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Effects of Cassava/Legumes Inter-cropping before Rice Season and Weeding Methods on Growth and Yields of Rice: Split-Plot Design Approach

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ABSTRACT

Lowland cereal cropping systems face shortages of nitrogen fertilizers, which are the most important nutrient limiting yields of cereals. Some studies have been carried out on the impact of preceding lowland rice cropping with cassava/legumes intercrop in the dry season on rice yields, in which the experimental treatments were arranged in a randomized complete block design fashion. However, given the variety of problems posed by uncontrolled weed growth on crop yields, none of such studies have taken into proper consideration, the impact of weed-control method(s) used during experimentation on rice yield. A field study was undertaken to ascertain the effects of preceding lowland rice with cassava/legumes intercrop during dry season and that of weeding methods, on growth and yields of rice using a split-plot design approach. The experiment was conducted on lowland experimental field of National Cereals Research Institute, Badeggi, in the Southern Guinea savanna zone of Nigeria during the 2013 cropping season. Seven intercropping systems (used as whole-plot treatments), four weeding methods (used as subplot treatments), and ten different rice parameters were used in the experiment, which was replicated three times. The results revealed that, for each parameter, the highest recorded rice yield was from the rice grown after intercropping Cassava with Aeschynomene legume followed by that grown after intercropping Cassava with Cowpea for every adopted weed-control method. For every intercropping system, the highest recorded rice yield was from the plot subjected to the Two-hand weeding at 3 & 6 weeks after transplanting (WAT) followed by Herbicide at 3 WAT plus hand-weeding at 6 WAT for each parameter.

Keywords: Split-plot Designs, Intercropping, Cassava, Legumes, Rice
Mathematics Subject Classification: 62K10
Journal of Economic Literature (JEL) Classification: C18

1. INTRODUCTION

Rice is a major staple food in the whole world and its production has been essential for many decades. It is a cereal grain that belongs to the grass family of *Poaceae* and with two species including *Oryza sativa* and *Oryza glaberrima*. More than one-third of the human population relies on rice for sustenance and it is therefore the most important of the world's food crops. There are between 4.6 – 4.9 million hacters of land in Nigeria available for rice production out of which only about 1.7 million hacters or 35 percent of the available land area is presently cropped to rice (Falaye *et al*, 2012). The upland rain fed lowland accounts for 55 to 60 percent of the cultivated rice land. An estimated 25 percent of Nigeria's rice area is under inland valley swamp rice production. The irrigated rice ecology accounts for about 18 percent of cultivated rice land and deep water or floating rice constitutes 5 to 12 percent of the national rice production area. Tidal (mangrove) swamp ecology contributes less than 2 percent to national rice production area (Imolehin and Wada, 2000).

Most countries face shortages of fertilizers, especially nitrogen (N), which is the most important nutrient limiting yields of cereals (PAL and SHESHU, 2001). Smallholder farmers of developing countries cannot afford to apply recommended rates of nitrogen and other fertilizers to lowland cereals such as rice, which has a high demand for the nutrient when grown in low-fertility soils. Legume roots harbor beneficial bacteria that incorporate nitrogen from the air into the soil, enriching the soil and reducing the need for nitrogen-containing fertilizers. Intercropping interrupts the movement of disease-causing organisms through a field, since many insects and fungi feed on just one type of crop. Therefore, intercropping of cassava and legumes such as mucuna, cowpea, soybean etc, during the post-rice season, could have a beneficial impact on the productivity of rice.

Crop rotation is an essential practice in sustainable agriculture because of its many positive effects like increasing soil fertility, controlling of crop pests and diseases and reducing crop competitiveness (Lieberman and Dyck, 1993). It is a technique that replenishes soil nutrients without the use of synthetic fertilizers. The positive effect of long-term rotation on crop yield has been recognized and exploited for centuries. During the last few decades, however, its benefits in terms of yield seem to have been ignored by farmers (Crookston, 1984). It is now evident that crop rotation increases yield and promotes agricultural sustainability (Mitchel *et al*, 1991). During the off-season, rain-fed rice lands are typically left fallow (George *et al*, 1992). The straw and fallow weed vegetation is subjected to grazing by livestock. In a minor fraction of the area with conducive residual soil water-holding capacity, and/or a high groundwater table, upland crops, including legumes, are grown in the post-rice season. This practice is most common where the soil texture is loamy and easy to till. In well-drained rice lands, upland crops are grown prior to rice during the dry-to-wet season transition period. Very short duration crops are advantageous to permit maturity before the soil becomes waterlogged.

Uncontrolled weed growth poses a variety of problems. On farms, weeds significantly reduce the harvest, or yield, of a crop by depriving the plants of light, moisture, and nutrients. Three foxtail weeds in a 30-cm (1-ft) row of corn, for example, can reduce the corn crop yield by 10 percent; 12 foxtail weeds can reduce it by 17 percent. Weed seeds mixed with grain reduce the quality of grain, and the presence of weeds in hay decreases its value. Weeds also reduce yields by harboring insects and diseases that attack crops. Toxic weeds in pastures where animals graze can, if consumed, poison animals or—in the case of cows and other milk-producing animals—taint their milk. Weeds are exceptionally tough plants and are able to reproduce aggressively. Thus for optimum grain yield, weeds must always be controlled, and four different weeding methods were used in this experiment.

Some studies have been carried out on the impact of preceding lowland rice cropping with cassava/legumes intercrop in the dry season on rice yields. For instance, Gbanguba *et al* (2011) study the effect of preceding lowland rice with cassava/legumes intercrop on weed dynamics and rice grain yield using a randomized complete block design approach. Three different legumes- *mucuna, soybean* and *cowpea*, were intercropped with cassava. The authors observed that the highest weed number was recorded in fallow plots throughout the study period and conclude that rotation of rice with cassava legume intercrop reduced weed population, weed dry matter and increase rice yield. In the same vein, Gbanguba *et al* (2014) investigated the performance of rice grown after cassava/legumes intercrop. The experimental layout was in the split-plot design fashion with intercropping system as the whole-plot factor and weeding method as the subplot factor. However, the authors considered the experiment to be a randomized complete blocks design with only intercropping system as the treatment and ignored the weeding method. The authors also stated that three different fertilizer brands - Urea (46%N), single superphosphate (18% P_2O_5) and muriate of potash (60% K_2O) were used in the experiment to supply 80 kg/ha N, 40 kg/ha P_2O_5, and 40 kg/ha K_2O/ha., but nowhere in the work was the effect of this factor accounted for. All this resulted in lots of vital information being lost.

Effects of water stress on rice crop yield have also been investigated by Venkatesan et al (2005) using some percentages of the stress treatment. The authors observed that the rice yield was affected by water stressing but the effect depends on the percentage of the stress treatment.

Venkatesan et al (2005) also investigated the yield and peak water demand for rice crop under staggered growing season and observed that the monthly peak water demands were less than peak water demand of normal cropping while the average yield per hectare obtained from normal and staggered cropping were comparable.

Leaf area of rice were estimated by Chen et al (2013) with leaf length(L) and leaf width (W) measurements using predictive regression models.

The present study therefore takes the experiment as it is (split-plot design), and investigates the effects of preceding cassava/legumes intercropping before rice season and that of weeding methods on growth and yields of rice.

Many agricultural experiments involve two classes of factors. Some are very difficult to change and are applied either to an entire field or to very large sections of a field. Other factors are easier to change and can be applied to smaller section of the field quite easily. For example, plows require a significant amount of time and labor to change. Consequently, one tends to use the same plowing method either for the entire field or at least for an entire row of a field. A Split-plot design is usually used with factorial sets when randomization of treatments becomes difficult, time-consuming and sometimes, even impossible. In this design, the experimental runs are performed in groups, where, in a group, the levels of the whole-plot factors are not reset. This creates dependence among subplot experimental units within a specific whole-plot experimental unit, thereby leading to compound symmetric variance-covariance structure for the observed responses, which further complicates the analysis. The split - plot structure requires two separate sets of randomization. One is for the whole – plot experimental units, and the second is for the subplot experimental units within each whole - plot experimental unit. These two sets of randomizations lead to two separate error terms for effects comparison, one for the whole-plot treatments (σ_{γ}^2), and one for the subplot treatments (σ_{ϵ}^2), as well as the interaction between whole-plot treatments and subplot treatments. Generally the subplot error variance is less than the whole plot error variance, because the subplots are usually more homogeneous than the whole plots. The two error terms change not only the way the design is run but also the analysis of the resulting data**.**

This study was therefore aimed at investigating the impacts of pre-cassava/legumes intercropping and weeding methods on the growth and yields of rice using split-plot design approach.

2.0 MATERIALS AND METHODS

A field study was undertaken in 2013 at the lowland experimental field of the National Cereals Research Institute Badeggi (9°45'N, 60°7'E, ALT 70.57 m) in the southern Guinea savannah zone of Nigeria with mean annual rainfall of 2066.3mm distributed between April to October in 2013 with maximum and minimum temperature of 30-38^{o}C and 14-26^{o}C respectively. The experiment was laid out using Split-plot Design approach with seven whole plots, each of four subplots, and was replicated three times. The seven whole-plot treatments included five different legumes intercropped with cassava IIT 427, the sole cassava and the natural fallow. The five legumes include Velvet bean (*Mucuna puriens)*, cowpea (*Vigna unguiculata)*, soybean (*Glyxine max)*, hyacinth bean (*Lablab purpureus*) and Jointvetche (*Aeschynomene histrix)*. Four different weeding methods were used as the subplot treatments and these include Two-hand weeding at 3 and 6 weeks after transplanting (WAT), Herbicide application at 3 WAT plus hand weeding at 6 WAT, One- hand weeding at 3 WAT, and the control (zero weeding). The cassava/legume cropping lasted till August when cassava was harvested. Those plots previously cropped with cassava/legume intercrops were followed by rice.

Raised beds for intercropping cassava and legumes were done manually. Beds were 2.5 m long, 0.5 m wide and 0.75 m high. Cassava was planted on the top sides of beds in two rows at inter and intra-row spacing of 0.5 m (ten stands per bed) and legumes were planted by the sides of the beds at inter and intra-row spacing of 0. 5 m x 0. 25 m respectively except for soybean which was drilled immediately the beds were constructed.

Rice seedlings were raised in the nursery. The rice variety used was Faro 52. The nursery was done in the second week of July and the seedlings were ready for transplanting at three weeks after seeding. The beds made for cassava/legume intercrop were leveled manually and rice transplanting was done at a spacing of 20 x 20 cm at the rate of two seedlings per hill.

2.1 Data Collection

Data were collected on ten different rice parameters. These include rice plant height, which was done by measuring the rice plant from the ground level to the flag leaf using ruler at 3, 6, 9 and 12 weeks after transplanting and at harvest; rice tiller per stool, which was measured by counting the number of rice shoots after the initial two seedlings transplanted at 3, 6, 9 and 12 weeks after transplanting; rice panicle per m^2, measured by throwing one meter square quadrate inside rice plants in each plot and counting the panicles of rice that fell inside it; rice grains per panicle, determined by counting grains on the sample panicles from each plot; weight of 1000 grains, taken after counting and weighing 1000 rice grains from each plot; and rice grain yield, determined by weighing rice grain from net plot of each plot using weighing scale. The weight was measured in kilograms per plot which was converted to kilogram per hacter.

2.2 Analysis

In the experiment, each of the two factors (whole-plot and subplot) were assumed to be fixed and the statistical model for the yield from each of the ten rice parameters is

$$y_{ijk} = \mu + r_i + \alpha_j + \gamma_{ij} + \beta_k + (\alpha\beta)_{jk} + \epsilon_{ijk} \qquad (1.1)$$

where y_{ijk} is the response from the *ijk*th subplot experimental unit, μ is the overall mean effect, r_i is the *i*th replicate effect (*i* = 1, …,3), α_j is the *j*th intercropping system effect (*j* = 1, …, 7), β_k is the *k*th weeding method effect (*k* = 1,…,4), $(\alpha\beta)_{jk}$ is the interaction effect of the *j*th intercropping system and *k*th weeding method, γ_{ij} is the whole plot random error term, which is assumed to be identically and independently distributed $N(0, \sigma_\gamma^2)$, where σ_γ^2 denotes the variability among the whole plot units, and ϵ_{ijk} is a subplot random error effect, also assumed to be identically and independently distributed $N(0, \sigma_e^2)$, and σ_e^2 denotes the variability among the subplot units. It is also assumed that γ_{ij} and ϵ_{ijk} are independent.

The collected data for each rice parameter were analyzed by means of DESIGN EXPERT (version 9.0.4) statistical package. Through this, effects of the intercropping system and weeding method were examined for their significance on the yield; marginal mean yields produced by each adopted weeding method when the rice was grown after each intercropping system were also examined and presented in charts. Finally, the intercropping systems and the weeding methods that produced the highest overall yield for each parameter were identified and recommendations made.

3.0 RESULTS AND DISCUSSIONS

The ANOVA Tables for each of the ten rice parameters were given in the APPENDIX. From these Tables, we observed that both the main effects of the whole-plot (intercropping system) and subplot (weeding method) factors were highly significant at both 1% and 5% levels for all the ten rice parameters. This implies that intercropping of cassava with each of the given legumes, growing cassava alone as well as keeping the land naturally fallow during the post-rice season significantly improves soil fertility for the overall productivity of rice; each of the adopted methods of weed control significantly improves soil fertility also. It was also observed from these Tables that except for the rice plant heights at 3 WAT and at 9 WAT, the interaction effects of the intercropping systems and weeding methods were highly significant for all other parameters. This implies that, except for the two stated parameters, the average yield of the parameters produced by each of the weeding methods depended strongly on the type of pre-intercropping system adopted during the post-rice season. For the two stated parameters with insignificant interaction effect, it implies that the average yield produced by each of the weeding methods was fairly constant for all the adopted pre-intercropping systems.

Rice plant height (cm)

For each parameter, the average plant height (cm) produced was significantly affected by the pre-cassava/legume intercropping system and the weeding method adopted. The tallest rice plant was observed in the plot pre-intercropped with *cassava/Aeschynomene* at 3 WAT for each of the adopted weed-control methods. The next tallest rice plant was produced by the plot pre-intercropped with *cassava/cowpea* for each of the weed-control methods. The heights of the rice grown after *cassava/soybean* and cassava/lablab were similar for the two-hand weeding (at 3 and 6 WAT) and herbicide application at 3 plus hand weeding at 6 WAT. The shortest rice plant was produced by the plot left naturally fallow before the rice-planting season for all the weeding methods. All this can be observed from the FIGURE 1 below.

At 6 WAT the tallest rice plant was produced by the rice grown after *cassava/cowpea* intercropping for each adopted weeding method. This was followed by the rice grown after *cassava/Aeschynomene* intercropping while the plot left naturally fallow before the rice season produced the shortest rice plant for each adopted weeding method. On the average, the tallest rice plant when the rice was grown after every intercropping system was achieved by weeding method 1 (2-hand weeding at 3&6 WAT) while the shortest plant was produced by the plot left without weeding as can be seen directly from FIGURE 2.

At 9 WAT, the tallest rice plant was produced by the rice grown after *cassava/Aeschynomene* intercropping for each weeding method except weeding method 2 (herbicide at 3 WAT and hand-weeding at 6 WAT), which produced its tallest rice plant when the rice was grown after *cassava/cowpea* intercropping. The heights of the rice grown after *cassava/soybean* and *cassava/lablab* intercrops were similar for all the weeding methods and the shortest rice plant was produced by the plot left naturally fallow before the rice-cropping season for each weeding method. On the average, weeding method 1 produced the tallest rice plant when the rice was grown after every intercropping system while the shortest rice plant after every intercropping system was produced by the plot left without weeding. All these can be seen directly from FIGURE 3.

At 12 WAT, except for weeding method 2 (herbicide at 3 WAT and hand-weeding at 6 WAT), the tallest rice plant was produced by the rice grown after *cassava/cowpea* intercropping for each weeding method. The weeding method 2 produced its tallest rice plant when the rice was grown after *cassava/Aeshynomene* intercropping. It was observed that the plot left naturally fallow before the rice season produced the shortest rice plant for each adopted weeding method. On the average, weeding method 1 produced the tallest rice plant when the rice was grown after every intercropping system while the shortest rice plant after every intercropping system was produced by the plot left without weeding, as can directly be observed from FIGURE 4.

At Harvest, the tallest rice plant was produced by the plot pre-intercropped with *cassava/cowpea* for every weeding method except weeding method 3 (one-hand weeding at WAT), which produced its tallest rice plant when the rice was planted after *cassava/Aeschynomene* intercropping. The plot left naturally fallow before the rice-cropping season produced the shortest rice plant for every weeding method. On the average, weeding method 1 produced the tallest rice plant when the rice was grown after every intercropping system while the shortest rice plant after every intercropping system was produced by the plot left without weeding, as can directly be observed from FIGURE 5.

Rice grain per panicle

Except for weeding method 2 (herbicide application at 3 plus hand-weeding at 6 WAT), the greatest number of rice grain per panicle was provided by the plot pre-intercropped with *cassava/cowpea* for every weeding method. The numbers of rice grain per panicle provided by the rice grown after *cassava/cowpea* and *cassava/Aeschynomene* intercrops were similar for the weeding method 1 (2-hand weeding at 3&6 WAT). The greatest number of rice grain per panicle for the weeding method 2 was given by the rice grown after *cassava/Aeschynomene* intercrop. The smallest numbers of rice grain per panicle observed for each weeding method was given by the rice grown after the plot was left naturally fallow. On the average, weeding method 1 provided the greatest number of rice grain per panicle when the rice was grown after every intercropping system while the smallest number after every intercropping system was provided by the plot left without weeding, as can directly be observed from FIGURE 6.

Weight of 1000 rice grain (g)

The heaviest 1000 rice grain weight was given by the rice planted after *cassava/Aeschynomene* intercrop for every weeding method except weeding method 4 (zero weeding), for which the maximum 1000 rice grain weight was observed in the rice planted after *cassava/cowpea* intercrop. The smallest observed 1000 rice grain weights for weeding methods 2, 3 and 4 were given by the rice grown after the plot was left naturally fallow while that for weeding method 1 was given by the rice grown after *cassava/soybean* intercrop. On the average, weeding method 1 provided the heaviest 1000 rice grain weight when the rice was grown after every intercropping system while the smallest weight after every intercropping system was provided by the plot left without weeding, as can directly be observed from FIGURE 7.

Rice tiller number per stool

The highest number of rice tiller per stool was given by the rice planted after *cassava/Aeschynomene* intercrop for every weeding method except weeding method 3, for which the highest number of rice tiller per stool was given by the rice planted after *cassava/mucuna* intercrop. The numbers of rice tiller per stool provided by the rice grown after *cassava/mucuna* and *cassava/Aeschynomene* intercrops were similar for weeding method 4 (zero weeding). The smallest observed numbers of rice tiller per stool for every weeding method were given by the rice grown after the plot was left naturally fallow. On the average, weeding method 1 provided the highest number of rice tiller per stool when the rice was grown after every intercropping system while the smallest number when the rice was grown after every intercropping system was provided by the plot left without weeding, as can directly be observed from FIGURE 8.

Rice panicle per m^2

The highest rice panicles per meter square was observed in the plot pre-intercropped with *cassava/Aeschynomene* for weeding methods 1 and 2 while weeding methods 3 and 4 produced their highest rice panicles per meter square each when the rice was grown after *cassava/cowpea* intercrop. The rice panicles per meter square provided by the weeding methods 1 and 2 when the rice was grown after every intercropping system were not significantly different. The smallest observed rice panicles per meter square for every weeding method were given by the rice grown after the plot was left naturally fallow. On the average, weeding method 1 provided the highest rice panicles per meter square followed by the weeding method 2 when the rice was grown after every intercropping system while the smallest rice panicles per meter square when the rice was grown after every intercropping system was provided by the plot left without weeding, as can directly be observed from FIGURE 9.

Rice grain yield (kg/ha)

The maximum rice grain yield (kg/ha) was produced by the rice grown after *cassava/Aeschynomene* intercrop for the weeding methods 1 and 2. The next highest grain yield was produced by the rice grown after *cassava/cowpea* intercrop for the weeding methods 3 and 4. The rice grain yields provided by the weeding methods 1 and 2 when the rice was grown after every intercropping system were not significantly different. The smallest observed grain yields for every weeding method were given by the rice grown after the plot was left naturally fallow. On the average, weeding method 1 provided the highest rice grain yields followed by the weeding method 2 when the rice was grown after every intercropping system while the smallest rice grain yields when the rice was grown after every intercropping system was provided by the plot left without weeding, as can directly be observed from FIGURE 10.

Overall, each of the ten rice parameters considered in this study was significantly affected by the intercropping system and the weed-control method and differences in parameter yields among intercropping systems depended strongly on adopted weed-control method. This implies generally that intercropping of cassava with legumes, or growing only cassava, or keeping the land naturally fallow before the rice-cropping season significantly improves soil fertility by enriching the soil and reducing the need for nitrogen-containing fertilizers. The extent to which each of the intercropping systems and weeding methods improves soil fertility varies from one to the other as indicated for each parameter by the corresponding average yields for each weeding methods when the rice was grown after every intercropping system.

For each of the ten rice parameters considered in this study, the best weed-control method for every intercropping system was the 2-hand weeding at 3&6 WAT followed by the Herbicide application at 3 plus hand weeding at 6 WAT while the least yields were recorded from the plots left without controlling weeds. This indicates the adverse effect of leaving a farmland without controlling weeds as they compete with more desirable plants for available light, water, and nutrients and significantly reduce the harvest or yield of a crop. The best intercropping system for every weed-control method was the *cassava/Aeschynomene* followed by the *cassava/cowpea* intercrops while the least yields were recorded from the plots left naturally fallow before the rice-planting season. This implies that pre-intercropping of land with cassava/legumes during the post- rice season enriches the soil better, with rice plant nutrients, than leaving the land naturally fallow.

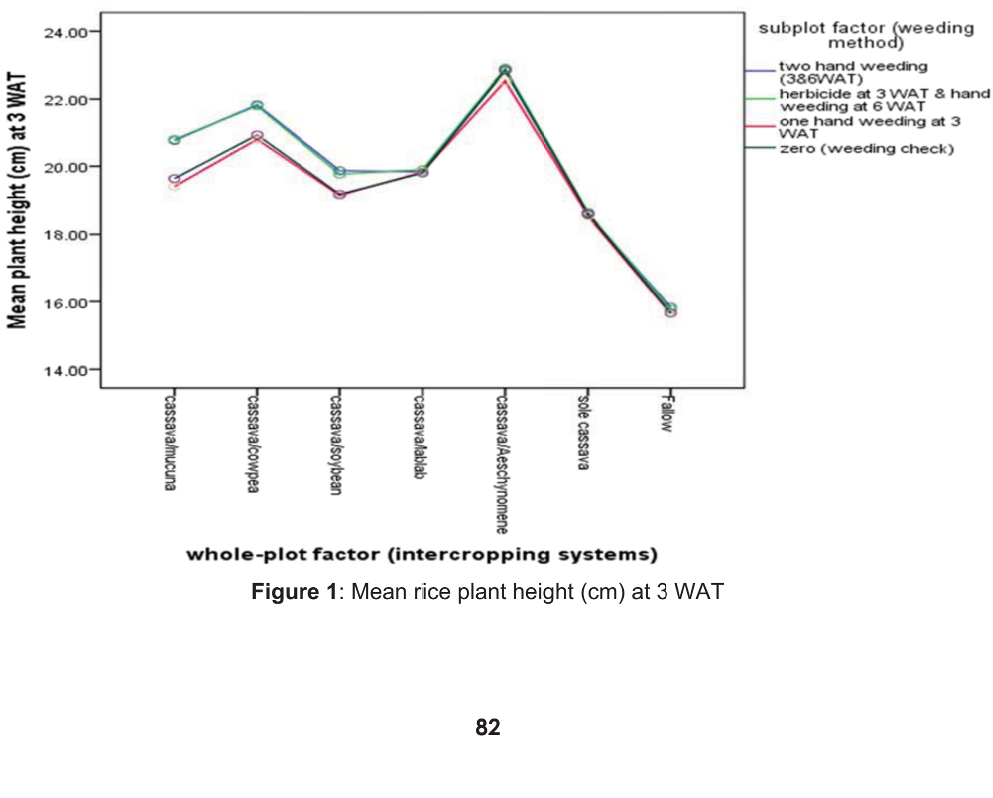

Figure 1: Mean rice plant height (cm) at 3 WAT

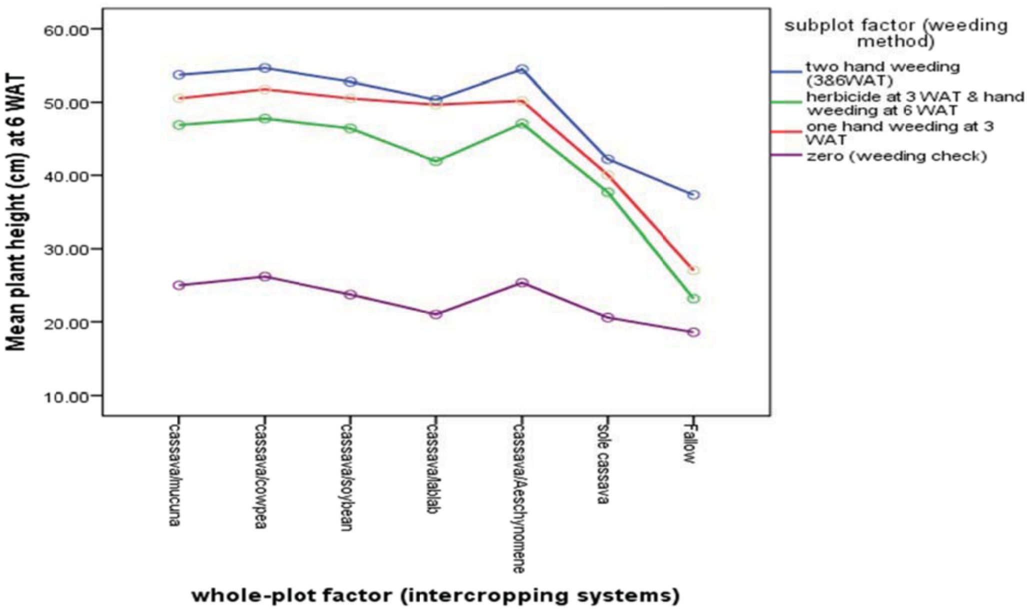

Figure 2: Mean rice plant height (cm) at 6 WAT

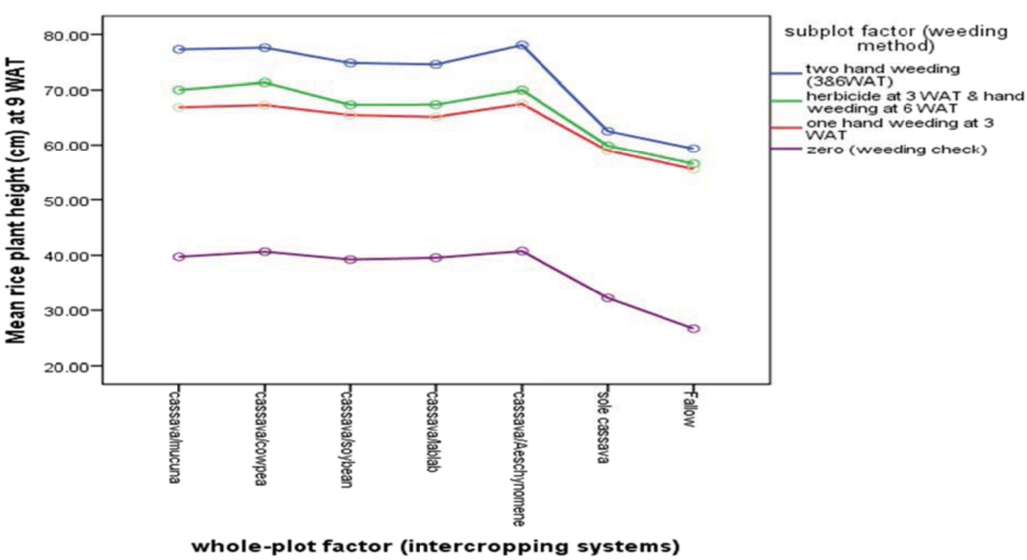

Figure 3: Mean rice plant height (cm) at 9 WAT

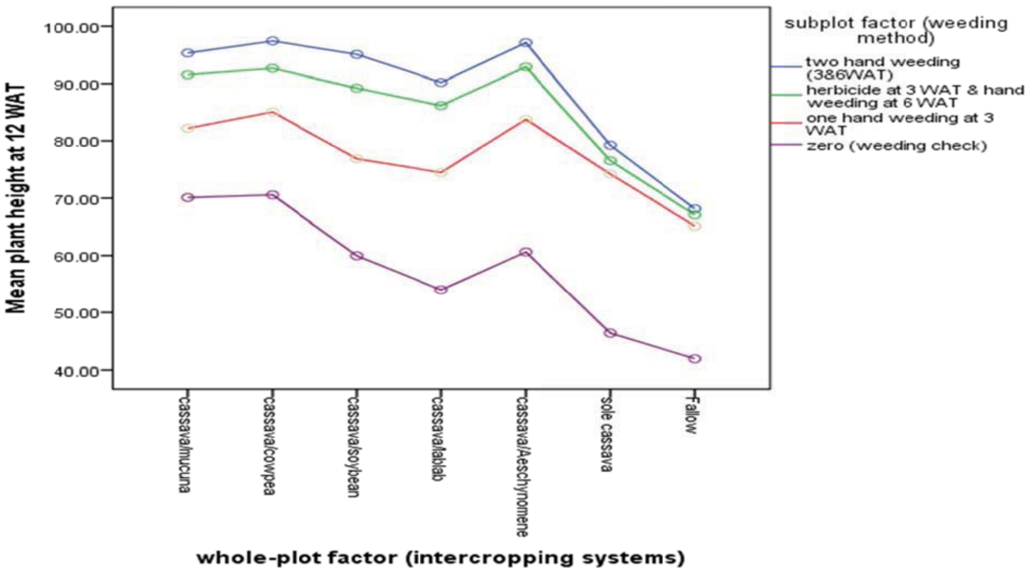

Figure 4: Mean rice plant height (cm) at 12 WAT

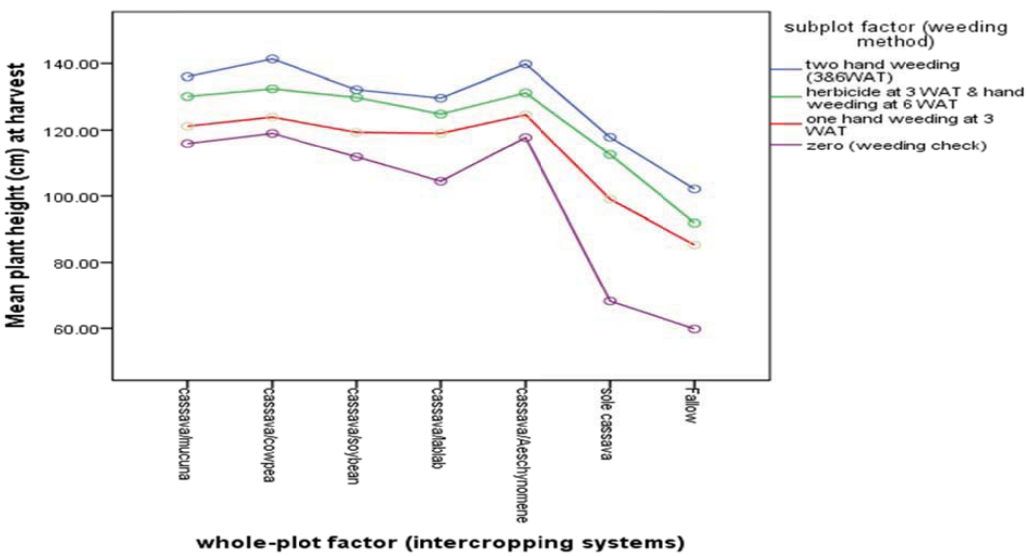

Figure 5: Mean rice plant height (cm) at harvest

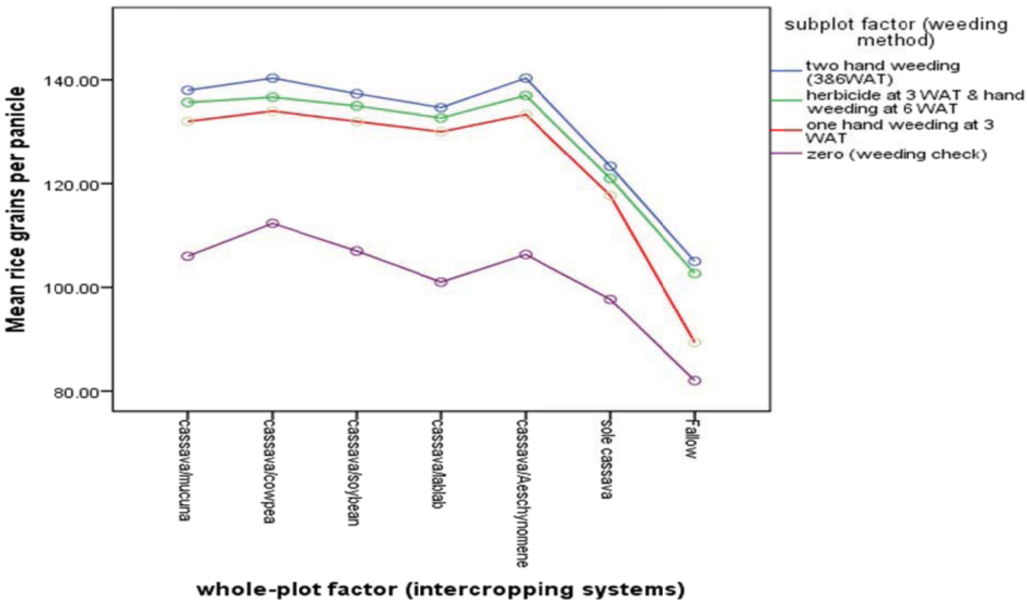

Figure 6: Mean rice grains per panicle

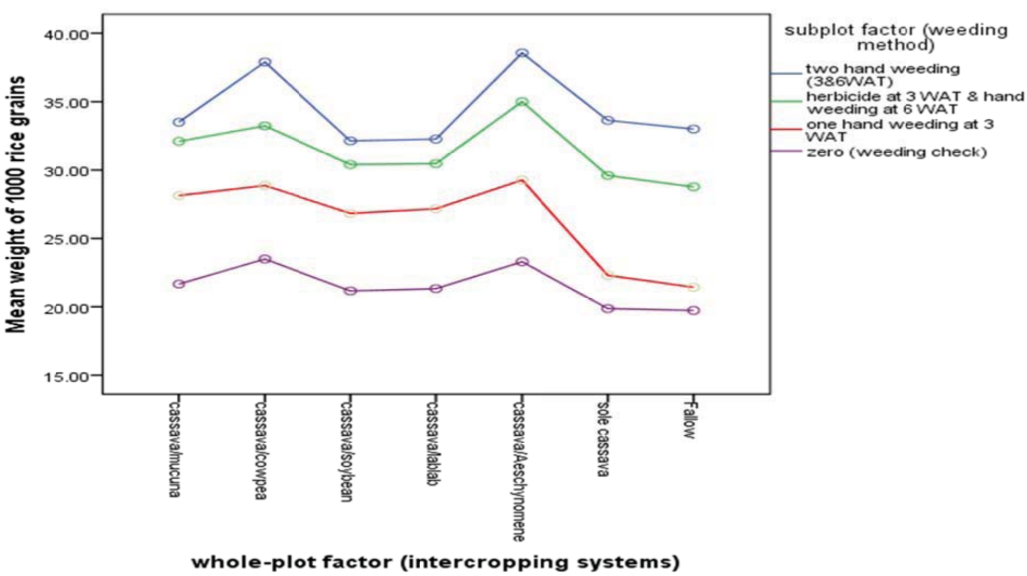

Figure 7: Mean weight of 1000 rice grains

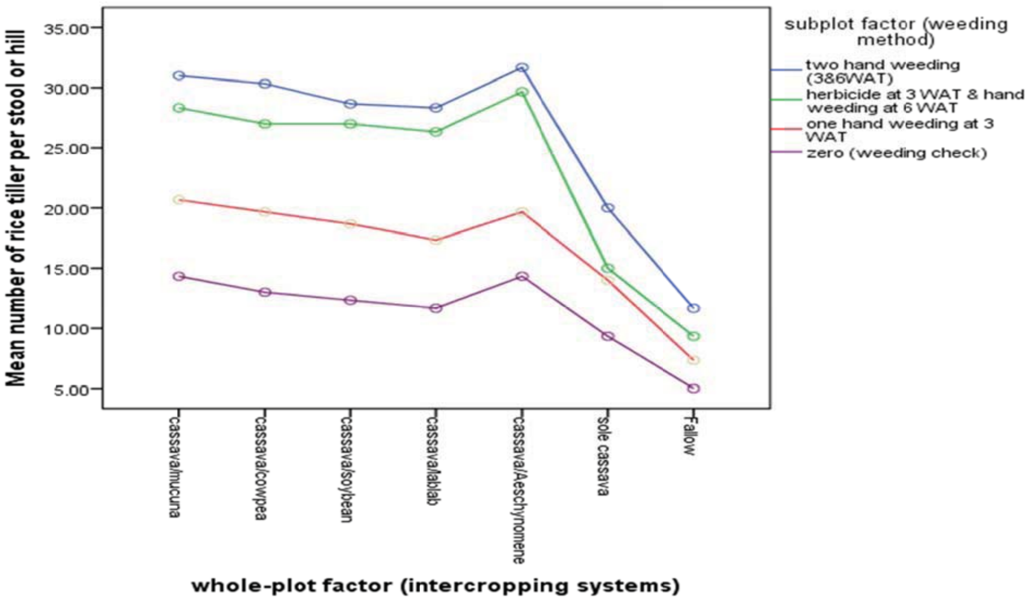

Figure 8: Mean number of rice tiller per stool or hill

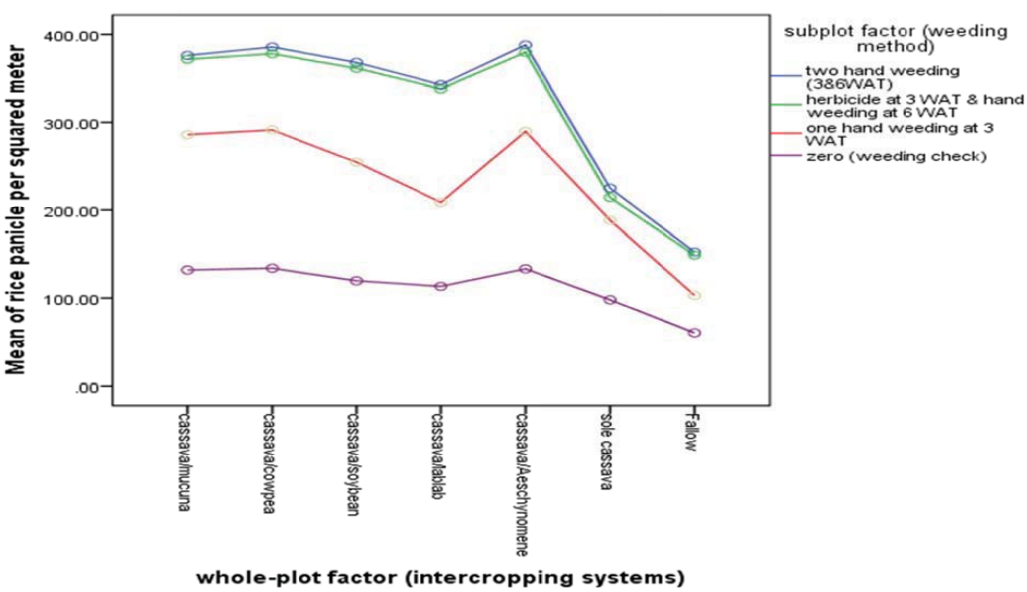

Figure 9: Mean rice panicle per m^2

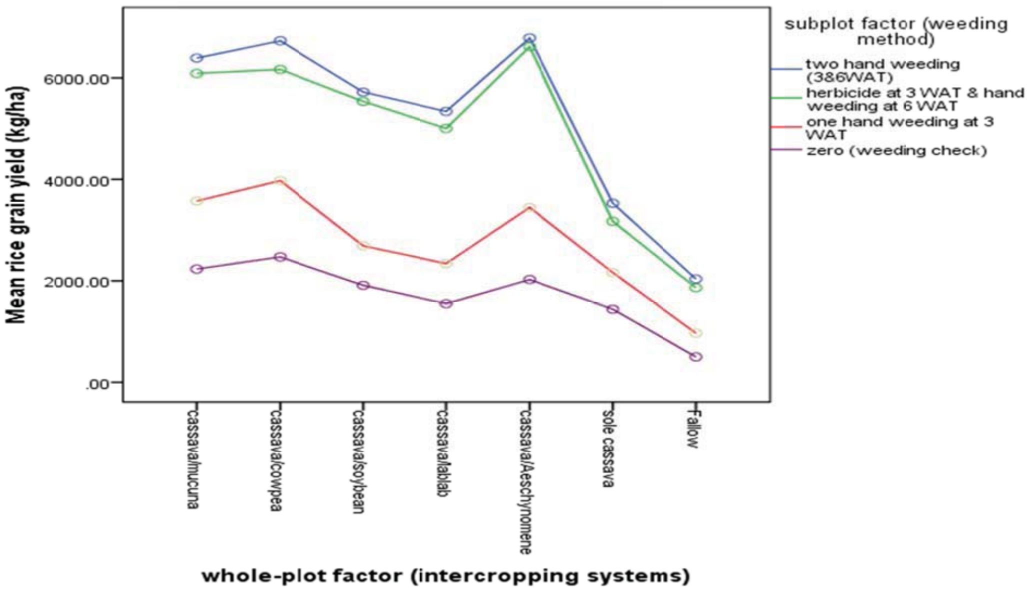

Figure 10: Mean rice grain yield (kg/ha)

4. CONCLUSIONS AND RECOMMENDATIONS

This study has established the soil-nutrient enrichment potentials of intercropping cassava with legumes before rice cropping and also that of weeding methods for overall productivity of rice. Movement of organisms that cause rice disease across the field was interrupted by the adopted intercropping technique since many insects and fungi feed on just one type of crop. Soil nutrients were replenished through the rotation of cassava/legumes with rice. Each of the adopted intercropping system have been shown to have positive impact on the yield of each of the ten rice parameters considered for every weed –control method. Also, each of the weed-control methods was observed to have positive impact on the yield of each rice parameter for every adopted intercropping system. It was observed that whichever weed-control method a practitioner may choose to adopt while farming rice, the field should be pre-intercropped with cassava and *Aeschynomene* and/or cassava and *cowpea* before the rice season, so as to attain optimum yield for every rice parameter being investigated. Also, whichever intercropping system a practitioner may want to adopt during the post-rice season, 2-hand weeding at 3&6 WAT and Herbicide application at 3 plus hand weeding at 6 WAT are, by this study, the highly recommended weed-control methods for optimum yield. Therefore, this study has identified the adopted technique as an alternative to synthetic fertilizers.

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APPENDIX

ANOVA TABLES FOR EACH OF THE TEN RICE PARAMETERS

Table 1: ANOVA Table for rice plant height(cm) at 3 WAT

Source	df	SS	MS	F	sig.
Block	2	3.302	1.651	1.168	0.344
Intercropping system (A)	6	354.229	59.038	41.756	0.000
Error(a)	12	16.967	1.414		
Weeding method (B)	3	4.840	1.613	11.437	0.000
Interaction (AB)	18	4.507	0.250	1.775	0.063
Error(b)	42	5.925	0.141		
Total	**83**	**389.77**			

Table 2: ANOVA Table for rice plant height(cm) at 6 WAT

Source	df	SS	MS	F	sig.
Block	2	1.007	0.503	0.024	0.976
Intercropping system (A)	6	3335.227	555.880	26.487	0.000
Error(a)	12	251.843	20.987		
Weeding method (B)	3	8687.687	2895.896	549.779	0.000
Interaction (AB)	18	585.788	32.544	6.178	0.000
Error(b)	42	221.230	5.267		
Total	**83**	**13082.782**			

Table 3: ANOVA Table for rice plant height(cm) at 9 WAT

Source	df	SS	MS	F	sig.
Block	2	29.540	14.770	1.933	0.187
Intercropping system (A)	6	2465.141	410.857	53.771	0.000
Error(a)	12	91.690	7.641		
Weeding method (B)	3	15243.521	5081.174	1433.592	0.000
Interaction (AB)	18	117.185	6.510	1.837	0.053
Error(b)	42	148.863	3.544		
Total	**83**	**18095.94**			

Table 4: ANOVA Table for rice plant height(cm) at 12 WAT

Source	df	SS	MS	F	sig.
Block	2	8.376	4.188	2.194	0.154
Intercropping system (A)	6	6446.908	1074.485	562.826	0.000
Error(a)	12	22.909	1.909		
Weeding method (B)	3	12253.797	4084.599	1477.272	0.000
Interaction (AB)	18	572.538	31.808	11.504	0.000
Error(b)	42	116.128	2.765		
Total	**83**	**19420.656**			

Table 5: ANOVA Table for rice plant height(cm) at harvest

Source	df	SS	MS	F	sig.
Block	2	31.566	15.783	11.458	0.002
Intercropping system (A)	6	20861.109	3476.852	2523.994	0.000
Error(a)	12	16.530	1.378		
Weeding method (B)	3	9792.407	3264.136	1874.145	0.000
Interaction (AB)	18	1865.463	103.637	59.504	0.000
Error(b)	42	73.150	1.742		
Total	**83**	**32640.225**			

Table 6: ANOVA Table for rice grains per panicle

Source	df	SS	MS	F	sig.
Block	2	11.595	5.798	0.234	0.795
Intercropping system (A)	6	11962.119	1993.687	80.353	0.000
Error(a)	12	297.738	24.812		
Weeding method (B)	3	11406.988	3802.329	935.729	0.000
Interaction (AB)	18	527.595	29.311	7.213	0.000
Error(b)	42	170.667	4.063		
Total	**83**	**24376.702**			

Table 7: ANOVA Table for 1000 rice grain weight

Source	df	SS	MS	F	sig.
Block	2	1.275	0.638	0.257	0.778
Intercropping system (A)	6	340.768	56.795	22.885	0.000
Error(a)	12	29.781	2.482		
Weeding method (B)	3	2038.966	679.655	495.725	0.000
Interaction (AB)	18	91.725	5.096	3.717	0.000
Error(b)	42	57.583	1.371		
Total	**83**	**2560.098**			

Table 8: ANOVA Table for rice tiller per stool or hill

Source	df	SS	MS	F	sig.
Block	2	2.952	1.476	1.763	0.213
Intercropping system (A)	6	2398.238	399.706	477.374	0.000
Error(a)	12	10.048	0.837		
Weeding method (B)	3	2691.274	897.091	982.900	0.000
Interaction (AB)	18	286.143	15.897	17.417	0.000
Error(b)	42	38.333	0.913		
Total	**83**	**5426.988**			

Table 9: ANOVA Table for rice Panicle/m^2

Source	df	SS	MS	F	sig.
Block	2	954.167	477.083	0.923	0.424
Intercropping system (A)	6	351843.976	58640.663	113.468	0.000
Error(a)	12	6201.667	516.806		
Weeding method (B)	3	584481.845	194827.282	1116.311	0.000
Interaction (AB)	18	60715.738	3373.097	19.327	0.000
Error(b)	42	7330.167	174.528		
Total	**83**	**1011527.56**			

Table 10: ANOVA Table for rice Grain yield (kg/ha)

Source	df	SS	MS	F	sig.
Block	2	278,216.007	139,108.004	2.588	0.116
Intercropping system (A)	6	119,785,563.4	19,964,260.56	371.364	0.000
Error(a)	12	645,111.159	53,759.263		
Weeding method (B)	3	180,360,354.0	60,120,117.99	2,711.481	0.000
Interaction (AB)	18	20,711,296.10	1,150,627.561	51.895	0.000
Error(b)	42	931,242.100	22,172.431		
Total	**83**				