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FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

EVALUATION OF SOURSOP AND SWEET ORANGE JUICES AS COMPONENTS OF EXTENDERS FOR BREEDER COCK SEMEN

Authors

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Abstract:

An experiment was carried out to evaluate the potentials of sweet orange juice and soursop juice as extenders for poultry semen. A total number of 15 breeder cocks, 45 -50 weeks of age were assigned to two treatment groups comprising of sweet orange juice and soursop juice in a complete randomized design. Composition of semen extended with Sweet orange juice include: T1(Control, semen without extender), T2 (Dextrose saline + 10% of sweet orange extender + semen), T3 (Dextrose saline + 20% of sweet orange extender +semen) , T4(Dextrose saline +30% sweet orange extender + semen), T5(Dextrose saline + 40% Sweet orange extender + semen), T6(Dextrose saline + 50% of sweet orange extender + semen), T7(Dextrose saline + semen). Composition of semen extended with soursop juice include: B1 (Undiluted semen), B2 (Dextrose saline + 10% 0f soursop extender + semen), B3(Dextrose saline + 20% of soursop extender + semen). B4 (Dextrose saline + 30% of soursop extender + semen), B5(Dextrose saline + 40% of soursop extender + semen), B6 (Dextrose saline + 50% of soursop extender + semen), B7(Dextrose saline + semen).The extender was added in ratio 2:1(extender : semen) and evaluated hourly using computer assisted semen analyser (CASA). The following parameters were Sperm concentration, Progressive motility, Non progressive motility, Average path velocity, Straight line velocity, Curvilinear velocity, Amplitude of lateral head, Linearity, Beat cross frequency, Wobbles and Linearity, The result shows that sweet orange juice and soursop juice inclusion and at different storage periods significantly ($p<0.05$) affect some of the semen parameters (Motility, Curvilinear velocity, Linearity and Beat cross frequency). The results revealed that sweet orange juice used as extender at 30% inclusion rate and at 3hours of storage period enhanced better kinetics of spermatozoa than other inclusion rate and at different storage period. Also soursop juice used as extender at 10% inclusion rate and at 2 hours of storage period enhanced better kinetics of spermatozoa than other inclusion rate and at different storage period. This study has revealed that sweet orange and soursop juices are potential diluents and can be incorporated as extender constituents in the preservation of breeder cock semen.

Keywords: *Rooster semen, Dextrose saline, Semen diluent, Sperm kinetics, Sweet orange, Soursop*

Introduction

On poultry farms, genetic selection is carried out mainly on the basis of family and individual indexes. These include traits desired in a particular type of commercial production system e.g. in a specific poultry specie. Continuous genetic selection towards meat or egg production decreases natural mating efficiency and semen quality, hence lower fertility levels (Lukaszewicz and Kruszynski, 2003). The conservation of germ- plasma from domestic and endangered avian species is essential and to this end, sperm cryopreservation has been practiced for decades. For example chicken were the first species reproduced using sperm cryopreserved in a buffered diluent containing glycerol (Gill and Barbato, 2001). The small number of males in a breeding stock compared to hens (ratio 1:10) is the reason for their important impact on flock fertility

Semen evaluation is a key tool to predict reproductive performance in the management of male fowls and turkeys (Donoghue et al., 2000). Sperm fatty acid composition has been the focus of many investigations (Cerolini et al., 2006). Thus, an effective antioxidant system is required to oppose spermatic cell membrane lipid peroxidation and the formation of reactive oxygen species causing sperm DNA fragmentation, responsible in part for male infertility, in animals and man (Greco et al., 2005). The antioxidant properties of vitamin E and its role in avian reproduction, in egg yolk and in embryonic tissues as in sperm membranes were widely reviewed (Sruai et al.,1996) and many experiments have been carried out on the dietary effect of vitamin E supplementation, considering its role on male fertility and testing its antioxidant properties . According to some authors (Castellin et al..1999; Mournaki et al., 2010) the administration of antioxidants such as vitamin E, selenium, vitamin C, and carotenoids may reduce the oxidative stress and improve sperm motility (Greco et al., 2005). In particular, the role of antioxidants is to contrast the spermatic cell membrane lipid peroxidation and sperm DNA fragmentation caused by reactive oxygen species, responsible for male infertility in animals and man. In rooster, in particular, (Mangiagalli et al. 2010) found positive effects of lycopene addition on fertility and qualitative characteristics of semen. The survival of sperm after collection in seminal plasma for longer periods during preservation at low temperatures requires dilution with appropriate extender in order to maintain viability of spermatozoa. Regardless of the extender constituents, however, viability of spermatozoa deteriorates at low temperatures during storage. Sperm cells are subject to oxidative stress resulting from lipid peroxidation, which can lead to reduced sperm viability and fertility (Donghue and Donoghue, 1997). Although semen contains antioxidants that counteract the damaging effects of lipid peroxidation and prevent excessive peroxide formation (Lewis et al., 1997), the endogenous antioxidative capacity of semen may be insufficient during storage (Maxwell and Salamon 1993). In vitro studies suggested that the addition of some antioxidants to semen extenders could improve the motility and survival of spermatozoa (Biloudea et al., 2002). Fruits are good sources of natural antioxidants, containing many different antioxidant components (Cao et al., 1999).

These antioxidants include carotenoids, vitamins, phenolic compounds and flavonoids and have proved to function as singlet and triplet oxygen quenchers, free radical scavengers and peroxide decomposers (Larson, 1988). In addition, natural foods and food-derived antioxidants such as vitamin C, E and phenolic phytochemicals have been reported to act as chemo-preventive agents against oxidative damage (Kiwon et al., 2003; Ondei et al., 2009). Cucumber (Cucumis sativus), pineapple (Ananas comosus) and orange (Citrus sinensis) are fruit-rich natural antioxidants renowned for their high concentrations of these vitamins and other antioxidants (Cutler et al., 2008). Improved survival rate of spermatozoa preserved with tomato juice at 5°C was observed in African catfish (Clarias gariepinus) (Adeyemo et al., 2007).

In addition, (Al-Daraji, 2012) reported the protective effect of orange juice on spermatozoa against the harmful effects of lipid peroxidation of white layer cocks' semen stored for up to 72 h. (Daramola and Adekunle, 2015) recently observed improved progressive motility ,acrosome .Available, affordable, effective and standard diluents still remain the major problem faced by poultry breeders all over the world. Labor, feed and energy costs are forcing poultry breeders to consider more economical ways of maintaining gene pools. One solution to reduce such costs is with the use of extended semen in poultry breeding industries. With diluted semen available from superior sires, poultry breeders will have the tool to increase genetic advancement per generation, gain a more precise evaluation of genetic improvement, allow optimum use of sires, and transfer of genetic materials worldwide. Nigeria poultry industry has not optimized the use of Artificial insemination in poultry due to non- availability of extender for semen dilution. The development of extender (soursoup juice and sweet orange juice) for poultry will enhance breeding soundness and the productivity in breeder farms. In Nigeria presently there is dearth of information on the success of natural and the locally made extender for cock semen and most of the extender available were developed in temperate region using their resources hence might not be and/or expensive in the tropic

MATERIALS AND METHODS

The research was carried out at the poultry unit farm of the Teaching and Research Farm of Agricultural Technology Department in the Federal Polytechnic Ado-Ekiti, Ekiti State. The study area is located between latitude 72o7N and longituden5o11E and 5o31E. The mean annual rainfall is 127mm with relative humidity of 70-85%. The location is situated at 437mm above sea level with mean annual humidity of 26.7%, The study was approved by the Agricultural Technology Department Research and Ethics Committee, The Federal Polytechnic, Ado Ekiti, Nigeria. the collection of semen was carried out at the poultry Farm.

Collection and Extraction of sweet orange and Soursop Juices

Fresh and ripe Citrus (Citrus sinesis L.) and Soursop (Annona muricata)fruits were purchased from the market. They were peeled and the juices extracted using juice

extractor of model MIKACHI model no MK 1706, according to the procedure of Adeyemo et al. (2007) with some modifications. The fresh orange and soursop were washed thoroughly using distilled water. The fruits were peeled (sweet orange and soursop) and thereafter cut into pieces and the seeds were removed (Orange and Soursop) and placed in a juice extractor. The juices collected from each fruit was put in separate plastic test tubes and centrifuged at 3500rpm for 15 minutes. The supernatant fluid obtained was decanted into a sterile bottle separately and used for the experiment. Further preservation in deep freezer is was carried out for the juice not to get spoilt and for it to be suitable at the time of use.

Animal housing and experimental procedure animal and management

The birds were raised on battery cages. Before arrival of cocks, the battery and floor of experimental site were thoroughly washed, dried and disinfected in order to kill harmful microorganisms. Fifteen breeder cocks of 45-50 weeks of age were purchase from CHI farms Ibadan and used for the study. All roosters were fed ad libitum with diets containing crude protein with 17% crude protein digestible energy 2800kcal/ME

Composition of Semen extended with Soursop and Sweet orange juices

Fourteen (14) different extenders were formulated using both Sweet orange and Soursop juices as indicated The experimental design is Completely Randomized Design (CRD).Each of the experiment consisted of seven (7) treatments replicated thrice. The undiluted and Dextrose saline extender served as positive and negative controls for both experiments. 15 Roosters were ejaculated into the same container to obtain semen pool, and was divided into equal parts. The extender were added at ratio 1:2 (semen: diluent).

Training of cocks for semen collection

Semen collection was carried out according to the modified semen collection procedure as outlined in Balogun et al., (2015). Prior to collection of the semen, the cock were trained for 2 weeks, after which semen was harvested and ejaculate taken to the laboratory for in vitro analysis. Semen was collected from all the cocks in each replicate using abdominal massage technique (Lake, 1957) and evaluated for semen quality characteristics. The abdominal massage techniques involved massaging the cloaca stroke and a squeeze of the region surrounding the cloaca to express semen. The semen was then milked down by firm finger pressure on either side of the vent into the labeled collecting tube. Semen volume: The volume of semen was measured when it had been milked down into the graduated collecting glass test tubes. Coloured semen that was not creamy white was discarded, as it might have been contaminated by faeces or blood. Sperm viability (percentages of progressive, non-progressive and immotile sperm cells). This variable was assessed from the diluted semen (1:2) and examined. One drop of the diluted semen was placed on the slide and covered with glass cover. Motility was expressed as the percentage of motile spermatozoa.

Extension of semen with extenders and evaluation

The pooled semen were allotted as described earlier and diluted with extender dose.

Diluted sample were mixed gently to allow equilibration and semen assessment took place immediately. Dilution rate is 1:2, (semen:diluent). Extended semen according to treatment was evaluated for motility, concentration, livability using standard procedures. Semen qualitative was assessed hourly

The data obtained were subjected to descriptive statistics and analysis of variance (ANOVA) using Minitab software at p = 0.05.

RESULTS

The result of the semen analysis is an indispensable tool in evaluating and treating infertility. Table 1 shows the potential of orange juice as extender for poultry semen using kinetics motion at the varying dilution rate (T1 - T7) at 0hrs.The trend of spermatozoa concentration in the various dilution rates of orange juice diluted semen revealed that the concentration declined with increasing dilution rate and least at 15.63 in Treatment 7. The semen motility and viability was statistically similar ($P>0.05$) across the treatments. The progressive motility of semen samples was not significantly affected ($P>0.05$) by the various concentrations of SOJ. However, the non-progressive motility of semen in T1,T2,T4, T5, T6 and T7 were similar ($P>0.05$) but only T1 at 26.28% had significantly ($P<0.05$) higher value than T3 at 7.64%. Curvilinear velocity (VCL) of semen in T1,T2,T3,T4,T6 and T7 were similar ($P>0.05$) but only T1 at 13.20% had significantly ($P<0.05$) higher value than T5 at 4.65%. The average path velocity (APV) and straight line velocity (VSL) of the semen samples were not significantly ($P>0.05$) affected. Linearity and straightness followed the same pattern where semen samples inT1,T2,T3,T5, T6 and T7 were similar ($P>0.05$) but only T5 at 75.15% had significantly ($P<0.05$) higher value than T4 at 24.24%.in linearity and T5 at 80.85% and T4 at 43.42% in straightness. Amplitude of lateral head was similar ($P>0.05$) among T1, T2, T3, T4, T5, T6 and T7 but only T4 and T5 differed ($P<0.05$) with values of 0.504um and 0.19nm respectively. Beat cross frequency of semen samples in T1, T3, T4 and T6 were significantly ($P<0.005$) higher than the semen samples in T2, T5 and T7. Wobble and liveability of semen samples were not significantly ($P>0.05$) affected by the various concentrations of Sweet orange juice.

Table 1: Kinetics of spermatozoa of breeder cocks semen extended with sweet orange juice at 0 hr

TREATMENT	T1 (UD SOJ)	T2 (10% SOJ)	T3 (20% SOJ)	T4 (30% SOJ)	T5 (40% SOJ)	T6 (50% SOJ)	T7 DS	SEM
SC (x10^{9})	19.76	18.45^{a}	18.21^{b}	18.17^{c}	18.02^{d}	17.22^{e}	15.63^{f}	0.34
+PM (%)	83.08	78.57	80.39	89.79	68.19	76.19	77.67	3.02
NPM (%)	26.28^{a}	23.11^{ab}	7.64^{b}	9.77^{ab}	9.57^{ab}	9.50^{ab}	14.42^{ab}	2.27
PM (%)	56.80	55.46	72.74	78.77	55.62	66.68	63.25	3.35
CV (um/s)	13.20^{ab}	10.19^{ab}	13.32^{ab}	17.66^{a}	4.65^{b}	11.19^{ab}	7.82^{ab}	1.31
APV (um/s)	9.82	8.47	7.74	9.86	4.32	6.96	6.74	0.70
SLV (um/s)	5.67	5.25	3.79	4.29	3.48	3.95	4.32	0.27
Linearity (%)	48.88^{ab}	58.31^{ab}	44.59^{ab}	24.24^{b}	75.15^{a}	55.53^{ab}	62.24^{ab}	5.06
S(%)	59.75^{ab}	65.55^{ab}	57.40^{ab}	43.42^{b}	80.85^{a}	65.83^{ab}	70.73^{ab}	3.74
ALH (um)	0.43^{ab}	0.36^{ab}	0.38^{ab}	0.504^{a}	0.19^{b}	0.33^{ab}	0.30^{ab}	0.03
BCF (Hz)	2.24^{ab}	1.42^{b}	3.18^{ab}	4.17^{a}	0.51^{b}	2.40^{ab}	0.97^{b}	0.36
Wobble (%)	78.75	88.10	72.02	55.82	92.77	76.96	87.68	3.72
Liveability (%)	92.11	90.53	87.72	85.72	91.22	92.26	94.64	0.65

a b: Means with different superscript on the same row are significantly different ($p<0.05$); SEM = standard error of means, SOJ = Sweet orange juice, DS = Dextrose saline, UD = Undiluted, SC = Sperm Concentration, +PM = +Percentage motility, NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinear velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency

The semen quality of sweet orange extended rooster semen for 1 hour is shown in Table 2.The motility of the semen samples in T1, T2, T4, T5, T6 and T7 were similar (P>0.05) but significantly different (P< 0.05) from the lowest motility obtained in semen group T3.Non progressive motility of semen samples in T2 was highest (P<0.05) compared to the similar (P>0.05) values obtained among T1, T3, T4, T5, T6 and T7. Progressive motility of semen samples in T1, T4, T5, T6 andT7 were not significantly (P>0.05) different but were significantly (P<0.05) higher than semen samples in T2 and T3. Curvilinear velocity of semen samples in T1, T2, T4, T5, T6 andT7 were similar (P>0.05) but significantly (P<0.05) higher than T3. Average path velocity (APV) and straight line velocity of the semen samples was highest (P<0.05) in T2 and the lowest value was obtained in T3. Linearity and straightness of semen samples in T3 was

significantly (p< 0.05) higher than the similar (P>0.05) values obtained in T1,T2,T4, T5, T6 and T7 Amplitude of lateral head (ALH) of semen in T2 was highest (P<0.05) followed by the similar (P>0.05) semen samples obtained in T1, T4, T5, T6 and T7 and least (P<0.05) in T3. Beat cross frequency (BCF) of semen samples in T1, T4,T5 and T7 were similar (P>0.05) but differed (P<0.05) from the least value obtained in T3. Wobble of semen samples in T3 had the highest (P< 0.05) value followed by semen sample in T2 and least (P<0.05) in T1,T4,T5,T6 and T7 with similar (P>0.05) values. Livability of semen samples was not significantly (P>0.05) affected by the various concentrations of Sweet orange juice.

Table 2: Kinetics of spermatozoa of breeder cocks semen extended with sweet orange juice at 1hr

TREATMENT	T1 (UD SOJ)	T2 (10% SOJ)	T3 (20% SOJ)	T4 (30% SOJ)	T5 (40% SOJ)	T6 SOJ)	T7 DS	SEM
PM (%)	90.69^{a}	89.74^{a}	58.69^{b}	90.37^{a}	91.15^{a}	90.62^{a}	90.65^{a}	2.24
NPM (%)	8.68^{b}	33.37^{a}	5.56^{b}	10.42^{b}	14.14^{b}	11.28b	15.75^{b}	1.96
PM (%)	82.01^{a}	56.37^{b}	53.14^{b}	79.95^{a}	77.01^{a}	79.34^{a}	74.88^{a}	2.37
CV (um/s)	18.38^{a}	21.55^{a}	4.99^{b}	18.86^{a}	19.32^{a}	18.76^{a}	20.36^{a}	1.07
APV (um/s)	10.16^{b}	14.54^{a}	4.54^{c}	10.45^{b}	10.95^{b}	10.61^{b}	11.56^{b}	0.58
SLV (um/s)	4.31^{b}	7.08^{a}	2.66^{c}	4.49^{b}	4.80^{b}	4.55^{b}	5.01^{b}	0.26
Linearity (%)	23.59^{b}	33.69^{b}	52.47^{a}	23.69^{b}	24.97^{b}	23.88^{b}	24.50^{b}	2.20
S(%)	42.61^{b}	48.76^{b}	57.62^{a}	42.91^{b}	43.90^{b}	42.87^{b}	43.25^{b}	1.35
ALH (um)	0.51^{b}	0.71^{a}	0.21^{c}	0.53^{b}	0.53^{b}	0.52^{b}	0.57^{b}	0.03
BCF (Hz)	4.48^{ab}	3.82^{b}	0.49^{c}	4.58^{ab}	4.38^{ab}	4.60^{ab}	4.71^{a}	0.29
Wobble (%)	51.6^{c}	68.27^{b}	90.82^{a}	55.46^{c}	56.71^{c}	55.89^{c}	56.69^{c}	2.65
Liveability (%)	81.21	84.22	87.61	87.53	90.44	91.77	82.36	0.87

a b: Means with different superscript on the same row are significantly different (p<0.05); SEM = standard error of means, SOJ = Sweet orange juice, DS = Dextrose saline, UD = Undiluted, +PM = +Percentage motility, NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinear velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency

Semen quality of sweet orange extended rooster semen for 2 hours is shown in Table 3. Percentage motility of semen in T1, T2,T3,T4and T7 were not significantly (P>0.05) different but higher (P<0.05)than semen in T6. Non progressive motility of semen

inT1,T2, T3, T4, T5 and T7 were similar (P>0.05) among themselves but differed (P<0.05) from the lowest value obtained in T6. Progressive motility and Curvilinear velocity (VCL) of semen samples in T1, T2, T3, T4, T5andT7 were significantly (P<0.05) higher than semen on T6. Average Path Velocity(APV) in semen on T1, T2,T3,T4 andT7 were similar (P>0.05) among themselves but higher and significantly different (P<0.05) from the values obtained in T5 andT6. Straight line velocity (VSL) of semen in T1, T2, T3, T4, T5and T7 were significantly (P<0.05) higher than semen in T6. Linearity of semen in T2,T3,T4,T5 and T6 were(P>0.05)but differed (P<0.05) from the lowest linearity obtained inT1andT7. Straightness of semen samples in T4, T5 andT6 were not significant (P>0.05) but were significantly (P<0.05) lower thanT1, T2, T3 and T7 which had similar (P>0.05) values. Amplitude of lateral head (ALH) of semen samples in T1,T2,T3,T4,T5 and T7 were similar (P>0.05) but significantly (P<0.05) higher than semen sample in T6. Beat cross frequency of semen samples in T1, T2 and T3 were similar (P>0.05) but significantly (P<0.05) higher than semen in T4, T5 and T6 which again were similar (P>0.05). Wobble of semen inT2,T3,T4,T5 and T6 were similar (P>0.05) but higher and differed (P<0.05)from the values obtained in T1 and T7. Liveability of the semen samples was not significantly (P> 0.05) affected by the various concentrations of sweet orange juice

Table 3: Kinetics of spermatozoa of breeder cocks semen extended with sweet orange juice at 2hr

TREATMENT	T1	T2 (UD SOJ)	T3	T4 (10% SOJ)	T5 (20% SOJ)	T6	T7 (30% SOJ)	SEM (40% SOJ
PM (%)	90.29^{a}	90.00^{a}	85.88^{ab}	86.64^{ab}	72.70^{b}	53.62^{c}	90.68^{a}	3.18
NPM (%)	10.80^{ab}	15.00^{a}	12.22^{ab}	8.78^{ab}	8.55^{ab}	2.67^{b}	11.66^{ab}	1.22
PM (%)	79.49^{a}	74.97^{a}	73.66^{a}	77.85^{a}	64.14^{ab}	50.96^{b}	79.01^{a}	2.57
CV (um/s)	16.70^{a}	16.14^{a}	14.86^{a}	9.87^{ab}	9.59^{ab}	3.67^{b}	18.82^{a}	1.45
APV (um/s)	10.74^{a}	9.94^{ab}	9.19^{abc}	7.07^{bc}	6.52^{c}	3.29^{c}	10.58^{a}	0.64
SLV (um/s)	4.60^{a}	4.85^{a}	5.42^{a}	4.18^{a}	3.87^{ab}	2.59^{b}	4.57^{a}	0.23
Linearity (%)	23.13^{b}	33.59^{ab}	35.93^{ab}	54.85^{ab}	57.24^{ab}	69.29^{a}	24.29^{b}	5.00
S(%)	42.77^{c}	49.17^{bc}	50.12^{bc}	63.00^{abc}	66.39^{ab}	80.08^{a}	43.27^{c}	3.54
ALH (um)	0.53^{a}	0.48^{ab}	0.44^{ab}	0.32^{bc}	0.30^{bc}	0.15^{c}	0.52^{a}	0.03
BCF (Hz)	4.94^{a}	3.64^{ab}	3.20^{abc}	1.85^{bc}	1.98^{bc}	0.41^{c}	4.45^{ab}	0.43
Wobble (%)	54.07^{b}	65.43^{ab}	68.26^{ab}	82.83^{ab}	81.56^{ab}	89.20^{a}	56.19^{b}	4.09
Liveability (%)	72.693	82.100	85.297	83.480	76.997	83.747	71.203	1.227

a b: Means with different superscript on the same row are significantly different (p<0.05); SEM = standard error of means, SOJ = Sweet orange juice, DS = Dextrose saline, UD = Undiluted, +PM = +Percentage motility, NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinea velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency

Semen quality of sweet orange extended rooster semen for 3 hours is shown in table 4. Percentage motility, progressive motility, average path velocity (VAP), straightness and Liveability of semen samples were not significantly (P>0.05) affected by the various concentrations of Sweet orange juice. Non progressive motility of semen in T2, T4, T5 and T7 were significantly higher (P<0.05) than T1, T3 and T6. However, the two groups were similar (P>0.05) among themselves but statistical difference (P<0.05) was obtained between the two groups. Curvilinear velocity (VSL) of semen in T2, T4 and T7 were similar (P>0.05) but were significantly higher (P<0.05) than those obtained in T3, T5 and T6. Linearity of semen in T3 and T6 were similar (P>0.05) but differed (P<0.05) from

Table 4: Kinetics of spermatozoa of breeder cocks semen extended with sweet orange juice at 3hr

TREATMENT	T1	T2	T3	T4	T5	T6	T7	SEM
		(UD SOJ)		(10% SOJ)	(20% SOJ)		(30% SOJ)	(40% SOJ)
(50% SOJ)	DS							
+PM (%)	90.29^{a}	90.00^{a}	85.88^{ab}	86.64^{ab}	72.70^{b}	53.62^{c}	90.68^{a}	3.18
NPM (%)	10.80^{ab}	15.00^{a}	12.22^{ab}	8.78^{ab}	8.55^{ab}	2.67^{b}	11.66^{ab}	1.22
PM (%)	79.49^{a}	74.97^{a}	73.66^{a}	77.85^{a}	64.14^{ab}	50.96^{b}	79.01^{a}	2.57
CV (um/s)	16.70^{a}	16.14^{a}	14.86^{a}	9.87^{ab}	9.59^{ab}	3.67^{b}	18.82^{a}	1.45
APV (um/s)	10.74^{a}	9.94^{ab}	9.19^{abc}	7.07^{bc}	6.52^{c}	3.29^{c}	10.58^{a}	0.64
SLV (um/s)	4.60^{a}	4.85^{a}	5.42^{a}	4.18^{a}	3.87^{ab}	2.59^{b}	4.57^{a}	0.23
Linearity (%)	23.13^{b}	33.59^{ab}	35.93^{ab}	54.85^{ab}	57.24^{ab}	69.29^{a}	24.29^{b}	5.00
S(%)	42.77^{c}	49.17^{bc}	50.12^{bc}	63.00^{abc}	66.39^{ab}	80.08^{a}	43.27^{c}	3.54
ALH (um)	0.53^{a}	0.48^{ab}	0.44^{ab}	0.32^{bc}	0.30^{bc}	0.15^{c}	0.52^{a}	0.03
BCF (Hz)	4.94^{a}	3.64^{ab}	3.20^{abc}	1.85^{bc}	1.98^{bc}	0.41^{c}	4.45^{ab}	0.43
Wobble (%)	54.07^{b}	65.43^{ab}	68.26^{ab}	82.83^{ab}	81.56^{ab}	89.20^{a}	56.19^{b}	4.09
Liveability (%)	72.693	82.100	85.297	83.480	76.997	83.747	71.203	1.227

a b: Means with different superscript on the same row are significantly different ($p<0.05$); SEM = standard error of means, SOJ = Sweet orange juice, DS = Dextrose saline, UD = Undiluted, +PM = +Percentage motility, NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinear velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency

the lowest values obtained in T1, T2, T4, T5 and T7. Amplitude of lateral head (ALH) of semen in T1, T2, T4, T5 and T7 were similar ($P>0.05$) but significantly higher ($P<0.05$) than those obtained in T3 and T6. Beat Cross Frequency (BCH) of semen in T1, T2, T4, T5, T6 and T7 were similar ($P>0.05$) but significantly higher ($P<0.05$) than the value obtained in T3. Wobble of semen in T3, T5

Semen quality of sweet orange extended rooster semen for 4 hours is shown in Table 5. Percentage motility, Progressive motility, curvilinear velocity, Average Path Velocity, Straight line velocity, Straight line velocity, Linearity, Straightness, Amplitude of lateral Head, Beat Cross Frequency, Wobble and Liveability were not significantly ($P>0.05$) affected by the various concentrations of sweet orange juice. Non progressive motility of semen samples in T1, T2, T3, T5, T6 and T7 were similar ($P>0.05$) but higher and significantly different ($P<0.05$) from the semen samples obtained in T4

	(UD SOJ)	(10% SOJ)	(20% SOJ)	(30% SOJ)	(40% SOJ			
(50% SOJ)	DS							
+PM (%)	91.37	78.75	79.68	89.96	83.14	90.12	68.44	3.68
NPM (%)	14.59^{ab}	16.24^{ab}	10.30^{ab}	7.19^{b}	17.81^{a}	8.46^{ab}	11.65^{ab}	1.25
PM (%)	76.78	62.51	69.38	82.78	65.52	81.67	56.79	3.51
CV (um/s)	19.43	16.26	12.30	18.18	17.34	16.06	11.25	1.37
APV (um/s)	11.33	10.10	7.79	9.83	10.36	13.02	7.12	0.73
SLV (um/s)	4.99	4.61	4.21	4.15	4.85	4.32	3.52	0.21
Linearity (%)	26.35	33.43	47.25	22.65	37.20	22.83	41.49	3.94
S(%)	44.03	46.75	60.39	42.05	52.55	42.49	52.53	2.87
ALH (um)	0.56	0.46	0.37	0.49	0.50	0.51	0.34	0.03
BCF (Hz)	4.46	3.29	2.58	4.46	3.66	4.65	2.42	0.37
Wobble (%)	58.32	70.28	72.57	54.10	66.64	53.72	75.09	3.35
Liveability (%)	81.21	84.22	87.61	87.53	90.44	91.77	82.36	0.87

a b: Means with different superscript on the same row are significantly different ($p<0.05$); SEM = standard error of means, SOJ = Sweet orange juice, DS = Dextrose saline, UD = Undiluted, sPM = +Percentage motility, NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinear velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency

Table 6 shows the potential of soursop juice as extender for poultry semen using kinetics motion at the varying dilution rates (B1 to B7) at 0hrs. The trend of spermatozoa concentrations in the various dilution rates of soursop juice diluted semen revealed that the concentrations declined with increasing dilution rates. Percentage motility of semen samples in B1, B2, B3, B4, B5 and B7 were similar ($P>0.05$) but significantly different ($P<0.05$) from the lowest semen motility obtained in T6. Non progressive motility of semen samples in B1, B2, B3, B6 and B7 were also similar ($P>0.05$) but significantly different ($P<0.05$) from the least value obtained in B4 and B5 with similar ($P>0.05$) values. Progressive motility, curvilinear velocity (VCL), straight line velocity (VSL), linearity, straightness, amplitude of lateral head {ALH), beat cross frequency (BCF), wobble and liveability of semen samples were not significantly ($P>0.05$) affected by the various concentrations of Soursop juice. The average path velocity (APV) of semen samples in B1, B2, B3, B5, B6 and B7 were similar ($P>0.05$) but significantly different ($P<0.05$) from the lowest semen APV obtained in B4.

Table 6: Kinetics of spermatozoa of breeder cocks semen extended with soursop juice at 0 hr

Treatment	B1 (UD SSJ)	B2 (10% SSJ)	B3 (20% SSJ)	B4 (30% SSJ)	B5 (40% SSJ)	B6 (50% SSJ)	B7 DS	SEM
SC (10^{9})	19.76	18.45	18.21	18.17	18.02	17.22	15.63	0.34
+PM (%)	91.50	67.12^{ab}	74.48^{ab}	69.92^{ab}	80.61^{ab}	58.73^{b}	66.29^{ab}	3.64
NPM (%)	29.74^{a}	12.47^{ab}	20.99^{ab}	2.00^{b}	5.22^{b}	10.32^{ab}	11.33^{ab}	3.04
PM (%)	61.76	54.65	53.46	69.92	72.39	48.41	54.95	3.22
CV (um/s)	14.09	5.05	13.49	5.09	5.61	6.72	5.85	1.35
APV (um/s)	11.39^{a}	4.69^{ab}	9.75^{ab}	4.23^{b}	5.38^{ab}	5.55^{ab}	5.49^{ab}	0.87
SLV (um/s)	5.88	3.42	4.79	3.07	4.33	2.92	3.63	0.38
Linearity (%)	45.96	68.94	43.44	63.55	76.23	54.73	72.51	4.94

S(%)	55.81	74.51	50.61	72.85	79.26	60.32	75.35	4.18
ALH (um)	0.51	0.20	0.45	0.19	0.23	0.27	0.22	0.04
BCF (Hz)	2.19	0.54	1.99	0.70	0.82	0.94	0.85	0.23
Wobble (%)	81.88	92.63	83.97	85.32	95.45	87.32	95.46	2.32
Liveability (%)	93.30	90.43	90.38	89.79	90.40	90.11	92.18	1.46

a b: Means with different superscript on the same row are significantly different ($p<0.05$); SEM = standard error of means, SSJ = Soursop juice, DS = Dextrose saline, UD = Undiluted, SC = Sperm Concentration, PM

Semen quality of soursop juice extended rooster semen for 1 hour is shown in Table 7. Percentage motility of semen in B1, B2, B3, B4, B5 and B7 were similar ($P>0.05$) but were significantly different ($P<0.05$) and higher than the semen motility obtained in B6. Non progressive motility of semen sample in B1 (undiluted semen) was significantly higher ($P<0.05$) than the values obtained in the other semen samples. The progressive motility, beat cross frequency (BCF), wobble and liveability of semen samples were not significantly ($P>0.05$) affected by the various concentrations of soursop juice. Curvilinear velocity (VCL) of semen samples in B1, B3, B4 and B5 though similar ($P>0.05$), differed ($P<0.05$)from similar ($P>0.05$) and lower values obtained other treatment groups. Average path velocity (APV) and straight line velocity of semen B1 (undiluted) were significantly higher ($P<0.05$) than semen of other treatment groups. Linearity and straightness of semen in B1 was significantly higher ($P<0.05$) than other semen treatment groups. Amplitude of lateral head (ALH) of semen samples in B1 and B5 though similar ($P>0.05$) differed ($p>0.05$) from the lowest semen samples obtained in B2, B3, B4, B6 and B7.

Table 7: Kinetics of spermatozoa of breeder cocks semen extended with soursop juice at 1 hr

Treatment	B1 (UD SSJ)	B2 (10% SSJ)	B3 (20% SSJ)	B4 (30% SSJ)	B5 (40% SSJ)	B6 (50% SSJ)	B7 DS	SEM
PM (%)	94.19^{a}	67.68^{ab}	83.52^{ab}	67.10^{ab}	77.27^{ab}	49.84^{b}	70.00^{ab}	4.51
NPM (%)	39.48^{a}	9.70^{b}	5.20^{b}	3.26^{b}	14.11^{b}	6.67^{b}	6.67^{b}	3.00
PM (%)	54.71	57.98	78.32	63.84	63.16	43.18	63.33	4.55
CV (um/s)	18.31^{a}	5.21^{b}	8.32^{ab}	8.22^{ab}	13.68^{ab}	3.21^{b}	4.14^{b}	1.56
APV (um/s)	14.24^{a}	4.79^{b}	5.56^{b}	5.35^{b}	8.46^{b}	3.03^{b}	4.16^{b}	0.95
SLV (um/s)	18.31^{a}	5.21^{b}	8.32^{b}	8.22^{b}	13.68^{ab}	3.21^{b}	4.14	1.56
Lincarity (%)	42.88^{b}	68.71^{ab}	70.33^{ab}	65.10^{ab}	40.28^{b}	92.50^{a}	98.82^{a}	6.39

S (%)	54.85^{b}	75.36^{ab}	75.65^{ab}	73.58^{ab}	52.65^{b}	97.48^{a}	98.62^{a}	4.86
ALH (um)	0.65^{a}	0.21^{b}	0.26^{b}	0.26^{b}	0.40^{ab}	0.12^{b}	0.17^{b}	0.05
BCF (Hz)	2.79	0.62	1.94	1.85	2.98	0.36	0.56	0.36
Wobble (%)	78.09	91.47	87.69	82.56	71.67	94.68	100.19	3.83
Liveability (%)	90.50	91.16	90.73	89.78	89.78	91.01	89.60	0.19

a b: Means with different superscript on the same row are significantly different ($p<0.05$); SEM = standard error of means, SSJ = Soursop juice, DS = Dextrose saline, UD = Undiluted, PM = +Percentage motility, NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinear velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency (BCF)

Semen quality of soursop juice extended rooster semen for 2 hours is shown in Table 8. Percentage motility of semen in B1, B2, B3, B4, B5 and B7 were similar ($P>0.05$) but significantly higher ($P<0.05$) than T6. Non progressive motility of semen samples in B1, B2, B4, B5 and B7 were similar ($P>0.05$) but significantly higher ($P<0.05$) than the values obtained in B3 and B6 which were similar ($P>0.05$) too. Progressive motility of semen samples in B1, B2, B3, B4, B6 and B7 were similar ($P>0.05$) but significantly higher than B5 semen group. Curvilinear velocity (VCL) and average path velocity (APV) of semen samples in B1, B2, B3, B4, B5 and B7 were similar ($P>0.05$) and significantly higher ($P<0.05$) than B6. Straight line velocity (VSL) of semen samples in B1, B2, B4, B5 and B7 were similar ($P>0.05$) but significantly different ($P<0.05$) and higher than semen samples in T3 and T6 semen treatment groups. Linearity of semen samples in B1, B3, B4, B5, B6 and B7, though similar ($P>0.05$) differed ($P<0.05$) from the lowest value recorded in T2.The amplitude of lateral head (ALH) of semen in B1, B2, B3, B4, B5, and B7 were similar ($P>0.05$) but significantly ($P<0.05$) higher than B6. The beat cross frequency (BCH), wobbles and liveability of semen samples were not significantly influenced ($P>0.005$) by the various concentrations of soursop juice

Table 8: Kinetics of spermatozoa of breeder cocks semen extended with soursop juice at 2 hr

Treatment	B1 (UD SSJ)	B2 (10% SSJ)	B3 (0% SSJ)	B4 (30% SSJ)	B5 (40% SSJ)	B6 (50% SSJ)	B7 DS	SEM
PM (%)	91.86^{a}	90.00^{ab}	70.60^{ab}	80.34^{ab}	83.21^{ab}	61.24^{b}	90.47^{ab}	3.64
NPM (%)	20.84^{ab}	15.00^{ab}	8.06^{b}	14.16^{ab}	33.67^{a}	4.44^{b}	17.79^{ab}	2.76
PM (%)	70.71^{ab}	74.97^{a}	62.55^{ab}	65.69^{ab}	49.48^{b}	56.47^{ab}	72.72^{ab}	2.86
CV (um/s)	13.95^{ab}	16.14^{ab}	13.27^{ab}	7.30^{ab}	20.89^{a}	4.93^{b}	14.45^{ab}	1.71

APV (um/s)	9.85^{ab}	9.94^{ab}	7.76^{ab}	6.41^{ab}	13.98^{a}	4.46^{b}	10.11^{ab}	0.95
SLV (um/s)	5.44^{ab}	4.85^{ab}	3.53^{b}	4.24^{ab}	6.46^{a}	3.37^{b}	5.27^{ab}	0.35
Linearity (%)	42.84ab	33.59b	37.54ab	67.49ab	43.31ab	78.91a	42.17ab	5.40
S (%)	55.58^{ab}	49.17^{b}	50.16b	78.18^{ab}	53.56^{b}	83.23^{a}	54.69^{ab}	4.01
ALH (um)	0.46^{ab}	0.48^{ab}	0.37^{ab}	0.29^{ab}	0.66^{a}	0.19^{b}	0.49^{ab}	0.05
BCF (Hz)	2.61	3.64	3.11	0.95	3.42	0.60	2.87	0.39
Wobble (%)	74.66	65.43	70.72	90.45	75.75	93.60	74.39	3.74
Liveability (%)	89.97	90.30	89.53	89.89	90.74	89.23	89.23	0.16

a b: Means with different superscript on the same row are significantly different ($p<0.05$); SEM = standard error of means, SSJ = Soursop juice, DS = Dextrose saline, UD = Undiluted, + PM = Percentage motility NPM = Non-Progressive motility, PM = Progressive motility, CV = Curvilinear velocity, APV = Average path velocity, SLV = Straight line velocity, S = Straightness, ALH = Amplitude of lateral head, BCF = Beat cross frequency

DISCUSSION

Semen analysis is an indispensable tool in evaluating and treating infertility. The trend of spermatozoa concentration in the various dilution rate of orange juice diluted semen revealed that the concentration declined with increasing dilution rates. The semen motility and viability was statistically similar across the treatments. Progressive motility of semen was not significantly affected by the various concentrations of sweet orange. The various concentrations of Sweet Orange juice used as extender in this study significantly affected sperm motility and the kinetic parameters except VSL and VAP. This result is in agreement with the report of Kumar and Das, (2005) that supplementing extenders with fruit juice consistently improved motility, acrosome integrity and membrane integrity and reduced sperm abnormality. The improvement in semen quality could be attributed to the presence of antioxidant such as vitamins and phenolic compounds which are known to function as antioxidants (Moussa et al., 2003).

The result revealed that motility and progressive motility increased in T1, T4, T5, T6 and T7. Motility is an important parameter used for semen evaluation. Concannon and Battista (1989) suggested that at least 40-50% sperm motility is necessary for success in artificial insemination. Neild et al., (2005) postulated that 20-30% sperm motility is necessary for pregnancy. Semen dilution influenced the viability of spermatozoa in this study. The higher the dilution rate the higher the viability of the spermatozoa. This is contrary to the report of Kumar and Das (2005) that increasing dilution ratio of semen would lead to loss of protective effect thereby resulting in reduced sperm viability.

Majority of the sperm parameters extended such as sperm motility, progressive motility, average path velocity, straight line velocity, curvilinear velocity, amplitude of lateral head displacement and beat cross frequency in semen on T1,T2,T3,T4,T5 and T7 were significantly higher than semen on T6 and it was observed that, all the motility characteristics of spermatozoa were significantly influenced by orange juice, which reiterated earlier findings in Boer cross and Barbari goats (Sundararaman and Edwin, 2005). Changes in the osmotic pressure during semen cryopreservation and thawing critically affected the motility and survival of the spermatozoa. This may be the most important deterrent to sperm survival during cryopreservation (Moussa et al., 2002). Furthermore, membrane destabilization might occur when the sperm plasma membrane undergoes a phase transition from the liquid crystalline phase to the gel phase due to a decrease in temperature during cryopreservation (Sundararaman and Edwin, 2008)

Non progressive motility, curvilinear velocity , linearity, amplitude of lateral head (ALH) beat cross frequency (BCF) and wobble of the semen samples across the treatments were all significantly affected, but the pattern of influence of sweet orange juice on those parameters was not orderly. However the spermatozoa progressive motility, liveability, \average path velocity (VAP), straight line velocity (VSL), amplitude of lateral head (ALH), curvilinear velocity (VCL) of the extended semen at 30% Sweet orange juice are statistically superior to other treatments at 3hours storage period..

The results indicated that the sperm motility parameters increased slowly as the duration increased. Other semen kinetics properties compared favorably with the control. The liveability of sperm cells are affected by the diluents across the treatments. The results of this study is in agreement with the suggestion of Moussa, et al. (2002) that vitamins and other antioxidants in fruit juice acted synergistically to protect sperm cells from lipid peroxidation and accounts for improvement in semen parameters. The inclusion of soursop at 2hours produced better spermatozoa kinetics than other hours and could be due to the antioxidants potentials of the orange that scavenged the free radicals and reactive oxygen species accumulation thereby inhibiting lipid peroxidation. Fruits contains phytoconstituents with array of antioxidants potential which confers on them good sources for semen preservation. The irreversible changes in the sperm membrane induced by lipid phase transitions during time taken may possibly affect the movement characteristics of spermatozoa during semen processing for cryopreservation (Deleeuw et al., 1990). In addition, sperm in storage are more vulnerable to oxidative stress due to peroxidation than sperm in freshly diluted semen (Neild et al., 2005). As semen is diluted many folds in the extender, it reduces the total antioxidant concentration in the medium and cells

(Kumar and Das, 2005). Many sperm are killed during cryopreservation. Thus, it is likely that cryopreserved sperm cells are posed to more ROS concentration and therefore many of the surviving cells exhibit as if they are capacitated or acrosome reacted (Bailey et al., 2000). The overall effects of these events may adversely affect quality of post semen.

CONCLUSION

This study revealed that sweet orange juice used as extender at 30% inclusion rate up to 3hours of storage period enhanced better kinetics of spermatozoa than other inclusion rates and at different storage periods. Also soursop juice used as extender at 10% inclusion rate up to 2 hours of storage period enhanced better kinetics of spermatozoa than other inclusion rates and at different storage periods. This study has revealed that sweet orange and soursop juices are potential diluents and can be incorporated as extenders constituents in the preservation of breeder cock semen.

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FUNGI ASSESSMENT OF FISHES CAUGHT IN THE TWO MAJOR FISHING GROUNDS IN ADO EKITI, EKITI STATE

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Abstract:

Microbial contamination of food is the main obstacle to ensuring food safety.For this, it's paramount to ascertain the safety of fish caught in the major waters in Ado Ekiti.22 fish sample was collected from the two major fishing grounds in Ado Ekiti Metropolis.After standard microbiological tests: Beauveria vuill, Penicillium chrysogenium, scolectrichum, Mucor spp, Aspergillus glaucus,Rhizopus spp, Penicillium notatum and Apshidawere all isolated In the water bodies, this assessment indicated the incidence of fresh fish contamination.These isolates are potential pathogens, and their presencecan pose health risks to humans in general and immunocompromised individuals.

Keywords: *Fungi, Isolates, Fishing grounds, Safety, Contaminant*

Introduction

Fish is an extremely perishable food item (Akande et al., 2012). Soon after death, fish begins to spoil. In the healthy live fish, all the complex biochemical reactions are balanced and the fish flesh is sterile. After death however, irreversible change that results in fish spoilage begins to occur. The resultant effect is the decomposition of the fish (Job et al., 2006). Various factors are responsible for fish spoilage. The quality of capture is important at determining the rate of spoilage. Notably are the fish health status, the presence of parasites, bruises and wounds on the skin and the mode by which the fish was captured. The caught fish quality depends on the handling and preservation, the fish received from the hands of the fishers after capture. The handling and the preservation practice after capture affects the degree of spoilage of the fish (Akande et al., 2012). Fish is one of the most important sources of animal proteins available in the tropics and has been widely accepted as good source of protein and other elements for maintenance of healthy

body (Sanni at al., 2016). In the last two decades, there has been an increased awareness of the nutritional and health benefits of fish consumption. Fish and other seafood are excellent sources of proteins, vitamins, and minerals; most of them are low in fat. Fish also provides a very good balance of nutrients, rich in Vitamin A and B complex and minerals .Proteins from seafood are of high quality and are easily digested also Vitamin A helps to protect the body from disease and Is important for proper growth and healthy eyes and skin (Colakoglu et al., 2016).

Fish are also responsible for a significant percentage of food borne diseases worldwide. It has been reported that in the United States, 10-19% of food-borne illnesses involved the consumption of fish and seafood, whereas, in Japan, 70% of food-borne illnesses have been attributed to consumption of raw fish. The true incidence of seafood-borne diseases worldwide is still unknown, as there is no surveillance system in developing countries (Zorrilla et al., 2013).

Fungi have a worldwide distribution and grow in a wide range of habitats, including extreme environments such as deserts or areas with high salt concentrations (Herman et al., 2011), as well as deep-sea sediments (Summer et al., 2002).Some can survive the intense UV and cosmic radiation encountered during space travel (Herman et al., 2011). Microorganisms are found mostly on the skin, gills, operculum and intestines of life and newly caught fish. Fish contamination can be linked to raw material, personnel, processing tools such as forklifts through leakage, openings in buildings and pets. Some pathogens may even become established in the processing plants from niches where they can survive for a long period of time. The quality of our fish is of major concern to the food processors, consumers and public health authorities and provisions of safe, wholesome and acceptable fish and fish products to consumers and control of microorganisms is essential to meet these objectives (Job et al., 2016) Among the common fungi found to be associated with smoked fish samples in Nigeria are Aspergillus flavus, A.terens, A. fumigatus, A. niger, Mucor sp., Cladosporium sp., Penicillium sp., Candida tropicalis and Fusarium moniliformis (Adebayo-Tayo et al., 2008 and Fafioyeet al., 2002).Moulds may be present without producing any toxin (Christanah et al, 2010), but the presence of toxigenic fungi increases the risk for mycotoxin production. Mycotoxins can be hepatotoxic nephrotoxic, carcinogenic, mutagenic and teratogenic, and in some cases may also be implicated in immunosuppressant and nutritional problems (Refai et al.,2010).The low water activity of the product, together with the high ambient temperatures in the tropics, creates an environment for the potential proliferation of many toxigenic fungi.
The research aims to isolate fungi in fishes caught in the two Major fishing grounds in Ado Ekiti, Ekiti State (Waterworks River and Ogbese River) Ado-Ekiti and its environment provide a possible solution to surmount the food poisoning caused by this microorganism.

MATERIALS AND METHOD

Materials

Swab sticks, distilled water, test tubes, ethanol, cotton wool, petridishes, antibiotic sensitivity discs (positive and negative), ruler, paper tape, hand glove, beaker, conical flask, stirrer, foil paper, bunsen burner.

Equipment

Weighing balance, oven, autoclave, microscope, refrigerator, incubator.

Sterilization

Glassware's were thoroughly washed with detergent, rinsined with distilled water and oven dried at 160^{0}C for 1 hour, and then the workbench was disinfected by swabbing with ethanol. All work in the laboratory was done in sterile environment.

Identification of fungal isolates

The fungal isolates were identified based on their macroscopic and microscopic characteristics.

The mycelia of the isolated fungi were picked on a slide, 2 drops of lactophenol cotton blue stain was added and covered with a cover slip, and the preparation was observed under the x10 and then x40 objective lens.mycelia of the isolated fungi were picked on a slide, 2 drops of lactophenol cotton blue was added and covered at an angle of 60^{0}C with a cover slip fungi isolate were identified based on their colonies morphology and microscopic characteristics at magnification of x40 objectives lens.

RESULTS

Table I: Macroscopy and microscopy characteristics of fungal isolates

S/N	Macroscopy	Microscopy	Suspected fungi
1	Mycelium is white or slightly coloured with a white fluffy to powdery appearance	Conidiophores are singly, irregularly grouped or in a cluster.	*Beauveriavuill*
2	Colonies are often green in colour	Branched conidiophores sprout on the mycelia.	*Penicillium chrysogenium*
3	Colonies appear in dark clusters	Conidiophores are in a loose pigmented cluster	*Scolectrichum*
4	Colonies are typically colour white to grey, and older colonies become grey to brownish colour due to the development of spores	The hyphae are non-septate and the sporangiophores are erect	*Mucor spp*

5	Velvety, wooly, whitish but later turned black fungal colony with the yellowish reverse side	Conidial heads are typically radial	*Aspergillus glaucus*
6	Colonies appear whitishcolour	Sporangiophores are not erect, and regular	*Apshida*
7	Creamy powdery growth that later turned black	Aseptate hyphae, unbranched sporangiosporesare from the foot of rhizoids that enlarged in a cup-shaped form with the mycelia region	*Rhizopus spp*
8	Colonies are often green in colour	Coniophores are branched sprout on the mycelia	*Penicillium notatum*

Table II: Fungi isolated from fresh fish sample purchased from water works and Ogbese river

		chrysogenium		*vulgaris*		*glaucus*			*notatum*
WW 1	-	+	-	-	+	–	.	–	-
WW 2	-	+	-	-	+	–	–	–	-
WW 3	+	-	-	+	-	–	.	–	–
WW 4	-	+	-	-	+	–	.	–	–
WW 5	-	+	-	-	+	–	.	–	–
Ogbese 1	+	-	+	+	-	–	.	-	-
Ogbese 2	+	+	-	+	-	-	-	-	-
Ogbese 3	+	+	-	-	+	–	.	-	-
Ogbese 4	-	+	+	-	-	–	.	–	-
Ogbese 5	+	+	+	+	+	.	.	-	-
Ogbese 6	+	-	-	+	+	–	.	-	-
Ogbese 7	+	-	+	+	+	–	.	–	–

Key
Positive = +
Negative = -
Control Nil

Table III: Cumulative frequency of fungi isolated from wild fresh fish sample

Fungi isolate	Number of occurrences	Frequency in percentage %
Beauveriavuill	7	12
Penicillium chrysogenium	8	14
Scolectrichum	4	7
Proteus vulgaris	6	10
Mucor spp	8	14
Aspergillus glaucus	10	17
Apshida	1	2
Rhizopus spp	7	12
Penicillium notatum	8	14
Total	59	100%

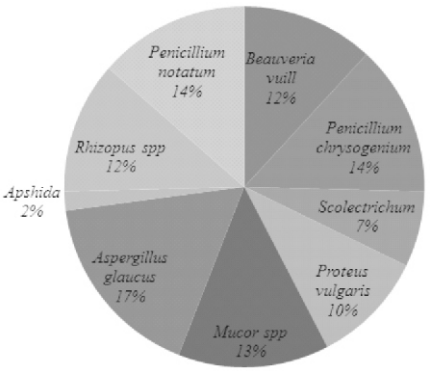

Figure 1: Cumulative frequency of fungi isolated from wild fresh fish sample

As shown in figure 1, it was observed that among these fungal species, Aspergillus glaucusis more predominant over other fungi isolates with (17%) occurrence,followed by Penicillium notatum(14%), Penicillium chysogenium(14%) and Mucor sppwere(13%) respectively, Rhizopus sppand Beauveriavuill(12%) respectively, Proteus vulgaris (10%), and Scolectrichumspp(7%) while Apshidahas (2%).

DISCUSSION

Table I shows the macroscopy and microscopy characterization of fungi isolated from fresh fish samples bought from different locations (Water works and Ogbese) all in ado-Ekiti. The mycelium is white or slightly coloured with a white fluffy to powdery appearance. Colonies are often green in colour, colonies appear in dark clusters, colonies are typically colour white to grey, older colonies become grey to brownish colour due to the development of spores, velvety, wooly, whitish but later turned black fungal colony with yellowish reverse side, colonies appear whitish in colour, creamy powdery growth that later turned black and colonies are often green in colour for the macroscopic while some microscopy appears that conidiophores are singly, irregularly grouped or in cluster. Branched conidiophores sprout on the mycelia, conidiophores are in the loose pigmented cluster, the hyphae are non-septate and the sporangiophores are erect.

The study demonstrated the occurrence of fungi.It was observed that among these fungal species, Aspergillus glaucus was more predominant over other fungi isolates with (17%) occurrence,followed by Penicillium notatum(14%), Penicillium chysogenium(14%) and Mucor spp(13%), Rhizopus sppand Beauveriavuill(12%) respectively, Proteus vulgaris (10%), and Scolectrichumspp(7%) while Apshidahas (2%).This analysis indicated the incidence of fresh fish contamination.These isolates are potential pathogens and their presence can pose health risks to humans in general and immune-compromised individuals.

The presence of high numbers of potentially pathogenic fungi can be emphasized as a negative phenomenon. Moreover, the majority of these identified fungal species are described as potential allergens and exposure to their spores may provoke immune responses in susceptible individuals. As a result, diseases such as allergic rhinitis,

bronchial asthma or extrinsic allergic alveolitis may develop in certain individuals. According to Rafai et al., 2004, long-term or repeated exposure to high concentrations of fungal spores in a range of agricultural products such as poultry and pond products is recognized as contributing to a decline in lung function and allergic reactions such as asthma and allergic alveolitis known as farmer's lung disease (Chamberlain et al., 2001).

CONCLUSION

The result of this study revealed thatfish sold in the water bodies are contaminated, and this may be as a result of certain factors like temperature which favours some organisms and the character of fish handler, by not maintaining personal hygiene, contaminated water taken in by the fishes which may contain faecal matter in their ecosystem which resulted in the isolation of enteric organism like bacteria's as well as other microorganisms which causes contamination like that of Aspergillus niger which may produce toxic material, when man consumes fish.

RECOMMENDATIONS

Contaminated fish could be dangerous, especially for sensitive populations such as children, the elderly and immune compromised people.It is therefore recommended that fish farmers should avoid fish with water contaminated with faecal matter of animal origin including humans.

The state government (Ekiti State) should push into action water body monitoring agencies to avoid contamination of water bodies and punish offenders with stiff penalties.

Also, fish processors need to be thoroughly educated on the need tomaintenance complete hygienic conditions during fish handling and processing.Exposure of fish for several hours in open-air to the environmental condition must be totally discouraged; the fish must be inside the refrigerator all the time.It is important that the sanitary condition under which fishes are handled, processed and stored be improved to reflect standard or good practices.

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INTERNET ACCESS AND AVAILABILITY OF E-RESOURCES: A PANACEA FOR ACADEMIC LIBRARIES DEVELOPMENT IN NIGERIA

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Abstract:

Internet is a vital tool that propels education in Nigeria to greater heights, especially the Polytechnics. As the world moves further into knowledge-based economy. Similarly, e-resources such as e-books, e-journals, online database, and websites are teaching tools (material) which presents the subject matter defined by the curriculum. This study therefore, investigates the benefits of internet access and availability of e-Resources in academic libraries on the reading habits of students in Nigeria Polytechnics on the needs of the users both present and in the future. The paper concludes by recommending that, library professionals need to take utmost care in developing a balanced digital collection, which will enhance the quality of the Academic Libraries and promote effective use of their resources by the clienteles.

Keywords: *Internet, e-Resources, Reading Habits, and Academic Library*

Introduction

Generally speaking, the convergence of information and communication technologies as typified by the Internet is increasingly having more influence on all aspects of the society as it has become an integral part of the daily lives of many people. It has had a transformative impact on the mode of information sharing and access globally. Information and knowledge disseminated through the slow process of oral communications or with paper materials can now be transferred rapidly from an individual to an infinite number of users through a number of media and formats. The Internet is the fastest growing communication technology and has emerged as a major source of information that connects people, data and other computers, reducing the world to the much talked-about global village. Bane and Milhemi (1995) described the Internet as the premier networks, everyone connected or as unmanaged web of computer plasma.

Technically and functionally, Hargittai (2015) defined the Internet as a worldwide network of computers, and a network of people using computers that make vast amounts of information available. Amichai-Hamburger and Hayat (2013) described the Internet as the creation of a continuous stream of computers linked together to form one grid, which enables interaction among hundreds of millions of people browsing the net. Huttner, et al (2013) posited that without the Internet, planes would not fly, financial markets would not operate, supermarkets would not restock, taxes would not get paid and the power grid would not balance the supply and demand for electricity. Aqil and Ahmad (2011) averred that the Internet places information on our finger tips and that it is everywhere, knocking at our door, making our life easy and smooth. UNESCO (2015) noted that the Internet has profound implications for African countries such as Nigeria as it has the potential to positively impact on the social, political, educational, technological and other spheres of lives of its people.

The education sector was among those that first embraced the use of Internet, and it has continued to broaden the breadth and depth of opportunities within institutions of higher learning worldwide. The Internet serves as a useful tool in support of the various educational activities that ranged from research to teaching. Thus, the Internet is a vital tool that will propel Polytechnics education to greater heights as the world move further into the knowledge-based economy. Polytechnics worldwide now invest a lot on Internet and e-resources because it reduces the time between the production and utilization of knowledge; improves co-operation and exchange of ideas with fellow researchers in other institutions, regions or countries, furthers the sharing of information; and promotes multidisciplinary research.

Literature Review

According to Wikipedia, (2022). Electronic Resources means Information (usually a file) which can be stored in the form of electrical signals, usually on a computer Information available on the Internet.

According to Library and Information Technology Glossary (2019) Term used to describe all of the information products that a library provides through a computer network.

According to Anglo American Cataloguing Rule 2 (AACR2 2005). Update, an electronic resource is material data and program(s) encoded for manipulation by a computerized device. This material may require the use of a peripheral directly connected to a computerized device (e.g., CD-ROM drive) or a connection to a computer network (e.g. the Internet). This definition does not include electronic resources that do not require the use of a computer, for example, music compact discs and videodiscs.

According to Gradman glossary (2017). A publication in digital format which must be stored and read on a computer device.

E-Resources are used by students for forming note and assignment. Electronic

resources have become major tools in carry out important information in the polytechnic by student and staff. Student nowaccess electronic resources right from the polytechnic libraries who had subscribed to many of these electronic resources and databases which are being access free of charge from the polytechnic and university libraries.

Some of these electronic resources and databases are available in various forms such like e-books, online journals, e-data archives, Health International Network Access to Research Initiatives (HINARI), Access to Global Online Research in Agriculture (AGORA), Joint System to Order Resources (J.STORE), The Essential Electronic Agriculture Library (TEEAL) and Ebscohost among others. This had enabled students to improve on their academic performance of Nigerian polytechnics.

Ashikuzzaman (2014) An electronic resource is defined as a resource which require computer access or any electronic product that delivers a collection of data, be it text referring to full text bases, electronic journals, image collections, other multimedia products and numerical, graphical or time based, as a commercially available title that has been published with an aim to being marketed. These may be delivered on CD ROM, on tape, via internet and so on. Over the past few years, a numbers of techniques and related standards have been developed which allow documents to be created and distributed in electronic form. Hence to cope with the present situation, librarians are shifting towards new media, namely electronic resources for their collection developments that the documents of users are better fulfilled. The e-resources on magnetic and optical media have a vast impact on the collections of University libraries. These are more useful due to inherent capabilities for manipulation and searching, providing information access is cheaper to acquiring information resources, savings in storage and maintenance etc. and sometimes the electronic form is the only alternative.

According to Wikipedia, (2019) Electronic Resources means Information (usually a file) which can be stored in the form of electrical signals, usually on a computer; Information available on the Internet.

Electronic resources according to International Federation of Library Association. IFLA(2012) are those materials that require computer access, whether through a personal computer, mainframe, or handheld mobile device. They may be accessed remotely via the internet or locally.

Chisenga, J. (ED) (2004) described electronic resources as electronic products that deliver a collection of data, be in text referring to full text databases, e-journals, e-books, image collections, other multimedia products and numerical, graphical or time based, as commercially available title that has been published with a sole aim of being marketed and information dissemination.

Reading is an art that provides a human being with the foundation upon which to erect his or her understanding of life as well as the elements with which to build his or her worldview. Tella and Akande (2007) described reading as 'reasoning involving meaningful interpretation of words, phrases and sentences requiring all types of thinking such as critical, analytical, creative, imaginative, educative, judgmental and

problem solving'. Clark and Rumbold (2006) observed that, in addition to personal and mental developments, reading is critical for ensuring one's access to social, economic and civic life. Against the backdrop of rapidly changing nature of life as well as the society, reading is considered to be crucial for people from all cross-sections of life for successfully coping with the complexities and challenges of the 21st century. In recent times, the emergence of digital technologies and various modes of social interaction, reading is facing a number of hurdles.

Reading and reading habit are two aspects that have received increasing attention in recent years. Reading habit is identified as the single most important determinant of a student's success in education and in our modern complex society (Sangkaeo, 1999). In the evolving knowledge society, reading is considered crucial for gaining the necessary information and insights, which prepare a person to face the diverse challenges of modern times. Reading should not be for passing exams alone but also for leisure and acquiring valuable information that will better one's life. Reading adds quality to life and provides access to culture and cultural heritage. He believed that reading empowers and emancipates citizens and brings people together. Shen (2006) opined that reading is one of the most important activities in life, through which we enter into the life and experiences of others and extend our knowledge, scope of experience, and enjoyment.

Academic library has been playing important role in supporting, teaching, learning and researches within the host Institutions, such as universities, polytechnics, colleges of education and other similar institutions. (Curzon et al, 2009 Lee and Teh, (2000), also add that, the academic community in the country has pioneered the establishment and use of the Internet and Web sites. As a result of these developments, academic libraries have been in more privileged position to provide better and more services to their users.

Research Questions A survey approach was used for this study

1. Are there functional internet services in the library?
2. How frequency the patron toward using e-resources of the library?
3. For what purpose patron make use of e-resources of the library?
4. Is the e-resources improved the reading habit of student?

Methodology

A survey approach was used for this study. A questionnaire was constructed to gather informational on how functional internet services in the library, how frequency the patron toward the use of available e-resources, for what purpose of usage and on how the e-resources improved the reading habit of student in the academic library.

Sample random technique was used to select 200 students who attended library practical from School of business, School of engineering and School of Science Federal Polytechnic Ado- Ekiti.

The questionnaire was given to each student. Out of 200 copies of the questionnaire given 150 were returned completed filled representing 75%. These were used for data analysis on the study

Data Presentation and Interpretation

The bellow table shows the analysis and result of internet services in line with objective of the case study in order to make a valid conclusion based on the problem for the study.

Table 1: Are there functional internet services in the library?

	DAILY	WEEKLY	MONTLY	NEVER	TOTAL (%)
Main Library	50(33.3)	30(20)	55(36.7)	15(10)	150 (100)

Table 1 shows responds on the library internet services to student 115(90%) accessed internet daily, weekly, monthly from Polytechnic Digital Library while 15(10) did not. This shows that majority of students were able to accessed internet in the library.

Table 2: How frequency the patron toward e-resources of the library?

	DAILY	WEEKLY	MONTHLY	NEVER	OCCASIONALY	TOTAL(%)
Agora	50(33.3)	40(26.7)	29(19.3)	6(4)	25(16.7)	150(100)
E-book	74(49.3)	46(30.7)	10(6.7)	20(13.3)	-	150(100)
Ebscohost	42(28)	56(37.3)	30(20)	22(14.7)	-	150(100)
E-journal	80(53.3)	50(33.3)	-	20(13.3)	-	150(100)
Internet	110(73.3)	40(26.7)	-	-	-	150(100)
J.Store	80(53.3)	30(20)	20(13.3)	20(13.3)	-	150(100)
Teeal	76(50.7)	44(29.3)	20(13.3)	10(6.7)	-	150(100)

Table 2: Shows how frequency the patron toward e-resources of the library 119(79.3%) and 130(86.7%) respondents accessed Agora and E-book daily, weekly and monthly respectively while 128(85.3%) and 130(86.6) respondents accessed Ebscohost and E-journal daily, weekly and month respectively. 150(100%), 130(86.6%), and140(93.3%) respondents accessed Internet, J.store, and Teeal daily, weekly and monthly respectively. This shows that majority of student were able to use these highlighted e-resources frequently.

Table 3: for what purpose patron make use of e-resources of the library?

Assignment	120 (80)
Note	30 (20)

Table 3. Shows purpose of usage and all student use e-resources for assignment 120 (80%), followed by Note 30(20%). This indicate that all of the students using e-resources for their studies.

Table 4. is the e-resources improved the reading habit of the students?

Agree	53(35.3)
Strongly Agree	97(64.7)
Disagree	-
Strongly Disagree	-

Table 4. Shows improved on reading habit of students 53(35.3) and 97(64.7) Students agree strongly agreed that e-resources actually improved their reading habit.

Discussion of the Findings

1. The study showed that majority of the students were able to access e-resources in the main library
2. The study also revealed that majority of the student frequently makes use of e-resources for their assignment on a daily, weekly and monthly and this indirectly contributed to the reading habit of student
3. The findings revealed that majority of the student uses e-resources for forming note in which can aid their studies
4. The study finally, showed that all respondents agreed that e-resources have contributed to their knowledge and their habit of reading.

Benefits of Internet and E-Resources on Reading Habits of the Student

The benefits of internet are as follows:

1. Information: The internet gives you access to information on any subjects of your choice. This makes the internet valuable research tool. Most sources such as newspaper and magazines have websites and a number of them only exist online
2. Research: you can make use of internet search facilities to research just about any topic you think of it. This information can only help you with school project, or a presentation at work. You can search for data you need or go to specific research site.
3. E-mail (Electronic Mail): Electronic mail enable us to exchanges message with people around the world, including friends, family members, colleagues, customers and even people you meet on the internet. E-mail is an exciting feature of the internet as well we can send and received message over long distances. It is also fast, easy and inexpensive.
4. Programme: you can find thousands of programmes that can be used on your computer, such as word processors, drawing, programmes, games and accounting programmes.
5. E-learning: E-learning is a training or education programmes by electronic means. E-learning involves the use of computer, or electronic devices to provide training on educational technology as a tool for learning. Distant education can be done by e-learning.
6. Job Search: internet makes life easy for both employers and job seekers as there are plenty of job site which connects employers and job seekers.
7. Online Shopping: you can order for products on the internet, while sitting at home. Also, you can purchase items such as books, music, and other products of your choice.

Conclusion and Recommendations

E-resources are sources of information where materials are access by individuals for their study and academic libraries need to take utmost care in developing balanced digital collectionsby ensured easy access of information on the internet and other databases for their research interest.

Based on these findings, I therefore recommending that, library professionals need to take utmost care in developing a balanced digital collection, which will enhance the quality of the Academic Libraries and promote effective use of e- resources in the library if they followed below information:

1. Nigerian polytechnic through their libraries should subscribe for more e-resources and databases that cover all curriculum and courses ran by the polytechnic.
2. The polytechnic administration should ensure constant electricity supply in the

campus so that these e-resources can be accessed.

3. Student should be encouraged to use e-resources by organizing training and workshop for them on how they can access e-resource of the library.
4. Student shouldbenotified by library management whenever they acquire new databases.

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GENOTYPE BY ENVIRONMENT INTERACTION EFFECT ON GROWTH AND YIELD STABILITY OF SIX SOYBEAN (Glycine Max L.) VARIETIES IN TWO DIFFERENT ECOLOGIES

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Abstract:

A study was conducted on six soybean varieties which were developed and tested for yield stability to determine which of the soybean varieties is ideal for which environment. Three early maturing soybean varieties (TGx 1740-2F, TGx 1876-4E, TGx 1019-2EN) and three medium maturing varieties (TGx 1937-1F, TGx1019-2EB, TGx 1904-6F) were obtained from (IITA) Ibadan, Nigeria and were planted in June and September in the early and late rainy seasons for three consecutive years of 2013, 2014 and 2015 at two locations namely, Akure and Ado-Ekiti ecologies. The experiment was a split plot arrangement using a 2 x 2 x 6 factorial combination of locations, sowing seasons and varieties arranged in randomized complete block design (RCBD) with three replicates. Each location had 24 plots replicated three times to make a total of 72 plots per location. Data obtained were subjected to genotype (G) by environment (E) interaction (GEI). Biplot analysis was applied with combined analysis of variance to examine the nature and magnitude of GEI and quantify their effects on soybean performance in the two experimental locations. Parameters observed included plant height (cm), number of filled pods, number of grains, days to first flowering and grain yield per plot.(t/ha). Data were analyzed and subjected using GGEBiplot Pattern Explorer The results depicted differential performance of soybean genotypes at different test environments and hence the interaction was crossover type. The GEI explained about 60 % of the variation which is more than double of the environment and four times of the genotypic effects of the total variation, however, it could be concluded that genotype and environment interaction had a highly significant association with most parameters evaluated. The mean separation ranked TGx 1937-1F as the highest yielder across the six environments.

Keywords: *Environment, Genotype, Interaction, Soybean varieties, Yield*

Introduction

Soybean plays a critical role in the lives of millions of people in Nigeria, providing a major source of dietary protein that nutritionally complements low protein staple cereal and tuber crops. (Agbogidi and Egho, 2012, Oyewusi et al, 2021). Drought is the most important abiotic stress limiting production of all crops worldwide. (Hall, 2004). More importantly, Nigeria is known as a victim with recurrent droughts that causes partial or total crop failure. In such situations, the relative magnitude of environment, genotype and their interaction (GEI) effects are a challenge that makes production difficult (Hall et al., 2003). Therefore, in the process of developing Soybean varieties for desirable traits, it is necessary to evaluate genotypes in contrasting environments in the rain forest and derived savanna ecologies. However, information on the effect of (GEI) on Soybean grain yield under diversified agro-climatic conditions is limited. The yielding ability of crop varieties is the ultimate result of favorable interaction of genotype with the environment. Environmental factors such as moisture content, time of sowing, air temperature and photoperiod length, soil characteristics differ across years and locations with profound influence at developmental stages while different responses and performance of genotypes observed in environment are desirable characteristic (Gauch et al., 2008, Oyewusi et al, 2021). Poor yield in Soybean may be due to unavailability of high yielding and stability of genotypes along with appropriate advance agronomic management practices (Oyewusi et al, 2021). Several varieties with high seed yield potential and growth habit like early maturity were identified and evaluated in adaptation trials to study seed yield stability in different ecological zones (IITA, 2020). There is therefore great need to test adaptation among Soybean cultivars to environmental conditions of the seasons of sowing and location in the ecological zones of Nigeria. Some environmental variation is predictable; they can be attributed to specific, characteristic features of the environment such as soil type, soil fertility, and plant density. Some variation is unpredictable e.g., rainfall, temperature, humidity. The stability of performance across environments may depend upon the magnitude of genotype x environment interaction. A genotype is considered to have agronomical stability if it yields well with respect to the productive potential of the test environment. Soybean grain yield as a complex character is associated with some yield components and influenced by environmental fluctuations (Choi et al. 2016, Oyewusi et al, 2021). Soybean yield potential in various agro-ecological environments vary depending on the compatibility with the agro-ecosystem, biotic and abiotic stress magnitudes, and level of crop management (Zanon et al. 2016, Adie et al. 2013; Kuswantoro 2016). It also leads to the interaction between genotype and environment (GEI), which caused difficulties in selecting superior lines (Kumar et al. 2014).

Materials and Methods

Land preparation and plot maintenance

Two seeds were sown after mild loosening of the soil surface with a hand fork for

seeds to germinate and emerge without obstruction at plant spacing of 40 cm × 15 cm at two grains per hill (inter- and intra- rows respectively) sown at a depth of about 2-3cm. Weeds were manually removed as the need arose in each year, 2-3 times and earthen of the plants to prevent lodging and the pods from touching the ground were carried out on the plots.

Source of planting materials and Experimental Design

The genetic materials used consisted of six soybean varieties which were developed and were tested for yield stability to determine which of the soybean varieties is ideal for which environment Three early maturing soybean varieties (TGx 1740-2F, TGx 1876-4E, TGx 1019-2EN) and three medium maturing varieties (TGx 1937-1F, TGx1019-2EB, TGx 1904-6F) Were obtained from International Institute of Tropical Agriculture (IITA) Nigeria and were planted in June and September in the early and late rainy seasons of 2013, 2014 and 2015 at two locations namely, Akure and Ado-Ekiti of the rainforest and derived savanna agro ecologies of South Western Nigeria.

The experiment was conducted in the early and late rainy seasons for three years making a total of six trials in a split plot arrangement using a 2 x 2 x 6 factorial combination of locations, sowing seasons and varieties arranged in randomized complete block design (RCBD) with three replications. Each location had 24 plots replicated three times to make a total of 72 plots per location. Each variety was planted using a 2.4 m × 4.5 m plot size at a plant spacing distance of 40 cm × 15 cm at two grains per hill. Weeds, pests and diseases were intensively controlled.

Data Collection and Analysis

Data obtained from the field trials were subjected to genotype (G) by environment (E) interaction (GEI). Biplot analysis was applied with combined analysis of variance to examine the nature and magnitude of GEI and quantify their effects on soybean performance in the two experimental locations. Parameters observed included plant height per plant, number of filled pods per plant, number of grain per plant, number of branches per plant, number of nodules, 100 grain weight, days to first flowering, and grain yield per plot. Grain yield per plot was converted to t ha–1.

Data were then analyzed and subjected to analysis of variance following stability parameters on varieties, environment and genotype x environment interaction to determine which variety showed stable performance over different environmental conditions using Coefficient of variability and Standard deviation analysis with GGEBiplot Pattern Explorer to determine which variety showed stable performance over different environmental conditions.. (Rakshit et al. 2012; Yan et al. 2000, Yan, 2001).

Results and Discussion

Analysis for G by E and Test Environment Evaluation

The sandy loam soil at the sites of study, a tropical rainforest and derived savannah is

an Alfisol classified (USDA Soil Survey staff, 1999).The pattern of rainfall is bimodal with the first peak occurring between June-July and the second in September, with a dry spell in August. The average temperature of the site is 27.5 °C, while the relative humidity ranges between 85% and 98% during rainy season and less than 60% during the dry season. The results of chemical properties at the experimental sites at Akure and Ado-Ekiti locations are presented in Table 1.The result shows that soil Ph at Akure experimental farm is neutral while Ado-Ekiti is slightly acidic. The soil organic matter (SOM) contents of the soils at both sites are low and falls lower than the critical (greater than 20g/kg). The SOM for Akure was 4.01kg/ha and that of Ado-Ekiti was 2.92kg/ha. Nitrogen (N) content of the soils also falls below 1.5g/kg critical value classified as low. The available phosphorus (P) fall below the medium range (8-20mg/kg) of critical P and the exchangeable potassium (K) fall within the critical range (0.2 cmol/kg) classed as low.

Table 2 shows the combined analysis of variance over environments which explained soybean grain yield was significantly ($p<0.001$) affected by environments (E), genotypes (G) and genotype by environment interactions (GE). Environment accounted for about 25.58% of the variation. The GE explained about 60 % of the variation which is more than double of the environment and four times of the genotypic effects of the total variation (14.87%). As shown by differential yield ranking of genotypes, the GE was crossover type. The purpose of test-environment evaluation is to identify test environments that effectively identify superior genotypes for the test environments.

The tested soybean varieties varied in their response to % emergence, plant height, number of nodules, filled number of pods/plant, number of grains/plant, days to first flowering and grain yield. Highest % germination was recorded for the early maturing soybean varieties, TGx 1740-2F, TGx 1876-4E, and TGx 1019-2EN. Similarly, shortest days to first flowering were recorded for the early maturing varieties while highest number of nodule was recorded for TGx 1740 -2F across the environments. Significantly higher value for grain yield was recorded almost consistently for TGx 1937-IF (Table 3-8).

Table 9 shows the Cumulative Mean Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Akure and Ado-Ekiti location in the early and late rainy season between 2013 - 2015. The highest value recorded for Akure in the early and the late rainy season across the planting period was TGx 1937 – IF (50.95 and 47.54) respectively. Conversely, the lowest value recorded in the early and late rainy season in Akure over the planting period was TGx 1904-6F (34.82 and 35.31) respectively.

Conversely, the best variety in Ado-Ekiti in the early and the late rainy season across the planting period was TGx 1937 – IF (52.81 and 48.35) respectively while the poorest variety recorded in the early and the late rainy season in Ado-Ekiti was TGx

1876 - 4E (33.42) and TGx 1904-6F was (34.58) respectively. The highest yielding variety for all tested environments was TGx 1937 – IF while the highest yielding location in the late rainy season was Akure (38.80). The best location across the planting period irrespective of season was Ado-Ekiti.

The genotype by environment interaction (GEI) Biplots analyses in Table 10 shows that the performance of soybean genotypes at the test environments differed and hence the interaction was crossover type. Soybean variety TGx 1937-IF combined both high mean yield and high stability performance across the test environments and could be characterized as well adapted while the most unstable variety with poor performance across locations were TGx 1740 -2F, TGx 1876-4E, and TGx 1904-6F. An analysis of the same varieties under contrasting climate conditions makes it possible to identify the characters and varieties that are less sensitive to changes in cultivation conditions, which is especially important under conditions of warming and climate instability. The genotype (years, locations and sowing seasons) interaction clearly demonstrated that genotype and environment interaction across the environment clearly plays a significant role in breeding adaptable soybean genotypes to the wide environment. TGx 1937-1F out yielded others because of its yield components such as, number of filled pods per plant and number of seeds per pod with some other growth traits like days to first flowering that does contribute to the highest yield.

This observation supports the earlier reports of Agbogidi and Egho, 2012, and Oyewusi et al, 2021) that plants respond differently to environmental factors based on their genetic makeup and their adaptation capability indicating the variability among species.

The mean performance analysis revealed that high yielding genotypes across the sowing dates over the three planting periods were: TGx 1937-1F and TGx1019-2EB whereas the most unstable variety with poor performance across locations were TGx 1740 -2F, TGx 1876-4E, and TGx 1904-6F. Thus, the outstanding performance by TGx 1937-1F in terms of yield and yield related traits made it the best performer across locations, sowing seasons and varieties. Atnaf (2013) found three ideal soybean genotypes as it exhibits both high mean yield and high stability performances across the test environments.

Another study reported that soybean genotype C1 (PS1539) was considered as an ideal genotype with high yield and high stability as demonstrated by low GEI (Bhartiya et al. 2017, Kim et al, 2020). Asfaw et al. (2009) reported that GEI was an important source of soybean yield variation. The use of Biplots was effective to graphically visualize the GEI pattern of genotypes and environments, and to determine the stability and adaptability of the genotypes. (Kumar et al. 2014, Yan and Kang, 2003, Yan and Tinka, 2006, Yan et al, 2007). The analysis of variance revealed that environments, genotypes and genotype × environment interactions accounted for 25.5%, 14.8% and 59.9% of sum of squares, respectively. In this present study, the

GEI was small in genotypic variation, whereas genotype (G) and environment (E) explained most of the variations.

This indicated that genotypes and environments are both important in governing the expression of this trait (Gedif et al 2014). Another report demonstrated that GEI effects were higher than those shown by the genotypic and the environmental effects (Bhartiya et al. 2017), and GEI effect was three times higher than the G and E effects (Cravero et al. 2010; Suwarto 2010).

Conclusion and Recommendation

The results depicted differential performance of soybean genotypes at different test environments and hence the interaction was crossover type. The GEI explained about 60 % of the variation which is more than double of the environment and four times of the genotypic effects of the total variation, however, it could be concluded that genotype and environment interaction had a highly significant association with number of grain filled pods per plant, number of nodules, number of seeds per plant and number of days to first flowering. The mean separation ranked TGx 1937-1F as the highest yielder across the six environments. These strongly associated traits could be exploited in crop improvement and as selection criteria in breeding programmes.

Study Limitations

The study was limited to Ado-Ekiti and Akure agro-ecological environment in the early and the late rainy season between 2013 and 2015. Further study could be done in other south western states to examine the GEI effect on Soybean production. These strongly associated traits could be exploited in other regions to examine their potentials and effect to soil and weather conditions of the planting seasons and locations.

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Competing Interests

The authors declare that no potential conflict of interest exist in this publication.

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Table 1 Pre- planting composite soil physical and chemical properties at experimental sites in Akure and Ado-Ekiti location

Soil Properties	Akure	Ado-Ekiti
Sand(%	70.4	84.4
Silt (%)	6.00	7.28
Clay (%)	23.6	8.32
Bulk density(g/cm3)	1.42	1.39
PH(water)	6.90	6.20
Soil moisture	13.9	13.4
Nitrogen (g/kg)	0.19	0.62
Available Phosphorus (mg/kg)	1.73	1.29
Exchangeable Na(cmol/kg)	0.02	0.18
Exchangeable K (cmol/kg)	0.02	0.32
Exchangeable Ca (cmol/kg)	1.47	2.47
Exchangeable Mg.(cmol/kg)	4.20	1.23
Organic carbon (g/kg)	2.33	1.70
Organic matter (g/kg)	4/01	2.92

Source of variation	DF	SS	MS	F-value	%SS
Environment(E)	5	3230932	646186	7.83	25.58
Genotype (G)	5	3322940	664588	8.01	14.87
Replicate (R)	2	2585297	1292649	15.7	
GE	25	3747387	149895	1.81	59.55
Error	10	3489186	348919		
Total	47	3876567	82480		

Table 2: Analysis of variance for grain yield (tha-1) of six soybean varieties evaluated at two locations for three consecutive years between 2013-2015 in (Akure and Ado-Ekiti) in the early and late rainy season
GE =Genotype x Environment interaction; DF =Degree of freedom; SS =Sum of squares; MS =Mean square

Table 3: Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Akure location in the early and late rainy season of 2013

Varieties	Location	Season	% Emergence	Plant Height (cm)	NOB	NON	Filled Pod Number/ Plant	Number of Grains/ Plant	100 Grain weight (g)	Days to First Flowering	Grain Yield (t/ha)	Mean	SD	CV
TGx 1740-2F	Akure	Early Rain	36.50	43.03	1.88	12.89	26.60	163.20	12.47	27.70	0.48	36.09	6.01	0.67
		Late Rain	34.19	54.9	1.72	13.40	21.19	149.51	10.09	30.19	0.43	35.07	5.92	0.66
TGx 1876-4E	Akure	Early Rain	37.11	45.44	2.28	9.72	29.52	198.50	11.47	37.91	0.69	41.40	6.43	0.71
		Late Rain	35.90	56.91	2.19	8.59	25.81	173.92	11.01	39.05	0.71	39.34	6.27	0.69
TGx 1019-2EN	Akure	Early Rain	36.40	44.30	2.03	9.75	31.09	179.09	11.51	31.50	0.74	38.44	6.20	0.69
		Late Rain	39.70	56.93	2.00	6.19	29.75	164.03	10.09	33.94	0.71	38.15	6.18	0.69
TGx 1937-1F	Akure	Early Rain	45.40	41.39	2.47	12.01	47.51	235.75	13.86	40.09	0.98	48.43	7.00	0.77
		Late Rain	41.28	43.12	2.49	10.89	40.08	200.19	12.07	41.18	0.91	43.58	6.60	0.73
TGx1019-2EB	Akure	Early Rain	45.90	43.33	2.38	9.91	38.71	205.10	12.267	42.67	0.79	44.56	6.68	0.74
		Late Rain	46.01	49.02	2.09	7.05	40.94	188.91	10.09	44.90	0.71	43.30	6.60	0.73
TGx 1904-6F	Akure	Early Rain	48.42	43.59	2.16	0.98	32.40	189.04	13.68	45.90	0.81	41.89	6.47	0.72
		Late Rain	47.09	48.92	1.19	1.09	29.89	164.91	11.89	40.29	0.76	38.45	6.20	0.69

SD-Standard Deviation. CV - Coefficient of Variability. NOB - Number of Branches. NON - Number of Nodules

Table 4: Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Ado-Ekiti location in the early and late rainy season of 2013

Varieties	Location	Season	% Emergence	Plant Height (cm)	NOB	NON	Filled Pod Number/ Plant	Number of Grains/ Plant	100 Grain weight (g)	Days to First Flowering	Grain Yield (t/ha)	Mean	SD	CV
TGx 1740-2F	Ado-Ekiti	Early Rain	31.30	48.04	0.82	10.82	21.50	153.30	10.37	25.60	0.41	33.57	5.79	0.64
		Late Rain	29.29	49.89	0.79	09.50	23.29	139.81	8.29	27.49	0.33	32.08	5.66	0.63
TGx 1876-4E	Ado-Ekiti	Early Rain	34.13	42.48	1.20	6.76	23.56	187.55	9.49	34.92	0.60	34.85	5.90	0.66
		Late Rain	32.97	51.99	1.18	4.53	19.82	161.97	8.81	33.02	0.59	43.99	6.63	0.74
TGx 1019-2EN	Ado-Ekiti	Early Rain	39.40	57.30	2.09	4.75	35.09	181.09	13.51	33.50	0.78	40.83	6.40	0.71
		Late Rain	33.70	59.93	1.01	3.19	22.75	154.03	8.09	35.94	0.61	34.81	5.90	0.66
TGx 1937-1F	Ado-Ekiti	Early Rain	43.41	50.33	3.43	8.00	37.52	255.71	13.80	45.00	1.28	50.94	7.14	0.79
		Late Rain	48.22	46.10	3.41	5.85	30.08	230.19	13.00	40.11	1.01	46.44	6.81	0.76
TGx1019-2EB	Ado-Ekiti	Early Rain	40.90	68.33	2.38	11.91	30.71	251.10	11.267	40.67	1.70	51.00	7.14	0.79
		Late Rain	48.01	53.02	2.09	13.05	43.94	108.91	9.09	46.90	1.11	36.23	6.02	0.67
TGx 1904-6F	Ado-Ekiti	Early Rain	41.42	70.59	1.16	1.98	30.40	159.04	8.68	49.90	1.61	40.53	6.37	0.71
		Late Rain	46.09	63.92	0.19	2.09	25.89	134.91	4.89	43.29	1.16	35.83	6.00	0.67

SD-Standard Deviation. CV - Coefficient of Variability. NOB - Number of Branches. NON - Number of Nodules

Table 5: Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Akure location in the early and late rainy season of 2014

Varieties	Location	Season	% Emergence	Plant Height (cm)	NOB	NON	Filled Pod Number/ Plant	Number of Grains/ Plant	100 Grain weight (g)	Days to First Flowering	Grain Yield (t/ha)	Mean	SD	CV
TGx 1740-2F	Akure	Early Rain	39.50	53.03	0.88	17.89	21.60	163.20	12.47	27.70	0.48	37.42	6.18	0.68
		Late Rain	38.19	64.9	2.72	15.40	27.19	149.51	10.09	30.19	0.43	37.62	6.13	0.68
TGx 1876-4E	Akure	Early Rain	37.11	25.44	2.28	9.72	31.52	198.50	11.74	37.91	0.69	39.43	6.28	0.70
		Late Rain	35.90	26.91	2.19	8.59	29.81	173.92	11.01	39.05	0.71	36.45	6.08	0.67
TGx 1019-2EN	Akure	Early Rain	36.43	24.39	2.02	9.78	31.00	189.02	12.52	33.57	1.80	37.84	6.15	0.68
		Late Rain	39.72	26.90	2.01	6.19	27.75	184.00	13.07	35.96	1.60	37.47	6.12	0.68
TGx 1937-1F	Akure	Early Rain	40.41	61.31	3.41	14.01	46.51	235.75	12.86	41.09	2.71	50.89	7.13	0.79
		Late Rain	45.28	73.10	2.46	11.89	41.08	220.19	9.07	44.18	1.91	49.91	7.06	0.78
TGx1019-2EB	Akure	Early Rain	41.90	63.33	1.38	4.91	33.71	125.10	13.267	44.67	1.79	36.67	6.06	0.67
		Late Rain	47.01	79.02	0.09	2.05	21.94	108.91	11.09	40.90	1.71	34.75	5.89	0.65
TGx 1904-6F	Akure	Early Rain	44.42	63.59	2.16	1.98	22.40	109.04	11.68	41.90	0.91	33.12	5.75	0.64
		Late Rain	46.09	68.92	2.19	1.09	19.89	104.91	4.89	45.29	0.86	32.68	5.72	0.64

SD-Standard Deviation. CV - Coefficient of Variability. NOB - Number of Branches. NON - Number of Nodules

Table 6: Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Ado-Ekiti location in the early and late rainy season of 2014

Varieties	Location	Season	% Emergence	Plant Height (cm)	NOB	NON	Filled Pod Number/ Plant	Number of Grains/ Plant	100 Grain weight (g)	Days to First Flowering	Grain Yield (t/ha)	Mean	SD	CV
TGx 1740-2F	Ado-Ekiti	Early Rain	41.55	63.02	2.87	21.89	31.61	183.31	13.47	37.71	1.40	44.10	6.64	0.74
		Late Rain	40.18	74.91	3.73	19.40	37.16	169.42	3.09	36.10	1.45	42.83	6.54	0.73
TGx 1876-4E	Ado-Ekiti	Early Rain	39.10	65.48	3.24	8.72	31.50	138.33	4..47	32.98	1.60	36.16	6.01	0,67
		Late Rain	38.96	76.95	3.18	4.59	39.80	193.44	3.01	34.03	1.76	43.97	6.63	0.74
TGx 1019-2EN	Ado-Ekiti	Early Rain	39.44	64.30	3.07	11.78	39.60	179.54	13.52	36.50	2.83	43.40	6.59	0.73
		Late Rain	41.75	66.95	3.06	0.19	17.28	164.52	11.07	38.90	2.69	38.49	6.20	0.69
TGx 1937-1F	Ado-Ekiti	Early Rain	38.43	71.36	3.40	18.01	36.50	245.51	13.86	44.02	2.76	52.65	7.26	0.81
		Late Rain	37.27	63.13	3.40	16.89	21.00	230.28	4.07	46.13	2.93	47.23	6.87	0.76
TGx1019-2EB	Ado-Ekiti	Early Rain	45.91	73.37	2.30	0.91	23.76	145.22	11.26	47.64	2.72	39.23	6.26	0.70
		Late Rain	49.04	69.06	2.02	1.05	23.44	138.93	7.09	49.96	1.71	38.03	6.17	0.69
TGx 1904-6F	Ado-Ekiti	Early Rain	44.46	73.50	3.12	0.98	32.42	179.11	6.68	46.91	0.96	43.13	6.57	0.73
		Late Rain	48.02	78.98	2.18	0.09	10.82	134.92	4.89	40.20	0.80	35.66	5.97	0.66

SD-Standard Deviation. CV - Coefficient of Variability. NOB - Number of Branches. NON - Number of Nodules

Table 7: Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Akure location in the early and late rainy season of 2015

Varieties	Location	Season	% Emergence	Plant Height (cm)	NOB	NON	Filled Pod Number/ plant	Number of Grains/ Plant	100 Grain weight (g)	Days to First Flowering	Grain Yield (t/ha)	Mean	SD	CV
TGx 1740-2F	Akure	Early Rain	31.51	69.03	2.87	21.82	21.61	173.31	10.47	33.71	2.02	40.71	6.38	0.71
		Late Rain	30.12	47.93	3.73	11.44	27.16	159.42	13.09	35.10	2.06	36.67	6.06	0.67
TGx 1876-4E	Akure	Early Rain	34.11	69.49	3.24	0.75	21.50	128.33	11..47	38.98	1.64	34.39	5.86	0.65
		Late Rain	33.93	48.90	3.18	0.54	29.80	143.44	9.01	32.03	1.97	36.64	6.05	0.67
TGx 1019-2EN	Akure	Early Rain	37.43	60.35	3.07	3.76	29.60	159.54	11.52	31.50	1.84	37.62	6.13	0.68
		Late Rain	43.72	61.94	3.06	4.17	27.28	134.52	10.07	30.90	1.60	35.25	5.94	0.66
TGx 1937-1F	Akure	Early Rain	39.41	61.34	3.40	15.02	31.50	275.51	11.86	41.02	2.71	53.53	7.32	0.81
		Late Rain	33.23	60.17	3.40	12.82	31.00	250.28	6.07	43.13	2.02	49.12	6.86	0.76
TGx1019-2EB	Akure	Early Rain	41.92	63.34	2.30	9.90	33.76	155.22	10.26	43.64	1.70	40.23	6.34	0.70
		Late Rain	42.03	59.08	2.02	8.00	13.44	168.93	9.09	46.96	1.72	39.03	6.25	0.69
TGx 1904-6F	Akure	Early Rain	40.40	43.55	3.12	5.90	12.42	109.11	5.68	43.91	0.96	29.45	5.43	0.60
		Late Rain	43.02	68.98	3.18	3.09	11.82	144.92	6.89	30.20	1.07	34.80	5.90	0.66

SD-Standard Deviation. CV - Coefficient of Variability. NOB - Number of Branches. NON - Number of Nodules

Table 8: Genotype by Environment interaction effect on growth, yield and yield characters of six soybean varieties in Ado-Ekiti location in the early and late rainy season of 2015

Varieties	Location	Season	% Emergence	Plant Height (cm)	NOB	NON	Filled Pod Number/ plant	Number of Grains/ Plant	100 Grain weight (g)	Days to First Flowering	Grain Yield (t/ha)	Mean	SD	CV
TGx 1740-2F	Ado-Ekiti	Early Rain	36.51	69.03	3.87	14.82	11.61	163.31	11.47	35.71	2.09	39.14	6.27	0.70
		Late Rain	35.12	57.93	2.73	11.44	17.16	139.42	9.09	31.10	1.95	33.99	5.83	0.65
TGx 1876-4E	Ado-Ekiti	Early Rain	31.10	62.41	2.20	1.71	11.58	108.30	10.42	33.98	1.64	29.26	5.41	0.60
		Late Rain	31.92	40.94	2.10	1.50	19.84	103.40	9.07	30.06	1.27	26.68	5.17	0.57
TGx 1019-2EN	Ado-Ekiti	Early Rain	36.43	50.35	2.07	2.76	23.60	149.54	12.52	34.50	1.87	34.85	5.90	0.66
		Late Rain	41.72	51.94	2.06	3.17	22.28	124.52	6.07	36.90	1.42	32.23	5.68	0.63
TGx 1937-1F	Ado-Ekiti	Early Rain	36.41	61.34	3.41	14.02	28.50	295.51	12.86	39.02	2.51	54.84	7.41	0.82
		Late Rain	33.29	65.17	2.44	13.82	26.00	270.28	5.07	44.13	2.22	51.38	7.18	0.79

TGx1019-2EB	Ado-Ekiti	Early Rain	43.92	61.34	1.30	8.90	31.76	145.22	11.20	41.64	1.50	38.53	6.21	0.69
		Late Rain	41.03	60.08	2.08	6.00	23.44	128.93	9.09	42.96	1.42	35.00	5.92	0.66
TGx 1904-6F	Ado-Ekiti	Early Rain	40.45	41.55	2.12	7.90	10.42	129.11	8.68	41.91	0.96	31.46	5.61	0.62
		Late Rain	43.08	58.98	2.18	9.09	13.82	114.92	7.89	39.20	1.07	32.24	5.68	0.63

Table 9: Cumulative Mean Genotype by Environment interaction effect of six soybean varieties in Akure and Ado-Ekiti location in the early and late rainy season between 2013- 2015

Varieties	Location	Season	Mean 2013	Mean 2014	Mean 2015	Cumulative Mean value 2013-2015	Varieties	Location	Season	Mean 2013	Mean 2014	Mean 2015	Cumulative Mean value 2013-2015
TGx 1740-2F	Ado-Ekiti	Early Rain	33.57	44.10	39.14	38.94	TGx 1740-2F	Akure	Early Rain	36.09	37.42	40.71	38.07
		Late Rain	32.08	42.83	33.99	36.30			Late Rain	35.07	37.62	36.67	36.45
TGx 1876-4E	Ado-Ekiti	Early Rain	34.85	36.16	29.26	33.42	TGx 1876-4E	Akure	Early Rain	41.40	39.43	34.39	38.41
		Late Rain	43.99	43.97	26.68	38.21			Late Rain	39.34	36.45	36.64	37.48
TGx 1019-2EN	Ado-Ekiti	Early Rain	40.83	43.40	34.85	39.69	TGx 1019-2EN	Akure	Early Rain	38.44	37.84	37.62	37.97
		Late Rain	34.81	38.49	32.23	35.18			Late Rain	38.15	37.47	35.25	36.96
TGx 1937-1F	Ado-Ekiti	Early Rain	50.94	52.65	54.84	52.81	TGx 1937-1F	Akure	Early Rain	48.43	50.89	53.53	50.95
		Late Rain	46.44	47.23	51.38	48.35			Late Rain	43.58	49.91	49.12	47.54
TGx1019-2EB	Ado-Ekiti	Early Rain	51.00	39.23	38.53	42.92	TGx1019-2EB	Akure	Early Rain	44.56	36.67	40.23	40.49
		Late Rain	36.23	38.03	35.00	36.44			Late Rain	43.30	34.75	39.03	39.03
TGx 1904-6F	Ado-Ekiti	Early Rain	40.53	43.13	31.46	38.37	TGx 1904-6F	Akure	Early Rain	41.89	33.12	29.45	34.82
		Late Rain	35.83	35.66	32.24	34.58			Late Rain	38.45	32.68	34.80	35.31
Grand Total Mean Value	Ado-Ekiti	Early Rain				41.03	**Grand Total Mean Value**	Akure	Early Rain				40.12
		Late Rain				38.18			Late Rain				38.80

SD-Standard Deviation. CV - Coefficient of Variability. NOB - Number of Branches. NON - Number of Nodules

Table 10: Evaluation of six tested soybean varieties and their mean performance for grain yield in Akure and Ado-Ekiti location between 2013 - 2015 showing which soybean variety won and in which environment using GGE Biplot Pattern Explorer

Bold black-Indicates high yielding varieties across seasons and locations. Bold red-Indicates poor yielding varieties across seasons and locations

Row/Column	Akure 1 2013 ERC	Akure 2 2013 LRC	Akure 3 2014 ERC	Akure 4 2014 LRC	Akure 5 2015 ERC	Akure 6 2015 LRC	Ado 1 2013 ERC	Ado 2 2013 LRC	Ado 3 2014 ERC	Ado 4 2014 LRC	Ado 5 2015 ERC	Ado 6 2015 LRC	Mean
TGx 1740-2F	36.06	35.07	-	-	-	-	-	32.08	-	-	-	-	8.601
TGx 1876-4E	-	-	-	-	-	-	34.85	-	36.16	-	29.26	26.68	10.58
TGx 1019-2EN													-
TGx 1937-1F	48.43	43.58	50.84	49.91	53.53	49.12	-	46.44	52.65	47.23	54.84	51.38	45.66
TGx1019-2EB	-	-	-	-	-	-	51.00	-	-	-	-	-	4.25
TGx 1904-6F	-	-	33.12	32.68	29.45	34.80	-	-	-	35.66	-	-	13.81
Mean	14.08	13.11	13.99	6.88	13.83	13.99	14.31	13.09	14.80	13.82	14.02	13.01	

FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

ANALYSIS OF MILK AND MILK PRODUCTS AS A MEANS OF POVERTY ALLEVIATION AMONG NOMADIC WOMEN IN GIWA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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Abstract:

This study analysed the poverty status among nomadic women in Giwa local government area (LGA) of Kaduna state in north-western Nigeria. Primary data were collected from 133 nomadic women selected through multi-stage sampling procedure. The data were analysed using descriptive statistics, net farm income (NFI) and Foster-Greer-Thorbecke (FGT) poverty measures. The result of analysis indicated that 36% of the women fell within the active age of 20-29 years, majority (91%) were married, 53% of the household had 6-10 members, 67.7% had nomadic education, only 4.5% had primary education. The poverty incidence of all the women in the study area was 34.58% with income less than ₦1655.8 per month. The incidence of poverty was high among the age of 30-39 (36.95%) but depth and severity were higher (0.32 and 0.44 respectively) among age group of 50 years and above. Also, nomadic women with no formal education (nomadic education) and 6-10 members in a household had the highest incidence of poverty (52.17% and 63.04% respectively). Based on the result, the study recommended that the nomadic women should be provided with formal education and the creation of the ruga settlement policy the federal government wants to adopt where a large portion of land in rural areas would be made available to provide comprehensive farming facilities for the farmers and feed for their animals.

Keywords: *Milk, Dairy products, poverty.*

Introduction

Billions of people around the world consume milk and dairy products every day and not only are milk and dairy products a vital source of nutrition for these people and it also provides livelihoods opportunities for the key actors/stakeholder (farmers, processors and marketers) in the diary value chain system at presented. (FAO, 2013). Nigeria is a potential market for 1.3 million tonnes of milk valued at about 450 billion annually (Anon, 2002; Annatte et al., 2012).

Milk is a complex mixture of proteins, carbohydrates, vitamins, minerals and other constituents dispersed in water. Based on the protein content of milk, it is generally regarded as “nature's most nearly perfect food” due to its rich protein content which contains more essential amino acids than any other natural food. In addition, milk is an important source of mineral substances, especially calcium, phosphorus, sodium, potassium, chloride, iodine, magnesium, and small amounts of iron. Calcium and phosphorus constitute a larger fraction in milk which is needed for the growth of bones and the proper development of newborns among these mineral constituents (Dandare et al., 2014).

Cow milk is the most universal raw material for processing dairy products resulting in the broadest spectrum of manufactured dairy products. At present, the number of animals bred for dairy purposes abound which include Cattle, Goat, Sheep, Horse, Donkey and Camel (Barlowska et al., 2011). In Nigeria, cattle is one of the major protein suppliers to its populace and the world as a whole. Nigeria has population of about 34.5 million goats, 22.1 million sheep and 13.9 million cattle (Lawal-Adebowale, 2012).

Dairy development in Nigeria involves various activities such as milk production, importation, processing, marketing, and consumption. Despite the unorganized system of the dairy industry, it still represents an important component of the agricultural sector of the economy with great institutional and social implications (FAO, 2007). Dairy products are also found mostly where the culture of people favors cattle rearing and where the climatic condition support grass land vegetation which provides the basic food for milk producing animals (Lawal et al.,2012). Dairy products appear in the market in different forms such as sour milk (Nono), cheese (wara), sour yoghurt (kindirmo), while some are imported in the form of sweetened concentrated milk, butter, cheese, and yoghourt.

This research was undertaken to analyse milk and milk products as a means of poverty alleviation among nomadic women in Giwa local government area (LGA) of Kaduna state. The specific objectives were to:

i. describe the socio-economic characteristics of the nomadic women;
ii. identify the cost and return of milk and milk products in the study area;
iii. determine the poverty status of the nomadic women;
iv. identify the constraints faced by the nomadic women in the study area.

MATERIALS AND METHOD

This study was conducted in Giwa local government area of Kaduna state, Nigeria. The Local Government has an estimated population of 286,427 people (NPC, 2006;

ISSA, et al., 2012). However, a survey conducted by the Kaduna state government projected the LGA population to rise to 425,696 and 453,201 (male, 225,695 and females, 227,506) for 2017 and 2018 respectively. The population of Giwa local government area is dominated by the majority Hausa/Fulani ethnic group. Farming, cattle rearing, and livestock production are the main occupation of the people of the local government area. A multistage sampling procedure was used, the first stage involved the purposive selection of Giwa local government area due to large proportion and homogeneity of Hausa/Fulani with high concentration of milk and milk product processing activities. The second stage involved purposive selection of Giwa and Shika village due to high intensity of women engaged in milk processing activities. The third stage involved random selection of one hundred and thirty-three (133) women milk processors using Yawwane's formulae. Structured questionnaire was administered to 133 women for the collection of primary data.

Descriptive statistics such as percentages, frequency distribution, arithmetic mean, variance and standard deviation will be used to achieve objectives (i) and (iv) which are the socioeconomic characteristics and constraints faced by the nomadic women in the study area, Gross margin analysis was used to determine objective (ii) which was to determine the cost and return of milk and milk products in the study area, this is given by the formula:

Gross margin (GM) = Total revenue (TR) – Total variable Cost (TVC)

GM = TR – TVC……..…… (1)

Total revenue (TR) is the total income obtained from the sales of the milk and milk products.

The Total Variable Cost (TVC) includes cost of labour, Amount of milk and fire wood.

Foster-Greer-Thorbecke (1984) was used to achieve objective (iii) of the study, which was to determine the poverty status of the nomadic women in the study area. The Foster-Greer-Thorbecke indices are specified as:

$$P\alpha = \frac{1}{N}\sum_{i=1}^{Hi}\left(\frac{Z-yi}{Z}\right)\alpha \quad \ldots\ldots (2)$$

$$P_0 = \frac{H0}{N} \quad \ldots\ldots (3)$$

$$P_1 = \frac{1}{N}\sum_{i=1}^{H1}\left(\frac{Z-yi}{Z}\right)\alpha \quad \ldots\ldots (4)$$

$$P_2 = \frac{1}{N}\sum_{i=2}^{H2}\left(\frac{Z-y2}{Z}\right)\alpha \quad \ldots\ldots (5)$$

Where,

P = is FGT parameter; α is a non-negative parameter, which takes the value 0, 1 and 2. When α = 0, this index gives the head count ratio or the incidence of poverty which will be the percentage of nomadic women that are classified poor in the study area.

When α =1, this index measures the poverty depth, it means percentage shortfall of income below poverty line while severity of poverty is measured when α =2.

N= Total number of nomadic women.
Hi = Head count of the poor (Number of poor farm household).
Yi = Income.
Z = Poverty line

RESULTS AND DISCUSSION

Socio-economic characteristics of the nomadic women

The result in table 1 show that 36% of the population fell within 20-29 years, 19.4% fell within 30-39 years while 19.5% fell within 40-49 years, those within <20 years and ≥ 50 years were 6.8% and 18.2% respectively. About 75% fell within the age of 20-49 years, women within this age range are adults and expected to be active, agile and can withstand stress which supports the findings of Kantiok (2007) that farmers below the age of fifty are still in their active age. The study also showed that 67.7% of the women in the study area do not have access to formal education, 27.8% had qur'anic education and 4.5% had primary school education. Muhammed et al., (2009); Habibu Bello (2016) noted that level of education is expected to influence farmers' adoption of agricultural innovations and decision on various aspects of farming, they also maintained that education is highly important for sustainable agricultural growth and development. It could also be seen from table 1that 53.1% of the women had a household size of 6-10 members which implies that there is anappreciable number of family labour participating in dairy products processing. The table shows that 91% of the women are married, according to Onubuogue et al., (2013) who reported that married farmers tend to have easy access to production variables such as land and large family size which are traditionally owned and provided by household heads (husbands) to compliment family labour, enhance production, resource use efficiency of the household farmers and to reduce the cost of hired labour, it also shows that 33.2% of the population had between 16-20 years' experience in dairy products processing, Ajani (2000) revealed that year of farming experience increased agricultural productivity among farming households in Nigeria.

Table 1: Distribution of nomadic according to socio-economic characteristics (n=133)

Age (years)	Frequency	Percentage	Mean
<20	9	6.8	
20-29	48	36.3	
30-39	26	19.4	
40-49	26	19.5	
= 50	24	18.2	36
Level of education			
Nomadic education	90	67.7	
Qur'anic education	37	27.8	
Primary education	6	4.5	
Household size			
1-5	26	19.6	
6-10	71	53.4	
11-15	3	2.3	
16-20	18	13.6	
=20	15	11.4	11
Experience (years)			
1-5	9	6.8	
6-10	6	4.5	
11-15	21	15.9	
16-20	44	33.2	
21-25	14	10.6	
>26	39	29.7	23
Marital status			
Married	121	91.0	
Single	6	4.5	
Widowed	6	4.5	

Cost analysis

The result in table 2 indicates that the total revenue (TR) for sour milk, sour yoghurt and butter are ₦2,475, ₦938 and ₦516 respectively, the sum of the total revenue (TR) is ₦3,929. The Gross Margin is 3051. The average rate of returns on investment (return per naira invested) is ₦2.81 for sour milk indicating that for every ₦1 invested, a profit of ₦1.81 was made, ₦1.06 for sour yoghurt indicating that for every ₦1 invested, a profit of 6 kobo was made and 0.58 for butter indicating that for every 1₦ invested there is a loss of 42 kobo. It can be concluded that dairy processing is profitable in the study area.

Table 2: Cost and returns

Cost and return item	Quantity	Unit value (?)	Value (?)	% Cost contribution
Variable costs				
Raw milk	7	37	259	29.5
Firewood	0.5	50	25	2.8
Preservative	1	10	10	1.1
Water	1	10	20	2.3
Labour	1	500	200	56.9
Total variable cost	-	-	814	-
Fixed costs				
Calabash	-	19	19	2.2
Pot	-	25	25	2.8
Spoon	-	20	20	2.3
Total fixed cost	-	-	64	-
Total cost	-	-	878	-
Revenue				
Sour milk	7.5	330	2475	62.9
Sour yoghurt	1.4	670	938	23.9
Butter	0.8	648	516	13.1
Total Revenue	-	-	3929	-
Gross Margin	-	-	3051	-
Return per naira invested	-	-	4.47	-

Determinants of the Poverty Status of the nomadic women

The Logit model was estimated using Stata 14.1 software in estimating the poverty status of the nomadic women in Giwa LGA of Kaduna State. The Pseudo R^2 was 0.34 implying that 34% of the poverty status of the nomadic women was accounted for by the model with a likelihood ratio test of 60.1043 and a degree of freedom of 5. All the variables included in the Logit model are jointly significant in determining the poverty status of the nomadic women. Therefore, the socioeconomic characteristics of the nomadic women have a significant effect on their poverty status.

The result showed that education is positive and significant at $p \leq 0.01$ level indicating a strong relationship with the poverty status of the nomadic women and suggesting that households with high level of education are more likely to improve their poverty status supporting the findings of Muhammed et al., (2009); Habibu Bello (2016) who noted that level of education is expected to influence farmers' adoption of agricultural innovations and decision on various aspects of farming, they also maintained that education is highly important for sustainable agricultural growth and development. Household size had a positive relationship with their poverty status and significant at $p \leq 0.1$ indicating that there is enough family labour level. Experience also had a positive influence on the poverty status and significant at $p \leq 0.01$ level supporting the finding of Ajani (2000) who revealed that year of farming experience increases agricultural productivity among farming households in Nigeria.

Table 3: determinants of the poverty status of the nomadic women

Variables	Coefficient	Standard error	Z-value	Marginal effect
Age	-0.0153^{ns}	0.0446	-0.34	-0.0037
Education	1.8144***	0.4587	3.96	0.4437
Household size	0.1546*	0.0890	1.74	0.0378
Experience	0.1331***	0.0524	2.54	0.0325
Incomes	-8.69e-07^{ns}	4.74e-06	-0.18	-2.13e-07
Constant	-4.5401***	0.9852	-4.61	
Numbers of observation	133			
Log likelihood ratio test	60.104			
Degree of freedom	5			
LR chi^2 (5)	63.26			
Prob > chi^2	0.00001			
Pseudo R^2	0.344			

Note; *** = p $\leq$ 0.01, * = p $\leq$ 0.1 an d ns = not significant

Poverty status of nomadic women

The result revealed that poverty incidence was high within the age of 30-39 (36.95%) but depth and severity was high within the age of 50 and above (0.32 and 0.44 respectively), the effects of age on poverty status could be supported with study by Dercon and Krishnan, (1998); Etim and Ukoha, (2010) who affirmed all possible pairs of the age categories have their poverty incidences significantly different from one another and this implied that age of household heads affects the level of poverty incidence, incidence of poverty status was high within the women with nomadic education (52.17%) while depth and severity (0.27and 0.44) were high within the women with qur'anic education. The women with primary education had the least poverty incidence of 13.0% implying that they are more open to adopt innovation, increase their production and reduce poverty. This is in agreement with earlier studies by Dudek, (2006); Fagernas and Wallace, (2007); FAO, (2008); Olorunsanya, (2009) and Etim and Patrick, (2010) that a higher level of educational attainment reduces rural household's poverty. households with 6-10 members had higher incidence of 63.04%, households with 16-20 members had high depth and severity (0.23 and 0.42). Household's with 16-20 members had the lowest poverty incidence because there is enough family labour and are more likely to help out in the farm but according to Ogundale, Okoruwa (2006) higher family size does not necessarily translate to higher use of family labour because some of the young able men prefer other jobs than farming, that's why the depth and severity were higher. Also, women with 26-30 years'r experience had a high incidence of 32.60% and severity of 0.51, women with 21-25 years' experience had the lowest incidence (4.3%), depth (0.36) was high within 6-10 years' experience. Ezra et at., 2017 said that it is expected that the higher the farmer's experience the better the productive capacity of the farmer.

Table 4: Incidence, depth and severity of poverty status according to socio-economic characteristics

	Frequency	Incidence (P_0)	Depth (P_1)	Severity (P_2)
Age				
<20	9	19.56	-	-
20-29	3	6.52	0.29	0.40
30-39	17	36.95	0.19	0.37
40-49	14	30.43	0.24	-
50 and above	3	6.52	0.32	0.44
Total	46	100		
Education				
Primary	6	13.04	-	-
Quranic	16	34.78	0.27	0.44
Nomadic	24	52.17	0.28	0.39
Total	46	100		
Household size				
1-5	11	23.91	0.23	-
6-10	29	63.04	0.29	0.38
11-15	-	-	-	-
16-20	6	13.04	0.23	0.42
21-25	-	-	-	-
26 and above	-	-	-	-
Total	46	100		
Experience				
1-5	6	13.04	0.21	-
6-10	3	6.52	0.36	-
11-15	6	13.04	0.33	0.39
16-20	14	30.43	0.27	0.35
21-25	2	4.34	0.28	-
26-30	15	32.60	0.08	0.51
greater than 30	-	-	-	-
Total	46	100		

CONCLUSION

The paper analysed milk and milk products as a means of poverty alleviation among nomadic women in Giwa Local Government of Kaduna state. The determinants of households' poverty status showed that education, household size and experience were found to be statistically significant at different level of significance, the coefficients of age and incomes of the nomadic women were negative. It can be

concluded that poverty level among the nomadic women was moderate. Weighted poverty index was used in attempting to decompose the poverty status of the nomadic women, socio-economic characteristics like age, education, household size and experience influenced their poverty status. The socioeconomic characteristics like age, household size, education and experience influenced their poverty status, therefore emphasis should be made to improve them thereby improving their poverty status.

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FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

ANALYSIS OF FARM LEVEL PRODUCTIVITY OF RICE FARMERS IN KANO STATE, NIGERIA: A TRANSLOG APPROACH

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Abstract:

In an effort to increase the productivity of rice for food security and reduce deflation of foreign reserves, the Kano State Government eases access to fertilizer, extension services and improved rice seed. Therefore, this paper focuses on farm-level productivity of rice farmers in Kano State, Nigeria using a translog frontier approach. Using a sample of 210 farming households from six local Government Areas of Kano State, comprising 105 technology adopters and 105 non-adopters, an exponential translog stochastic frontier production function was used to estimate production efficiencies. The outcomes of the analysis showed that production levels of rice can substantially be improved through the reduction of technical inefficiencies. Though adopters (76%) were more efficient than non-adopters (53%), the difference had no causal interpretation considering that both groups were in different geographical location. Also, access to adequate farmland and credit will encourage farmers to improve the scale of production that will enable them to take advantage of economies of scale.

Keywords: *Adopters and non-adopters, production efficiency, rice technologies.*

Introduction

Nigeria is the largest rice producer in West Africa, accounting for about 71% of the total regional output. Nigeria's rice production also accounted for 35% of the African production in 2007 (Gourichon, 2013). Currently, rice is grown on an estimated area of 5.8 million hectares with an annual production output of about 6.7 million tonnes in Nigeria (NAERLS, 2019).

Rice (Rice bicolor (L.) Moench) is widely grown as a food crop in Sub-Saharan Africa (SSA), but commercialization has proved difficult for several reasons in the past. Rice is grown in marginal, semi-arid environments characterized by low and erratic rainfall. In drought years, growers prioritize household food security and are reluctant to sell, making it difficult for buyers to ensure a consistent supply. Semi-arid environments are also characterized by low population density, poor infrastructure, and limited access to markets, which raises transaction costs, reduces incentives for both growers and buyers, and consequently creates a wide gap between supply and

demand (Masese et.al., 2018).

According to FAO (2019), the shortfall is a key pointer to the fact that the sector faces many challenges, notably limited adoption of research findings and technologies owing to farmers preference for varietal and trait attributes, high cost of farm inputs including improved seed, fertilizer, and agro-chemicals, lack of access to improved seed for some farmers who are willing to adopt, poor access to credit and an outdated land tenure system that constrains access to land (1.8 ha/farming household) and a very low level of irrigation development (less than 1 percent of cropped land under irrigation). Other problems include inefficient fertilizer procurement and distribution, inadequate storage facilities and poor access to markets have all combined to keep agricultural productivity low (average of 1.2 metric tons of cereals/ha) with high postharvest losses and waste (FAO, 2019).

According to Rooney (2018), rice is not just a commodity but has been a determinant of survival and an integral part of life and culture of this region over millennia. In the olden days, rice was produced at a subsistent level to meet the immediate consumption need of individual households was largely grown by subsistence farmers. However scientific advancement and subsequent discovery of the multifarious usage stimulated the commercialization of rice. Today, rice is a valuable industrial crop for brewing alcoholic and non-alcoholic drinks as well as in the baking and confectionery industry (Aduba et.al., 2013). This was also affirmed by Rooney, (2018) who postulated that recently rice demand in the malting and confectionery industries has increased significantly, especially in Nigeria.

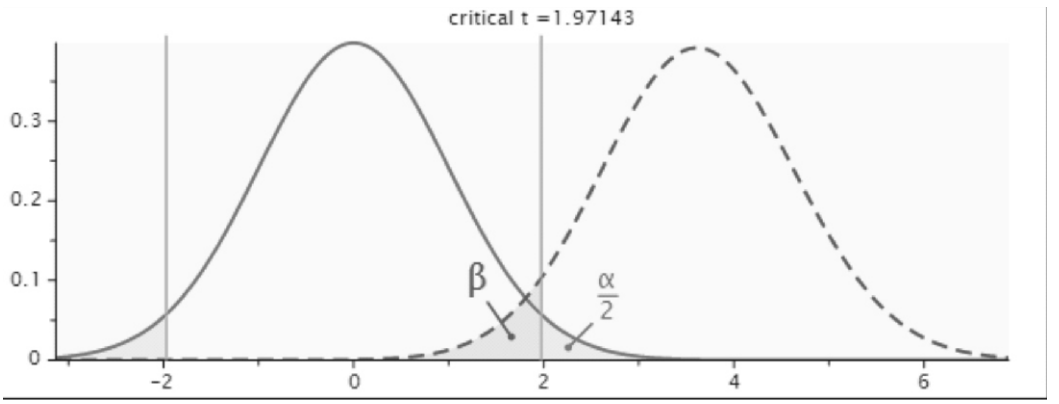
Even though increased demand for local rice is expected to benefit smallholder farmers and contribute to increased livelihood and poverty reduction of farmers in northern Nigeria, analysis of historical trends in agricultural productivity and intensification shows that, compared to other regions, Sub Saharan Africa (Nigeria in particular) cereal yields, agricultural value-added per worker and total factor productivity, are much lower than in Asia and Latin America (AGRA, 2016). There is very little room for expanding the area under cultivation, but rising productivity and crop diversification have been remarkable over the past two decades. However, such growth is forecast to slow down factoring in the losses due to pandemic, drought, rising prices of agricultural inputs and food, and climate variability and change and poverty.

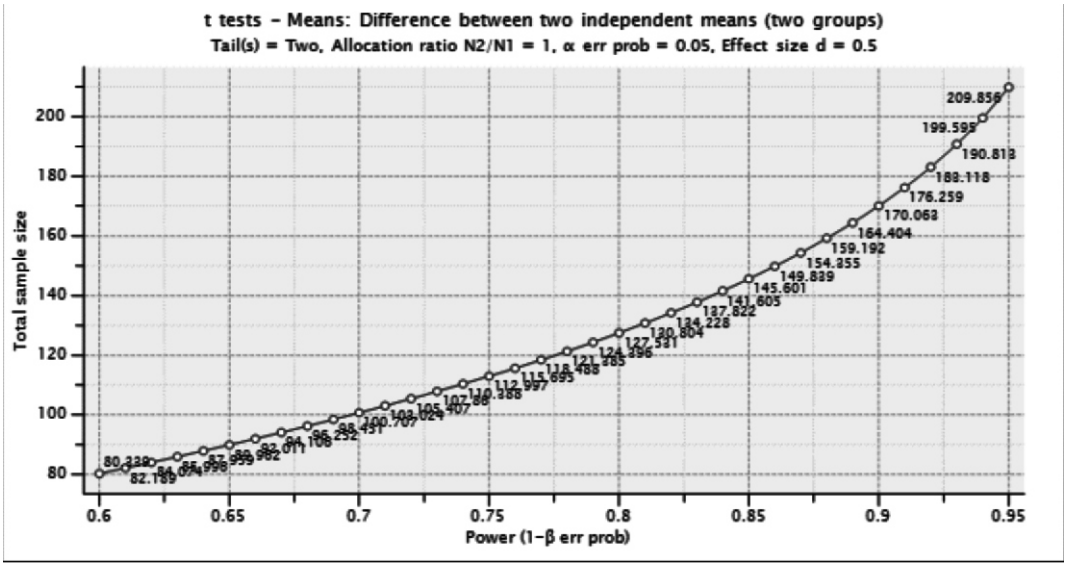
According to the NBS (2019) report on poverty and inequality shows that 40.1 percent of the total population were classified as poor. In other words, on average 4 out of 10 individuals in Nigeria have real per capita expenditures below 137,430 Naira per year. This translates to over 82.9 million Nigerians who are considered poor by national standards. This situation, however, presents a paradox considering high-level agricultural activities taking place in the northern region, no noticeable success has been achieved in this direction. FAO, (2001), opined that smallholder farmers produce much of the developing world's food. Yet they are generally much poorer than the rest of the population in these countries, and are less food secure than even the urban poor. The agency, further highlighted some broad household strategies for escape from poverty and hunger. This includes; (a) intensification of production; (b)

diversification of agricultural activities for increased output value; (c) increased farm size; (d) and expansion in off-farm income. While increased productivity in rice production is key to increasing livelihood and alleviate poverty in northern Nigeria, it is necessary that farmers at all level adopt the improved varieties of rice which can result to intensification of production and increased output value without necessary increasing the farm size.

METHODOLOGY

A multistage sampling procedure was used with the first stage being the purposive selection of six (06) Local Governments out of the (44) Local Governments in Kano States. The purposive selection was due to the high concentration of rice farmers, where rice technologies are being promoted for research in the six (06) Local Governments Areas. These Local Government Areas comprise Bichi, Danbatta, DawakinTofa, Kunchi, Makoda and Ungogo. The second stage involves a proportionate random selection of three (03) villages from each of the six (6) LGAs where rice technologies have been, and are still being promoted for research by development partners in Nigeria: Bichi (Bichi, Hugulawa and Yan Gwarzo), Danbatta (Danbatta, Gwandu and Maje), Dawakin Tofa (Ganduje, Jemomi and Tattarawa), Kunchi (Dankwai, Kunchi and Ungwan Gyartai), Makoda (Danya, Sabon Ruwa and Tangaji), Ungogo (Chiromawa, Dorayi, Kadawa), this resulted in a total of eighteen (18) villages. In the third stage, power analysis software was used to arrive at the accurate sample size of 210 rice farmers with actual power of 0.95 at two tail tests. Based on this power analysis, the farmers were stratified into adopters and non-adopter of rice technology in the study areas (figure 1 and 2).





Analysis:	A priori: Compute required sample size		
Input:	Tail(s)	=	Two
	Effect size d	=	0.5
	α err prob	=	0.05
	Power (1-β err prob)	=	0.95
	Allocation ratio N2/N1	=	1
Output:	Noncentrality parameter δ	=	3.6228442
	Critical t	=	1.9714347
	Df	=	208
	Total sample size	=	210
	Actual power	=	0.9501287

Model specification

Stochastic frontier production function

The stochastic frontier is an econometric and parametric approach. The model has the potential to separate the effects of the symmetric error term (noise) from the asymmetric error term (technical inefficiency)

Rice production in Kano is a single output with multiple inputs in production. The study uses the stochastic frontier production model in assessing the efficiency of rice farmers

Note that the inefficiency effects model (2) can only be estimated if the technical inefficiency effects are stochastic and have a specific distribution.

Relationships between the inputs and outputs are expressed as:

$$y_{li} = f\left(x_i, \beta_j\right).\exp(\varepsilon_{ki}) \quad \textbf{(1)}$$

$$\varepsilon_{ki} = v_{ki} - u_{ki} \quad \textbf{(2)}$$

where $y_l \in$ $_{++}$ is an $N \times l$ vector of outputs; $y_i \in$ $_{+}$ is an $N \times j$ matrix of factors of production; $f(\bullet)$ is the optimal production practice; β_j is an $N \times j$ vector of regression parameters; $\exp(\bullet)$ is the exponential operator; ε_{ki} is a composite error term with v_{ki} and v_{ki} being the statistical and one-sided error terms, respectively; $l = 1, 2, ..., L$, $j = 1, 2, ..., J$ and $i = 1, 2, ..., N$ denote inputs used and outputs produced, respectively. Equations (1) or (2) are referred as the stochastic frontier production function (Aigner *et al.,* 1977; Meeusen and van den Broeck, 1977). Taking the natural logarithm of (1) gives:

$$\ln y_{li} = \ln f\left(x_i, \beta_j\right) + v_{ki} - u_{ki} \quad \textbf{(3)}$$

v_{ki} is a symmetric and independently distributed (*i.i.d*) error term, which represents the variability in output due to uncontrolled factors such as weather, pests and diseases, error of measurements and statistical noise.

u_{ki} represents the shortfall in output which is a deviation from the maximum output due to technical inefficiency implying that u_{ki} can be viewed as the proportion of observed output that can be increased using same inputs. In other words, u_{ki} is the proportion of actual output lost due to technical inefficiency (Kumbhakar and Wang, 2015). Thus, u_{ki} is referred to as the output oriented technical inefficiency with values ranging between 0 and 1 (Kumbhakar and Lovell, 2000). If its value is close to 1, the decision-making unit (DMU) is close to full technical efficiency, but when the value is close to 0 the DMU is close to full technical inefficiency.

With proper manipulation Kumbhakar (2014b) affirmed that the level of technical efficiency can be defined as:

$$TE_i = y_i \Big/ f\left(x_i, \beta_j\right).\exp(\varepsilon_{ki}) \quad \textbf{(4)}$$

Jondrow *et al.,* 1982, opined that based on the conditional mean function, the estimation of the DMU-specific technical efficiency conditional on the composite error term can be expressed as:

$$TE_i = E\left(-u_i \middle| \varepsilon_i\right) = \sigma^* \left[f^*\left(\varepsilon_i \lambda / \sigma\right) \Big/ \left(1 - F^*\left(\varepsilon_i \lambda / \sigma\right)\right)\right] - \varepsilon_i \lambda / \sigma \quad \textbf{(5)}$$

where $\sigma^* = \sigma_u^2\sigma_u^2/\sigma$; $\lambda = \sigma_u^2/\sigma_v^2$; $f^*(\bullet)$ is the standard normal probability density function; $F^*(\bullet)$ is the standard cumulative density function and $\sigma^2 = \sigma_u^2 + \sigma_v^2$ is the variance of the composite error term; σ_u^2 is the variance of the one-sided error term assumed to be homoscedastic; σ_v^2 is the variance of the statistical noise assumed to be homoscedastic; σ^2 is the variance of the composite error term with a significant estimate indicating the correctness of model (1); λ is the relative variability between the statistical noise and the technical inefficiency error where a positive and significant estimate implies that there is technical inefficiency in the production process and that the difference between the actual and expected maximum output is dominated by technical inefficiency (Hayatullah, 2017). Based on the λ parameterization by Aigner *et al.* (1977), the log-likelihood function of the model in [1] can be estimated as:

$$\ln(L) = -(N/2)\left(\ln 2\pi + \ln\sigma^2\right) + \sum_{i=1}^{N}\left[\ln\phi\left(\varepsilon\lambda/\sigma\right) - 1/2\left(\varepsilon_i/\sigma\right)^2\right] \qquad \textbf{(6)}$$

According to Battese and Corra (1977), unlike the formulation of the log-likelihood function (LLF) using the γ parameterization, the LLF from (3) is derived as

$$TE_i = E\left(-u_i|\varepsilon_i\right) = \sigma^*\left[f^*\left(\varepsilon_i\lambda/\sigma\right)/\left(1 - F^*\left(\varepsilon_i\lambda/\sigma\right)\right)\right] - \varepsilon_i\lambda/\sigma$$

$$\ln(L) = -(N/2)\left(\ln(\pi/2) + \ln\sigma^2\right) + \sum_{i=1}^{N}\left[1 - \phi\left(\frac{z_i\sqrt{\gamma}}{\sigma^2}\sqrt{\frac{\gamma}{1-\gamma}}\right)\right] - \frac{1}{2\sigma^2}\sum_{i=1}^{N} z_i^2 \qquad \textbf{(7)}$$

where z_i is a skewed normally distributed random variable; the gamma parameter $\left(\gamma = \sigma_u^2/\sigma^2\right)$ lies between 0 and 1 and should not be interpreted as the proportion of output produced that is accountable for by technical inefficiency (Kumbhakar *et al.*, 2014b); $\sum$ is the summation operator. If the value is significantly close to one, it is said that the production system is influenced by technical inefficiencies, but if the value is significantly close to zero, the deviation from the frontier output is induced essentially by the statistical noise (Battese and Corra, 1977; Coelli, 1995; Kumbhakar *et al.*, 2014b; Yang *et al.,* 2020). The maximum production function assumes several forms among which the most common are the Cobb-Douglas (CD) and the translog function. The CD is nested into the translog, implying that the CD function can be viewed as a restricted version of the translog function.

In alignment with Coelli*et al.* (2005), the translog model is specified as

$$\ln y_i = \beta_0 + \sum_{j=1}^{J} \beta_j \ln x_{ji} + \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{jk} \ln x_{ji} \ln x_{ki} + v_i - u_i \qquad \textbf{(8)}$$

where y_i is the output, x_{1i}, x_{2i}, …, x_{ni} are inputs; β_j and β_{jk} are regression parameters; v_i is the statistical noise; u_i is the one-sided error term and $\ln$ is the natural logarithm operator. If $\sum\sum \beta_{jk} = 0$, the translog model reduces to the Cobb-Douglas model, in which case the parameter β_j represents the output elasticity of the input *n*. Therefore, returns to scale is given by $\sum \beta_j$ where it will be decreasing, constant or increasing if $\sum \beta_j < 0$, $\sum \beta_j = 1$ or $\sum \beta_j > 0$, respectively. In order to statistically test whether the CD is significantly nested in the translog model, the F-test and likelihood ratio test have been extensively used (Coelli et al., 2005; Kumbhakar *et al.*, 2014b). The test focuses on the joint null hypothesis that the parameters of the interaction terms in equation (8) are zero. The test procedure based on the F-test is to assess the closeness between the estimates of the sum of squares residuals (*SSR*) of the restricted (e.g., Cobb-Douglas) and unrestricted (Translog) models by means of the F-statistic which can be defined as:

$$F = \left[\left(SSR_R - SSR_U \right) / J \right] / \left[SSR / \left(N - K \right) \right] \qquad \textbf{(9)}$$

where SSR_R is the SSR of the restricted model; SSR_U is the SSR of the unrestricted model; J is the number of restrictions; N is the number of observations in the sample; K is the number of restricted explanatory variables in the model. The null hypothesis is rejected at the $100 \times \alpha\%$ level of significance if the estimate of the F-statistic exceeds the critical value $F_{1-\alpha}\left(J, N-K\right)$ in which case the translog model is preferred to the CD model as the more appropriate model for representing the relationship between inputs and outputs, otherwise the CD model is better; $F_{1-\alpha}(\bullet)$ is the standard cumulative density function; α is the level of significance. The LR test approach consists of evaluating the closeness between the estimates of the log-likelihood function (*LF*) of the restricted and unrestricted models via the LR statistic:

$$LR = \left(\ln LF_R - \ln LF_U \right) \quad \chi^2 \left(J \right) \qquad \textbf{(10)}$$

where LF_R is the LF of the restricted model; LF_U is the SSR of the unrestricted model; $\chi^2(\bullet)$ is a chi-square distribution function. The null hypothesis is rejected at the $100 \times \alpha\%$ level of

significance if the estimate of the LR statistic exceeds the critical value $\chi^2_{1-\alpha}(J)$ in which case the translog model is preferred to the CD model as the more appropriate model for representing the relationship between inputs and outputs, otherwise the CD model is better. If the translog is the preferred model, the output (production) elasticity of the input x_{ji} will be given as:

$$e_{x_{ji}} = \partial \ln y / \ln x_{ji} = \beta_j + \sum_{k=1}^{J} \beta_{jk} \ln x_{ki} \qquad \textbf{(11)}$$

The implication of equation [11] is that the RTS of the translog function is not invariant of the initial input levels which is given as:

$$RTS = \sum_{j=1}^{J} Ex_{ji} = \sum_{j=1}^{J} \left(\beta_j + \sum_{k=1}^{J} \beta_{jk} \ln x_{ki} \right) \qquad \textbf{(12)}$$

In equation (8) the distribution of the composite error term is not consistent with the error term in classical linear regression analysis which makes it impossible for ordinary least square estimator to be unbiased (Yang *et al.,* 2020). Different approaches have been proposed to estimate equation (8). These approaches are usually grouped into two namely distribution free and distribution based with each group having both advantages and disadvantages (Kumbhakar, 2014b). The distribution free approaches include the corrected Ordinary Least Square (Winsten, 1957; Forsund and Hjalmarsson, 1987; Kumbhakar, 2014b), the corrected mean absolute deviation (Kumbhakar, 2014b) and the thick frontier approach (Humphrey, 1991; Kumbhakar, 2014b). The distribution-based approaches take on different distributions of statistical and the one-sided error terms. These approaches include single equations Stochastic Frontier (SF) production and cost functions (Aigner *et al.,* 1977; Meeusen *et al.,* 1977; Kumbhakar, 2014b; Ahmadzai, 2017), stochastic frontier systems, primal cost and profit systems (Kumbhakar, 2014b). It should be noted that the stochastic frontier translog production function presented in equation (8) was estimated as our main model in this study where y_i is the quantity of rice produced (kg/ha); x_{1i} is the quantity of seed (kg/ha); x_{2i} is the quantity of inorganic fertilizer (kg/ha); x_{3i} is the quantity of organic fertilizer (l/ha); x_{4i} is the quantity of herbicide (l/ha); x_{5i} is the quantity of pesticide (l/ha) and x_{6i} is the quantity of labour (man-day/ha).

RESULTS AND DISCUSSION

1.0 Production elasticity and returns to scale

Table 1, present the null hypothesis which stated that there is no significant difference between the OLS CD and the SF translog (exponential, half-normal and truncated) was tested and the null hypothesis was rejected. In other words, the production technology exhibited a translog form. Moreover, the rejection of the null hypothesis is evidence of the presence of a one-sided error term,

which is the actual production of rice deviated from its expected maximum essentially due to technical inefficiency. However, a discriminatory assessment of the distribution of the one-sided error term revealed that the exponential stochastic frontier production function (SFPF) was better than the half-normal and truncated SFPF. This implies that the exponential SFPF was the most appropriate model for explaining the relationship between inputs and outputs of rice crops (Laksana *et al.,* 2013; Ng'ombe *et al.,* 2015). Furthermore, the hypothesis that the production function of rice for adopters was the same as that of the non-adopters was rejected at 1% level of probability. The implication is that the exponential translog SFPFs was estimated for both adopters and non-adopters separately.

Table 1: *Likelihood ratio test for rice production function*

Test	Null hypothesis	LR	χ^2	Decision
1	OLS Cobb-Douglas Vs OLS translog	164.52***	36.40	Rejected
2	OLS translogVs SF Expon. Translog	141.34***	9.82	Rejected
3	OLS translogVs SF Half-normal translog	66.7***	5.414	Rejected
4	OLS translogVs SF Truncated translog	142.35***	9.143	Rejected
5	SF Expon. translogVs SF Half-normal translog	-78.73	1.642	Accepted
6	SF Expon. translogVs SF Truncated translog	-5.0831	3.412	Accepted
7	Adopters Vs non-adopters	174.1***	48.91	Rejected

***<0.01; OLS=Ordinary Least Squares; SF=Stochastic Frontier

The maximum likelihood (ML) estimates of the exponential translog SFPF for rice for adopters and non-adopters are presented in Table 2. The Wald statistic for the adopters (Wald =451.29, p<0.01) and non-adopters (Wald =651.06, p<0.01) were statistically significant at 1% level of probability, which implies that the factors of production jointly influenced the production of rice among the adopters and non-adopters. The estimate of lambda for the pooled (λ=2.28, p<0.01), adopters (λ=2.27, p<0.01) and non-adopters (λ=2.46, p<0.01) were equally all positive and statistically significant at 1% level of probability. The finding confirmed the previous result that there was technical inefficiency among both adopters and non-adopters. This is in line with the work of Mukhtar *et. al.* (2018) who showed that the maximum rice output is not achieved due to technical inefficiency.

The elasticity of seed was 0.98 and is significant at 1% level or probability implies a direct relationship between yield and quantity of seeds and that rice production was inelastic to changes

in the quantity of seeds uses. A unit increase in the quantity of seed will increase the rice by 89%, holding other variables constant (Table 3). This finding is in line with the *a priori* expectation. The elasticity of yield with respect to seed for adopters and non-adopters was 1.4 and 0.58, respectively, holding other variables constant. The adopters will have a high yield more than double compare to non-adopters. This finding is at variance with Shamsudeen *et. al.* (2018) who observed that the quantity of seeds used had a negative influence on rice output in Sagnarigu District of Ghana.

The elasticity of fertilizer was 0.32 and was significant at 1% level of probability, indicating a direct relationship between fertilizer and yield, and that yield was inelastic to changes in fertilizer. A unit increase in fertilizer quantity to certain extent by 1%, will increase the rice yield by 32%, all things being equal. According to Agber *et. al.,* (2012), micro-dosing with inorganic fertilizer can increase yields regardless of the timing of application.

Similarly, there was a positive and inelastic relationship between yield and the use of agrochemical such that an increase in the use of agrochemical by 1 unit would increase the yield by 76.6%, all things being equal. It can also be said that there was a direct relationship between yield and the use of agrochemicals among adopters and non-adopters of improved rice technologies. The finding is in line with *a priori* expectation given that agrochemicals application reduces pest and disease infestation when applied appropriately. This finding is in line with Chaudhary *et al.,* (2018), that the application of pre-emergence herbicide together with one manual weeding can provide satisfactory weed management.

Table 2: *Maximum likelihood estimates of exponential translog stochastic frontier production function*

Variable	Param.	Pooled	Adopters	Non-adopters
Constant	β_0	2.20 (5.14)	54.12 (22.51)**	5.43 (5.34)
Seed	β_1	7.44 (1.02)***	24.32 (3.32)***	9.02 (2.04)***
Fertilizer	β_2	1.31 (1.24)	-1.56 (2.45)	2.04 (2.16)
Agrochemical	β_4	-1.09 (2.55)	-12.23 (4.17)***	-0.82 (3.34)
Labour	β_6	8.22 (3.02)***	12.01 (7.11)*	9.01 (3.12)***
½* Seed^2	β_7	2.29 (0.43)***	3.56 (1.44)***	3.19 (0.76)***
½* Fert^2	β_8	0.21 (0.05)***	0.59 (0.28)**	0.36 (0.12)***

½* Agrochemical^2	β_9	-0.61 (0.41)	-3.51 (0.65)***	0.25 (0.49)
½* labour^2	β_{10}	-3.65 (1.32)**	-12.11 (3.74)***	-3.76 (1.76)**
Seed*Fertilizer	β_{11}	0.52 (0.12)***	0.73 (0.36)**	0.52 (0.13)***
Seed*Agrochemical	β_{12}	-0.45 (0.36)	0.44 (0.86)	-0.24 (0.39)
Seed*Labour	β_{13}	0.12 (0.59)	4.37 (1.43)***	0.29 (0.6)
Fertilizer*Agrochemical	B_{14}	-0.58 (0.18)***	0.06 (0.18)	-0.75 (0.12)***
Fertilizer*Labour	β_{15}	-1.16 (0.27)***	-0.97 (0.95)	-1.05 (0.41)***
Agrochemical*Labour	β_{16}	2.18 (0.56)***	8.16 (1.18)***	1.68 (0.59)***
Sigma_u	σ_u	0.52 (0.05)***	0.71 (0.06)***	0.49 (0.05)***
Sigma_v	σ_v	0.48 (0.02)***	0.23 (0.04)***	0.45 (0.03)***
Lambda	λ	2.28 (0.05)***	2.27 (0.09)***	2.46 (0.06)***
Log-likelihood		-1329.17	-2312.88	-1206.24
Wald chi2(24,)		984.15***	451.29***	651.06***
Number of observations		210	105	105

***<0.01, **<0.05, and *<0.1; Input quantities and output are in natural logarithm.

In overall the RTS estimate was 0.2, indicating that there was an increasing RTS in rice production. The significance of the assumption of CRTS was rejected at 1% probability level indicating that doubling all the inputs would less than double the output, all things being equal. Sadiq (2015) equally found that there was a DRTS among rice farmers in Niger State, Nigeria. The estimates of the RTS among adopters and non-adopters were 0.16 and -0.12, respectively, the hypothesis of constant RTS (CRTS) was only rejected for non-adopters. In other words, rice production among the adopters exhibited an IRTS, but a DRTS among the non-adopters, provides further evidence that adopters and non-adopters allocated inputs differently.

Table 3: *Estimates of the output elasticity and returns to scale*

Variable	Pooled	Adopters	Non-adopters
Seed	0.98 (0.34)***	1.4 (0.42)***	0.58(0.02)***
Fertilizer	0.32(0.04)***	0.15 (0.12)	0.35 (0.06)***
Agrochemical	0.767 (0.103)***	0.48 (0.23)**	0.82 (0.11)***
Labour	-0.609 (0.194)	-0.87 (0.38)	-0.87 (0.21)*
Return to Scale	0.2 (0.27)	0.16 (0.59)	-0.12 (0.29)**
RTS =1	1.02 (0.27)***	1.16 (0.59)	0.88 (0.29)***

***<0.01, **<0.05, and *<0.1.

Technical Efficiency

Table 4 shows a pooled mean Technical Efficiency (TE) of 0.65, implying that rice farmers achieved 65% of potential output. In other words, 35 percent of the expected maximum output was lost due to technical inefficiencies. The estimate of TE is below the 81% TE of rice production in Kano State, Nigeria reported by Mukhtar *et.al.* (2018), This could partly be related to the use of the DEA, a methodology which links all deviations from maximum output to technical inefficiencies and therefore does not account for statistical noise (Zamanian *et al.,* 2013).

Table 4: *Technical efficiency of Rice Producers*

	Pooled		Adopters		Non-adopters	
Eff. Class	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
<0.21	8	3.8	7	7.0	5	4.8
0.21-0.40	44	21.0	17	15.9	23	22.2
0.41-0.60	84	40.0	29	28.1	42	40.2
0.61-0.80	52	24.8	28	27.1	27	25.4
0.81-1.00	22	10.5	23	22.0	8	7.4
Total	210	100	105	100	105	100
Mean	0.65		0.76		0.53	
Min	0.02		0.02		0.02	
Max	0.90		0.94		0.86	

TE was 0.76 and 0.53 for adopters and non-adopters of rice technologies, respectively implying that 76% and 53% of potential output was attained by each category. TE of the least and most efficient farmer was 0.02 and 0.90, respectively suggesting that the least technically efficient rice farmers can still increase output by 98 percent with the existing level of inputs while the most technical efficient farmer can still increase production by 10% percent using the same level of production resources. In a nutshell, adopters were more technically efficient than non-adopters, though the difference was not quite important. However, the observed difference in technical efficiency between adopters and non-adopters does not have any causal interpretation because adopters and non-adopters were clearly different in observed characteristics. Abdul-Rahaman at.el., (2021) showed that adopters of improved cereal crops were significantly more technically more efficient than non-adopters after accounting for observed and/or unobserved characteristics.

CONCLUSION AND RECOMMENDATIONS

In conclusion, estimates of production efficiency in rice farming in this study highlighted the differences between adopters and non-adopters using an exponential translog stochastic frontier production models. Outcomes of the analysis showed that production levels of rice can substantially be improved through the reduction of technical inefficiencies. Though adopters were more efficient than non-adopters, the difference had no causal interpretation considering the geographical location of both groups. Also, access to adequate farm land and credit will encourage farmers to improve scale of production that will enable them to take advantage of economies of scale.

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DIGITAL SIGNAL CLASSIFICATION USING SPECTRAL AND STATISTICAL FEATURES IN WIRELESS COMMUNICATION AND COGNITIVE RADIO NETWORK

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Abstract:

The need for wireless communication applications are increasing and the available electromagnetic spectrum band is getting crowded geometrically. Classification of digital signals is one of the biggest problems in Wireless and Cognitive Radio Networks. This paper presents digital signal modulation classifier based on spectral and statistical features using support vector machine. The objective of this work is to design and implement an automatic digital signal classification technique for wireless communication and cognitive radio network (CRN) capable of classifying multiple digital signals simultaneously. The proposed work utilizes support vector machine (SVM) tool in MATLAB 2019a for the classification of BPSK, QPSK, 16QAM, 64QAM and OFDM digital modulation types. SVM maps the input vectors (radio frequency dataset) nonlinearly into a high dimensional feature space, constructs the optimum separating hyper plane in that space and makes the non-separable data separable. Computer simulations of five digitally modulated signals corrupted by additive white Gaussian noise (AWGN) were carried out over a range of signal-to-noise-ratio (SNR) of 0 - 15dB. Simulations show satisfactory results even when evaluated at a signal-to-noise ratio (SNR) as low as 0dB. It can be observed that, even for the worst-case scenario of SNR = 0 dB, the average classification accuracy of all 16QAM and 64QAM modulations are 93.3% and 92.5% respectively. The proposed technique provides a promising solution and cost-effective classification technique for digital signal modulation types in wireless communication and cognitive radio networks.

Keywords:Wireless Communication, Digital Signal Classification, Cognitive Radio Network, Support Vector Machine, Modulation Scheme

Introduction

Cognitive radios (CR) are intelligent communications devices that use knowledge of the external environment and user needs to reconfigure themselves to optimize quality of service (QoS). Knowledge of the external

environment is generally comprised of information extracted from the propagation channel modeling and the identification of other signals present on the channel. Modulation classification consists of signal feature extraction and pattern recognition (Al-makhlasawy et al., 2012). Cognitive Radio works on this dynamic Spectrum Management principle which solves the issue of spectrum underutilization in wireless communication in a better way. This radio provides a highly reliable communication. In this the unlicensed systems (Secondary users) are allowed to use the unused spectrum of the licensed users (Primary users). Cognitive radio will change its transmission parameters like wave form, protocol, operating frequency, networking and others. Figure 1 shows the Dynamic Spectrum Access in Cognitive Radio.

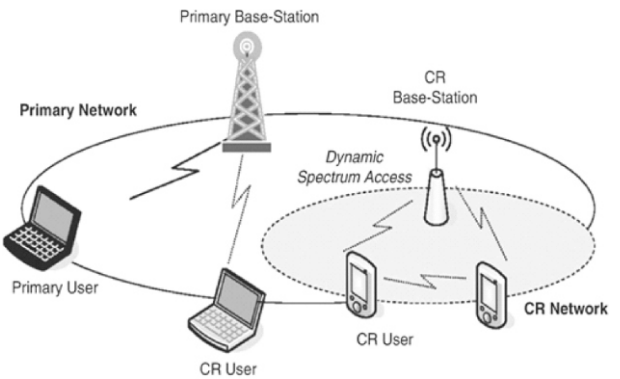


Figure 1: Dynamic Spectrum Access Cognitive .

Traditional algorithms of modulation recognition could mainly be separated into two groups: likelihood-based (LB) and feature-based (FB) approaches (Dobre, et al., 2007). LB approaches are based on hypothesis testing theory where the performance based on decision theoretic is optimal but suffers high computation complexity. Therefore, feature-based approaches as suboptimal classifiers were developed for application in practice. In particular, the feature-based approaches usually extracted features for the preprocessing and then employed classifiers to realize modulation classification.

Conventional FB approaches heavily rely on the expert's knowledge, which may perform well on specialized solutions but poor in generality and suffer high complexity and time-consuming. To tackle these problems, machine learning (ML) classifiers have been adopted and shown great advantages, for example, support vector machine (SVM) in Wang and Ren (2009).

This paper presents digital signal modulation classifier based on Spectral and Statistical Features using support vector machine. The objective of this work is to design and implement an automatic digital signal classification technique for wireless communication and cognitive radio network (CRN) capable of classifying multiple digital signals simultaneously.

2. Related Works

Cognitive radio (CR) is a promising technology that provides improved spectrum utilization by enabling opportunistic access to the licensed spectrum band by unlicensed users (Akyildiz et al., 2006). The CR is as an intelligent wireless communication system that is aware of its environment and is capable of learning from the environment and adapts its transmission parameters, such as frequency, modulation, transmission power and communication protocols (Mitola and Maguire, 1999).

The development of automatic signal classification systems that can automatically detect and classify a radio signal's modulation format has received worldwide attention (Popoola and Olst, 2013). Considerable research work has been carried out over the past few years on automatic signal classification. The following related works were reviewed and reported based on their domain, methodologies and limitations.

Popoola and Olst (2011) proposed an employment of neural network for sensing primary radio signals in a CR environment. The various sensing methods for detecting user's signals are examined ahead of AMC detection method for sensing the presence/absence of authorized users. It assesses the sensing of digitally modulated primary radio signals and presents that the sensing method promises better performance as all radio devices in the CR environment making use of a type of modulation technique when transmitting their signals.

implemented support vector machine (SVM) and weighted K-nearest-neighbor (KNN) classification techniques for cooperative spectrum sensing. The received signal strength at the CR users are treated as features and fed into the classifier to detect the availability of the primary user (PU). Each instance of PU activity (i.e., availability and unavailability) is categorized into positive and negative classes (respectively). The support vectors were obtained by maximizing the margin between the separating hyperplane and data for minimization of classification errors. The effect of different kernels through quantifying in terms of detection probability by representing the receiver operating characteristic (ROC) curves was investigated. Furthermore, weighted KNN classification technique was proposed for CSS and the corresponding weights were calculated by evaluating the area under ROC curve of each feature.

Studies Orthogonal Frequency-Division Multiplexing (OFDM) based signal detection in cognitive radio systems. This work uses two difference input signal, PSK (Phase-Shift Keying) modulated signal with distributed Gaussian noise and QAM (Quadrature Amplitude Modulation) modulated OFDM (Orthogonal Frequency-Division Multiplexing). Comparison of these two signals focuses on receiver operating curve (ROC) that is represented by probability of detection (P_d) as a function of probability of false alarm (P_f). Initially, PSK modulated with distributed Gaussian noise is used as an input signal. Then, the input signal is replaced with OFDM signal. Comparison is further analyzed by changing period of sensing time. Through

numerical simulation, input signal based on OFDM reveals better performance compared with distributed Gaussian signal. Furthermore, from simulation shows that performing sensing with longer time is able to improve the performance of energy detector.

In , the author(s) investigate the AMC in time-varying channels by using the deep learning method for high classification accuracy. Specifically, use modulation constellation diagram (CD) as the key feature and propose a slotted constellation diagram (slotted-CD) scheme in order to extract the feature of the time-evolution of the CD due to channel variation. The objective is to develop an advanced neural network for modulation classification, where the output sub-images from the slotted-CD feature extractor are first processed separately by a number of parallel convolutional neural networks and then further processed by a recurrent neural network for exploring their time relationship. Experimental results show that the fading channels when compared with the traditional deep learning based AMC schemes.

3. Support Vector Machine

Support Vector Machines (SVMs) are a new type of pattern classifier based on a novel statistical learning technique that has been recently proposed by Vapnik and his co-workers (Cortes and Vapnik, 1995). Unlike traditional methods (e.g. Neural Networks), which minimize the empirical training error, SVMs aim at minimizing an upper bound of the generalization error through maximizing the margin between the separating hyperplane and the data (Amari and Wu, 1999).

SVM is derived from the statistical learning theory which shows many special advantages in solving small-sample learning problems, high dimensional pattern recognition and regression analysis. SVM uses kernel functions to map the input data to a high dimensional feature space in which a non-linear classification problem can be processed as a linear classification problem. Compared with the neural network, the SVM is based on more solid mathematical theory, can effectively solve the construction of high dimensional data model under finite samples, and can converge to the globally optimal. The core of SVM is solving the optimal linear hyper-planes which will completely classify the signals. Suppose we have training data as follows:

$$\left\{(x_1, y_1), \left((x_2, y_2)\right), \ldots \left(\left(x_j, y_j\right)\right),\ x \in R^d,\ y \in \{+1, -1\}\right\} \quad (1)$$

where x_i is the feature space, $y_i = +1$ means the signal belongs to the first class, $y_i = -1$ means the signal belongs to the second class. Key features which are sensitive with modulation type and insensitive with SNR variation were extracted in order to obtain input features for the classifier. Since the feature vectors are not perfectly linear separable despite of the mapping strategy, a slack variable $\delta^{(j)}$ was introduced for every feature vector $y^{(j)}$ in case of possible classification errors. For all training samples j = 1, ..., J, the classifier should satisfy the condition shown below:

$$s_b^{(j)} \cdot \left[\boldsymbol{w} \cdot \emptyset\left(y^{(j)}\right) + \omega_0\right] \geq 1 - \delta^{(j)} \quad (2)$$

where **w** is the weight vector, $\phi(\cdot)$ is a non-linear kernel function and ω_0 is the bias. The slack variable $\delta^{(j)}$ should satisfy $\delta^{(j)} \geq 0$ for j=1,…,J. and $0 \leq \delta^{(j)} \leq 1$ indicates marginal classification errors while $\delta^{(j)} \geq 1$ suggests there is a misclassification. Based on (3), the following convex optimization problem holds:

$$w, \delta^{(j)}, \delta^{(j)}, \underset{j=1,\ldots J}{min} \quad \frac{1}{2}\|w\|^2 + \xi \cdot \sum_{j=1}^{J} \delta^{(j)} \quad (3)$$

$$\text{s. t.} \quad s_b^{(j)} \cdot \left[w \cdot \phi\left(y^{(j)}\right) + \omega_0\right] \geq 1 - \delta^{(j)} \quad (4)$$

$$\delta^{(j)} \geq 0, \text{ for j = 1, …, J.} \quad (5)$$

where ξ is the soft margin constant weight factor. For sufficiently large ξ, the problem (3) determines the boundary that minimizes the number of errors in training set.

The Lagrange multiplier method and the Karush-Kuhn-Tucker (KKT) conditions are then applied in order to derive the optimal solutions. Let $\tilde{\lambda}^{(j)}$denote the solution of the dual problem, the nonlinear decision function of the classifier is attained as:

$$F_d(y^*) = sgn\left(\sum_{j=1}^{J} \tilde{\lambda}^{(j)} s_b^{(j)} K\left(y^*.y^{(j)}\right) + \omega_0\right) \quad (6)$$

Where sgn(·) is the sign function, y* is the testing energy feature vector and k(y*, $y^{(j)}$) is the kernel function.

In Zhou, Lin, and Zhu (20202) the author(s) investigate the AMC in time-varying channels by using the deep learning approach for high classification accuracy. Specifically, use modulation constellation diagram (CD) as the key feature and propose a slotted constellation diagram (slotted-CD) scheme in order to extract the feature of the time-evolution of the CD due to channel variation.

Zhang and Zhai (2011) proposed support vector machine based spectrum sensing to develop a real-time approach for detection. The sample data were classified as PU or not by training and testing on proposed SVM classification model in time domain. For linear classification, kernel function is proposed to map the input low dimensional vector into a high dimensional feature space.

4. Material and Methods

Dataset contains orthogonal frequency-division multiplexing (OFDM) signals-with-noise and noise-only samples. As the supervised machine learning techniques need labeled data to distinguish between different categories, this generated data is also assigned labels. The two categories of data mentioned above are labeled as Signal and Noise, respectively. Half of the elements in dataset are those where signal is present and the rest are only noise elements. Dataset generation algorithm is presented as Algorithm 1. First OFDM signals are generated with BPSK, QPSK, 16-QAM, and 64-QAM.Then signal power is adjusted depending upon the SNR value. Then additive white Gaussian noise (AWGN) is added and also the Signal label is

assigned. SNR is varied from 0dB to 15dB. Next noise-only signals are generated and Noise label is assigned. Finally we store the generated signals in the dataset.

In this work, a multiclass soft-margin support vector machine (SVM) is used to classify signals of different modulation scheme based on spectral and statistical features extracted from raw recorded in-phase (I) and quadrature (Q) samples.

Algorithm 1: Dataset generation algorithm.

1: Iterations = 250

2: SNR value from 0dB to 15dB

3: ModType = BPSK (It stores the modulation type which can have one of the four values BPSK, QPSK, 16-QAM and 64-QAM).

4: Generate OFDMsignal

(i) T = OFDM(ModType)

(ii) S = Power Adjustment(T, SNR value) + WGN

(iii) Assign Signal label

5: Generate Noise

(i) N =WGN

(ii) Assign Noise label

6: Dataset = concatenate(Dataset, S, N)

7: UpdateModType

8: Until all ModTypes go to step 4

9: Update SNR value

10: Until all SNR values go to step 3

11: Iterations = Iterations - 1

12: Go to step 2 if iterations > 0

Algorithm 1: Dataset generation algorithm

SVM maps the input vectors (radio frequency dataset) nonlinearly into a high dimensional feature space, constructs the optimum separating hyper plane in that space and makes the non-separable data separable. Five digitally modulated signals (BPSK, QPSK, 16QAM, 64QAM and OFDM) corrupted by additive white Gaussian noise (AWGN) were considered over a range of signal-to-noise-ratio (SNR) of 0 - 15dB.

Summarily, Modulation classification based on SVM consists of five steps:

(i) Extract feature: Extract the key features and convert these features according to the data format of the SVM.

(ii) Select kernel function: Select an appropriate kernel function. RBF kernel function selected.
(iii) Calculate parameters of kernel function: Find the best parameters of kernel function with cross validation.
(iv) Train samples: Train the signal samples and obtain a classifier model.
(v) Classify signals: Classify the data with the model obtained in the training step.

5. Experimental Setup

Heterogeneous transceiver hardware (i.e., low-grade universal software radio peripherals (USRPs) and high-grade lab instruments), and in-band interference from a modulated signal were considered. Each element of the dataset is 1ms of captured data sampled at 50MHz. From each element a feature vector of 12 features, statistical and spectral, was computed. The modulation schemes used were BPSK, QPSK, 16QAM, 64QAM for both the desired signal and co-channel interference (OFDM) represented by 1, 2, 3, 4, and 5 respectively. Figure 2 Shows Snapshot of Spectra and statistical features extracted while Figure 3 shows Train and Test Interface.

2	sigma_aa	sigma_a	sigma_af	mu_42_f	snr	gamma_2	gamma_4	psi	papr	n_c	c_42	c_63	tx_mod
3	0.309236377	0.371189535	0.385017309	3.721286009	0.11097302	0.000567226	0.000376359	0.103671111	9.733589634	0.45596	0.040616932	0.155662252	64QAM
4	0.310321659	0.372374028	0.396526747	3.894202612	0.11097302	0.000548179	0.000346823	0.096411929	9.958111411	0.45728	0.023718901	0.007850485	64QAM
5	0.308296978	0.367926717	0.394265353	4.209043779	0.11097302	0.000508756	0.000323346	0.099319927	12.4736781	0.46048	0.08575501	0.655612667	64QAM
6	0.309745193	0.371211767	0.394777047	4.194171551	0.11097302	0.00055688	0.000378309	0.096672595	10.49188866	0.45388	0.026014568	0.12590653	64QAM
7	0.312253028	0.376263887	0.393980144	3.897214521	0.11097302	0.000579895	0.000571994	0.102824807	16.21628415	0.4557	0.065707015	0.525593693	64QAM
8	0.31022194	0.370900989	0.387725449	3.842231483	0.11097302	0.000571453	0.000430557	0.102888502	11.3680494	0.4568	0.027152298	0.156434779	64QAM
9	0.308603793	0.369413912	0.393014556	3.998447295	0.11097302	0.000546864	0.000335682	0.101564214	11.85128834	0.45632	0.059025859	0.089716321	64QAM
10	0.306806177	0.365885347	0.399188097	3.806842211	0.11097302	0.000503915	0.00028139	0.104822077	12.13330682	0.45692	0.104848406	0.084931484	64QAM
11	0.307725459	0.368392825	0.39537652	3.692238974	-0.0665248	0.000527903	0.000360242	0.101162873	11.83647506	0.4578	0.076432138	0.389233985	64QAM
12	0.30739361	0.367365599	0.396735073	3.80062176	-0.0665248	0.000504158	0.000266952	0.09410952	11.2030869	0.45834	0.094349519	0.207801502	64QAM
13	0.311505944	0.373935074	0.396152243	3.98950824	-0.0665248	0.00058183	0.000390005	0.097409919	9.731230839	0.45562	0.00588719	0.321767168	64QAM
14	0.309226096	0.369405508	0.396914358	3.813164382	-0.0665248	0.000596503	0.000369957	0.101032116	10.73506783	0.45642	0.055875658	0.320190281	64QAM
15	0.309828281	0.37140882	0.393478826	4.092804362	-0.0665248	0.000551873	0.000350353	0.097985551	12.37694607	0.45716	0.03753928	0.054617568	64QAM
16	0.308464944	0.369354725	0.396430705	3.801296554	-0.0665248	0.000553119	0.000379405	0.103254899	11.9389441	0.45606	0.045752983	0.272443683	64QAM
17	0.312430054	0.375626981	0.395333158	3.836522659	-0.0665248	0.000562647	0.000424116	0.099798404	11.60328532	0.45718	0.055387288	0.306646657	64QAM
18	0.309339613	0.3711209	0.395968854	3.955265412	-0.0665248	0.000541316	0.000314503	0.103462815	13.81155483	0.45736	0.048961638	0.184985022	64QAM
19	0.308211297	0.368746191	0.396201724	4.15477184	-0.04136168	0.000540121	0.000403225	0.097901307	10.64095083	0.45712	0.094528258	0.324063404	64QAM
20	0.310586989	0.373404592	0.394893788	3.876777063	-0.04136168	0.000576704	0.000440038	0.093938462	11.78352594	0.45488	0.004424706	0.07523751	64QAM
21	0.311553508	0.375438482	0.394831019	4.038791661	-0.04136168	0.000614573	0.000463437	0.110299386	10.01302309	0.45442	0.031833841	0.445115189	64QAM
22	0.308048308	0.368389934	0.389959266	3.972184426	-0.04136168	0.000535045	0.000338076	0.104976483	9.980036163	0.45722	0.076656387	0.300594921	64QAM
23	0.309537351	0.370849371	0.390856136	3.691186841	-0.04136168	0.000585907	0.000482105	0.102919362	12.32768876	0.45708	0.030505315	0.174035555	64QAM
24	0.30838667	0.368887931	0.395769352	4.342677482	-0.04136168	0.000547565	0.000381156	0.101953916	13.37970216	0.45922	0.06547747	0.503444643	64QAM

SA_CFO_0_Cable_baseline_0dB_SNR

Figure 2: Snapshot of Spectra and statistical features extracted

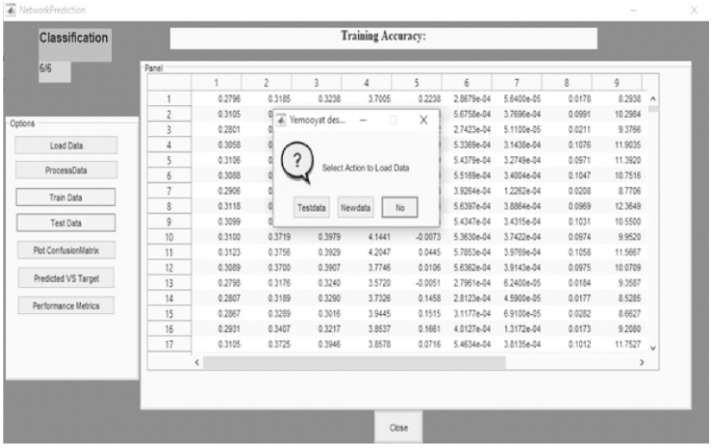
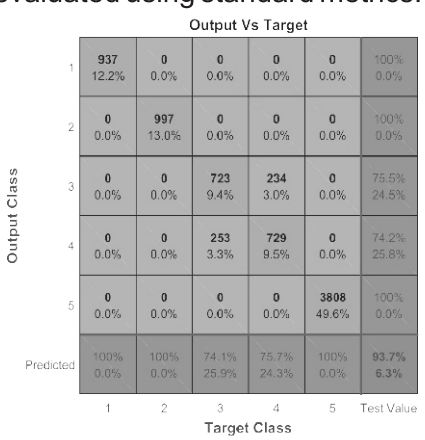


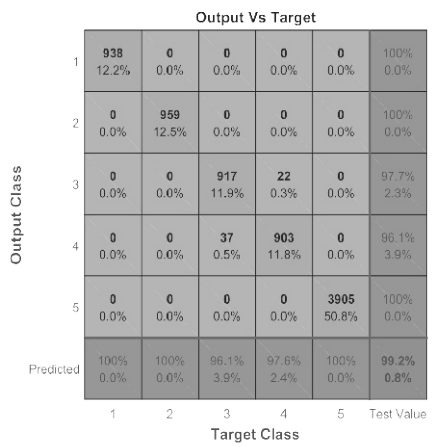
Figure 3: Train and Test Interface

The data set consists of twenty-five thousand, six hundred (25,600) samples which is divided into seven thousand, six hundred and eighty (7680) and seventeen thousand, nine hundred and twenty (17,920) of testing and training dataset respectively. Making twenty-five thousand, six hundred (25,600) instances, the testing test has nine hundred and nineteen (919), nine hundred and forty-seven (947), One thousand and nineteen (1019), (933) nine hundred and thirty-three and three thousand, eight hundred and sixty-two (3862) BPSK, QPSK, 16QAM, 64QAM and OFDM instances respectively.

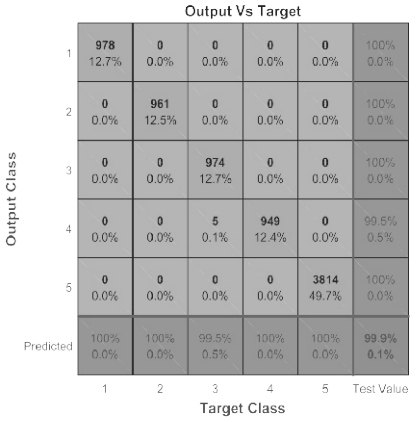
6. Results and Discussion

The simulation result of the proposed classifier is presented in this section. Carrier frequencies were assumed to be estimated correctly or to be known. Thus, only complex base-band signals were considered. The simulated signals were also band-limited and AWGN was added according to SNRs, 0, 5, 10, and 15dB respectively. The performance of the RBF kernels classifier with grid search technique was evaluated using standard metrics.

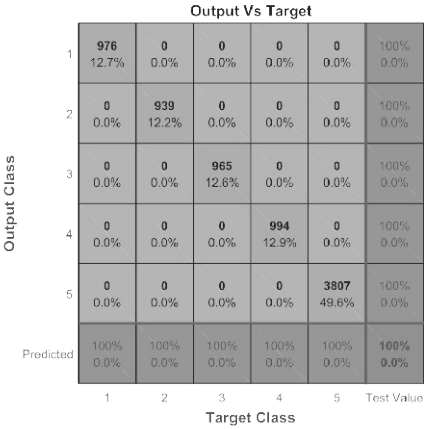




(a) SNR=0dB



(b) SNR=5dB



(c) SNR=10dB

(d) SNR=15dB

Figure 4: Accuracy matrix of the classifier at 0dB, 5dB, 10dB and 15dB respectively

Looking at the bottom rightmost cell of the confusion matrices in Figure 4, it can be observed that the overall percentages of correct signal classification achieved are 93.7%, 99.2%, 99.9% and 100% respectively. Thus, the performance of the classifier increases as the SNR level is increased. The results are presented in Figure 4(a), 4(b), 4(c), and 4(d) at SNR of 0, 5, 10, and 15dB respectively. From the results we show that the overall success rate classification in SVM increase as SNR value increase. Table 1 depicts success classification rate of signal segment that were recorded using spectral analyzer connect via cable when the carrier frequency offset is zero. Taking a closer look at the diagonals of the confusion matrices, it can be seen that most of the confusion is happening between the two QAM modulations. It can be observed that, even for the worst-case scenario of SNR = 0 dB, the average classification accuracy of all 16QAM and 64QAM modulations are 93.3% and 92.5% respectively.

Table 1: Success Classification Rate at different SNR value

SNR	0 dB	5 dB	10 dB	15 dB	Average Accuracy (%)
BPSK	100	100	100	100	100
QPSK	100	100	100	100	100
16QAM	75.5	97.7	100	100	93.3
64QAM	74.2	96.1	99.5	100	92.5
OFDM	100	100	100	100	100
Accuracy (%)	93.7	99.2	99.9	100	

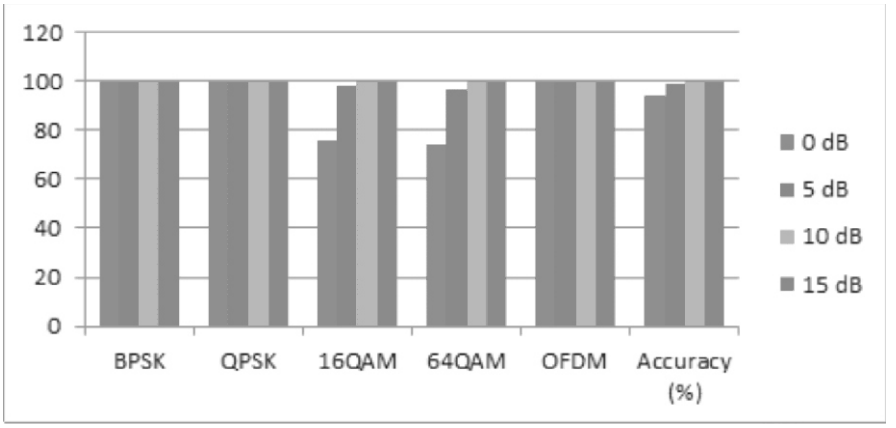


Figure 5: Graphical representation of success classification rate of different modulation scheme at different SNR value

7. Conclusion

This paper has presented an approach for digital signal classification based on spectral and statistical feature extracted using SVM as a classifier. The proposed technique provides a promising solution and cost-effective classification technique for digital signal types in wireless communication and cognitive radio networks. Through the simulation results, it was observed that the algorithm based on SVM performs well in signal classification. In the future work, more types of modulated signals and other signal analysis methods such as wavelet packet transform could be explored.

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VARIATION IN THE TOTAL PROTEIN CONTENT AND AMINO ACIDS PROFILE AMONG *Oryza sativa, Oryza glaberrima* AND THEIR INTER-SPECIFIC PROGENIES

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Abstract:

This research work was aimed at evaluating the variation in the total protein content and amino acids profile among Oryza sativa, Oryza glaberrima and their inter-specific progenies. The rice cultivars were field –grown, harvested at maturity and processed into milled rice. The milled rice was then analysed for total protein content and amino acids profile. Total protein content was determined using Kjedahl technique while amino acids were determined using water 616/626 LC (HPLC) instrument. The results showed that the total protein content ranged 9.5± 0.1% - 13.0 ± 0.1% before pre-cooking and 12.9 ± 0.1% - 9.5± 0.1% after pre-cooking, and amino acids range of 9.8 ± 0.2 – 0.4 ± 0.1 before pre-cooking and 9.7 ± 0.1 – 0.3 ± 0.1 after pre-cooking. Results also revealed that there were no significant variations in total protein content and amino acids profile among the parent varieties and hybrid progenies at 0.05 significant levels. Significant variation was also not observed in protein and amino acids content at 0.05 significant levels before and after pre-cooking in some of the rice genotypes, indicating that there was little or no loss of protein nutrient during pre-cooking. However, the amino acids content of rice varieties before pre-cooking strongly correlation with amino acids content of the rice varieties after pre-cooking. WBK 150 -B –B –B –F_4 and WBK 42-B-B-2-F_4 have the highest protein values of 12.9 ± 0.1% and 13.6 ± 0.1% respectively. Tyrosine/phenylalanine was the most abundant amino acid with values ranging 7.4 ± 0.1 – 9.7±0.2 while tryptophan was the limiting amino acids with values ranging 0.3 ± 0.1 – 2.3 ± 0.1. Variation in protein and amino acids content was contributed by both genetic and environmental factors. Broad sense heritability was high with value range of 0.5% - 0.99% indicating that the genetic makeup of the hybrid is very much like that of the parental line. The progenies of the hybrids such as WBK 150 -B –B –B –F_4 and WBK 42-B-B-2-F_4 have the potential of meeting the protein need of rice consumers and are therefore recommended for commercial production. The entire result indicates that the newly developed rice seeds have suitable gene that are closely related to that of its parents; as a result the rice seed can be commercially produced for consumption. Information derived from this research work can be used to characterize the hybrid rice since they are still breeder's seed.

Keywords: *Protein Content, Amino Acids, Oryza Sativa, Oryza Glaberrima, Inter-Specific Progenies.*

Introduction

Half of the world's population depend on rice as the major food source (Wu et al., 2002). Increasing rice production and improving its nutritional quality is expected to make a tremendous impact towards improving the livelihood of millions of households in Nigeria. Rice is a member of the grass family (poaceae) and belong to the genus Oryza. The genus Oryza includes 20 wild species and 2 cultivated species (Cultigen). The wild species distributed in the humid tropics and subtropics of Africa, Asia, Central and South America and Australia. Of the cultivated species, African rice (O. glaberrima Steud) is confined to West Africa. Whereas Asia rice (O. sativa L.), is now commercially grown in 112 countries, covering all continents (Bertin et al., 1971). Oryza sativa was introduced to Africa about 500 years ago, and farmers there have adapted it to their rice production system, developing many local varieties of the Asian species and turning Africa into another secondary source of diversity (Nassirou and He, 2011). West Africa dependent on rice as their primary source of food energy and protein however, majority of Africa rice was imported. Therefore, there was need to develop African rice that will meet the FAO/WHO recommended daily nutritional need. Scientists were therefore spurred to start crossing species of rice. A cross between Oryza sativa and Oryza glaberrima gave birth to an excellent hybrid referred to as NERICA. NERICA combines the best traits of both species of cultivated rice, (the African rice O. Glaberrima steud and the Asian rice O. sativa L.), these are high yield potential and the ability to thrive in harsh environment (Nassirou and He, 2011).

Although rice is a good cereal from nutritional standpoint, it does not contain all the essential nutrients required by man. Rice contains about 78% - 90% carbohydrate, and about 6% - 9% protein. Although it can supply a high level of calorie in the diet, the protein quality and quantity is inadequate. Consequently, rice alone cannot meet the protein requirement of the human body. Rice protein is limited in essential amino acids such as lysine, isoleucine, threonine, tryptophan, methionine and cysteine (Enwere, 1998). Essential amino acids, which humans cannot synthesize but need for physiological requirement, must be supplied from the diet. Therefore, rice nutrient traits for these amino acids and proteins are very important for human health and wellbeing. The improvement of the nutrient quality of rice grain is one of the main goals for rice breeders. Although the phenotypic variation for many nutrients quality traits of rice might be influenced by environmental conditions, it is mainly affected by genetic main effect and genotype × environment (G×E) interaction effect during the growth cycle (Cheng and Zhu 1999; Shi et al., 2000). The protein content and composition of amino acids in indica rice had shown high heritability and significant variation among genotypes (Chai et al., 1995). The protein contents of rice fluctuate according to the variety grown and can also be affected by growing condition such as early or late maturing, soil fertility and water stress (Hoseney,1986).

Rice protein is suitable for use by those with food allergen because it contains no food allergen and even for tube feeding of infants, the elderly and the severely ill. It has a mild flavour similar to that of cream of rye cereal and may be used for beverages,

sprinkled on cereals and yoghourt; add to cooked dish to boost the protein content without adding fat or a lot of calories (Nassirou and He, 2011). Although rice is a carbohydrate based food, it also contains amino acids, which are building block of protein. A unique process is used to isolate a protein from the carbohydrate portion of the rice. This assay processes have resulted to an extensive amino acid profile that includes 19 amino acids, 9 essential amino acids and ten non- essential amino acids making a "complete" protein (Nassirou and He, 2011). No food allergens commonly found in wheat, soya milk, nut, corn eggs proteins are not found in rice. We believed that this research outcome will present a new hybrid progenies with an improved protein and amino acids profile better than the parent stocks that will measure up with Food and Agricultural Organization / World Health Organization recommended daily protein intake.

MATERIALS AND METHODS

3.1 Sample Collection

The work involved field experiment and laboratory analysis. Ten varieties of rice were collected from the resource centre of Alliance for Green Revolution in Africa, situated at the Biotechnology Research and Development Centre (BRDC) of Ebonyi State University, Abakaliki. Details of the samples are given in the table below.

Table1. Sample description

Names	Description of varieties used
RAM 86	*O. glaberrima*, long grains with the ability to thrive in harsh environment.
RAM 24	*O. glaberrima,* long grain with the ability to thrive in harsh environment.
IR 77674-B-20-1-2-1-3-12-B	*O.sativa,* Asian origin with high yield potential.
IR 77674-3B-B-8-22-20-4	*O. sativa*, Asian origin with high yield potential.
NERICA 1	Inter-specific with high yield, high nutritional quality and acceptable grain quality to both farms and consumers.
WAB 450	Inter-specific with high yield, high. nutritional quality and acceptable grains.
WBK 150-B-B-B-F_4	Progeny with long grains and high yield.
WBK 106-B-1-F_3	Progeny with moderately sized grains and high yield potential.
WBK 35-B-B-4-f_3	Progeny with moderately sized grains and high yield potential.
WBK 42-B-B-2-F_4	Progeny with long grains and high yield potential.

3.2 Rice cultivation

3.2.1 Land preparation

The experimental site was cleared and the debris removed before tilling. The rice nursery was cultivated at the upland part of the experimental site, three weeks (3) later the rice was potted for effective transfer into the green house of Biochemistry / Biotechnology Department. Prior to the transplant, each pot was filled with loamy soil and poultry manure. The rice was transplanted after watering the pot for two days to allow evaporation of heat from the poultry manure.

3.2.2 Fertilizer application

Fertilizer was applied to the nursery for effective growth, while poultry manure was used during transplant and ammonium sulphate was used during seed bearing.

3.2.3 Harvest and processing

The rice samples were harvested, 90 days after transplant, grains from different varieties were collected dehulled and dried for 3 days before parboiling. Parboiling in this context refers to the processing stages in which rice undergo before milling.

3.3.0: Crude protein determination The crude protein content of the sample was determined using the Kjeldahl technique (Pearson, 1976). The method involved digestion of samples, distillation of digest and titration of distillate.

3.4.0: Analysis of amino acids

The analysis of amino acids was done using Waters 616/626 High Performance Liquid Chromatography LC (HPLC Water Model 616/626) instrument (Bartolomeo and Federico, 2006). The sample preparation and determination was carried out in the following stages:

Hydrolysis, Derivatization, Separation of derivatised amino acids and Data processing/ interpretation and calculations of the final results

3.6.0 Statistical analysis

In all the experiments, data collected were subjected to analysis of variance (ANOVA). Treatment means were separated by LSD procedure. All statistical analysis was done using SAS Software version 9.1and at 0.05 probability level. Genetic variance, environmental variance. Phenotypic variance and Broad sense heritability were estimated from the ANOVA mean square according to Burton, (1951).

4.0 RESULTS

4.10: Total Protein Content Among the Rice Genotypes before and after pre-cooking

TABLE 4.1 Total Protein in %

Varieties	Before pre cooking	after-pre cooking
RAM 86	10.6 ± 0.1^{d}	11.0 ± 0.1^{b}
RAM 24	12.6 ± 0.2^{b}	9.3 ± 0.1^{d}
IR 77674-B-20-1-2-1-3-12-B	11.2 ± 0.1^{c}	10.2 ± 0.1^{c}
IR 77674-3B-B-8-22-20-4	10.0 ± 0.1^{d}	9.6 ± 0.1^{d}
NERICA	9.5 ± 0.1^{e}	9.8 ± 0.1^{d}
WAB 450	12.0 ± 0.1^{b}	9.2 ± 0.1^{d}
WBK 150-B-B-B-F_4	12.6 ± 0.1^{b}	12.9 ± 0.1^{a}
WBK 106-B-1-F_3	10.3 ± 0-1^{d}	9.6 ± 0.1^{d}
WBK 35-B-B-4-F_3	11.4 ± 0.1^{c}	9.4 ± 0.1^{d}
WBK 42-B-B-2-F_4	13.0 ± 0.1^{a}	10.6 ± 0.1^{c}
GM + SE	11.32 ± 0.79	10.16 ± 0.77
Pr	0.00001	0.000 1
$LSD_{0.05}$	0.3151	0.3452

Mean value in column followed by the same letter are not significantly different at 0.05 significant level

TABLE 4.2 Variation in amino acids profile among rice varieties before pre-cooking . (mg/ml)

Var.	Lysine	Arginine	Histidine	Isoleucine	Leucine	Cy/Meth	Ty/Ph	Threonine	Tryp tophan	Valine
1.	4.6 ± 0.1^{c}	8.4 ± 0.1^{c}	2.8 ± 0.1^{a}	4.8 ± 0.1^{bc}	8.5 ± 0.1^{c}	3.4± 0.1^{cb}	9.7 ± 0.2^{a}	4.0 ± 0.1^{b}	0.8 ± 0.1^{dc}	6.8 ± 0.1^{ab}
2.	4.2 ± 0.1^{d}	8.4 ± 0.1^{c}	1.7 ± 0.1^{e}	4.75 ± 0.2^{c}	8.2 ± 0.1^{d}	3.5± 0.1^{b}	8.8 ± 0.1^{c}	4.1 ± 0.1^{b}	1.2 ± 0.1^{bc}	6.6 ± 0.1^{bc}
3.	3.8 ± 0.0^{e}	8.8 ± 0.1^{ab}	2.3 ± 0.1^{b}	4.4 ± 0.2^{d}	9.3 ± 0.1^{a}	4.0± 0.1^{a}	7.4 ± 0.1^{d}	4.3 ± 0.1^{a}	1.2 ± 0.1^{bc}	6.4 ± 0.1^{cd}
4.	4.4 ± 0.1^{cd}	8.6 ± 0.1^{bc}	2.3 ± 0.1^{b}	4.6 ± 0.2^{cd}	8.8 ± 0.1^{b}	3.2± 0.1^{bc}	9.3 ± 0.1^{c}	4.0 ± 0.1^{b}	0.9 ± 0.1^{c}	6.8 ± 0.1^{ab}
5.	4.6 ± 0.1^{c}	8.8 ± 0.1^{ab}	2.4 ± 0.1^{b}	4.6 ± 0.1^{cd}	8.4 ± 0.1^{c}	3.3± 0.1^{bc}	9.4 ± 0.1^{b}	4.1 ± 0.1^{b}	0.6 ± 0.1^{d}	6.1 ± 0.1^{d}
6.	4.7 ± 0.0^{bc}	7.9 ± 0.1^{d}	2.5 ± 0.0^{ab}	5.3 ± 0.1^{a}	7.6 ± 0.1^{e}	3.4± 0.1^{b}	8.9 ± 0.1^{c}	3.9 ± 0.1^{c}	0.5 ± 0.1^{d}	6.6 ± 0.1^{b}
7.	5.8 ± 0.1^{a}	8.4 ± 0.1^{c}	2.6 ± 0.1^{ab}	4.7 ± 0.1^{c}	8.3 ± 0.1^{d}	3.9± 0.1^{a}	9.1 ± 0.1^{c}	4.2 ± 0.1^{a}	2.4 ± 0.1^{a}	7.1 ± 0.1^{a}
8.	3.8 ± 0.1^{e}	6.55 ± 0.1^{e}	1.8 ± 0.2^{c}	5.1 ± 0.1^{a}	8.65 ± 0.1^{b}	3.1± 0.1^{bc}	9.6 ± 0.1^{a}	3.85 ± 0.1^{c}	0.4 ± 0.1^{e}	6.5 ± 0.1^{b}
9.	4.9 ± 0.1^{b}	8.85 ± 0.1^{ab}	2.5 ± 0.1^{ab}	4.85 ± 0.1^{b}	8.8 ± 0.1^{b}	2.8± 0.1^{d}	9.4 ± 0.1^{b}	3.3 ± 0.1^{d}	1.2 ± 0.1^{bc}	6.6 ± 0.1^{b}
10.	4.3 ± 0.1^{d}	9.0 ± 0.1^{a}	2.35 ± 0.1^{b}	4.6 ± 0.1^{cd}	7.6 ± 0.1^{e}	3.4± 0.1^{bc}	9.6 ± 0.1^{a}	4.1 ± 0.2^{b}	1.3 ± 0.1^{b}	6.3 ± 0.1^{dc}
GM +SE	4.52 ± 0.4	8.365 ± 0.5	2.33 ± 0.2	4.77 ± 0.2	8.45 ± 0.3	3.45± 0.1	9.12 ± 0.3	4.02 ± 0.2	1.17 ± 0.4	6.58 ± 0.2
Pr	0.0001	0.0001	0.0006	0.004	0.0001	0.0002	0.0001	0.0003	0.0001	0.0016
$LSD_{0.05}$	0.3627	0.3558	0.3229	0.3379	0.2905	0.3151	0.4017	0.3071	0.31 51	0.2151

Mean values in column followed by the same letters are not significantly different at 0,05 significant levels.

1=Ram 86, 2=Ram24, 3=IR-77674-B-20-1-2-1-3-12-B, 4=IR 77674-3B-B-8-2-2-20-4,5=NERICA 1, 6=WAB 450, 7=WBK-B-B-B-F_4 8=WBK-106-B-1-F_3 9=WBK-35-B-B-4-F_3, 10=WBK 42-B-B-2-F_4

TABLE 4.3 Variation in amino acids profile among 10 rice varieties after pre- cooking (mg/ml)

Var.	Lysine	Arginine	Histidine	Isoleucine	Leucine	Cy/Meth	Ty/Ph	Threonine	Tryp tophan	Valine
1.	4.6 ± 0.3^{a}	8.8 ± 0.1^{a}	2.4 ± 0.1^{a}	4.4 ± 0.1^{d}	8.1 ± 0.1^{d}	3.6± 0.1^{b}	9.3 ± 0.1^{b}	4.0 ± 0.1^{c}	0.9 ± 0.1^{c}	6.7 ± 0.1^{a}
2.	3.6 ± 0.1^{d}	8.0 ± 0.1^{c}	1.95 ± 0.1^{c}	4.9 ± 0.2^{b}	8.1 ± 0.1^{d}	3.8± 0.2^{a}	9.8 ± 0.1^{a}	4.2 ± 0.1^{c}	1.3 ± 0.1^{b}	6.7 ± 0.2^{a}
3.	4.4 ± 0.2^{b}	8.75± 0.1^{a}	2.4 ± 0.1^{a}	4.5 ± 0.2^{d}	8.9 ± 0.1^{a}	3.9± 0.1^{a}	9.3 ± 0.1^{b}	4.3 ± 0.1^{b}	1.3 ± 0.1^{b}	6.3 ± 0.1^{c}
4.	4.5 ± 0.1^{a}	8.4 ± 0.1^{c}	2.4 ±0.1^{a}	4.5 ± 0.2^{d}	8.8 ± 0.2^{a}	3.2± 0.1^{c}	9.0 ± 0.1^{c}	4.9 ± 0.1^{a}	1.0 ± 0.1^{c}	6.6 ± 0.1^{b}
5.	4.5 ± 0.0^{a}	8.6 ± 0.1^{b}	2.4 ± 0.1^{a}	4.5 ± 0.1^{d}	8.4 ± 0.1^{c}	3.3± 0.1^{c}	8.4 ± 0.1^{b}	4.1 ± 0.1^{c}	0.7 ± 0.1^{d}	6.1 ± 0.1^{d}
6.	3.6 ± 0.1^{d}	7.3 ± 0.1^{d}	2.6 ± 0.0^{a}	5.9 ± 0.1^{a}	7.8 ± 0.1^{e}	3.6± 0.1^{b}	9.3 ± 0.1^{b}	4.0 ± 0.1^{c}	0.8 ± 0.1^{d}	6.4 ± 0.1^{b}
7.	3.7 ± 0.2^{d}	8.5± 0.1^{b}	2.0 ± 0.1^{b}	4.9 ± 0.1^{b}	8.2 ± 0.0^{d}	3.8± 0.1^{a}	9.1 ± 0.0^{c}	4.5 ± 0.2^{b}	0.5 ± 0.1^{e}	6.9 ± 0.1^{a}
8.	4.7 ± 0.1^{a}	6.2 ± 0.1^{e}	1.9 ± 0.1^{c}	5.0 ± 0.2^{b}	8.6 ± 0.1^{b}	3.1± 0.1^{c}	9.6 ± 0.1^{a}	3.8 ± 0.1^{d}	2.3 ± 0.1^{a}	6.3 ± 0.1^{c}
9.	4.2 ± 0.2^{c}	8.8 ± 0.1^{a}	2.4 ± 0.1^{a}	4.8 ± 0.1^{c}	8.4 ± 0.1^{c}	2.8± 0.1^{d}	9.6 ± 0.1^{a}	3.8 ± 0.1^{d}	0.3 ± 0.1^{f}	6.3 ± 0.1^{c}
10.	4.4 ± 0.1^{b}	8.8 ± 0.1^{a}	2.3 ± 0.1^{b}	4.4 ± 0.1^{d}	8.1 ± 0.1^{d}	3.0± 0.1^{c}	9.0 ± 0.1^{c}	4.1 ± 0.2^{c}	0.9 ± 0.1^{c}	6.6 ± 0.1^{b}
GM +SE	4.22 ± 0.3	8.12 ± 0.6	2.27 ± 0.2	4.69 ± 0.2	8.33 ± 0.3	3.41± 0.3	9.19 ± 0.3	4.17 ± 0.2	1.0 ± 0.4	6.5 ± 0.18
Pr	0.0023	0.0001	0.0080	0.0122	0.0003	0.0002	0.0002	0.0003	0.0001	0.0056
$LSD_{0.05}$	0.4907	0.3267	0.3229	0.3379	0.2367	0.3190	0.3190	0.2989	0.2989	0.3151

Mean values in column followed by the same letters are not significantly different at 0,05 significant levels.

1=Ram 86, 2=Ram24, 3=IR-77674-B-20-1-2-1-3-12-B, 4=IR 77674-3B-B-8-2-2-20-4,5=NERICA 1, 6=WAB 450, 7=WBK-B-B-B-F_4 8=WBK-106-B-1-F_3 9=WBK-35-B-B-4-F_3, 10=WBK 42-B-B-2-F_4

TABLE 4.4 Comparison of different amino acids(aa) in 10 rice varieties before pre- cooking in (mg / ml)

aa.	1	2	3	4	5	6	7	8	9	10
Lysine	4.6^{d}	4.2^{c}	4.9^{d}	4.6^{f}	3.8^{g}	4.4^{d}	4.6^{d}	4.7^{c}	5.9^{d}	3.8^{e}
Arginine	8.4b	8 .4^{b}	8.8^{b}	9.0^{b}	8.8^{b}	8.6^{b}	8.8^{b}	7.9^{b}	8.4^{d}	6.6^{e}
Histidine	2.8^{g}	1 .8^{g}	2.5^{g}	2.4^{h}	2.3^{h}	2 .3^{h}	2.4^{g}	2.5^{h}	2.6^{g}	1.8^{g}
Isoleucine	4.8^{d}	4 .8^{d}	4.9^{d}	4.6^{e}	4.4^{e}	4 .6^{e}	4.6^{d}	5.3^{d}	4.7^{e}	5.1^{d}
Luecine	8.5^{b}	8 .2^{b}	8.8^{b}	8.0^{b}	9.3^{a}	8 .8^{b}	8.4^{c}	7.6^{b}	9.1^{a}	8.7^{b}
Cy/Meth	3.4^{f}	3.5^{f}	2.8^{g}	3.4^{f}	4.0^{f}	3 .2^{f}	3.3^{f}	3.4^{g}	3.9f^{e}	3.1^{f}
Ty/Ph	9.7^{a}	8 .8^{a}	9.4^{a}	9.6^{a}	7.4^{d}	9 .3^{a}	9.4^{a}	8.9^{a}	9.1^{a}	9.6^{a}
Threonine	4.0^{e}	4 .1^{e}	3.3^{f}	4.1^{e}	4.3^{e}	4 .0^{e}	4.1^{e}	3.9^{f}	4.6^{e}	3.9^{f}
Tryptophan	0.8^{h}	1 .2^{h}	1.2^{h}	1.3^{h}	1.2^{h}	0 .9^{i}	0.6^{i}	0.5^{i}	2.4^{g}	0.4^{i}
Valine	6.8^{c}	6 .6^{c}	6.6^{c}	6.3^{d}	6.4^{d}	6 .8^{c}	6.1^{c}	6.6^{c}	7.1^{c}	6.5^{c}
M + SE	5.575	5.316	5.275	5.445	5.413	5.295	5.829	5.170	5.451	5.491
Pro	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
$LSD_{0.05}$	0.3445	0.3502	0.3049	0.2742	0.3328	0.2848	0.3238	0.3336	0.3586	0.2777

Mean values in column followed by the same letters are not significantly different at 0,05 significant levels.

1=Ram 86, 2=Ram24, 3=IR-77674-B-20-1-2-1-3-12-B, 4=IR 77674-3B-B-8-2-2-20-4,5=NERICA 1, 6=WAB 450, 7=WBK-B-B-B-F_4 8=WBK-106-B-1-F_3 9=WBK-35-B-B-4-F_3, 10=WBK 42-B-B-2-F_4

TABLE 4.5.Comparison of different amino acids (aa) in different rice varieties after pre- cooking in (mg / ml)

aa.	1	2	3	4	5	6	7	8	9	10
Lysine	4.6^{d}	3.6^{f}	4.2^{f}	4.4^{d}	4.4^{e}	4.5^{e}	4.5^{c}	3.6^{g}	3.7^{f}	3.6^{f}
Arginine	8.8b	8 .0^{b}	8.8^{b}	8.8^{a}	7.8^{c}	8.4^{b}	8.6^{a}	7.3^{c}	8.5^{b}	6.2^{d}
Histidine	2.4^{h}	2 .0^{g}	2.4^{i}	2.3^{f}	2.4^{g}	2 .4^{g}	2.4^{g}	2.6^{h}	2.0^{g}	1.9^{g}
Isoleucine	4.4^{e}	4 .9^{d}	4.8^{e}	4.4^{d}	4.5^{e}	4 .6^{e}	4.6^{e}	4.9^{e}	4.9^{d}	5.0^{e}
Luecine	8.1^{b}	8 .1^{b}	8.4^{c}	8.1^{b}	8.9^{b}	8 .8^{a}	8.4^{a}	7.8^{b}	8.2^{b}	8.6^{b}
Cy/Meth	3.6^{g}	3 8^{f}	2.8^{h}	3.0^{e}	3.9^{f}	3 .2^{f}	3.3^{e}	3.6^{g}	3.8f	3.1^{h}
Ty/Ph	9.3^{a}	9 .8^{a}	9.6^{a}	9.0^{a}	9.3^{d}	9 .0^{a}	8.4^{a}	9.3^{a}	9.1^{a}	9.9^{a}
Threonine	4.0^{f}	4 .2^{e}	3.8^{f}	4.1^{d}	4.3^{e}	4 .9^{d}	4.1^{d}	4.0^{f}	4.5^{e}	3.8^{f}
Tryptophan	0.9^{h}	1 .3^{h}	0.3^{i}	0.9^{g}	1.3^{h}	1 .0^{h}	0.7^{g}	0.8^{i}	0.5^{h}	2.3^{f}
Valine	6.7^{d}	6 .7^{c}	6.3^{d}	6.6^{c}	6.3^{d}	6 .6^{c}	6.1^{d}	6.4^{d}	9.9^{c}	6.4^{c}
M + SE	5.475	5.483	5.520	5.463	5.229	5.266	5.413	5.342	5.313	5.296
Pro	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
$LSD_{0.05}$	0.4266	0.3328	0.3358	0.3474	0.3049	0.3113	0.0220	0.3328	0.3 358	0.2742

Mean values in column followed by the same letters are not significantly different at 0,05 significant levels.

1=Ram 86, 2=Ram24, 3=IR-77674-B-20-1-2-1-3-12-B, 4=IR 77674-3B-B-8-2-2-20-4,5=NERICA 1, 6=WAB 450, 7=WBK-B-B-B-F_4 8=WBK-106-B-1-F_3 9=WBK-35-B-B-4-F_3, 10=WBK 42-B-B-2-F_4

TABLE 4.6 Comparison of variation in total protein and amino acids(aa) in 10 rice varieties before and after pre- cooking in (mg / ml)

TRAITS	1	2	3	4	5	6	7	8	9	10
Lysine	ns	ns	***	ns	ns	ns	ns	ns	ns	ns
Argnine	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Histidine	ns	ns	ns	***	ns	ns	ns	ns	ns	ns
Isoleucine	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Leucine	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cyst/ meth	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tyr/phe	ns	ns	***	ns	***	ns	ns	ns	ns	ns
Threonine	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tryptophan	ns	ns	ns	ns	ns	ns	***	***	ns	ns
Valine	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
T. protein	ns	***	***	ns	ns	***	ns	ns	***	***

Ns = not significant different, * = significant at P $\leq$ 0.01**

TABLE 4.7 Correlation coefficient relationship between varieties and amino acids profile before and after pre- cooking

Varieties	amino acids profile correlation coefficient
RAM 86	1.0
RAM 24	0.9
IR 77674-B-20-1-2-1-3-12-B	1.0
IR 77674-3B-B-8-22-20-4	1.0
NERICA 1	0.8
WAB 450	0.9
WBK 150-B-B-B-F_4	1.0
WBK 106-B-1-F_3	0.9
WBK 35-B-B-4-F_3	1.0
WBK 42-B-B-2-F_4	1.0

TABLE 4.8 Mean square, variance ratio and coefficient variation of amino acids.

TRAITS	GMS	MSE	MEAN	VR	CV%
Lysine	0.70	0.02	4.51	26.50***	3.60
Argnine	1.03	0.02	8.37	40.39***	1.90
Histidine	0.21	0.02	2.33	10.33***	6.21
Isoleucine	0.14	0.02	4.77	6.05***	3.17
Leucine	0.46	0.02	3.45	27.06***	1.56
Cyst/ meth	0.24	0.02	3.40	12.44***	4.15
Tyr/phe	0.90	0.03	9.12	27.90***	1.31
Threonine	0.22	0.01	4.02	11.59***	3.42
Tryptophan	0.65	0.02	1.05	32.96***	13.46
Valine	0.16	0.02	6.58	07.96***	2.14
T. protein	2.49	0.02	10.11	12.43***	1.39

***** = significant at p ≤ 0.01, VR = variance ratio, CV = coefficient of variation**

TABLE 4.9 genetic, environmental, phenotypic variances and heritability among varieties

TRAITS	Vg	Ve	Vp	H^2
Lysine	0.034	0.02	0.035	0.97
Argnine	0.050	0.02	0.051	0.98
Histidine	0.009	0.02	0.010	0.90
Isoleucine	0.006	0.02	0.007	0.85
Leucine	0.022	0.02	0.023	0.95
Cyst/ meth	0.011	0.02	0.22	0.50
Tyr/phe	0.044	0.03	0.046	0.96
Threonine	0.011	0.01	0.012	0.92
Tryptophan	0.032	0.02	0.033	0.97
Valine	0.007	0.02	0.008	0.88
T. protein	0.124	0.02	0. 125	0.99

Vg = genetic variance, Ve = environmental variance, Vp = phenotypic variance and H^2 = broad sense heritability

DISCUSSION

This result provided an insight into the protein content of these ten rice species before and after pre- cooking. The result of this research indicates that the hybrid progeny recorded the highest protein content of 13.0 % before pre-cooking, which is a

welcome development. It has been documented that most diets in developing countries are deficient in protein, especially essential amino acids (Ladeji et al; 1995). Several studies have shown that children and adults consume less than 10 % protein per day which is lower than the recommended daily requirement of 16 % protein (Byrd-Bredbenner, 2002). Result showed that the new variety WBK 150-B-B-B-F_4 with protein value 0f 13.0 $\pm$ 0.1% has the potential of meeting 16 % daily protein requirement in children.

Result of the experiment indicated that total protein after pre-cooking decreased remarkably in some varieties, but most prominent in RAM 24, IR 77674-B-20-1-2-1-3-12-B, WBK 42-B-B-2-F4, WBK 35-B-B-4-F_4 which recorded significant decrease in total protein content after pre- cooking. This result is in agreement with the work of Juliano (1993), who affirm that washing and cooking lead to 2 – 7% nutrient lost. The amino acids values obtained in this research work are much higher than the figure obtained by Oko et al., (2012) in their new rice variety E4212 with protein value of 7.94 %. The protein value of our new varieties are in agreement with the result of Koichi et al; (2013) who asserted that milled NERICA varieties have protein values ranging from 8.33– 13.64%. The protein values obtained in this research work is generally high in all the varieties and there are relative balance in protein composition with values ranging from 9.5 – 13.0 % which is within the range obtained by Koichi et al; (2013) in NERICA varieties.

The result also indicated that there were significant variations in total protein content among varieties ($P \leq 0.05$). .This research finding in table II supports the work of Kim et al (2009) who assert that protein content varies in O. sativa. The work was also supported by the finding of Juliano and Villareal (1993), who reviewed that the protein content in rice varies between varieties. The protein values obtained in this research work were generally high in all the varieties and are relative balanced in protein composition with values ranging from 13.0 – 9.5 % which is within the range obtained by Koichi et al; (2013) in NERICA varieties. It has been documented that most diets in developing countries are deficient in protein, especially essential amino acids (Ladeji et al; 1995). Several studies by (Byrd-Bredbenner, 2002) have shown that children and adults consume less than 10 % protein per day which is lower than the recommended daily requirement of 16 % protein. Result showed that the new variety WBK 150-B-B-B-F_4 has the potential of meeting 16 % daily protein requirement in children.

Research results showed that the level of essential amino acids in ten rice varieties are relatively adequate except in cystine/methionine and tryptophan in which their grand mean values are 3.45$\pm$ 0.25 and 1.17$\pm$ 0.40 respectively. More so, results indicated that these rice varieties and progenies were of high quality since it contains all the essential amino acids (Table 4.2). However, this research result was not in accordance with the result of Enwere, (1998). Who assert that amino acids in plant

ranged 7- 9%. But was in line with the work of Khidir et al, (2002) who revealed that there were variability in amino acids compositions between rice species. The result also revealed that there were significant variations in amino acids content observed in some varieties before and after pre-cooking, indicating that pre-cooking also leads to decreased amino acids composition (table 4.6).. These rice varieties are of high quality since it contained all the essential amino acids. This claim was further substantiated by the work of Karina et al., (2013). Who affirm that rice protein contain all the essential amino acids.

Pre-cooking is cooking process engaged by some rice consumers in other to make sure that there rice were well washed of all impurities. However, this research work have shown that nutrient lost occur as a result of this pre-cooking practice (table 4.6). It is therefore advisable for rice consumers most especially poor and the less privileged one who cannot afford costlier protein food in their meals to disengage in this practice. The research results showed correlation coefficient of between 0.8 – 1.0 This positive correlation coefficient indicates strong relationship between amino acids of the parent rice varieties and there hybrid progenies. In other words the progenies are closely related to the parent in amino acids composition (table 4.7).

The mean, mean squares, error mean square, variance ratio and coefficient of variation are summarized in (Table 4.8). The amino acids have high mean values except tryptophan and histidine. This result is similar to the finding of Karina et al., (2013) who assert that oryza gumaepatula accessions contain high level of protein and amino acids except tryptophan. The content of these amino acids showed large variation among parents and hybrid progenies (Table 4.8) which indicated that it was possible to improve the nutrient traits of hybrid rice. This result was in accordance with the work of Wu et al., (2004) who indicated that large variation in parent and hybrid indica rice can result to improving it nutrient traits. The high coefficient variation observed in histidine, cyst/meth, and tryptophan indicates high variability and instability while low coefficient variation in arginine, leucine, tyrocine/phenylalanine, and total protein indicate low variability and high stability.

Estimation of genetic variance, environmental phenotypic variance and broad sense heritability

Estimates of genetic variance, environmental variance, phenotypic variance and broad sense heritability are summarized in (Table 4.9). The variation observed in a particular trait could be as a result of genetic factors or environmental factors. The broad Heritability in the work was high, this implies that the progenies resembles the parents genetically. The performances of lysine, arginine, tyrosine/phenylalanine, tryptophan, and total protein are controlled more by genetic effect than the

environmental effect because the values of genetic variances are higher than the values of their environmental variance, in other words majority of the phenotypic expression are contributed by the genetic traits and less by the environmental effluence. But the performances of histidine, isoleucine, cyst/meth and valine are controlled
more by environmental factors than the genetic factors because values of their environmental variances are higher than their genetic variance (table x). Broad sense heritability is high. This implies that the hybrid species resembles the parent genetically. The broad sense heritability H^2 ranged 50% - 99%, total protein content has the highest value of 99% while cyst/meth has the lowest value of 50%.

CONCLUSION

The variation in total protein content and amino acids among the ten rice varieties are contributed by both genetic and environmental factors. It was also shown in the research result that broad sense heritability was high with values ranging from 0.5 – 0.99, indicating that the hybrid progenies are genetically stable. The rice varieties under consideration have proved to contain all the essential amino acids which determine the quality of protein and nutrient quality of rice and therefore can make good nutrient. It was also observed in this research work that some varieties recorded significant decrease in protein and amino acids content before and after pre-cooking, indicating that pre-cooking results to nutritional lost. While the decrease was prominent in total protein content it was less pronounced in amino acids profile. Therefore, pre-cooking result to loss in protein nutrient. The correlation coefficient revealed that amino acids content amongst rice genotypes are positively correlated. The research result also indicates strong genetic resemblance between parent and hybrid. However, the broad sense heritability result indicates that environment also play some roles in the variation recorded in protein and amino acids amongst the varieties. However, the overall results indicate that there was significant variation in amino acids content of the entire genotypes.. Some of the new breed such as WBK 150-B-B-B-F_4 and WBK 42-B-B-2 F_4 have appreciable level of protein composition and amino acids value compared to their parent stock.

RECOMMENDATION

The hybrid progenies (WBK 150-B-B-B-F_4 and WBK 42-B-B-2 F_4) are recommended for growth and commercial production since they have improved agronomic and nutrient values. Information from this research work will help to fully characterize these hybrid progenies since they are still breeders' seed. Other nutritional parameters such as carbohydrate, lipid, vitamin and mineral composition of those varieties could also be investigated. Fertilizer application and soil fertility could be

further evaluated on since these also affect the protein and amino acids composition of rice. These will help to fully characterize the new variety

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FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

EVALUATION OF FUNCTIONAL PROPERTIES OF STARCH EXTRACTED FROM DEFATTED NATURAL RUBBER SEED MEAL

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Abstract:

Starch extracted from defatted natural rubber seed meal had been analyzed for its functional properties. Starch was isolated from the sample using 0.2 % NaOH solution. The deffated natural rubber seed meal had high content of starch; 82.9 – 88.8 g/100g. The functional properties of the starch showed that water absorption capacity (WAC) ranged between 275 to 280 %; oil absorption capacity (OAC), 316 to 372 % and least gelation concentration (LGC) 6 to 10 % (w/v). The results of the effect of ionic concentration on gelation of the starch showed that least gelation concentration ranged between 4.0 and 10.0 % (w/v). The swelling power and solubility of the starch of the defatted rubber seed flour ranged between 36.3 to 37.3 % and 4.0 to 8.0 % respectively. The results generally revealed that both swelling power and solubility of the starch were highly pH dependent.

Keywords: *Evaluation, Functional Properties, Starch, Extraction, Defatted, Natural Rubber, Seed Meal.*

Introduction

The major economic importance of the natural rubber tree has traditionally been based on the latex, a colloidal milky liquid suspension of very small particles produced by bark tapping (Cook, 1962; Webster and Paardekooper, 1989; Backhaus, 1985 and Ko et al., 2003) which is used in the manufacture of wide range of industrial and domestic products. Over the years, little attention was paid to the utilization of the rubber seeds except as sources of seedlings (Nwankwo et al., 1986) while the ones left in the bush would either rot or consumed by rodents and other animals (Uzu et al., 1986).

Rubber seed has been reported to have a lot of potentials for preparation of various industrial and household products. It has been recognized that the seeds of rubber was a potential source of a good vegetable (Uzu et al, 1986). Unconfirmed report had shown that dry rubber seed kernels when crushed were used as some thickeners by

certain communities in Delta and Edo States, Nigeria (Uzu et al 1986). In Indonesia, it was reported that after adequate treatment, rubber seed was in the diet of people in rubber plantations (Stosic and Kaykay, 1981).

The major products of the rubber seeds are the meal or the flour and its oil which are produced by mechanical pressing (Hardjosuwito and Hermans, 1987) and or by solvent extraction (Nwokolo and Akpapunam, 1985) while the cake is the defatted seed meal. The seed meal or the cake has been reported to have high digestible nutrients than some conventional seed meals and is highly promising as further protein supplements in livestock and animal dietary (Stosic and Kaykay, 1981; Babatunde and Pond, 1988; Nguyen and Duong, 2003).

Natural rubber is a polymer, with a high a molecular weight compounds consisting of long chains of one or more types of molecules, called monomers (Cook, 1962; Adeosun, 2004; Brydson, 1978). Vulcanization (or curing) produces chemical links between the loosely coiled polymeric chains. Elasticity occurs because the chains can be stretched and the cross links cause them to spring back when the stress is released.

Starch is the major reserve polysaccharides of higher plants where it occurs in storage organs such as seeds, tubers or roots and also in smaller quantities in stem and leaves. It exists as water insoluble, roughly spherical granules whose shape, size and size distribution are characteristics of the particular plant species (Banks and Muir, 1980). Depending upon the source, starch granules can range from 0.5 to 175m in diameter (Thomas, 1988). The molecular structure within the granules is ordered and at least partially crystalline as evident from optical, thermal and X-ray studies (Manners, 1968).

Starch from various sources has received more attention in the recent times in the area of purity, yield and its resistance to abiotic stress (Ceballos et al., 2006; Benesi, 2005). Some of these starch sources have low acceptability among farmers and suitability for dietary and industrial applications. Various starches from different sources have been studied for granule structure, pasting properties, functional properties such as swelling and solubility, X – ray diffraction and thermal analyses (Gomes et al., 2005; Zaidu et al., 2007), and some of these sources need to be improved to meet up with the demand of dietary and industrial applications. A lot of breeding programmes aimed at producing cultivars with high quality starch from different sources of starch have been initiated.

The functional properties are chemicals which affect whichbhe processing and behaviour in food systems as judged by the quality attributes of the final product

(Acobundu et al., 2003). These basically show the interaction between the structure, conformation, physicochemical properties of starch, other food components and the nature of the environment in which these are measured or associated (Marcone, 2000). The functional properties are influenced by and vary according to the source of starch and other food components, method(s) of isolation, precipitation, drying, concentration modifications and several environmental conditions such as temperature, pH and ionic strength. These parameters affect solubility and other related properties (Aluko and Yada, 1995).

Starches are usually composed of several discrete different properties, thus functionality associated with certain starch preparations may not reflect the properties of the total starch, but rather that of the components (Chel-Guerrero et al, 2002).

As a result of this, systematic determination of functional properties should be made when developing new sources of starches. This is to evaluate and possibly help predict how new starches may behave in specific systems, as well as demonstrate whether or not such starches can be used to replace conventional ones.

METHODOLOGY

SOURCES OF RAW MATERIALS

The rubber seed used in this study are from cultivated and uncultivated rubber trees collected from three towns in Ekiti and Ondo States of Nigeria. The uncultivated or wild rubber seeds otherwise called Funtumia elastica are from Odo-owa and Ado-Ekiti in Ekiti State of Nigeria. The cultivated rubber seed otherwise known as Hevea brasilliensis were collected from Federal School of Agriculture, Akure Ondo State of Nigeria. The rubber seed flour after grinding before it was extracted is undefatted while after it was extracted using hexane is defatted and after extraction using 2% NaOH, is starch samples.

The rubber seeds were handpicked from the ground from various sampling points. After obtaining the seeds, they were cleaned and separated from sand, pebbles and other dirty materials. The seeds were also cracked followed by separation of the shell/pods from the seed. The resultant kernels were later taken out for drying. The seed kernels were dried in the oven at 60 ^{0}C for 48 hours in order to ensure its dryness to constant weight.

ISOLATION AND PURIFICATION OF STARCH

Dried rubber seeds were milled to fine powder and sieved using 75µm sieve. The oil from the flour was later extracted using n-hexane. The defatted rubber seed flour was stored in polythene bags and kept in a refrigerator prior to use.

1kg of the defatted flour sample was soaked in four litres of distilled water and the pH was adjusted to between 8.0 and 8.5 using 0.2% (w/v) of NaOH solution at 4^{o}C for 12

hours. The defatted flour was blended for 30 minutes using warring blender. The slurry obtained following the blending was re-suspended in 5 litres of distilled water and the pH was adjusted to 8.0, using 0.5M NaOH solution. While keeping the pH at 8.0 – 8.5 the mixture was stirred manually for 30 minutes. The suspension obtained was sieved using 75 µm sieve and centrifuged for 30 minutes at 10,000 rpm. The starch obtained was washed with water twice before drying in the air for 48hours. It was stored in polythene bag until use.

FUNCTIONAL PROPERTIES OF STARCH

Functional properties (water and oil absorption capacity, swelling power, solubility, effect of pH on swelling power and solubility, effect of temperature on swelling power and solubility, gelation studies, effect of pH on gelation) of the starch extracted from the deffated natural rubber seed meal was carried out using standard procedures as described by Sathe and Salunkhe, (1981).

RESULTS

Table 1 Functional properties of starch extracted from rubber seed flour

%	RSSAD	RSSAK	RSSOD
WAC	280	275	280
OAC	353	372	316
LG	6.0	4.0	6.0
SP	37.3	36.3	36.8
S	6.0	8.0	0.52

RSSAD = sample Ado, RSSAK = sample Akure, RSSOD = sample Odo Owa

WAC = Water Absorption Capacity
OAC = Oil Absorption Capacity
LG = Least Gelation
SP = Swelling Power
S = Solubility

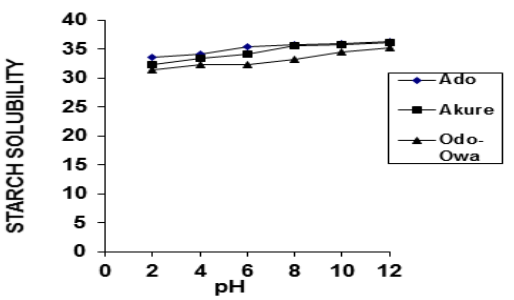

Fig 1: Effect of pH on Solubility of the Starch extract from defatted rubber seed flour

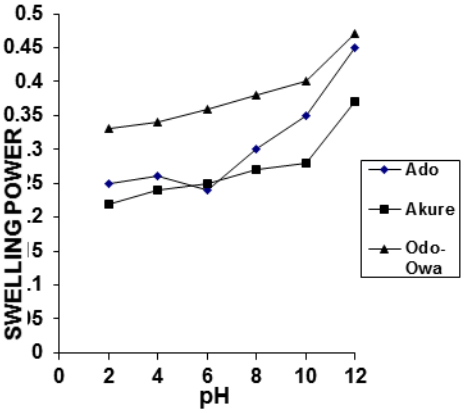

Fig 2: Effect of pH on Swelling Power of the Starch extract from defatted rubber seed flour

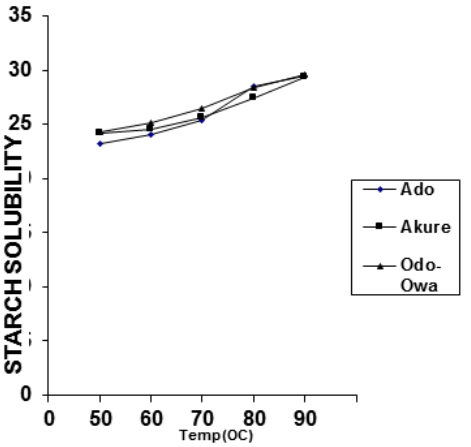

Fig 3: Temperature effect on solubility of starch extracted from rubber seed flour

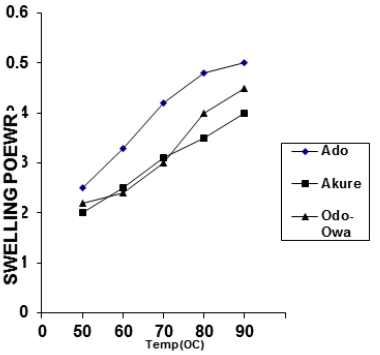

Fig 4: Temperature effect on swelling power of starch extracted from rubber seed flour

Table 2: Thermal / gelatinization properties of starch extracted from rubber seed flour

Samples	To(°C)	Tp(°C)	Tc(°C)	? Hgel(J/g)	PHI(J/g/°C)	R(°C)
RSSAD	99.30	123.54	144.56	1292.37	5.96	48.48
RSSAK	99.90	121.57	150.19	5806.05	267.93	43.34
RSSOD	100.33	121.18	146.65	7852.08	376.60	41.70

To = Onset Temperature
Tp = Peak Temperature
Tc = Conclusion Temperature
R = Gelatinization Range 2(Tp – To)
ΔHgel = Enthalpy of Gelatinization
PHI = Peak Height Index

DISCUSSION

Tables 1 presents the functional properties of starch from rubber seed flour. The Water absorption capacity (WAC) ranged from 275 – 280%. The values obtained for all the samples were generally higher than the values reported for soybean flour with 130% (Humbert and Soluski, 1974), fluted pumpkin with 85% (Fagbemi and Oshodi, 1991) and 120% for lupin seed flour (Sathe et al., 1982) but in agreement with the report of ripe and unripe banana flour which ranged from 250 – 338% according to Fagbemi, (1999).

The high values of WAC are an index of its ability to absorb and retain water which in turn influences the texture and mouth feel of food products.

The oil absorption capacity (OAC) of the starch from the rubber seed flour ranged from 316 – 372%. The starch extracts have high OAC than taro flour 190%; pigeon pea 89.7% (Oshodi and Ekperijin, 1989); chick pea, 140% (Bencini, 1986); yam beans 142% (Edem et al., 1990). The report is in agreement with those reported for ripe and unripe banana flour which ranged from 225 – 371% (Fagbemi, 1999). Oil absorption capacity is attributed to the physical entrapment of oil and this influences the flour retainer and mouth feel of food products such as ground meat formulations, doughnuts, pancakes, baked goods and soups (Kinsella, 1976; Akinyede et al., 2005).

The least gelation concentration (LGC) of the starch from the rubber seed flour recorded 4 – 6% (m/v) as seen on table 1. The LGC value for RSSAK gave 4% (m/v) while that of RSSAD and RSSOD gave 6% (m/v). Generally the RSFAK had a better gelating ability than the others. This could probably due breeding pattern in the plant

as compared to the wild or uncultivated pattern of RSFAD and RSFOD. It has been reported that a cassava starch in Uganda varieties had been undertaken to improve them by crossing them using hybridization method. It was observed that there was tremendous improvement on the physicochemical and functional properties of the starch (Nuwamanga et al., 2010).

Looking at the general trends of all the samples, it was observed that RSSAK has better gelation ability than RSSAD and RSSOD. This could be probably due to the effect of plant breeding available in the plant. RSSAK is Hevea brasiliensis and it is a cultivated rubber seed, unlike the others. It has been reported that well bred lucerne plant flour using dialled crosses was analysed for functional properties (Chloupek and Plhak, 1986) and the results showed that the functional properties was influenced mainly by the breeding method.

The effects of temperature or pH on solubility and swelling power of the starch from the rubber seed flour are shown in figures 1 to 4 respectively. The style of swelling varied from one sample to another. The pattern of swelling also followed the same trend with that of solubility as they are both pH and temperature dependent. The results also show that the highest swelling power of all the samples was observed at pH 12 while the lowest swelling power observed at pH 2. There is a progressive increase from pH 2 to 12. It has been reported that under alkaline conditions, starch may undergo partial gelatinization, thus resulting in high swelling power. This probably accounts for higher swelling power of the starch at the extremes of alkaline range as reported by Adebowale and Lawal, (2003).

The thermal / gelatinization results are presented in Table 10. The onset gelatinization temperature for all the samples ranged from 99.30 to 100.33^{o}C while that of the peak temperature ranged from 121.18 to 123.54^{o}C and conclusion temperature ranged from 144.56 to 150.19^{o}C. All the values obtained are (Chavan et al., 1999); field pea, (Ratnayake et al., 2001); black bean, chide pea and pinto bean (Hoover and Ratnayake, 2002).

The enthalpies of gelatinization ranged from 1292.32 to 7852.08J/g. The values from the literature for potato starch, (Kaur et al., 2007); legumes starch (Adebowale and Lawal, 2003); and starch from pigmented maize (Agama – Acevedo et al., 2005). High values obtained in the ΔHgel of the rubber seed starches are a reflection of the granular composition of the starch. It has been reported that the gelatinization of a starch is controlled in part by molecular structure of amylopectin crystallites, starch composition and granule architecture, which entails crystalline to amorphous ratio. Meanwhile the peak height index (PHI) of the samples ranged from 5.96 to 376.60J/g/^{o}C. This is higher than the values obtained for potato (Kaur et al., 2007). PHI is the ratio ΔHgel of the gelatinization range (R) and is a measure of uniformity of gelatinization. The difference in PHI values probably may be due to the difference in composition and granule structures among the various starches of the rubber seed flour (Kaur et al., 2007).

CONCLUSION

Choosing the source of starch for a particular industrial application is dependent on the desired functional property for such industrial process. Uncultivated specie of rubber seed, for example, proved to be a better product to choose as source of starch product where swelling is important because it gives highest yield at low temperature which suggests that the operating system in such plant could be kept at low temperature and yet a good product will be obtained. However, the cultivated specie of rubber seed (Akure) gave better starch property where hydrophilic property is desired.

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FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

RESPONSE OF ONION (*Allium Cepa*) PLANTED ON DIFFERENT FALLOWED SOILS IN SOUTHWESTERN NIGERIA

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Abstract:

The purpose of the present study was to investigate the response of onion planted on different fallowed soils. The Pot experiment was conducted at the Green house in the Teaching and Research Farm, Department of Agricultural Technology, of the Federal Polytechnic, Ado Ekiti. The treatments consisted of use of five different year-fallowed soils namely, No fallow (F_0), 1 year fallow (F_1), 2 year fallow (F_2), 3 year fallow (F_3) and more than 3 year fallow ($F_{>3}$) respectively. The experiment was laid out in a Completely Randomized Design (CRD) and replicated thrice. Soil Parameters evaluated were physical properties (Bulk density, moisture content and porosity) and chemical properties (pH, N, P, K, Ca, and Mg). Growth parameters evaluated were plant height and number of leaves) and Yield parameters were number of leaves per plant, bulb diameter and average yield of bulb). Result showed that soils on F_0 significantly ($p \leq 0.05$) had the lowest values for growth and yield parameters. However, onions grown on fallowed for 3 years and above (F_3 and $F_{>3}$) promoted significantly higher growth parameters than other treatment. The results also indicated that fallowed soils left for more than three years ($F_{>3}$) had significantly higher values for bulb diameter and the average weight of bulb than the non-fallowed soils (F_0). The result confirms better performances of onion under an improve conditions like prolonged fallowed soil conditions.

Keywords: *Fallow, Soils, Growth, Onion*

Introduction

Fallowing is an agricultural management technique practiced over many centuries by farmers to restore soil productivity after cropping, mainly by accumulation of nutrients, water, and/or organic matter (Sarmiento, 2000). Rain-fed agriculture alternating with unmanaged or natural fallow is widespread in

semiarid regions of Africa, but little information on changes in soil properties, soil degradation, or natural rehabilitation due to this practice is available. The primary reason for land fallowing is to stabilize crop production by forfeiting production in one or more season(s) in anticipation that there will be at least partial compensation by increased crop production the next season (Ikpe et al. 2003; Shock et al., 2013). Other objectives of land fallowing are to maximize soil water storage through improved water intake and decreased evaporation; maximize plant nutrient availability; minimize soil erosion hazards; and minimize energy and economic inputs (Miranda et al 2009). Soil texture determines water holding capacity, thereby influencing how well land is fallowed can buffer the influence of variable growing season precipitation on crop yield (Hulugalle et al. 1998). Generally, soils of the humid tropics are highly weathered and acidic, with pH ranging from 3.5 to 6.0 and mineralogy dominated by low activity clays. The important characteristics of low activity clay soils are low cation exchange capacity (CEC), which is normally less than 8 cmol kg^{-1} of soil, and low base saturation (Samake´ et. al., 2005). Type and length of fallow are also important for soil fertility restoration, improvement of soil properties and control of weeds (Cantero-Martinez et al., 2006).

Onion (Allium cepa L.) is an important vegetable crop valued for its pungent or mild flavour and for being the essential ingredient of the cuisine of many regions. World production of onion is estimated at over 61.6 million metric tons of bulb, and yield per hectare averaged 18.45tons with Nigeria's average yield put at 14.8 tons (FAOSTAT, 2006). Based on the level of consumption, onion is the major spice in the diet, ranking 5th most important vegetable in Nigeria (Denton and Ejeifo, 1990). Among the various factors affecting the yield of onions, adequate mineral nutrient management plays a major role to optimize the quality and quantity of the harvested plant products (Lakshmi and Sekhar, 2018). There is an acute shortage of onion in relation to its requirement therefore confined to semi-arid zones of Nigeria. This necessitates an improvement of per hectare yield, which is possible through adoption of fallow system which enhances high yielding varieties and rapid increase in crop population. Hence the farmers can in turn obtain good remuneration by producing this important crop through utilization of marginal lands owing to its increasing demand in local market and exportation commodity. Therefore, the objective of this study was to determine the performance of onion planted on different fallowed soils.

MATERIALS AND METHODS

The pot experiment was conducted in the Green house, Teaching and Research Farm of the Agricultural Technology department, Federal Polytechnic Ado-Ekiti. Soil samples were collected at 0-15 cm (topsoil) depth from different land left to fallow for different times, which were desired for the experiment. The soil properties were determined by using standard laboratory procedures as the soils were sent to the

departmental laboratory to analyze for organic carbon, total nitrogen, available phosphorus and exchangeable potassium. Particle sizes distribution was determined by the hydrometer method while Soil pH in CaCl2 (0.01M) was determined using glass electrode pH meter. The soil organic carbon was determined using the Walkley-Black method (Nelson and Sommers, 1982). The total nitrogen was determined by Kjeldahl digestion method (Bremner and Mulvaney, 1982) and the available phosphorus was determined using the Bray-1 method (Olsen and Sommers, 1982). The potassium (K) was determined using the flame photometer (Rhoades, 1982).

Experimental Design and Layout

Based on the previous use of land for over four (4) years within the teaching and research farm, Fallow soils were selected and collected from their respective sites and were subsequently arranged in pots inside the greenhouse. The treatments were No fallow (F_0), 1 year fallow (F_1), 2 year fallow (F_2), 3 year fallow (F_3) and more than 3 year fallow ($F_{>3}$) respectively. The experiment was laid out in a completely randomized design (CRD) due its simplicity with five treatments and three replications. Onion hybrid variety Bombe red seeds were raised in the nursery trays before transplanting into respective plots after four weeks.

Nursery Management: The nursery was watered every for 4-5 days to stimulate the release of nutrients. The onion seeds were drilled 20 cm apart. The pots were irrigated daily using watering can. Weeds were frequently removed as they emerge in the nursery by hand pulling.

Planting: The seedlings were transplanted when they are 10-15 cm long i.e. 30-35 days of sowing. The intra and inter-row spacing were 10 and 20cm respectively.

Irrigation: The irrigation of seedlings was done by surface irrigation method, where the water will be drawn from the source using watering can to convey the site and distributed to the pots.

Weeding: Weeding was carried out by hand picking.

Data Collection: Data on the growth and yield parameters were recorded.

Plant height (cm): This was measured at 3, 6, 9 and 12 Week After Transplanting (WAT). The process involved measuring the length of the seedlings using meter rule from the base to the aerial point of the plant.

Number of leaves: This was measured at 3, 6, 9 and 12 WAT by counting the number of leaves on site at the time.

Bulb diameter (cm): This was determined at harvest with the use of a venier caliper to take the circumference of the bulb.

Average weight of bulb: This was determined at harvest which involved weighing the bulbs harvested from each treatment plot using weighing balance.

Statistical analysis:The collected and recorded data from all the above parameters were analyzed using analysis of procedure for CRD in accordance with Gomez (1984). Significantly different means among the treatments were further be separated using least significant difference (LSD) at 5 % level of significance.

RESULTS

Table 1: Mean ± standard deviation of soil properties at 0 – 15 cm depth of the fallowed and non fallowed sites before experimentation.

Soil Property	F_0	F_1	F_2	F_3	$F_{>3}$
Sand (%)	78.00±1.50	77.00±1.50	77.00±1.00	75.00±1.00	72.00±2.00
Silt (%)	10.00±0.50	10.00±0.50	10.00±1.00	8.00±1.00	8.00±1.00
Clay (%)	12.00±1.00	13.00±1.00	13.00±1.00	17.00±1.00	20.00±1.00
pH (H_2O)	4.90±0.20	5.40±0.20	5.50±0.20	5.90±0.10	6.10±0.10
Organic C (%)	1.50±0.30	2.06±0.25	2.43±0.12	3.05±0.15	3.72±0.25
Total N (%)	0.12±0.02	0.23±0.03	0.27±0.02	0.40±0.03	0.46±0.02
Available P (mg kg^{-1})	6.40±1.04	11.20±2.30	10.80±1.20	8.80±1.00	12.60±1.50
Exch. K (Cmol kg^{-1})	0.09±0.01	0.14±0.01	0.14±0.01	0.16±0.01	0.20±0.03
Exch. Ca (Cmol kg^{-1})	1.48±0.23	1.66±0.20	1.75±0.12	2.92±0.32	2.84±0.30
Exch. Mg (Cmol kg^{-1})	0.27±0.03	0.27±0.03	0.28±0.02	0.37±0.02	0.45±0.03

F_0= Non fallowed soil, F_1=soil fallowed for 1 year, F_2= soil fallowed for 2 year, F_3= soil fallowed for 3 year, $F_{>3}$= soil fallowed for more than 3 year

Table 2: Effect of Fallowed soils on Plant Height (cm)

Fallow period	3 WAT	6 WAT	9 WAT	12 WAT
F_0	10.85	12.35	14.53	15.56
F_1	10.66	14.07	18.21	20.30
F_2	11.73	14.61	19.01	21.54
F_3	12.14	15.95	22.33	27.51
$F_{>3}$	12.50	16.76	24.08	30.85
LSD $_{(0.05)}$	NS	1.16	2.21	4.12

NS=Not Significant: F_0= Non fallowed soil, F_1=soil fallowed for 1 year, F_2= soil fallowed for 2 year, F_3= soil fallowed for 3 year, $F_{>3}$= soil fallowed for more than 3 year

Table 3: Effect of Fallowed soils on the number of leaves

Fallow period	3 WAT	6 WAT	9 WAT	12 WAT
F_0	3.00	3.00	3.33	4.00
F_1	3.00	3.00	4.00	5.67
F_2	3.33	3.33	5.00	7.23
F_3	3.33	4.00	6.55	7.85
$F_{>3}$	4.00	4.00	7.00	9.82
LSD $_{(0.05)}$	NS	NS	0.89	3.82

NS=Not Significant: F_0= Non fallowed soil, F_1=soil fallowed for 1 year, F_2= soil fallowed for 2 year, F_3= soil fallowed for 3 year, $F_{>3}$= soil fallowed for more than 3 year

Table 4: Effect of Fallowed soils on the yield of Onion

Fallow period	No of leaves/plant	Bulb diameter (cm)	Avg. weight of bulb (g)
F_0	5.02	4.14	10.42
F_1	5.67	5.21	11.77
F_2	7.23	6.83	15.30
F_3	7.85	8.7	16.96
$F_{>3}$	9.82	9.27	17.83
LSD $_{(0.05)}$	3.82	3.31	5.80

NS=Not Significant: F_0= Non fallowed soil, F_1=soil fallowed for 1 year, F_2= soil fallowed for 2 year, F_3= soil fallowed for 3 year, $F_{>3}$= soil fallowed for more than 3 year

DISCUSSION

Result of Soil Analysis Table 1 shows the physical and chemical properties of soils taken from the experimental sites at 0-15cm depth. The results of the soil physical analysis showed that the sand particles were reducing as the fallow year increased. Inversely, the clay particles increased as the fallow year is increased. The soil chemical analysis result indicated that pH increased from being moderately acidic to slightly acidic, as the fallow period increased. Soil Organic Carbon (%), Total Nitrogen (%) and Available Phosphorus (mg/kg) observed similar higher trends with prolonged fallowed period. Exchangeable bases like Calcium and Magnesium also significantly increased as the fallow year increased. However, there was no significant increase in the value of Potassium even as the fallow year increased.

The result of the soil properties at the respective fallow sites reveals high percentage of sand particles than silt and clay. Other chemical properties were also evaluated before the commencement of the experiment as shown in Table 1. The result of plant height of the onion at 3, 6, 9, and 12 week showed a significant ($p < 0.05$) effect of fallow periods only at 6, 9 and 12 weeks after transplanting, as presented in table 2. At 3rd week after planting, the plant showed no significance different ($p < 0.05$) from each treatment as they were statistically the same in height, but at 9th and 12th week, the plant height of onion plants were also observed to be statistically ($p < 0.05$) the highest with $F_{>3}$ soils than other fallow periods. Furthermore, at 10th week after planting, it was observed that F_0 had significantly ($p < 0.05$) lower plant height values than the fallowed soils. Similar results were observed for the number of leaves values, there was no significant difference among the number of leaves at the 3rd and 6th weeks after transplanting.

However, the leaves increased significantly with the length of fallow at 9th to 12th weeks after transplanting. This could be to the fact pointed out that as number of leaves increase the bulb diameter also increases Seran et al (2010). The yield parameter at the time of harvesting shown on table 3. Number of leaves, Bulb diameter and the average bulb of the treatments, which were statistically significant different and higher in $F_{>3}$ when compared to the control treatment F_0. This also suggest that the use of long fallowed soils ensures the quick release of nutrient and provides the plant with what is needed at the appropriate time, therefore plant will face no limitation during the time of yield. Thus, the present results agree with the previous work conducted by Seran et al (2010).

CONCLUSION AND RECOMMENDATIONS

The results obtained from the study shows that the fallowed soils had a significant effect on the growth and yield performances of onion. Most of the measured growth and yield parameters were better in soils allowed to fallowed more than three years among other treatments. This result translated into better growth and yield characters of onion planted on the soil and improved productivity of onion. Therefore, to ensure maximum yield and productivity for onion, it is recommended that soils for planting should fallowed and also fallow periods of minimum of two years should be maintained.

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FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

INTEGRATING GEOCHEMICAL AND GEOPHYSICAL PARAMETERS TO ASSESS THE GROUNDWATER POTENTIAL WITHIN THE FEDERAL POLYTECHNIC COMMUNITY, ADO EKITI, SOUTHWESTERN NIGERIA

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Abstract:

Most developed and developing countries are not only relying heavily on borehole as a primary source of drinking, but also as a source of water supply for both farming and manufacturing use. The reliance on groundwater is such that it is necessary to guarantee that there are substantial quantities of water supply which will be of high quality. Twenty vertical electrical sounding were conducted coupled with eight (8) water samples collected from the boreholes within the study with the intent to adequately address the problems of seasonal water supply shortage and to establish the quality of groundwater within the study area and its environs. The samples were carefully collected with sterilized bottles to avoid contamination. The temperature and pH values were measured and recorded at the point of sampling. The average results of the physiochemical parameters include; temperature (27.1°C), pH (7.9), Electrical Conductivity (125 um), Total Solids (152.2mg/l), Total Dissolved Solids (125.5mg/L), Total Hardness (431.6mg/l), Calcium Hardness (12.3mg/l), Magnesium (244.5mg/l), Sulphates (90.6mg/l), Chlorides (93.9mg/l) and Alkalinity (186.3mg/l). Majority of these parameters apart from the manganese hardness, total hardness, cations of calcium and magnesium fall within the WHO standard for drinking water. The high concentration of these hardness and cations are possibly from source rock within the borehole environments. From this studies four (4) different types of curves; HA, QH, H, KH types were identified. The curve QH type is predominant in the area. These curve types support the occurrence of groundwater in the basement Complex of Nigeria. This indicates that the samples under study met the world organization standards for drinking water

Keywords: *Groundwater, Alkalinity, Electrical Resistivity, Terrameter and magnesium*

Introduction

Potable water has been a source of concerns in this study area and its environs while the few successful well and boreholes drilled within this area had been reported of pollution (Dada, 2006; Fakolade et al., 2020). The community in this environment has not only solely relying on ground water as a primary source for drinking, but also source of water supply for both agriculture and industrial use (Ajibade and Wright, 1989; Offodile, 2002). Therefore, geophysics for both groundwater resource mapping and water quality evaluations has increased dramatically over the last 10 years due to the rapid advancement in microprocessors and associated numerical modeling solutions (Ajayi and Adegoke, 1988). However, despite its spectacular success, for groundwater studies, the use of geophysics is still often not generally accepted. This is due to poor publicity of the potential use of geophysics, complexity in its technicalities and interpretation procedures and cost limitations. The increasing demand for quality water supply within the Federal Polytechnic community, Ado-Ekiti and its environs has prompted this project. Electrical resistivity method is one of the most diversified geophysical methods compromising a variety of techniques such as spontaneous potential electromagnetic induced polarization and equipotential method each of these various techniques depends on one or combination of different electrical properties of materials on earth (Monier-williams et al., 1990 and Zohdy et al.,1993). Olayinka (1990) reported that geophysical survey are useful application especially in hydrogeological investigation of groundwater and geological mapping (aquifer delineation lithological boundary and detection of groundwater contamination).

This project attempts to unraffle the benefits involved in adopting geophysics for groundwater exploration and subsurface contamination studies through identification of various aquiferous units that are contaminates free within the study area and to identify the geological, geophysical and chemical characteristics of the study area by comparing, correlating and integrating the parameters.

Some researchers (Ajibade and Wright, 1989; Emenike, 2000; Oyedele, 2001; Ariyo, and Banjo, 2008) worked around sedimentary environment and concluded that high resistivity materials (dry sand and gravel) could be associated with fresh groundwater in porous aquifer while low resistivity may be due to the presence of clay or blackish water (Barker, 1990). The types and relative concentration of the chemical constituent in groundwater provides information on their evolution, solubility, flow, history and source of recharges (Ayolabi and Daniel, 2005; Adeoti and Ishola, 2008; Singhal et al., 2010). According to Kalimas and Gregorauskas (2002) the low pH values may have resulted from the production of CO_2 from microbial respiration whereas high nitrate level in drinking water may cause methemoglobinemia in infants under four years, as well as in adults with particular enzyme deficiency.

Several models have been proposed to describe the infiltration rate (Ibrahim et al.,

2004; Adiat et al., 2012; Rao et al., 2014) this was found suitable to determine infiltration of fluid in subsoil.

1. Geology of the Study Area

The geology of the study area falls within Ado-Ekiti, the southwestern basement complexes of Nigeria (Rahaman, 1976). The study area lies within coordinates; Latitude 7° 33′ to 7° 42′ N and Longitude 5° 11′ and 5° 20′ E respectively. The terrain is a low-lying environment enclosed with isolated hills, ridges and inselbergs that are dome shaped with boulders littering all over the base of these rocks are (Ayoade, 1982). The rocks in this area is made of the migmatite-gniess suites, the older granite suites (Rahaman, 1988), the meta-sediments, the diorite, dolerite and granodiorite suites that arises during series of orogenic episodes coupled with weathering of preexisting rocks. The major lithological rock units are basically crystalline basement rocks. These include coarse grained charnokite, fine grained granite medium grained-granite and porphyritic biotite-hornblende granite.

The age of these rocks is assumed to be about 1,850 million years (Oyawoye, 1964; Rahaman, 1988). The Pan African granites (older granites) in this study area intruded all the pre-existing rocks including the gneiss-migmatite-quartzites complex and schist belts during the Proterozoic to early Palaeozoic (600 ± 150 million years). They consist of suites of Porphyritic and non- porphyritic granites, Granodiorite, Adamellite, Tonallite and quartz-diorite (Jones and Hockey, 1964). These rocks are made up of concordant and discordant dykes, veins and irregular bodies of basement complex, the relative depth and degree of weathering depends on the mineral grain, size of the crystalline rocks, their intensity of fracturing, and the relative proportion of ferromagnetic mineral
(Bayowa et al., 2012).

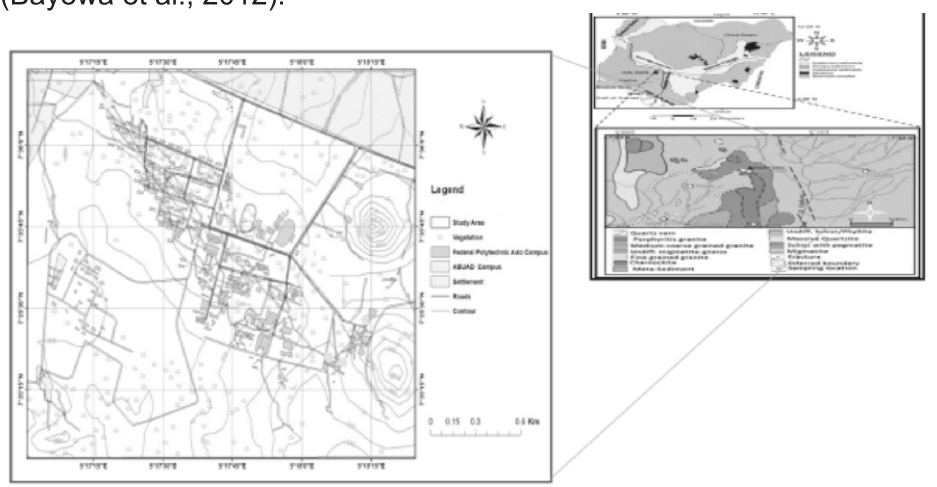


Fig. 2.1: Geological map and location map of the study area

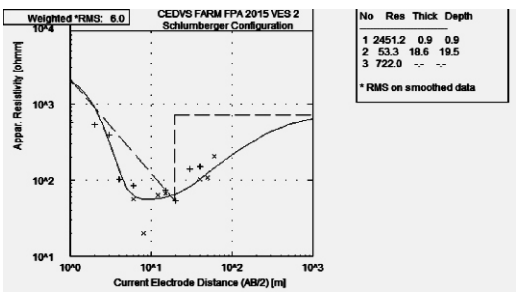
1. MATERIALS AND METHODS

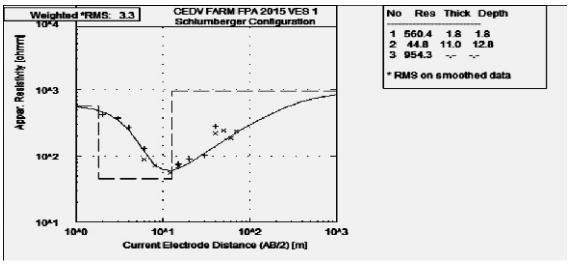
3.1 Water sample analysis

Eight water samples were collected from the boreholes within the study area to determine their physicochemical and chemical parameters. Sterilized bottles were used to collect the samples, they were properly rinsed before collection and with the cork tightened after sampling to avoid exposure to wind and sunlight. The physicochemical parameters of the water samples were measured on the field with calibrated instruments. These include; pH, temperature, turbidity and conductivities of the water samples measured with pH-meter, thermometer, and conductivity meter respectively. The total dissolved solid (TDS), Total suspended solid (TSS), total solid (TS) and Total hardness (CaCO3mg/l) were conducted with the standard methods. The inorganic and non-metallic constituents (nitrate, chloride, phosphate, sulphate) analyses were assessed in the laboratory using standard procedures. Chloride, nitrate, sulphate, phosphate were determined using colorimetric, turbidometric and ascorbic acid method respectively. Water samples were digested with conc HNO_3 to release metals, bound to organic and particulate or adsorbed on particulate matter, in a measurable form by flame absorption photometer.

1.2 Vertical electrical sounding (VES)

Vertical electrical sounding (VES) wase conducted to prospect for water bearing formation and groundwater contamination around the dumpsite using the ABEM WADI (SAS 1000B) terrameter The equipment used during the sample collections include: hammer, connecting cable, global positioning system (GPS), tape rule, recording sheet, reel of calibrated rope. The Schlumberger array whereby potential electrode remain fixed while the current electrode is expanded simultaneously about the centre of spread were used where (AB =MN/2). The geological data obtained from this study were subjected to qualitative and quantitative analyses. The result of the VES data was presented as curves, and was plotted on a bi-log graph paper. Initial interpretation of the eight VES curve were done by partial curve matching and final interpretation on computer iteration using winResist2 software, this was used to generate a geo electric section of the subsurface (fig . 3.1)





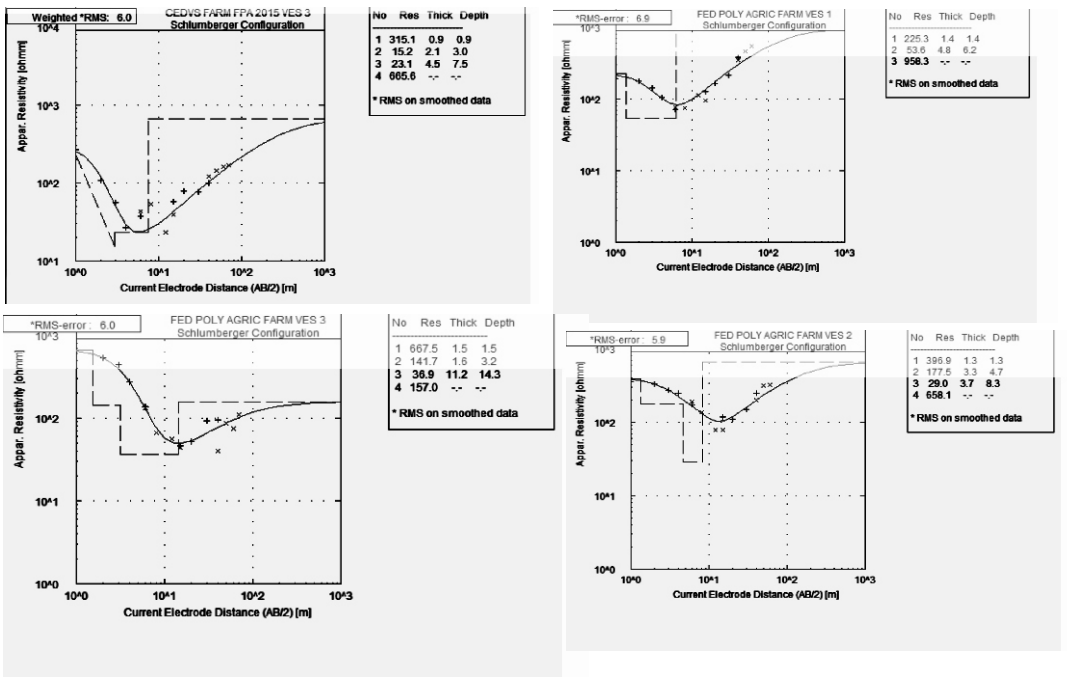


Figure 3.1: Computer Iteration Showing Ves 1- Ves6

4. RESULTS AND DISCUSSION

4.1 Geochemical Data Analysis

Table 4.1 shows the result obtained from the chemical parameters of eight (8) samples boreholes analysed.

The temperature of the samples ranges from 26.6^{0C} to 27.6^{o}c. These fall below 30^{O}C stipulated by WHO (2009) as the standard for potable water. Temperature is capable of affecting the state and level of other parameter such as conductivity and bacteriological activity of any sample (Akankpo and Igboekwe, 2011).Warm temperature, gives rise to accelerated bacterial activity thereby creating, potentials for odour to develop through depletion of oxygen due to bacterial oxidation of organic and nitrogenous compounds that may be present in water.

The $_{P}H$ value of the samples range from 6.9-8.8 mg/l, and as shown in Table 4.1. The values fall within the (WHO, 2009) standard for drinking water which is 6.9 – 8.5, although little variation was observed in sample L5. This might be resulted either from the source rock through which the water flows across or effluent permeates and leached into the boreholes. The water is good for human and plant consumption (Kalimas and Gregorauskas, 2002). The increased concentration of P^{H} in borehole may supports the growth of algae and allow the value growth for fish eggs.

Table 4.1: Geochemical analysis result of analyzed samples from the study area. (Chemical parameters) inmgL^{-1}

PARAMETERS	L1	L2	L3	L4	L5	L6	L7	L8	Mean	Range	WHO 2009
P^{H}	8.6	8.6	6.9	7.8	8.8	7.5	7.3	7.3	7.9	7.3 -8.8	6.5-8.5
Temperature ^{o}C	26.6	27.6	27.1	26.6	27.6	27.1	27.3	27.2	27.1	26.6-27.6	30
Electrical conductivity (µs/cm)	40	38	150	75	143	68	72	120	88.3	38-150	1250
Total Solid	230	72.2	68.6	228.8	53.6	70.1	191.4	302.6	152.2	68.6-302.6	500
Total dissolved Solid	180	60.2	58.3	180.2	45.6	59.5	179.6	240.2	125.5	45.6-240.2	500
Total Alkalinity	60	30	170	30	160	350	350	340	186.3	30-340	600
Ca hardness	212	158	52.8	54.08	87.3	91.5	12.3	95.7	95.5	12.3-212	200
Mg Hardness	432	58.3	147.6	589.92	37.5	116.5	528.5	77.9	248.5	37.5-587.9	50
Total Hardness	644.8	216.3	200.4	644	124.8	208	540.8	873.6	431.6	124.8-873.6	150
Calcium	425	316	98.2	216.7	83.4	366.8	450.2	383.5	292.5	83.4-425	75
Mg	566	192.1	80.2	783.9	15.1	25.3	80.9	212.3	244.5	15.1-783.9	50
Chloride	50	43	200	62.3	198.3	71.4	61.1	65.4	93.9	43-200	250
Sulfate	120	62	61	122	60	62	112.8	0.0	90.6	60-124.88	400

The electrical conductivity value range from 38-150 µm with average conductivity value of 88.3 µm as seen in table 4.1. Electrical conductivity is mostly affected by the presence of dissolved ions in water. In this study area the electrical conductivity falls below that of the (WHO, 2009) drinking water standard of 200mg/l. Electrical conductivity can be to the hardness of water, the more dissolved ions (Ca^{2+}, Mg^{2+}, etc.) present in water, the more its conductance and hence its hardness (Barker, 1990). Total dissolved solids and electrical conductivity related in this study, conductivity is proportional to the dissolved solids, they both show analogous trend in all the sites.

The concentration of Magnesium Hardness in the samples varies from 37.5 – 589.92 mg/l. This is indicating the high concentration of magnesium in the wells. This value is above the (WHO 2009) standard of 50 mg/l although the value of sample L5 is very low with a value of 37.5 mg/l. High concentration of magnesium in this water if consumed can lead to vomiting, diarrhea, muscle slackness, nerve problem and depression. Therefore the boreholes water will requires to be treated before consumption and for any industrial use.

The calcium hardness concentration in the boreholes ranges from 12.3 - 212mg/l and

this is below the consumption limit of (WHO, 2009) drinking water standard of 200 mg/l with the mean concentration of 94.46 mg/l as seen in samples L3, L4 and L7 of table 2 respectively. The water therefore has to be well treated to meet the permissible range of (WHO, 2009), due to the importance of calcium to the body of both plant and animal. The low concentration of this in the water could lead to soft teeth and bones.

The Total dissolve solids values varies from 53.6 to 302.6mg/l as shown in the table 4.1. TDS are usually indicators for the general water quality, due to their direct effects on the aesthetic value of the water by increasing turbidity. The acceptable range of Total Solid is 500 mg/L. Regardless from the values of Total Solid results, all the water samples showed low level of contaminants. The highest Total Solid value was observed at borehole L8 might be due to the actions of agriculture practice around the boreholes. However; all the values were within the (WHO, 2009) standard of 500 mg/L. The results of both Total suspended solid and Total Dissolve Solid showed that the drinking water cannot cause health problem to the consumers. Therefore the water is safe in terms of Total Solid content.

The Total Hardness values range from 124.8 - 873.6 mg/l with the average value of 431.59 mg/l. The presence of magnesium and calcium are consistent with the level of the hardness observed based on the overall mean of the values from the analysis. Comparing this with the (WHO, 2009) standard of 150mg/l falls above the WHO (2009) standard for potable water. Effect of hardness would be excessive usage of soap, precipitate form on hardware and in pipeline which increased temperature and $_{P}$H.

The average values of Chloride is found to be 93.9 mg/l. Sample L3 has highest with a value of (200mg/l), while least value is sample L2 with 43mg/l. Chloride's concentration is within the (WHO, 2009) standard of 250 mg/l. This means that the water has a low salinity.
The observed alkalinity is within the range of 30-350. Alkalinity in water should be sufficient to enable a balanced and stable formation with chemical coagulation. Samples L2 and L4 have the lowest value which is 30 each and sample 6 and 7 has the highest value which is 350 mg/l. Sample L3, L5, L6, L7 and L8 does not conform to World Health Organization (WHO, 2009) standard for drinking water.

Sulphate ion has an average value of 90.68mg/l of the total sample. Sample L8 has the highest value with 124.8mg/l and sample L5 has the least value of 60mg/l as shown in Table 4.1. The (WHO, 2009) standard for Sulphate ions is 400mg/l, this shows that the water samples are still within the (WHO, 2009) standard. Sulphate concentration also affects the taste of water. Sulfate affects the taste of water if it

exceeds a concentration of 250 mg/l. High sulfate levels may cause corrosion for plumbing, particularly
Copper sriping. Figure 4.1 summarises the physiochemical parameters present in the ground water

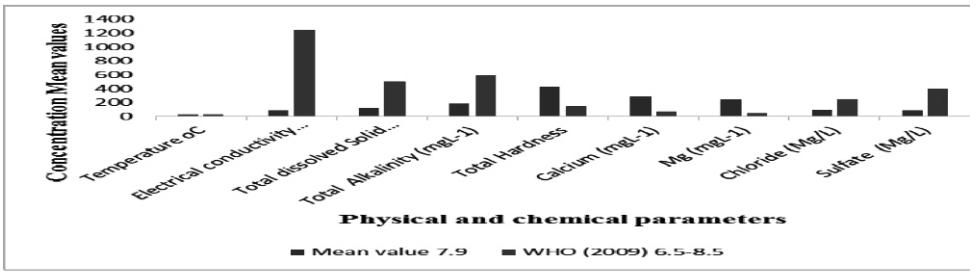


Figure 4.1: graphical representation of physical and chemical concentration of the samples under study

4.2 Geophysical survey

Four (4) different types of sounding curves were obtained from the study area, these Include the 4 -layer (HA, QH, H, KH) types. The QH type is predominant in the area. These curve types are usual pointers to the possibility of the occurrence of groundwater in the basement Complex of Nigeria (Olayinka and Olorunfemi, 1992; Olorunfemi and Fasuyi, 1993). Details of the geoelectric parameters of each VES are presented in Table 3-8. The resistivity values obtained ranges from 15Ωm to 2451 Ωm. The results of the vertical electrical sounding is as presented in the table below;

Table 4.2: Summary of various layers observed in the study

VES	Layer	Resistivity (Ohm-m)	Thickness (m)	Depth (m)	Probable Lithology	Hydro-geological Significance	C t
1	1	560 - 2451	0.9 - 1.8	0.9 -1.8	Lateritic top soil	Poor Aquifer	
	2	45 - 53	11 - 18.5	13 - 19.5	Sandy Clay	Good Aquifer	
	3	954	8	>13 - 20	Weathered Basement/Basement	Fair Aquifer Potential	
2	1	315	0.9	0.9	Lateritic top soil	Poor Aquifer	
	2	15	2.1	3.0	Sandy Clay	Fair Aquifer	
	3	23	4.5	7.5	Weathered Basement with veins	Aquifer Potential is good with thickness advantage.	

	4	666	8	>8m	Basement Complex, shallow fractures	Fair Aquifer due to moderate Ohm-m.	KF
3	1	225.3	1.4	1.4	Lateritic top soil	Poor Aquifer	
	2	53.6	4.8	6.2	Sandy Clay	Fair Aquifer	
	3	958.3	8	>6m	Weathered Basement Basement Complex	Poor Aquifer Potential	HA
4	1	396.9 - 667.5	1.3 - 1.5	1.3 - 1.5	Lateritic top soil	Poor Aquifer	
	2	177.5 - 141.7	3.3 - 1.6	3.1 - 4.6	Sandy Clay	Fair Aquifer	
	3	29.0 - 36.9	3.7 - 11.2	8.3 - 14.3	Weathered Basement with veins	Good Aquifer Potential	QF
	4	658.1 - 157	8	>8 - 14	Basement Complex	Fair Aquifer due to possible fracture	

The VES geoelectric section relates VES 1, 2, 3, 4, 5 and 6 in the NW-SE direction. Four distinct geoelectric layers can be identified on the section. The first layer with resistivity values varying between 225 and 2451 Ωm and the layer thickness values between 0 and 1.9 m was associated with the topsoil. The second layer with resistivity values ranging between 15 and 177.5 Ωm and depth to base of the layer ranges between 1.6 and 19.5m was referred as the sandy clay. The third layer was taken as the weathered basement rock with layer resistivity values range between 23 and 958.3 Ωm within the depth of 4.5-20m. The forth layer was taken as the fresh basement with layer resistivity values range between 157 Ωm and 666 Ωm with the depth greater than 8m below the surface. All ves point shows great characteristics of groundwater occurrence because of their low resistivity and the thickness of the top soil but the resistivity values beneath VES 3and ves5 (15Ωm to 29Ωm) reveals significant zones with anomalously low resistivity and these have been attributed to the presence of conductive contaminant plume. (Monier-williams et al., 1990; Atakpo, 2009). The electrical resistivity varies between different materials, depending mainly

on variation in the water contents and dissolved ions in the water. The analysis and interpretation of the survey data showed different types of geoelectric layers. The data obtained from the physiochemical analysis were also correlated with the WHO (2009) water standard and was presented in form of a table 4.1.

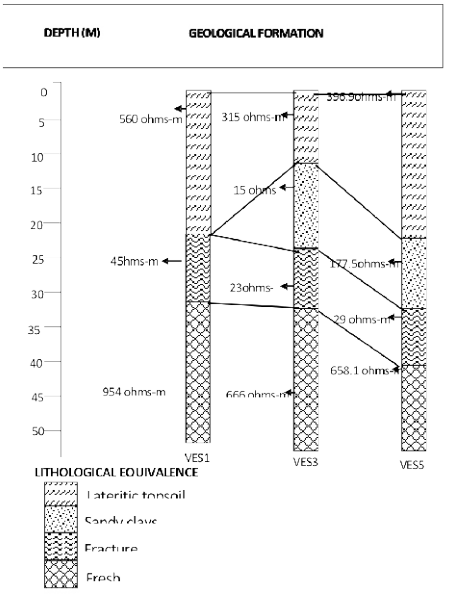


fig. 11* geoelectric section of the study area

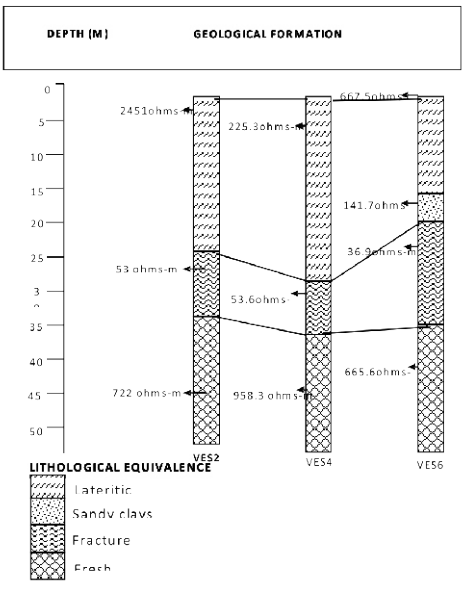


Fig12: geoelectric section of the study area.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The overall results revealed the behaviour of the vertical electrical sounding (VES) with the spatial distribution of the aquifer and the attitudes of the geochemical elements present in the boreholes within the study area. The vertical electrical sourding curves revealed four geoelectric layers. This was observed that VES 3 and VES 5 revealed significant zones with very low resistivity and these have been attributed to the presence of conductive contaminant plume, while all the sample revealed high concentrations of TH (431.6), Ca^{2+} (292.5) and Mg^{2+} (244.5) that are found to be above the permissible limit of WHO (2009) in these samples. This might possibly from the rocks through which the water flows. The slight increase in pH value in this sample 5 (8.8) indicate a slight increase in alkalinity in nature, although this may not have any hazard to human consumption but it may contribute to corrosiveness of pipe works

The results obtained from both geophysical and geochemical analysis serves as a pointer that they can be integrated to characterize the pollution level of an aquifer (Israil et al., 2007).

This shows that the groundwater within the study area is partially contaminated in

locations VES 3 and VES 5 while the analysis conducted on the eight different borehole water samples within the area shows that they fall within the WHO (2009) standards, they are good for domestic and industrial usage. The samples only require minimal routine treatment before use. Conclusively, a constant monitoring of the groundwater quality is highly recommended especially at the study area where concentrations were fairly on the high side.

5.2 RECOMMENDATION

The government or community should come to the aid of the citizens of the study area by setting up a mini water treatment facilities to minimize and prevent the effect(s) of these contaminants. Vaccination program against predominant typhoid fever sickness/disease, cholera and other water borne diseases that may results into greater percentage of death in the future need to be organized for the citizens around this study area. Government/ community enlightenment campaign should be organize on the requirement and procedures necessary to undergo maintenance when the need necessitates. The community must be carried along before a borehole can be sited in the community in order to avoid it being located near a pit latrine or a dumpsite. This will minimize the leaching of harmful substance into underground water. Also chemical, physical and biological test should be carried out regularly to know how palatable the water in this study area is good for consumption

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COMPARISON OF SOME SELECTED TECHNIQUES FOR DETECTING MULTICOLLINEARITY IN MULTIPLE REGRESSION ANALYSIS

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Abstract:

Multicollinearity is a severe problem in multiple regression analysis. The problem arises as a result of infringement of the assumption that independent variables are linearly independent. In this study, four different methods; Farrar-Glauber test, Condition number, determinant and R-square, for detecting multicollinearity in datasets were considered and the best among them was identified. The distribution of random error was generated using R software. Nine different sample sizes of n = 10, 20, 30, 50, 100, 150, 200, 300 and 500 were used. Also, three different cases of correlation coefficient were considered among predictive variables relating to a low correlation (0.1-0.3), mild correlation (0.4-0.6) and high correlation (0.7-0.9), respectively. It was discovered that the Farrar-Glauber test performed best among the selected methods at all levels.

Keywords: Farrar-Glauber test, Condition number, Determinant, R-square, multicollinearity

Introduction

Multiple linear regression is a statistical technique widely used in handling many variables in a dataset. It allows users to estimate models that describe the distribution of a response variable alongside with other variables called explanatory or independent variables. Multiple regression is used for the interpretation of regression coefficients and the least-squared solution is good at giving correct estimate and valuable results of independent coefficients. One of the assumptions for the interpretation of the least squared method is the lack of significant relationship between the independent variables (absence of multicollinearity): $Cov(X_i, X_j) = 0$; i j. However, there are situations where independent variables are nearly collinear, that is, lying on or passing through the same straight line. Such a situation is

termed multicollinearity, which is one of the serious problems being encountered in Econometrics.

Multicollinearity appears when two or more independent variables in the regression model are correlated, a little bit of multicollinearity sometimes will cause big problems. More often than not, explanatory variables are intercorrelated and as well produce significant effects on one another. The inter-correlation between explanatory variables is known as multicollinearity. Multicollinearity occurs in the regression model of two or more independent variables that are significantly correlated not only with the dependent variable but also with one another (Young, 2017). According to (Belsley, Kuh and Welsch, 1980), multicollinearity is well agreed to be present if there is an approximately linear relationship, that is, shared variance among some of the independent variables in a dataset. Bowerman and O'Connel (1990) stated that the term 'multicollinearity' refers to a situation in which there is an exact or very close to exact linear relation among two or more independent variables, though this situation may arise as a result of mistake. This relationship between explanatory variables disrepute the results of multivariable regression analyses.

Multicollinearity as a notion could also be defined in terms of orthogonality, a situation where all eigenvalues of the design matrices are equal to one and the design matrix is of full rank. However, if at least one eigenvalue is different from one, most especially when equal to zero or close to zero, then non-orthogonality exists, implying that multicollinearity is present (Vinod and Ullah, 1981).

However, many econometric literature are of the opinion that independent variable construct are non-collinear in the population. Hence, any observed multicollinearity in empirical data is constructed as a “sample based” problem not as representative of the underlying population relationship (Kmenta, 1986). It would be erroneous and somewhat misleading to form the opinion that independent variables will often be purely orthogonal at the level of population especially when the research is based on behavioural matter. Whether multicollinearity in datasets is seen as artificial sampling or the true picture of the population relationship, it can only be ascertained if the dataset is subjected to a regression analysis. This is because multicollinearity has many potential undesirable consequences.

Imdadullah, Aslam and Altaf (2016) presented mc test in R-statistical package that computes popular and widely used multicollinearity diagnostic measures using the Hald data (Hald, 1952) bundled in mc test package for checking of existence of collinearity among regressors by using omcdiag () and imcdiag () function to get idea about which regressors may be the reason of multicollinearity.

Akinniyi and Sanni (2017) examined the analysis using economic data that the

presence and severity of multicollinearity, as well as the pattern and location of multicollinearity which can be easily detected by Farrar-Glauber test. This study showed that variable

2. Methodology

2.1 Selected Tests Used to Detect Multicollinearity

2.1.1 Farrar-Glauber Test

This test was proposed by Farrar and Glauber (1967) to detect multicollinearity based on the assumption that X is multivariate normal. The following tests were proposed by the author with the analysis in three stages.

Stage 1: The use of 2 - test

$$\chi^2_{cal} = -\left[(n-1) - \frac{1}{6}(2k+5)\right]\log SDV$$

Where n is the number of samples, k is the number of independent variables and SDV is the standard determinant value.

$$\text{SDV} = \begin{vmatrix} 1 & r_{12} & r_{13} \\ r_{12} & 1 & r_{23} \\ r_{31} & r_{32} & 1 \end{vmatrix}$$

The correlation coefficient between the independent variables computed through the product moment correlation

$$r_{x1xj} = \frac{n\sum X_i X_j - \sum X_i \sum X_j}{\sqrt{\left[n\sum X_i^2 - (\sum X_i)^2\right]\left[n\sum X_j^2 - (\sum X_j)^2\right]}}$$

Stage 2: The use of F-test

$$F_{cal} = \frac{R^2_{X1.X2.X3\ .\ .\ Xf/(k-1)}}{1 - R^2_{X1.X2.X3\ .\ .\ Xk/(n-k)}}$$

When n = sample size and k = number of independent variables

Stage 3: The use of *T*-test

Here, partial correlation coefficients are computed among the independent variables while their statistical significance is tested with t-statistic. Partial coefficient between two variables X_i and X_j show degree of correlation between them while other variables are kept constant.

$$r^2_{XiXj \quad . \quad . \quad . \quad X_k} = \frac{(r_{ij} - r_{ij}r_{ij})^2}{(1 - r^2_{ij})(1 - r^2_{ij})}$$

Test statistic

$$t^* = \frac{(rxixj \quad . \quad . \quad . \quad)/\sqrt{(T-K)}}{\sqrt{(1-r^2_{xixj \quad . \quad . \quad xk})}}$$

Where, rxixj^2… x_k is the partial correlation coefficient between x_i and x_j

The observed value t^* is computed with the theoretical t value with $v = (T\text{-}K)$ degree of freedom at a chosen level of significance.

2.1.2 Determinant (X'X)

The determinant of normalized correlation matrix, R = X'X without intercept can be used to indicate existence of collinearity among independent variables, it provides information about singularity (departure from orthogonality) of a correlation matrix. The determinant X'X on the scale is 0 <|X'X |1 (Cooley and Lohnes, 1971). If X'X |~0, then collinearity exists among regressors (Asteriou and Hall, 2007). Determinant is always in square matrices. It can be defined as completeness. For instance, if A is a 22 matrix, its determinant is A = $a_{11}a_{22}$–$a_{12}a_{22}$. Thus, the generalized definition of determinant is:

$$\text{Det A} = \sum_{\pi} \varepsilon_{\pi} a_1 j_1 \, a_2 j_2 \quad . \quad . \quad . \quad a_k j_k$$

While its properties include;

$\det A = \det A^1$

$\det(\alpha A) = k \det A$

$\det(AB) = (\det A)(\det B)$

$\det(A^{-1}) = (\det A)^{-1}$

detA B C D =det D det (A-BD-1C) If det D 0

2.1.3 Coefficient of Determination (R^2)

The R^2 is monotonic non-reducing function with number of regressors included in the model, it means that R^2 indicates how well the regression fits the data (Gujarati and Porter, 2008; stock and Watson, 2010). However, the higher the R^2, the more regressors are prone to multicollinearity, since R^2 is affected by regressors sharing their variance (Gujarati and Porter (2008).

2.1.4 Condition Number

It is a way of testing the degree of multicollinearity through the magnitude of the eigenvalues of the correlation matrix of independent variables. Large variability among the eigenvalues indicate a greater degree of multicollinearity. Two features of these eigenvalue are of interest:

(a) Eigenvalues of zero indicates exact collinearity. Therefore, very small eigenvalues indicate near linear dependencies or high degree of multicollinearity.

(b) The square root of the ratio of the largest to the smallest eigenvalue

$K = \max \min 12$

K is the condition number which is a commonly employed index of the "instability" of the least-squares regression coefficients; the rule is that if K is between 100 and 1000, there is a moderate to strong multicollinearity but if it exceeds 1000, there is severe multicollinearity.

3. Results

The response variable used was generated using $y = x_1 + x_2 + x_3 + x_4 + ei$. Four different independent variables were generated from the multivariate normal distribution. We considered nine different sample sizes of n = (10, 20, 30, 50, 100, 150, 200, 300 and 500) related to relatively small (n=10, 20, 30), medium (n= 50, 100, 150) and large (n = 200, 300, 500) sample sizes. Also, three different cases of correlation coefficient were considered among predictor variables relating to a low correlation (0.1-0.3), mild correlation (0.4-0.6) and high correlation (0.7-0.9), respectively. R progamming software was used for the data analysis (Chamber, 2008)

Table 1: Overall Multicollinearity Diagnostics Results

Sample Size(n)	Methods	CASE 1: 0.1 - 0.3 MC-Results Detection	CASE 2: 0.4 - 0.6 MC Results Detection	CASE 3: 0.7 - 0.9 MC Results Detection
10	|X'X|	0.2470	0.0727 0	0.000000e+00
	Farrar ^{2}	0	15.0745 1	1
	CN	8.0404	25.3299 0	2.264492e+02
	R^2	0	0.9915 1	1
	Adjusted R^2	17.8104	0.9846	NaN
		0		NA
		0.9485		0.9732 1
		1		0.9598
		0.9073		
20	|X'X|	0.5911	0.1754 0	0.000000e+00
	Farrar ^{2}	0	27.4195 1	1
	CN	8.2811	16.0924 0	6.042747e+02
	R^2	0	0.9263 1	1
	Adjusted R^2	14.3277	0.9067	3.478902e+08
		0		1
		0.8866		0.9423
		0		1
		0.8563		0.9315
30	|X'X|	0.6291	0.2132 0	0.000000e+00
	Farrar ^{2}	0 11.9346	39.7926 1	1
	CN	0	25.4352 0	NaN
	R^2	21.4531	0.9141 1	NA
	Adjusted R^2	0	0.9003	NaN
		0.8733		NA
		1		0.9348 1
		0.8530		0.9272
50	|X'X|	0.7899	0.3550 0	0.000000e+00
	Farrar ^{2}	0	47.3827 1	1
	CN	10.7899	16.2921 0	1.670461e+03
	R^2	0	0.8826 0	1
	Adjusted R^2	14.9558	0.8722	NaN
		0		NA
		0.8219		0.9114 0
		0		0.9057
		0.8060		

1: Collinearity is detected by the test; 0: Collinearity is not detected by the test; NaN: not available

3.1 Discussion of Results

From Table 3.1, when sample size was 10 for Case 1 at low correlation, the determinant (X'X), Farrar ^{2} and condition number (CN) indicated absence of multicollinearity, while the R^2 indicated presence of multicollinearity and the adjusted R^2 indicated that 91% of the difference in response can be explained by regressors in the model. For Case 2 at mild correlation, the determinant (X'X) and CN indicated absence of multicollinearity, the Farrar^2 and R^2 indicated presence of multicollinearity while the adjusted R^2 gave that 98% of the distinction in response can be explained by regressors in the model. For Case 3 at high correlation, the determinant (X'X), Farrar ^{2} and R^2 indicated presence of multicollinearity, the CN was not available while the adjusted R^2 showed that 96% of the discrepancy in response can be explained by the regressors in the model.

When sample size was 20 for Case 1 at low correlation, the determinant (X'X), Farrar^2, CN and R^2 indicated absence of multicollinearity, while the adjusted R^2 indicated that 86% of the disagreement in response could be explained by independent variables in the model. For Case 2 at mild correlation, the Farrar ^{2} and R^2 showed presence of multicollinearity, while the determinant (X'X) and CN indicated absence of multicollinearity. The adjusted R^2 showed that 91% of the variability in response variable could be fully explained by independent variables in the model specification. For Case 3 at high correlation, the determinant (X'X), Farrar ^{2}, CN and R^2 indicated presence of multicollinearity, while the adjusted R^2 indicated 93% of the divergence in response variable could be explained by the model containing the independent variables.

When sample size was 30 for Case 1 at low correlation, the determinant (X'X), Farrar^2 and CN revealed absence of collinearity, R^2 indicated presence of multicollinearity while the adjusted R^2 showed that 85% of the variableness in response could be explained by independent variables in the model. For Case 2 at mild correlation, the Farrar ^{2} and R^2 indicated presence of multicollinearity while the determinant (X'X) and CN indicated absence of multicollinearity. The adjusted R^2 showed that 90% of the variation in response could be explained in the model by regressors. For Case 3, at high correlation, the determinant (X'X) and R^2 indicated presence of multicollinearity, while the Farrar ^{2} and CN were not available. The adjusted R^2 said that 93% of the discord in response could be explained by regressors in the model specification.

When sample size was 50 for Case 1 at low correlation, the determinant (X'X) , Farrar^2, R^2 and CN indicated absence of multicollinearity, while the adjusted R^2 indicated 81% of the discordance in response can be explained by the model. For Case 2 at mild correlation, the Farrar ^{2} indicated presence of collinearity, while the determinant (X'X), R^2 and CN indicated absence of multicollinearity. The adjusted R^2 showed that 87 % of the variation could be explained by regressors in the model. For Case 3 at high correlation, the determinant (X'X) and Farrar ^{2} indicated presence of multicollinearity but the CN result was not available. The adjusted R^2 showed that 91% of the variation in response can be explained by the model.

When sample size was 100 for Case 1 at low correlation, the Farrar^2 revealed presence of multicollinearity, while the determinant (X'X) , R^2 and CN indicated absence of multicollinearity. The adjusted R^2 showed that 84 % of the discord in response could be explained by the model. For Case 2 at mild correlation, the Farrar ^{2} indicated presence of collinearity, while the CN, R^2 and determinant (X'X) did not detect existence of collinearity. The adjusted R^2 indicated that 89 % of the difference in response can be explained by the model. For Case 3 at high correlation, the Farrar^2, CN, R^2 and determinant (X'X) indicated presence of multicollinearity, while the adjusted R^2 indicated that 92 % of the discrepancy in response could be fully explained by the model.

When sample size was 150 for Case 1 at low correlation, the Farrar^2 showed the presence of multicollinearity, while the CN, R^2 and determinant (X'X) could not detect the presence of collinearity. The adjusted R^2 showed that 86% of the variation in response can be explained by the model. For Case 2 at mild correlation, the Farrar ^{2} indicated presence of multicollinearity, while the CN, R^2 and determinant (X'X) did not detect the existence of collinearity. The adjusted R^2 showed that 91% of the variation in response can be explained by the model. For Case 3 at high correlation, the CN,R^2 and determinant (X'X) indicated presence of multicollinearity, while the Farrar^2 was not available. The adjusted R^2 revealed that 93% of the variation in response can be explained in the model.

For Case 1, at low correlation, and when sample size was 200, the Farrar ^{2} indicated presence of collinearity in the model specification, while the CN, R^2 and determinant (X'X) indicated absence of multicollinearity, the adjusted R^2 revealed that 89% of the difference in response can be explained by the model. For Case 2 at mild correlation, the Farrar^2 indicated presence of collinearity, while the CN, R^2 and determinant (X'X) indicated absence of multicollinearity. The adjusted R^2 indicated that 93% of the discord in response can be explained by regressor variables in the model. For Case 3 at high correlation, the Farrar^2, CN,R^2 and determinant (X'X) indicated presence of multicollinearity. The adjusted R^2 revealed that 94 % of the variation in response can be explained by regressor variables in the model.

For Case 1 at low correlation, Case 2 at mild correlation and when sample size was 300, the Farrar ^{2} indicated presence of multicollinearity while the determinant (X'X) , R^2 and CN could not detect the presence of multicollinearity. The adjusted R^2 indicated 88% and 92% of the disharmony in response can be explained by the model in case 1 and case 2, respectively. For Case 3 at high correlation, the determinant (X'X) and R^2 indicated presence of multicollinearity, while the Farrar ^{2} and CN results were not available. The adjusted R^2 indicated that 94% of the variation in response could be explained by the model.

For Case 1 at low correlation, Case 2 at mild correlation and when sample size was 500, the Farrar^2 indicated presence of multicollinearity, while the determinant (X'X),R^2 and CN indicated absence of multicollinearity. The adjusted R^2 showed that 86 % and 91 % of the variation in response can be explained in the model for Case 1 and Case 2.

For Case 3 at high correlation, the Farrar^2 and CN were not available while the determinant (X'X) and R^2 indicated presence of multicollinearity. The adjusted R^2 indicated that 93 % of the variation in response variable can be explained by regressor variables in the model.

Table 2: Summary of Findings for Multicollinearity Diagnostics Results

Sample Size(n)	Coefficient of Correlation(r)	Best
10	Low	R^2
20		None
30		R^2
50		None
100		Farrar ^{2}
150		Farrar ^{2}
200		Farrar ^{2}
300		Farrar ^{2}
500		Farrar ^{2}
10	Mild	Farrar ^{2}, R^2
20		Farrar ^{2}, R^2
30		Farrar ^{2}, R^2
50		Farrar ^{2}
100		Farrar ^{2}
150		Farrar ^{2}
200		Farrar ^{2}
300		Farrar ^{2}
500		Farrar ^{2}
10	High	|X'X| , Farrar ^{2}, R^2
20		|X'X|, Farrar ^{2},CN,R^2
30		|X'X| , R^2
50		|X'X| ,Farrar^2
100		|X'X| ,Farrar^2,CN, R^2
150		|X'X|, CN,R^2
200		|X'X| , Farrar ^{2},CN,R^2
300		|X'X| ,R^2
500		|X'X| ,R^2

4.0 Conclusion

This paper focused on four methods; Farrar-Glauber, Condition number, determinant and R-square, for detecting multicollinearity problems with respect to overall multicollinearity. The results showed that all the methods were good but the little differences among the values were used to identify which method gave the best model compared with others. Comparatively, Farrar ^{2} and R^2 were good at low and mild correlation at different sample sizes. However, Farrar^2 dominated at high correlation. It was observed that the Farrar-Glauber test performed best, effectively, efficiently and superior in detecting overall multicollinearity problems at all the three levels of correlation coefficient among the selected tests.

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FEDPOLAD JOURNAL OF SCIENCE AND AGRICULTURAL TECHNOLOGY (FEDPOLADJSAT)

EFFECT OF TILLAGE, SPENT BLEACHING EARTH AND SPACING ON GROWTH AND YIELD OF BAMBARA GROUNDNUT (*Vigna Subterranean (l.) Verdc.*) IN OWO, SOUTHWESTERN NIGERIA

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Abstract:

Bambara groundnut in recent time is assuming a recognizing dimension as it has potential of supplementing other important legumes like Beans, but the knowledge of best Tillage method, nutrients requirement and Spacing vary with ecology, hence the need for verification of a better condition for its cultivation. A field experiment was conducted from May – August, during the 2020 cropping season at Rufus Giwa Polytechnic, Owo, Ondo State, to evaluate the effect of Tillage, Spent Bleaching Earth (SBE) and Spacing on the vegetative growth and yield of Bambara groundnut. The 2 x 3 x 3 factorial experiment comprised of Tillage method at two levels (mound and ridge), Spent Bleaching Earth (SBE) at three levels (0, 5 and 10 t ha-1) and Spacing at 3 levels (50x 50cm, 50x 40cm and 50x30cm) fitted into a Randomized Complete Block Design (RCBD) at 3 replications. Results showed that Bambara groundnut had increased vegetative growth and yield as influenced by the two Tillage methods. Plots treated with 10t ha-1 SBE had significantly ($p<0.05$) more leaves than plot that received 5t ha-1and 0t ha-1(control plots) at all sampling dates, whereas, yield indices increased significantly with application of 5t ha-1 of SBE, but not significantly different from values obtained from 0t ha-1(control plot). Also, spacing of 50x30cm produced significantly highest number of leaves more than 50x50 and 50x40cm. The LAI of plants spaced at 50x30 recorded the highest values at 3 and 9 WAP and are significantly different from values obtained from spacing of 50x50 and 50x40cm. Application of 5t ha-1 and spacing of 50x30cm interacted with any of the two tillage methods to produce the highest vegetative growth values as well as the overall yield of Bambara groundnut in the study area.

Keywords: *"Bambara groundnut", "Growth", "Spacing", "Spent Bleaching Earth", "Tillage, "Yield".*

Introduction

Bambara groundnut [*Vigna subterranean (L.*) Verdc.] is a pulse with underground fruit–set that is cultivated largely by subsistence farmers across West African countries like Nigeria, Ghana, Sierra Leone, Ivory coast

(Quedraogo *et al.,*2012). The highly nutritive seed was reported to contain 63% carbohydrate, 19% protein and 6.5% oil, hence referred to as complete food (Quedraogo *et al.,*2012; Akpalu *et al.,*2012). In Nigeria, production and consumption are confined within the rural setting where its food security potentials, drought resistant habit, relative resistance to pest and diseases and little demand on soil nutrient are used to characterize it as a legume of note that can be used for reducing the over dependence on cowpea (*Vigna unguiculata L.*) and it can also be fed to animals (Sessay *et al*., 2004; Anchirinah *et al.,*2001; Mwale *et al.,*2007; Jorgensen *et al.,*2010, 2011; Massawe *et al.,*2002).

Effa *et al.,* (2016) reported that Bambara ground nut is a crop that increased photosynthetic capacity through rhizobium mediated biochemical sequences in the host plants roots causing nodulation and the fixing of nitrogen required by the plant. It was also noted that Bambara groundnut has the ability to fix up to 28.42kg N /ha in the Sudano-Sahelian zone of Nigeria (Yakubu *et al.,*2010). Bambara groundnut yields have been reported to vary considerably among sites, seasons, genotypes (Quedraogo *et al.,*(2012), mounding times; Akpalu *et al.,* (2012), Spacing, plant densities, landraces and nutrient status maintenance effects have been documented by Effa *et al.,* (2016), Alhassan *et al.,* (2012), Mkandiwire and Sibuga (2002) and Jakusko and Belel (2009), Sessay *et al.* (2004) and Berchie (2010) respectively, from different locations. These showed that soil nutrient potential, cultural activity and ecology have been contributing to variation in yield from different location.

The extent to which tillage, organic manures and spacing affect growth, seed yield and yield components of Bambara groundnut in different agroecological zones of Nigeria have not been satisfactorily investigated. Tillage practices are critical components of soil management systems and it creates an ideal seedbed condition for plant emergence, plant development and unimpeded root growth for crop production. Inappropriate tillage practices could inhibit crop growth and subsequently, the yield (Quedraogo *et al.,*2012). Selection of an appropriate tillage practice for the production of Bambara groundnut is a step in realizing optimum growth and yield.
The role of organic manure in crop cultivation is of prime importance under humid condition and the use of SBE (Spent Bleaching Earth) as organic source for crop growth and yield have been documented by Aderibigbe *et al.,*(2017). According to Niagaraj *et al.,*(2001), high yields of groundnut, a crop that is related to Bambara groundnut can be obtained with better management of soil fertility, especially when it is organically managed. Recently, organic agriculture is gaining increased attention due to its numerous benefits such as the maintenance of dynamics of soil nutrient status and provision of healthy food products.

Plant density is an important agronomic factor that manipulates micro environment of the field and affects growth, development and yield formation of crops. Within certain limits, increase of Plant Population Density (PPD) decreases the growth and yield per

plant but the reverse occurs for yield per unit area (Kouassi and Zoro, 2010; Caliskan *et al.,*2007).
Crop failure and low yield have been recorded from subsistence farmers in the study area. This is primarily due to farmers' poor knowledge of appropriate tillage methods (Eifediyi *et al.,*2020), soil nutrient complementing methods (Gnangui *et al.,*2019) and inappropriate spacing (Egbe *et al.,*2009) embarked upon in the cultivation of Bambara groundnut. Therefore, to facilitate increased Bambara groundnut production among farmers in this agro-ecological zone, the need to assess the effects of Tillage, SBE as organic source and Spacing on the growth and yield of Bambara groundnut calls for attention. This becomes imperative because of the threatening effect of climate change and ineffective conservational management adopted by farmers, which is affecting yield.

Materials and methods

The experiment was conducted in 2020 at the Teaching and Research Farm, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria (latitude 07^0 11^N and longitude 05^0 35^E, altitude 35m above sea level). The site is characterized by mean annual rainfall between 1300 mm – 2000 mm with an average temperature of 300C. Relative humidity ranges from 85% during the raining season to less than 25% during the dry season. The soil physical and chemical properties is shown in table 1a. Seed was sourced locally from Oka- Akoko, Ondo State. Spent Bleaching Earth (SBE), a waste material from vegetable oil refinery was collected from JOF Ideal Family Farm, Owo Benin Express way, Owo, Ondo state (table 1b).

The 2 x 3 x 3 factorial experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications. Treatments were two levels of tillage (mound and ridge), three levels of SBE (control, 5t ha-1and 10t ha-1) and three levels of spacing (50x50, 50x40, 50x30cm) giving a plant population density of 40,000, 50,000 and 66,667 plant ha^{-1} respectively. Each plot measured 8.1 x 8.1m and a work space of 0.5m was established between plots. The soil was mechanically ploughed, harrowed and later, hand hoe was used in shaping to mound and ridge. Treatments were randomly allocated to experimental units by the use of table of random numbers at 2 weeks after land preparation.

Seeds were sown with a dibbler at a depth of 3-5cm at two seeds per stand. Supplying and thinning were done simultaneously at 15 days after planting (DAP). Weeding was done with hand hoe 3 weeks after sowing and a total of three weeding were done before crop cover and subsequent pegging.
Data were collected for the vegetative and yield components response using 5 sampled plants taken at random from the middle rows to avoid edge effect. The vegetative parameters measured were; leaf area index (LAI), stem girth (cm), number of leaves, plant height (cm) and 50% flowering at 3, 6 and 9 WAP; and reproductive parameters measured were number of pods / plant, weight of pods / plant, weight of

pod plus plant, weight of 100 pods, shaft weight / plant, seed weight / plant, yield / hectare and harvest index. Data were subjected to analysis of variance to determine the significance differences between treatments means by using Genstart software package. Duncan's multiple range tests (DMRT) was employed in comparison of individual treatment means at $p < 0.05$.

Results

Effect of Tillage, SBE and Spacing on Vegetative Growth of Bambara Groundnut at 3,6 and 9 WAP

At 3WAP tillage methods performance on the vegetative indices measured were not significantly different in this study, though variations occurred among values but were not separable at $p<0.05$ levels. Plots treated with 10t ha-1 SBE had increased LAI and plant height at significant level ($p<0.05$) more than 5t ha-1 and 0t ha-1 plots. The highest number of leaves were obtained with the application of 10t ha-1 and 5t ha-1 SBE without significant difference from each other, while the least number of leaves / plants were obtained from 0t ha-1 plot. Values of stem girth and days to 50% flowering stage were not significantly different ($p<0.05$) for 10t ha-1, 5t ha-1 and 0t ha-1. Also, spacing of 50x30 cm enhanced significant ($p<0.05$) increase in number of leaves and LAI, whereas, spacing of 50x50 and 50x40 cm recorded lower values that were not significantly ($p<0.05$) different from each other. Similarly, there were no significant ($p<0.05$) difference in values of plant height, stem girth and days to 50% flowering stage across the three Spacing studied (Table 3).

Vegetative parameters increased linearly as the plant age increased. At 6WAP tillage methods had positive influence on the vegetative parameters obtained from the plots. Values were not significantly different ($p<0.05$) from each other. SBE, however, significantly affected the number of leaves in order of increased magnitude with 10t ha-1> 5t ha-1 > 0t ha-1. Values of LAI, plant height and stem girth obtained from application of 10t ha-1 were not significantly different from values obtained with application of 5t ha-1 SBE, but were significantly higher from values obtained from control plots. Also, SBE did not show any influence on the stem girth at all levels of application. Plant Spacing showed significant effect on number of leaves and LAI.
Spacing of 50x30cm recorded significantly higher number of leaves when compared to plants at spacing of 50x50cm, but not significantly different from plants spaced at 50x40cm. Similarly, values of number of leaves from spacing of 50x40cm were not significantly ($p>0.05$) different from spacing of 50x50cm. The interaction between Tillage methods and SBE levels and spacing and tillage methods did not have significant variation on vegetative growth of Bambara groundnut. Though, SBE and spacing interacted to produce the significant values in number of leaves, LAI and plant height (Table 4).

At 9 WAP, tillage methods did not influence the vegetative growth of Bambara

groundnut at significant level ($p<0.05$). There were observed variations in values of vegetative parameters as influenced by SBE. Plots treated with 10t ha-1 recorded the highest values in number of leaves, plant height and stem girth as compared with values from 5t ha-1 and control plot. But no significant different in values obtained from plots treated with 10t ha-1 and 5t ha-1. Spacing had significant influence on number of leaf, LAI, plant height, stem girth, but not with days to 50% flowering date. Apart from the value of number of leaves that is significantly different, all other parameters showed non-significant difference between Spacing of 50x30 and 50x40cm. Tillage / SBE and Tillage / Spacing did not show any significant interactive effect on the vegetative growth of Bambara groundnut, but Spacing of 50x30cm and 10t ha-1 of SBE interacted to influence the vegetative growth of Bambara groundnut (Table 5).

Effects of Tillage, Spent Bleaching Earth (SBE) and Spacing on Yield and Yield Component of Bambara Groundnut

The yield and yield component of Bambara groundnut were not significantly ($p>0.05$) affected by Tillage methods. Values of number of pod / plant, weight of pod / plant, weight of pod + plant, seed weight, weight of 100 pods, harvest index and yield ha-1obtained from application of 5t ha-1 of SBE were higher than values of 0t ha-1 plots, but not significantly ($p>0.05$) different from each other. However, the values were significantly ($p>0.05$) different from the values obtained from the application of 10t ha-1of SBE. The shaft weight / plant was not significantly influenced by the spacing implemented. Spacing of 50x30cm and 50x40cm recorded higher non-significant values in number of pods / plants. 50x50cm spacing recorded the highest number of weights of pod / plant and shaft weight / plant. The seed weight, harvest index, and yield / hectare were significantly ($p>0.05$) influenced by spacing of 50x30cm. The weight of pod / plant and weight of 100 pods were not significantly different among the three spacing studied. Interaction between tillage and SBE on yield parameters were not significant ($p>0.05$). Also, the interaction of tillage and spacing showed non-significant effect on yield and yield component value at $p>0.05$ levels. Application of 5t ha-1 of SBE with Spacing of 50x30cm interacted to significantly influenced the number of pod / plants, weight of pod and plant, harvest index and yield / hectare of Bambara groundnut (Table 6).

Discussion

Effect of Tillage, Spent Bleaching Earth and Spacing on the Vegetative Growth of Bambara Ground-nut

Tillage practices are critical components of soil management systems that brings about the changes in organic matters and also creates an ideal seedbed condition for plant emergence, plant development and unimpeded root growth (Sylvester *et al.,*2015; Ohu, 2011; Onwualu, 2006). The tillage methods in this study involve the manipulation of the soil to create conducive seedbed for plant germination, root

penetration, growth and development. For instance, number of leaves, leaf area index, plant height, stem girth and days to 50% flowering date progressed positively at 3, 6 and 9WAP without any clear difference between the tillage methods. This indicate the effectiveness of the two tillage methods to influence vegetative growth and development in Bambara groundnut. Aikins and Afuakwa (2010) observed similar tillage methods being used by small holder's farmers in producing cowpea (*Vigna unguiculata (L.)* Walp) in agro-ecological zone similar to the study area under rainfed agriculture.

The effect of Spent Bleaching Earth as organic material in boosting soil nutrient was significant on the vegetative growth phases of Bambara groundnut as observed in this study. This is in agreement with the results of Aderibigbe et al. (2017) in SBE effect on the growth and yield of maize (Zea mays L.). Similarly, the leaf yield of Eggplant (*Solanium macrocarpon L*.) and growth and fruit yield of Okra were significantly influenced with application of manure amended with SBE (Aderibigbe, 2017; Loh *et al.,*2013). Therefore, this work and the likes of Ali *et al.,* (2009) and Nabil *et al.,* (2015) showed that differential influence in vegetative growth of Bambara groundnut was due to the application of SBE on the soil.

The positive response of Bambara groundnut to spacing of 50 x 30cm had significant influence on most vegetative parameters considered at 9WAP, irrespective of the tillage methods and the levels of SBE applied. The significant low growth responses in stem girth and plant height at 6WAP could be due to the plant diverting assimilates to profusely branched and root proliferation at the nodes to enhancing gravitation at flowering for early fruiting which is more synthate demanding than energy required for plant's vertical growth and stem girth development. It could also be that the effect of genetic factors moderating the plant architecture was age effective, making the plant to respond to gravity rather stem thickening and elongation. However, spacing has been documented by Effa *et al.,*(2016) and Akpalu *et al.,*(2012) to have influence on plant height in competition for light energy and other growth resources. The observation of this experiment at 9WAP for spacing of 50 x 30cm, agreed with their report. Moreover, the interactive effect of spacing and 10 t ha-1of SBE evaluated influenced the vegetative growth of Bambara groundnut at 9WAP than the combined spacing and 0t ha-1 SBE (control) treatment. This could be attributed to the potential ability of SBE to mobilize some plant nutrients and micro-organism in already pulverized soil via the tillage methods, therefore enhancing vegetative growth.

Effect of Tillage, Spent Bleaching Earth and Spacing on the Reproductive and Yield Components of Bambara Ground-nut

The processes of physical manipulation of the soil observed in the two tillage methods have factored the non-significant yield obtained from this study. Ohu, 2011 reported that tillage helps to achieve fitness of tilt, smoothness, aeration, porosity, friability and optimum moisture content which facilitated good growth and yield of crops.

Spent bleaching earth at 10 t ha-1 recorded reduced yield and yield components of Bambara groundnut in relation to 5t ha-1 and 0t ha-1(SBE). Abate (2008) had observed that as the levels of available nitrogen increased in the soil, the amount of nitrogen fixed symbiotically generally decreased to favour the vegetative growth of the crop. The reduced yield and yield components of Bambara groundnut observed in this study could be attributed to vegetative growth resulting from excessive deposition of nitrogen above the requirement of Bambara groundnut. Also, agreeing with finding of Effa *et al*., (2016) that Bambara groundnut makes little demand on soil nutrients due to its ability to fix nitrogen it required through Rhizobium or Brady rhizobium mediated biochemical sequence for its growth and development. The enhanced vegetative growth of Bambara groundnut with application of 10 t ha-1 spent bleaching earth (SBE) was at disadvantage of yield and yield components of the plant as obtained in this experiment. At 6WAP Bambara groundnut was noticed to have reduced plant height and small stem girth which can be attributed to the period of pod filling which require the diversion of more nitrogen. In this study, the trend of decline in yield and yield component with the application of spent bleaching earth might probably be connected with the depressed symbiotic activity due to increase deposit of nitrogen leading to increased amount of nitrogen fixed and the sank therefore partitioned into vegetative growth, taking advantages of ample space provided to grow vegetative, rather than converting energy in the form of photosynthesis-derived sugar to yield and yield components. Also, wider Spacing (Akpalu *et al.,*2012; Akmal *et al.,*2010; Havlin, 2007) enhanced wider soil volume for root growth and nutrient absorption for individual plant development as emphasized in this study. This study observed that the closest spacing of 50 x 30cm produced the heaviest yield and highest response for yield components of Bambara groundnut, mainly because of increased number of plant / m2, resulting in effective leaf area capturing solar energy for significant increase in yield of crop (Effa *et al.,*2016; Chaniyara *et al.,*2001).

Conclusions

In conclusion, 10t ha-1 spent bleaching earth positively affected vegetative growth of Bambara groundnut at the expense of seed yield. Also, vegetative growth and yield were highest at Spacing of 50 x 30cm at all levels of SBE application. For effective yields, farmers should adopt any of the method of tillage used in this study, with spacing of 50 x 30cm and application of between 0t ha-1 to 5t ha-1of spent bleaching earth for Bambara groundnut production in the study area.

Recommendation

Further research should be conducted to know the relative amount of spent bleaching earth that will be suitable to enhance both the vegetative growth and yield of Bambara groundnut, in order to prevent wastage of resources.

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Table 1a- Physical and chemical properties of soil at the experimental site in 2020

Soil Properties	**Value**
Textural class	Sandy loam
Sand (%)	76
Silt (%)	10
Clay (%)	13
Organic carbon (%)	0.75
Total nitrogen (%)	0.24
pH (H20 1:1)	5.85
Ca (cmol/kg)	1.26
Mg (cmol/kg)	0.25
Na (cmol/kg)	0.78
Electrical conductivity (cmol/kg)	2.66
CEC (cmol/kg)	0.06
Available P (mg/kg)	19.88
Zn (ppm)	0.77
Cu (ppm)	0.38
Mn (ppm)	41.45
Fe (ppm)	60.72

Table 1b- Chemical composition by ash (% oxides by wt) of SBE (Spent Bleaching Earth)

SiO2	60.4	56.9	71
Al2O3	11.5	9.24	11
Fe2O3	9.3	8.27	1.61
MgO	5.2	4.32	1.01
CaO	1.7	3.9	2.51
Na2O	0.4	0.08	1.70
K2O	1.2	0.96	2.28
MnO2	NA	0.10	0.05
TiO2	NA	0.90	0.30
P2O5	NA	4.87	0.05

Source; Taiko Supreme 1B supplied by Taiko Clay Marketing Sdn. Bhd. (2006).

Table 2:Weather data observed during the growth period of Bambara groundnut in 2020

Month	Rainfall (cm)	Mean Temperature (0_c)	Relative humidity %	Sunshine (Hrs).
May	146.10	25.50	80	60
June	216.80	25.65	83	66
July	105.30	25.10	84	72
August	124.90	24.90	82	74
September	275.60	24.50	83	64
0ctober	49.00	24.70	79	65
Total	1017.70	150.35	491	401
Mean	169.62	25.06	81.83	66.83

Source: Rufus Giwa Polytechnic Meteorological Station, Owo, Ondo state, Nigeria.

Table 3; Effect of Tillage, SBE and Spacing on the vegetative growth of Bambara groundnut at 3 WAP

	Parameter				
Treatments	**NOL**	**LAI**	**PLH (cm)**	**STG (mm)**	**DTO 50%**
Tillage					
Mound T1	270.00a	3.46a	11.96a	0.40a	40.01a
Ridge T2	269.00a	3.48a	12.01a	0.40a	40.01a
SBE t/ha					
SBE 0	54.10b	2.16c	13.25c	0.39a	40.00a
SBE 1	59.70a	2.77b	13.32b	0.39a	39.98a
SBE 2	65.11a	2.81a	13.46a	0.40a	39.97a
Spacing (cm2)					
50x50	245.66b	3.39b	12.00a	0.40a	40.00a
50x40	240.98b	3.39b	12.00a	0.39a	40.00a

50x30	248.21a	3.52a	12.03a	0.39a	40.00a
Interaction					
Till x SBE	ns	ns	ns	ns	ns
Till x SPA	ns	ns	ns	ns	ns
SBE x SPA	**	**	**	ns	ns

NOL- number of leaves; LAI- leaf area index; PLH- plant height (cm); STG- stem girth (mm); DTO - days to 50% / 100% flowering stage; ns- not significant; **- significant at p> 0.05; TILL- Tillage; SBE- spent bleaching earth; SPA- Spacing (cm).
Values followed by similar letters under the same column are not significantly different at p=0.05 according to Duncan's multiple range test.

Table 4; Effect of Tillage, SBE and Spacing on the vegetative growth of Bambara groundnut at 6 WAP

	Parameter				
Treatments	**NOL**	**LAI**	**PLH (cm)**	**STG (mm)**	**DTO 50%**
Tillage					
Mound T1	300.09a	3.48a	23.92a	0.41a	40.00a
Ridge T2	301.00a	3.48a	23.87a	0.40a	40.00a
SBE t/ha					
SBE 0	226.56c	2.33b	13.25b	0.40a	40.00a
SBE 1	247.17b	2.47a	13.32ab	0.40a	39.98a
SBE 2	276.42a	2.48a	13.46a	0.40a	39.97a
Spacing (cm2)					
50x50	234.14c	3.58a	13.42a	0.40a	40.00a
50x40	258.31b	3.62a	13.38a	0.39a	40.00a
50x30	260.61a	3.61a	13.38a	0.39a	40.00a
Interaction					
Till x SBE	ns	ns	ns	ns	ns
Till x SPA	ns	ns	ns	ns	ns
SBE x SPA	**	**	**	ns	ns

NOL- number of leaves; LAI- leaf area index; PLH- plant height (cm); STG- stem girth (mm); DTO - days to 50% / 100% flowering stage; ns- not significant; **- significant at p> 0.05; TILL- Tillage; SBE- spent bleaching earth (0=control, 1=5t / ha-1, 2= 10t/ha-1); SPA- Spacing (cm).
Values followed by similar letters under the same column are not significantly different at p=0.05 according to Duncan's multiple range test.

Table 5; Effect of Tillage, SBE and Spacing on the vegetative growth of Bambara groundnut at 9 WAP

	Parameter				
Treatments	**NOL**	**LAI**	**PLH (cm)**	**STG (mm)**	**DTO 50%**
Tillage					
Mound T1	330.09a	3.50a	15.62a	0.40a	40.00a
Ridge T2	330.10a	3.51a	15.59a	0.40a	40.00a
SBE t/ha					
SBE 0	289.01b	3.28b	14.46a	0.39a	40.00a
SBE 1	342.92a	3.22bc	15.58a	0.39a	40.00a

SBE 2	344.02a	3.38a	15.58a	0.40a	40.00a
Spacing (cm)					
50x50	348.02b	3.64b	15.22a	0.40a	40.00a
50x40	362.09a	3.65b	15.45a	0.41a	40.00a
50x30	368.22a	4.11a	15.48a	0.41a	40.00a
Interaction					
Till x SBE	ns	ns	ns	ns	ns
Till x SPA	ns	ns	ns	ns	ns
SBE x SPA	**	**	ns	ns	ns

NOL- number of leaves; LAI- leaf area index; PLH- plant height (cm); STG- stem girth (mm); DTO - days to 50% / 100% flowering stage; ns- not significant; **- significant at p> 0.05; TILL- Tillage; SBE- spent bleaching earth; SPA- Spacing (cm).
Values followed by similar letters under the same column are not significantly different at p=0.05 according to Duncan's multiple range test.

Table 6: Effect of Spent Bleaching Earth and Spacing on reproductive growth of Bambara groundnut

	Parameters							
Treatments	**NOP**	**WP/P**	**WP+P**	**W100P**	**SHWGT**	**SWGT**	**HI**	**Y/Ha**
Tillage								
Mound T1	**24.56a**	**128.21a**	**421.81a**	**220.01a**	**77.21a**	**98.81a**	**66.18a**	**2032.41a**
Ridge T2	**24.66a**	**126.74a**	**422.96a**	**219.89a**	**77.18a**	**98.09a**	**66.20a**	**2032.80a**
SBE (t/ha)								
SBE 0	**23.86a**	**122.64a**	**440.14a**	**230.41a**	**75.86b**	**100.26a**	**79.98a**	**1662.11a**
SBE 1	**24.12a**	**122.82a**	**438.29a**	**230.22a**	**74.98bc**	**100.02a**	**79.76a**	**1661.62a**
SBE 2	**21.66b**	**119.21b**	**322.76b**	**211.65b**	**82.21a**	**87.69b**	**61.21b**	**1432.14c**
SPA (cm)								
60X50cm	**15.02c**	**194.28a**	**400.21b**	**315.06a**	**78.88a**	**96.81c**	**40.21c**	**1868.24c**
60X40cm	**25.09b**	**142.68c**	**400.18c**	**300.44b**	**71.92b**	**98.25b**	**42.22b**	**1891.16b**
60X30cm	**27.62a**	**146.22b**	**400.22a**	**311.89b**	**70.26c**	**100.44a**	**46.82a**	**1992.22a**

SBE (Spent Bleaching Earth), SPA (Spacing cm), NOP (number of pods / plant), WP/P (weight of pod/
plant g), WP+P (weight of pod plus plant g), W100P (weight of 100 pods g), SHWGT (weight of shaft g), SWGT (weight of seed), HI (harvest index) and Y/Ha (kg / ha), ns (not significant at p=0.05), ** (significant at p> 0.05)
Values followed by similar letters under the same column are not significantly different at p=0.05 according to Duncan's multiple range tests.

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CROP WATER USE, GROWTH AND YIELD OF EGGPLANT (*Solanium Aethiopicum L.*) UNDER THREE IRRIGATION REGIMES IN FADAMA SOIL OF OWO, SOUTHWESTERN NIGERIA

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Abstract:

Fadama soils (inland valley swamps) are characterized by shallow water table depth which can supply important percentage of crop water demand (ET) via up-flow which constitutes a significant component in the root zone water balance of crops. The pattern of water use, growth and yield of eggplant (Solanum aethiopicum L.) grown in the fadama during the dry season was investigated in Owo, a humid rainforest zone of Nigeria. The study involved an experiment laid out in Randomized Complete Block Design (RCBD) which evaluated the effects of controlled gravity-drip irrigation system on the water use, growth and yield of eggplant. Field plot was 5 x 4m and seedlings were transplanted at spacing of 90 x 90cm on flat. Treatments consisted of water application Once a week, Twice a week and No-irrigation (Control) which were randomly allocated to plot at 3 replicates. Data were collected on pattern of water use as it affected agronomic parameters of root and shoot biomass, leaf area, flowering and fruiting characters of eggplant. Irrigation regimes significantly ($p<0.05$) increased growth and yield of eggplant. The sequence of depletion and replenishment of soil moisture differed between the irrigation regimes. The values of roots, shoot dry weights, leaf areas, fruits number, and fruits weight were higher in twice irrigation per week over once irrigation and control (zero irrigation). Complementing water status of fadama soil via irrigation increased water use, growth and yield of eggplant. The use of drip irrigation at twice weekly is ideal for the production eggplant during the dry season in fadama soil in the study area.

Keywords: *"eggplant", "fadama", "gravity drip irrigation", "growth", "irrigation regime", "yield".*

Introduction

Eggplant, a perennial bush, grown as annual, has been propagated as land races locally in many villages by generation of farmers in South Western Nigeria where it is generally called '*IGBA, IKAN or IJEGUN*'. Eggplant

(*Solanum aethiopicum*.L) is one of the five most important vegetable species in the West and Central Africa (Mei Han *et al*., 2021; Kamga *et al*., 2010; Schipper, 2000) and also ranked the most important local vegetable fruit species that is grown commercially and is allocated larger land acreage, next to pepper, than the other vegetables. The eggplant is a very good source of dietary fiber, potassium, manganese, copper, magnesium, niacin, folate and vitamins B1, B6 (He *et a*l., 2009).

This local fruit vegetable is important for food security and it can be harvested piecemeal for home consumption or to spread the marketing season (Schipper, 2000). Despite high nutrient content (Mei Han et al., 2021; He *et al.,* 2009) and low production cost (Sanni and Okeowo, 2016), production has been confined mainly to upland farming, mainly during the wet season, hence low productivity of this crop. The Fadama is good for farming especially fruit vegetables like pepper and eggplant (Tsoho and Salau, 2012; Okunola, 2009; Agele *et a*l., 2006)

Inland valley swamp (Flood Plains/Valley swamps/ Fadama) are low lying areas including streams, channels and streamlets, depressions which are water logged or flooded in wet season (Martin and Muhammad, 2021; Turner, 1977). They are used for agricultural production in sub-Sahara Africa and the total Fadama land area is estimated at 85 million, only 10% to 15% is used for agriculture. Most of the inland valley swamps are concentrated in the inter–tropical zones where rainfall is more than 700mm per annum. About 3.5 million hectares of Nigeria landmass are Fadama lands out of which 2 million hectares are put under small scale irrigation (Okunola, 2009). These lands (Fadama) in Ondo State are occupied by small scale farmers cultivating land area ranging between 0.01 – 5.00-hectare land area above which over 80 percent of the farmers having less than 2.0 hectare (Okunola, 2009). Fadama land cultivation is therefore a way out of the land pressure on land use for farming by small holder farmers.

Fadama System of farming is an agricultural production system that is advocated to supply an all year round food production particularly fruit vegetable like pepper, eggplant and others, since they are grown in raining season in south Western Nigeria. In addition, it implies the cultivation of crop two times under supplementary irrigation in receded flood valley tray.
This type of farming enhances self-sufficiency in food (arable fruit vegetable; eggplant) production and also ensure all year round fruit vegetable availability, thus ensuring abundant of the crop in the market and with about double fold yield than that of the rain fed cultivation (Aladetoyibo, 2001, Luna Al-Hadidi *et al*., 2022).

Irrigation is an important factor that affects the yield and quality of crops when soil moisture is limiting (IWMI, 2002). Irrigation technology plays an important role in making water available for agricultural production of crops at all time of the year, and it has become necessary in that rainfall is inadequate and the distribution is variably

spatial (poor distribution) in agriculture producing area (Punial and Pande, 1975).

Assouline (2002) report corroborated the above and further stated that of the estimated 71.2 million hectares of Nigeria cultivated land, barely fifty percent (50%) is put to use due to water constraint; which means that the agricultural output (produce) declines as a result of erratic rainfall pattern. Hence, complementing with irrigation becomes a way out of the constraint. Irrigation concept as a whole involves artificial or conscious effort to augment soil water supply during period of deficit or in area of deficit to meet the additional requirement of crops during the wet season and supply water to farmland during dry periods. That is, supplemental moisture gains of the soil to adequately propelled crop growth and development with direct relationship to yield. This conscious effort at making water available at off periods in the Fadama concept places emphasis on absolute management of both land and water to provide food for all year round for the needs of the ever increasing population of the country. The objective of this paper therefore was to know WUE (Water Use Efficiency) of egg-plant in relation to the biomass accumulation, fruit yield and yield components under three irrigation regimes with drip irrigation method in Fadama soil (inland valley swamp). This will enhance the recommendation of water application approach that facilitate continuous production of egg-plant in fadama soil (inland valley swamp) of the study area.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in the research farm of Rufus Giwa Polytechnic, Owo, a southwestern part of Nigeria (latitude 7^0 11^N and longitude 5^0 35^E, altitude 35m above sea level) is located within the humid region of Nigeria. Owo lies in the rain forest zone with mean annual rainfall of between 1300-1600mm and with an average temperature of 27.5^0C. The relative humidity ranges between 85% and 100% during the rainy season and less than 60% during the dry season period.

Treatment and experimental procedure

The experiment was carried out between October, 2020 to April 2021 to examine the effects of irrigation regime on yield and water productivity of fadama grown eggplant in inland valley swamp in the study area using drip irrigation technique. The irrigation regimes are (i) no irrigation (control), (ii) once /week irrigation and (iii) twice / week irrigation

Land Preparation

The experimental site consisted of three blocks each of which measures 13.50 x 90m. The land was manually cleared, packed, and herbicide was applied at the rate of 3 liters per hectare to further prevent weed competition on the plots.

Treatment Allocation and Planting

Treatments (no irrigation, once / week irrigation and twice / week irrigation) were

randomly allocated to plots by balloting method. Each treatment was replicated 3 times per block. 1 seedling was planted per stand and was replicated 10 plants per plot.

Irrigation Strategies

Irrigation water was applied using the gravity drip irrigation system while water was delivered to plant via point source emitters of 2 liters'/hour discharge rate. The emitters were installed on lateral per row of crop and were spaced 90 X 90 cm apart. Irrigation buckets were suspended on 2m high iron stanchion to provide the required hydraulic heads (1WM1, 2002).

Irrigation was imposed using low-head (gravity) drip system. Irrigation consisted of application of 1.38 liters of water per stand at once / week and twice / week.

Drip irrigation was applied using point source emitters, the emitters were selected with a coefficient of variation (CV) of 0.03 (CV for good emitter is <0.05). The manufacturer's chart showed 0.96m as the pressure at which laterals would operate to ensure emitters discharge (deliver) of the specified amount of water rate.

Pressure variation in the lateral is kept within the range of emitter uniformity (En) for the drip system, En was estimated as 0.94 peak evapotranspiration (ET peak) rate for the crop under drip irrigation treatment was estimated as ET peak=ET0*P/85 (Schwab et al.,1993), where; ET peak is the evapotranspiration rate for the month or period; ET_0 is the reference evanpotranspiration, for the month/period (e.g. 5.1 mm/day) P is the total area covered by the crop leaf area (cm) which is assumed 80% (Agele et al., 2015). There were pre-irrigation of two days before planting of the crop and thereafter, the adopted irrigation water treatment was imposed. The treatments were typified by the difference in the plant available water (PAW) or soil moisture stress at which irrigation were carried out.

AGRONOMIC PRACTICE

Weeding- weeding were done manually using simple hand hoe to remove competing weed from the field. Occasionally, rouging was carried out by pulling weed with hand.

Plant Measurement- Data were collected on root and shoot biomass, leaf area development, flowering and fruiting characters and fruit yield of eggplant.

Soil Measurement

Soil at the site of the experiments was sampled and analyzed for physical (textural class, bulk density, water holding capacity) and chemical (organic matter, N, P, K, Ca, Mg, CEC, electrical conductivity and PH) properties using standard laboratory procedure.

Core examples were taken at increment depths of 10cm to 60cm depth while bulk density was determined for the samples taken at each soil depth and the values were used to convert gravimetric soil moisture content to volumetric ($cm^3 . cm^{-3}$). (Table 1a)

Gravimetric soil moisture content and soil water pressure heads was measured using

tension meter installed at 0.2, 0.35, 0.50m below soil surface at 0.1m from eggplant stand.

Weather variables at the site of experiment during crop growth cycle (soil and air temperatures, vapuor pressure deficit (Vpd), solar radiation, wind speed were monitored from Meteorological observatory, 500 meters from site of experiment.

From the experimental field, six samples were collected from different replicates at 50% flowering stage to crop harvest for the experiment.

Data amassed were subjected to analysis of variance (ANOVA) while significant treatment means were separated using Duncan Multiple Range Method at 5% level of probability.

RESULTS

The meteorological variables of the site of study are presented in tables 1a and b.

Trends in rainfall distribution at the site of the study during eggplant growth showed that the rainfall is characterized by gradual rise from the month of January until it reaches the peak in the month of August. Thereafter, it declined in the month of September slightly to December when a little break in rainfall was experienced. However, the months of September and October are characterized by heavy but infrequent rainfalls and this is the second modal rainfall. November marks the onset of the dry season. Relative humidity of the study site is very high, more than 90% during the night and early in the morning falling to between 37 and 77% was observed on the site during the period of the experiment (October, 2021) while maximum relative humidity ranges between 93 and 100%. Solar radiation ranges between 14.21 and 15.16MJ/m^2/day. Wind speed ranged between 3.20 and 5.71Km/hr.

The growing environmental conditions of the post rainy season are dominated by high available energy, atmospheric demand (vpd), supra-optimal air and soil temperatures.

More marginal growing environment was experienced particularly during the flowering and fruiting stage of eggplant. The dry season is a terminal drought situation, despite the few (negligible) rains, this period is characterized by dry spells (of varying intensities and duration) which occurred between rainfall episodes. Under the prevailing weather condition there are high probabilities of exceeding crop specific high temperature thresholds and limiting soil water status during the dry season. These environmental condition strongly impacted growth duration, dry matter production, efficiencies of water use and fruit yield in egg plant.

Table 1a- Physical and chemical properties of soil at the experimental site in 2021

Soil Properties	Value
Textural class	Sandy-loam
Sand (%)	76
Silt (%)	10
Clay (%)	13

Organic carbon (%)	0.75
Total nitrogen (%)	0.24
pH (H20 1:1)	5.85
Ca (cmol/kg)	1.26
Mg (cmol/kg)	0.25
Na (cmol/kg)	0.78
Electrical conductivity (cmol/kg)	2.66
CEC (cmol/kg)	0.06
Available P (mg/kg)	19.88
Zn (ppm)	0.77
Cu (ppm)	0.38
Mn (ppm)	41.45
Fe (ppm)	60.72

Table 1b. Meteorological conditions at the site of the experiment (October, 2020 – May, 2021)

	Year 2020				Year 2021				
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
Rainfall (mm)	275	148.6	31.3	18.4	27.1	17.3	64.8	104.9	146.1
Min. temp. (0c)	24.4	24.2	23.5	24.1	24.2	23.7	25.0	23.9	24.3
Max.temp. (0c)	26.9	28.4	31.0	32.0	32.6	33.6	31.7	31.8	29.7
Rh(%)	81.7	72.8	63.9	52.0	48.1	47.2	41.9	48.7	55
VPD (kPa)	2.42	2.81	3.05	2.76	2.82	3.0	3.20	3.5	3.10
Total sunshine (hr)	138	219	235	193	191	219	238	206	183
S/R (MJ/m2/d)	12.4	13.8	15.8	14.1	12.3	16.1	17.8	17.1	17.2
Open H_2O evap.(mm)	97	102	130	148	209	185	238	132	108

The trends in the value of soil moisture taken at 10cm depth in the planting with zero irrigation (control) were different from once and twice irrigation per week. The trends in soil temperature taken at 10cm depth for 1500 hours are shown (Fig 1), average soil temperature ranged from 28.05^{0}c in December to 28.25^{o}c at flowering and maturity in March. Soil moisture contents decreased (with increased soil temperature) at successive weeks from planting to flowering. However, during the flowering and fruiting periods, irrigation enhanced soil moisture content at 10cm depth. The soil moisture contents ranged from 30% to 68%. During the October period soil water content was higher possibly from the late rains of the second modal rainfall pattern

which terminates about November.

The sequence of depletion and replenishment of soil moisture under once and twice weekly irrigation regime are shown in fig 2. There were variations in the soil moisture content in eggplant root zone depth (0-60cm). Early in the season at crop establishment and vegetative growth stages, differences in soil moisture storage (replenishment) between irrigation regimes (once and twice / week) were found to be similar. A general rise in stored soil moisture was observed within the first to the sixth week after eggplant transplanting and before crop attained peak vegetative growth (maximum leaf area/ canopy cover). Nevertheless, higher moisture was stored in twice / week irrigation at mid-season (peak vegetative growth at 50% flowering (early reproductive / fruiting period). At this period the stored moisture in the soil profile increased down the soil profile.

Soil moisture contents under twice / week irrigation were higher due to the more frequent replenishment of moisture and moisture accumulation around the root zone of eggplant. The more frequent water application via the drip irrigation system to the crop root zone facilitated refill of soil column and larger storage of water. As the crop reaches maturity, soil moisture storage was influenced by irrigation. Soil water evaporation and climatic demand and crop moisture extraction / uptake increased. Trends in soil water potential (moisture tension) during the period of the experiments are presented in Fig 3. There were changes in soil water potential within the crop root zone surface (0-20 cm) and sub soil (20-60cm) depths. This indicate that soil moisture was not adequate in meeting egg-plant water requirement (evapotranspiration) in circumstance of the growing environmental conditions of the dry season. The values of the water stress index (1- ETa/ETo) ranging from 0.4 at seedling establishment / mid-season to less than 0.1 at reproductive growth phase were obtained (figure 4). The observed changes in CWSI indicates the inability of soil moisture storage to satisfy eggplant water requirements (Eta)

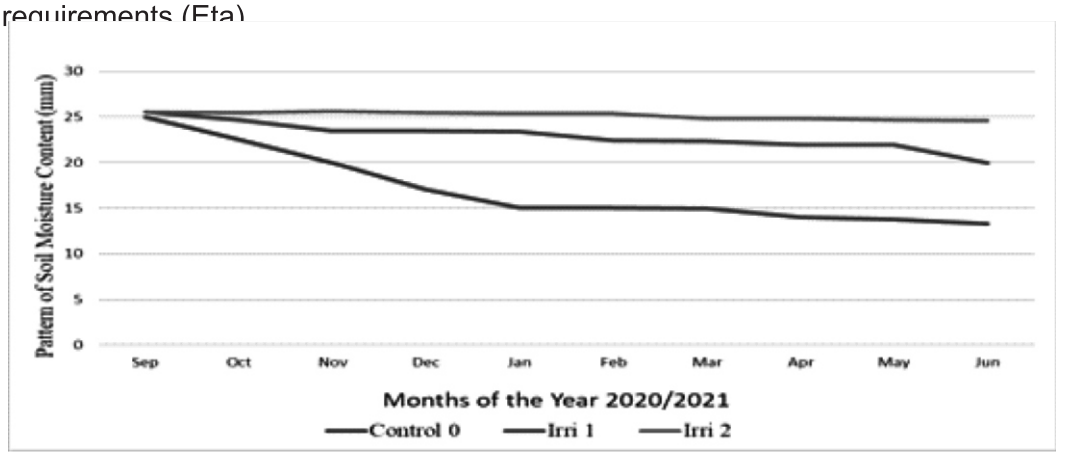

Figure 1- Effect of Irrigation Regimes on Pattern of Soil Moisture Contents During Eggplant Growth

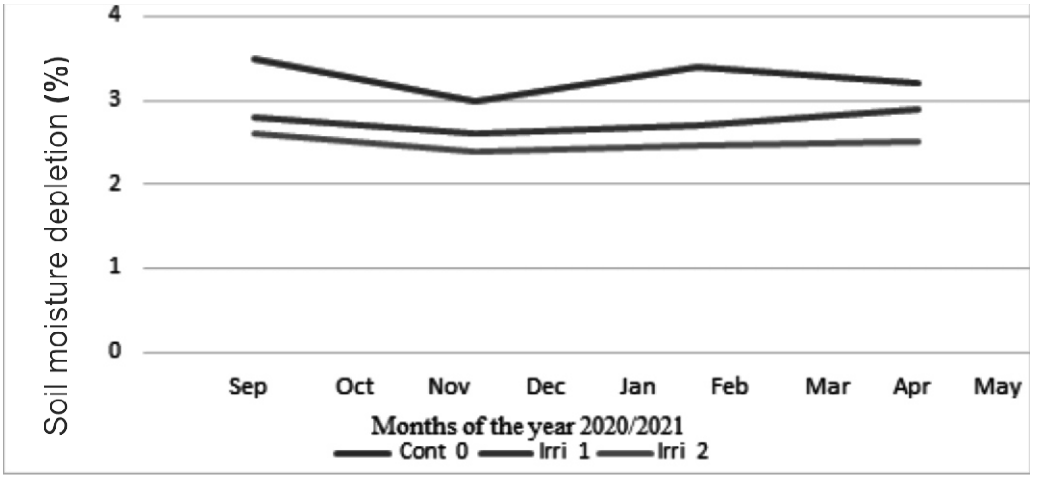

Figure 2- Effect of Irrigation Regimes on Pattern of Soil Moisture Depletion During Eggplant Growth

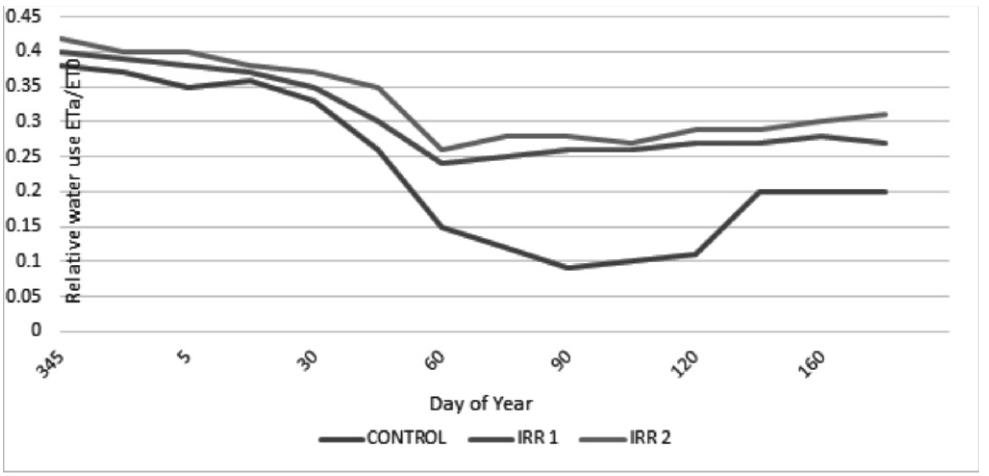

Figure 3: Effect of Irrigation Regimes on the Pattern of Relative Water Use During Eggplant Growth

EFFECTS OF IRRIGATION REGIMES ON THE GROWTH AND YIELD OF EGG PLANT

Irrigation regimes involving variable rates of water application (control, once and twice weekly) during eggplant growth affected its growth and yield characters. The trends of development obtained in leaf and plant height of eggplant were similar under the imposed once and twice irrigation regimes. Although, higher value of leaf area was produced by eggplant under twice weekly irrigation which nevertheless, were not

significantly different from value produced by once weekly irrigation (table 3). However, values of roots and shoots dry weights were higher in twice over once weekly irrigation. Application of irrigation twice weekly delayed the onset of flowering. The delayed in the onset of flowering appeared to have translated to fruiting advantages for twice weekly irrigation. In addition to the higher weight of fruits harvested the efficiency of water use for fruits production improved for twice weekly irrigation.

Table 2. Growth and yield parameters of eggplant at 3 irrigation regimes.

Irrigation regimes	Root lenght (cm)	Root dry weight (g)	Shoot dry weight (g)	Leaf area (cm^2)	50% flowering (days)	No of fruit harvested	Fruit yield (t/ha)	WU efficiency (t/ha mm)	Harvest. index.
Residual Moisture (control).	21.1	27	108.2	.62	28	43	10.40	.031	.28
Once Weekly	13.8	21	122.8	.62	32	62	11.70	.044	.54
Twice Weekly	15.3	18.4	128.1	.70	37	75	14.50	.048	.60
LSD (0.05)	3.4	.7	2.6	.02	3.5	5.2	2.72	.010	.03

DISCUSSION

The dry season is characterized by scanty rainfall and high solar radiation which lead to high soil water evaporation and climatic demand (low humidity), these environmental conditions are known to affect biomass accumulation and seed setting and yield of eggplant as supported by Shao *et al.,* (2009), Jagadish *et al.,* (2010) and Joko *et al.,* (2011). In addition to the growing environmental conditions of the site of experiment, the soil moisture management strategies adopted (irrigation regimes via drip irrigation method) and plant water extraction / depletion produced differences in soil moisture storage in the root zone of eggplant.

During the reproductive growth phase especially about crop maturity, there were sharp declines in soil moisture storage, however, soil moisture contents under both once and twice irrigation regimes were similar due in part to maximum leaf area / canopy cover. Plant biomass accumulation especially leaf development and hence canopy cover appeared to have effected differences in soil moisture evaporation and crop water consumption (evapotranspiration) (Famuwagun and Agele 2010).

For eggplant grown on residual soil moisture (control), the rapid rates of soil moisture depletion and the decrease in soil water storage, as observed in this experiment, appeared to be due to high climatic demand which enhanced soil water evaporation. In addition, lower fruit weight in term of yield can be attributed to increasing soil moisture deficit at flowering (anthesis) and fruiting period (Benjamin and Nielsen,

2006; Duan *et al.,* 2007; Praba *et al.,* 2009; Demirevska *et al.,* 2009).

The high temperature and low relative humidity (high saturation vapour pressure deficit – SVPD) presumably aggravated soil water evaporation and the depletion of stored soil moisture, the resultant moisture deficit stress effect could have depressed dry matter accumulation and hastened leaf senescence in egg plant

Irrigation ensure regular water supplies to meet the water demand of cultivated crop (eggplant) (Joko *et al.,* 2011) which facilitated good vegetative growth and enhanced higher yield. Twice irrigation regimes throughout crop growth promoted growth and yield characters of eggplant and the effects were significant on fruit yield production. Application of irrigation twice weekly on eggplant growth improved its root and shoot biomass and fruit yield over residual moisture in the study area. Irrigation is known to ameliorate the hydrothermal regimes of soil. The improved soil moisture status under twice irrigation could have enhanced plant establishment and improved seedling vigour of growth, dry matter accumulation and fruit yield of eggplant.

Plant biomass (roots and shoot dry weight) and leaf area were better under twice irrigation strategy and the improved growth was accompanied by high fruit yield and water use efficiency (WUE). Similar report was confirmed by Agele *et al.,* (2010) and Joko *et al.,* (2011).

Agele *et al.,* (2010) established the potential of agricultural resources of inland swamp valley based on the appropriate use of irrigation technology to produce pepper fruit during the dry season in the study area. This was also confirmed by this work.

Conclusion

The experiment revealed that water productivity, growth and yield of eggplant in inland swamp valley during the dry season depend on the availability of moisture within the root zone of crop to drive crop water requirement. The amount of water applied via irrigation also depends on the climatic demand, growth phase of crop and edaphic factors. Among the three water irrigation method adopted, the twice weekly irrigation is the most promising one followed by once weekly irrigation.

1. Twice irrigation per week reduces moisture stress and compensate for the climatic demand that is associated with dry season.
2. On the average the twice irrigation per week and once irrigation per week increase yield by 25% and 19.8% whereas 0 irrigation (residual soil moisture) reduces yield by 11%.
3. Twice irrigation per week treatment has significantly improved the water productivity of eggplant in inland valley swamp.

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