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PLANT GROWTH PROMOTING BACTERIA-FUNGI AS GROWTH PROMOTER IN WHEAT PRODUCTION

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ABSTRACT

Pot treatment for the bio fertilizer was applied as follows: Trt1 (1g), Trt2 (2g), Trt3 (3g), Trt4 (4g), and Trt5 (Control). The field treatments for the bio-fertilizer were applied as follows: T1 (Control), T2 (100% Mineral Fert (400kg/Ha)), T3 (100% biofert (60kg/Ha)), T4 (100% Mineral fert + 100% biofert), T5 (75% Mineral fert + 100% biofert), T6 (50% mineral fert + 100% biofert), T7 (75% Mineral fert + 75% biofert), T8 (75% mineral fert + 50% biofert), T9 (50% mineral fert + 75% biofert), T10 (50% mineral fert + 50% biofert). Both experiments were laid out as RCBD with three replicates. Effect of bio-fertilizer was significant ($P<0.05$) for all the parameters (height, number of leaves, root length, fresh and dry weight, number of tillers and grain yield). From the pot trial Trt3 gave the best results. For the field trial, on the basis of grain yield, T8 ranked first (6 427 kg/ha) and T2 ranked second (6 107 kg/ha). Treatment T5 ranked third (5 784 kg/ha). Treatment T9 resulted least performance regarding grain yield of 4 616 kg/ha for treatments with combination of mineral fertilizer and bio fertilizer. It can therefore be concluded that 75% mineral fertilizer in combination with 100% and 50% bio fertilizer gave the best result and could prove cost effective when the application protocol is properly followed. This recommendation corroborates with the fact that inorganic fertilizers are becoming too expensive to procure by small-scale farmers.

Contribution/ Originality: The paper's primary contribution is finding that bio-fertilizers can be used to minimize the use of chemical fertilizers in wheat production and yet achieving satisfactory yields. Small-scale farmers can produce wheat cheaper and at the same time getting high yields.

1. INTRODUCTION

One of the critical management practices that promote best wheat production is the optimum utilization of fertilizers. According to Khosro and Yousef [1] the most important constraints militating improved crop yield in developing countries worldwide and especially among resource poor farmers is soil infertility. Maintaining soil quality in wheat production can therefore reduce the problems of land degradation, decreasing soil fertility and rapidly declining production levels in large part of the world wheat producing that need the basic principles of good farming practice. Mfilinge, et al. [2] is of the opinion that, low crop production is a general challenge facing most subsistence farming systems in Sub Sahara Africa. These low yields are pronounced in cereals and are often associated with declining soil fertility and reduced nitrogen fixation due to biological and environmental factors.

Sinha, et al. [3] argues that bio fertilizers keeps the soil environment rich in micro and micro nutrients via nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth regulators, production of anti-biotics and biodegrading of organic matter in the soil. Bio fertilizers when applied as seed or soil inoculant, multiply and participate in nutrient cycling leading to improved crop productivity. Because almost 60 to 90% of the applied inorganic fertilizers are lost and the remaining 10 to 40% is taken up by plants, bio fertilizers can be important component of integrated nutrient management system to sustain productivity and environmental safety [4].

Zimbabwe like the rest of the world has experienced a remarkable reduction in soil fertility. Alteration of soil factors restrict root growth resulting in nutrient stress. Changes in regional nutrient requirements are most remarkable where cropping systems are altered to accommodate shifts in ecozones or alter farming systems to capture new uses from existing systems [5]. Water and nutrient uptake has been impacted heavily.

Lately, seasons have significantly been getting shorter impacting on the proper development and maturation of the crop resulting in reduction of its full potential. Research on crop development has lagged behind the impact of climate change. There is therefore, need to advance research to come up with new technology in crop varieties and drought mitigating measures that counteract the impact of climate change [6].

Due to global climate change, the modification in plant nutrient pattern of soil and also the photosynthesis rate and amount of root exudates are affected during the crop growth [7]. Attention therefore needs to be directed to combating the adverse effect of climate change and modify the existing agronomic and genetic techniques for better yield potential and environmental safety [6].

Because of the influence worldwide change of climate on flora and biota, improvement in crop production in a sustainable manner has to take centre stage to support the ever increasing population. Because rhizobacteria inoculums as a technology has had documented positive results [6] in crops such as maize, rice, soyabeans, rye, the researchers embarked on this research project to ascertain its benefits on locally bred wheat varieties under Zimbabwe conditions.

2. RESEARCH METHODOLOGY

2.1. Site Description

The pot experiment was conducted at Africa University Farm located at 18°53'70.3" South and 32°36'27.9" East and at an altitude of 1131m. The mean annual precipitation is approximately 800-1000 mm with most of rain falling between December and February. The average summer temperature is 27ºC and winter temperature is about 7ºC. The medium used in the pot experiment was a sandy loam soil. The soil at AU farm is a red sandy clay loam, Fersiallitic 5E soil under Zimbabwe soil classification system [8]. The medium used in the pot experiment was sandy loam soil.

3. EXPERIMENTAL DESIGN, TREATMENTS AND ESTABLISHMENT

Pot and field experiments were conducted. The pot experiment was done to investigate the effect of two bio fertilizers as both growth promoter and biocontrol agent in wheat production. The field experimental was carried out to determine the effect of a bio fertilizer on growth, yield and quality of wheat at varying levels in combination with mineral fertilizer. All experimental treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Wheat seeds were surface sterilized by dipping seeds for 30 sec in 70% ethanol solution followed by 2mins in $HgCl_2$ (0.1%). The seeds were washed thoroughly with sterile distilled water 3 times.

3.1. Soil Analysis

Soil samples for laboratory analyses were collected for both pot and field experiments. The soil for pot experiment was taken from Africa University nursery garden in April of 2019. The soil was a clay-loam, dark brown color, slightly acidic to almost neutral but within the optimum soil pH range for crop production, hence liming was not necessary. Nutritionally, the soils are relatively fertile with marginally high levels of residual nutrients with the following properties based on the ($CaCl_2$) scale: pH (6.1), N (20.55), P (44.83), K (2.41), Mg (3.88), Ca (2.68). The soil was collected, sieved and oven-sterilized prior to potting in 5L undrained pots.

3.2. Potting and Sowing

The oven-sterilized (steaming method) soil was left to cool prior to pot filling. The soil was filled by volume into 5kg plastic pots. The pots were laid out in Randomized Complete Block Design (RCBD) with three replications. The microbial inoculant was added separately to the soil according to the treatments. The microbial inoculant granular was uniformly mixed into the top 3 cm soil in the respective treatments. Seeds were carefully selected for uniformity. Control treatment pots were sown with un-inoculated surface sterile seeds. Twenty seeds were sown in each pot, and later seedlings were thinned after emergence. Two separate sets of the same treatment structure were maintained for destructive plant sampling and measurement of agronomic parameters. The soil in each pot received equal volume of water and moisture was maintained with regular additional measured volumes.

Pot treatments were applied as follows; Trt_1 - One gram of biofert inoculation, Trt_2 - Two grams of biofert inoculation, Trt_3 - Three grams of biofert inoculation, Trt_4 - Four grams of biofert inoculation and Trt_5 - No biofert inoculation

4. BIO FERTILIZERS USED IN THE POT EXPERIMENT

The bio-fertilizers used in this study are described as follows;

i) Tricho powder, it contains *Trichoderma harzianum* at a minimum concentration of $1.0x10^6$ colony forming units.

ii) Kangto granule (microbial consortium), it contain *Bacillus amyloliquefaciens**, *Paenibacillus polymyxa*, *Rhodobacter capsulatus*, *Lactobacillus acidophillus*, *Saccharomyces cerevisiae*, *Trichoderma harzianum*, *Aspergillus oryzae* (*Contains at least 1.0×10^7 colony forming units per gram dry weight of the product). The biofertilizrs were applied as follows: at planting (Kangto granule); Control, 1g, 2g, 3g, 4g per pot and as folia spray (Tricho powder).

5. FIELD EXPERIMENT MATERIALS

The recommended full dose of the basal mineral fertilizer was 400kg/Ha (6-23-23), topdressing 350 kg/Ha AN. The application rate for the microbial consortium material was 60kg/Ha. Both the basal mineral fertilizer and bio-fertilizer were applied as a basal dress and covered prior to seed sowing. Wheat seeds of variety SC Select were planted in 10 rows of 15cm apart and length of 3 meters at an optimum plant population of 220-250 plants/m^2.

Guard plots of the same wheat variety were planted surrounding the field experimental plots. All other general agronomic practices were followed throughout the duration of the trial.

Field treatments were applied as follows;

T_1 - Control (No mineral fert, No biofert)

T_2 - Mineral Fert 100% (Recommended Dose of Fert)

T_3 - Biofert (microbial consortium)

T_4 - Mineral Fert 100% + BioFert (microbial consortium) 100%

T_5 - Mineral Fert 75% + BioFert 100%

T_6 - Mineral Fert 50% + BioFert 100%

T_7 - Mineral Fert 75% + BioFert 75%

T_8 - Mineral Fert 75% + BioFert 50%

T_9 - Mineral Fert 50% + BioFert 75%

T_{10} - Mineral Fert 50% + BioFert 50%

6. DATA COLLECTION

Samples were collected at 30, 60 and 90 days after sowing (DAS) for the following determination:

Plant Height: this was measured using a meter rule from the base of the plant to the top of the leaves and expressed in centimeters (cm).

Number of leaves: leaves were counted from the base of the plant to the top most leaf.

Fresh weight of leaf and root: four plants were randomly selected and carefully uprooted then weighed using a digital sensitive scale. The weight was divided by four to get an average expressed in grams (g).

Dry matter of shoots and roots: the plant materials were obtained and dried in an oven at 70°C until the weight was constant in about 48hours. A sensitive digital scale was used to measure the weight expressed in grams (g).

Root Length: Four plants were selected at random and were pulled out after saturating the root zone with water to reduce damage to the roots. The roots were then washed in running water and the root length was measured using a ruler and expressed in centimeters.

Leaf length: four plants were randomly selected. Leaf lengths were measured using a meter rule and the average leaf length was obtained by dividing with the number of leaves measured, expressed in centimeters (cm).

Number of tillers: four plants were randomly selected. The tillers were counted and then the total was divided by four to get the average tillers per plant.

Tissue nutrient content: plant samples were collected at harvest. Initially, plant samples were oven dried and ground into a fine powder using a mixer grinder and then used for analysis following standard methods where the separated plant parts were oven dried at 70°C for 48 hours and weighed. The oven-dried samples were ground to a fine powder in a Retsch electric hammer mill, passed through a 2 mm sieve, and packed in khaki sample bags for laboratory analysis. The ground samples were digested by micro Kjeldahl method [9] and the N,P,K were determined using Kjeldahl digestion procedure as described by Okalebo, et al. [10] *Grain yield:* All the grain received from net plots were weighed. On the basis of grain yield per plot, grain yield $ha^{-1}$was calculated in kilograms as follows:

$$\frac{\text{Grain yield plot}^{-1}}{\text{Plot size (m}^2)} \times 10\ 000$$

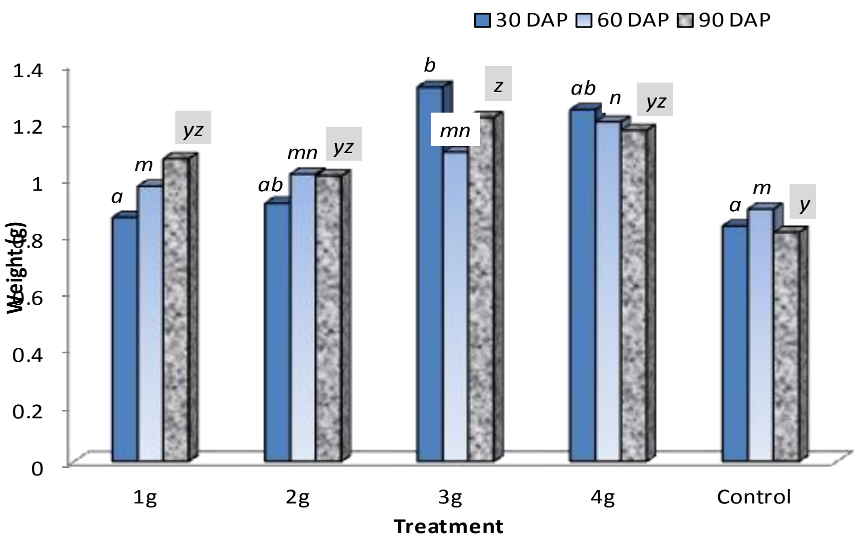
7. RESULTS

Data collected was analyzed statistically using the GenStat Analysis of Variance (ANOVA) software. Differences between means were determined using the Least Significant Difference (LSD) test at P=0.05 level.

7.1. Pot Trial

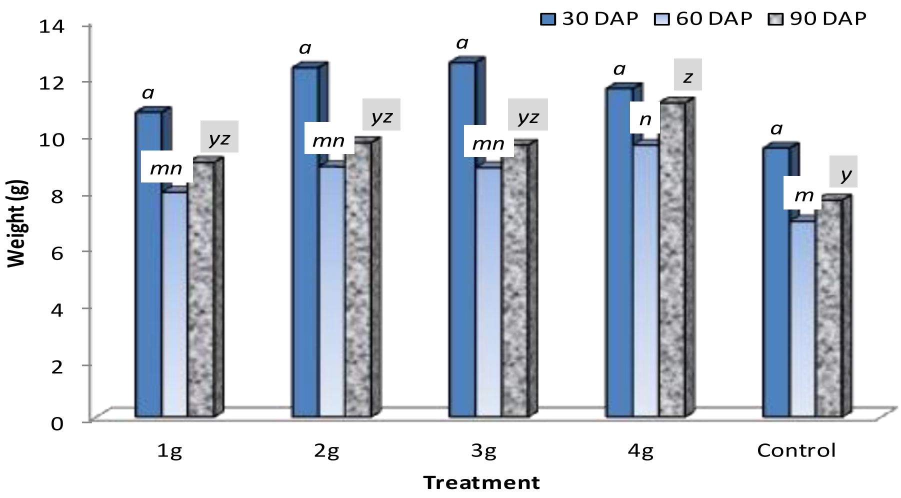
7.1.1. Fresh Root Weight

As shown in Figure 1, data regarding the effect of bio fertilizer on fresh root weight was significant at $p<0.05$. Trt_3 recorded the highest (1.32g) fresh root weight at 30days after sowing (DAS) and also highest (1.21g) at 90DAS. At 60DAS the highest (1.20g)) fresh root weight was recorded from Trt_4. All Control treatments recorded the lowest fresh root weight though figures were not statistically different ($p>0.05$) from Trt_1 and Trt_2. The mean fresh root weight at 30DAS, 60DASand 90DAS recorded was 1.032g, 1.032g and 1.052g respectively.



Biofertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt3 = 3g Trt_4 = 4g Trt_5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-1. Effect of bio fertilizer inoculum on fresh root weight.

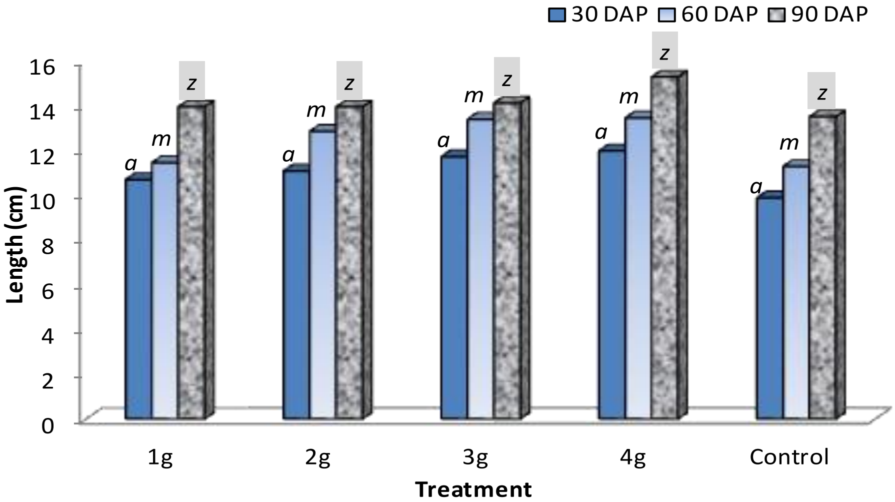
7.2. Fresh Shoot Weight



Biofertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-2. Effect of bio fertilizer inoculum on fresh shoot weight.

As indicated in Figure 2, the effect of bio fertilizer application level on fresh shoot weight at 30DAS was not statistically different ($p>0.05$) across all treatments applied. At 60DAS, fresh shoot weight recorded from Trt_5, Trt_1, Trt_2 and Trt_3 was non-significant from each other. Trt_4 recorded the highest fresh shoot weight of 9.59g and 11.08g at 60DAS and 90DAS respectively. The mean fresh shoot weight at 30DAS, 60DAS and 90DAS recorded was 11.33g, 8.41g and 9.40g respectively.

7.3. Root Length

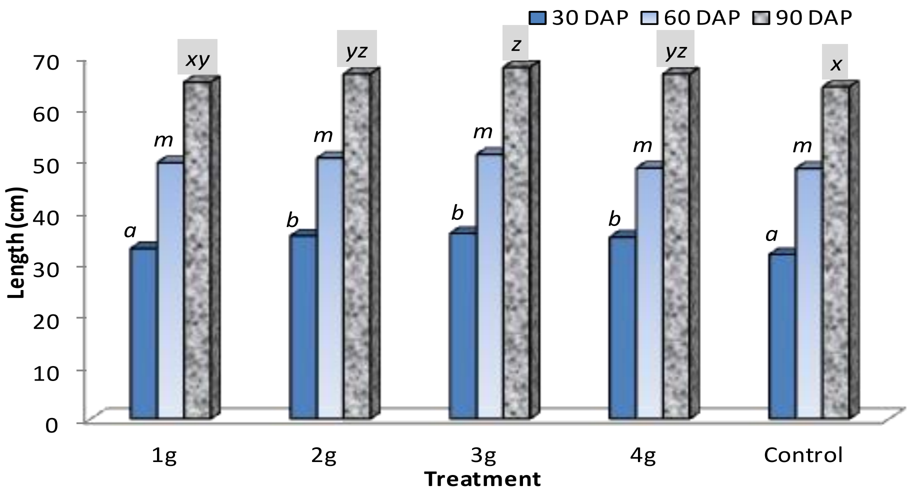


Biofertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-3. Effect of bio fertilizer inoculum on root length.

Figure 3 shows results of the effect of bio fertilizer application levels recorded. These were not significantly ($p>0.05$) different from each other at 30DAS, 60DAS and 90DAS. However, the root length numerically increased in the order $Trt_5<Trt_1<Trt_2<Trt_3<Trt_4$. At 30DAS, 60DAS and 90DAS the control recorded numerically the lowest root length compared to other treatments and the highest root length was recorded from Trt_4.

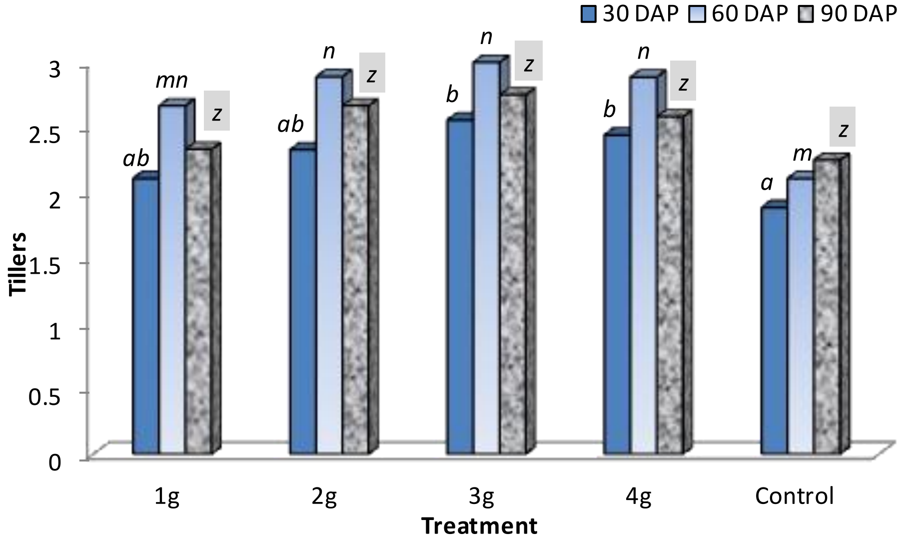
7.4. Leaf Length

As indicated in Figure 4, the effect of bio fertilizer application levels were not significantly ($p>0.05$) different from each other for leaf length at 60DAS. However, at 30DAS data recorded shows that Trt_5 recorded significantly ($p<0.05$) the lowest leaf length while leaf lengths recorded from Trt_1, Trt_2, Trt_3 and Trt_4 were not significantly ($p>0.05$) different from each other. At 90DAS the highest leaf length of 67.94cm was recorded from Trt_3. However, leaf length was not significantly different from Trt_2 and Trt_4. The mean leaf length at 30DAS, 60DAS and 90DAS recorded was 34.39cm, 49.59cm and 66.09cm respectively.



Bio-fertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-4. Effect of bio fertilizer inoculum on leaf length.

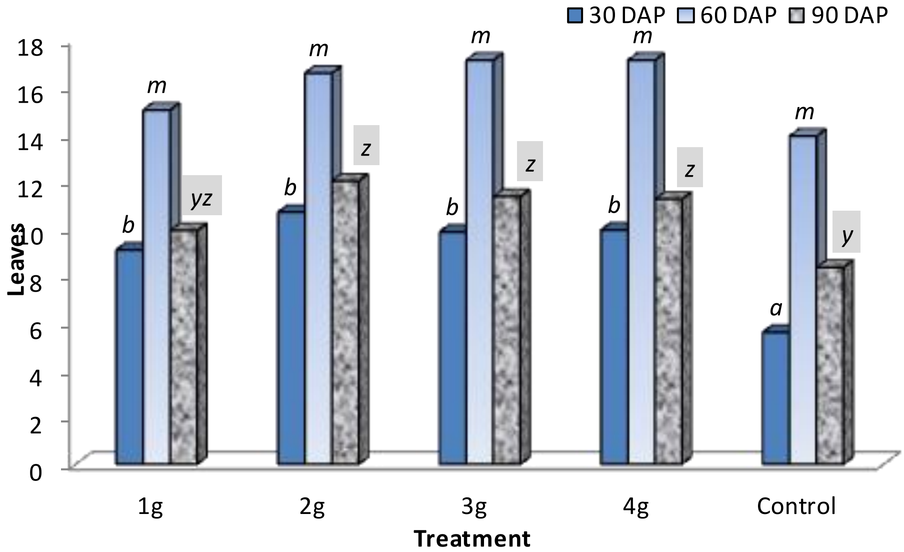
7.8. Number of Tillers



Bio-fertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt3 = 3g Trt4 = 4g Trt5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-5. Effect of bio fertilizer inoculum on number of tillers.

Number of tillers recorded was significant ($p<0.05$) for the effect of the bio fertilizer application levels Figure 5. At 30DAS and 60DAS the number of tillers recorded was numerically highest from Trt_3 (2.56 and 3.00 respectively) but not statistically different from Trt_1, Trt_2, Trt_4. At 90DAS the number of tiller recorded were not significantly ($p>0.05$) differently from each other for the treatments. However, Trt_5 recorded the lowest number of tillers numerically compared to the rest of the treatments at 30, 60 and 90DAS. The mean number of tillers at 30DAS, 60DAS and 90DAS recorded was 2.52, 2.71 and 2.25 respectively.

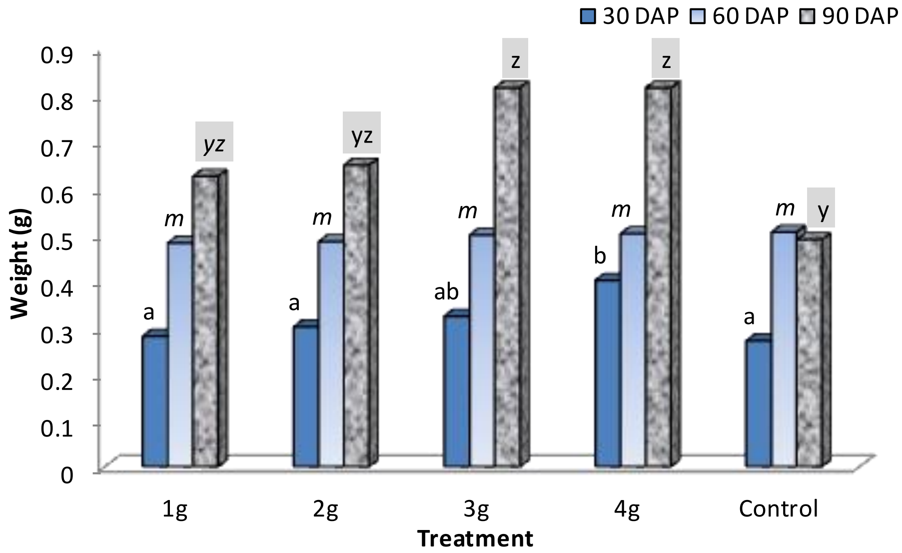
7.9. Number of Leaves



Bio-fertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt3 = 3g Trt4 = 4g Trt5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-6. Effect of bio-fertilizer inoculum on number of leaves.

As shown in Figure 6, Number of leaves recorded were only significant ($p<0.05$) at 30 and 90DAS. The highest number of leaves recorded at 30DAS and 90DAS was from Trt_2, 10.67 and 11.33 respectively. Means from Trt_1, Trt_2, Trt_3 and Trt_4 were not statistically ($p>0.05$) different from others at 30DAS and 90DAS. At 60DAS Trt_5 recorded numerically the lowest (13.89) leaf numbers while Trt_3 and Trt_4 recorded the highest (17.11) number of leaves. The mean number of leaves at 30DAS, 60DAS and 90DAS recorded were 9.02, 15.93 and 10.55 respectively.

7.10. Dry Root Weight

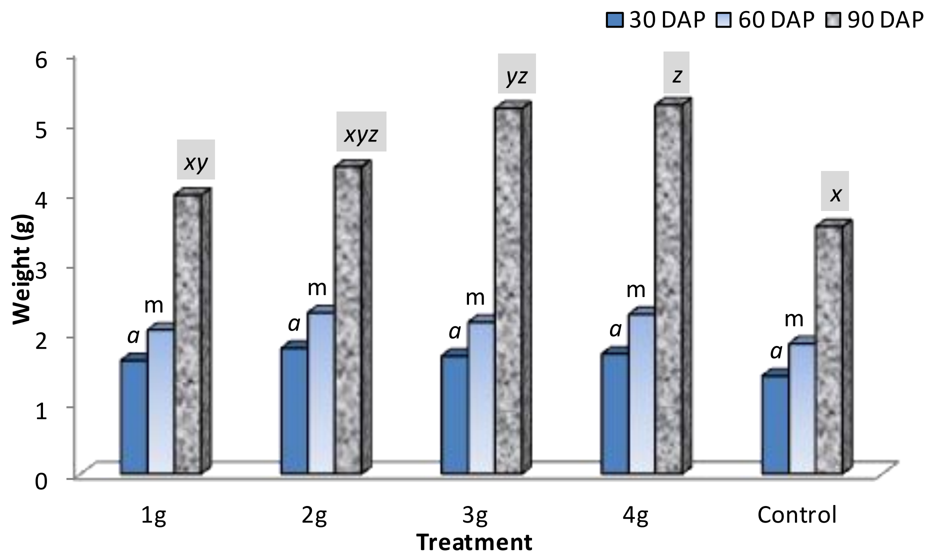


Bio-fertilizer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-7. Effect of bio-fertilizer inoculum on dry root weight.

Effect of different treatments on dry root weight was statistically ($p<0.05$) different as shown in Figure 7. The highest dry root weight at 30DAS was recorded from Trt_4 (0.40g) but did not statistical differ from Trt_3 (0.32g). At 60DAS, the means recorded for dry root weight show that they did not differ ($p>0.05$) for all treatments. However, at 90DAS Trt3 and Trt_4 recorded the highest dry root weight of 0.50g. The mean dry root weight at 30DAS, 60DAS and 90DAS recorded were 0.32g, 0.49g and 0.68g respectively.

7.11. Dry Shoot Weight

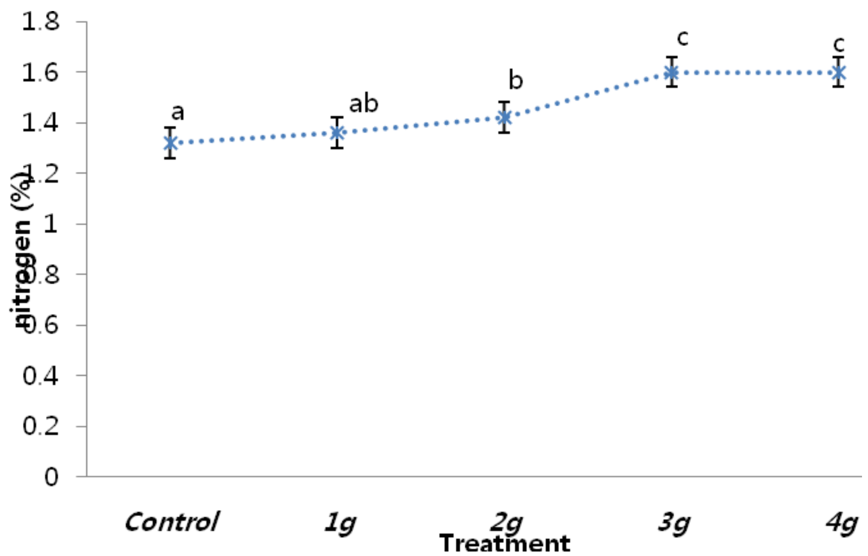
Figure 8 shows result pertaining to dry shoot as affected by bio fertilizer application levels. Means recorded shows that effect of bio fertilizer on dry shoot weight was statistically ($p<0.05$) different. The highest dry leaf weight at 90DAS was recorded from Trt_4 (5.24g) though it did not significantly differ from Trt_2 (4.36g) and Trt_3 (5.19g). At 30DAS and 60DAS the means recorded for dry leaf weight show that they did not differ ($p>0.05$) for all treatments. However, Trt_5 recorded the lowest dry shoot weight compared to the other treatments. The mean dry shoot weight at 30DAS, 60DAS and 90DAS recorded was 1.63g, 2.12g and 4.45g respectively.



Biofertilzer treatments: Trt₁ = 1g Trt₂ = 2g Trt₃ = 3g Trt₄ = 4g Trt₅ = Control
**columns not sharing a common letter differ significantly at 0.05 probability.*
Figure-8. Effect of bio fertilizer inoculum on dry shoot weight.

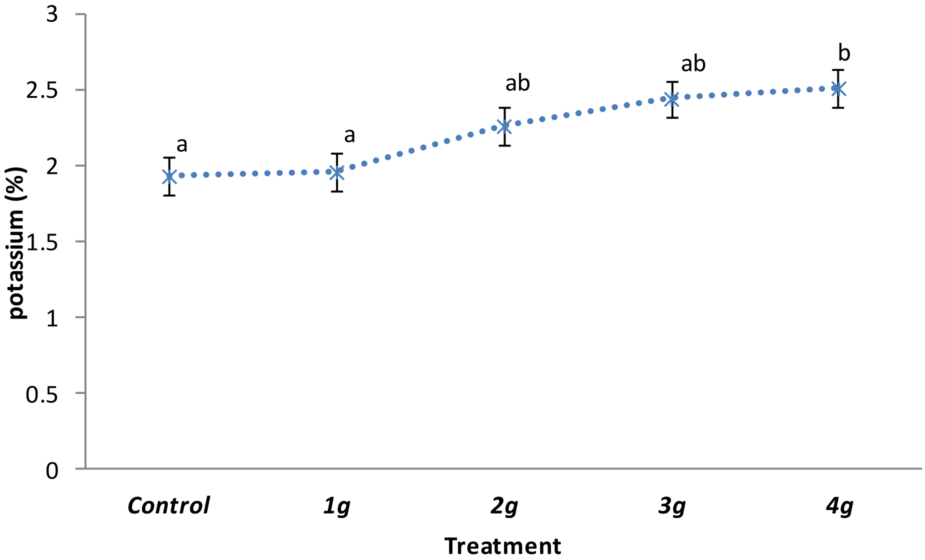
7.12. Tissue Nitrogen (N)

Data regarding tissue nitrogen percentage (N %) as affected by application levels was significant ($p<0.05$) among treatments as shown in Figure 9. Nitrogen percentage in the plant tissue was increasing with increase in the application level of the bio fertilizer. The highest tissue N % (1.6 %) was recorded in Trt_3 and Trt_4. Control treatment recorded the least tissue N % (1.32 %) and it did not differ statistically ($p>0.05$) from Trt_1 which recorded a tissue N % of 1.36 %. The mean tissue nitrogen content recorded was 1.46 %.



Biofertilzer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**points not sharing a common letter in a column differ significantly at 0.05 probability.*
Figure-9. Effect of bio-fertilizer on tissue nitrogen content.

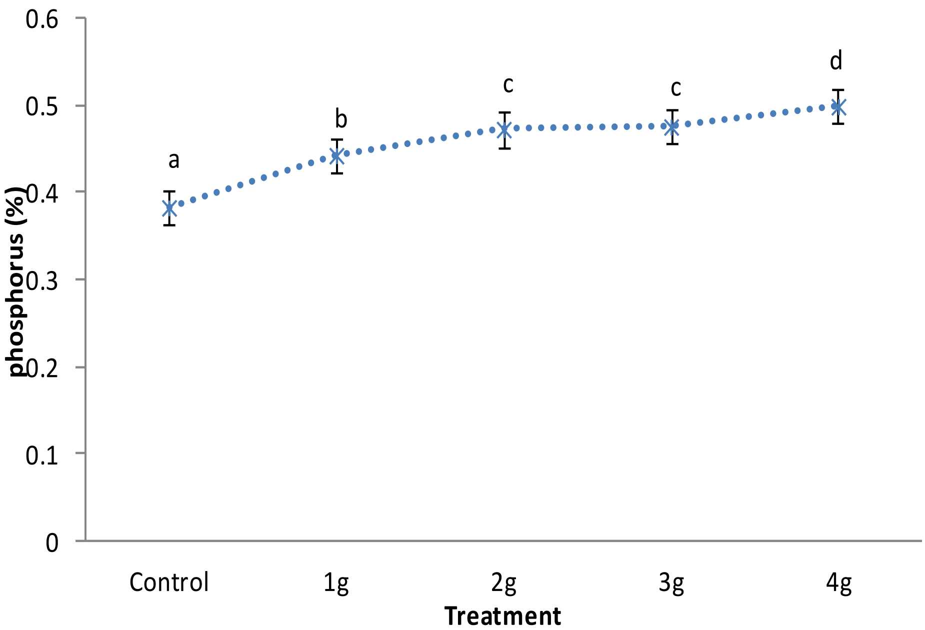
7.13. Potassium (K)



Biofertilzer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**points not sharing a common letter in a column differ significantly at 0.05 probability.*
Figure-10. Effect of bio fertilizer on tissue potassium content.

Tissue potassium percentage (K %) was significant among treatments as shown in Figure 10. Tissue K % was increasing with increase in the application level of the bio fertilizer. The lowest tissue K % (1.93 %) was recorded in Trt_5 which was not statistically different with regard to tissue K % in Trt_1 (1.96 %), Trt_2 (2.26 %) and Trt_3 (2.44 %). Trt_4 recorded the highest tissue K % (2.51 %). The mean tissue potassium content recorded was 2.22 %.

7.14. Phosphorus



Biofertilzer treatments: Trt_1 = 1g Trt_2 = 2g Trt_3 = 3g Trt_4 = 4g Trt_5 = Control
**points not sharing a common letter in a column differ significantly at 0.05 probability.*
Figure-11. Effect of bio-fertilizer on tissue phosphorus content.

Results on effect of varying bio fertilizer application level on tissue phosphorus percentage (P %) was significant ($p<0.05$) among treatments Figure 11. The trend shows that as the bio fertilizer level increased so did the tissue P % recorded. Trt_4 recorded the highest P % (0.50 %) while Trt5, without any bio fertilizer applied, had significantly the lowest tissue P % recorded of 0.38 %. The mean tissue phosphorus content recorded was 0.45 %.

7.15. Field Trial

7.15.1. Plant height

Plant height was statistically different ($p<0.05$) among treatments Table 1. The lowest plant height (64.00 cm) was observed in T_1 and did not differ ($p>0.05$) with plant height observed in T_3 (64.33 cm). The tallest plants were observed from T_7 (75.67cm). The mean plant height recorded was 71.60 cm.

Table-1. Means of effect of combination of mineral fertilizer and bio-fertilizer on plant growth parameters.

Treatment	Height	Root Length	Fresh weight root	Dry root weight	Grain weight (kg ha^{-1})
T_1	64.00^{a}	17.30^{a}	4.52	1.85^{a}	2 949^{a}
T_2	74.67^{bc}	20.30^{c}	6.10	3.64^{de}	6 107de
T_3	64.33^{a}	18.53^{b}	4.67	2.09^{a}	4 982^{bc}
T_4	74.67^{bc}	22.87^{e}	7.88	2.32^{ab}	5 256^{bcd}
T_5	73.33^{bc}	20.10^{c}	7.30	2.36^{abc}	5 784^{cde}
T_6	74..00^{b}	19.97^{c}	6.96	2.68^{abcd}	5 733^{cde}
T_7	75.67^{c}	20.31^{c}	7.75	3.82^{e}	5 711^{cde}
T_8	75.33^{c}	21.60^{d}	5.09	3.30^{bcde}	6 427^{e}
T_9	70.00^{b}	19.90^{c}	6.28	3.45^{cde}	4 616^{b}
T_{10}	70.00^{b}	19.80^{c}	5.02	2.53^{abc}	5 184^{bc}
Mean	*71.60*	*20.07*	*6.16*	*2.80*	*5 275*
$LSD_{0.05}$	5.089	1.225	4.388	1.094	0.87711
CV %	2.3	3.0	11.0	10.8	9.3

Note: *figures not sharing a common letter in a column differ significantly at 0.05 probability.

T_1 - Control (No mineral fert, No biofert)
T_2 - Mineral Fert 100% (Recommended Dose of Fert)
T_3 - Biofert *(*microbial consortium*)*
T_4 - Mineral Fert 100% + BioFert (microbial consortium) 100%
T_5 - Mineral Fert 75% + BioFert 100%
T_6 - Mineral Fert 50% + BioFert 100%
T_7 - Mineral Fert 75% + BioFert 75%
T_8 - Mineral Fert 75% + BioFert 50%
T_9 - Mineral Fert 50% + BioFert 75%
T_{10} - Mineral Fert 50% + BioFert 50%

7.16. Root Length

Data regarding root length recorded was significantly ($p<0.05$) different among treatments Table 1. Plants with the shortest root length were observed in T_1 (17.30 cm) followed by T_3 (18.53 cm) and differed ($p<0.05$) from T_1. The longest plant roots were observed from T_4 (22.87 cm) followed by T_8 (21.60 cm). All treatments above the treatment mean (20.07 cm) had bio fertilizer except for T_2 only.

7.17. Fresh Root Weight

Results pertaining to fresh root weight shown in Table 1 were not statistically different ($p>0.05$) among the treatments under study. However, numerically the lowest fresh root weight was recorded in T_1 (4.52 g) while T_4 (7.88 g) recorded the highest followed by T_7 (7.75 g). The mean fresh root weight recorded was 6.16 g.

7.18. Dry Root Weight

Table 1 shows data regarding dry root weight as affected by bio-fertilization with varying levels of mineral fertilizer. There were significant differences ($p<0.05$) among treatments for dry root weight. The highest dry root weight (3.82 g) was observed in T_7 followed by T_2 (3.64 g). Dry root weight for T_1 (1.85 g), T_3 (2.09 g), T_4 (2.32 g),

T_5 (2.36 g), T_6 (2.68 g) and T_{10} (2.53 g) were below the treatment mean of 2.80 g. All treatment above the mean of the treatments (2.80 g) had bio-fertilizer.

7.19. Grain Yield

As shown in Table 1, grain weight was significant ($p<0.05$) among the treatments. Apart from T, the highest grain weight was recorded among the treatments with mineral fertilizer combined with bio-fertilizer. For treatment with combination of mineral fertilizer and bio-fertilizer the highest grain weight (6.427 kg/ha) was observed in T_8 followed by T_5 with an average grain weight of 5.784 kg/ha. The lowest grain weight was recorded in T_9 (4.616 kg/ha) and T_{10} (5.184 kg/ha) respectively for treatment with combination of mineral fertilizer and bio fertilizer. The mean grain weight recorded was 5.275 kg/ha.

8. DISCUSSION

Efficient use of NPK fertilizers plays major role in successful crop production because of its role in chlorophyll, protein, nucleic acid, hormones and vitamin synthesis, cell division and cell elongation. Similarly, Bio fertilizers contain live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic micro-organisms used for application to seed, soil or composting areas with the objective of increasing number of such micro-organisms and accelerate those microbial processes which augment the availability of nutrients that can be easily assimilated by plants. The significant ($p<0.05$) effect of bio-organic fertilizers at varying levels of mineral (NPK) fertilizers on the growth and yield of wheat demonstrated the positive effect of bio fertilizer (Microbial consortium containing *Bacillus amyloliquefaciens*, *Paenibacillus polymyxa*, *Rhodobacter capsulatus*, *Lactobacillus acidophillus*, *Saccharomyces cerevisiae*, *Trichoderma harzianum*, *Aspergillus oryzae*) when supplied to wheat alone and in combination at varying levels of the recommended dose of N-P-K fertilizers. on the influence of bio fertilizes on plant height, number of leaves, number of tillers, fresh weight for roots and shoot, dry weight for root shoot, root length, physiochemical properties for N-P-K, and grain yield kg ha^{-1} is in agreement with Higa and Kinjo [11] who also obtained increased wheat yields from the seed inoculated with bio fertilizers. This is because more soil organic materials inoculated with bacteria and fungi are degraded to make available nutrients to the growing plant and thus reduce the nutrient and energy losses from organic materials caused by naturally occurring oxidative process-quick decomposition. Also, bacteria had beneficial effect on plant growth because they release auxins to the root zone to enhance growth [12] and ultimately grain yield. Zaki, et al. [13] also concluded that bio fertilizer inoculation produced significant increment in all wheat growth characters. Several scholars are in agreement of the positive effect of bio fertilizers on improved grain yield of wheat along with mineral fertilizer [14-17].

Mahdi, et al. [18] ascertained the effect of bio fertilizers on the growth and seed yield of wheat and concluded that, dual inoculation of wheat seeds with bio fertilizers was superior to single ones. Metin, et al. [19] reported that application of bio fertilizer is considered today to limit the use of mineral fertilizers and supports an effective tool for descent development under less polluted environments, decreasing agricultural costs, maximizing crop yield due to providing them with an available nutritive elements and growth promoting substances. Wali [20] suggested applications of bio fertilizers as a sustainable way of increasing crop yields and economize their production as well. Any source of bio fertilizer has greater efficiency on growth characters of wheat plants as compared to normal straight fertilizers. Ahmed, et al. [21] reported that under organic and bio fertilization, the highest dry matter accumulation in shoot system and spikes and the highest yield and yield components recorded in Gemmiza10 cultivar fertilized and inoculated with yeast and Azotobacter. Similar to the results of this study, Yadav, et al. [22] also revealed that all the PSB treatments were found effective to increase seed yield as compared to control (without combination) and farmers practice (120kg N ha^{-1}).

Both fresh and dry weight of the roots and the shoot increased with increase in the application levels of the bio fertilizer in the current pot experiment because of the increase in the nutrient uptake from improved plant root growth. Khan and Zaidi [23] also reported that the inoculation of bio fertilizers significantly increased the dry matter by 2.6-fold above the control, increased N and P concentrations, and quality of wheat grains than that of non-inoculated plants. Better growth parameters can be attributed to increasing nutrient uptake levels over the control. These findings are supported by the findings by Patel, et al. [24]; Pandey, et al. [25] and Kaur, et al. [26]. The bio fertilizer could have augmented uptake of mineral nutrients in the plants resulting in more chlorophyll content and carbohydrate synthesis leading to amplified cell division and enlargement of the cell size thus resulting in better height of the plant and fresh weight [27]. The availability of mineral compounds in the soil increase and can be easily absorbed by plant roots with soil application of Bio fertilizers [28]. The improve mineral content for NPK could be as a result of the chelating and reducing effect of the microbes in the bio fertilizer as explained by Mutetwa, et al. [29]. Karen, et al. [28] ascribe the increase in both fresh weight and dry weight with application of the bio fertilizers compared to the treatment without to the improvement in biological yield resulting from taller plants.

9. CONCLUSION AND RECOMMENDATIONS

A number of studies on a wide range of agricultural crops have reported the ability of bio fertilizers in improving establishment, plant growth and yield. The present study was done to investigate the effect of Biofertilizers in wheat production at varying combination with mineral fertilizers. From the results obtained in this study, the application of the microbial consortium material evaluated in general had a promotive effect on the physiology and physiochemical parameters of wheat, which was translated into enhanced plant growth, despite different levels of application and combinations with mineral fertilizer. Kangto granule treatments appeared to enhance above-ground growth (shoot length, fresh and dry weight) and root growth at varying levels compared to treatments without the bio fertilizer (Control). In the pot experiment, an increase level of application of the bio fertilizer resulted in improved growth and development and mineral nutrient uptake of the plant. For the field experiment, combinations of mineral fertilizer and bio fertilizer produced better results over the control or mineral fertilizer alone or bio fertilizer alone. Better yield was observed with reduced mineral fertilizer but in combination with bio fertilizer. Several other parameters showed improved effect of mineral fertilizer in combination with bio fertilizer than singular application of the fertilizers.

In terms of grain yield kg ha^{-1}, T_8 comprising of 75% recommended rate of 6-23-23 fertilizers (400 kg/ha) in addition to 30 kg/ha Kangto granule had superior results with 75.33 cm plant height, 21.60 cm root length, 3.30 g dry root weight and 6 427 kg grain yield ha^{-1}. It is therefore recommended that treatment T_8 be adopted in wheat production for the best grain yield. However, this treatment did not differ from results recorded for T_2, T_5, T_6 and T_7. In view of the fact that mineral fertilizers are harmful to the environment and people are advocated to go-green and eat organic, a recommendation to go by with this background is T_6 comprising of 50% recommended rate of 6-23-23 fertilizer (400kg/ha) in addition to 60 kg/h Kangto granule since the yield is statistically not different from T_8. This recommendation corroborates with the fact that inorganic fertilizers are becoming too expensive to procure by small-scale farmers. Also, the Bio fertilizers could be obtained cheaply and exploited. Besides organic fertilizers like Kangto granule bio fertilizers have some secondary beneficial effect on the soil properties and hence environmentally friendly.

It can therefore be concluded that 75% mineral fertilizer in combination with 100% and 50% biofertilizer gave the best result and could prove cost effective when the application protocol is properly followed.

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