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Growth Parameters of *Zea mays* (Maize) and *Talinum triangulare* (Water Leaf) in Variable Iron and Potassium Growth Media

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigates the effects of soil heterogeneity and nutrient fortification on the growth rates of two important food crops - maize (*Zea mays*) and waterleaf (*Talinum triangulare*). With increasing population pressures and climate change impacts posing challenges to food security, strategies are needed to improve crop yields, especially in developing economies. The research conducts greenhouse trials to measure plant growth parameters in simulated potassium and iron-fortified heterogeneous, homogeneous, and control soil treatments. Key growth parameters like number of leaves, stem height and leaf area were measured weekly for both crops across the different treatment conditions. The mean weekly longest leaf length of *T.triangulaire* in the control, homogenous and heterogenous treatments were 1.71cm, 1.47cm and 1.79cm respectively while

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that of *Zea mays* were 22.65cm, 18.63cm and 15.70cm respectively. Similarly, the mean weekly stem height and stem width were 0.33cm, 0.65cm, 0.56cm and 0.81cm, 1.24cm, 1.29cm for the control, homogenous and heterogenous treatments of *T.triangulaire* while that of *Zea mays* for the mean weekly stem height and leaf width were 10.00cm, 6.44cm, 6.08cm and 2.11cm, 1.42cm, 1.46cm for the control, homogenous and heterogenous treatments respectively. There was no significant difference (p >0.05) in the growth parameters of *Zea mays* between treatments. Similarly, no significant difference was observed in the growth parameters of *T.triangulaire* between treatments. However, there was a significant difference (p>0.05) in the growth parameters of both crops. This suggests a species-specific response to spatial distribution of nutrients. The study aimed to understand how soil heterogeneity, when combined with nutrient amendments, influences plant growth dynamics. Findings from this work could guide nutrient management strategies and inform efforts to improve crop productivity amid soil resource variability. By focusing on maize and waterleaf - staple food and vegetable crops widely consumed globally - the findings have implications for enhancing food crop cultivation and contributing to sustainable development goals around food security, nutrition, and agricultural practices resilient to environmental changes.

Keywords: Iron; potassium; heterogenous; Talinum triangulare; Zea mays; growth parameters; growth mediums.

1. INTRODUCTION

“Climate alter is a biological challenge confronted by the full world. Climate change could be a diligent variance within the climatic components for a significant length of time which appears noteworthy distinction within the behavior of climatic conditions of a range or regions due to the developing collection of nursery gasses within the climate” [1]. “Climate alter includes the orderly perception recordings and handling of the different components of climate such as rainfall temperature stickiness discuss weight wind clouds and daylight some time recently any standardization of the climatic implies or normal can be arrived at. Plant water stretch may be a condition caused by either dry spell or soil water logging which actuates plant physiological dysfunctions that’s competent of causing a decrease in plant survival capacity subsequently driving to insufficient vegetation of the world” [2]. “Plant water stretch frequently time caused by dry spell and steady water logging do have a major effect on plants development and improvement subsequently coming about in lower surrender and conceivable trim disappointment” [2]. “Moreover lacking water supply to the roots may be caused when the transpiration rate gets to be intense, but when an abundance water happens it comes about in decreased seed germination and seedling foundation” [3]. It can be proposed that from day break of farming gentle to extreme dry season and water logging have been major generation constraining variables [3]. Water push makes lacking circumstance within the rhizopore lower plants’ water potential and turgor weight to the degree that the plants confront challenges in executing typical physiological capacities [4] Be that as it may a wide assortment of plants are known for the tolerance of water dry season push and oxygen insufficiency amid the grown-up stages of their life cycle [5]. All plants have resistance to water push but the degree shifts from species to species. For case surge touchy plants like *Zea Mays* Lycopersicum esculentum Glycine max and Heliantus butt are killed within the waterlogged conditions whereas plants like Oryza sativa *Talinum triangulare*can withstand water-logging for an impressive time.

Soil heterogeneity refers to the un-uniform distribution pattern of soil resources (e.g. nutrient, water and microbe) [6]. It includes two components, i.e. qualitative and configurational components. The former reflects differences in soil nutrients, moisture, microbes etc. between locations in the soil [47,56,29], while the latter refers to the patch size of these locations [26]. Soil heterogeneity as a key characteristic of soils [30,34,35] significantly affects plant dynamics such as root distribution [40] and plant biomass [11,50,40]. “Soil heterogeneity varies both horizontally and vertically [61,62], while most studies developed soil heterogeneity in two dimensions, i.e. either horizontally or vertically” [48]; [68,69]. However, “soil heterogeneity in natural ecosystems varies in three dimensions, i.e. both horizontally and vertically, while only a few studies have explored such effects on plants” [41,43,44,45]. Note that soil heterogeneity in this study refers to configurational heterogeneity.

Soil heterogeneity significantly affects plant biomass, and several previous studies found that soil heterogeneity tends to improve plant biomass via promoting nutrient capture [51] or increasing resource absorption from nearby patches [40]. “Relative higher soil heterogeneity could support higher plant diversity” [43]. “Moreover, a community including more species tends to have higher biomass” [67,70]. Therefore, higher soil heterogeneity is expected to support more biomass. This could be derived from complementary effects [32,46,12], which refers to plants from different species having different traits such as different root geometries, and they could occupy totally different spaces, fulfilling complementary functional roles [46]. It includes two main effects, i.e. niche differentiation (i.e. increasing resource-use efficiency, [63] and facilitation (i.e. positive interaction between species, [38,39,42]. “Biomass allocation is crucial for understanding the plant dynamics and structure and functioning of plant communities” [55]. However, these studies did not clearly consider the joint effect of soil heterogeneity and species composition [4931].

Maize (*Zea mays*) is a vital cereal edit of the world. It is positioned as the third most imperative cereal crops taken after by rice and wheat within the world [28]. It is utilized as a staple nourishment in numerous parts of the world. As a cereal trim it can effectively be developed beneath precipitation condition requiring small administration hones and less sum of capital which can meet the extra nourishment necessity of the world [7] Additionally being a crop plant having an expansive leaf zone it is more proficient in changing over sun based vitality to dry matter than most other cereals which can deliver tall natural abdicate as well as grain surrender generally in a shorter period of time due to its special photosynthetic instrument [19]. Close to this it may be a multipurpose edit which gives nourishment to human creatures nourish and feed for poultry and animals [9] In terms of nourishment it has tall wholesome esteem as it contains around 72% starch 10% protein 4.8% oil 8.5% fiber 3.0% sugar and 1.7% fiery remains [24]. In Nigeria maize is basically utilized as nourishment for people bolster (poultry dairy and angle) Green cob bubbled simmered and pop feed and fuel. It is primarily utilized in poultry industry which needs 90% of add up to yearly maize request. The people groups of Nigeria particularly southern portion are habituated in rice based nourishment framework. But the normal per unit production of rice is lower than the maize [13]. Maize is superior than rice and wheat in terms of wholesome esteem [57]. So in case the conventional rice based nourishment propensity can be differentiated using maize it can play a crucial part within the nourishment security of Nigeria. At show the yearly prerequisite for maize in Nigeria is 1.6 million metric tons [6], but as it where 1.02 million metric ton of maize is created within the nation per annum [13]. So Nigeria needs more maize generation to meet its annual demand for different employments which thrust forward for expanded maize development. Physiological development examination may be a way to survey what occasions happens amid plant development and inevitably it is critical within the prediction of surrender of trim [33]. Biomass dividing is imperative for edit generation and plants more often than not occupy gathered biomass to other plant parts to guarantee and keep up a tall generation capacity [60]. It is one of the strategies to analyze yield-influencing components and plant development [15]. So, plant development examination is considered as pivotal within the improvement of beneficial lines and assortments.

Water leaf (*Talinum triangulare*) could be a catholic weed having a place the family Taliniaceae and commonly found in muggy tropics [10]. It has been recorded for a few nations in West and Central Africa; it is claimed to have South American root but an African root may not be questioned [12] Water leaf is an erect glabrous lasting herb (80-100cm tall) more often than not unequivocally branched; roots are swollen and meaty [14] The takes off are substitute basic nearly sessile and juicy [15]. Water leaf is eaten as vegetables all through the tropics counting numerous nations in West and Central Africa particularly in arrangements of somewhat glossy soups and stews to complement the boring fundamental dish. In South West Nigeria it is called Gbure it is commonly cooked as Efo soup with fixings as a delicacy [16] In Cameroon where it is called Bolki and utilized within the planning of Belok-soup and as a treatment for measles but in Asia (India) it is utilized for treating diabetes [17]. It is additionally utilized as poultice on wound inflammations and tumors decoctions are utilized for difficult eyes and to help recuperation from blows and falls [18]. Water leaf has been made into tonic from its roots too as feed for raising snails. It is frequently planted as a decorative plant or edging plant in gardens. Water leaf shows an entirety extend of organic and pharmaceutical exercises such as anti-inflammation, anti-fungal and anti-bacterial properties [19]. *Talinum triangulare* develops best beneath muggy conditions at a temperature of 30 0C. Development is quick amid down-pouring season but moderates down impressively amid the dry season [20]. It is a shaded and cloudy climate adoring plant. They are generally engendered through stem cuttings (10- 15cm) but seed germination is inescapable. *T. triangulare* takes 3weeks from planting some time recently to begin with collect; the primary 1-3 harvest gives the most excellent verdant quality for promoting [21]. Be that as it may, a rain-fed trim with great weeding, excrement, watering and bug and illness administration can stay on field for 60-180 days [22].The yield range is 10-60t/ha [22]. In this way, in arrange to completely accomplish the most excellent abdicate expressed; water, a fundamental soil dissolvable is required. Water breaks up supplements within the soil for the plants [23]. Subsequently, legitimately overseen water application empowers steady supplements supply to the crops, progress soil quality and secure plant quality. It is indicated that water application must not surpass agronomic application rate (sum less or equal to edit necessities) and not connected when soil is solidified, snow-covered or soaked [24]. Be that as it may, in Nigeria particularly Lagos State where there's an increment in the populace, unsettling influence to characteristic environment, flooding and tall request for vegetables (*Talinum triangulare*), numerous ranchers are confronted with the challenges of which watering administration is best for developing vegetables and in this way, upgrade efficiency, accessibility, abdicate and money related compensation. It is against this that this consideration tends to decide the impacts of diverse watering administrations on the development of T. triangulare [25].

The final two decades have seen the expanding significance of vegetable generation and utilization in southern Nigeria. It has ended up a major occupation of numerous little scale makers in both country and urban communities of Akwa Ibom State, for occasion. Agribusiness in Nigeria is, be that as it may, characterized by an expansive number of these small-scale agriculturists, scattered over wide regions of arrive, with property extending from 0.05-3.0 hectares per agriculturist, moo capitalization and a moo abdicate per hectare [53]. The smallholder ranchers have too been characterized by a moo level of asset utilization, moo levels of efficiency, moo returns to work and a moo level of capital investment [54], in spite of the fact that they control an endless extent of the beneficial agrarian assets in Nigeria [1]. Waterleaf (*Talinum triangulare*) could be a non-conventional vegetable edit of the portulacea family which started in tropical Africa and is widely developed in West Africa, Asia, and South America [59]. Waterleaf as a vegetable has a few inalienable characteristics which makes it alluring to small-holder agriculturists and customers. Firstly, it could be a brief length trim which is due for gather between 35-45 days after planting [58]. Furthermore, it is utilized as a “softener” when cooking sinewy vegetables such as Afang (Gnetum africanum), Atama (Heinsia crinata), and fluted pumpkin (Telferia occidentalis). [36] Famous that the takes off and youthful shoots are utilized to thicken sauce and it is devoured in expansive amounts within the Southern portion of Nigeria. Healthfully, waterleaf has been demonstrated to be tall in crude protein (22.1%), fiery debris (33.98%), and rough fiber (11.12%). It moreover has a few therapeutic values in people and acts as a green scavenge for rabbit nourish administration [27,4]. In expansion, waterleaf generation gives a complementary source of pay to small-scale cultivating family units [64]. The request for waterleaf is in this manner expanding among the occupants of the country, thus widening the residential request and supply hole of the item. Most investigative efforts on waterleaf generation within the ponder range have centered on asset utilization [64,66,65]. There has been a lack of data on the development lists and parameters of maize and of the waterleaf subsequently, a test was conducted to analyze the development files and development parameters on both maize and water leaf.

The emergence of covid19, insecurity and herdsmen clashes brought a whole lot of distortions in the living standard of humans including certain domesticated plants. For example, due to the poverty level in Nigeria humans cannot feed themselves talk more of having enough for their domestic animals. A whole lot has been done and more still needs to be done to bring about the necessary balance humanity desires.

This brings us to the point where the need for this project is emergent because since the attack of Farmers by herdsmen and kidnappers the labour reduced drastically and this has affected food production hence the need for alternative food supplies in case of scarcity of a particular food due to poor production affected by a lot of factors of which covid19 is chief. There is a need to improve crop production by exploring nutrient management options that can improve plant growth. Certain parameters help in the search for better alternatives to improve crop yields for human consumption, as these parameters impacts on the yield of crops in general. Examples of such parameters are, stem length, leaf size, leaf number, soil, water, sunlight etc. There has been a paucity of information on soil heterogeneity in both natural and controlled ecosystems and only a few studies have explored such effects on plants [40,41,43,45]. An experiment was conducted to assess the growth rate of *zea mays* and *talinum triangulare* (waterleaf) in potassium and iron- fortified heterogeneous, homogenous and controlled soil growth medium. To further understand the complex factors that affect plant growth in realistic field scenarios. This has implications for improving crop yield and production.

This nutrient enhancement and management strategy will need control conditions where plant growth is assessed before wider application in the cultivation of plants especially consumed by humans and animals. Plant growth can only be assessed via measured parameters that could be used as indices for plant growth hence the need for this study.

Maize (*zea mays*) and *Talinum triangulaire* are staple food and vegetables commonly and widely consumed across African and many continents of the world, for their nutritional value for humans and animals. Increasing population and changing climate pose challenges to food security. Hence the need to explore strategies to improve food crop production in developing economics and the quest for these addresses one of the United Nations sustainable development goals.

This study assessed the growth parameters of *Zea mays* and *Talinum triangulare* (waterleaf) in potassium and Iron fortified heterogeneous, homogeneous (1000 mg/kg Fe and K added) and control (o mg/kg Fe and K added) growth medium for potential application in Agriculture.

2. MATERIALS AND METHODS

Maize (*zea mays*) and water leaf was selected for pot trials based on the fact that it is commonly consumed. Maize (*Zea mays*) is one of the most widely cultivated cereal crops globally, serving as a staple food for millions of people. Maize (*zea mays*) and water leaf (*Talinum triangulaire*) was used in a greenhouse pot trial modelling the simulated in situ heterogeneity. Herbage samples were processed and analyzed for the concentrations of iron in roots and shoots at the end of the growth period using appropriate analytical methods and equipment e.g. the Atomic Absorption Spectrometer (AAS). Data collected from this study was analyzed using appropriate statistical tools. Growth medium samples were also analyzed for the concentrations of iron. These data will provide information on the uptake potential of the maize and the availability of these nutrients to potential consumers of these crops.

2.1 Experimental Design

Four heterogeneity models were simulated (using excel computer models with a combination of the Robust ANOVA- a visual basic programme developed based on a FORTRAN programme and previous work [8], which will generate levels of heterogeneity similar to those that had been found in field sites and previous field studies. The scale of heterogeneity used, the plant species selected, and the mean F_e concentrations that were chosen, were based on conclusions of pot trials in earlier studies [52] The sample size was determined using power analysis to estimate the minimum number of replicates required to detect a statistically significant difference between means of different treatments based on the assumption that data will be normal in their distribution. Data from the seed germination was used for power analysis having confirmed they are normally distributed using the Kolmogorov Smirnov test. It is impossible to simulate the exact in situ heterogeneity (real life situation). The actual spatial heterogeneity of nutrients can only be estimated by sampling at the field site, and it is practically impossible to recreate the exact in situ heterogeneity in pot trials. In view of this potential complexity, the model of heterogeneity was designed to simulate as closely as practicably possible the in-situ heterogeneity of trace elements measured at this scale in field sites in an earlier study [52] with a range of intermediate HF (HF ranged from 1 to 3.22 (3.22 at the 20 m scale). The proposed simulation of heterogeneity factors (HF) was 1.00, 1.25, 2.00 and 3.19 while an overall mean concentration of approximately 1000 mg/kg in all treatments was maintained the simulation was based on the log-normal distribution observed in those field sites, with increasing values of geometric standard deviation (GSD) and hence the values of HF. The central cell (C3) of all treatments was maintained at 1000 mg/kg Fe. This is to ensure that the heterogeneity treatment did not differentially affect the early establishment of the seedling.

2.2 Seed Germination Experiment

Prior to seed germination experiment, one seed tray was washed and sterilized with household bleach (one part to nine parts of water), thoroughly rinsed with tap water and finally with reverse osmosis water and air dried to ensure they were sterile for seed sowing [8]. Tray was labeled with the name of plant to be sown and date sown on them. Seed trays with drain holes were used to prevent water-logged conditions after seeds had been sown. A light density fine grade, Sinclair vermiculite of (grain size 2.0-5.0 mm) with neutral pH7 (which is lighter and easier for seeds to breakthrough it) was used for sowing seeds. It was watered with tap water until evenly moist before sowing seeds and then placed in the seed trays about 1cm below the rim. The seeds were sprinkled thinly on the vermiculite, or according to supplier's instruction if present and covered thinly with vermiculite. After sowing, the large tray with drain holes was used to cover tray to let in light and air, prevent medium from drying out and becoming damp as well. They were left to germinate in a greenhouse under a photoperiod of 16 hours of natural light and maintained at a temperature of 30 C ± 5°C.The Tray was removed once germination occurred. Watering was done carefully when the top of the seed trays appeared dry using a fine spray watering can, and water was sprinkled gently to avoid resetting or disturbing the seeds. The surface was kept evenly moist and never dried out. *Zea mays* considered for initial transplanting into unspiked growth medium after 7 days of germination to ensure proper growth and establishment before the actual transplant into the trace metal spiked growth medium. After germination and the development of the first true leaves, plants of approximately equal size were selected and transplanted into the centre of separate circular 1litre pots (15 cm deep and 12 cm wide) pots for each species containing unspiked growth medium (washed silver sand, John Innes compost II, 7 parts sand to 3-part compost). Thirty seedlings of *zea mays* were transplanted into pots (making a total of 30 seedlings) and thirty stems of water leaf of unspiked growth medium first for two weeks and were watered daily using a fine rose watering can. This was maintained under 16 hours of natural light at 30±5℃ in the greenhouse. At two weeks after the first transplanting, ten seedlings of each species were transplanted into the 15 pots containing growth medium spiked with Fe at concentrations of 1000 mg/kg Fe added (homogenous)and 0 mg/kg Fe added treatment (control) and heterogenous treatment where also the simulation for homogenous and heterogenous treatments.

A total of 30 pots was maintained (1000 mg/kg (homogenous) and 0 mg/kg added treatment (control and heterogenous treatments) for 6 weeks under a photoperiod of 16hours of natural sunlight at 30 ± 5°C in the greenhouse. These were maintained in 3.5-litre square pots (dimensions 17 cm x 24 cm) in a simple randomized block design both in 1000 mg/kg Fe added and 0 mg/kg added Fe as control and heterogenous treatment were rotated clockwise by 90o weekly to reduce the effect of uneven environmental conditions within the greenhouse. Randomized blocks were between treatments, because of the number of the available space/m2 of greenhouse benches. Similarly, *Talinum triangulare* was maintained in the Nursery before transplantation.

2.3 Green House Pot Experiments

Fifteen (15) rigid square pots (14 X14 cm and 17 cm deep) were thoroughly washed with detergents and labeled with names of plant species three treatments e.g. Homogeneous, heterogeneous and control (Solomon-Wisdom *et al.,* 2015). A customized cell divider made from a 1 mm clear polyethylene terepthalate glycol (PTEG) sheet was inserted into the pots to produce a 5 by 5, 2-dimensional grid with each cell measuring 25 mm square and 170 mm deep. This was used to create the designed heterogeneity models. The relatively thin PETG helped to maintain the heterogeneity design by reducing the collapse of each column after its removal. Labeled paper liners were inserted into each cell while filling cells with growth media. It provided a filling template, to help to maintain the structural integrity of the divider and minimize spillage from adjacent cells. The gap between the paper liners and the outer edge of the pot was packed with an inert Sinclair Perlite (grain size 2.0-5.0 mm) because of the non-vertical sides of pots. Cells were filled according to the particular designed model of heterogeneity. Filling of the pots was done in two stages to ensure that an equal volume of growth medium goes into the cells and that the growth medium is evenly distributed throughout the pot. The gently compacted growth medium was measured with a 100 ml customized container into each cell according to the design. The growth medium will be tapped down before an additional 50 ml will be added and tapped down again. Completed pots were placed on drip trays and arranged on benches in the randomized block design with blocks of 3 rows and 3columns.

The growth medium was moistened from below by capillary action before transplanting seedlings already established in an unspiked growth media for two weeks. Tap water was applied using a fine rose watering can. This ensured that the heterogeneity was disturbed to a minimal extent. The percentage moisture content of the growth media was taken. The pH of the growth media was taken. The established seedlings of the selected plant species were transplanted into the centre of each treatment after two weeks of growing in the unspiked growth media. Ten replicates of each treatment were maintained in the greenhouse for six weeks under simulated sunlight using light-emitting diodes (LED) lights (under a photoperiod of 12 hours) at 30 ±5 C.

2.4 Data Collection and Analysis

Growth data such as plant height, number of true leaves, number of dead leaves and the longest leaf length were taken at initial transplant (week 1) and at harvest week 12. Stem height, leaf length and stem width of the different varieties were measured to the nearest 0.1mm using a tape rule and a caliper.

For the purpose of this experiment, growth rate will be expressed in terms of Growth index (GI) [37], who estimated growth index in terms of measured plant height and width. However, GI was not a key variable in this experiment but merely an additional means of assessing growth rate during the growing period. Growth index was mathematically expressed as GI=height (mm)+Width at widest point+width 90degree to first width/3 [37]. Growth index values will be stated with 2 standard errors on the mean.

3. RESULTS

Fig. 1 presents the weekly longest leaf length of maize in the heterogeneous iron and potassium growth medium. The result of the mean leaf length for the control, homogeneous and heterogeneous were 22.65cm, 18.63cm and 15.70cm respectively. A comparison of the mean across the three treatments showed that the control treatment has the highest mean leaf length followed by the homogeneous treatment and then the heterogeneous treatment. The control was 0.2145 times higher than the homogeneous and 0.4427 times higher than the heterogenous. This suggests that the control treatments are rich naturally in Fe and K that favors leaf growth, while the homogeneous and heterogeneous treatments had slightly lower mean leaf lengths.

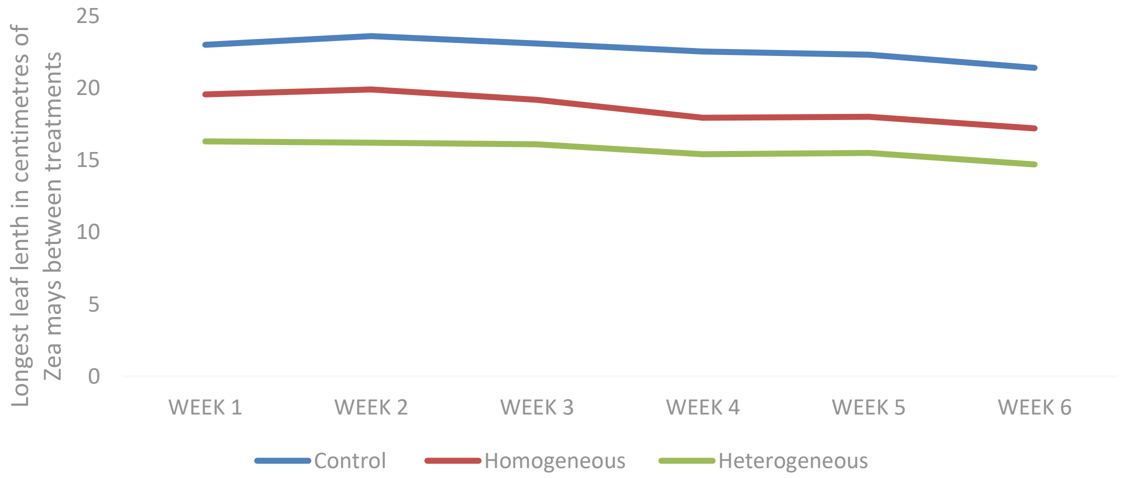

Fig. 1. Comparison of the longest leaf lenth of *Zea mays* between treatments

In Fig. 2, the mean weekly leaf width for the control, homogeneous and heterogeneous were 2.11cm, 1.42cm and 1.46cm respectively. A comparison of the mean across the three treatments showed that the control treatment had the highest mean leaf width followed by the heterogeneous and then the homogeneous treatment. The control was 0.5 times higher than the homogenous and 0.4 times higher than the heterogenous. The heterogenous treatment had its peak leaf width at week 1 and then began to decline till week 6. The homogenous treatment had the lowest leaf width of the three treatments.

The mean weekly stem height in the control, homogeneous and heterogeneous were 10.00cm, 6.44cm and 6.08 cm respectively as shown in Fig. 3. A comparison of the mean weekly stem height across the three treatments showed that the control treatment had the highest mean stem height followed by the homogeneous and then the heterogenous. The control was 0.6 times higher than the homogenous and the homogenous. The homogenous treatment began to increase from week 2 and declined at week 5 and was higher than the heterogenous treatment. Towards the sixth week, the stem height of the homogenous began to decline while the heterogenous continue to have almost constant variation. In all treatments, there were no significant differences ($p>0.05$).

Fig. 4 presents the results of the growth parameter of water leaf in the heterogenous iron and potassium growth medium. The mean leaf length for the control, homogeneous and heterogeneous were 1.7cm, 1.47cm and 1.79cm respectively. At week 3, the three treatments almost had the same leaf length. After week 3, all the treatments began to decline. At week 5, the heterogenous was higher than the control and that of the homogenous. The heterogenous treatment was 0.05 times higher than the control and 0.2 times higher than the homogenous. The heterogeneous treatment had the highest mean leaf length followed by the control, then the homogeneous treatments.

The mean leaf width for the control, homogeneous and heterogeneous treatments were 0.81cm, 1.24cm, and 1.29 cm respectively as shown in Fig. 5. The heterogenous was 0.6 times higher than the homogenous and 0.04 times higher than the control. In terms of stem heights, the treatments were similar. At week 4, the stem height of the homogenous increased and then crashed and began to decline steadily at week 5, whereas the control and the heterogenous have constant trends of variation.

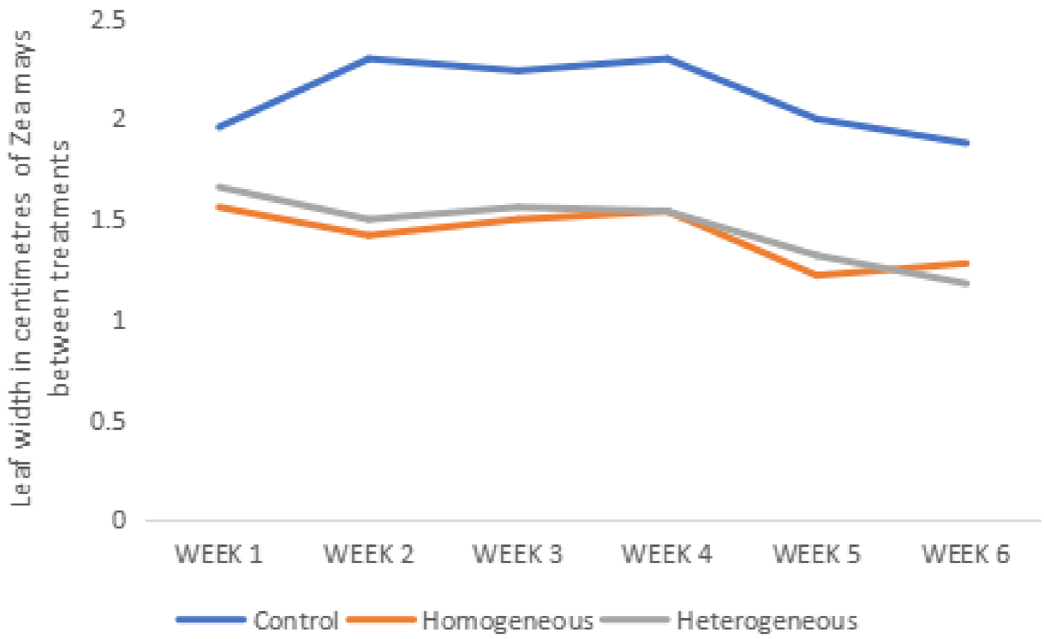

Fig. 2. Comparison of Leaf width of *Zea mays* between treatments

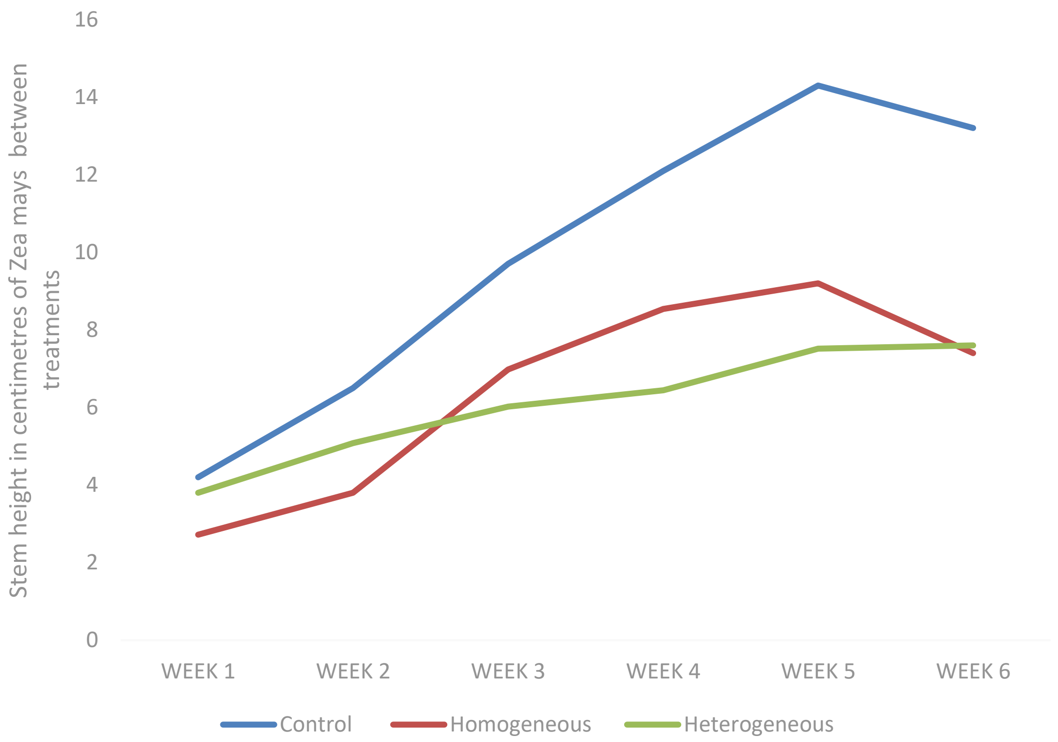

Fig. 3. Comparison of stem height of *Zea mays* between treatments

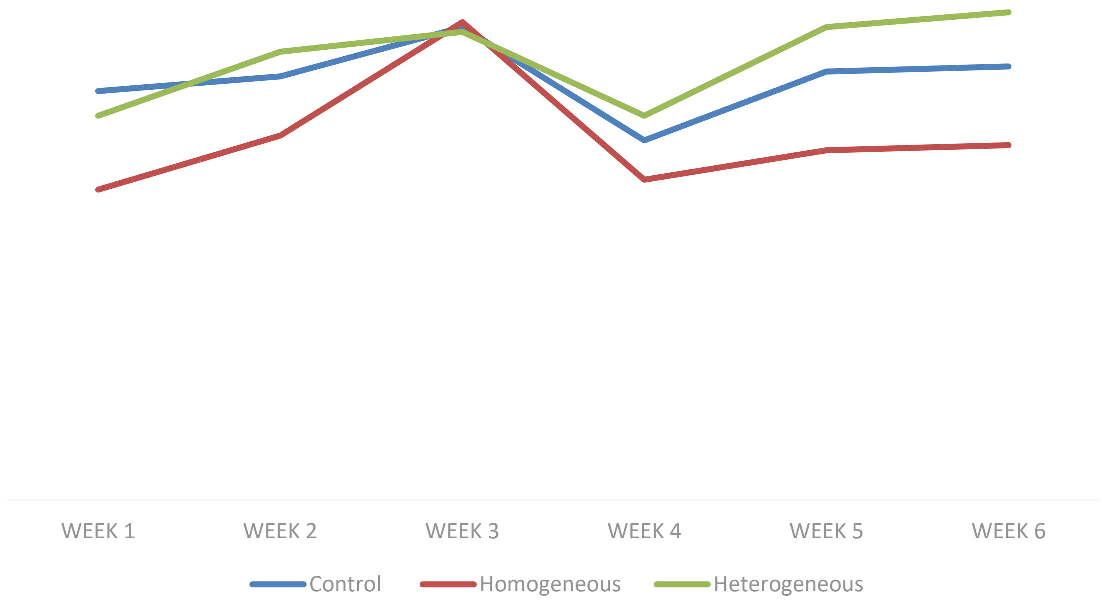

Fig. 4. Comparison of longest Leaf length of Talinum triangulaire between treatments

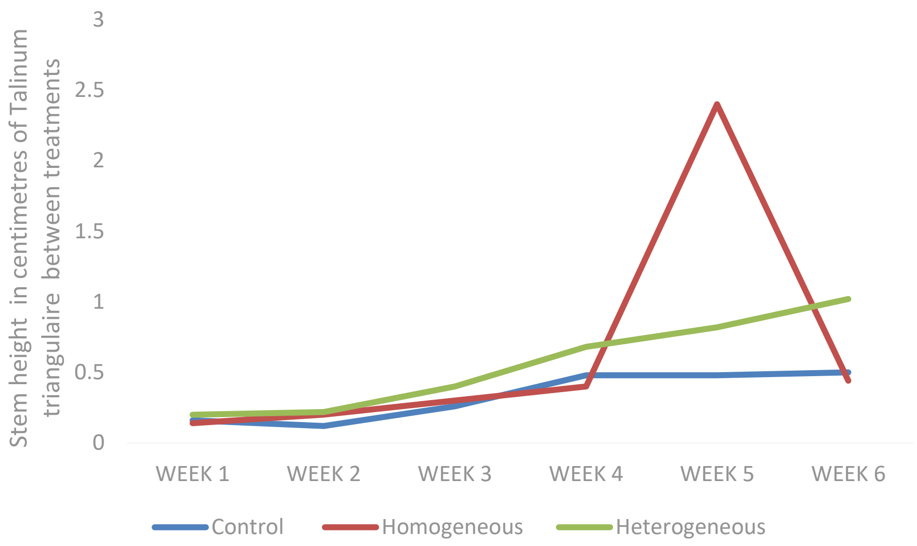

Fig. 5. Comparison of stem height of *Talinum triangulaire* between treatments

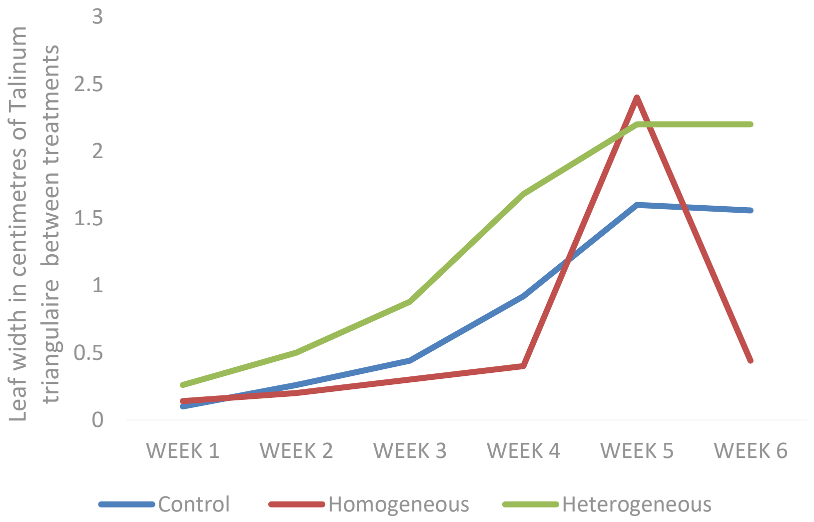

Fig. 6. Comparison of leaf width of *Talinum triangulaire* between treatments

The heterogeneous treatments and homogeneous treatments had the highest leaf width. The mean leaf width for the control, homogeneous and heterogeneous were 0.33cm, 0.65cm and 0.56 cm respectively as shown in Fig. 6. The homogeneous treatment had the highest mean leaf width followed by the heterogeneous treatment and then the control. The homogenous was 0.96 times higher than the control and 0.16 times higher than the heterogenous treatment. The three treatments had similar trend of variation from week 1 to 3. At week 4, the homogenous treatment increased and then began to decline at week 5, whereas both control and heterogenous treatments peaked at week 5 and maintained the trend till harvest at week 6.

Fig. 7 presents the comparison of growth parameters of *T.triangulaire* between treatments. The comparison of the mean weekly leaf length of *T.triangulaire* showed that the heterogenous treatment had the highest leaf length followed by the control and homogenous treatment respectively. The mean weekly leaf width showed that there was no significant difference ($p>0.05$) between the homogenous treatment and of the heterogenous treatment but the heterogenous is slightly higher than the homogenous treatment. The control had the lowest leaf width. The mean weekly stem height showed that the homogenous treatment was higher than all the three treatments, but there was no significant difference (p>0.05) between the homogenous and heterogenous treatments as well. The control had the lowest leaf stem height.

Fig. 8 presents the comparison of growth parameters of *Zea mays* between treatments. The mean weekly longest leaf of *Zea mays* showed that the control had the longest leaf of all the treatments followed by the homogenous treatment whereas the heterogenous had the shortest leaf of all the three treatments. In the mean weekly leaf width, there was no significant difference (p>0.05) between the three treatments, but the control had the highest leaf width of the three treatments.

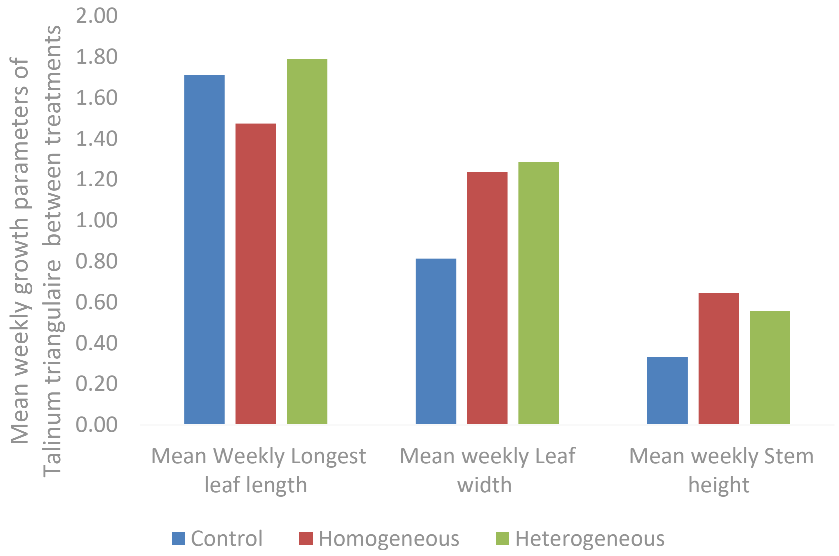

Fig. 7. Comparison of growth parameters of *Talinum triangulaire* between treatments

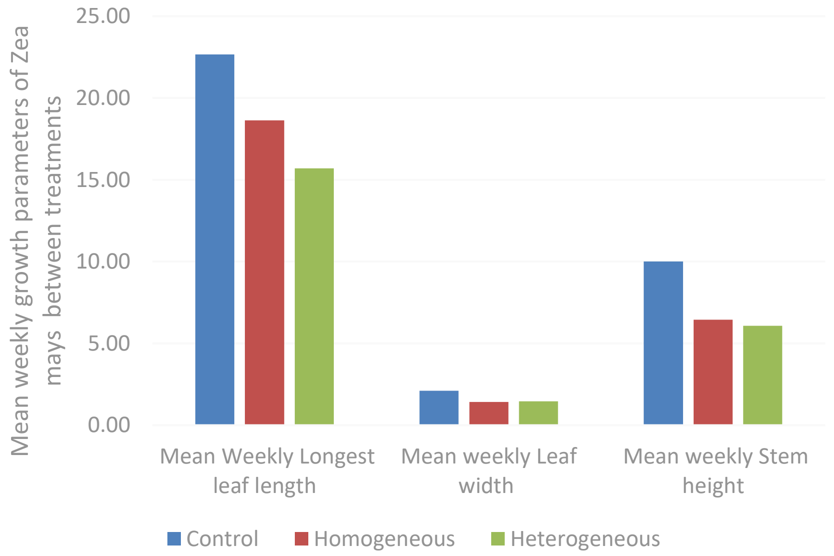

Fig. 8. Comparison of mean weekly growth parameters of *Zea mays* between treatments

The control treatment had the highest stem height of the three treatments. Both homogenous and heterogenous treatments had a similar trend of variation stem height.

The comparison between *Zea mays* and *T.triangulaire* showed that both plants behave differently in the growth parameters which may be due to some internal physiological mechanisms.

4. DISCUSSION

This research provides insights into the growth rate of maize and water leaves in a heterogeneous iron and potassium growth medium. The measurements taken include leaf length, leaf width, and stem height for different treatments (control, homogeneous, and heterogeneous).

It is evident that the control treatment had the highest mean leaf length, followed by the homogeneous treatment, and then the heterogeneous treatment. This suggests that the natural soil is originally rich in Fe and K that favored this plant growth. On the other hand, the homogeneous and heterogeneous treatments had slightly lower mean leaf lengths, indicating less optimal growth conditions in this treatment. This implies that a homogenous growth medium is not realistic for plant growth. However, the heterogenous treatment displayed a closer picture of the natural soil than the homogenous. Both plants showed slight differences in the growth parameters, suggesting differential internal metabolic adaptations and physiology. Complex soil factors might also have influenced the growth parameters of the plants.

The control treatment again exhibits the highest mean leaf width, followed by the heterogeneous treatment, and then the homogeneous treatment. This implies that the control group had the widest leaves, indicating better growth conditions for leaf expansion. The homogeneous and heterogeneous treatments had narrower leaves on average.

The control treatment demonstrated the highest mean stem height, followed by the homogeneous treatment, and then the heterogeneous treatment. This indicates that the control had optimal growth, resulting in taller stems compared to the other treatments.

The heterogeneous treatment exhibited the highest mean leaf length, followed by the control treatment, and then the homogeneous treatment. This also indicates that the heterogeneous treatment provided more conducive conditions for water leaf growth than the homogenous, similar to natural soil conditions.

The heterogeneous and homogeneous treatments had higher mean leaf widths compared to the control treatment, suggesting that these treatments leaf expansion and consequently vegetative growth.

The homogeneous treatment demonstrated the highest mean stem height, followed by the heterogeneous treatment, and then the control treatment. It showed that the homogeneous treatment resulted in taller water leaf stems compared to the other treatments.

5. CONCLUSION

Based on the results presented, it can be concluded that the control treatment consistently exhibited the highest mean values for leaf length, leaf width, and stem height in both maize and water leaf growth. This suggests that the control treatment provided the most favourable conditions for overall plant growth.

The homogeneous treatment often ranked second in terms of mean values, indicating moderately favourable growth conditions. On the other hand, the heterogeneous treatment consistently demonstrated the lowest mean values for the measured parameters, indicating less optimal growth conditions.

These findings highlight the importance of maintaining plants in varying soil conditions to promote optimal plant growth. In the context, this study focuses on iron and potassium growth medium heterogeneity, it is evident that variations in nutrient distribution can have a significant impact on plant growth. The control treatment, which likely had the most realistic nutrient distribution, resulted in the best growth outcomes. The control soil is naturally rich in K and Fe. The heterogenous treatment growth parameters also showed that nutrients can be optimized especially in cases of deficient soils to support crop production.

Current tread seeks to fortify plant growth medium to improve crop production to provide a solution to food security. In light of this, attention should be given to crops as well especially those that are consumed as leafy vegetables such as water leaf.

6. RECOMMENDATION

Based on the results and conclusions drawn from the study, here are five recommendations:

1. Soil amendment should be done in such a way that the natural nutrient requirements of the plants are not significantly distributed.
2. Conduct nutrient analysis: Carry out regular nutrient analysis of the growth medium to determine the nutrient composition and identify any variations or deficiencies. This information can guide the formulation of appropriate fertilization strategies to ensure optimal nutrient levels for plant growth. Nutrient analysis can be performed through soil testing or tissue analysis of the plants.
3. Optimize growth conditions: Apart from nutrient distribution, it is important to consider other growth factors such as light intensity, temperature, and water availability. Provide adequate light exposure, maintain suitable temperature ranges, and ensure proper irrigation practices to create optimal growth conditions for the plants. Consistency in these environmental factors can promote better plant growth and development.
4. Conduct further research: To gain a deeper understanding of the relationship between nutrient heterogeneity and plant growth, additional research is recommended. Investigate different nutrient concentrations, distribution patterns, and their impact on various plant species. This will provide valuable insights into the specific effects of nutrient heterogeneity and guide the development of targeted agricultural practices.
5. Implement precision agriculture techniques: Explore the use of precision agriculture technologies to monitor and manage plant growth. Techniques such as remote sensing, geospatial analysis, and variable rate application can help identify spatial variations in nutrient levels and tailor fertilizer application accordingly. This approach can optimize nutrient distribution, minimize waste, and improve overall crop productivity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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