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Potential Of Rhizobium Inoculation And Arbuscular Mycorrhizal Fungi To Improve Yield Of Cowpea Genotypes In Afgoye District, Lower Shabelle Region, Somalia

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Abstract: Cowpea (*Vigna unguiculata* L.) is an important legume crop in sub-Saharan Africa grown for leaf, grain and fodder. The decline in soil fertility limits cowpea production and farmers heavily use inorganic fertilizers to compensate for the lost soil nutrients. Unfortunately, frequent use of inorganic fertilizers leads to environmental problems including salinity, nutrient runoff, contamination of water bodies, as well as being non-renewable. The aim of this study was to determine the positive effects of Rhizobial inoculants and Arbuscular Mycorrhizal fungi on growth and yield of cowpea, to check if these environmentally friendly bio-fertilizers can be a good alternative to inorganic fertilizers. Field experiment was conducted in Afgoye district, Somalia, to evaluate the effect of rhizobium inoculation and arbuscular mycorrhizal fungi as bio-fertilizers with or without mineral fertilizer (NPK) on yield of two Kenyan cowpea varieties: Machakos 66, Katumani 80 and a Somali local landrace. Treatments consisted of T_1: Control (zero fertilizer), T_2: Rhizobium (250 g for 15 kg of seeds), T_3: Arbuscular mycorrhizal fungi (3 g per plant), T_4: NPK fertilizer (2 g per plant), T_5: Rhizobium (125 g for 15 kg of seeds)+NPK fertilizer (1 g per plant), T_6: Arbuscular mycorrhizal fungi (1.5 g per plant)+NPK fertilizer (1 g per plant), T_7: Rhizobium (125 g for 15 kg of seeds)+Arbuscular mycorrhizal fungi (1.5 g per plant)+NPK fertilizer (1 g per plant) arranged in a randomized complete block design with 3 replicates per treatment. Data collected on fresh weight, dry weight of the leaves and grain yield were subjected to analysis of variance using SPSS. Significant means were separated using Duncan multiple range test at 95% level of confidence. Results showed that the sole NPK (2 g per plant) followed by Rhizobium (125 g for 15 kg of seeds)+Mycorrhiza (1.5 g per plant)+NPK (1 g per plant) recorded the highest fresh weight (665.8 g per plot, 643.8 g per plot) and dry weight of leaves (97.3 g per plot, 97.2 g per plot). Rhizobium (125 g for 15 kg of seeds)+Mycorrhiza (1.5 g per plant)+NPK (1 g per plant) achieved the highest grain yield (1253.5 kg ha^{-1}) followed by sole NPK (2 g per plant) and Rhizobium (125 g for 15 kg of seeds) +NPK (1 g per plant) with 1225.7 kg ha^{-1} and 1202.2 kg ha^{-1}, respectively. The control recorded the lowest grain yield (998.8 kg ha^{-1}). M66 variety produced 440.6 kg ha^{-1} and 74.7 kg ha^{-1} higher grain yield than that recorded in the local landrace and K80 variety, respectively. The local landrace achieved the highest fresh and dry weight of leaves. Based on the findings of this study, combination of Rhizobium (125 g for 15 kg of seeds) + Mycorrhiza (1.5 g per plant)+NPK (1 g per plant) followed by Rhizobium (125 g for 15 kg of seeds)+NPK (1 g per plant) improved both leaves and grain yield of cowpea thus can be used to complement the use of mineral fertilizers in cowpea production. Further studies on effect of Rhizobium inoculation and Arbuscular mycorrhizal fungi on the nutritional quality of cowpea produced should be conducted.

Keywords: Arbuscular mycorrhizal fungi, Cowpea, Rhizobium, Yield

1. Introduction

According to the Food and Agriculture Organization [1], there is evidence that the global hunger is expanding where the available data indicates that the number of persons suffering from starvation has been on the rise in the last three years. The report also shows that the figure of people impacted by malnutrition or long-standing food impoverishment has increased from 804 million in 2016 to almost 821 million in 2017. This has been further exacerbated by the ever-growing population and rising food intake which have consequently augmented the need for use of fertilizers to improve food production. Although the fertilization is needed, a high reliance on non-organic fertilization can cause uncountable environmental dangers. It has been reported recently [2] that one of the key worldwide obstacles is how to guarantee food security for an increasing global population and at the same time warranting lasting sustainable development. Food production must rise by 70% to feed the world's population, which is expected to grow by 34% by 2050 to 9.1 billion people [2]. The growing middle class in developing economies, changing lifestyles, and climate change together place a heavy burden on the planet's resources, including declining freshwater supplies, biodiversity, and fertile land. As a result, a coordinated and innovative strategy to the worldwide effort to confirm sustainable food production and consumption is essential [3], [4]. It is necessary to improve food and fibre production because of the growing population figures, food security needs to pace with this worrying situation of population growth and to meet the anticipated greater demand for food [5]. The declining soil fertility is a key factor that negatively affecting to produce enough food to satisfy the ever-increasing demand for food due to the escalating figures of world population. It has been noted in [6] that in contrast to parts of North America, Europe and Asia, the majority of Sub-Saharan Africa (SSA) soils are obviously poor in productivity characterized by inadequate nitrogen (N), and ordinarily low in phosphorus (P), sulfur (S), magnesium (Mg) and zinc (Zn). The use of environmentally friendly bio-fertilizers will improve cowpea production thus enhancing overall food security for a rapidly growing global population. According to [7], agriculture and land degradation have numerous and complicated relationships. Water and soil interaction, poor management of crop, untenable misuse of soil nutrients and farming in areas of delicate soils are some of the main reasons of land degradation [8]. According to [9] the cost of cleaning up the United Kingdom's drinking water that have been polluted by chemical pesticides from agriculture was estimated to be £120 million in 1996, plus other expenditures that may arise from the ecological impact of their use. Improving sustainable agriculture systems that reduce the use of pesticides and inorganic fertilizers can help to reduce environmental pollution. It has been emphasized [10] that developing ways to decrease the use of non-organic fertilizers, farming systems can become more sustainable. Bio-fertilizers are a safe alternative to mineral fertilizers reducing the ecological disturbance, enhance soil texture by improving pH while they produce nitrogen, phosphorus and potassium (NPK) and much better than manures. Bio-fertilizers are artificially multiplied cultures of specific soil microorganisms that can boost soil fertility and crop productivity [11]. They make nutrients that are often abundant in soil or air available to plants [12]. Therefore, this study was conducted to evaluate the effect of rhizobium inoculation and arbuscular mycorrhizal fungi on cowpea yield.

1.2 Statement of the Problem

The research problem is the decrease in soil fertility which leads to low crop productivity [13]. To compensate the lost soil nutrients, farmers heavily use inorganic fertilizers which subsequently leads to environmental problems including salinity, nutrient runoff, contamination of water bodies, as well as being non-renewable [14]; [15]. Thus, determining the positive effects of Rhizobium inoculants and Arbuscular Mycorrhizal fungi on growth and yield of cowpea, and use of these environmentally friendly bio-fertilizers can be a good alternative to the synthetic fertilizers.

2. MATERIALS AND METHODS

2.1 Description of the trial site

The field study was conducted in Afgoye District, Middle Shabelle province, Southern Somalia. The experimental site lies on latitude 2.147633°N and longitude 45.128063°E at an altitude of 126m above sea level. The area receives mean annual rainfall of 538mm. It experiences four seasons, two wet and two dry. The long rainy season is experienced between April and June, followed by a dry season from July to September. Between October and November, a short season of rain. The second and primary dry season is experienced between December and March. The soils in the region are sandy loam [16].

2.2 Plot establishment

Land preparation was conducted by mechanically ploughing the land to fine tilth. The experimental plots were slightly raised high to ensure that inter-plot spacing is maintained. Plots measured 24m^2 (6m by 4m) separated by 1m alleys and 1.5m foot paths between the replicates. Each plot was labelled with a code showing variety and treatment.

2.3 Treatments and application

Cowpea (*Vigna unguiculata*) certified seeds of Machakos 66 (M66) and Katumani 80 (K80) were sourced from Simlaw Seeds Company Limited (Kenya) and the landrace was sourced locally in Somalia. The fertilizers consisted of Rhizobium inoculant (Mak-bio-N fixer), Mycorrhizal fungus (Rhizatech) and NPK fertilizer. The Rhizobium was sourced from Makerere University while the Mycorrhizal fungus was obtained from Dudutech Kenya Limited. The application of bio-inoculants and NPK fertilizer was done in the field at planting. The Rhizobium inoculant (Mak-bio-N fixer) was applied at the recommended rate of 250g/15 Kg seeds. This was done by mixing the cowpea seeds with the inoculant and immediately sown. Mycorrhizal fungus (Rhizatech) and NPK fertilizer were applied at rate of 3g and 2g per planting hill respectively. To prevent cross-contamination, the fertilizer-free control plots were planted first, then the other treatments. The treatments consisted of T_1: Control (zero fertilizer), T_2: Rhizobium (250g/15Kg seeds), $T_{3:}$ Mycorrhiza (3g/Plant), T_4: NPK fertilizer (2g/plant), T_5: Rhizobium (125g/15kg seeds+ NPK fertilizer (1g/plant), T_6: Mycorrhiza (1.5g/plant)+NPK (1g/plant), T_7: Rhizobium (125g/15 Kg seeds)+Mycorrhiza (1.5g/plant)+NPK (1g/plant) in a randomized complete block design (RCBD) where each treatment has three replicates. Two cowpea seeds were sown per hill and seedlings were thinned 14 days after sowing. Sowing of cowpea seeds was done at a depth of 4-5cm at a spacing of 60cm between rows and 20cm between plants while the spacing of the landrace which is a spreading type was 120cm between rows and 80cm between plants. Weeding was carried out thrice during the experimental period. Irrigation was conducted once in a week.

2.4 Data collection

The parameters assessed were:

Fresh weight of leaves: The weight of fresh cowpea leaves was assessed at maturity of the two evaluated varieties and the local landrace. Three tagged plants from each plot were uprooted and leaves harvested and weighed using a digital weighing scale recorded in grams.

Dry weight of leaves: The dry weight of cowpea leaves was assessed at maturity stage. This was determined by harvesting cowpea leaves from the three tagged plants per plot. The harvested leaves were then dried in the open air for 7 days and the weight for each of the plots was determined using a digital weighing scale and recorded in grams.

Grain yield of cowpea: The yield of cowpea grains was determined at maturity of the three evaluated genotypes. This was determined by uprooting three tagged plants from each plot, pods harvested, dried and weights were taken by use of digital weighing balance recorded in grams. The estimated yield per hectare was determined by combining the yield from the sampled three plants per plot and multiplied by the total number of plots per hectare.

2.5 Data analysis

The data on fresh weight, dry weight of cowpea leaves, and grain yield were summarized in MS excel spreadsheet and subjected to analysis of variance (ANOVA) using SPSS version 22 to determine if there were significant differences between treatment means at ($P<0.05$). If the ANOVA indicated that there were significant differences at $P<0.05$, a post hoc test using the Duncan Multiple range test was performed.

3. RESULTS AND DISCUSSION

3.1 Fresh weight of leaves

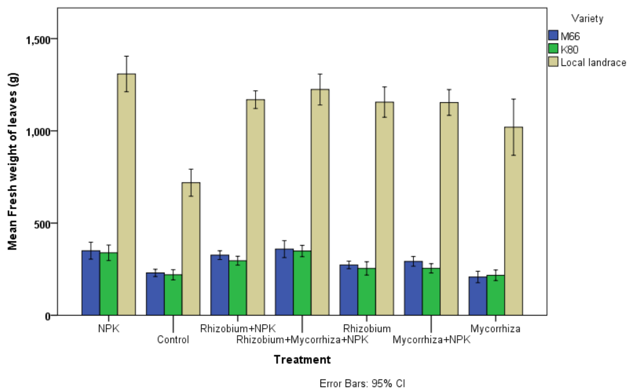

***Figure 1:** Mean fresh weight of leaves of the three varieties*

Figure 1 showed that the local landrace had the highest fresh weight of cowpea leaves in all treatments evaluated, followed by the M66 and K80 varieties, respectively. When ANOVA was used to determine if there was a significant difference in fresh weight of leaves produced for the three varieties or for the seven treatments, the ANOVA summary obtained was as shown in Table 1.

Table 1: ANOVA summary for fresh weight of leaves

Tests of Between-Subjects Effects

Dependent Variable: Mean Fresh weight of leaves (g)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	887.444	2	443.722	.128	.880
Treatment	987198.984	6	164533.164	54.842	.000
Variety	19010926.921	2	9505463.460	3168.354	.000
Treatment * Variety	563298.968	12	46941.581	15.647	.000
Error	252010.667	84	3000.127		
Corrected Total	20892838.040	125			

a. R Squared = .988 (Adjusted R Squared = .982)

The analysis of variance (ANOVA) revealed a statistically significant ($P<0.05$) difference between the treatments, varieties and interactions Variety*Treatment on fresh weight of leaves achieved. LSD test was then used to compare the mean fresh weight of the leaves recorded in the three kinds, and the findings are summarized in Table 2.

Table 2: LSD summary for fresh weight of leaves of the three varieties

	(I) Variety	(J) Variety	Mean Difference (I-J)	Std. Error	Sig.
LSD	M66	K80	15.5714	11.95254	.196
		Local landrace	-816.0952*	11.95254	.000
	K80	M66	-15.5714	11.95254	.196
		Local landrace	-831.6667*	11.95254	.000
	Local landrace	M66	816.0952*	11.95254	.000
		K80	831.6667*	11.95254	.000

*. The mean difference is significant at the 0.05 level

The results in Table 2 showed that the mean fresh weight of leaves differed significantly ($P<0.05$) between M66 and local landrace, K80 and local landrace. The local landrace achieved the highest fresh weight of leaves by recording 816.0952g and 831.6667g than that recorded in M66 and K80 varieties, respectively. The Duncan Multiple Range Test was used as a post hoc test to compare the means of fresh weight of leaves for the treatments, and the findings are summarized in Table 3.

Table 3: Post hoc test for fresh weight of leaves under different treatments

Mean Fresh weight of leaves (g)

	Treatment	N	Subset 1	Subset 2	Subset 3	Subset 4
Duncan[a,b]	Control	18	389.5000			
	Mycorrhiza	18		481.4444		
	Rhizobium	18			561.0000	
	Mycorrhiza+NPK	18			566.8333	
	Rhizobium+NPK	18			597.0000	
	Rhizobium+Mycorrhiza+NPK	18				643.8333
	NPK	18				665.7778
	Sig.		1.000	1.000	.065	.233

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 3000.127.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05.

The results in Table 3 showed that application of sole NPK at 2g/plant achieved the highest fresh weight (665.7778g/plot) of leaves compared to rest of the treatments but its effect was comparable to that recorded in Rhizobium (125g/15Kg seeds)+Mycorrhiza (1.5g/plant)+NPK (1g/plant) which recorded leaf fresh weight of 643.8333g/plot. The control had the lowest fresh weight of leaves (389.5g/plot). The high fresh weight of leaves observed in these treatments may have contributed by optimum nutrient supply particularly Nitrogen and Phosphorus which had favorable effect on the increase of leaf growth rate. This is due to high rate of photosynthesis or sufficient cell expansion or both factors [17]. Nitrogen and Phosphorus optimum fertilization levels often affect the capacity of legume crops to produce the biomass necessary to realize their higher yield potential [18]. These results on leaf fresh weight compare with those of earlier studies by [19], [20], who found a significant increase in the fresh weight of cowpea leaves after the application of NPK fertilizer and its combination with Rhizobium or Mycorrhizal inoculants compared to non-inoculated seeds.

3.2 Dry weight of leaves

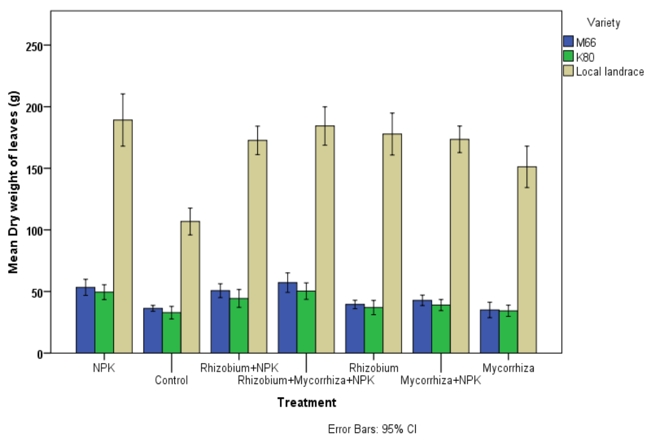

Figure 2: *Mean dry weight of leaves of the three varieties*

Figure 2 showed that in all the treatments evaluated, the local landrace recorded the highest dry weight of leaves followed by M66 and K80 varieties. When analysis of variance (ANOVA) was used to test if there was a significant difference in dry weight of leaves for the three varieties or for the seven treatments, the ANOVA summary obtained was as shown in Table 4.

Table 4: ANOVA summary for dry weight of leaves

Tests of Between-Subjects Effects

Dependent Variable: Dry weight of leaves (g)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	1.27.444	2	63.722	.712	.495
Treatment	20422.429	6	3403.738	37.476	.000
Variety	417482.873	2	208741.437	2298.272	.000
Treatment * Variety	13114.238	12	1092.853	12.032	.000
Error	7629.333	84	90.825		
Total	1343150.000	126			
Corrected Total	460466.540	125			

a. R Squared = .983 (Adjusted R Squared = .975)

The analysis of variance (ANOVA) revealed a statistically significant ($P<0.05$) difference between the treatments, varieties and interactions Variety*Treatment on dry weight of leaves achieved. LSD test was then used to compare the mean dry weight of the leaves recorded in the three kinds, and the findings are summarized in Table 5.

Table 5: LSD summary for the dry weight of leaves of the three varieties

	(I) Variety	(J) Variety	Mean Difference (I-J)	Std. Error	Sig.
LSD	M66	K80	3.9286	2.07967	.062
		Local landrace	-120.0952*	2.07967	.000
	K80	M66	-3.9286	2.07967	.062
		Local landrace	-124.0238*	2.07967	.000
	Local landrace	M66	120.0952*	2.07967	.000
		K80	124.0238*	2.07967	.000

*. The mean difference is significant at the 0.05 level

Results in Table 5 revealed a difference between M66 and the local landrace, K80 and the local landrace, which was statistically significant ($P<0.05$). The local landrace achieved the highest dry weight of leaves by recording 120.0952g and 124.0238g dry weight of leaves than that recorded in M66 and K80 varieties, respectively. The Duncan Multiple Range Test was then used as a post hoc test to compare the means of dry weight of leaves for the treatments, and the findings were summarized in Table 6.

Table 6: Post hoc test for dry weight of leaves under different treatments

Dry weight of leaves (g)

	Treatment	N	Subset 1	Subset 2	Subset 3	Subset 4
Duncan[a,b]	Control	18	58.6667			
	Mycorrhiza	18		73.5000		
	Rhizobium	18			84.7778	
	Mycorrhiza+NPK	18			85.1111	
	Rhizobium+NPK	18			89.2222	
	Rhizobium+Mycorrhiza+NPK	18				97.2778
	NPK	18				97.3333
	Sig.		1.000	1.000	.191	.986

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 90.825.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05.

The post hoc results (Table 6) showed that sole application of NPK (2g/plant) resulted in the highest dry weight (97.3333g) of leaves followed by Rhizobium (125g/15kg seeds) +Mycorrhiza (1.5g/plant)+NPK (1g/plant). The lowest dry weight of leaves was recorded from the negative control treatment. The highest dry weight achieved in sole NPK could be attributed to higher leaf fresh weight recorded in this treatment.

3.3 Cowpea grain yield

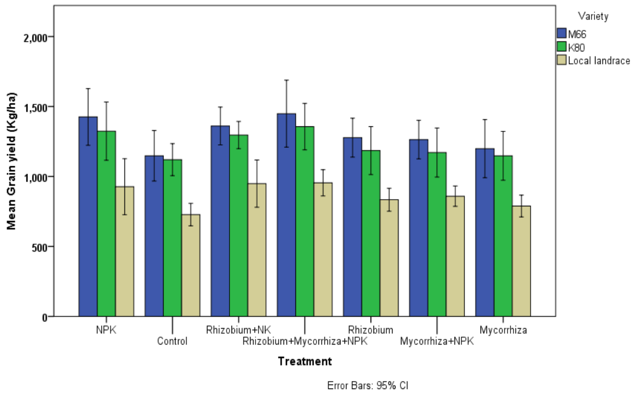

Figure 3: *Cowpea grain yield*

Figure 3 showed that the M66 variety recorded the highest grain yields followed by K80 and the local landrace. When ANOVA was used to test if there was a significant difference in weight of grains for the three varieties or for the seven treatments, the ANOVA summary obtained was as shown in Table 7.

Table 7: ANOVA summary for yield of grains

Tests of Between-Subjects Effects

Dependent Variable: Mean Grain Yield (Kg ha^{-1})

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	39287.803	2	19643.901	1.007	.371
Treatment	1006807.488	6	167801.248	8.603	.000
Variety	4669074.619	2	2334537.309	119.683	.000
Treatment * Variety	41512.027	12	3459.336	.177	.999
Error	1228883.351	63	19506.085		
Total	169469354.440	126			
Corrected Total	8065103.934	125			

a. R Squared = .848 (Adjusted R Squared = .698)

There was a statistically significant difference (P<0.05) between the treatments and varieties on grain yield, as shown in analysis of variance (ANOVA) Table 7. However, the interactions Treatment *Variety had no significant effect on weight of grains. To compare the mean yield of grains for the three varieties, LSD was used, and the results obtained were presented in Table 8.

Table 8: LSD summary for yield of grains for the three varieties

	(I) Variety	(J) Variety	Mean Difference (I-J)	Std. Error	Sig.
LSD	M66	K80	74.7355*	30.47722	.017
		Local landrace	440.5595*	30.47722	.000
	K80	M66	-74.7355*	30.47722	.017
		Local landrace	365.8240*	30.47722	.000
	Local landrace	M66	-440.5595*	30.47722	.000
		K80	-365.8240*	30.47722	.000

*. The mean difference is significant at the 0.05 level

The outcomes presented in Table 8 revealed that there was a significant (P<0.05) difference between M66 and K80, as well as M66 and the local landrace. The M66 variety achieved 440.5595 Kg ha^{-1} and 74.7355 Kg ha^{-1} higher grain yield than that recorded in the local landrace and K80 variety, respectively. The highest grain yield achieved in the M66 variety suggested that this variety could be adopted for grain production by Somali farmers and improve food security. These results compare with those of [21] who reported higher grain yield of cowpeas in M66 variety. Variations in grain yield weight across cowpea genotypes can be ascribed to their genetic makeup. These findings are consistent with those of [22], [23], who found significant variance among types in terms of yield characteristics. These variances could be attributable to the genetic factors that occur within distinct varieties [22].

The Duncan Multiple Range Test was then used as a post hoc test to compare the means of grain yield of cowpea for the treatments, and the findings were shown in Table 9.

Table 9: Post hoc test for yield of grains under different treatments

Mean grain yield (Kg ha^{-1})

	Treatment	N	Subset 1	Subset 2
Duncan[a,b]	Control	18	998.8424	
	Mycorrhiza	18	1045.3318	
	Mycorrhiza+NPK	18	1098.1867	
	Rhizobium	18	1098.9582	
	Rhizobium+NPK	18		1202.1603
	NPK	18		1225.6943
	Rhizobium+Mycorrhiza+NPK	18		1253.4722
	Sig.		.052	.305

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 19506.085.
a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = .05.

The results in Table 9 showed that application of Rhizobium (125g/15Kg seeds)+Mycorrhiza (1.5g/plant)+NPK (1g/plant) achieved significantly (P<0.05) highest grain yield (1253.4722 Kg ha^{-1}). It was followed by sole NPK (2g/plant) and Rhizobium (125g/15kg seeds)+NPK (1g/plant) with 1225.6943 Kg ha^{-1} and 1202.1603 Kg ha^{-1}, respectively. The lowest grain yield (998.8424 Kg ha^{-1}) was recorded from the negative control treatment. The mean grain yield achieved in sole Mycorrhiza (3g/plant), Mycorrhiza (1.5g/plant)+NPK (1g/plant) and sole Rhizobium (250g/15kg seeds) did not significantly differ from that achieved in the negative control treatment. The high grain yield achieved in the combined application of Rhizobium, Mycorrhiza and NPK could be attributed to their synergistic interactions and better adaptability of the inoculants to the ecological conditions hence their ability to infect and form a positive association with cowpea under the prevailing conditions [24], [25], [26]. Thus, resulting to better growth and increased yields. These findings are consistent with the findings of [27], who found that combined application of Rhizobium inoculant and mineral fertilizers is an effective soil fertility management technique. Like other legumes, cowpeas gain from rhizobium bacteria's fixation of nitrogen. It guarantees a sufficient supply of vital nutrients for plant growth and reproductive development when combined with mycorrhiza, which improves nutrient absorption, increasing pod production and grain weight [28], [29], [30]. Mycorrhiza can improve nutrient uptake[27], rhizobium facilitates nitrogen fixation[31], [32]. Together, these factors promote better plant development, resulting in higher pod number and grain weight. The higher grain yield achieved in dual application can be attributed to the combined application of Rhizobium and or mycorrhizal and NPK fertilizer. This might be due to the translocation of essential metabolites and photosynthates to the growing parts of the plant. In addition, there was no significant difference in yield between the plots that received the combined application of Rhizobium+NPK, Rhizobium+Mycorrhiza+NPK and the plots that received sole NPK fertilizer. Therefore, it is best to simply use a combination of Rhizobium inoculants and Arbuscular Mycorrhizal with NPK, since the extra expense of chemical sole NPK application does not justify the yield that would result from applying them.

4. CONCLUSIONS AND RECOMMENDATIONS

Our study demonstrated that the yield attributes of cowpea were significantly affected by different fertilizer combinations and cowpea genotype used. The local landrace achieved the highest fresh and dry leaf weight of cowpea leaves while the M66 variety produced the highest grain yield. Based on the findings of this study, combination of Rhizobium (125 g/15 kg seeds)+Mycorrhiza (1.5 g/plant)+NPK (1 g/plant) followed by Rhizobium (125 g/15 Kg seeds)+NPK (1 g/ plant) improved both leaves and grain yield of M66, K80 and the Somali local landrace cowpea genotypes. Thus, can be used to complement mineral fertilizers in enhancing soil fertility and cowpea production. Farmers interested in cowpea leaf yield and grain yield should be encouraged to adopt the cultivation of the Somali landrace and M66 variety, respectively. Further studies on effect of Rhizobium inoculation and Mycorrhiza on the nutritional quality of cowpea yield produced should be conducted.

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