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GOVERNMENT OF THE GAMBIA

NATIONAL AGRICULTURAL RESEARCH INSTITUTE

ANNUAL RESEARCH REPORT FOR 2015 CROPPING SEASON

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1.0 AGROFORESTRY/CROPPING SYSTEMS AND RESOURCE MANAGEMENT

1.1Effects of different NPK rates on growth and yield of maize (Zea mays L)

Introduction

Nitrogen is the most important mineral nutrient quantitatively for plant growth. Adequate N nutrition of plants is critical for high yields and quality of harvested dry matter. Therefore, the wise use of NPK to optimize crop returns should be the principal objective of every farmer.

Adequate N nutrition of plants is critical for high yields and quality of harvested dry matter. Therefore, the wise use of NPK to optimize crop returns should be the principal objective of every farmer. The overall objective of the research was to quantify yield responses of maize to NPK inorganic fertilizer on maize growth and yield. To achieve this, the study specifically determined the effect of cultivars, NPK rates on growth, development and yield of three maize varieties.

Materials and Methods

The experiments were conducted in Yundum in the West Coast Region, Sapu in Central River Region south and Girob Kunda in Upper River Region research fields to determine the effect of cultivars, NPK rates on growth, development and yield of three maize varieties.

Land preparation was by conventional tillage (disc ploughing). A split plot design with four replication was used. Treatment consists of, no NPK (0 kg ha^{-1}), the recommended rate of NPK (200 kg ha^{-1}), twice the recommended NPK rate (400 kg ha^{-1}, half of the recommended NPK rate (100 kg ha^{-1}) and ¼ of the recommended rate of NPK(50 kg ha^{-1}) . Nitrogen, P and K were basally applied at two weeks after planting and top dressed with urea 27 days after planting. The fertilizer (NPK) was row placed and incorporated in the top soil layer. The seeds of the three varieties DMR, Swan and NCD with maturity days of 90 for DMR and Swan and 120 days for NCD were hand planted at a spacing of 80 cm x 40 cm (inter and intra row) on July 21 for site III, July 22 for Sapu and July 24 for Giroba Kunda respectively. Weeding was manual and was done as required.

Composite soil samples were randomly taken from each study site by driving a soil auger into the soil, and samples were taken at two depths (0-15 cm and 15-30 cm) respectively for soil classification and characterization prior to planting. Soil samples were air dried and ground to pass a 2 mm sieve before

analysis. Measurements were made on soil pH both in water neutral KCL in a soil water/solution ratio of 1:2 using the glass electrode. Organic matter was determined using loss of weight ignition procedure. Total N, macro-cation (Ca, Mg and Na) and available P were not determined because the equipment required to do that are yet to be purchased.

Results and Discussion

The obtained results revealed that plant height was affected by different NPK rates applied (Table 1), with the highest plant height obtained by treatment 4. The increase in plant height with different NPK rates can be attributed to the fact that nitrogen promotes plant growth and increases the number and length of the internodes which results in progressive increase in plant height.

Similar results were reported by Sharma (2010), Turkhede and Rajendra (2011), Koul (2010) and Saigusa et al. (2012). However, the increase in plant height attained by treatment 4, in this study can be explained by the efficiency of NPK as an essential nutrient for the plant. This result is in agreement with the finding of Sahid *et al*. (2010) and Bindra and Kharwara (2011).

As shown in Table 1 stover (biomass) production was not statistically affected by varying the rate of fertilizer application even though stover weight increased when fertilized with different NPK rates. The highest biomass production was obtained in treatment 4 (200 kg ha^{-1}) with a value of 1.0 kg ha^{-1}; whereas the control produced the lowest stover weight (0 kg ha^{-1}) with 0.8 kg ha^{-1} representing 44.45% reduction in biomass as compared with other treatments. The increase in stover weight could possibly be ascribed to the fact that nitrogen often increases plant growth and plant height and this resulted in more nodes and internodes and subsequently more production of leaves. In this respect, Okajina et al. (2010), Sawi (2012) and Jhones et al. (2012) found that nitrogen fertilization, significantly increased the number of leaves and they suggested that the increasing in number of leaves may be as a result of increasing number of nodes.

The present study showed that, the number of days to 50% tasseling was not affected by the different NPK treatments (Table 1). Nitrogen application did not accelerate the time to reach 50% tasseling as compared to the control. These results are fully in contrast with the findings of Richard et al. (2011) who reported that nitrogen decreased the interval from seeding to flowering.

The attained results showed that, different rates of NPK affected the fresh cob weight of the crops as compared with the control (Table 1). Moreover, the fresh cob weight increased progressively by NPK treatments as compared with other nitrogen rates with the exception of treatment 5. The increase in fresh cob weight under NPK application can be attributed to the positive effect of nitrogen on all the growth parameters investigated in this study. These findings are in conformity with the findings of other investigators particularly, Ellis et al. (2009), and Singh et al. (2012).

The results summarized in Table 1 revealed that, NPK application influenced dry cob weight during the 2015 season. Cob weight is a function of growth parameters. The differences in dry cob weight may be due to the nutrients included in each NPK, which was higher when plants were treated by NPK. These results were in full conformity with those reported by El Amin (2009) and Abdel Gader (2009).

The greatest number of cobs per plot was observed for variety 1 while the least was in variety 2 (Table 1). The difference between variety 1 (DMR-SR) and each of variety 2 (Suwan2) and variety 3 (NCB) was not significant at $P<0.05$. Similarly, average seed weight 1000 grain weight in grams was recorded in DMR-SR which was closely followed by Swan and NCB respectively. In terms of grain yield in ton ha^{-1} the reverse was observed where DMR-SR recorded the heaviest followed by NCB and Suwan 2 respectively. The lower grain yield in variety 2 (Swan2) could be due to the fact that it had the lowest cob count compared to DMR-SR and Suwan 2.

Comparing of means, in terms of grain yield, no significant difference were observed treatments 1 (0 kg ha^{-1}), 2 (100 kg ha^{-1}) and 3 (50 kg ha^{-1}) however, significant differences were observed between treatment 4 (200 kg ha^{-1}) and 1 (0 kg ha^{-1}). There were no significant differences in grain yield between treatments 4 (200 kg ha^{-1}) and 5 (400 kg ha-1) in spite of much higher grain yield of treatment 4 (200 kg ha^{-1}) compared to treatment 5 (400 kg ha^{-1}).

Grain yield was significantly influenced by fertilizer treatment. The effect of fertilizer rate on the number of cobs per plot as well as the 1000-seed weight was not significant. None of the yield components were significantly influenced by maize variety and there was no significant interaction of maize variety with fertilizer application.

Statistically, treatment 4 (200 kg ha^{-1}) and 5 (400 kg ha^{-1}) produced similar number of grains ton ha^{-1}even though treatment 4 (200 kg ha^{-1}) produced the highest number of grains.

Effect of fertilizer treatment on 1000-seed weight presented in Table 1 was not affected by fertilizer treatment. 1000-seed weight was reduced from 234.2 g in treatment 4 (200 kg ha^{-1}) to 231.8 g and 228.3 g for treatment 2 (100 kg ha^{-1}) and treatment 1 (0 kg ha^{-1}), representing 19.97% and 19.67% respectively. Treatment 4 (200 kg ha^{-1}) produced the highest seeds compared to either treatment 3 (50 kg ha^{-1}) or treatment 5 (400 kg ha^{-1}) sown crops.

Table 1. Response of maize to different rates of NPK fertilizer application in 2015 cropping season in Yundum

Varieties	Stand count	plant ht (cm)	Days 50% Tasseling	Cob count	Cob fresh (kg)	Cob dry (Kg)	Stover (Kg)	Grain (ton/ha)	1000 grain (g)
1	27	131	58	26	2.3	1.8	1.4	0.4	239.5
2	23	120	59	16	1.0	0.8	0.9	0.2	231.4
3	26	133	59	20	1.5	1.2	0.8	0.3	224.3
Lsd	NS	NS	NS	NS	NS	NS	NS	NS	NS

CV (%)	8.3	6.6	1.2	38.8	20.3	21.7	17	22.5	3.1
Treatments									
1	24	124.0	58	17	1.3	1.0	0.8	0.50	228.3
2	24	124.3	58	19	1.3	1.0	0.9	0.60	231.8
3	24	125.0	58	19	1.4	1.1	0.9	0.82	232.1
4	25	129.3	58	21	1.6	1.2	1.0	1.07	234.2
5	24	127.0	58	20	1.5	1.2	0.9	1.05	234.1
Lsd	3.6	14.2	NS	6.3	0.32	0.3	0.22	0.30	NS
CV (%)	17.5	13.7	5.4	41.1	34.9	39.5	29	45.8	27.1

Conclusion/Recommendation

Generally, the results showed that maize responded well to the NPK level 4 with regards to plant count, plant height but have a similar effect on days to 50% tasselling, number of cobs, fresh and dry cob weight, Stover and grain yield with treatment 5. This result is inconclusive and thus need to be repeated over time. However, the findings of this research suggest that attainment of sustainable yield output farmers could apply the recommended rate of NPK.

1.2 Effect of nitrogen application rate on yield and yield component of six maize varieties

Introduction

Nitrogen is highly volatile and readily leached. Similarly, increasing high cost of fertilizer has made the knowledge of the effectiveness of its use by maize and other crops inevitable. In view of these factors, the cropping systems and resource management programme carried out field research to ascertain efficient and cost effective use of NPK to optimize crop returns of small scale subsistence farmers.

Materials and Methods

A split plot design with main plots assigned to fertilizer levels whilst the sub plots assigned to maize varieties. The Maize varieties used were**:** DMR-SR, Jeka, Swan2**,** OBA Super 2, NCB, and TZE-Y. The fertilizer (N) levels used were**: 1 (**0), **2** (50), **3** (100), **4** (150), **5** (200).

The following parameters were collected: Planting date, Plant count at 21 DAE, Plant count at Harvest, Plant height at 21, 45 DAE, Plant at harvest, Ear height, plant count, Pest and diseases, Plant vigor, Soil samples

Results and Discussion

The effects of different N rates on the growth, yield and yield component of six maize genotypes are presented in (Fig. 1). Generally, N rates showed no significant (*P<0.05*) difference between maize genotypes on all observed parameters except for cob count with genotype 3 having the highest mean of 50 cobs (Fig. 1). Maize genotypes showed significant (*P<0.05*) response to different N levels on cob count with an Lsd of 7.08 (Figure 1).

In terms of grain yield, Jeka had the highest yield with 200 kg N ha^{-1} application, followed by NCB, Oba Super2 and the least was recorded for TZE-Y with a value of 1.37 ton ha^{-1}. For the 100 kg N ha^{-1}, the highest was recorded for Oba Super2 closely followed by Swuan2 and NCB with 150 N kg ha^{-1} (1.5 t ha^{-1}) respectively. For the 150 kg N ha^{-1}, NCB recorded the highest while the least was recorded for TZE-Y with a value of 0.8 ton ha^{-1} (Figure 1).

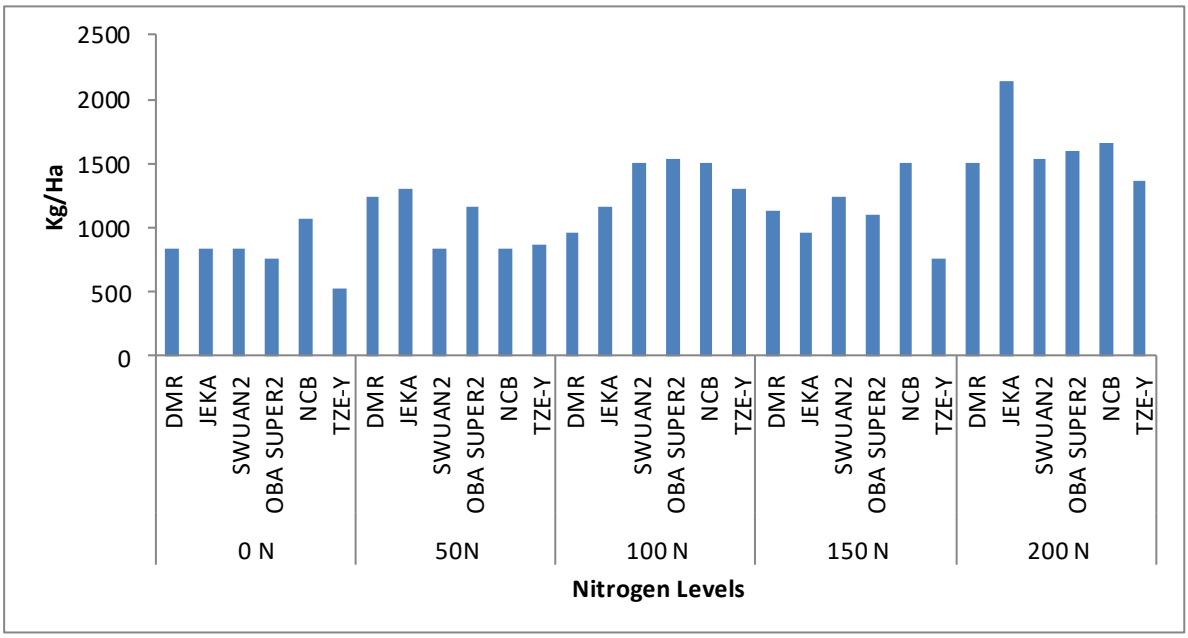

Figure 1. Maize genotypes grain yield as influence by N levels

For the 1000 grain weight no significant difference were observed between the 200 kg ha^{-1}N level and the 100 kg ha^{-1}N level even though the 200 kg ha^{-1}N level recorded the highest 1000 grain weight. A similar trend was observed between where the 0 kg ha^{-1}N level recorded a slightly higher 1000 grain weight than the 50 kg ha^{-1}N level. Statistically no significant differences were observed amongst all the N levels applied in terms of 1000 grain weight.

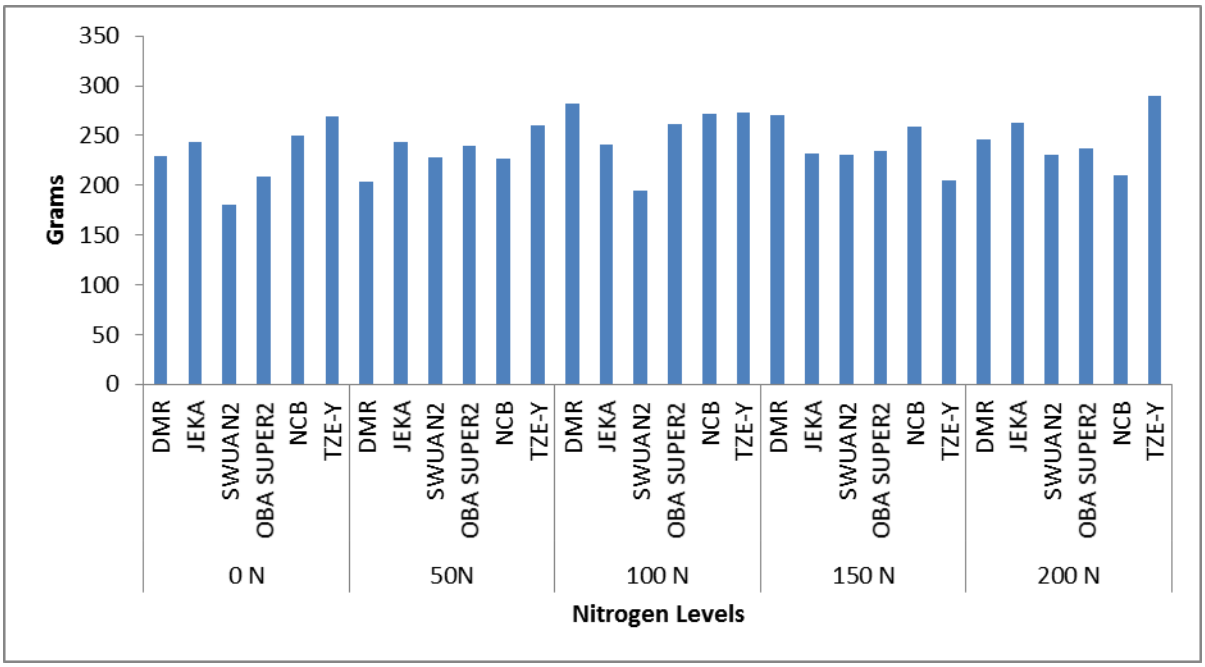

Figure 2. Maize genotypes 1000 grain weight as influence by N levels

The tallest plant was recorded in 200 kg ha^{-1}N level with Jeka recording 168.5 cm followed by NCB, Oba Super 2 and DMR-SR with values 165 cm, 163.8 cm and 158.7 cm respectively. Comparatively, no significant difference was observed between the 100 kg ha^{-1} N and the 50 kg ha^{-1} N levels even though the 100 kg ha^{-1} N had a slight edge over the 50 kg ha^{-1}N level.

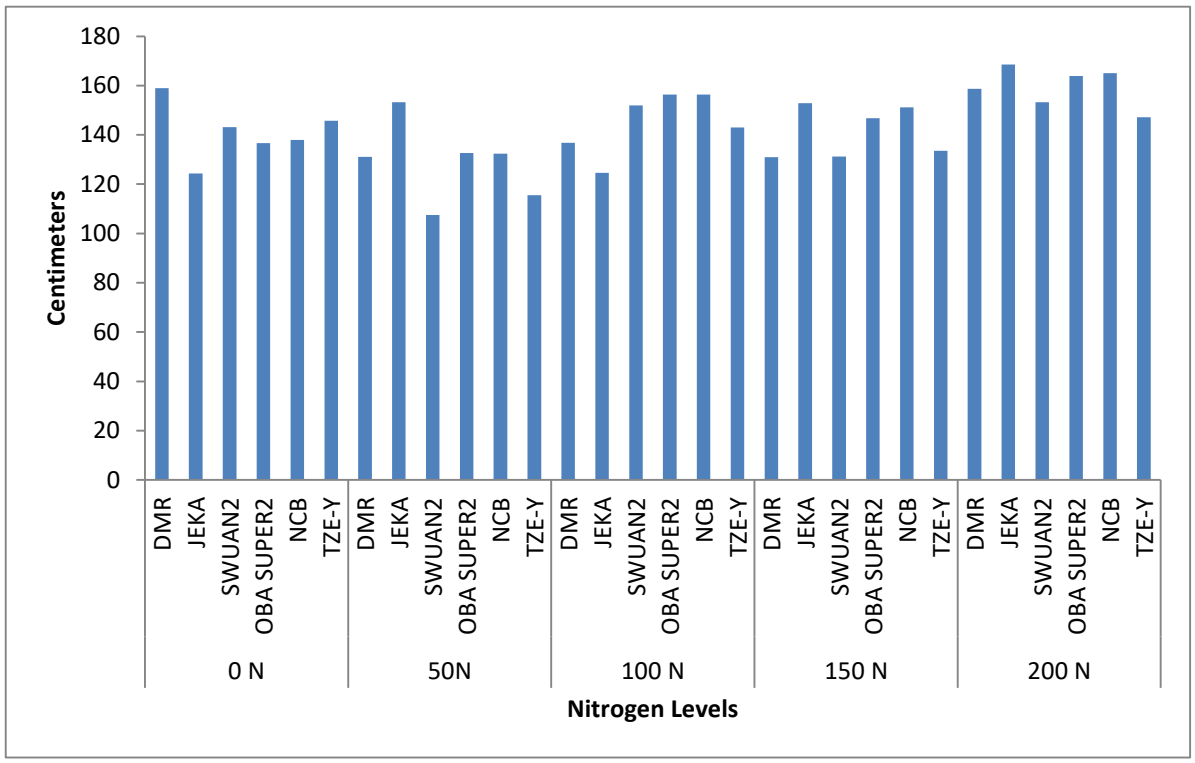

Figure 3. Maize genotypes plant height as influence by N levels

Conclusion/Recommendation

In conclusion, all the six maize varieties responded differently on all the studied parameters in terms of N levels which suggest that more need to be done in order to come up with a variety that dominates the rest.

2. 0 PEST MANAGEMENT PROGRAM

2.1 Efficacy of Aflasafe biological product in Groundnut and maize Fields

Introduction

Since 2010, IITA in collaboration with the United States Department of Agriculture, Agriculture Research Service (USDA-ARS), University of Gaston Berger and Direction de la Protection des Vegetaux (DPV; Senegal) identified Senegalese a toxigenic strains which formed the active agent of an indigenous biological control product named Aflasafe SN01. In efficacy trials conducted for 4 years in hundreds of farmers' fields, Aflasafe SN01 cut down aflatoxin contamination in maize and groundnut by > 80%.

The bio control technology was extended to The Gambia at the request of the Gambia Groundnut Council (GGC) and National Agriculture Research Institute (NARI) to improve the quality of maize and groundnut, expand market and gain experience with the technology.

Maize and groundnut samples were collected in 7 regions across The Gambia in March 2014 to determine the presence of Senegalese Aflasafe SN01 strains in The Gambia.

To test the efficacy of Aflasafe SN01 for reduction of aflatoxin in maize and groundnut, 2 tons of the product was produced at the IITA-Ibadan manufacturing plant and exported to The Gambia after obtaining necessary imports and export permits.

The Aflasafe activity is part of a pilot project in Africa.The Gambia is the latest country to join twelve (12) others in Africa that have benefited in the implementation of this new project called ''Aflasafe initiative''. It is expected to last for five years in the Gambia and will be hosted at the National Agricultural Research Institute (NARI).The Aflasafe initiative is a programme designed to protect Gambia's agricultural produce from been contaminated with Aflatoxin

Objectives

- To enhance the quality of crop products through reducing aflatoxin contamination in groundnut and maize in The Gambia by 90%.
- Contribute to enhancing groundnut and maize marketing for export trade for the Country
- Contribute to minimising health risks caused by aflatoxin contamination in The Gambia

Materials and Methods

The extension agents working within North Bank Region (NBR), Central River Region-North (CRR-N) and West Coast Region (WCR) of The Gambia assisted in the selection of the villages with respect to the stage of the targeted crops (groundnut and maize). The selection of the three regions was based on a survey made earlier on in all the regions of The Gambia to determine the aflatoxin endemic areas of the country. In the second year (2015) another region that is Lower River Region (LRR) was included. Thus the villages that were selected in the first year and second year of the Aflasafe initiative project were Fass Saho, Pakau Njogou and Chilla-jurunku in NBR, Sukuta, Chamen, kataba Omar Ndow, Conteh and Bakadagy in CRR-N and Jarra Medina, Bureng and Badumekoto in LRR Tambakunda, Julafare, Sitanunku, Siwol and Kusamai in WCR.

The application of the biological agent and soil sampling on the selected fields were conducted in early September in both 2014 and 2015. Farmers whose fields were chosen for application were enlightened about the product and it's important with regards to Aflatoxin control. Almost twenty (20) young people from chosen village were trained on how to apply the Aflasafe product before the application started in the villages. They were also trained on how to take soil samples in the selected fields. The trained men were then deeply involved in the application of the Aflasafe SNO1 product and the soil sampling in their respective fields with the involvement and supervision of the team from NARI, GGC, IITA and DPV.

A total of 190 ha and 200 ha of Aflasafe product was applied in Gambian fields in 2014 and 2015 seasons respectively at a rate of 10 kg/ha. For each farmer's field that was treated, an untreated control field was maintained to compare efficacy of Aflasafe SN01 application.

In the first year, samples were collected in early December and all samples were arranged and transported to IITA for analysis. The second year samples are yet to be taken.

Results and Discussion

Since 2010, IITA in collaboration with the United States Department of Agriculture, Agriculture Research Service (USDA-ARS), University of Gaston Berger and Direction de la Protection des Vegetaux (DPV; Senegal) identified Senegalese a toxigenic strains which formed the active agent of an indigenous biological control product named Aflasafe SN01. In efficacy trials conducted for 4 years in hundreds of farmers' fields, Aflasafe SN01 cut down aflatoxin contamination in maize and groundnut by > 80%.

The biocontrol technology was extended to The Gambia at the request of the Gambia Groundnut Council (GGC) and National Agriculture Research Institute (NARI) to improve the quality of maize and groundnut, expand market and gain experience with the technology.
Maize and groundnut samples were collected in 7 regions across The Gambia in March 2014 to determine the presence of Senegalese Aflasafe SN01 strains in The Gambia. The study showed that the strains that make up Aflasafe SN01 are present and well distributed in The Gambia. Therefore, it was safe to deploy Aflasafe SN01 in the country.
NARI, GGC and Department of Agriculture (DOA) collaborated with IITA and DPV to initiate the application of Aflasafe SN01 in selected fields in The Gambia.

To test the efficacy of Aflasafe SN01 for reduction of aflatoxin in maize and groundnut, 2 tons of the product was produced at the IITA-Ibadan manufacturing plant and exported to The Gambia after obtaining necessary imports and export permits.

Objective:
The objective of the trial was to determine the efficacy of Aflasafe SN01 in The Gambia to minimize health and trade risks associated with aflatoxin contamination**.**

Material and methods

In 2014, efficacy trials were located in: Fass Saho and Pakau Njogou in North Bank Region (NBR); Sukuta, Chamen, and Bakadagy in Central River Region-North (CRR-N); and Tambakunda, Julafare and Sitanunku in West Coast Region (WCR).
In September 2014, 45 groundnut fields were treated in NBR region, while in the CRR-N region 26 maize and 65 groundnut fields were treated and in WCR region, 37 groundnut fields were treated making a total of 147 groundnut and 26 maize fields. For each treated field, an untreated control field was maintained to compare efficacy of Aflasafe SN01 application.
In December 2014, samples were collected from 15 groundnut fields in each of the three regions, while 20 maize samples were collected from CRR-N region for aflatoxin analysis.
At least two extension agents in each region assisted in the selection of the villages and farmers who willingly participated in the field trials, field inoculation and sample collection.

Results and Discussion

Generally, aflatoxin concentration in groundnut was higher than in maize in untreated fields.
In groundnut, aflatoxin reduction was 97.1%, with a mean aflatoxin concentration of 2.3 ng/g in the treated fields, compared to 80.6 ng/g in samples in control fields.
In maize, aflatoxin reduction was 94.7%, with a mean aflatoxin concentration of 2.6 ng/g in the treated samples, compared to 48.9 ng/g in samples from the control fields (Table 1). The reduction in aflatoxin concentration is as a result of aflasafe application.

Table 2. Aflatoxin concentration (ng/g or ppb) in groundnut and maize grains/kernels from control and Aflasafe SN01 treated fields in The Gambia

Crop	Fields (No.)	Treatment	Mean Aflatoxin	Reduction (%)
Maize	20	Treated	2.6***	94.7
		Control	48.9	
Groundnut	44	Treated	2.3***	97.1
		Control	80.6	

NB: Mean aflatoxin concentration in grains from 20 maize fields and 44 groundnut fields. Control refers to fields in which Aflasafe SN01 was not applied; treated refers to fields to which Aflasafe SN01 was applied at the rate of 10 kg/ha. Aflatoxin reduction (%) = [1 – (aflatoxin in treated fields) / aflatoxin in

control fields] × 100. Significance (Student's t-test) indicated by * ($P < 0.05$), ** ($P < 0.01$) and *** ($P < 0.001$) are for differences between the aflatoxin concentrations in pairs of treated and control fields.

Proportion of samples that met the aflatoxin standards in the control and Aflasafe-treated fields.

Results have indicated that in maize, 95% of the treated fields had aflatoxin levels lower than 20 ng/g, which is the acceptable limit for safe consumption in the USA; compared to only 45% of the untreated fields. Similarly, 80% of the treated fields exhibited aflatoxin levels lower than 4 ng/g, which is the acceptable level for safe consumption in the EU, compared to only 30% of the untreated fields. Only 5% of the treated samples were considered unfit for human consumption (> 20 ng/g) compared to 55% in the untreated fields (Table 3).

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In groundnut, 93% of the fields showed aflatoxin levels lower than 20 ng/g compared to only 81% in the control fields. Similarly, 86% of the treated fields exhibited aflatoxin levels lower than 4 ng/g compared to only 61% in the control fields. Only 7% of the treated samples were considered unfit for human consumption (> 20 ng/g) compared to 18% in the untreated fields (Table 3).

Table 3. Proportion of aflatoxin standards in maize and groundnut samples from fields that were either treated or not treated (control) with the bio control product Aflasafe SN01 in The Gambia

Crop	Aflatoxin concentration (ng/g)	Fields (%)	
		Treated	Control
Maize	<4	80.0	30.0***
	<10	85.0	40.0***
	<20	95.0	45.0***
	>20	5.0	55.0***
Groundnut	<4	86.4	61.4***
	<10	90.9	77.3***
	<20	93.2	81.8***
	>20	6.8	18.2***

Aflatoxin data were based on 20 maize fields and 44 groundnut fields. Significance (Student's t-test) indicated by *** ($P < 0.001$) are for differences between the proportions in pairs of treated and control fields.<4 ng/g is the EU/Nestlé acceptable limit; <10 ng/g is the World Food Program acceptable limit; <20 ng/g is the United States Food & Drugs Administration regulation limit; >20 ng/g is unacceptable level of aflatoxin for food.

Conclusion/Recommendation

The biological control product Aflasafe SN01 dramatically reduced aflatoxin contamination of maize and groundnut in farmers' fields in The Gambia. Adoption and use of Aflasafe SN01 by farmers can improve

safety of maize and groundnut consumed and can enhance profitability of maize and groundnut-based enterprises.

2.2. Integrated control of red spider mites using botanical and entomo-pathogen approaches

Introduction

Pest management innovations are no exception. For instance, the promotion of synthetic pesticides in the control of insect pests though effective, is expensive and has raised health and environmental concerns (Talukder, 2006; Isman, 2007). The risks associated with use of synthetic insecticides are even higher among small scale farmers because of poverty and lack of skills to obtain and handle pesticides appropriately (Saxena *et al*., 1990). Thus, pests particularly insects, continue to ravage crops and without proper protection systems, farmers continue to lose most of their produce. Botanical pesticides are agricultural pest management agents which are based on plant extracts. In modern times these have been used as alternatives to synthetic chemicals in organic pest management.

Objectives

- To reduce incidence of red spider mite infestation on tomato ;
- To identify organic product (s) that is (are) effective in the control of Red Spider Mites on solanaceous crops
- To determine farmers' indigenous knowledge and the factors that influences the use of botanicals as alternatives to synthetic insecticides in pest management.

Materials and methods

The approach was a participatory one, which involves on-farm trials with researchers in collaboration with extension agents and farmers to ensure easy scientific knowledge transfer and quick adoption of best practices. The experimental design adopted for the trial is a Randomized Complete Block Design (RCBD) with 6 treatments replicated 3 times.

This research work targeted three regions in The Gambia; West Coast Region (WCR), Lower River Region (LRR) and Central River Region North (CRRN). One village was selected in each region (Brufut in WCR, Jarra Madina in LRR and Kaur in CRRN). The justification for these sites is to assess the suitability of the technology in different rainfall ecological zones of the Country.

Tomato variety called Roma was used as test crop. Seedlings were nursed in boxes so that there will be homogeneity in height and vigour. The seedlings were transplanted in the field at the age of 21 days. The

plots were demarcated at 1m x 4m after ploughing. The trial was weeded and frequency of weeding depended on the level of weed infestation.

The treatments for the trial are as follows;

1. 100 ml *of BaccillusThungilence* (BT) into 10 L of water.
2. 4 kg of ground neem leaves into 10 L of water plus 4 g of detergent.
3. 500 g of ground garlic into 10 L of water plus 4 g of detergent.
4. 50 ml of BT and 2 kg of ground neem leaves into 10 L of water plus 2 g of detergent.
5. 50 ml of BT and 250 g of ground garlic into 10 L of water plus 2 g of detergent.
6. Control (No treatment).

Grinding of treatments was carried out using a mortar and pestle. After grinding, the materials were soaked in water over night before application was conducted.

During the preparation of the treatments, about 10 farmers were invited from the surrounding to learn how the process and application were carried out with the participation of the extension agents. Application of different treatments was done five times during the plant live-cycle. Treatments application started at about 3 weeks after transplanting and it was done at an interval of one week between each other.

Basal and topdressing applications were carried out at the rate of 200 kg/ha of (NPK: 15:15:15) and 100 kg/ha of (urea 46% N) respectively.

- Data collection on the density of red spider mites infestation levels was done after each treatment application.
- Data collection on leave canopy (Leaf Area Index) before harvest
- Yield (fruit) data was also collected

All data collected were subjected to ANOVA (analysis of variance) using the GenStat statistical package. Means were separated using the least significant difference (LSD) at $P < 0.05$.

Results and Discussion

The Table 4 showed the effect of the botanicals and the biological agent on leaf area index of tomato at harvest. There were significant differences ($P>0.05$) increased leaf area index of tomato at harvest with neem having the highest means of 56.7 (Table 4). In general, application of Neem alone was more efficient in increasing leaf area index of tomato than their combinations.

Table 4. Leaf Area Index at Harvest

Treatments	Garlic	BT	Neem	Garlic +BT	Neem +BT	Control
Means	25.0	26.7	56.7	16.0	20.7	10.0
LSD (0.05)	25.36					
CV (%)	15.5					

The effect of the botanicals and biological agent applications on population of red spider mites' infestation per plot on tomato is presented in Table 3. Generally data showed an increasing trend in the number of red spider mite with an increase in crop growth rate. Comparatively, neem application had the least density of red spider mites across the weeks except at the third week of data collection.

Application of botanical and biological agent reduced the number of red spider mite on tomato at the fifth week after transplanting with neem having the lowest density of red spider mite (26.3) which was significantly different from the Garlic alone treatment. In the same week (fifth week after transplanting) the treatment Garlic produced significantly higher red spider mites infestation than any other treatment expect for that of sole BT application (Table 5).

At the seventh week after transplanting, the neem application treatment manifested the lowest number of live red spider mites infestation which was significantly different from the control treatment.

Table 5. Means Number of Live Insect per Plot at Different Intervals

Treatments	**No. of Live Insect (3^{rd} WAT^{1})**	**No. of Live Insect (4^{th} WAT)**	**No. of Live Insect(5^{th} WAT)**	**No. of Live Insect (6^{th} WAT)**	**No. of Live Insect (7^{th} WAT)**
Garlic	5.0	66.0	119.7	127.	106.
BT	7.0	41.7	69.3	216.	276.
Neem	6.7	3.3	26.3	23.	48.

Garl +BT	2.3	4.0	36.7	128.	124.
Neem +BT	1.7	6.0	54.0	103.	264.
CTRL	12.3	3.3	56.0	70.	349.
LSD (0.05)	NS	NS	54.48	NS	249.2
CV (%)	46.0	75.2	27.3	41.6	18.3

[1]Weeks after Transplanting

Generally, high insect mortality with significant differences were recorded at the 7th week after transplanting. Comparatively, at 7th week after transplanting the neem + BT treatments manifested significantly higher Red spider Mites motility rate with a mean of 60 than any other treatment expect for that of sole BT application (Table 6). In addition, Neem+Bt treated plots recorded the highest mortality rate of red spider mite at the 7th week after transplanting. This indicates that the mixtures of these two environmentally friendly materials (Neem +Bt) can be effective in killing red spider mites.

Table 6. Mean number of dead insect per plot at different intervals after transplanting

Treatments	**No. of Dead Insect (3rd WAT[1])**	**No. of Dead Insect (4th WAT)**	**No. of Dead Insect (5thWAT)**	**No. of Dead Insect (6th WAT)**	**No. of Dead Insect (7th WAT)**
Garlic	8.0	11.3	6.3	3.0	28.3
BT	12.0	2.7	4.3	10.0	35.3
Neem	2.0	5.3	5.0	1.7	20.3
Garlic +BT	12.0	0.7	1.3	12.0	27.3
Neem +BT	0.7	4.7	6.7	5.0	60
CTRL	3.7	6.0	4.3	0.7	31.0
LSD (0.05)	NS	NS	NS	NS	28.14
CV (%)	72.1	12.3	30.5	14.6	23.6

[1]Weeks after Transplanting

Generally the yield was low to effect any significant difference (*P> 0.05*) between treatment and between marketable and non-marketable fruits. The control produce comparable fruit yield with Neem. However, the former produced the highest number of un-marketable fruits (Table 7). This shows that application of botanicals and the biological agent has slight effect on fruit quality.

Generally, single application of Neem increased leaf area index of tomato than other treatments in this research work. This illustrates that the Neem application can increase leaf area index by reducing foliar damage of tomato at harvest. This is in line with Oparaeke, (2007) who reported that the Neem extracts have the ability to effectively control many pest at the field level. Similarly, Elhag, (2000) reported that botanicals, such as Neem seed extracts prevent ovipositor and also act as anti-feedants for many field pest. Generally, low density of red spider mite in Neem treated plots also indicates an increase number of marketable fruits over all. Highest marketable fruit yield (0.23 g) of Neem treatment could be as a result of low pest density and thus reduced defoliation and an increased photosynthesis rate due to high leaf area.

Table 7. Mean number of dead insect per plot at different intervals after transplanting

Treatments	**Marketable Fruit (g)**	**Non Marketable Fruit (g)**
Garlic	0.03	0.00
BT	0.04	0.01
Neem	0.23	0.02
Garlic +BT	0.04	0.01
Neem +BT	0.07	0.01
CTRL	0.10	0.17
LSD (0.05)	NS	NS
CV (%)	56.1	133.9

Conclusions /Recommendation

From the finding of this research, it could be concluded that Neem stands as the best option for repelling red spider mite on tomato. On the other hand, Neem+BT treated plots got the highest mortality rate of red spider mite thus proved to be an option for eradicating red spider mite on tomatoes.The use of botanicals such as the neem extracts should be part of the IPM approaches that can be encourage for wider usage within The Gambia.

Therefore, there is a need to conduct long-term research in multi-locations to determine the sole and combined effects of botanicals and biological control on yield of tomato so as to establish their sustainability in crop production.

2.3 Screening of rice storage facilities against pests and fungal molds infestation

Introduction

Post-harvest losses of grains and cereals among rural farmers of developing countries are considerable. Most of these loses occur during storage due to the use of inefficient structures that allow pests and moistures to enter, thus causing quantities and qualitative losses. It is estimated that 25-30% of all the food produced is wasted due to inadequate storage (Murtthy, 2010) The Food and Agriculture Organization of the United Nations (FAO) also succeeded in introducing household metal silos in 16 countries across Asia, Africa, and South America (Household Metal Silos, 2010). (Little research are have been done on them that is what makes such research an urgent one under Gambian farmers' storage conditions).

Objectives

- To test metal Silos against locally available storage facilities in The Gambia**.**
- To Sensitize farmers on the use of different types of storage facilities

Materials and Methods

Three sites were selected representing the different agro-ecological zones, i.e. (1) West Coast Region (Katakor village), (2) Lower River Region (Jenoi Village) and (3) Central River Region- South (Taifa village). In each location, only one farmer was identified for the conduct of this experiment. The local storage facilities were farmer own and the different treatments were replicated three times under farmer condition. Twenty five kg of rice seed was stored in each of the storage facilities for a period of six months, a periodic inspection, sampling and observations were carried out.

Treatments were as follows;

1) **Nylon bags**
   - seed-dressing chemical (seedox)
   - Neem + eucalyptus powder seed dressing
   - No treatment
2) **Metal Silos**
   - seed-dressing chemical (seedox)
   - Neem + eucalyptus powder seed dressing
   - No treatment
3) **Jute bags (50 kg container)**
   - seed-dressing chemical (seedox)
   - Neem + eucalyptus powder seed dressing
   - No treatment
4) **Empty oil drums (20 L container)**

- seed-dressing chemical (seedox)l
- Neem + eucalyptus powder seed dressing
- No treatment

During the implementation process, three periodic sampling were used:

a) Grain samples were collected at Taifa, Jenoi and Katakor villages before treatment application.

b) One month after treatment, first sample collection was done at Taifa, Jenoi and Katakor villages;

c) Two months after first sample collection, another sample was collected at Taifa, Jenoi and Katakor.

All laboratory analysis were to determine (Percentage germination, Insects and mould incidences.

(a) Insect infestation count, (b) Black and moldy grains

Data analysis

Data analysis was conducted using GenStat statistical package. Least Significant Difference (LSD) at 5% was used to separate the means.

Results and Discussion

In West Coast Region, the highest levels of black and moldy rice grains within the different rice storage materials was observed during the 3rd data collection; where the nylon bag recorded the highest levels of 1.99 % of black and moldy grains and metal silos recorded the lowest (1.20%) (Table 8). However, in West coast Region, there was no significant difference recorded between the treatments.

Table 8. Percentage of fungal molds within different rice storage containers in West Coast Region

Treatments (Storage containers)	1st Collection on % B&M	2nd Collection on% B&M	3rd Collection on % B&M
Metal Silos	0.353	0.403	1.20
Plastic Drum	0.360	0.470	1.34
Nylon Bag	0.853	0.670	1.99
Jute Bag	0.567	0.387	1.42
LSD	NS	NS	NS
CV %	49.8	67.1	60.8

In Lower River Region, no significant difference was recorded in the first and third collection but in the second collection, the metal silo recorded significantly difference values against the nylon bag, illustrating that percentage black and moldy rice grains in the metal silos was significantly higher than the nylon bag.

Table 9. Percentage of fungal molds within different rice storage containers in Lower River Region

Treatments (Storage containers)	1st Collection on % B&M	2nd Collection on % B&M	3rd Collection on % B&M
Metal Silos	0.10	**1.08**	2.44
Plastic Drum	0.28	0.58	1.29
Nylon Bag	0.08	**0.39**	1.66
Jute Bag	0.01	0.60	1.28
LSD	NS	0.62	NS
CV%	85.8	46.5	75

In Central River Region-South, difference were there in the first and second data collection but were not significant however in the third data collection there was significant difference between the metal silo and the jute bag containers as indicated in Table 8. The jute bag container recorded 1.42% in terms of black and moldy grains and the metal silos recorded 0.62% (Table 10).

Table 10. Percentage of fungal molds within different rice storage containers in Central River Region-South

Treatments(Storage containers)	1st Collection on % B&M	2nd Collection on % B&M	3rd Collection on % B&M
Metal Silos	0.10	0.26	**0.62**
Plastic Drum	0.19	0.31	0.66
Nylon Bag	0.18	0.20	0.65
Jute Bag	0.45	0.43	**1.42**
LSD	NS	NS	0.79
CV%	67.1	64	47

During the laboratory analysis, insect were only found to infest the rice grains sampled from West Coast Region (Figure 4). No infestations were found in the stored grains in the other two regions. In West Coast Region therefore the container that recorded the highest count of insect infestation was the jute bag (118) and this was significantly different from all the other containers as indicated in figure 4. The container that had least infestation was the nylon bag with a count of 5 insect infestation and this was followed by the metal silo which had a count of 19 insects within the storage duration of three months.

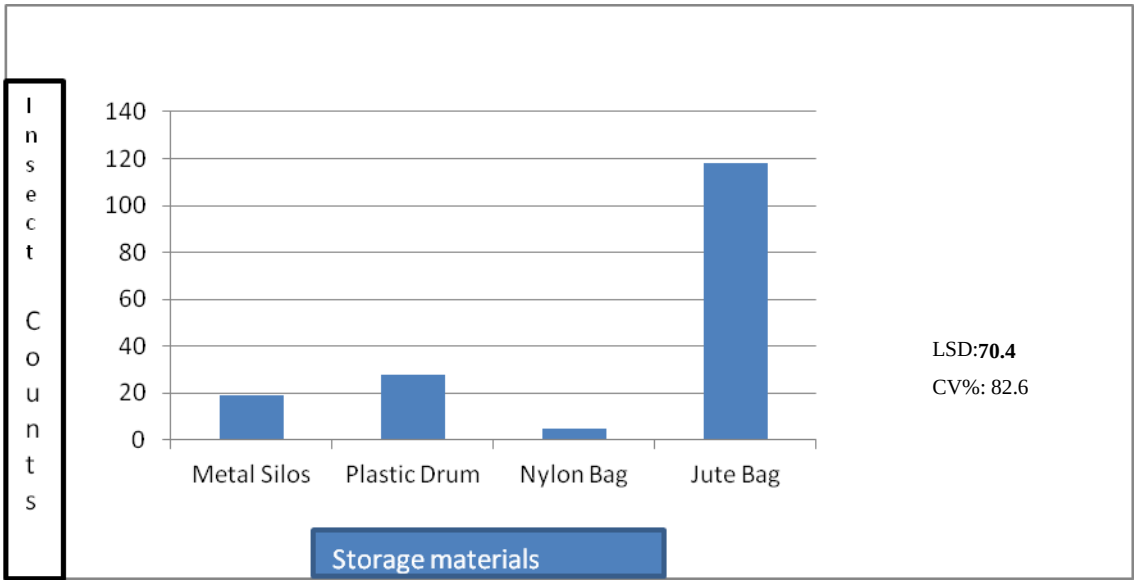

Figure 4. Insect infestation within different storage material in West Coast region of The Gambia

This research work was conducted to basically look at the performance of the metal silos against other storage containers. The second year research has shown that there were few significant differences recorded between the various treatments with regards to black and moldy caused by fungus; which illustrate that there is no much difference between the various storage facilities. In some of the locations such as West Coast Region of The Gambia no significant difference was recorded at all in terms of the black and moldy (Table 8). However, in Central River Region-South, the metal silo even performed better than the jute bag storage container (Table 10).

In terms of insect infestation, the metal silo was the second best in terms of insect infestation levels and performed significantly better than the jute bag as far as rice grain storage is concerned (Figure 4); illustrating that the metal silo is more appropriate than the jute bag with regards to insect infestation.

Furthermore because the metal silos are made of metal (unlike the other storage material tested in this research work), they may not easily get worn out making them more durable and stronger than other containers.

It is also important to note that the tested crop is not very prune to problems of storage especially in terms of insect attack. It is envisage that if the tested crop was groundnut there would have been more interesting results since groundnut is more pruned to storage problems than rice.

Conclusion/Recommendations

Based on the second year results, it can therefore be concluded that the metal silo is slightly better than the jute bag in terms of fungal mold attack and also in terms of insect pest infestation at storage level. However, it can perform almost at the same level like the other storage materials (Nylon bag and Plastic drum) in terms of fungal mold attack and insect infestation.

The work is not conclusive yet since the third year results should also be considered. However, based on the results, the metal silo container can be integrated in the Gambian agricultural systems for the storage of rice grains.

3.0 CEREALS PROGRAM

3.1 Evaluation of extra-early (80 to 85 days) and early (90- 95 days) maturing maize varieties

Introduction

With this narrow germplasm base, the exposure of The Gambian farmer to shocks of climate change such as persistent droughts, erratic unstable rains and emerging pests and diseases continued as a threat. These challenges pose by changing climate to increase and sustain crop productivity, dictate efforts to evaluate and select maize varieties for adaptation and adoption by farmers under different climate change situations across agro ecological zones of the country.

Objectives

1. To evaluate the performance and identify promising early and extra-early maturing drought tolerant varieties of maize, for regional adaptation from National Agricultural Research Systems (NARS) and International Agricultural Research Centers (IARCs)

2. To promote regional diffusion and exchange of germplasm materials from regional collaborators.

Materials and Methods

The trials were carried out in 2 locations namely: Jambur and Fass Chamen in West Coast Region. The trials consist of 10 varieties of extra early and 12 varieties of early maturing maize. The experimental design used was a randomized complete block design with 3 replications.

Planting was done with plot consisted of two 5-meter rows spaced 0.75 m between the rows within-row spacing of 40 cm. There were 2 plants/stand. Basal fertilizer was applied at the rate of 200 kg ha^{-1} of 15:15:15 NPK at 4 weeks after planting due to late availability of fertilizer and top dressing with 100 kg ha^{-1} of urea.

Data on grain yield and other agronomic characteristics such as stand count, days to 50% flowering number of cobs, dry cob weight, 1000grain weight, grain yield ha^{-1}, were collected. Data was analysed using Genstat Discovery Edition 4.

Results and Discussion

Table 11 showed the results of the extra-early maturing maize evaluation trial carried out in Jambur, Days to 50% flowering showed no significant differences between varieties.

Maize grin yield ranged from 2.93 tons ha^{-1} to 4.31 tons ha^{-1}. The highest yield was obtained from variety 2 (EV DT-W 2008) with mean grain yield of 4.31 tons ha^{-1} and the lowest from variety 5 (TZE-Y) with mean yield of 2.93 tons ha^{-1}. In addition, 4 varieties (EV DT-W 2008, TZE-W, LSR-W, DMR-SR) out yielded the check more than 0.5 ton ha^{-1} (Table 11).

Table 11. Mean Agronomic traits and grain yield of Extra-early (80 to 85 days) maturing maize

Designation	Variety	Days to 50% flowering	Number of Cobs/plot	dry cob wt (g)/plot	1000grain wt (g)	Grain Yield ha^{-1} (tons)
TZEE-W	1	54	35	3366.67	263.53	3.69
EV DT-W 2008	2	53	41	3666.67	252.90	4.31
TZE-W	3	55	34	4033.33	238.77	4.18
DMR-ESR-W	4	55	29	3033.33	267.97	3.33
TZE-Y	5	52	25	2633.33	255.40	2.93
TZE-LSR-W	6	55	35	3933.33	258.40	4.04
TZEE-Y	7	53	30	3133.33	269.50	3.24
DMR-SR	8	53	33	3366.67	272.13	4.18
DMR-ESR-Y	9	53	33	3266.67	263.53	3.69
SUWAN 2	10	55	36	3333.33	257.03	3.42
Lsd $_{(0.05)}$		ns	**10.08**	**1492**	**42.07**	**0.649**
P-value		ns	**0.163**	**0.709**	**0.872**	**1.583**

Results and Discussion

This activity was carried out in Fass Chamen. Results show no significant differences between the varieties for days to 50% flowering. Thousand grain weights were recorded and no significant difference

was observed from the analysis of variance. The highest weight was recorded from variety 5 (2011DTMA-Y STR) with mean weight of 292.8g while the lowest was from variety 12 (NCB) with mean weight of 197.4 g.

Maize grain yield showed significant differences between the varieties. The mean grain yield ranged from 0.27 to 1.87 tons ha^{-1}. The highest grain yield was recorded from variety 2 (TZE-W) with mean grain yield of 1.87 and the lowest from variety 10 (TZE-W DT C4 STR C4) with mean grain yield of 0.27 tons ha^{-1}. From the results obtained 6 varieties showed yields higher above 1.0 ton ha^{-1} compared to the local checks (TZE-W , 2009 DTE-Y STR Syn, 2011DTMA-W STR, 2009 DTE-W STR Syn, 2009 TZE-Y DT STR , TZE – W DT STR Syn C0) respectively (Table 12).

Table 12. Mean Agronomic traits and grain yield of early (90 to 95 days) maturing maize

Designation	Variety	Days to 50% flowering	1000 grain wt (g)	Dry Cob wt. (g)	Grain Yield ha^{-1} (tons)
TZE – W DT STR Syn C0	1	50	232.9	966.7	1.11
TZE-W	2	50	222.4	1633.3	1.87
TZE COMP3 DT C2 F2 (RE)	3	52	240.4	933.3	1.07
2011DTMA-W STR	4	53	211.0	1200.0	1.51
2011DTMA-Y STR	5	54	197.4	816.7	0.93
2009 DTE-Y STR Syn	6	52	218.1	1100.0	1.60
2009 DTE-W STR Syn	7	53	213.0	1077.2	1.31
2009 TZE-W DT STR	8	53	245.3	783.3	0.89
2009 TZE-Y DT STR	9	53	230.6	1200.0	1.31
TZE-W DT C4 STR C4	10	55	254.2	266.7	0.27
JEKA	11	53	240.2	234.4	0.64
NCB	12	59	292.8	566.7	0.36
Lsd $_{(0.05)}$		**ns**	**77.29**	**733.4**	**0.82**
P-Value		**ns**	**0.220**	**0.030**	**0.01**

RICE BREEDING ACTIVITIES

Introduction

Rice is a traditional staple food in many parts of Africa including The Gambia. This has been largely driven by high rate of population growth and urbanization. Rice production is being threatened by biotic and abiotic stresses as well as climate change. Production constraints differ as one move from rice ecology to another. In general, however, the decline in area under rice cultivation is greater in the lowland ecology notably in the mangrove swamp ecology compared to the upland ecology. This is due to the reason that the mangrove swamp and rain-fed ecologies are critically affected by drought, rice yellow mottle virus, iron toxicity, salinity, and acidification.

Despite the availability of improved varieties in the system, plant breeders must provide constant supply of new varieties to avoid erosion of yield potential that will enable farmers to adapt to a changing world. The immense potential of the lowland and mangrove ecologies can only be realized through the process of varietal screening, participatory varietal selection and subsequent adoption by farmers.

Objectives

The objectives of the screening activities are as follows:

- To identify rice varieties adapted to Irrigated lowland ecologies through evaluation for agronomic traits, resistance/tolerance to abiotic and biotic stresses and good grain quality.
- To identify salt tolerant varieties and to check for their adaptability and reaction to ARGM, RYMV and bacterial blight and tolerance to salinity stress.
- To offer farmers a chance of selecting from an elite group of salt tolerant/irrigated rice varieties that may perform better than the existing ones or their local varieties.

3.3 Participatory Advanced Trial (PAT) for Irrigated Lowland Dry Season

Materials and Methods

The Participatory Advanced Trial (PAT) for irrigated lowland during the period under review was carried out at Sapu, in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consist of 11 varieties including the local check. A Randomized Complete Block design was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

The data collected was subjected to analysis of variance using Genstat, adjusted varieties means were calculated and compared for agronomic traits.

Results and Discussion

Table 11 shows the results of the Participatory Advanced trial under Irrigated Lowland at Sapu in the Central River Region during the dry season. Generally, analysis of variance showed significant differences between the varieties. Days to 50% flowering ranged from 97 to 101 days. The highest number of days was recorded for variety 9 (Sahel 108) with 101 days and lowest from variety 6 (FAROX 521-146-H1) with 97 days from sowing. (Table 11).

Panicle length ranged from 21.70 cm to 24.53 cm. The longest panicle was recorded from variety 6 (FAROX 521-146-H1) with mean length of 24.53 cm and the shortest from variety 9 (SAHEL 108) with mean length of 21.70 cm.

Plant height analysis of variance showed no significant differences between the varieties with $P>0.05$. Results of plant height ranged from 98.33 cm to 104.00 cm. The tallest plant was recorded from variety 4 (WAB 2066-14-FKR3-R1-WAC1-WASB) with mean of 104.00 cm and the shortest from variety 11 (IET 3137) with 98.33cm.

Grain yield ranged from 4.82 tons ha^{-1} to 5.73 tons ha^{-1}. The highest yield was obtained from variety 10 (Sahel 201) with mean yield of 5.73 tons ha^{-1} and lowest from variety 8 (WAB 2081-WAC2-2-TGR2-WAT1-9) with mean yield of 4.82 tons ha^{-1} (Table 13). Results indicated that 34 varieties had yields higher than the local check (IET 3137). In conclusion, 9 varieties (FAROX 521-139-H1, WAB 2152-TGR 4, FAROX 521-101-H1, IET 3137 (Local check), WAB 2066-14-FKR3-R1-WAC1-WASB, WAB 1572-10-B-B-FKR 4-WAC1-1-TGR 2-WAT10-1, WAB 2098 WAC1-FKR2-4-TGR1, FAROX 521-146-H1, Sahel 201) had yields of 5.0 tons ha^{-1} and selection will be based on yield and other agronomic traits (Table 13).

Table 13. Agronomic Data and grain yield of PAT Irrigated Lowland rice varieties at Sapu Dry Season 2015

Designation	TRT	Days to 50% flw	Plant Ht. (cm)	Panicle m^2	Pan. Length (cm)	1000 Grain wt (g)	Grain Yield tons ha^{-1}
FAROX 521-101-H1	1	98	100.67	243	22.27	25.80	5.23
WAB 1572-10-B-B-FKR 4-WAC1-1-TGR 2-WAT10-1	2	98	101.33	322	23.27	26.50	5.58
WAB 2098 WAC1-FKR2-4-TGR1	3	98	101.33	306	23.57	26.93	5.60
WAB 2066-14-FKR3-R1-WAC1-WASB	4	98	104.00	338	23.23	26.23	5.56
FAROX 521-139-H1	5	99	105.67	399	22.83	26.73	5.00
FAROX 521-146-H1	6	97	100.00	316	24.53	26.17	5.60
WAB 2152-TGR 4	7	99	100.33	332	23.57	26.23	5.05
WAB 2081-WAC2-2-TGR2-WAT1-9	8	99	101.00	342	23.40	26.73	4.82
SAHEL 108	9	101	101.67	313	21.70	25.73	4.95
SAHEL 201	10	98	100.67	308	24.00	24.70	5.73
IET 3137 (Local check)	11	96	98.33	392	23.40	25.07	5.50
P- Value		**0.679**	**0.482**	**<0.001**	**0.010**	**0.382**	**0.196**
Lsd $_{(0.05)}$		**4.191**	**5.836**	**43.64**	**1.247**	**1.942**	**0.772**

3.4 Participatory Evaluation Trial (PET) for Irrigated Lowland Dry Season

Materials and Methods

The Participatory Evaluation Trial (PET) for irrigated lowland during the period under review was carried out at Sapu, in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consist of 35 varieties including the local check. An Alpha lattice design was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100 kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

Results and Discussion

Table 12 shows the results of the Participatory-Environment trial under Lowland Irrigated swamp at Sapu in the Central River Region during the dry season 2015. Generally, analysis of variance showed significant differences between the varieties. From the analysis of variance, days to 50% flowering, panicle number, 1000 grain weight and grain yield per hectare shows highly significant difference between varieties with $P<0.05$.

Days to 50% flowering ranged from 80 to 101 days. The highest number of days was recorded from variety 10 (IR 78581-12-3-2-2) with mean of 101 days and lowest from variety 6 (IR 83141-B-19-B) with 80 days from sowing. (Table 14).

Panicle number ranged from 9 to 17. The highest panicle number was recorded from variety 33 (Sahel 134.) with mean number of 17 and the shortest from variety 29 (WANXIAN 926) with a mean of 9.

Grain yield ranged from 3.22 tons ha^{-1} to 6.58 tons ha^{-1}. The highest yield was obtained from variety 21 (GANJAY (ACC 76349)) with mean yield of 6.58 tons ha^{-1} and lowest from variety 2 (IR 71146-97-1-2-1-3) with mean yield of 2.42 tons ha^{-1}. Results indicated that 5 varieties (4, 5, 12, 15, and 21) had yields of 6 tons ha^{-1}(BP234E-MR-11, MR 254, CT18148-10-4-2-3-4-1-M, IR 82574-643-1-2, and GANJAY (ACC 76349) respectively (Table 14).

Table 14. Agronomic Data and grain yield of PAT Irrigated Lowland rice varieties at Sapu Dry Season

Designation	TRT	Days to 50% FLW	Pan. No	Plant Ht. (cm)	1000 Grain wt. (g)	Grain Yield ha-1 (tons)
HHZ 11-Y11-Y3-DT1	1	88	13	93.87	19.54	5.22
IR 71146-97-1-2-1-3	2	81	12	114.37	23.60	3.22
IR 73888-1-4-5	3	91	13	106.37	20.70	5.79
BP234E-MR-11	4	81	12	116.39	20.90	6.01
CT18148-10-4-2-3-4-1-M	5	85	15	110.41	25.03	6.23
IR 83141-B-19-B	6	80	13	110.63	23.40	5.56
IR 78545-49-2-2-2	7	91	12	110.43	22.99	3.77
CHAITE 6	8	88	14	103.64	21.07	4.50
HHZ 5-5-SAL 9-Y3-Y1	9	88	14	102.11	23.79	5.07
IR 78581-12-3-2-2	10	101	10	112.00	20.88	5.67
IR 78119-24-1-2-2-2	11	95	15	106.13	19.88	5.67
MR 254	12	91	13	110.81	23.53	6.02
IR 80404-28-2-3-2	13	86	14	103.04	22.82	5.02
IR 82635-B-B-145-1	14	92	13	105.76	20.69	5.82
IR 82574-643-1-2	15	86	14	100.21	20.50	6.22

IR 81363-86-2-3-2-2	16	91	14	106.18	22.37	4.44
NSIC RC152	17	92	12	105.78	20.60	4.08
IR 78913-B-10-B-B-B	18	91	13	91.21	20.93	5.10
PR 26703-3B-PJ 25	19	91	16	107.61	22.14	4.60
IR 77512-128-2-1-2	20	90	12	99.15	19.32	4.25
GANJAY(ACC 76349)	21	92	14	108.22	22.19	6.58
IR 65192-4B-17-3	22	88	14	139.38	21.62	3.98
IR 81494-10-1-3-3-1	23	81	13	100.66	22.56	4.69
WAB 2066-6-FKR 4-WAC 1-TGR 1-B-WAT-B9	24	93	14	113.43	22.89	5.17
WAT-B9	25	93	14	107.64	22.05	3.23
PCT 6\0\0\0>19-1-4-3-1-1-1-1-1-M	26	91	14	110.19	25.95	5.42
MR 255	27	95	14	116.55	21.39	3.08
IR 82574-573-2-1	28	90	15	110.36	24.20	4.85
WANXIAN 926	29	92	9	114.06	24.61	3.85
IR 62141-114-3-2-2-2	30	96	13	118.65	21.79	5.23
HHZ 9-D7-SAL2-DT1	31	88	13	104.51	19.13	5.18
Sahl108	32	85	14	94.28	20.18	5.60
Sahel 134	33	86	17	95.49	19.89	4.66
Sahel 201	34	98	13	108.27	21.15	3.35
IET 3137	35	86	13	103.49	20.18	3.50
P-Value		<0.001	0.0190	0.339	<0.001	0.004
Sed		0.9308	1.5200	11.67	1.41	1.26

3.5 Participatory Evaluation Trial (PET) for Irrigated Lowland, wet season

Materials and Methods

The Participatory Evaluation Trial (PET) for irrigated lowland during the period under review was carried out at Sapu, in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consist of 35 varieties including the local check. An Alpha lattice design was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100 kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

Results and Discussion

Table 13 shows the results of the Participatory-Environment trial under Lowland Irrigated swamp at Sapu in the Central River Region. Generally, analysis of variance showed significant differences between the varieties. From the analysis of variance, days to 50% flowering, plant height, 1000 grain weight, and grain yield per hectare , shows highly significant difference between the varieties with *P<0.05*. Days to 50% flowering ranged from 85 to 108 days. The highest number of days was recorded from variety 8 (ARS119-1-4-B) with mean of 108 and lowest from variety 35 (IR 19746 - local check)) with 85 days from sowing. (Table 15).

Panicle length ranged from 20.22 cm to 23.97 cm. The longest panicle was recorded from variety 10 (ARS126-2-B--1-4) with mean length of 23.97 cm and the shortest from variety 25 (HHZ12-SAL8-Y1-SAL1) with mean length of 20.22 cm.

Plant height analysis of variance showed significant differences between the varieties with *P<0.05*. Results of plant height ranged from 64.57 cm to 83.02 cm. The tallest plant was recorded from variety 8 (ARS119-1-4-B) with mean of 83.02 cm and the shortest from variety 20 (ARS755-3-B-3-B) with 64.57cm.

Grain yield ranged from 2.42 tons ha^{-1} to 5.78 tons ha^{-1}. The highest yield was obtained from variety 13 (ARS127-B-2-B-2) with mean yield of 5.78 tons ha^{-1} and lowest from variety 35 (IR 19746 (local check)) with mean yield of 2.42 tons ha^{-1} (Table 15). Results indicated that 34 varieties had yields higher than the local check (IR 19746 (local check)). Six of the varieties (ARC39-145-P-2, ARS105-3-2-B, ARS127-B-2-B-2, ARS144-4-2-B-B, ARS153-1-B-B, and Sahel 134) showed yields above 5 tons ha^{-1}. Thousand grain weight indicated significant difference with *P<0.05*.

In conclusion all the tested varieties had yields higher than the local check. The selection for the next stage of the trial will be based on the yield, other agronomic trait and farmers' perception about the varieties base on their selection criteria.

Table 15. Agronomic Data and grain yield of PET Irrigated Lowland rice varieties at Sapu

Designation	TRT	Days to 50% FLW	Plant Ht (cm)	Pan. No.	Pan. Length (cm)	1000 Grain wt. (g)	Grain Yield ha^{-1} (tons)
ARC36-2-1-2	1	98	73.62	17	22.98	36.68	4.01
ARC36-2-P-2	2	98	71.20	17	23.02	37.48	3.32
ARC36-4-EP-2	3	103	**67.64**	18	21.13	35.76	3.24
ARC39-145-P-3	4	96	67.69	17	21.04	36.29	4.21
ARC39-145-P-2	5	100	72.44	19	21.29	34.75	5.44

ARS105-2-2-B	6	100	68.82	22	21.07	33.69	4.88
ARS105-3-2-B	7	100	67.83	18	21.41	34.28	5.31
ARS119-1-4-B	8	102	83.02	19	22.03	36.46	4.28
ARS126-2-B-1-2	9	97	66.26	20	20.98	33.81	4.30
ARS126-2-B--1-4	10	96	71.85	16	23.97	39.60	3.08
ARS126-3-B-1-2	11	96	75.94	19	21.18	38.43	3.02
ARS127-1-1-3	12	102	69.26	19	20.32	37.68	3.97
ARS127-B-2-B-2	13	105	68.01	18	21.00	34.72	5.78
ARS134-1-2-B-1	14	100	69.72	22	22.37	37.91	3.76
ARS134-B-B-B	15	106	71.90	18	21.23	35.18	4.55
ARS137-B-1-1-1	16	100	64.74	18	20.77	37.68	4.95
ARS144-4-2-B-B	17	103	68.71	19	21.19	35.16	5.75
ARS153-1-B-B	18	103	67.29	21	20.01	35.52	5.27
ARS169-2-B-3-B	19	102	71.14	23	20.90	35.90	4.75
ARS755-3-B-3-B	20	100	64.57	20	22.86	35.02	4.59
ARS765-4-B-B	21	106	67.07	18	21.40	34.88	4.94
CT18527-10-4-3-1-2-1-1P	22	87	77.58	16	21.21	37.34	3.32
CT21426-P9-4P-2SR-3-1SR-1P	23	102	78.87	17	22.90	39.13	3.55
GOLMY	24	100	70.14	19	20.57	36.44	3.66
HHZ12-SAL8-Y1-SAL1	25	86	67.34	21	20.22	33.11	4.19
HHZ15-D17-SAL4-SAL1	26	98	72.23	21	21.26	35.45	4.93
HHZ5-DT1-DT1	27	88	76.87	20	21.32	37.15	3.14
HHZ5-SAL9-Y3-Y1	28	88	69.66	19	20.91	38.36	3.55
HHZ8-SAL6-SAL3-SAL1	29	98	74.69	17	21.79	34.20	3.65
Huang-Hua-Zhan	30	100	72.19	20	21.75	34.72	4.50
JRC2	31	**108**	79.94	21	21.85	37.49	3.86
MGC3	32	102	84.19	20	23.58	34.78	2.90
Sahel 134	33	86	70.75	22	20.71	34.46	5.22
Sahel 208	34	100	77.46	19	21.53	36.69	4.52
IR 19746 (local check)	35	**85**	66.39	21	22.73	37.38	2.42
P-Value		**<0.001**	**<0.001**	**0.926**	**0.306**	**<0.001**	**<0.001**
Sed		**0.239**	**3.677**	**3.368**	**1.248**	**1.384**	**0.7411**

3.6. Participatory Varietal selection (PVS) for Irrigated Lowland, Wet Season

A field visit was carried out at maturity for farmers to select varieties of their choice from the 35 varieties including the local variety. Farmers were asked to select 3 varieties they would like to grow in their fields. Results from the PVS revealed that varieties 8 (ARS119-1-4-B 9) 12 (ARS 127-1-1-3), 15 (ARS134-B-B-B), 18 (ARS153-1-B-B), 19 (ARS169-2-B-3-B), 24 (GOLMY), 26 (HHZ15-D17-SAL4-SAL1), 30 (Huang-Hua-Zhan) and 33 (Sahel 134) were selected by famers (Table 14). The variety with the most turnout votes was variety 33 (Sahel 134) with 10 votes follow by varieties 26 (HHZ15-D17-SAL4-SAL1) 24 (GOLMY) and 15 (ARS134-B-B-B), (Table 16).

Table 16. Participatory Varietal Selection at Sapu

Variety	TRT	VOTES	Criteria for choosing
ARS119-1-4-B	8	6	Good tillering ability, high yielding, high spikelet fertility, good grain size, high and heavy panicle number etc
ARS127-1-1-3	12	4	
ARS134-B-B-B	15	6	
ARS153-1-B-B	18	3	
ARS169-2-B-3-B	19	3	
GOLMY	24	7	
HHZ15-D17-SAL4-SAL1	26	9	
Huang-Hua-Zhan	30	4	
Sahel 134	33	10	

Participatory Varietal Selection at Sapu Irrigated Lowland Rice field

3.7. Participatory Advanced Trial (PAT) for Irrigated Lowland, Wet Season

Materials and Methods

The Participatory Advanced Trial (PAT) for irrigated lowland during the period under review was carried out at Sapu, in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consist of 11 varieties including the local check. Randomized Complete Block design was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

The data collected was subjected to analysis of variance using Genstat, adjusted varieties means were calculated and compared for agronomic traits.

Results and Discussion

Table 15 shows the results of the Participatory Advanced trial under Lowland Irrigated swamp carried out at Sapu in the Central River Region. From the analysis of variance, days to 50% flowering, plant height, panicle length, panicle number showed no significant difference between the varieties with $P>0.05$ (Table 17).

Grain yield ranged from 4.34 tons to 8.43 tons ha^{-1}. The highest yield was recorded from variety 4 (PR 26703-3B-PJ 25) with mean yield of 8.43 tons ha^{-1} and the lowest from variety 2 (CT18148-10-4-2-3-4-1-M 1) with mean yield of 4.34 tons ha^{-1} (Table 7). Results have indicated that 5 of the varieties 1, 4, 7, 9, and 10 (IR 73888-1-4-5, PR 26703-3B-PJ 25, IR 82574-573-2-1, Sahel 108, Sahel 201**)** showed yields ranging from 6.0 to 8.0 tons ha^{-1} (Table 17).

Table 17. Agronomic Data and grain yield of PAT irrigated lowland Sapu

Designation	Variety	Days to 50% FLW	Plant Ht. (cm)	Pan. Number	Pan. Length (cm)	1000 Grain wt. (g)	Grain yield ha^{-1} (tons)
IR 73888-1-4-5	1	90	66.90	21	20.67	35.10	6.24
CT18148-10-4-2-3-4-1-M	2	85	73.00	21	21.67	38.17	4.34
IR 83141-B-19-B	3	80	71.22	15	20.33	38.17	4.93
PR 26703-3B-PJ 25	4	90	68.57	17	21.00	36.00	8.43
IR 65192-4B-17-3	5	88	69.33	16	20.67	37.83	5.11
WAT-B9	6	95	72.77	17	20.67	39.13	4.50
IR 82574-573-2-1	7	90	66.67	19	20.33	40.40	7.85
HHZ 9-D7-SAL2-DT1	8	88	71.00	18	21.67	33.17	4.76
Sahel 108	9	85	70.87	18	19.67	35.90	8.28
Sahel 201	10	95	69.43	17	19.67	37.43	7.73
IR 19746 (local check)	11	85	67.67	18	20.67	37.83	5.13
P-Value		**ns**	**0.82**	**0.544**	**0.944**	**<0.001**	**<0.001**
Lsd (0.05)		**ns**	**8.62**	**5.448**	**3.177**	**2.119**	**2.070**

3.8. Participatory Evaluation Trial (PET) for Salinity, Wet Season

Materials and Methods

The Participatory Evaluation trial (PET) for salinity during the period under review were carried out at Lamin-Abuko in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consists of 25 varieties including the local check. An Alpha Lattice Designs was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100 kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

A field day was carried out at maturity for farmers to select varieties of their choice. Farmers were asked to select 3 varieties they would like to grow in their fields.

Results and Discussion

Table 16 shows results obtained from Lamin-Abuko trial. From the results obtained, days to 50% ranged from 88 days to110 days. The longest days was recorded from variety 24 (ARS14-210-RIL-94) and the lowest from varieties 5 (ARS14-204-RFL-9) and 11 (ARS14-204-RFL-25) respectively (Table 18).

Results of plant height ranged from 59.9 cm to 99.0 cm. The tallest plant was recorded from variety 25 (Yaya Mano) and the shortest from variety 24 (ARS14-210-RIL-94). Results from plant height showed significant differences.

Panicle length plays a very important role in the mangrove where many farmers harvest by panicle picking method using knife. Panicle length ranged from 20.1 cm to 23.5 cm. The longest panicle was recorded from variety 22 (ARS14-208-RAM-69) with mean length of 23.5 cm and shortest from variety 17 (ARS14-204-RFL-34) with mean length of 20.1 cm (Table 16).

Grain yield ranged from 1.80 tons ha^{-1} to 3.54 tons ha^{-1}. The highest yield was obtained from variety 13 (ARS14-204-RFL-27) and the lowest from variety 16 (ARS14-204-RFL-33) (Table 16). Results indicated that all the varieties yielded higher than the local check (Yaya Mano) except varieties 16 and 7 respectively (Table 18).

Table 18. Agronomic Data and grain yield of mangrove swamp rice varieties at Lamin-Abuko

Designation	Variety	Days to 50%	Plant ht. (cm)	Pan. Length (cm)	1000 grain wt. (g)	Grain yield ha^{-1} (tons)
ARS14-204-RFL-2	1	91	71.3	21.3	28.16	2.03
ARS14-204-RFL-3	2	89	71.0	21.1	31.17	2.53
ARS14-204-RFL-5	3	89	71.0	22.0	31.64	2.42
ARS14-204-RFL-8	4	89	73.4	20.9	32.56	2.68
ARS14-204-RFL-9	5	88	73.9	20.8	31.59	2.79
ARS14-204-RFL-11	6	89	76.0	20.8	30.93	2.92
ARS14-204-RFL-12	7	89	73.5	21.7	28.01	1.87
ARS14-204-RFL-15	8	89	73.8	22.6	32.05	3.42
ARS14-204-RFL-21	9	91	75.6	20.8	31.14	2.27
ARS14-204-RFL-24	10	89	73.3	22.4	32.99	2.84
ARS14-204-RFL-25	11	88	75.8	22.9	36.44	2.90
ARS14-204-RFL-26	12	90	74.7	21.7	32.77	3.11
ARS14-204-RFL-27	13	90	74.0	21.2	32.02	3.54
ARS14-204-RFL-28	14	90	73.5	22.4	26.84	3.01
ARS14-204-RFL-32	15	89	80.1	21.2	31.77	2.74
ARS14-204-RFL-33	16	91	69.8	21.3	31.39	1.80
ARS14-204-RFL-34	17	90	74.7	20.1	28.08	2.52
ARS14-204-RFL-35	18	90	68.1	20.8	31.98	2.69
ARS14-204-RFL-36	19	89	74.7	20.3	31.84	2.16
ARS14-204-RFL-37	20	89	74.5	20.6	32.03	2.40
ARS14-204-RFL-38	21	90	71.7	18.7	33.16	3.12
ARS14-208-RAM-69	22	90	63.9	23.5	32.58	1.96
ARS14-210-RIL-78	23	90	66.0	23.2	32.56	2.13
ARS14-210-RIL-94	24	110	59.9	20.7	25.32	1.99
Yaya Mano	25	90	99.0	23.2	36.13	1.95
P-value		**0.003**	**<0.001**	**0.031**	**<0.001**	**<0.001**
Sed		**1.132**	**4.132**	**1.142**	**1.912**	**0.6913**

3.9. Participatory Evaluation Trial (PET) for Salinity Wet Season

Materials and Methods

The Participatory Evaluation trial (PET) for salinity during the period under review were carried out at Kaiaf, in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consist of 25 varieties including the local check. An Alpha Lattice Designs was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100 kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

A field day was carried out at maturity for farmers to select varieties of their choice. Farmers were asked to select 3 varieties they would like to grow in their fields.

Results and Discussion

Table 17 shows results obtained from Participatory Evaluation Trial at Kaiaf. From the results obtained, days to 50% flowering ranged from 83 to 99 days. The longest days were recorded from variety 8 (ARS14-204-RFL-15) and the lowest from varieties 25 (Aja Mano) (Table 19).

Results of plant height ranged from 63.25 cm to 80.65 cm. The tallest plant was recorded from variety 25 (Aja Mano) and the shortest from variety 3 (ARS14-204-RFL-5). Results of plant height showed no significant differences.

Panicle length plays a very important role in the mangrove where many farmers harvest by panicle picking method using knife. Panicle length ranged from 14.34 cm to 20.34 cm. The longest panicle was recorded from variety 12 (ARS14-204-RFL-26) with mean length of 20.34 cm and shortest from variety 24 (ARS14-210-RIL-94) with mean length of 14.34 cm (Table 19).

Grain yield ranged from 1.52 tons ha^{-1} to 2.84 tons ha^{-1}. The highest yield was obtained from variety 8 (ARS14-204-RFL-15) and the lowest from variety 23 (ARS14-210-RIL-78) (Table 19). Results indicated that 13 of the varieties yielded higher than the local check (Aja Mano) (Table 19).

Table 19. Agronomic Data and grain yield of mangrove swamp rice varieties at Kaiaf

Designation	TRT	Days to 50% FLW	Panicle exertion	Panicle number	Plant Ht. (cm)	Panicle Length (cm)	1000 grain wt. (g)	Grain Yield ha^{-1} (tons)
ARS14-204-RFL-2	1	94	3	8	72.79	17.99	34.93	1.91
ARS14-204-RFL-3	2	98	3	10	77.10	17.64	36.10	2.49
ARS14-204-RFL-5	3	97	5	9	63.25	18.36	38.13	2.44
ARS14-204-RFL-8	4	96	1	11	75.79	19.69	36.75	2.09
ARS14-204-RFL-9	5	96	1	11	80.34	17.04	36.70	2.60
ARS14-204-RFL-11	6	98	3	9	69.09	15.29	36.10	1.79
ARS14-204-RFL-12	7	96	3	8	71.34	15.65	36.43	1.87
ARS14-204-RFL-15	8	99	3	14	76.23	17.15	34.93	2.84
ARS14-204-RFL-21	9	95	1	5	96.33	19.48	36.20	1.78
ARS14-204-RFL-24	10	95	7	10	70.10	16.37	35.73	2.00
ARS14-204-RFL-25	11	95	2	7	72.56	16.63	38.33	2.11
ARS14-204-RFL-26	12	96	5	11	61.58	20.34	35.60	2.41
ARS14-204-RFL-27	13	97	3	9	75.75	14.34	35.20	1.89
ARS14-204-RFL-28	14	96	5	7	73.35	17.69	35.53	2.26
ARS14-204-RFL-32	15	96	3	10	75.89	19.33	36.53	2.00
ARS14-204-RFL-33	16	96	3	11	71.76	14.97	35.90	2.10
ARS14-204-RFL-34	17	96	7	11	67.10	16.96	34.80	1.88
ARS14-204-RFL-35	18	96	3	10	76.64	17.99	35.33	2.40
ARS14-204-RFL-36	19	98	5	17	71.00	17.09	35.23	2.31
ARS14-204-RFL-37	20	91	3	10	74.88	15.91	36.13	2.19
ARS14-204-RFL-38	21	95	1	11	72.09	17.21	36.30	2.01
ARS14-208-RAM-69	22	97	1	6	73.81	19.16	36.37	2.01
ARS14-210-RIL-78	23	95	3	9	74.12	17.30	36.33	1.52
ARS14-210-RIL-94	24	94	7	9	64.02	14.34	36.03	1.82
Aja Mano (local check)	25	83	1	8	80.65	17.29	37.07	2.06
P-value		0.017	<0.001	<0.001	ns	<0.001	0.593	0.041
Sed		2.897	0.1874	0.05507	2.648	0.1529	1.304	0.3135

3.10. Participatory Varietal Selection (PVS)

Results

A field day was carried out at Kaiaf during maturity for farmers to select varieties of their choice from the 35 varieties including the local variety. Farmers were asked to select the best 3 varieties they would like to g--row in their fields based on their criteria.

Results indicated that Variety 16 (ARS14-204-RFL-33) had the highest votes followed by variety 9 (ARS14-204-RFL-21) as show in table 10. Other varieties were also selected by farmers. The reasons for selecting these varieties were based on tolerance to salinity, high yielding, plant height, panicle well exerted, and high tillering ability and among others.

Table 20. PVS results of Participatory Evaluation Trial for salinity at Kaiaf

Variety	TRT	VOTES	Reasons for Selection
ARS14-204-RFL-2	1	4	
ARS14-204-RFL-3	2	3	
ARS14-204-RFL-8	4	5	
ARS14-204-RFL-9	5	3	
ARS14-204-RFL-21	9	8	
ARS14-204-RFL-24	10	4	
ARS14-204-RFL-27	13	4	
ARS14-204-RFL-32	15	3	
ARS14-204-RFL-33	16	18	
ARS14-204-RFL-35	18	3	
ARS14-204-RFL-36	19	4	
ARS14-210-RIL-78	23	5	

Participatory Varietal Selection at Kaiaf Mangrove Swamp Rice filed

3.11. Participatory Advanced Trial (PAT) for Salinity

Materials and Methods

The Participatory Advanced Trial (PAT) mangrove swamp during the period under review was carried out Toniataba in collaboration with AfricaRice. The trial was a research-managed trial.

The trial consists of 11 varieties including the local check. A Randomized Complete Block designs was used with 3 replications at transplanting. Plot size of 1m x 5m was used for each variety. Fertilizer was applied at the rate of 200kg ha^{-1} of NPK and 100kg ha^{-1} of urea (46%). Application of basal was at 2 weeks after transplanting and top dressing of 100 kg ha^{-1} of urea (46%) was applied in 2 splits at 21 days after transplanting and at panicle initiation. Monitoring continued throughout the duration of the trial and data were collected on the following parameters: Plant height, Plant stand, days to 50% flowering, panicle exertion, panicle number, 1000 grain weight, Grain Yield kg ha^{-1}, Spikelet fertility, and phenotypic acceptability. However, few data are reported in this report.

Results and Discussion

Table 21 illustrated the results obtained from Toniataba. From the results obtained, days to 50% showed significant differences between the varieties. Days to 50% ranged from 73 days to 98 days. The longest days was recorded from variety 11 (Jara Mano) and the lowest from varieties 4 (ARS14-B-004-V-04), 7 (ARS14-B-007-V-07), 8 (ARS14-B-008-V-08), 10 (ARS14-B-010-V-10) (Table 21).

Panicle length plays a very important role in the mangrove where many farmers harvest by panicle picking method using knife. Panicle length ranged from 18.3 cm to 21.0 cm. The longest panicle was recorded for variety 11 (Jara Mano) with mean length of 22.89 cm and shortest for variety 3 (ARS14-B-003-V-03) with mean length of 15.56 cm (Table 21).

Plant height results ranged from 65.33 cm to 102.33 cm. Results from the analysis of variance showed significant differences between the varieties with *P-value < 0.05*. The tallest plant was recorded for variety 11 (Jara Mano) and shortest for variety 1 (ARS14-B-001-V-01).

Grain yield ranged from 2.17 tons ha^{-1} to 3.69 tons ha^{-1}. The highest yield was obtained for variety 9 (ARS14-B-009-V-09) with mean yield of 3.69 tons $ha^{-1}$and the lowest for variety 5 (ARS14-B-005-V-05) with mean yield of 2.17 tons ha^{-1} (Table 21).

In conclusion, 5 varieties (ARS14-B-002-V-02, ARS14-B-004-V-04, ARS14-B-008-V-08, ARS14-B-009-V-09, and ARS14-B-010-V-10) showed yields higher than the local check (Aja Mano) with more than 3.0 tons (Table 21).

Table 21. Agronomic Data and grain yield of Participatory Advanced Trial at Toniataba

Designation	TRT	Days to 50% FLW	Plant Ht. (cm)	Panicle Length (cm)	Panicle number	1000 Grain wt. (g)	Grain Yield ha^{-1} (tons)
ARS14-B-001-V-01	1	75	65.33	18.78	12	35.57	2.59
ARS14-B-002-V-02	2	75	70.33	18.00	16	36.10	3.48
ARS14-B-003-V-03	3	76	68.22	15.56	15	34.07	2.83
ARS14-B-004-V-04	4	73	69.33	19.33	17	35.47	3.58
ARS14-B-005-V-05	5	74	67.00	17.33	10	36.10	2.17
ARS14-B-006-V-06	6	75	67.00	18.00	14	34.87	2.62
ARS14-B-007-V-07	7	73	69.56	17.22	13	36.33	2.75
ARS14-B-008-V-08	8	73	68.44	17.89	15	36.37	3.00
ARS14-B-009-V-09	9	75	70.56	16.78	16	37.13	3.69
ARS14-B-010-V-10	10	73	76.22	17.67	12	36.70	3.31
Local Check (Jara Mano)	11	98	102.33	22.89	10	36.97	2.75
P-value		ns	<0.001	0.022	5.211	<0.001	0.539
Lsd (0.05)		ns	6.249	3.261	0.105	1.121	1.477

Figure 5 shows the pH level in different solutions at trial sites. The results indicated that the highest pH level was recorded at Toniataba and lowest at Kaiaf.

Figure 6 shows the EC level at Trial sites. The results indicated that the highest EC level was recorded at Toniataba with a value of 6.8 and the lowest from Kaiaf with a value of 5.5

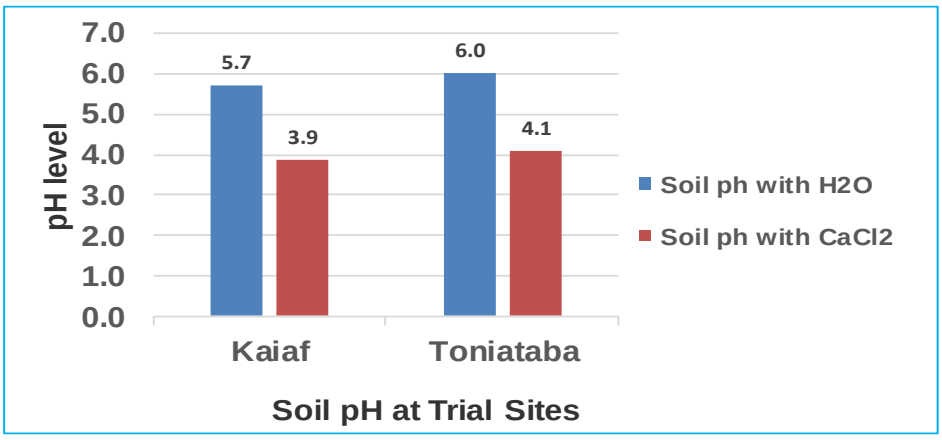

Figure 5. pH level at trial sites

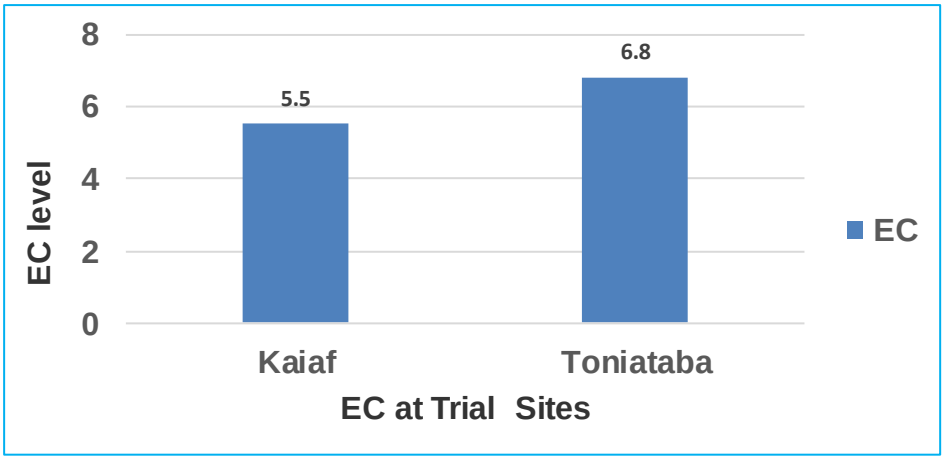

Figure 6. EC level at trial sites

3.12. On-Farm Nnutrient Omission Trial

Introduction

Nutrient management provides science-based principles for determining optimal N, P, and K fertilizer rates for a specific field with rice. With nutrient management, N rates are determined based on a target yield, estimated crop response to fertilizer N, and a targeted agronomic efficiency for fertilizer N (kg increase in grain yield per kg applied N). The P and K rates are determined through a nutrient balance approach, which considers estimated P and K inputs from irrigation water and organic materials added during the crop; carryover of P and K in crop residues from the previous crop, removal of P and K in harvested grain, and estimated response of the crop to P and K fertilizers.

Materials and Methods

The on-farm nutrient trial was carried out in Central River Region (CRRN) with four treatments: -N, -P, -K, and NPK for a given location and for a targeted rice yield of 9 tons ha^{-1}. A total of 20 farmers were to evaluate the optimal N rate based on crop response to N, P rate based on crop response to P and estimated P balance, K rate based on crop response to K and estimated K balance. A plot size of 5 m x 5 m ($25m^2$). The rates of N, P and K depend upon the targeted potential yield (i.e. 9 tons). The fertilizers used were urea (46-0-0), Triple Super Phosphate (0-46-0) and Potassium Chloride (0-0-60). Soil samples were collected and sent to AfricaRice for nutrient analysis.

Results and Discussion

Results illustrated that the most important macro element that enhance plant height is Nitrogen (N), followed by Phosohorous (P) and then potassium (K). the highest plant height was recorded for nutrient combination of NPK whilst the lowet was for PK (Figure 7)

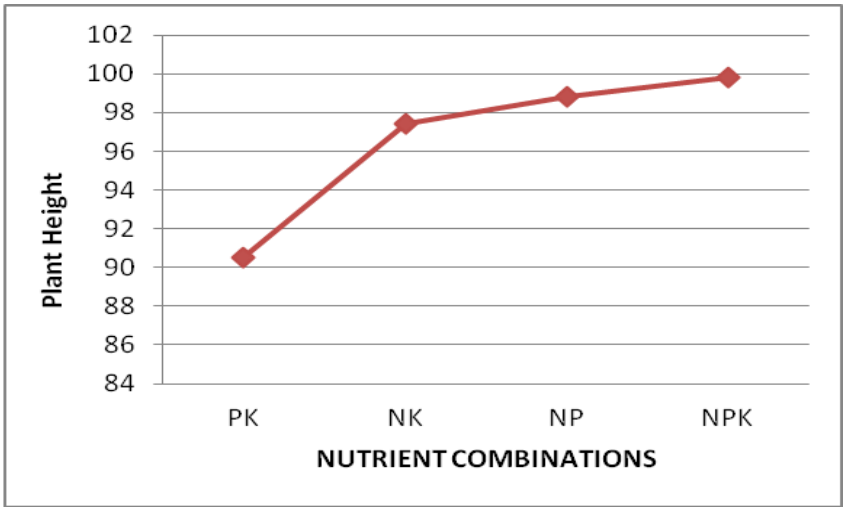

Figure 7. Plant height of nutrient combinations at harvest

The highest tiller number was recorded for NK (-P) followed by NPK whilst the lowest tiller was recorded for PK (-N). This shows that N is an important component of improving plant's tillering ability (Figure 8).

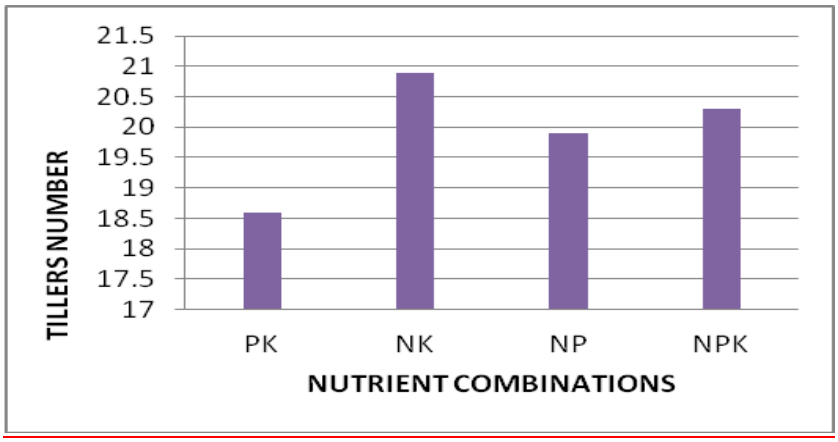

Figure 8. Tiller Numbers of the Nutrient combinations at Harvest

Figure 9 illustrated that NK (-P) has the longest days to 50% flowering as compared to the other treatments. The results demonstrated that P deficient soil will have relatively longer days to maturity for rice when compared to N and K deficient soils.

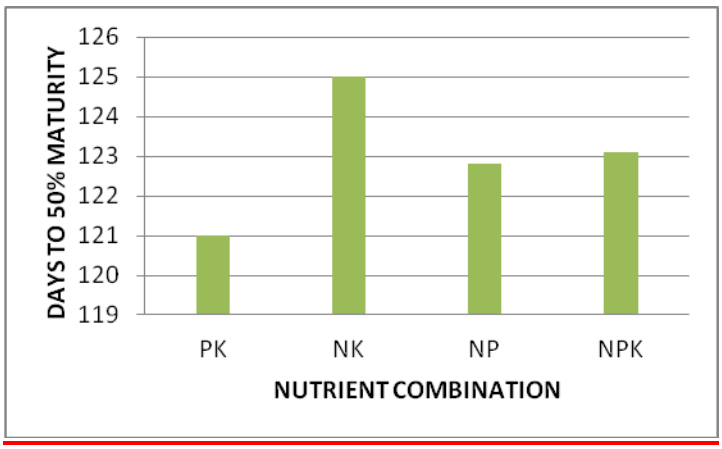

Figure 9. Days to 50% maturity of nutrient combinations

Results have indicated that PK (-N) has the lowest yield with mean yield of 5000 kg ha^{-1}, followed by NK (-P) then NP (-K). A combination of the 3 nutrients (NPK) has the highest yield with mean yield of 7000 kg ha^{-1} (Figure 10). The results indicated that the most important macro element that affects rice yield is N, followed by P and K, though a combination of the three elements gave higher yields.

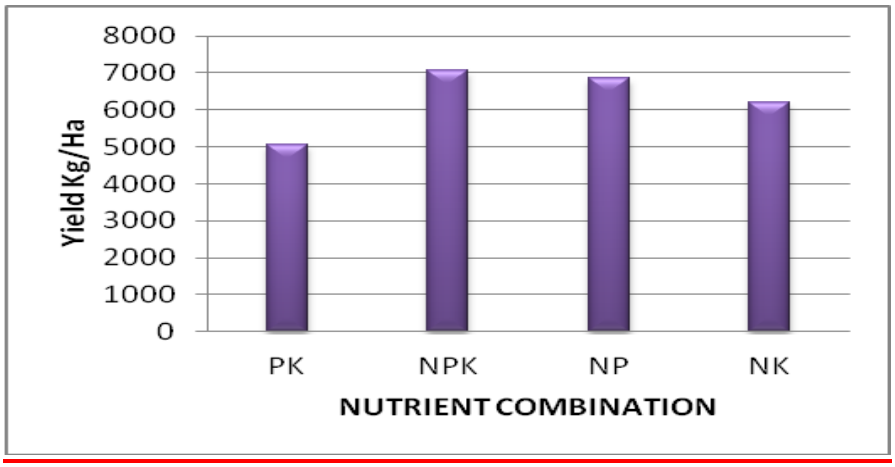

Figure 10. Yield kg/ha of the nutrient combinations

3.13. Emergency Rice Initiative (ERI)

Introduction

The National Agricultural Research Institute in collaboration with Department of Agricultural Services had embarked on the distribution of 40 tons of Quality seed including NERICA and some upland varieties for key rice growing communities in West Coast Region (Hub 1). This activity is in accordance with the implementation of the project funded by People Republic of Japan through AfricaRice Centre. The key partners involved in this activity were seed technology unit, Farmers platform in the Hubs, Catholic Relief Service and other local NGOs. The selected varieties include NERICA 6, NERICA 14, P163, IET 3137, IR 19746-26-2-3-3-1 and Tainung Sen 14 (table 20).

Objective

- To support small holder rice farmers by providing them access to essential inputs such as seed, inorganic fertilizer and knowledge with respect to good agricultural practices.

Materials and Methods

This activity was carried out in 2015 cropping season a total of 15 hectares of seed production was carried out targeting an average yield of 4 tons ha^{-1}, which will lead to 60 tons of quality seed per country. Each farmer in a Hub received 25 kg of certified seed. Recommended rate of fertilizer at 200kg ha^{-1} of NPK (15-15-15) ha^{-1} was applied at 2 weeks after transplanting. Top dressing of 100 kg ha^{-1} of urea (46% N) ha^{-1} was applied after second weeding.

Results and Discussion

Table 22 shows the seed produced in Central River Region (CRR) by seed growers and distributed. Seed distribution in Table 23 shows the communities and farmers from the respective villages in West Coast Region who benefited from the seed distribution. A total of 1650 farmers (950 women & 700 men) in the upland ecology benefited from the seed distribution. A total of 41.37 tons of upland varieties were distributed in West Coast Region.

Table 22. Seeds produced and quantity distributed in Hub 2 (CRR)

Communities	Rice varieties	Quantity Produced (tons)	Quantity Distributed (tons)
WELLINGARA	IET 3137	6	5
	P163	5	
	NERICA 6	7	6
	IR 19746-26-2-3-3-1	4	2
JAHALLY	IET 3137	7	6
	P163	6	5
	NERICA 6	8	9
	IR19746-26-2-3-3-1	7	5
SAPU RESEARCH FARM	NERICA 14	4	2
TOTAL		**54**	**40**

Table 23. Seed distributed in rice sector development hub 1

Community	**Rice ecology/Hub**	**No. of farmers by Gender**	**Quantity of Seeds distributed (tons)**
Sintet	Upland Ecology	180 (80 men & 100 women)	4.5
Dobong	Upland Ecology	100 (50 men & 50 women)	2.5
Bwiam	Upland Ecology	110 (50 men & 60 women)	2.75
Sibanor	Upland Ecology	50 (15 men & 35 women)	1.25
Gifanga	Upland Ecology	100 (40men & 60 women)	2.5
Ndemban	Upland Ecology	50 (20 men & 30 women)	1.25
Killy	Upland Ecology	70 (35 men & 35 women)	1.75
Kanilai	Upland Ecology	55 (15 men & 40 women)	1.4
Sutusinjang	Upland Ecology	85 (30 men & 55 women)	2.2
Kabokor	Upland Ecology	50 (25 men & 25 women)	1.25
Sifoe	Upland Ecology	45 (20men & 25 women)	1.13
Gunjur	Upland Ecology	45 (15men & 30 women)	1.13

Kasanyi	Upland Ecology	50 (15men & 35 women)	1.25
Somita	Upland Ecology	40 (20men & 20 women)	1
Block	Upland Ecology	50 (20 men & 30women)	1.25
Tumani Tenda	Upland Ecology	85 (50 men & 35 women)	2.13
Kitty	Upland Ecology	70 (30 men & 40 women)	1.75
Jambur	Upland Ecology	130 (40 men & 70 women)	3.25
Berefet	Upland Ecology	160 (60men & 100 women)	4
Medina	Upland Ecology	45 (10men & 35 women)	1.13
Wellingara	Upland Ecology	40 (20 men & 20 women)	1
Kanlagie	Upland Ecology	40 (20 men & 20 women)	1
Total			**41.37 tons**

4. SEED TECHNOLOGY UNIT (STU)

Introduction

Agriculture is the prime mover of The Gambian economy and as such it is important that its performance remains satisfactory. Towards this goal, improved seeds have been widely recognized as the main element in enhancing agricultural productivity and production.

Crop research undertaken by NARI has over the years, introduced and released good crop varieties into the farming systems basically for the major field crops, which farmers depend on year around production. Inevitably, this resulted to continuous use of varieties which eventually led to deterioration in both genetic and physical purity due to out-crossing and mechanical admixtures.

Currently, varietal maintenance and purification by seasonal regeneration of released varieties is a strategic approach in ensuring the availability of pure foundation seeds of the three major field crops (Groundnut, Rice and Maize) for certified seed production by out growers.

Objective

- To provide high quality foundation seeds of the major field crops of the Gambia e.g. groundnuts, rice and maize to specialized seed producers (Individuals & Organizations).

Materials and methods

The activities implemented by the Seed Technology Unit in 2015 cropping season were as follows:

Foundation seed multiplication in Yundum (Site III), the 2 Seed Centers and Sapu Irrigated lowland Swamp. Planting was done from the 15thJuly –26th August, 2015. The Findi (Momo) was hand planted by broadcasting and incorporated to create and increased seed-soil contact to allow seeds to imbibe moisture and hasten germination.

Generally, for all the crops (maize, g/nut, cowpea and findi) emergence was satisfactory. Plant establishment was visible and evident for all the crops two weeks after planting. There was a major pest (caterpillars) incident at early plant establishment.

Weeding and basal fertilizer application at the rate of 200kg ha-1 of NPK (15:15:15) was done for all the crops. First weeding and basal fertilizer application was done simultaneously for all the four crops and was successful. Second weeding and top dressing with urea was also done for the maize and findi, exempting the legumes (G/nut and Cowpea) in the top dressing with urea as they can fix their own nitrogen.

Rogueing was done to ensure varietal purity so as to meet the required standards. At most, 3 rogueing was done during the crop cycle (Vegetative, Reproductive and Maturity Phases).

Rogueing in Progress in a Groundnut Seed Field, Site III, Yundum

Harvesting, Drying and Processing

The crops were harvested at physiological maturity proceeded by drying and processing.

No	Crop	Variety	Date of Harvesting	Date of Processing
1	Cowpea	Mellagh	13th-30th Oct, 2015	30-11-2015
		Yasin	15th -25th Oct, 2015	03-11-2015
2	Findi	Momo	15-10-2015	30-10-2015
3	Groundnut	Ex-Dakar	29th Oct -1st Nov, 2015	30th Nov- 5th Dec, 2015
		73-33	2nd Nov – 15th Nov, 2015	6th – 15th Dec, 2015
4	Maize	TZEE-Y	10th – 15th Nov, 2015	10th – 20th Jan, 2016

Results and Discussion

Table 24 shows the yield obtained from the foundation seed production for upland crops. The highest yield was obtained from the maize production with 1.128 tons. The seed production for upland crops were very low due to the heavy rains experienced during the wet season. The yields for the cowpea was low than all

the crop due to pest infestation at flowering. Table 25 shows the yield from the rice seed production during the dry season 2015. A total of 9.9 tons of rice was produced.

Table 24. Groundnut, Maize, Cowpea and Findi Foundation Seed Multiplication

Crop	Variety	DOP	Area (ha)	Yield (kg/ha)
Groundnut	Ex-Dakar	17-07-2015	1	619
	73-33	15-07-2015	3	506
Maize	TZEE-Y	21-07-2015	3	1128
	Mellagh	20-08-2015	1	32
Cowpea	Yasin	26-08-2015	1	4.5
Findi	Momo	24-07-2015	0.25	40

Table 25. Foundation Rice seeds produced in 2015 Dry Season

No	Variety	Area (ha)	Yield (kg)
1	WAB 105	3	2900
2	IR 19746	1	700
3	Sahel 134	3	600
4	IET 3137	5	4700
6	Red Rice	3	1000
Total			**9900**

Seed Laboratory Services

During the period under review (1st January to 31st December, 2015), the Seed Technology Unit (STU) provided laboratory services to various institutions and individuals in the form of seed viability analysis (germination testing), moisture content tests, seed physical purity analysis etc.

The Seed Technology Unit (STU) provided laboratory services to the following institutions and individuals during the period under review. A total of 458 samples were tested for germination and moisture content analysis (Table 26).

Table 26 Laboratory services provided to Institutions and individuals

Name	Address	Crop	# of Samples	Parameters tested	
				Germ (%)	MC (%)
WAAPP	Abuko	Rice	29	✓	✓
		Maize	32	✓	✓
		Cowpea	2	✓	✓
				✓	✓

NARI Cereals Unit	Brikama	Rice	8	✓	✓
NARI CSRM Unit	Brikama	Maize	6	✓	✓
		Rice	6	✓	✓
Zoeve Seeds	China	Rice	6	✓	✓
		Maize	1	✓	✓
Nema Project	Bakau	Rice	360	✓ ✓	✓ ✓
Kanilai Farms	Kanilai	Groundnut	1	✓	✓
		Maize	2	✓	✓
NARI GLOS Unit	Brikama	Maize	3	✓ ✓	✓ ✓
		Cowpea	1	✓	✓
Musa Bojang	Mandina	Maize	1	✓ ✓	✓ ✓
Total			**458**		

Technicians on Final Evaluation of Maize Germination

Conclusion

It was a challenging year to implement the planned activities. The foundation rice seed multiplication in Sapu swamps could not be implemented due to flooding. Generally, it was not a busy year for the seed testing laboratory, nonetheless, laboratory services were rendered to some institutions and individuals.

5. GRAINLEGUMES AND OIL SEED PROGRAM

5.1 Groundnut Preliminary yield observational Nursery

Introduction

Groundnut is one of the most important and popular crop cultivated throughout the tropical and sub-tropical areas where annual precipitation is between 1000-1200mm for optimum growth. There is a growing demand for groundnut as food, in-terms of confectionery products. It is a rich source of oil, protein, minerals (P, K, Mg and Ca) and vitamins (B1, E and K). The developing countries account for about 94 % of the world groundnut production grown mostly in Africa and Asia.

Groundnut is an important cash crop in the subsistence farming systems as well as an important food source. It is one of the most important and most popular crops cultivated in The Gambia. There is a growing demand for groundnut as food, in-terms of confectionery products. It is a rich source of oil, protein, minerals (P, K, Mg and Ca) and vitamins (B1, E and K).

Objectives

1. To evaluate the growth performance of groundnut cultivars at preliminary stage
2. To evaluate the yield and yield components.
3. To increase the quantity of groundnut cultivars for preparation of the advance yield trial

Materials and Methods

Two varieties, SH 470P and PH 243C received from Bukina Fasso and planted at site III during the 2015 rainy season. The observation nursery was laid out in a plot size of 4 m x 4 m at a spacing of 50 cm x 12 cm. The land was ploughed and planting was done on the 15th July, 2015 with one seed per hole, fertilizer (N: P: K) 15:15:15 was also applied at the rate 100 kg/ha prior to planting. The first weeding was done two weeks after sowing and the second weeding three weeks after the first weeding. Harvesting was done on the 10th October, 2015 when the crop reached physiological maturity. Data was collected on the following parameters: stand count at emergence, days to 50 % flowering, stand count at harvest, dry haulm weight and dry pod weight.

Results and Discussion

The results on stand count at emergence showed that cultivar SH470P had greater plant population of 51250 plants per hectare than cultivar PH243C which had 50000 plants per hectare. The same trend continued on stand count at harvest where varieties SH470P had a plant population of 50000 plants per hectare and cultivar PH243C had 44375 plants per hectare. The results on dry haulm and dry pod yields proved that varieties SH470P is more promising than varieties PH243C with yields of 1018.75 kg/ha 737.50 kg/ha of haulm, 756.25 kg/ha and 681.25 kg/ha of dry pod respectively (Table 27).

Table 27. Mean pod yield and other agronomic characteristics

Variety	Stand count at emergence per ha.	Days to 50 % flowering	Stand count at harvest/ha	Dry haulm yield kg/ha	Dry pod yield kg/ha
SH470P	51250	30	50000	1018.75	756.25
PH243C	50000	32	44375	737.50	681.25

Conclusion/Recommendation

The results showed that varieties SH470P is more promising than varieties PH243C in all the parameters collected. It is recommended to include these two varieties in the advance yield trial on-station to verify the results before the release of the varieties.

5.2. Cowpea National Variety Evaluation Trial

Introduction

Cowpea is generally grown in The Gambia as food for human consumption rather than as an export crop. Cowpea yields are generally low in The Gambia especially under farmer managed condition, because most of the farmers don't have access to improved varieties of cowpea coupled with poor agronomic practices and low soil fertility. The demand for cowpea seeds is gaining momentum in the farming communities but yet to meet the demand due to lack of improved varieties for the farming communities.

Cowpea is grown because of the grains for human beings and fodder for livestock and it also provides the major source of high quality and affordable protein as well as an important source of B vitamins. Thus not

only the grains but cowpea vegetative parts also make an important nutritional contribution. Significant progress has been made in breeding determinate and indeterminate varieties with high grain yield and early maturity.

Cowpea yields are generally low especially under farmer managed condition, lack of improved varieties of cowpea coupled with poor agronomic practices and low soil fertility. The demand for cowpea seeds is gaining momentum in the farming communities.

Objectives

1. To evaluate the yield performance of cowpea varieties under a wide range of environments
2. To provide the Grain legume and Oil Seed programme with an opportunity to select varieties directly as seeds or as a source of breeding programme
3. To provide Gambian farmers with an opportunity to select varieties of their choice either directly as seeds or commercial purposes

Materials and Methods

The experiment was conducted at Yundum (West Coast Region), Sapu (Central River Region) and Giroba Kunda (Upper River Region) in 2015 cropping season. The trial was laid out in a randomized complete block design with three replications and four treatments. The experimental plot size used was 4 m x 5 m with a spacing of 75 cm x 20 cm. The treatments were Mounge, Pakau, Dji Guiya and Chamen. A common basal dose of compound fertilizer N-P-K (15:15:15) was applied at the rate of 100 kg/ha. Sowing ranged from 15th to 23rd July, 2015 at Yundum, Sapu and Giroba Kunda respectively with two seeds per hole and thinned to one plant per stand at two weeks after planting.

Three weeding were done at an interval of 2 weeks for all the trials. Spraying was done at 30, 40 and 50 days after planting using Deltamethrine at the rate of 5 ml per litre of water to control aphids and thrips. The parameters collected were stand count at emergence and at harvest; days to 50% flowering, grain and haulm yields. Harvesting was done on the 10th, 18th and 19th October, 2015 for Yundum, Sapu and Giroba Kunda respectively.

The results obtained from this experiment were subjected to statistical analysis of variance and mean separation. Growth and yield parameters were measured such as stand count at emergence and harvest, days to 50% flowering, grain and haulm yields.

Results and Discussion

The results indicated significant difference ($P<0.01$) among treatment means on stand count at emergence in three sites. At Yundum station, treatment 1 (Mounge) had the greatest stand count with a mean of 31944 plants per hectare but similar to treatments 3 (Dji Guiya) and 4 (Ex- Chamen) with means of 31389 and 31388 respectively. Treatment 2 (Pakau) was significantly lower than the rest of the treatments. At

Sapu station, treatment 3 (Dji Guiya) had the greatest mean stand count with a mean of 35555 but similar to treatment 1 and 4 with means of 32500 and 26945 respectively. Treatment 2 was significantly lower than the rest of the treatments with a mean of 16111 plants per hectare. At Giroba Kunda, treatment 3 (Dji Guiya) had the greatest mean stand count with a mean of 105000 plants per hectare and significantly different ($P < 0.01$) from the rest of the treatments. Treatment 4 (Ex- Chamen) had the lowest mean stand count but similar to treatments 1, 3 and 4 with means of 37222, 34199 and 33627 plants per hectare.

The results on days to 50 % flowering indicated significant difference ($P < 0.01$) among treatment means. At Yundum station, treatment 4 had the longest days with a mean of 48 days and significantly different from the rest of the treatments. Treatment 2 and 3 were significantly lower than treatments 1 and 4. At Sapu station and Giroba Kunda, the same trend was observed on days to 50 % flowering. Treatment 4 also had the longest days to 50 % flowering and significantly different ($P < 0.05$) from the rest of treatments with a mean of 45 days. Treatment 2 and 3 had the shortest days to 50 % flowering with a mean of 37 days each but similar to treatment 1 with a mean of 39 days.

The results on stand count at harvest indicated significant difference ($P < 0.01$) among the treatment means. At Yundum station, Treatment 1 had the highest mean stand count at harvest with a mean of 25000 plants per hectare but similar to treatments 3 and 4 with means of 23889 plants per hectare each. Treatment 2 had the lowest mean stand count at harvest with a mean of 11667 plants per hectare and significantly different from the rest of the treatments.

At Sapu station, treatment 3 had the highest mean stand count at harvest with a mean of 30000 plants/ha but similar to treatment 1 with a mean of 28611 plants/ha. Treatment 2 had the lowest mean stand count at harvest with a mean of 4444 plants/ha and significantly different from the rest of the treatments. At Giroba Kunda, significant difference ($P < 0.01$) was also observed on stand count at harvest. Treatment 1 had the highest stand count with a mean of 32222 plants/ha but similar to treatment 3 with a mean of 30572 plants. Treatment 2 was significantly lower than the rest of the treatments with a mean of 5000 plants/ha.

The results on dry haulm yield indicated no significant difference ($P < 0.05$) among treatment means at Yundum station. At Sapu station, significant difference was observed on dry haulm yield. Treatment 1 had the highest haulm yield with a mean of 1333.33 kg/ha but similar to treatment 4 with a mean of 1111.11 kg/ha. Treatment 2 had the lowest haulm yield with a mean of 305.56 kg/ha. At Giroba Kunda, significant differences were also observed on dry haulm yield. Treatment 1 had the highest dry haulm yield with a mean of 805.56 kg/ha but similar to treatment 3 and 4 with means of 605.17 and 799.89 kg/ha respectively. Treatment 2 had the lowest dry haulm yield with a mean of 131.95 kg/ha and significantly different from the rest of the treatments. The results on grain yield indicated no significant differences ($P < 0.05$) at Yundum, Sapu and Giroba Kunda. Treatment 3 (Dji Guiya) had the most stable yield across locations with a mean yield of 143.52 kg/ha. The grain yield was generally low across locations due to poor germination, heavy rainfall and pest infestation.

Table 28. Mean grain yield and other agronomic characteristics

	YUNDUM					**SAPU**					**GIROBA KUNDA**				
Variety	Stand count at emergence	Days to 50 % flowering	Stand count at harvest	Haulm yield kg/ha	Grain yield kg/ha	Stand count at emergence	Days to 50 % flowering	Stand count at harvest	Haulm yield kg/ha	Grain yield kg/ha	Stand count at emergence	Days to 50 % flowering	Stand count at harvest	Haulm yield kg/ha	Grain yield kg/ha
Mounge	31944	39	25000	1380.56	119.44	32500	39	28611	1333.33	138.89	37222	39	32222	805.56	152.78
Pakau	20278	37	11667	333.34	111.11	16111	37	4444	305.56	91.67	105000	37	5000	131.95	125.00
Dji Guiya	31389	37	23889	916.67	152.78	35555	37	30000	888.89	152.78	34199	37	30572	604.17	125.00
Ex-Chamen	31388	48	23889	583.33	152.78	26945	48	16111	1111.11	125.0	33627	45	21110	799.89	111.11
CV (%)	12.25	0.72	16.21	52.29	21.91	19.74	1.43	16.31	20.93	27.28	16.26	6.58	11.58	28.10	28.60
Prob..Level	**	**	**	NS	NS	**	**	**	**	NS	**	*	**	**	NS
LSD Value	7035.95	0.577	6836.257	839.347	58.671	10956.164	1.15	6447.778	380.465	69.264	9381.64	5.191	5140	328.685	-

Conclusion and Recommendations:

Based on the results of the study, the grain yields were generally low but treatment 3 (Dji Guiya) was the most stable variety across locations with a mean pod yield of 143.52 kg/ha. Hence this is the first year of the study, it is recommended that studies be repeated in all the regions in the country to verify the results before technology is extended to farmers.

7. FISHERIES AND AQUACULTURE PROGRAM

7.1 Effect of Fish Pond water on carrot growth characteristic

Introduction

Fish and Carrot (*Daucus carota sub-species New kuroda*) were integrated (Jan – May 2015) as a trial using only organic manure as well as recycling pond waste in a view to sustain productivity. Application of organic manures will aid in the improvement of soil textural class to become loamy. Loamy soils composed of sand, silt and clay in a relatively even concentration and are considered ideal for gardening and agricultural uses.

Objective: To determine the effects of fish pond water on carrot production

Materials and method

An area of 77 m^2 was prepared and used with a bed size of 1 m x 4 m square. Carrot seeds were sown. The treatments were fish pond water, tap water and combination of fish pond water and tap water.

Results

The results indicated that a combination of pond and tap water had a positive effect on plant height in the month of April compared to control (tap water) and pond water. Whereas in March, control treatment (tap water) seem to perform better than other treatments with mean height of 76.3 (figure 16).

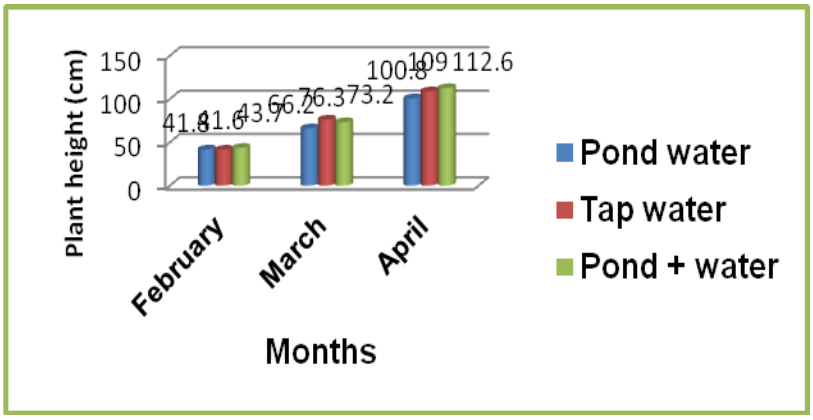

Figure 11. Mean plant height response to treatments

Conclusion

Fish waste is a good additional nutrient supply for crops which is economical as compare to chemical fertilizer. It can be concluded that the pond waste plus tap water performed better than all the sole pond waste in terms of plant height. There is the need to repeat the trial.

8. AGRICULTURAL PRODUCE CHEMISTRY LABORATORY (APCL)

The Laboratory continues to render support services to laboratory clientele and scientific officers. The services generally include routine chemical analysis for wholesomeness, quality for marketing and other research purposes. Laboratory Certificates are issued to its clientele and the results are used to support marketing/pricing of commodities. Laboratory clientele are sensitized and advised on how to collect samples such as weight/size and number of samples to be submitted for analysis.

Samples were received from the following laboratory clientele: Gambia Groundnut Corporation (GGC), Royal Enterprise, Abden Company Ltd./World Food Programmed (WFP), Hon. Minister of Agriculture, Ramatoulie Keita, NaWFA, Food Safety and Quality Authority, Afronut, The Gambia Standard Bureau /WFP Schools.

The routine Chemical analyses carried out were as follows: aflatoxins, moisture content, insoluble impurities in fats and fatty oil, oil content and Free Fatty Acid (FFA). For the reporting period a total of one hundred and forty two (142) samples were received (Table 29).

Table 29. Produce/product and number of samples received

Produce/Products	**Nº of Samples**
Decorticated groundnut (HPS)	117
Cashew Nuts	1
Decorticated groundnut (FAQ)	/ Un decorticated 4 / 8
Groundnut cake	1
Crude Groundnut oil	7
Beans	1
Peanut Butter	3
Milled Rice	2
Palm Oil	1
Flamboyant Delonix	1
Total	142

Results and Discussion

Total of 35 samples were received from Ex-GGC of which, out of which 30 were positive, 23 negative, 23 above EU threshold and 27 above US. For Royal Enterprise, 37 samples in total of which 9 were positive, 28 negative, 30 within EU threshold and 27 within US threshold. Cashew GAM Ltd. brought 1 cashew sample which was negative. Results from analysis of other chemical showed that all samples analyzed are within the range for international standards (Table 30).

Table 30 Aflatoxin Analysis for 2015 Season

Company/Enterprise/Individual	Total Samples	Total aflatoxin Positive (ppb)*	Total Aflatoxin Negative (ppb)*	# of Samples within threshold (EU)*	# of samples within threshold (US)*
Ex-GGC	35	30	23	23	27
Royal Enterprise	37	9	28	30	33
NAWFA	1	0	1	1	1
Cashew GAM	1	0	1	1	1
Afronut	4	2	2	2	4
FSQA	15	6	9	9	9

ppb: parts-per-billion, EU: European Union, US: United States

EU Threshold: <4ppb, US Threshold: <10 ppb

Table 31. Other chemical analysis

Company/ Enterprise/ Individual	**Total Number of Samples**	**Number of with Insoluble Impurities in oil**	**Number of with Oil content**	**Number of samples with Free fatty acid**	**Number of samples with moisture content**	**Number of samples with % foreign materials**	**Number of samples with % split**	**Number of with % imperfect kernel**
Ex-GGC	7	7	-	7	7	-	-	-
Royal Enterprise	11	-	8	9	10	10	10	10

Hon. Minister of Agriculture (Flamboyant tree)	1	-	-		1	-	-	-
Abden Company/ WFP	2	-	-	-	2	-	-	-
Ramatoulie Keita	1	-		1	-	-	-	-
TGSB/WFP	1	-	-	-	1	-	-	-

Constraints/ Recommendations

The Laboratory urgently needs functional Fume Cupboard/hood, and Electrical Grinder suitable for cereals and groundnut/Dickens Hammer Mill. The blenders presently used are not suitable and are very slow. Training on the use of the High Performance Liquid Chromatography (HPLC) was conducted by the consultant but not completed.

Laboratory equipment and methodologies are changing from time to time; therefore staff need to be updated in the form of short/long term training. Staff need to have internship training to other laboratories in the Sub-Region and developed countries to gain more experience.

10.0 SOCIO-ECONOMIC ANNUAL PROGRESS REPORT FOR

Introduction

The Socio-Economic Program mandate is to gather information and analyze data to produce reliable information that will contribute to the economic growth of the country. Its specialty is to assess farmers' agricultural constraints, technology diffusion and adoption, agricultural production and productivity, cost /benefits analysis, agricultural marketing strategies and constraints among others.

As part of its mandates, the program has undertaken the following activities during 2014 to 2015 period.

Activities implemented

- Bio-saline end-line survey
- Baseline on Integrated control of red spider mite using botanical and entomo-pathogen approaches

10.1. Bio-Saline end-line Survey

Introduction

The purpose of the end-line survey was to establish some of the key successes that the project activities has improve the livelihood of the beneficiaries and the challenges faced during the implementation process. During the survey, socio economic and institutional issues within the local community were identified and the means to which sustainability concerns for on-farm management are evaluated. In this context, possible scenarios of agricultural and livestock production systems were assessed which included; 1) public/private/community based irrigation development and management, 2) investment in irrigation technology/water harvesting and 3) better integration of crops and feed for livestock production systems. As a result, some of the key tables from the reports are presented below.

Materials and Methods

The end-line survey was designed to capture both quantitative and quantitative data on pre-defined variables. As a result, both approaches were used to generate data for the exercise.
The end-line survey was carried out in West Coast Region specifically in the project villages where vegetable production is prominent. Purposive sampling method was used to select the three villages as the villages are predetermined.

Random sampling was used to select the respondents from each of the selected villages. Forty (40) respondents from each village were selected randomly. A total of one hundred (120) respondents were interviewed.

Table 32 Villages and number of respondents identified for the survey

Region	Village	No. of Respondents
West Coast Region	Ndembane Village	40
	Pirang Village	40
	Sanyang Village	40

Qualitative Tools

This involves the use of open ended questions to reveal the reflection of the farmers' through the level of performance with the use of technology and the possible adjustment that are required for better use. In addition, it will bring out some key important information that can be used to draw valuable points on the recommendation.

Statistical Tool used in Data Analysis

The statistical tool used in this survey was Stata 13. It was used to run frequencies and descriptive statistics with data available.

Results and Discussion

The results of the survey presents the findings from both qualitative and qualitative in different areas of intervention ranging from key socioeconomic information to production and key challenges faced by farmers in farming and their livelihood.

Socio-demographic information of the respondents

This involves some basic important information about the respondents which helps authenticate the data collected. It can equally reflect some key information about the household situation (size, economic, educational etc.) that affects their livelihood.

Table 33 presents socio-demographic information on the age of the household heads and size of the households. The results showed the mean age of household heads as 56 with 85 as the maximum and the minimum age at 25 years. The mean household size is 13 with a maximum of 40 and a minimum of 4. This indicates that household sizes are relatively large and substantial number of household interviewed has a fair working age household heads.

Table 33. Age of household head and size

Variable	Obs.	Mean	Std. Dev.	Min	Max
Age of the household head	115	56.017	15.94	25	85
Household size	116	13.078	6.57	4	40

Table 34 present the distribution and number of household members base on gender by different age categories. It shows that female has the highest mean (2 persons) under < 5 year per household and maximum of 10 as compared to male. This is also the case in ages 5 ≥ 10 year for the maximum, although male has the highest when it comes to mean. However, male has the overall dominance in the case of the maximum number of persons as compared to female. The mean number of persons per household between ages 18 ≥ 65 year is higher in female while > 65 year is higher in male. Overall, the distribution of number of persons living in household by gender does not vary that much. Furthermore, there is high number of people between age category 18 ≥ 65 year which fairly represent working population in most household in the Gambia.

Table 34. Distribution of household members by age categories

Sex	Year	Obs.	Mean	Std. Dev.	Mean	Max
Male	< 5 year	83	1.99	1.11	1	5
Female		75	2.03	1.507	1	10
Male	5 ≥ 10 year	69	2.19	1.873	1	13
Female		70	2.07	2.066	1	16
Male	11 ≥ 14 year	51	1.47	1.007	1	7
Female		45	1.47	0.694	1	4
Male	15 ≥ 18 year	48	1.67	1.173	1	6
Female		43	1.35	0.65	1	4
Male	18 ≥ 65 year	101	2.58	1.478	1	8
Female		100	2.68	1.563	1	7
Male	> 65 year	21	1.38	1.322	1	7
Female		19	1.16	0.375	1	2

The table 35 above is describing the household members by gender who earns income from non-farming activities. The results indicated that female has the highest number (2 persons) in mean age bracket of ≥18 years that earn income from non-farming activity as compare to male. However, similar case is observed under the age category of ≤ 18 years where male has the highest (3 persons) with a maximum of 7. This shows that besides farming activities, women are

dominant income earners from non-agricultural activities as compare to men even though the difference is not significant.

Table 35. Number of household members who earn income from non -farming activities

Sex	Age	Obs.	Mean	Std. Dev.	Min	Max
Male	≥18 years	85	2.01	1.508	1	10
Female		43	2.33	1.643	1	7
Male	≤ 18 years	15	3.2	1.781	1	6
Female		13	3.08	1.935	1	7

Table 36 presents the distribution of sex and level of education attained by household heads. It shows that higher percentage (88%) of household heads is men as compare to women with 12%. Meaning that significant number of households is headed by men. For the case of education, only 14% of the respondents are indicated to be able to read and write. Insignificant number depicted to have completed primary education, technical/vocational schools, college/university, 7% have attended secondary education, while significant number of respondents 56% responded to have learned quranic. The illiteracy levels of the farmers were estimated at 11% which is high and may have negative effects in the livelihood of farmers. It is evident that knowledge can contribute positive impact in farmers by enabling them to learn and adopt good agricultural.

Table 36. Sex and level of education of the head of the household

Sex	Freq.	%
Male	102	87.93
Female	14	12.07
Level of education		
Illiterate	13	11.21
Read and write	17	14.66
Attended/completed primary school	5	4.31
Attended/completed secondary school	9	7.76
Attended/completed technical/ vocational School	3	2.59
Attended/completed college/ university	3	2.59
Quranic	66	56.9

Table 37 presents the main occupation of the household heads. It indicates that significant percentages of household heads are crop farmers only, followed by crop and livestock farmers. Seasonal employed are about 14% and petty trading 9%. Livestock farmers has the lowest percentage (2%) followed by self-employed people (5%). This indicates significant percentage of the household interviewed depend on agriculture as their main source of livelihood.

Table 37. Main occupation of the household heads

Occupations	Freq.	%
Agriculture (crop and livestock)	23	19.83
Agriculture crop only	48	41.38
Agriculture livestock only	2	1.72
Petty trading	10	8.62
Permanent employment	10	8.62
Seasonal employment	17	14.66
Self-employment	6	5.17

Table 38 presents the source of drinking water for the households. Significant percentage (36%) of the respondent indicates that they source their drinking water from public taps, followed by dug wells with 29% of the respondents. Private hand pumps, private taps, and public hand pump respectively are reportedly less common as shown in Table 38.

Table 38. Main source of drinking water for the household

Source of water	**Freq.**	**%**
Private tap	19	10.27
Private hand pump	16	8.65
Public tap	67	36.22
Public hand pump	27	14.59
Dug well	54	29.19
Other specify	2	1.08
Total	**185**	**100**

Table 39 described number of households who own agricultural land. The results of the survey portrays that 83% of the respondents interviewed owned agricultural land while 16% do not. This means that, significant percent of the households owned land for farming.

Table 39. Number of household who own agricultural land

	Freq.	**%**
Yes	89	83.18
No	18	16.82
Total	**107**	**100**

Table 40 present the use of irrigation for crop production. Significant percentage (94%) of the household interviewed revealed that farmers in the survey communities are using irrigation for permanent crop production while only 5% are not using irrigation. In addition, from those that have not been irrigating 62% of them stated that they were irrigating their tree crops during the

last five years compare to 37% who indicated that they were not irrigating their tress crops for the past years. This reveals that irrigation is vital to these farming communities as nearly 100% of the respondents declared that they are using irrigation for crop production.

Table 40 Use of irrigation for crop production

Land for permanent crops (trees, fruits trees etc.)	**Freq.**	**%**
Yes	108	94.74
No	6	5.26
Total	114	100
If no, have you ever use irrigation during the last five years		
Yes	10	62.5
No	6	37.5
Total	**16**	**100**

Table 41 shows the different sources of irrigation water used by the farmers. The results stated that 65% of the households used dug well as their main source of irrigation, followed by borehole 29%.The table further revealed that river and other sources are less use for irrigation by farmers. This may be as a result of distance between community gardens from water sources.

Table 41. Different sources of irrigation water used by the farmers

Variables	**Freq.**	**%**
River (diversion	5	3.97
Dug well	82	65.08
Borehole	37	29.37
Others	2	1.59
Total	**126**	**100**

Table 42 reveals access to irrigation water by different communities. The results depicted that 66% of the respondents have access to free communal water sources and a reasonable percentage (29%) also responded to have access to membership/group irrigation water. Private and other means of accessing irrigation water are not common. The interpretation of the result can be further explained that most of the household farming communities are depending on free/communal water source of irrigation as the most prevalent.

Table 42. Access to irrigation water

Variables	**Freq.**	**%**
Private	16	10
Member ship in a group	37	23.13
Free/communal access	106	66.25

Other means specify	1	0.63
Total	**160**	**100**

Table 43 reveals cash spent on buying food items from the market by households. On average, D16, 046.76 is spent to purchase food grains and flour by households with a maximum spending of D72, 000 recording the highest level of spending by household. It also indicates that average money spent on buying livestock related food was low compared to spending on other food items. The average estimated total amount of money spent by household is D20, 758.56 while the maximum is D95, 400. However, it is worthy to note that households have different economic strength and size that could influence their economic behavior.

Table 43. Cash spent on buying food items from the market by household

Variables	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Amount of money spent to purchase food grains and flour	111	16046.76	12084.09	350	72000
Amount of money spent to purchase livestock food	44	2890.91	2688.46	100	9000
Amount of money spent to purchase fish and related food	97	10122.89	1152.05	10	54000
Estimated total amount of money spent to buy food from markets /shops	111	20758.56	21400.67	300	95400

Table 44 shows the cash spent on farming activities by households in 2015. It indicates that considerable amount of household income was spent on purchase of farm input (seed, fertilizer, chemicals, etc.) as shown in the mean and maximum spending. This followed by hired farm labor with an average of D1, 173.29 and maximum of D10, 000. Less expenses by famers is incurred on veterinary drugs and treatments with values of D296.72 as mean and D2000 as maximum. Other expenditures such as payment of tractors, oxen and market related expenses also forms a significant portion of the total household expenses.

Table 44. Cash spent on farming activities by household

Variables	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
To hire farm labor (value in kind and cash paid)	73	1173.29	1688.628	100	10000
For purchase of farm inputs(seeds, fertilizer, chemicals	90	1770.54	2552.933	56	21200
Payment for traction power rented (tractor, oxen etc.)	50	848.5	586.408	125	3000

For purchase of farm tools and implements (plough, spade, fork, etc.)	47	322.12	394.065	25	2000
For purchase of animal feed (hay, concentrates, salt, etc.)	10	535	560.779	100	2000
For livestock veterinary (drugs, treatment, etc.)	32	296.72	387.762	5	2000
Expenses related to irrigation water (water association, canal maintenance etc.)	10	507	639.133	100	2000
Land related (land tax, land rent land contract fee)	5	611	851.561	130	2100
Market related cost(sales tax transport)	34	700.74	995.187	50	4800

Table 45 presents the amount of money spent on non-farming and non-food items by households. It shows that average number of the households spent considerable amount of household income on social and festival events, followed by children's school expenses. Household furniture and utensils also take good proportion of the household income. Less income was utilized on household medication.

Table 45. Money spent on non-farming and non-food items by household

Variables	Obs.	Mean	Std. Dev.	Min	Max
For children's school	108	5531.16	8475.675	150	700000
For social and festival events	71	9582.47	13437.72	300	100000
For household medication (drugs, treatment)	99	2035.05	2997.043	110	17000
For clothing and foot wear	113	4440.35	4407.539	200	30000
For house construction and maintenance	30	4906.5	5415.785	500	25000
For household furniture, utensils.	45	4490.78	5728.93	65	28000

Table 46 presents agricultural labor input contributed by household women. The survey shows that almost about (40%) of agricultural labor input were contributed by household women during last year cropping season. Between 24 and 26% of the households stated that women contribution to agricultural labor input can certainly reached between half and three-fourth. Only a minor percent of the respondents stated that women's contribution to agricultural labor input was minimal.

Table 46. Agricultural labor input contributed by household women

	Freq.	%
Almost all	46	40
Three fourth	28	24.35
Half	30	26.09
One third	7	6.09

A quarter	1	0.87
Small amount	3	
Total	**115**	**100**

Table 47 presents the statistics on the involvement and participation of farmers in the ICBA/SSA project activities. It indicates that 79% of the farmers responded that they are involved in the ICBA/SSA and only 21% responded otherwise. Furthermore, about 78% also revealed that they have participated in the project activities, while 23% did not. This portrays that quite a number of the respondents were involved in ICBA/SSA project and they have participated in the process of implementation.

Table 47. Involvement and participation of respondents in the ICBA/SSA project

Are you involved in the ICBA/SSA project	**Freq.**	**%**
Yes	90	78.95
No	24	21.05
Total	114	100
Did you participate in the demonstration of farmers field activities of ICBA/SSA project		
Yes	86	76.79
No	26	23.21
Total	**112**	**100**

Conclusion

The survey shows that household sizes are relatively large and substantial number of households has a fair working age household heads. Overall, the distribution of number of persons living in household by gender does not vary and high number of people are between age category $18 \geq 65$ and significant number of household heads are men. The literacy level among household heads is relatively very low, and their main occupation is farming. This indicates significant percentage of the household interviewed highly depend on agriculture as their main source of livelihood.

In addition, quite a number of households have agricultural land and the average farm size is estimated at 2 ha/household. It is also evident that good proportion of the available household land is allocated to annual crops (excluding forage crops) production as compared to permanent crops (fruit trees, etc.) among others.

The survey also reveals that the main source of household income is crop production. Besides farming activities, the result shows that women are dominant income earners from non-agricultural activities as compare to men even though the difference was not significant. It also shows that bulk of the household income spent on food is allocated to the purchase of food grains and flour compare to other food items. In addition to income spent on household food, high amount of money is also spent on social and festival events, and children's school.

In the survey communities, good number of them sources their drinking water from the public taps, and dug wells. Private hand pumps, private taps, and public hand pump respectively are reportedly common. Furthermore, significant percentage of the household interviewed also revealed that farmers in the survey communities are using irrigation for permanent crop production and dug well and boreholes are their main source of irrigation.

Recommendation

Furthermore, the qualitative result also shows that most of the respondents wanted the ICBA/SSA project to expand their scope. The new component (s) or activities that need to be considered in order to make the project successful includes:

1) To improve on the provision of difference sources of water ranging from well, boreholes, taps, drips, sprinklers etc. within the communities of their intervention;
2) To provide some garden inputs such as seed and fertilizer;
3) Help communities to expand and fence their gardens
4) Provision of credit facilities to farmers.
5) Increase training opportunities for farmers especially on good agricultural practices
6) Timely intervention of project activities in order to realize the best production potentials.

10.2. Baseline on Integrated control of red spider mite using botanical and entomo-pathogen approaches

Introduction

The country's development policy emphasizes the need to enhance vegetable production for local consumption and export. However, the sector is being threatened by both biotic (insects, fungi, bacteria, viruses, nematodes, weeds, etc.) and abiotic factors linked to the environment, and together the overall effects on production is estimated at 30% losses; especially the introduction of pests whose control is becoming difficult due to their development of insecticide resistance. These pose a challenge to train farmers in acquiring the practical knowledge and skills to identify and control these factors through preventive and curative control strategies including Integrated Pest Management (IPM) approaches. It is evident that pest/insect damage lowers the crop's value because the market demands clean, unblemished produce. Growers need to quickly recognize insect problems and practice early control to prevent a buildup and keep insect pests from getting out of control. The average home vegetable gardener grows more than a dozen different types of vegetables, and each may be attacked by several different species of insects. Managing and controlling insect pests is one of the keys to successful vegetable gardening which is the main objective of the survey with special emphasis on red spider mites.

Overall objective

The overall objective is to contribute to the reduction of pest infestation and incidence by introducing an eco-friendly integrated pest management using botanical and entomo-pathogens practices.

Specific Objectives

- To reduce incidence of red spider mite infestation on tomato by 30% at the end of the project;
- To identify organic product (s) that is (are) effective in the control of Red Spider Mites on solanaceous (tomato) crops;
- To document farmers' indigenous knowledge and the factors that influences the use of botanicals as alternatives to synthetic pesticides in pest management.

Materials and Methods

Sampling Design for the Survey

The baseline survey was carried out in three regions (West Coast, Lower River, and Central River Region North) of The Gambia and specifically in the potential villages where vegetable production is prominent. Purposive sampling method was used to select two villages from each region. The selection of the villages depended on geographical distribution in the community; meaning that villages were not next to each other.

Random sampling was used to select the respondents from each of the selected villages. Ten (10) respondents from each village were selected randomly. A total of sixty (60) respondents from six villages were interviewed for the baseline (Table 48).

Table 48. List of regions, villages and number of respondents identified for the survey

No.	Region	Village	No. of Respondents
1	West Region	Lamin Village	10
		Sibanor	10
2	Lower River Region	Jara Kanikunda	10
		Jara Madina	10
3	Central River Region North	Kaur Wafh Town	10
		Jahour Mandinka	10

Quantitative Tool

This involves the use of structured questionnaires targeting individual household respondents with the sample size stated above. It is intended to reveal data on the socio-demographic information and all other associated data in relation to the indicators given in the survey document. It was designed to reveal the survey report statistically and allow for possible recommendation from the results.

Statistical Tool used in Data Analysis

The statistical tool used in this survey was Stata 13. It was used to run frequencies and descriptive statistics.

Results and Discussion

The results of the survey presents the findings from different areas of intervention ranging from key socioeconomic information to major pest problems with special emphasis on red spider mites.

Socio-demographic information of the respondents

Table 49 shows the socio-demographic information of respondents based on age and household size, which is further disaggregated into male and female. The mean age of the respondents is 44.58 and 80 as the maximum, while the minimum age is 20 years. This indicates a large dispassion of age among women gardeners in the areas of intervention. In addition to age, the mean household size is estimated at 16 and the maximum is 67, while the minimum is 5 persons per household. The interpretation from the results showed a large average household size of the families within the areas visited. The results further showed that females have high dominance over male in the household visited with a mean 8 and maximum of 35 for female and mean of 7 and maximum of 32 for male.

Table 49. Age and household size of the respondents

Variable	Obs.	Mean	Std. Dev.	Min	Max
Age (years)	58	44.58	13.39	20	80
Household Size	58	15.55	10.47	5	67
Male (number)	58	7.33	5.39	1	32
Female (number)	58	8.22	5.69	2	35

The level of education of the respondents is considered to be an important factor as it may have direct influence on the daily operations in management and control of pests and diseases in their gardens. Generally, the educational level of farmers in The Gambia is considered to be very low as shown in Table 50. Reasonable percentages (45%) of farmers have attended informal (Madarasa) type of education. Only 8% have attended primary and about 2% in the case of Secondary education. Significant percentage (43%) of farmers in the survey has not attended any form of education. This may have direct consequences on the preparedness of farmers to control and manage pest that destroy their crops; due to limited information on basic life cycle of the most disturbing pests.

Table 50. Literacy level of the respondents

Educational Level	Freq.	%
None	26	43.33
Primary	5	8.33
Secondary	1	1.6
Informal (Madarasa)	27	45
Others	1	1.67
Total	**60**	**100**

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Table 51 reveals the frequency distribution of respondents based on their main occupation. In this regards, farmers are grouped in three main categories. Such that, all those farmers engaged in crop production and gardening as a primary source of living are considered as “crop farming”; likewise for fishing and handcraft. The result showed that 97% of farmers are engaged in crop production and only 2% is engaged in both fishing and handcraft as a source of living. This indicates that quite a number of farmers in these areas are basically involved in farming (field crop & gardening) as a source of livelihood (Table 51).

Table 51. Main occupation of the respondents

Main occupation	**Freq.**	**%**
Crop farming	58	96.67
Fishing	1	1.67
Handcraft making	1	1.67
Total	**60**	**100**

Red spider Mites

Mites are common pests in landscapes and gardens that feed on many fruit trees, vines, berries, vegetables, and ornamental plants. Although related to insects, mites aren’t insects but members of the arachnid class along with spiders and ticks. Spider mites, also called web spinning mites, are the most common mite pests and among the most ubiquitous of all pests in the garden and on the farm. There is a special interest in this baseline survey to examine the prevalence of red spider mites and level of their damage especially on tomatoes. The following tables (49, 50 and 51) under discussion portray individual respondent perception about the red spider mites from the variety of vegetable crops that they grow in their gardens.

Table 52 reveals the frequency distribution of different horticultural crops attacked by red spider mites. Significant number of respondents responded that crops such as okra, bitter tomatoes, eggplant, pepper and tomatoes respectively are highly prone to red spider mites attack. However, the survey has a special interest in the case of tomato in order to establish the magnitude of red spider mite damage in tomatoes. It is interesting to note that red spider mites are reported as a pest of vegetable crops and a concern for farmers engaged in gardening.

Table 52. Crops attacked by red spider mites

Crop Attacked	**Freq.**	**%**
Egg plants	46	22.12
Bitter tomatoes	48	23.08
tomatoes	19	9.13
Pepper	29	13.94

Okra	49	23.56
Cabbage	3	1.44
Sorrel	10	4.81
Onion	1	0.48
Others	3	1.44
Total	**208**	**100**

It has been observed that red spider mites attack crops at different growth stages. Results from Table 53 reveals that a number of respondents (88 out of 208) confirmed that red spider mites attack is predominant during flowering. In addition, reasonable number of respondent (68 out of 208) also reported that they are more prevalent during maturity stage. Furthermore, it is clear from the results red spider mite attack can be in any stage of the crop, although the attack can be severe in some stages than others.

Table 53. Stages of attack by red spider mite

Stage of Attacked	**Freq.**	**%**
Germination	3	1.44
Flowering	88	42.31
Maturity	68	32.69
Germination & Flowering	7	3.37
Germination & Maturity	4	1.92
Flowering & Maturity	28	13.46
Germination, Flowering & Maturity	10	4.81
Total	**208**	**100**

Table 54 shows the severity of red spider mite attack on vegetable crops as reported by farmers. Significant number of respondents (138 out of 208) reported that red spider mites attack is very severe and 60 out of 208 reported that it is severe. Only 10 respondents responded that their attack is less severe, which is quite insignificant. Overall, from the result red spider mites attack have posed a serious concern to farmers involved in vegetable production.

Table 54. Severity of red spider mite attack

Severity of Damage	**Freq.**	**%**
Very Severe	138	66.35
Severe	60	28.85
Less severe	10	4.81
Total	**208**	**100**

Synthetic Pesticides and application

Table 55 present the different categories of pesticides and their frequency of application by farmers. It shows that significant percentages (93%) of farmers apply pesticides and only a negligible percentage of about 7% respondents don't apply pesticides. Furthermore, higher percentage (41%) of respondents also reveals that they apply more of botanical pesticides as compare to synthetic with 21% of respondents. In addition, 38% responded that they use both botanical and synthetic pesticides on their crops. This signifies that quite a number of farmers in these area use pesticides regardless of it being synthetic or botanical to protect their crops from pest damage

Table 55. Categories of pesticides and frequency of usage by farmers

Do you apply pesticides?	**Freq.**	**%**
No	4	6.67
Yes	56	93.33
Total	60	100
Type of pesticide applied		
Synthetic pesticides	12	21.43
Botanical (locally made)	23	41.07
Both	21	37.5
Total	**56**	**100**

Table 56 reveals the pesticides usage and methods of application by the respondents. It indicates that significant percentage (79%) of the respondents reported that they take full decision on the application of different type of pesticides to control pest and only about 21% do not take full decision on their own during this process. Furthermore, reasonable percentages (45%) of the respondents do not wear any protective gear when applying these chemical to their crops; thereby exposing them to the hazardous treats of the chemical which has some health implications. Most of the farmers who apply chemicals are ignorant of the health implications and as such they do not make consultation. In addition, the methods of pesticides applications are also reported in Table 53. Respondents who used other application method forms the highest (36%). Manual spraying shows little attention compared to the rest of the other methods.

Table 56. Pesticide usage and methods of application

Do you take full decision to during application	**Freq.**	**%**
No	12	20.69
Yes	46	79.31
Total	58	100
Do you wear protective gear		

No	26	45.61
Yes	31	54.39
Total	57	100
Method of application		
manual spray	2	3.23
Watering can	21	33.87
Hand sprayer	4	6.45
knapsack Sprayer	13	20.97
other	22	35.48
Total	**62**	**100**

Botanical Pesticides

Results indicates that quite a number (48 out of 58) of the respondents (83%) does not have any form of training on pesticide application and only 10 out of 58 reported to have had training on pesticide application (Table 57). This shows a very low level of farmers' knowledge in the use and application of some of these pesticides (chemicals and botanicals) which are very much detrimental to one's health. However, 70% of the respondents reported that they use recommended methods in pesticide application and fair percentage of about 30% reported that they don't use any recommended method(s).

Table 57. Training and use of recommended methods in pesticide application

Have you received training	**Freq.**	**%**
No	48	82.76
Yes	10	17.24
Total	58	100
Do you use recommended methods		
No	17	29.82
Yes	40	70.18
Total	**57**	**100**

Table 58 presents the sources from which farmers acquire pesticides (synthetic and botanical). Higher percentage (67%) of the respondents acquire them from their surroundings (forest). This indicates that majority of farmers use the botanical which are mostly derived from plant materials. Other sources such as shops and village market with percentage of 11% and 6% respectively are highly associated to synthetic pesticide products. About 16% of the respondents also have other ways of accessing/acquiring pesticides.

Table 58. Sources of pesticides for farmers

How do you access pesticides/botanical	Freq.	%
Village market	*4*	*5.71*
Forest/surround environment	47	67.14
Pesticide shops	8	11.43
Other	11	15.71
Total	**70**	**100**

Table 59 presents different forms of botanicals that are used by the respondents in controlling pests. A significant percentage (65%) of respondent uses Neem products to control pest compare to other plants. Neem is generally known for its bitterness as a result many people use it as a deterrent for most pest spices. Apart from Neem, other plants such as Eucalyptus and Acacia (with percentages of 22 and 11 respectively) are used by the respondents to control pests.

Table 59. Type of botanicals use by farmers to control pests

Botanical used	Freq.	%
Paper	1	1.59
Neem leaves	41	65.08
Acacia	7	11.11
Eucalyptus	14	22.22
Total	**63**	**100**

Conclusion and Recommendation

It has been observed that red spider mites attack vegetables at different growth stages. However, the attack is more severe during flowering and maturity. Vegetables that are highly prone to red spider mites attack okra, bitter tomatoes, eggplant, pepper and tomatoes.

Base on the findings from the study, it is strongly recommended that the following points to be noted:

(i) Farmers should be equipped with good agricultural practices through training.
(ii) Farmers should be sensitize on the hazard of synthetic pesticides,
(iii) Farmer should be encouraged to use botanicals more often as compared to synthetic
(iv) Farmer should be monitored and guided in order to ensure that required dosage and proper application method are used.