted in a randomized block design of 6 treatments and 10 replications. A grid method of farm design was employed. Total area measuring 12m x 12m in length was demarcated into 6 smaller grids representing each treatment plot measuring 2 x 2 meters each. The treatments applied were dried biomass of *Chlorella vulgaris* grown from different substrates; Chicken substrate, Salt substrate (BG 11 medium), Fertilizer as growth substrate, Commercial *C. vulgaris*, NPK 2010 and Control/ no treatment designated as; A, B, C, D, E and F. Treatments A, B, C are plots treated with *C. vulgaris* grown in different substrates, E is treatment plot cultivated with only NPK fertilizer, while F is control plot with no treatment.

The bio-fertilizer application method used was main field application method using a rotary hole marker, 2cm holes round each sample plant root were marked separately in each of the treatment plots. Method of application adopted was according to Fiato, Yuhan, Allen and Zhao (2014). *C. vulgaris* effect on crop production was examined through rate of root, shoot, and leaf growth. This measurement was gotten from measuring 10 randomly selected plants from each plot, from the base to the tip using a measuring tape. Measurement was in three replicates between days 20, 40 and 90 at maturation.

Other measured variables included; plant nutrient profile. Samples used for the analysis; *Z. mays* leaves and roots, were collected manually from each of the six experimental treatment plots in two replicates. Using a shear, leaves and were strategically collected from plots A – F, roots were gently pulled up from the soil, passed through running water to remove the clinging soil and root tissues were cut out, allowed to air-dry, bagged in zip lock bags and properly labelled for analysis. This was air dried and weighed, further drying in the oven was done and weighted and ground into powder for further analysis. **Leaf and Root analysis** was according to the method by (Shah, *et al* 2015), nutrient availability and uptake by the plants were measured through NPK analysis of the vegetative parts. Cob size measurement were also taken. Method of determination of the anions was adopted from Thangiah, (2019). Potassium concentration was determined using AAS Perkin – Elmer model. Calcium and magnesium determination was by EDTA complexometric titration method. Sodium was determined by the method according to, Grant & Osanloo (2014). The method of determination of nitrogen was by the Kjeldahl distillation technique according to Bremmer and Mulvaney, (1986).

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Results and Discussion

Treatmenteffectof Microalgalbiofertilizer on Test Crop

Results from table 1 shows growth profile of test crops from the different treatment plots at 20-days and 40 days post planting. The shoot and leaf count for ten randomly selected plants in all the experimental plots 20 days after germination and 6 days after initial treatment. All experimental plots had an average of two leaves, ranging between 1 – 2 in plot A, 2 – 3 in plots B, C, E and F and 1 – 3 in plot D. Average shoot lengths ranged from 6.26 – 8.05cm in plots D and B respectively. All plots on the average showed same growth pattern and rate in leaf formation. Same is applicable to shoot development except for plots B that showed an average shoot length of 8.05cm which was 28.6% higher than most, 19.6% higher than control plot F and 5.64% higher than inorganic fertilizer plot E.

40 days after germination, 6 days after the second treatment and 28 days after initial treatment, results collected from same 10 randomly selected plants as used in the first treatment from the different treatment plots showed average leaf count range of 3 – 8 in plot A, 4 – 8 in plot B, 5 – 8 in C, 4 – 7 in D and F, 5 – 9 in E. Plots C (*C. vulgaris* grown in NPK substrate) and E, treated with inorganic fertilizer showed better leaf count after second treatment with mean leaves count of 7 in each treatment. Mean leaf counts of plots A and B were closely related while that of Plots D (commercial *C. vulgaris*) and F (control) were the same in terms of leaf formation after the treatment and performed lower than all the other plots.

In shoot length development after second treatment, shoot lengths ranged from 13 – 65cm in A, 22 – 71.4cm in B, 43.5 – 66.5 C, 31 - 62.3cm D, 24.3 – 65cm in E and 35.5 – 56cm in F. An overall shoot range of 13 – 71cm was observed from plots A and B respectively. Average shoot lengths ranged from 42.85cm in plot F (control) – 58.6cm in C (*C. vulgaris* grown in NPK substrate), which is a 36.8% increase in length from the control. This was followed by shoots from treatment plot E which is 16.7% higher than the control and 14.6% lower than plot C samples. Other treatment plots showed; 2.68% A, 10.15% B, 11.1% D increase in average shoot length from control.

Table 1: Table showing the mean growth rate of *Zea mays* shoot and leaves 20 and 40th days after planting in the different treatment plots A – F

	S 20DAP	L 20DAP	S 40DAP	L 40DAP
A	7.65±1.45	1.70±0.48	44.00±17.00	6.30±1.42
B	8.05±0.48	2.10±0.32	47.24±20.41	6.20±1.75
C	7.44±1.74	2.10±0.32	58.58±7.20	6.80±1.03
D	6.26±2.39	1.90±0.57	47.63±10.79	5.90±0.99
E	7.62±1.48	2.20±0.42	50.02±11.84	6.90±1.45
F	6.73±1.65	2.20±0.42	42.85±9.50	5.60±0.97
Mean	7.29±1.68	2.03±0.45	48.40±13.80	6.28±1.33
CV	22.38406	0.3858392	27.75355	20.71684
LSD	1.463419 NS	21.16384 NS	12.165 NS	1.167124 NS

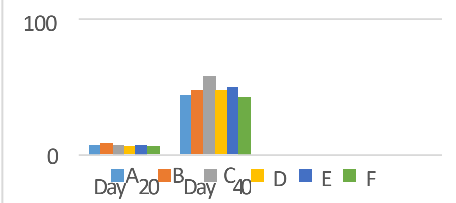

Fig. 1: Chart showing growth pattern (plant height) of Z.mays cultivated with *C. vulgaris* 20 and 40 …

DOI: https://doi.org/10.5281/zenodo.16677486

Fig. 1 shows the average growth pattern of *Z. mays* cultivated with *C. vulgaris* 20 and 40 days post planting. At 20 days post planting, most of the treatments showed plant height range of 6.26 – 8.05 with an average height of 7.29. Day 40 shiwed a range value of 42.85 - 58.58cm with an average height of 48.38cm. Control plot had the lowest value in both 20 and 40 days post-planting, while treatment C showed the highest leaf increase at day 40.

Tables 2 and 3 shows the result of data from tissue analysis (leaf and root) of maize plants cultivated with the different *C. vulgaris* biofertilizer samples. Result shows that treatment plot B had the highest leaf accumulation of N (3.58) which is an increase of 2% from control treatment F value and P (24.24%) increase from control. Treatment D had the lowest uptake of N in leaf (2.74) 21.9% decrease from control but had the highest K uptake (0.83) a 13,7% increase from control value. Nitrogen was more present in roots from treatment B (3.09) which is a 15.7% increase from control value of 2.67 as observed in leaves from this same treatment but showed a Phosphorus reading of 0.41 a 10.9% value lower than control. This was a deviation from observed values found in leaves from the same treatment plot. Potassium was found present in more quantity in roots from treatments A (1.21), B (1.16) followed by D (1.01) and least in E (0.76), which was a little lower than F (0.88). Treatment F which was the control plot had the least amount of accumulated N (2.67) and sodium (0.20) in the root. It also showed a lesser quantity of potassium accumulation in the root compared to the leaf.

Observation from results from the tables show that nitrogen and phosphorus were higher in the leaf compared to the root. Highest nitrogen value of 3.58mg/L was observed in the leaf from treatment B (which is the BG 11 substrate grown *C. vulgaris*), while the lowest value of 2.74mg/L was observed in (treatment D) commercial *C. vulgaris*. Nitrogen root values ranged from 2.67mg/L (lowest value) found in control plot (treatment F) to 3.09mg/L in treatment B. Mean leaf nitrogen values of 3.30 and 2.85 mg/L were observed for both leaves and roots respectively. Observed Phosphorus values ranged from 0.49 (plot C) – 0.66mg/L (plot B) in leaf and 0.41mg/L (plot B) – 0.51 (plot E) in root with mean values of 0.54 and 0.46mg/L for leaves and roots. Potassium values observed were in the ranges of 0.69 (plot C) – 0. 83mg/L (D) and 0.76 (E) – 1.21 (A) for leaf and roots respectively, with a mean value of 0.74 for leaves and 0.99 for roots. This shows a total mean NPK values of 3.3:0.54:0.74 for leaf and 2.85:0.46:0.99 for roots, thus N and P were accumulated more in leaves than in roots while K was more in roots. Results showed that average leaf accumulation of Nitrogen and Phosphorus were higher in leaves than in root. All experimental plots also recorded a higher Phosphorus and Nitrogen value in leaf than in roots except plot D where Nitrogen was 7.7% higher in root (2.95) than in leaves (2.74). Potassium value was however higher in root in all experimental plots than in leaves. Leaves stored higher values of Magnesium in all the plots than roots, this is an indication that the experimental plant retained more potassium in their roots while retaining more magnesium in their leaves. Roots storage of Sodium was higher in plots A, B. D and F. Plot C had same Sodium value for both roots and leaves (0.26) while Plot E was slightly higher in leaves than in roots. Calcium values were higher in roots in plot A only, while leaves had greater Calcium storage in the remaining plots.

Statistically, uptake of P by treatment C and D were not significant. Mg presence in leaves from treatment plots C and E were not significantly different while observed Sodium in B, D, E and F were same. N accumulation in roots from treatment C and E were not

DOI: https://doi.org/10.5281/zenodo.16677486

significantly varied while N accumulation in the rest of the treatment plots showed a significant difference in their quantities.

Results from table 4 below shows the mean values of the results of the effect of the different treatments on the test crop at maturation. Result shows that *C. vulgaris*-based bioferilizers from treatment plot B performed better than even inorganic fertilizer (E) in average plant height. All other *C. vulgaris*-based treatments performed better than the control which had the least performance output of (99.2cm). In average leaf formation, treatment C, closely followed by A which are also *C. vulgaris*-based treatments had the highest mean leaf count of 11.0 and 9.5 followed by inorganic fertilizer treatment E (9.25). The least mean leaf count of 8.75 was recorded in commercial *C. vulgaris* (D). Average cob size recorded which is an indication of yield showed the best soil enhancers in the study as *C. vulgaris*-based treatments A, C and B in that order with cob sizes of 12.0cm, 11.0 and 10.0cm respectively. Treatment B value slightly fell lower than E while the control showed the least recorded mean cob size of 8.5cm.

Results from table 1 showed plant height growth range of 3 – 36% which is an indication that maize plants used in the study grew in lengths of between 3 – 36% by day 40. Highest plant length was in plot C, followed by E, D and B. This is similar to the study by University of Texas using *C. vulgaris* for tomato and herb cultivation which found out that the plants grew 21% taller and yielded 25% more than plants grown in their control beds, which is a suggestion of the fact that *Chlorella* species improve crop production compared to commercial inorganic fertilizer. However, the plant height increase observed at day 40 was a little similar to that of Vyomendra and Kumar (2016), that found out that treatment of maize plant with biofertilizer showed a 48.21% increase in plant height after 60 days, 61. 84% increase in potassium content and increased leaves number compared to the control.

Results of mean shoot length showed that *C. vulgaris* combination with NPK performed better

than all the other treatments after the second application. *C. vulgaris* based treatments had better

shoot development than the control (44.00, 47.24 and 58.58 for A, B and C respectively against

the 42.85cm of the control), followed by plot E (inorganic fertilizer plot). This agrees with Chen

et al (2011), who noted that plants performed better when a co-treatment of inorganic fertilizer and

microalgae were used and also is in agreement with the study carried out by Surindra, Suther and

Rashmi, Verma, (2018).

According to Haroun and Husseni, (2003), their study, attributed the increase in shoots to the

secretion of plant growth regulators by the algae. The observed significant increase in plant shoot

in response to the different treatments are in good conformity with the increase in growth and plant

length as well as NPK content. In agreement with these results, Adams, (1999), observed significant increase in growth parameters and nitrogenous compounds in some plants treated with

biofertilizers and he attributed the increase to nitrogenase as well as nitrate reductase activities of

the microalgal treatment.

Plots D (commercial *C. vulgaris*) and F (control) were the same in terms of leaf formation after first treatment and performed lower (5.9 and 5.60) than all the other plots, an improvement of 50.8%, 45.2%, 61.8%, 48.3%, 34.1% and 42.9% for treatments A, B,

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C, D, E and F at the time of maturation from the results observed after the second

Treatment	N (%)	Ca (%)	Mg (%)	K (%)	P (%)	Na (%)
A	3.37±0.01[c]	3.62±0.01[e]	1.39±0.01[a]	0.75±0.01[b]	0.56±0.01[b]	0.29±0.01[a]
B	3.58±0.01[a]	3.93±0.01[c]	1.29±0.01[c]	0.76±0.01[b]	0.66±0.01[a]	0.19±0.01[c]
C	3.30±0.01[d]	4.11±0.01[a]	1.10±0.01[e]	0.69±0.01[d]	0.49±0.01[d]	0.26±0.01[b]
D	2.74±0.01[e]	4.03±0.01[b]	1.35±0.01[b]	0.83±0.01[a]	0.51±0.01[d]	0.20±0.01[c]
E	3.30±0.01[d]	4.02±0.01[b]	1.10±0.01[e]	0.71±0.01[d]	0.53±0.01[c]	0.21±0.01[c]
F	3.51±0.01[b]	3.83±0.01[d]	1.24±0.01[d]	0.73±0.01[c]	0.50±0.01[d]	0.19±0.01[c]
Total	3.30±0.28	3.92±0.17	1.24±0.12	0.74±0.05	0.54±0.06	0.22±0.04
CV	0.2145999	0.1804611	0.5702474	0.9512647	1.313511	2.446912
LSD	0.0173023***	0.0173023***	0.0173023***	0.0173023***	0.0173023***	0.0173023***

treatment. Leaf formation analysis showed average leaf performance at maturation as C≥A≥E≥B≥D≥F. This shows an improvement in leaf count in *C. vulgaris* treatment compared to the control. This results conforms to the findings of Vyomendra and Kumar (2016), who observed better leaf count in *C. vulgaris* treated maize plants.

The observed corn cob at maturation showed the corn cobs from treatment A had a 41.2% increase from control plot F and 14.3% increase from inorganic fertilizer treated plot E. whereas plot B showed 5% increase from plot E and 17.64% from F. Treatment C showed a 29.4% increase in average cobs size from F and a 4.8% from E, while treatment D recorded a 10.5% difference in size in observed cobs from treatment E and an 11.8% increase from treatment F. Treatment E average cobs were 23.5% higher than control plot F. This shows treatment performance as A≥C≥E ≥B≥D in cob performance against control F while treatments A and C outperformed the inorganic fertilizer plot E, B showed a 5% decrease in performance compared to plot E.

Table 4: Table showing the average plant height, leaf width and cob size of *Zea mays* at maturation 90 days in the different treatment plots.

Treatment plots	Plant height (avg.)	Leaf	Cob size
A.	127.0	9.5	12.0
B	109.5	9.0	10.0
C	112.0	11.0	11.0
D	104	8.75	9.5
E	118.0	9.25	10.5
F	99.2	8.0	8.5

Table 2: Table showing nutrient content of leaves of samples from plots A – F

DOI: https://doi.org/10.5281/zenodo.16677486

Table 3: Table showing nutrient content of Roots of samples from plots A – F

compared with the *C. vulgaris* biofertilizers thus agreeing with the findings of Vyomendra and Kumar(2016).This

Treatment	N (%)	Ca (%)	Mg (%)	K (%)	P (%)	Na (%)
A	2.82±0.01^{d}	4.11±0.01^{a}	1.17±0.01^{a}	1.21±0.01^{a}	0.48±0.01^{b}	0.36±0.01^{a}
B	3.09±0.01^{a}	3.22±0.01^{d}	1.10±0.01^{b}	1.16±0.01^{b}	0.41±0.01^{d}	0.28±0.01^{b}
C	2.88±0.01^{c}	2.93±0.01^{f}	0.98±0.01^{d}	0.96±0.01^{d}	0.46±0.01^{c}	0.26±0.01^{c}
D	2.95±0.01^{b}	3.11±0.01^{e}	1.04±0.01^{c}	1.01±0.01^{c}	0.48±0.01^{b}	0.25±0.01^{c}
E	2.74±0.01^{e}	3.62±0.01^{b}	0.92±0.01^{e}	0.76±0.01^{f}	0.51±0.01^{b}	0.23±0.01^{d}
F	2.67±0.01^{f}	3.41±0.01^{c}	1.17±0.01^{a}	0.88±0.01^{e}	0.46±0.01^{a}	0.20±0.01^{e}
Mean	2.85±0.14	3.40±0.40	1.06±0.10	0.99±0.16	0.46±0.03	0.26±0.05
CV	0.2478178	0.2082789	0.6681324	0.7124502	1.52613	2.702319
LSD	0.0173023***	0.0173023***	0.0173023***	0.0173023***	0.0173023***	0.0173023***

DOI: https://doi.org/10.5281/zenodo.16677486

Table 3: Table showing nutrient content of Roots of samples from plots A – F

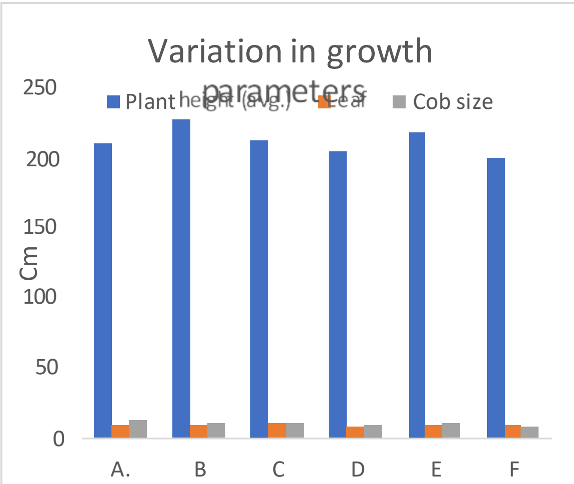

FIG 2: graph showing variation in growth parameters in plant height, leaf length and cob size.

The positive and negative control plots (E and F) had the least amount of Potassium as well as Nitrogen and Sodium when compared with the *C. vulgaris* biofertilizers thus agreeing with the findings of Vyomendra and Kumar (2016). This observed growth in biofertilizer crops is as a result of the presence of special sets of biologically active compounds including; plant growth regulators which are useful in shoots and roots development as well as in other things, Ordog, (1999).

Numerous studies such as that of (Shariatmadari *et al.*, 2011 and Koliei *et al.*, 2012) observed that biological fertilizers have the ability to change soil nutrients, improve seed germination, plant growth as well as yield. El- Shanshoury and Hamada (1988), reported that the mineral content of *Zea mays* were enhanced by treatment with extracts of biofertilizers. The study also observed a marked increase of ammonia – N, amide – N and total soluble N compared to the control. This reported increase was attributed to the activities of nitrogenase and or nitrate reductase activity of the microalgae. *C. vulgaris* biofertilizer in plot C performed better than inorganic fertilized plot, control plants were found to be shorter in heights compared to plants in other treatments. Nevertheless, both organic and inorganic treatments didn't show much impact on the shoot development at the early stage, agreeing with the result from study from Shah, *et al.*, (2015) that showed that organic and inorganic treatment didn't significantly influence days to emergence of maize plant. However, Plant height result showed a significant difference in the influence of organic and inorganic treatment on it.

Vyomendra and Kumar (2016), in their study showed a 90.86% increase in plant weigh and 73.97% increase in phosphorus when two algal species were used, Hanan, (2014). Thus, it is recommended that a combined algal mixture study be looked into. The process of microalgal biofertilization is a natural means of increasing plant growth and yield through adding nutrient to soil for the purpose of plant growth. this has a tremendous impact in decreasing pollution and soil contamination due to the totally natural nature of the treatment. Thus, this biofertilization process can be viewed as a great substitute for chemical fertilization.

5.2.Conclusion

In times like this, when hunger and food insecurity is prevalent in many parts of the world, efforts to improve the yield and availability of stable food should be given top priority. This study has shown that microalgae *C. vulgaris* grown from easily accessible substrates can improve maize plant growth indices comparable to inorganic NPK fertilizer. Different substrates used to grow the *C. vulgaris* ranged from animal waste to inorganic component and fertilizer.

Organically fertilized maize plants showed better shoot development than inorganically treated plot and the plants were discovered to

DOI: https://doi.org/10.5281/zenodo.16677486

grow 36% taller in height compared to the control within approximately 90 days of planting. However, *C. vulgaris* that was grown from NPK substrate was found to outperform all the other *C. vulgaris* samples on the whole. This result suggests that in as much as there is an advocating on the reduced use of inorganic fertilization, its use in microalgal growth for crop cultivation is an interesting concept that should not be ignored.

Finally, organic fertilization using *C. vulgaris* has been shown to produce better results both in terms of crop growth and output but also in terms of soil health. Similarly, the indication of its' better productivity in comparation with inorganic fertilization also strongly leans towards its acceptance as a better and cheaper alternative to inorganic fertilizer. as it does not only increase plant growth and yield but also impacts positively environment in general as well as being a cheaper and healthier alternative to the inorganic fertilizer. The study revealed and confirmed that good quality and efficacious biofertilizer can be successfully produced from *C. vulgaris* microalgae.

Based on the findings of this study, it is therefore recommended that; large scale animal farmers be educated on the possible uses of animal waste in organic agriculture and its possible disposal route as a substrate for *C. vulgaris* culture as a biofertilizer for crop production. Researchers should be aware of the different modes of presentation of biofertilizer and *C. vulgaris* microalgal fertilizer in order to proffer suggestions to local farmers and farmers cooperatives on the easier and better methods of application and use of the biofertilizers. The massive production of *C. vulgaris* in and around homes should also be encouraged for small holder farmers by the department of agriculture as a veritable option for the growth of organically produced plants for home use.

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