EVALUATION OF QUALITY OF CERTIFIED RICE SEEDS FROM SELECTED SEED COMPANIES IN NIGERIA

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MTECH/SAAT/2017/7455

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ABSTRACT

Field and screen house experiments were conducted during the rainy season of 2018 with a survey at Kano, Katsina and Zaria in the year 2019. The treatment was a factorial combination of two varieties of rice (FARO44 and FARO 52) and four selected seed companies (Company A, company B, company C, and company D) arranged in a Randomized Complete Block Design (RCBD) with three replications at the National Cereal Research Institute (NCRI) Badeggi) and Edozhigi in southern guinea savannah agro-ecological zone. The parameters measured at the field were plant height, days to 50 % flowering, number of tillers, number of panicle, seed weight and seed yield. The screen house experiment was a factorial combination of the varieties and seed companies arranged in a Completely Randomized Design (CRD) with three replications. The parameter measured during the screen house experiment includes seedling emergence test and seedling emergence index. Data collected were subjected to analysis of variance (ANOVA), principal component analysis and performance index. The survey data was analysed using qualitative and quantitative statistical bar charts. The analysis of variance showed that variety had a significant effect on plant height at 2 WAT and at harvest. Companies had a significant effect on plant height at 2 WAT and 4 WAT, seed weight, number of panicles and seed yield at 1 % level of probability. The result of principal component analysis (PCA) revealed that the first three principal components accounted for 99.42 % of the total variation. FARO 44 produced the highest seed qualities, growth and yield components than FARO 52. Company C produced better seed quality attributes, growth and yield components than the other seed companies. The result of survey data revealed that premier seed company had proper monitoring, no field rejection by (NASC), highest buyback and lowest price of foundation seeds than the other companies. It is therefore recommended that rice producing farmers should engage seed company C for increased growth, yield and seed quality of rice in the southern guinea savanna zone of Nigeria.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Rice *(Oryza sativa* L.*)* is a staple food in Nigeria, many countries of Africa, and other parts of the world. This is the most important staple food for about half of the human race (Imolehim, *et al.,* 2000). Saka *et al*. (2009) classified rice as the most important food depended upon by over 50 percent of the World population for about 80 percent of their energy need. Due to the growing importance of the crop, Food and Agriculture Organization (FAO,2013) estimated that annual rice production should be increased from 586 million metric tons in 2001 to meet the projected global demand of about 756 million metric tonnes by 2030. The global rice consumption rates have been on the rise within the last 20 years, with sub-Sahara Africa experiencing an increase of more than 50 % (Samarendu, 2013). The current global rice consumption is 408 million metric tons with China and India consuming more than 50 % of this (FAO, 2013). Nigeria national rice consumption estimated at 540, 000 tons has been rising steadily at an average rate of 12 % compared to wheat 4 % and maize 1 % per year (Onyango, 2014; GAIN Report, 2015). The upward trend has been attributed to population growth and changing feeding habits.

In the West African sub region, Nigeria has experienced a well-established growing demand for rice caused by rising per capita consumption and consequently the insufficient domestic production had to be complemented with enormous import both in quantity and value at various times (Saka *et al*., 2009). According to United State Agency for International Development (USAID), Nigeria’s rice sub sector is dominated by weak and insufficient producer, imperfect market linkage due to poor infrastructure and limited efficiency of distribution network which has resulted to low productivity and participation of farmers in the rice field (USAID, 2010).

In order to reduce the rate of rice importation, Saka *et al*. (2009) were of the opinion that disseminating improved varieties and other modern inputs as a composite package to rice farmers is very important. Nwite *et al*. (2008) indicated that the adoption of technologies and improved management practices should lead to substantial yield increase in rice production.

The number of rice consumption is increasing at the rate of 1.5 % annually while its production at present increases only at the rate of 1.0 % annually (Jeon, 2011). According to the United Nation (UN) estimation, the world population will increase from 6.7 billion at present to about 8 billion by 2025, therefore rice production must increase from 440 million tons at present to 475 million tons by 2020 (Jeon, 2011). Food Agriculture Organization (FAO) estimates that by 2050 the world rice requirement will be 524 million tonnes which required annual increase of 2 million tons from the present level of production.

1.2 Statement of the Research Problem

There are polluted seeds being sold by seed companies to farmers which are constituting grain mopping resulting to gaps between seed companies and the seed end users. There are also poor seed usages as the farmers do not patronise the seed companies directly for their seeds. They prefer to get it from a nearby market which affects the quality of their output.

Surveys conducted in 2009 by the Africa Rice Centre (Africa Rice) and National Agricultural Research Services (NARS) partners in 16 countries in sub-Saharan Africa, involving more than 30,000 farming households, provide a good source of information on seed access by rice farmers (Bonou *et al.*, 2012). Bonou *et al.,* (2012) also analysed farmer involvement in different types of seed transactions, that is, the extent to which farmers use their own saved seed (farmer-saved seed) and are engaged in different market and non-market seed transaction activities. These farmers obtained seed from their previous harvest or they buy, exchanged or received seed from other farmers within their own village or from neighbouring villages. There have been speculations that locally produced rice that is supplied in the markets has a mixture of more than one rice variety (Muhunyu, 2012). It is difficult to detect whether the seeds that are planted are impure or the mixing happens during harvesting, milling or in the market stalls. Some handlings are done informally, and some of the commercial rice seeds on sale may not meet the required standards for seed production. Farmers risk planting rice seeds that are genetically impure. This could translate to an increase susceptibility to diseases, reduced grain quality, poor response to improved management, uneven plant maturity, and a consequent increase in yield gaps.

1.3 Justification of the Study

Despite the potentials of rice in addressing the increasing food demand of the growing population in Africa as well as diverse uses to which it is subjected to, the average production of certified rice seed in Nigeria is currently below world average (Dontsop *et al.*, 2011). The stability in certified rice purity level, agronomical desirable, commercially acceptable varieties and availability of rice to farmers is the ultimate goal in certified rice seed program; which is the pre-requisite in achieving sustainability. Research in Nigeria has shown that production and processing technologies have not been able to meet the increasing demand for rice seed (FAO, 2013). The activities of various seed companies and their out-growers are some of the major constraints to achieving full potential of certified rice seed production in Africa.

Evaluation of the various certified rice seeds available in Nigeria seed companies is important so as to know if the quality of their certified seeds has improved, establish their source of certified rice seed purity; whether purity matters to farmers, what sustains certified rice seed quality at farmers level and to also know what contamination has to do to farmers. Thus, this project tends to address issues of accessibility, seed quality, and purity, to effectively contribute to increasing productivity and sustainability of rice seed systems in selected seed companies in Nigeria.

To keep the pace with the growing population, and increase rice consumption rates, it is imperative to increase rice production. Planting quality seed, use of appropriate nutrient levels and good soil and crop management practices are crucial in reducing the current gap in rice production in Nigeria. It is crucial to establish a best-fit between the nutrient supply and crop nutrient demand, by determining the suitable site and variety specific balanced nutrient application rate. With evaluation of seed qualities from different seed companies in Nigeria, the yield gap can be reduced optimally. To be able to achieve a 70 % and above rise in rice yield, use of good quality seeds of the preferred variety from a reliable seed company is imperative.

1.4 Aim and Objectives of the Study

The aim of the study is to evaluate the quality of certified rice seed production from selected seed companies in Nigeria.

1.4.1 Objectives of the Study

1. To access agro-morphological performance of certified rice seed from selected seed companies.
2. To evaluate the quality of certified rice seeds from selected seed companies.
3. To evaluate the certified rice seed outgrower scheme from different seed companies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Rice

Oryza sativa was first cultivated in south-east Asia, India and China between 8000 and 15000 years ago (Normile, 2004). *O. glaberrima* has been cultivated since approximately 1000 BC (Murray, 2005). Current cultivation for *O. sativa* is worldwide, extending from latitude 35^0S (New South Wales and Argentina) to 50^0 N (Northern China) over 110 countries. Ninety percent of all rice is grown and consumed in Asia. Cultivation area utilize approximately 10 % of all available crop land worldwide (144 million ha) with only wheat covering more surface area. Rice is also grown from sea level to 3000 m and in both temperate and tropical climates.

O. sativa is the most widely grown of the two cultivated species. It is grown widely, including Asian, North and South American, European Union, Middle Eastern and African countries. *O. glaberrima* however, is grown solely in West African countries. *O. sativa* and *glaberrima-sativa* species are replacing *O. glaberrima* in many parts of Africa due to higher yields (Linares, 2002).

Domestication of wild rice's probably started about 9,000 years ago (Farooq, 2011). Development of annuals at different elevations in East India, northern Southeast Asia, and western China was enhanced by alternating periods of drought and variations in temperature during the Neo-thermal Age about 10,000 to 15,000 years ago (Kole, 2006).

O.glaberrima was first discovered and domesticated in the super continent called Gondwana land. Domestication in Asia could have occurred independently and concurrently at several sites within or bordering a broad belt that extends from the plains below the eastern foothills of the Himalayas in India through upper Myanmar, northern Thailand, Laos, and Vietnam to south western or southern China (Kole, 2006).One of these cultivated species, *O. sativa* is indigenous to Asia, while the other, *O. glaberrima* is indigenous to Africa. The latter was reported to be distributed mainly in the savannah along the southern fringes of Sahara Desert (Oka, 2000). The species was first grown as a crop in the central Niger delta and Sokoto basins among other places, but later the cultivation spread into bush fallow upland farming systems of the western forest zones. Today it is still being cultivated as a lowland crop in Kebbi and Sokoto States of Nigeria in the Rima River flood plains and as upland crop in the Zuru Local Government Areas in Kebbi State. The species can also be found in mixtures and sometimes almost replacing the Asian species varieties in the farmers' fields both in the shallow swamps and the inland valleys and flood plains of the Niger and Benue valley and also in the dry land rice fields of the southern parts of the country (Maji *et al.,* 2002).

2.2 Taxonomy of Rice

Rice belongs to the grass family Poaceae (Kirk, 2000). It belongs to the genus *Oryza*, of the tribe *Oryzeae*, of the subfamily Bambusoideae or Ehrhartoideae, of the family Poaceae. There are 12 genera within the *Oryzeae* tribe (Vaughan, 2003). The genus *Oryza* contains approximately 22 species of which 20 are wild species and two, *Oryzasativa* and *Oryza glaberrima*are cultivated. Of the two species, Asian cultivated rice, *Oryza Sativa*, is cultivated worldwide. *Oryza glaberrima*, the African grown rice, is planted on a limited scale in West Africa (Kole, 2006). This shows the distribution of *Oryza* species all over the world except Antarctica. At various times, more than 100 names have been proposed for the *Oryza* species, including 19 for *O. sativa* alone (Oka 2000; Lu, 2004). Recently, Vaughan (2003) has proposed a new nomenclature for cultivated and wild rice in Aisa. Research has suggested that the progenitors of *O. sativa* are the Asian species. These are *O. rufipogon*and *O. nivara,* which are perennial and annual respectively

(Vaughan and Morishima, 2003). Within the cultivars that have been developed, there are a range of forms bearing more or less similarity to the wild progenitors.

2.3 Rice Seed Biology

Seed development is a unique attribute of plants providing them the privilege of perpetuating genetic information over generations, by safeguarding against environmental changes. Physiologically, it is a combined effect of two complex developmental processes, embryo and endosperm development. In case of dicots, majority of the seed volume is formed by the embryo at maturity and the endosperm is consumed by the embryo during the course of seed development. (Adesanya, 2016).

The rice seed consist of brown rice (caryopsis) and the hull, which encloses the brown rice. It mainly consists of the embryo and endosperm. The surface consists of several thin layers of differentiated tissues that enclose the embryo and endosperm. The palea, lemmas, and rachilla constitute the hull of *indica rice*. A single grain weighs about 10 - 45 mg at 0% moisture content. Grain height, width, and thickness vary widely among varieties. Hull weight averages about 20% of total grain weight. (Adesanya, 2016).

Agronomically, it is convenient to regard the life history of rice in terms of three growth phases; vegetative, reproductive and ripening. A 120 days variety when planted in a tropical environment spends about 60 days in vegetative phase, 30 days in reproductive phase, and 30 days in the ripening phase (WARI, 2001).

2.4 Rice Production in Nigeria

Rice is an increasingly important crop in Nigeria. It is relatively easy to produce and is grown for seed and for home (grain) consumption. In some areas there is a long tradition of rice growing, but for many, rice has been considered a luxury food for special occasions only however with the increased availability of rice, it has become part of the everyday diet of many in Nigeria (Onimawo *et al.*, 2010).

Rice grows in all the agro-ecological zones as diverse as the Sahel of Borno State and the coastal swamps of the southwest and south-south (Longtau, 2003). According to Longtau (2003), six rice growing environments have been identified; they are upland, hydromorphic, rain-fed lowland, irrigated lowland, deep inland water and mangrove swamp. According to Damola (2010), rice growing environment in Nigeria are usually classified into five rice ecosystems: rain-fed lowland which accounts for 47 % of total rice production area, rain-fed upland (30 %), irrigated lowland including large-scale irrigation schemes and small-scale irrigation schemes account for 16 % of total rice area, deep water (5 %) and mangrove swamp accounting for less than 1 % of total rice area. The irrigated land rice ecology is the most recently developed rice environment in Nigeria. Irrigation is supplied from rivers, wells, boreholes and other sources to supplement rainfall for full rice crop growth (Imolehin, 2000). This ecology accounts for about 18 % of cultivated land, and yields ranges from 2 to 4 tonnes/ha. It contributes to 20 % of the natural rice supply (Singh *et al.*, 1997).

2.5 Rice Seed Industry

The evolution of the seed sector is in general tightly linked with the evolution of research and development approaches in Africa. The rice seed systems are characterized by the coexistence of a formal sector where seed is produced and commercialized by government agencies and private seed companies, and an informal sector where seed is produced by and exchanged among farmers (FAO, 2013).

2.5.1 Formal seed system

The formal seed system is characterized by an institutionally organized production and distribution of released and registered varieties by public and private organizations following defined quality control mechanism (WARI, 2001). The institutionally organised production in formal system in Nigeria includes, public sector research and development agencies; public and private seed companies including other seed entrepreneurs (seed dealers, traders) and community led institutions (cooperatives, groups) that have organized and quality ensured seed production and delivery.

2.5.2 Informal seed system

The informal seed sector is usually defined as the total of seed production activities of farmers, mostly small-scale farmers. In contrast, the formal sector refers to seed production activities by the public and commercial sector. Synonyms used for informal seed sector are ‘local’ or ‘farmers’ seed system(s). A clear-cut distinction between the informal and formal seed system does not exist in the situations where public or private institutions are engaged in the production of uncertified, unlabelled or registered seed lots. Farmers’ produce, selected and stored seed is still the predominant source of seed in the world (Longtau, 2003).

2.6 Classes of Seed

2.6.1 Nucleus seeds

Nucleus seeds are the basic seed class for seed production. The seeds are maintained by the breeders for further multiplication. It is produced under the direct supervision of the plant breeder concerned. It is produced based on the various crop multiplication techniques and methods. Nucleus seeds usually possess high percentage of genetic purity (Singh *et al.*, 1997).

2.6.2 Breeder seeds

Breeder seeds are produced using nucleus seeds in the research institute under the supervision of a breeder. The seed or vegetative propagated material directly controlled by the originating or the sponsoring breeder or institution which is the basic seed for recurring increase of foundation seed (Jeon, 2011).

2.6.3 Foundation seed

It is the progeny of breeder seed. The seed stock handled to maintain specific identity and genetic purity, which may be designated or distributed and produced under careful supervision of an agricultural experiment station (Imolehin, 2000). This seed is the source of all other certified seed classes either directly or through registered seed.

2.6.4 Certified seed

It is the progeny of the foundation seed. Its production is so handled to maintain genetically identity and physical purity according to standards specified for the crop being certified. It should have the minimum genetic purity of 99%. Certified seed may be the progeny of foundation seed, provided this reproduction does not exceed two generations beyond foundation seed and provided that if certification agency determines the genetic and physical purity (Longtau, 2003).

2.7 Economic Importance of Seed Production

Availability of quality seeds of improved cultivar is considered crucial for realizing optimum productivity in different agro-climatic conditions. In seed production, adequate care is given from the purchase of seeds up to harvest following proper seed and crop management techniques (FAO, 2013). The benefit of seed production includes higher income and high-quality seed for next sowing. There are two major types of seed production i.e. varietal and hybrid seed production which is based on the type of seed used for multiplication. Varietal seed production involves single parent multiplication while hybrid seed production involves two or more parent multiplication (USAID, 2010).

Substantial increase in yield and quality of crops depends upon a number of factors which includes inputs like fertilizers, irrigation and plant protection measures and sustainable agronomic practices. However, the use of high-quality seed thus plays a pivotal role in the crop production. The use of poor-quality seeds nullifies the utility of all agronomic practices. Economically, the cost of seed is a very small component of the total cost of production. It is important to use the seed confirming to the prescribed standards in terms of high genetic purity, physical purity, physiological quality and health quality for the purpose of seed production (Sindhur, 2004).

2.8 Evaluation of Rice Varietal Purity

Genetic purity, also known as varietal purity, is a key aspect in quality control. For varietal purity to be achieved, quality seeds should be used. Aspects of quality seeds involve seed purity, vigour, germination and health (Venkata, 2014). Genetic purity tests must be done during seed certification procedures to rid crops of ambiguous crop varieties and misuse of brand names by the sale of spurious seeds. Genetic purity of seed can be assessed by carrying out grow-out-test that involves representative samples to be checked. Qualitative and quantitative characteristics (descriptors), related to seed quality are used for varietal identification (Anjana *et al*., 2016). For a variety to be considered true to type, it must meet the requirements for the DUS (Distinctness, Uniformity and Stability) tests. A variety is said to be distinct if it is clearly different from any other variety that is known at the time of filling application for protection. It is said to be uniform if it is sufficiently identical in its relevant characteristics. Its stability is gauged by its relevant characteristics remaining unchanged over several propagations (Venkata, 2014). Apart from the use of morphological characteristics, methods such as molecular markers, biochemical markers and chemical methods can be applied (Venkata, 2014).

Some of the molecular markers used include the Random Amplification of Polymorphic DNA (RAPD), Sequence Characterized Amplified Region (SCAR), Short Sequence Repeats (SSR), and Sequence Tagged Site (STS). Other molecular techniques involve the use of biochemical markers, and peroxidise test. Some chemical methods like the potassium hydroxide test, sodium hydroxide test and ferrous sulphate colour test have also been used (Venkata, 2014).

In agricultural production, seed is a critical input. It is and agronomic base, which has a huge economic value and it determines crop productivity. The quality of seed used determines the total yield output of a crop (Krishnan and Surya, 2005). Varietal purity is a key indicator of seed quality. Despite affecting yield, it also influences the crop production practices. Good crop management practices combined with good quality seed translates to high crop productivity.

Globally and locally, studies on the determination of the genetic purity of crops have been conducted on several crops such as sunflower, maize, castor, horticultural crops and rice (Shankar *et al*., 2013). Genetic purity test, which have been done on lowland varieties, involved the assessment of agronomic traits and use of microsatellites, to establish the relationships between the varieties. (Africa Rice Centre, 2008).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Field Experiment

A field experiment was carried out during the rainy cropping season of 2018. The field was ploughed, harrowed and leveled with hoe before layout to ensure maximum seed-soil contact at planting. The experiment was conducted to determine the purity and quality levels of certified rice seed samples from selected seed companies including seed companies that got interventions from ATASP-1 project.

3.1.1 Source of seeds

Seed of two certified rice varieties FARO 44 and FARO 52 were used for the study. The certified rice seeds were obtained from four seed companies namely: Company A, Company B, Company C and Company D.

3.1.2 Experimental location:

Two separate trials were conducted. Plant growth and seed production trial was conducted at the National Cereal Research Institute (NCRI) Badeggi (latitude 9^0 04^1 N and longitude 6^0 07^1 E) and Edozhigi (latitude 9^0 50^1 N and longitude 5^0 50^1 E) in southern guinea savannah agro-ecological zone.

3.2 Experimental Design and Layout

The trials were factorial combination of two varieties of rice (FARO 44 and FARO 52) and four selected seed companies (Company A, Company B, Company C and Company D) fitted into a Split Plot Design with three replications. Gross plot size was 3 m x 3 m with 1m between each replication and 0.5 m between each plot.

3.3 Cultural Practices

3.3.1 Land preparation

Land preparation was done by clearing the field and ridging the field using hoe.

3.3.2 Nursery and transplanting

The seeds were raised in the nursery and then transplanting of the seeds was done at 3 weeks old from the nursery. Gross plot size was 3 m x 3 m with 1m between each replication and 0.5 m between each plot.

3.3.3 Weeding

Manual weeding was carried out at 3 and 6 weeks after transplanting (WAT) using hoe.

3.3.4 Fertilizer application

Basal application of fertilizer NPK 15-15-15 was done a week after transplanting at the rate of 100kg N and 40 kg P_2O_5 and 40 kg K_2O / ha. The remnant 40 kg N was top dressed at flowering using urea 40 % N as source.

3.3.5 Harvesting and processing

Seeds were harvested at maturity by cutting with a sickle and threshed for further data collection.

3.4 Data Collection

3.4.1 Plant height

Plant height of 5 tagged plants were taken at 2 WAT, 4 WAT and at maturity using a meter rule from soil surface to tip of the tallest panicle (awns excluded) and the average recorded.

3.4.2 Days to 50 % flowering

This was taken from the 3 weeks period of nursery, days of transplanting to the date when half of the plants population in a plot flowered.

3.4.3 Number of tiller

The total number of tillers from each of the five randomly selected plants was counted at 42 and 63 days after transplanting (DAT).

3.4.4 Number of panicles

Panicle numbers of the five randomly selected plants were counted manually at plants maturity (at harvest).

3.4.5 Seed weight

Three replicates of 1000 seeds were counted and weighed on a sensitive measuring scale (Metler balance), and the means were recorded as 1000 seed weight.

3.4.6 Seed yield

The seed obtained after threshing for each plot were weighed and expressed in kg / ha using the formula:

$$\text{Seed yield} = \frac{\text{Seed weight}}{\text{Harvested plot area}} \times 10{,}000$$

3.5 Screen house experiment

Screen house evaluation was conducted at the National Cereal Research Institute (NCRI) Badeggi (latitude 9^0 04^1 N and longitude 6^0 07^1 E) and it include seedling emergence test which was laid out in a Factional combination Complete Randomized Design (CRD) with three replications.

3.5.1 Seedling emergence test

Fifty seeds were sown in a bucket filled with 10 kg sterilized riverbed sand in three replicates for each variety. The buckets were constantly kept moist. Seedling emergence count was taken from 5, 6, 7, 8, 9, and 10 days after planting (DAP) and was used to calculate emergence percentage (E%) and Emergence Index (EI), according to Adesanya (2016):

$$E\% = \frac{\text{number of seedlings emerged 10 Days after Planting (DAP)}}{\text{Total number of seeds planted}} \times 100$$

$$EI = \frac{\sum (Nx)\,(DAP)}{\text{Number of seedlings that emerged 10 DAP}}$$

Where Nx = Number of seedlings that emerge on the day x after planting.

DAP = Days after planting.

3.6 Field Survey

A survey in form of questionnaire to study the modalities of certified rice seed production by selected seed companies and their out-growers in Kano, Katsina and Zaria. The survey was carried out to evaluate the certified rice seed out-grower scheme system to ascertain its impact on the certified rice seed quality available to farmers. The questionnaire was designed to get information from the selected four seed companies and ten out-growers from each of the seed companies. Each seed company was giving one questionnaire while ten of their outgrowers also provided answers to the questionnaires.

3.7 Data Analysis

Analysis of Variance (ANOVA) was carried out using the Statistical Tool for Agricultural Research (STAR) to determine the significance of the main effects and interactions. Treatment means were separated using Student New-man Keuls (SNK) at 5 % probability. Correlation between the parameters was done using STAR. The survey data was tabulated analysed using bar charts.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Agronomic traits of FARO 44 and FARO 52 at Badeggi, Edozhigi and Combined

The ANOVA mean square of agronomic traits of two lowland varieties of four seed companies at Badeggi, Edozhighi and combine on plant height at 2, 4 WAT and at harvest are shown on Table 4.1. Plant heights at 2 WAT and at harvest were significant with varieties at both locations and combine (Table 4.1). Seed company was significant on plant height at 2 WAT at badeggi and combine and on plant height at harvest at Edozhighi. The interaction of variety and company were significant on plant height at 2 WAT and 4 WAT at Badeggi and combine and on plant height at harvest at Edozhighi (Table 4.1).

The ANOVA mean square of agronomic traits of two lowland varieties of four seed companies at Badeggi, Edozhighi and combine on Days to 50 % flowering, number of tillers and number of panicle are shown on Table 4.2. Variety was not significant on days to 50 % flowering, number of tillers and number of panicle at badeggi, edozhighi and combined (Table 4.2). Company was only significant on number of tillers at badeggi (Table 4.2). The interaction of variety and company were significant on number of tillers at badeggi, number of panicle at badeggi and edozhighi (Table 4.2).

Table 4.1: ANOVA mean square of agronomic traits of two lowland rice varieties of some four seed companies

	Plant height at 2 WAT			Plant height at 4 WAT			Plant height at harvest		
SV	Badeggi	Edozhighi	Combined	Badeggi	Edozhighi	combined	Badeggi	Edozhighi	combined
Replication	2.3069	3.8079	3.0574	9.9550	0.3179	5.1365	5.1171	1.6650	3.3911
Variety (V)	67.9057 **	1.0417 *	42.8841 **	3.7763	0.0417	1.5123	5368.5459**	4845.0417**	10206.8751**
Error a	0.2552	0.1079	0.01816	6.3870	0.3029	3.3450	16.0431	0.3017	8.1724
Company (C)	11.0281 *	0.8383	6.7044 *	0.6506	1.9167	1.1815	9.7179	8.2904*	3.1796
V x C	14.9436 *	0.4606	5.0909 *	19.3405 *	1.4650	15.6137**	5.9604	6.0550*	6.4026
Error b	1.9508	1.4040	1.6774	3.6948	1.7754	2.7351	6.8621	1.5678	4.2149

*= significant at 5 % level of probability; ** = highly significant at 1 % level of probability; SV = Source of variance

Table 4.2: ANOVA mean square of agronomic traits of two lowland rice varieties of some four seed companies

	Days to 50 % flowering			Number of Tillers			Number of Panicle		
SV	Badeggi	Edozhighi	Combined	Badeggi	Edozhighi	Combined	Badeggi	Edozhighi	Combined
Replication	1.1250	0.3750	0.7500	0.5104	0.1250	0.3177	3.1354	0.3750	1.7552
Variety (V)	0.6667	0.0009	0.3333	1.5000	5.0417	6.0208	3.0104	0.0052	1.5052
Error a	3.7917	1.6250	2.7083	0.5937	2.5417	1.5677	1.6354	0.3750	1.0052
Company (C)	1.6111	0.0006	0.8056	2.2500*	1.3750	3.5069	4.5382	5.5000	9.8108
V x C	1.6667	0.0004	0.8333	1.6944*	0.1528	1.3958	9.7326*	8.0000**	16.3663
Error b	1.5139	1.0000	1.2569	0.3993	0.8889	0.6441	2.4688	1.2083	1.8385

*= significant at 5 % level of probability; ** = highly significant at 1 % level of probability; SV = Source of variance

The ANOVA mean square of agronomic traits of two lowland varieties of four seed companies at Badeggi, Edozhighi and combine on seed weight and seed yield are shown on Table 4.3. Variety was only significant on seed weight at edozhighi (Table 4.3). The company was significant on seed weight and seed yield at edozhighi location (Table 4.3). The interaction of variety and company were significant on seed weight and seed yield at badeggi and edozhighi location (Table 4.3).

Table 4.3: ANOVA mean square of agronomic traits of two lowland rice varieties of some four seed companies

	Seed Weight			Seed Yield		
SV	Badeggi	Edozhighi	Combined	Badeggi	Edozhighi	Combined
Replication	0.1667	0.5038	0.3352	0.3876	0.0371	0.2123
Variety (V)	1.0417	5.7038*	0.9352	0.4579	0.2424	0.017
Error a	0.1667	0.4288	0.2977	0.2297	0.0354	0.1326
Company (C)	0.5972	4.0315**	1.4185	0.4083	2.0286**	2.1239
V x C	2.5972*	6.4815**	7.6519	1.3245*	2.9517**	3.8844
Error b	0.5556	0.4107	0.4831	0.2746	0.2566	0.2656

*= significant at 5 % level of probability; ** = highly significant at 1 % level of probability; SV = Source of variance

4.2 Mean values of FARO44 and FARO52 obtained from Four Seed Companies at Badeggi

4.2.1 Plant Height at 2 WAT at Badeggi

The mean values of plant height at 2 WAT of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. Plant height at 2 WAT was significantly different among the varieties and seed companies. The highest plant height was recorded by FARO 44 obtained from Company C while all the other seed companies produced statistically similar heights respectively at Badeggi. Under FARO 52, Company B, Company C and Company D produced statistically similar plant height respectively while Company A produced the shortest plants at Badeggi (Table 4.4).

4.2.2 Plant Height at 4 WAT at Badeggi

The mean values of plant height at 4 WAT of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. Companies had a significant effect on plant height at 4 WAT, such that, FARO 44 obtained from Company B produced the tallest plants though statistically similar with FARO 44 obtained from Company A while FARO 44 obtained from company C produced the shortest plants at Badeggi. The variety FARO 52 obtained from company B, company C and company D produced statistically similar tall plants at 4 WAT respectively while FARO 52 seed obtained from Company A produced the shortest plants in this study (Table 4.4).

4.2.3 Plant height at Harvest at Badeggi

The mean values of plant height at harvest of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. Plant height at harvest of FARO 44 was significantly different among the seed companies. The tallest plants of FARO 44 was recorded from company C though statistically similar with FARO 44 obtained from company A while statistically similar shorter plants at harvest of FARO 44 were recorded from company B and company D respectively in this study. Similar taller plants of FARO 52 were produced from seeds obtained from company A and company D while similar shorter plants were also recorded from seeds obtained from company B and company C respectively in this study.

4.2.4 Days to 50 % flowering at Badeggi

The mean values of days to 50 % flowering of FARO 44 and FARO 52 obtained from four seed companies at Badeggi are shown in Table 4.4. The number of days to 50 % flowering of FARO 44 was significantly different among the seed companies. The earliest days to 50 % flowering of FARO 44 was recorded from company C while similar longer days to 50 % flowering were recorded from company A, company B and companies D respectively. Plant height of FARO 52 was not significantly different among all the seed companies in this study at Badeggi.

4.2.5 Seed weight at Badeggi

The mean values of seed weight of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. The weight of seed of FARO 44 was significantly different among the seed companies. The heaviest seeds of FARO 44 was from company C than those produced from seeds obtained from company B seed company while similar lighter seeds of FARO 44 were recorded from the seeds obtained from company A and company D respectively at Badeggi in this study. The heaviest seeds of FARO 52 were similarly produced from seeds obtained from company A and company D while lighter seeds of FARO 52 were similarly produced from seeds obtained from company B and company C at Badeggi in this study.

4.2.6 Number of tillers at Badeggi

The mean values of number of tillers of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. The number of tillers of FARO 44 and FARO 52 were significantly different among the seed companies. The highest number of tillers of FARO 44 was recorded from the seeds obtained from company C than that of the seeds of FARO 44 obtained from company A and company B which produced statistically similar number of tillers while the lowest number of tillers of FARO 44 was recorded from the seeds obtained from company D at Badeggi. The highest number of tillers of FARO 52 was produced from the seeds obtained from company C than the values recorded from company A and company D which produced statistically similar number of tillers while the lowest number of tillers of FARO 52 was recorded from the seeds obtained from company B at Badeggi (Table 4.4).

4.2.7 Number of panicles at Badeggi

The mean values of number of panicles of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. The number of panicles of FARO 44 and FARO 52 were significantly different among the seed companies. The highest number of panicles of FARO 44 was recorded from the seeds obtained from company C while the lowest number of panicles of FARO 44 was recorded from the seeds recorded from company D. Similar highest number of panicles of FARO 52 were recorded from the seeds obtained from company A, company C and company D respectively while the lowest number of panicles of FARO 52 was recorded from the seeds obtained from company B in this study.

4.2.8 Seed yield at Badeggi

The mean values of seed yield of FARO 44 and FARO 52 obtained from four seed companies at Badeggi and are shown in Table 4.4. The seed yield of FARO 44 and FARO 52 were significantly different among the seed companies in this study. The highest seed yield of FARO 44 was recorded from the seeds obtained from company C than that recorded from company A and company B which produced statistically similar seed yield of FARO 44 while the lowest seed yield of FARO 44 was recorded from the seeds obtained from company D at Badeggi. Statistically similar highest seed yield of FARO 52 were recorded from the seeds obtained from company A, company B and company D respectively while the lowest seed yield of FARO 52 was recorded from the seeds obtained from company B at Badeggi (Table 4.4).

Table 4.4: Mean values for eight agronomic traits of FARO44 and FARO52 obtained from Four Seed Companies at Badeggi

Varieties	Seed companies	Plant Height at 2 WAT (cm)	Plant Height at 4 WAT (cm)	Plant Height at Harvest (cm)	Days to 50 % flowering	Seed Weight (g)	Number of Tillers	Number of Panicles	Seed yield (t/ha)
FARO44	Company A	47.85±0.60	67.05±1.43	99.79±0.99	66.50±0.43	25.00±2.24	12.00±0.37	10.58±0.37	4.00±0.44
	Company B	47.42±1.23	68.80±1.75	99.23±0.69	67.00±0.52	25.83±2.33	11.92±0.27	11.67±0.33	4.55±0.48
	Company C	50.23±0.60	64.15±1.99	100.22±0.92	65.83±0.65	27.28±2.98	12.92±0.27	13.17±0.79	5.48±0.78
	Company D	47.60±0.94	66.35±1.96	99.12±1.19	66.83±0.40	25.00±2.24	11.17±0.48	9.17±0.60	3.50±0.48
FARO52	Company A	49.45±0.44	64.68±1.77	129.58±0.34	66.83±0.48	26.17±1.89	12.67±0.33	12.17±0.48	4.83±0.51
	Company B	50.35±0.63	66.93±1.44	127.93±0.88	66.67±0.33	25.00±2.24	12.00±0.37	9.67±0.42	3.65±0.41
	Company C	50.40±0.43	67.17±1.06	127.60±1.42	66.67±0.49	25.00±2.24	13.33±0.33	12.00±0.58	4.50±0.45
	Company D	50.47±0.68	65.98±1.82	129.90±1.06	66.67±0.49	25.83±2.20	12.83±0.31	12.17±0.60	4.70±0.42
	Mean	**49.30**	**66.50**	**114.17**	**66.02**	**25.64**	**12.09**	**11.33**	**4.40**
	$LSD_{0.05}$	**2.20**	**3.80**	**7.04**	**NS**	**1.20**	**1.20**	**2.64**	**0.90**

LSD = Least Significant Difference, SY = Seed Yield

4.3 Mean values of FARO44 and FARO52 obtained from Four Seed Companies at Edozhigi

4.3.1 Plant height at 2 WAT at Edozhigi

At Edozhigi, FARO 44 and FARO 52 produced statistically similar plant height across all the seed companies (Table 4.5).

4.3.2 Plant height at 4 WAT at Edozhigi

The mean values of plant height at 4 WAT of FARO 44 and FARO 52 varieties obtained from four seed companies at Edozhigi are shown in Table 4.5. Irrespective of the rice varieties, plant height was not significantly different among all the seed companies in this study.

4.3.3 Plant height at Harvest at Edozhigi

The mean values of plant height at harvest of FARO 44 and FARO 52 obtained from four seed companies at Edozhigi and are shown in Table 4.5. Plant height at harvest of FARO 44 was not significantly different among all the seed companies in this study. Similar taller plants at harvest of FARO 52 were produced from the seeds obtained from company A, company B and company D while the shortest plants at harvest of FARO 52 was recorded from seeds obtained from company C in this study.

4.3.4 Days to 50 % flowering at Edozhigi

The mean values of days to 50 % flowering of FARO 44 and FARO 52 obtained from four seed companies at Edozhigi are shown in Table 4.5. The numbers of days to 50 % flowering of FARO 44 and FARO 52 varieties were not significantly different among all the seed companies in this study.

4.3.5 Seed weight at Edozhigi

The mean values of 1000 seed weight of FARO 44 and FARO 52 obtained from four seed companies at Edozhigi and are shown in Table 4.5. The heaviest seeds of FARO 44 were recorded from the seeds obtained from company C compared with FARO 44 seeds obtained from company A, company B and company D which produced similar lighter seeds respectively at Edozhigi. The seed weight of FARO 52 was not significantly different among all the seed companies at Edozhigi in this study (Table 4.5).

4.3.6 Number of tillers at Edozhigi

The mean values of number of tillers of FARO 44 and FARO 52 obtained from four seed companies at Edozhigi and are shown in Table 4.5. The number of tillers of FARO 52 was significantly different among the seed companies only. The number of tillers of FARO 44 was not significantly different among all the seed companies at Edozhigi in this study. The highest number of tillers of FARO 52 was recorded from the seeds obtained from company A, company C and company D respectively while the lowest number of tillers of FARO 52 was recorded from the seeds obtained from company B at Edozhigi.

4.3.7 Number of panicle at Edozhigi

The mean values of number of panicles of FARO 44 and FARO 52 obtained from four seed companies at Edozhigi and are shown in Table 4.5. The number of panicles of FARO 44 and FARO 52 was significantly different among the seed companies in this study. The highest number of panicles of FARO 44 was recorded from the seeds obtained from company C while the lowest number of panicles of FARO 44 was recorded from the seeds obtained from company D at Edozhigi. The highest number of panicles of FARO 52 was recorded from the seeds obtained from company A than that recorded from company A and company D which had statistically similar number of panicles of FARO 52 while the lowest number of panicles of FARO 52 was recorded from the seeds obtained from company B at Edozhigi.

4.3.8 Seed yield at Edozhigi

The mean values of seed yield of FARO 44 and FARO 52 obtained from four seed companies at Edozhigi and are shown in Table 4.5. The seed yield of FARO 44 and FARO 52 were significantly different among the seed companies in this study. The highest seed yield of FARO 44 was recorded from the seeds obtained from company C than the other seed companies while the lowest seed yield of FARO 44 was recorded from the seeds obtained from company D at Badeggi. The highest seed yield of FARO 52 was recorded from the seeds obtained from company A than that recorded from company A and company D which produced statistically similar seed yield of FARO 52 while the lowest seed yield of FARO 52 was recorded from the seeds obtained from company B at Edozhigi in this study (Table 4.5).

Table 4.5: Mean values for eight agronomic traits of FARO44 and FARO52 obtained from Four Seed Companies at Edozhigi

Varieties	Seed companies	Plant Height at 2 WAT (cm)	Plant Height at 4 WAT (cm)	Plant Height at Harvest (cm)	Days to 50 % flowering	Seed Weight (g)	Number of Tillers	Number of Panicles	Seed yield (t/ha)
FARO44	Company A	48.73±2.93	69.67±5.90	98.33±5.54	67.00±1.59	30.00±0.35	12.00±1.56	11.00±0.23	4.95±0.26
	Company B	49.93±3.95	69.47±6.64	100.27±9.67	67.00±2.11	31.00±0.58	12.00±1.44	12.00±0.21	5.58±0.23
	Company C	49.20±2.46	68.37±3.46	98.73±4.98	67.00±1.58	33.90±0.45	13.00±2.01	14.00±0.11	7.11±0.25
	Company D	49.47±4.70	70.33±7.8	100.13±8.67	67.00±2.16	30.00±0.22	11.67±1.32	10.00±0.00	4.50±0.22
FARO52	Company A	49.37±4.61	68.43±4.94	129.33±5.55	67.00±1.22	30.33±0.33	13.00±2.33	13.00±0.11	5.92±0.27
	Company B	49.87±3.85	69.93±5.93	127.87±4.32	67.00±2.34	30.00±0.76	12.67±2.33	10.00±0.90	4.50±0.26
	Company C	50.30±4.62	69.33±4.33	125.00±6.11	67.00±2.34	30.00±0.77	13.67±2.54	12.00±0.67	5.40±0.28
	Company D	49.47±3.46	69.80±4.98	128.93±6.13	67.00±5.33	30.67±0.67	13.00±1.56	12.00±0.22	5.52±0.32
	Mean	**49.54**	**69.42**	**113.58**	**67.00**	**30.74**	**12.63**	**11.75**	**5.43**
	$LSD_{0.05}$	**NS**	**NS**	**12.13**	**NS**	**1.14**	**NS**	**1.76**	**0.80**

LSD = Least Significant Difference, SY = Seed Yield

4.4 Combined mean values obtained from Four Seed Companies at Badeggi and Edozhigi

The result of combined mean also revealed that companies had no significant effect on plant height of rice at 2 WAT in this study (Table 4.6). The combined mean values of plant height at 4 WAT was not significantly different among all the seed companies (Table 4.6). The combined mean values showed that, company C produced the earliest days to 50 % flowering while company A, company B and company D produced statistically similar longer number of days to 50 % flowering in this study (Table 4.6). The combined mean values of plant height at harvest were not significantly different among all the seed companies in this study (Table 4.6). The combined mean value of seed weight was not significantly different among all the seed companies in this study (Table 4.6). The combined mean values of number of tillers were significantly different among the seed companies (Table 4.6). Such that, the highest number of tillers was recorded from the seeds obtained from company C than that of company A while similar lowest number of tillers were recorded from the seeds obtained from company B and company D respectively in this study. The combined mean value of number of panicles was significantly different among the seed companies (Table 4.6). the highest number of panicles was recorded from company C than that recorded from company A while similar lowest number of panicles were recorded from the seeds obtained from company B and company D and respectively in this study. The combined mean values of seed yield were significantly different among the seed companies in this study (Table 4.6). The highest seed yield was recorded from the seeds obtained company C while statistically similar lowest seed yield was recorded from the seeds obtained from company A, company B, and company D respectively in this study.

Table 4.6: Combined mean values for eight agronomic traits obtained from Four Seed Companies at Badeggi and Edozhigi

Seed companies	Plant Height at 2 WAT (cm)	Plant Height at 4 WAT (cm)	Plant Height at Harvest (cm)	Days to 50 % flowering	1000 Seed Weight (g)	Number of Tillers	Number of Panicles	Seed yield (t/ha)
Company A	48.65±0.43	65.87±1.14	114.69±4.52	66.67±0.31	25.58±1.41	12.33±0.26	11.38±0.38	4.41±0.34
Company B	48.88±0.79	66.37±1.09	113.58±4.36	66.83±0.30	25.42±1.54	11.96±0.22	10.67±0.40	4.10±0.33
Company C	50.32±0.35	65.66±1.17	113.91±4.21	66.25±0.41	26.14±1.81	13.13±0.21	12.58±0.50	4.99±0.45
Company D	49.04±0.70	66.17±1.28	114.51±4.70	66.75±0.30	25.42±1.50	12.00±0.37	10.67±0.61	4.10±0.35
Mean	**49.22**	**66.01**	**114.17**	**66.63**	**25.64**	**12.35**	**11.32**	**4.40**
$LSD_{0.05}$	**1.92**	**2.03**	**2.80**	**NS**	**0.62**	**0.68**	**1.51**	**0.60**

LSD = Least Significant Difference, SY = Seed Yield

4.5 Principal Component Analysis Used to Quantify the Effect of Seed Companies

The principal component and percentage contribution of seed companies on agronomic performance of two rice varieties are shown in Table 4.7. The first principal component contributed 80.66 % to the total variation in the population (Table 4.7). Plant height at harvest contributed more to the variation. Plant height at 2 WAT, number of tillers, number of panicle, plant height at 4 WAT and days to 50 % flowering contributed low to the variation while 1000 seed weight contributed negatively to the first component. The second principal component contributed 14.95 % of the total variation. Characters with the highest contribution to the component include 1000 seed weight, plant height at 4 WAT and seed yield. Number of panicles, plant height at 2 WAT, days to 50 % flowering, number of tillers and plant height at harvest contributed low to the variation respectively. The third principal component accounted for 1.82 % of the total variation in the population. Plant height at 4 WAT contributed the highest to the variation. Days to 50 % flowering and plant height at harvest contributed low to the variation while all the other characters contributed negatively to the third component (Table 4.7). Days to 50 % flowering and 1000 seed weight contributed more to the variation in principal component four. Seed yield, number of panicle, plant height at harvest and number of tillers contributed low to the variation while plant height at 2 WAT and plant height at 4 WAT contributed negatively to the forth component (Table 4.7). The fifth principal component accounted for 0.79 % of the total variation with number of panicle, plant height at 4 WAT, grain yield and number of tillers producing the highest contributions to the variation respectively. Days to 50 % flowering contributed low to the variation. The negative contribution were recorded from seed weight, plant height at 2 WAT and plant height at harvest respectively (Table 4.7) Cumulatively, these 5 principal components showed 99.42 % of the total variation in the population.

Table 4.7: Principal Component Analysis for Effect of Seed Companies on Agronomic Performance of Two Rice Varieties

Parameters	PC 1	PC 2	PC 3	PC 4	PC 5
Plant Height at 2 WAT (cm)	0.0686	0.0596	-0.3671	-0.8509	-0.2033
Plant Height at 4 WAT (cm)	0.0037	0.5552	0.6105	-0.3290	0.4572
Days to 50% Flowering	0.0031	0.0590	0.0569	0.3047	0.0497
Plant Height at Harvest (cm)	0.9969	0.0105	0.0294	0.0623	-0.0130
Seed Weight (g)	-0.0243	0.8026	-0.2679	0.2391	-0.4321
No. of Tiller	0.0236	0.0487	-0.1643	0.0541	0.1221
No. of Panicle	0.0162	0.0920	-0.5646	0.0626	0.7170
Seed Yield (t/ha)	0.0000	0.1720	-0.2664	0.0839	0.1769
Standard deviation	14.9693	6.4450	2.2515	1.8152	1.4829
Proportion of Variance	0.8066	0.1495	0.0182	0.0119	0.0079
Cumulative Proportion	0.8066	0.9561	0.9744	0.9862	0.9942
Eigen Values	224.0785	41.5383	5.0691	3.2949	2.1991

PC – Principal component

4.6: Performance Index of the seed companies on quality seeds of the two rice varieties

The yield of FARO 44 range among the seed companies was showed in Table 4.8. FARO 44 obtained from company C recorded the highest seed yield and performance index of 100 % which outperformed all other seed companies with a lower percentage yield reduction from the potential yield. FARO 44 obtained from company D recorded the lowest grain yield and lowest performance index with a higher yield reduction from the potential yield (Table 4.8).

The yield of FARO 52 among the companies was showed in Table 4.8. FARO 52 obtained from company A recorded the highest grain yield, while FARO 52 obtained from company D recorded the lowest yield (Table 4.8). The seeds of FARO 52 obtained from company A and company D produced similar highest performance index while FARO 52 obtained from company B recorded the lowest performance index in this study. The percentage yield reduction from the potential yield was also showed in the table. The least yield reduction from the potential yield was recorded with FARO 52 obtained from company A while the highest yield reduction from the potential yield was recorded with FARO 52 obtained from company D (Table 4.8).

Table 4.8: Performance Index of Four Seed Companies on Quality Seeds of Two Rice Varieties (FARO44 and FARO52)

Varieties	Seed Companies	Seed Yield (SY) (t/ha)	SY-LSD	Performance Index	Ranking	% Yield Reduction from the Potential Yield
FARO44	Company A	4.00	3.39	0.00	c	-50.00
	Company B	4.55	3.94	33.33	b	-43.19
	Company C	5.48	4.87	100.00	a	-31.48
	Company D	3.50	2.89	0.00	c	-56.25
FARO52	Company A	4.83	4.22	33.33	a	-31.04
	Company B	3.65	3.04	0.00	b	-47.86
	Company C	4.50	3.89	33.33	a	-35.71
	Company D	4.70	4.09	33.33	a	-32.86
	Mean	**4.42**				
	$LSD_{0.05}$	**0.61**				

LSD = Least Significant Different, SY = Seed Yield

4.7 Effect of Varieties on Seedling Emergence Percentage (%)

Seedling emergence was significantly different among the varieties, such that, FARO 44 produced the highest seedling emergence percentage than FARO 52 which produced the lowest seedling emergence percentage in this study (Figure 4.1).

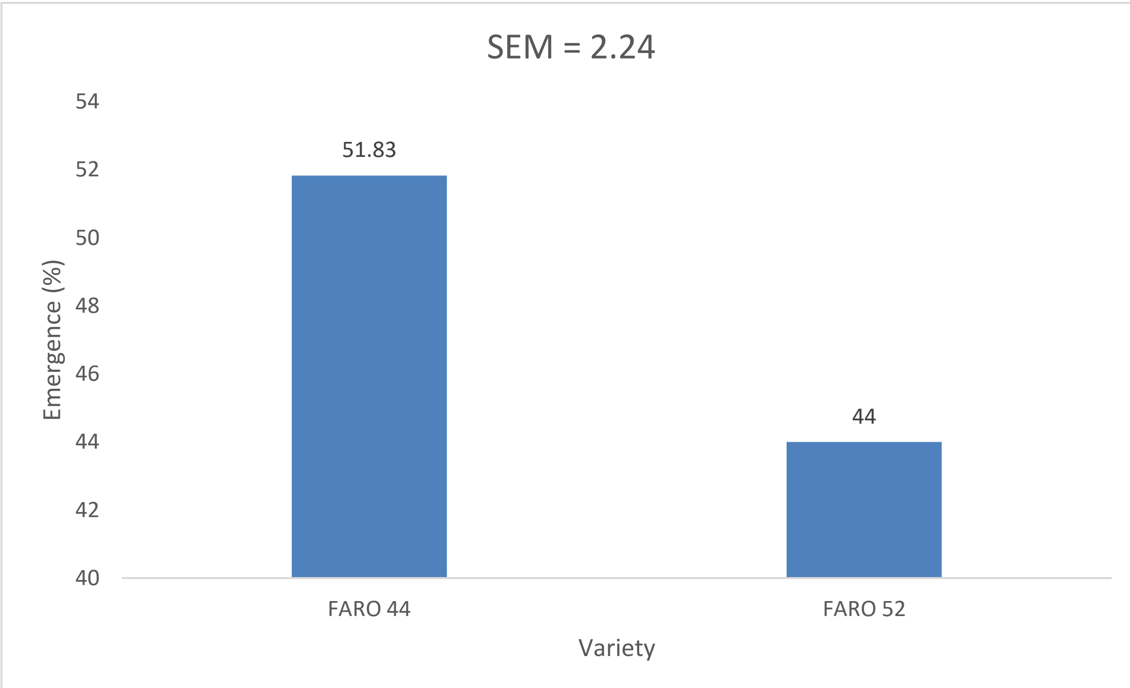
4.7.1 Effect of seed companies on seedling emergence percentage (%)

The effect of seed producing companies on seedling emergence percentage is shown in Figure 4.2. Seed producing companies had a significant effect on the seedling emergence percentage of rice in this study. The seeds obtained from company C produced the highest seedling emergence percentage though statistically similar with seeds obtained from company D and company A while company B produced the lowest seedling emergence percentage.

4.7.2 Interaction between varieties and seed companies on seedling emergence

The interaction between varieties and seed companies indicated statistical similar highest emergence percentages was recorded with FARO 52 and company C, followed by FARO 44 and company A, FARO 44 and company C, FARO 44 and company D and FARO 52 and company D while the interaction between FARO 44 and company B recorded the lowest seedling emergence values (Figure 3).

Figure 4.1: Effect of variety on seedling emergence



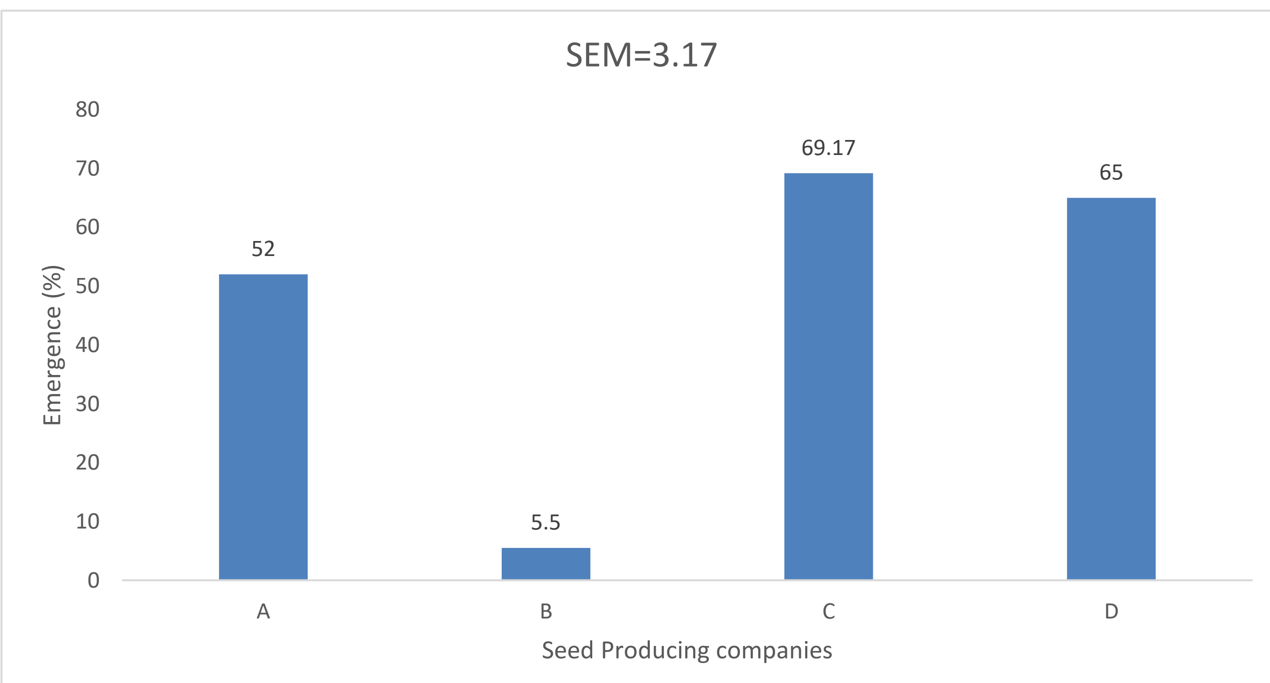


Figure 4.2: Effect of seed producing companies on seedling emergence

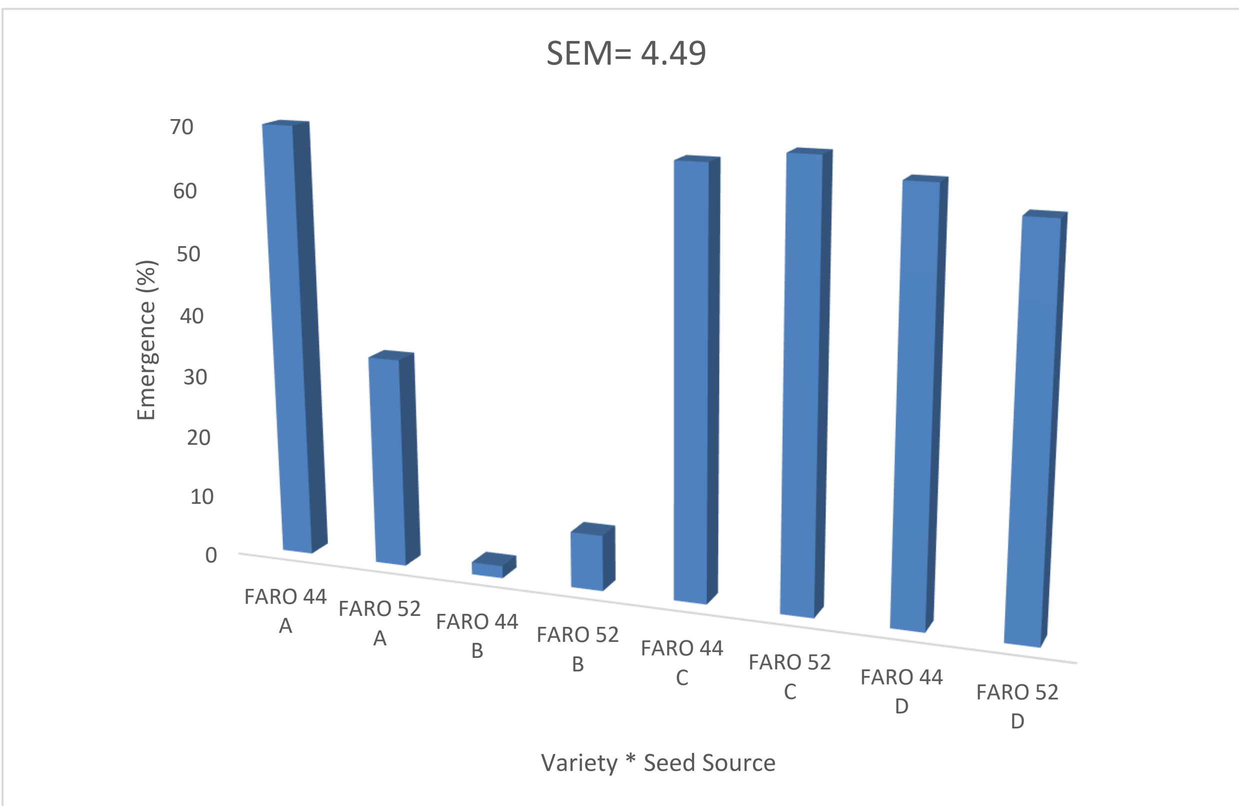


Figure 4.3: Interaction effect of variety and seed producing companies on seedling emergence

4.8: Statistical Analysis of Questionnaires From Outgrowers

4.8.1: Foundation seed received from seed company

The result on figure 4.4 shows that all the outgrowers received their foundation seeds from their various seed companies.

4.8.2: Average quantity of foundation seed received from seed companies

Figure 4.5 show the average quantity of foundation seeds received from the seed company by their outgrowers. The average quantity of foundation seed received ranged between 100 kg and 50 kg (Figure 4.5). The outgrower from company A received the highest average seed of 100 kg while outgrowers from company C and company D received the lowest average seed (50 kg).

4.8.3: Number of visit to seed companies by the National Agricultural Seed Council (NASC)

Figure 4.6 show the number of seed company and National Agricultural Seed council (NASC) officials visit to the outgrowers' field and how often the NASC officers visit the field. From the result, company C officials visited their outgrowers more than the officials of other seed companies followed by company B and company D (Figure 4.6).

For NASC official visit, the result showed that the officials visited all the seed companies' field but visited company C outgrowers field more often followed by company B outgrowers' field.

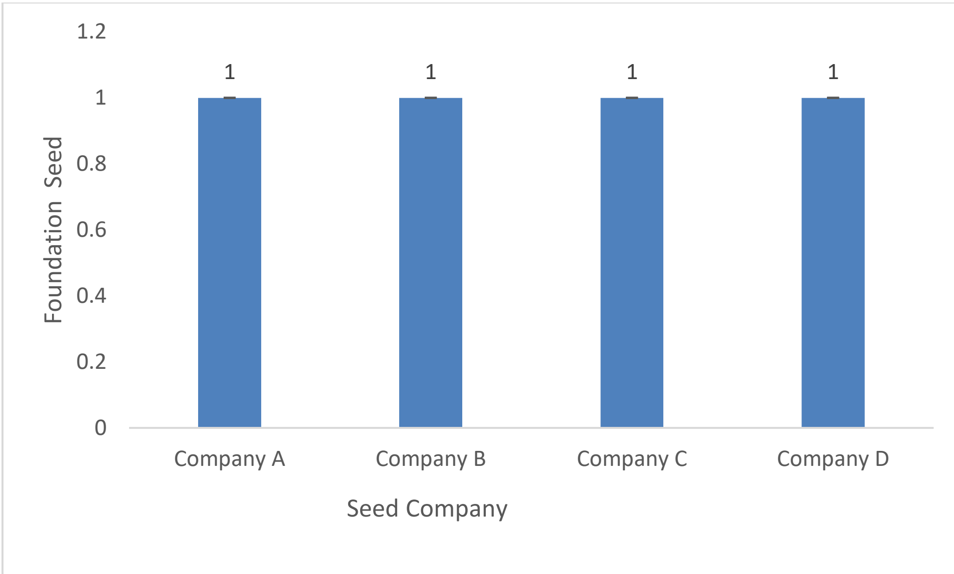


Figure 4.4: Foundation seeds from seed companies

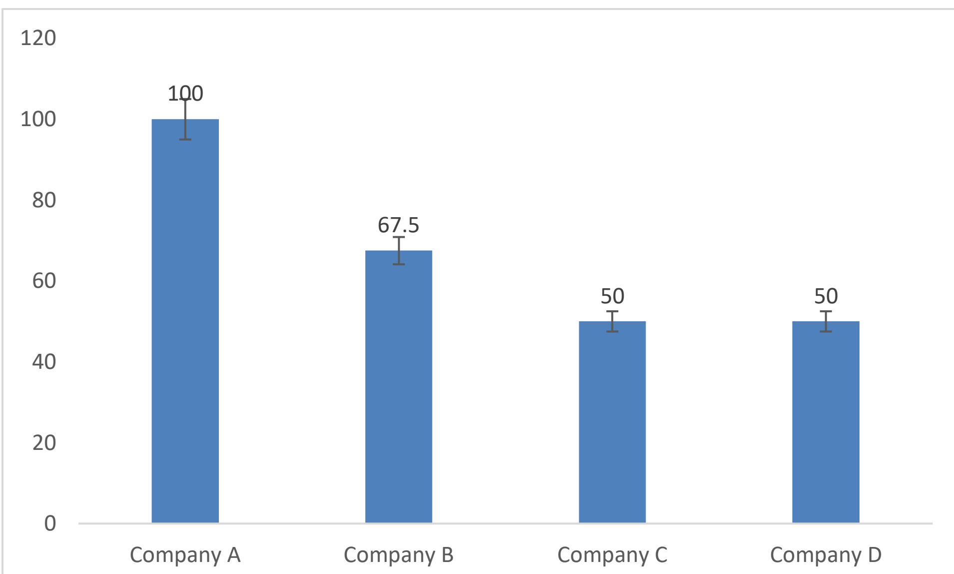


Figure 4.5: Average quantity of foundation received from seed company

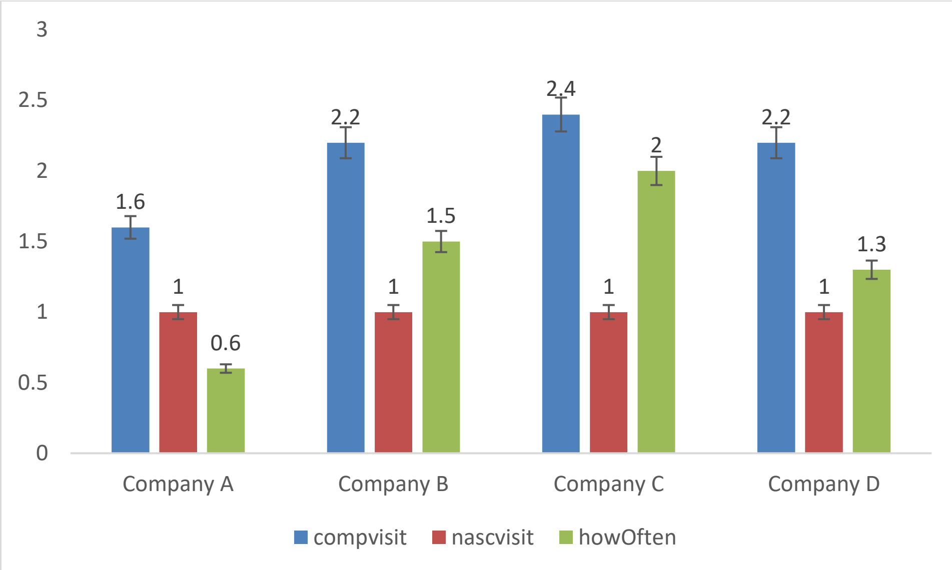


Figure 4.6: Seed company official visit, NASC visit and How often to the outgrower field

4.8.4: National Agricultural Seed Council outgrowers field rejection

Figure 4.7 showed NASC outgrower field rejection and outgrowers agronomic practices on the field. The result showed that there was no rejection of field by NASC officials company A, B, C and D respectively (Figure 4.7). For the agronomic practices, the result showed that all the outgrowers practiced the required agronomic practices like nursery bed preparation, transplanting, timely application of fertilizers and herbicides, weeding and adequate water supply on their field (Figure 4.7).

4.8.5: Quantity of seed buyback by the seed companies and their prices from the outgrowers in 2016 to 2018

Figure 4.8 showed the quantity of seed buyback by the seed companies and their prices from the outgrowers from year 2016 to year 2018. The result obtained from the outgrowers showed that the highest buyback was from company C in year 2016 while the lowest buyback was from company A in 2016. In 2017, company C had the highest buyback while company A had the lowest buyback. The result obtained from year 2018 showed that company C had the highest buyback while company D recorded the lowest buyback from their outgrower (Figure 4.8).

The price ranged between N134 and N295 across the seed companies in 2016. The highest price was recorded by company D while company C recorded the lowest price in 2016 (Figure 4.8). In 2017, the price ranged between N290 and N154 across the seed companies. The highest price recorded was from company D while the lowest price was recorded by company C from the outgrowers (Figure 4.8). The 2018 price of seed buyback from the outgrowers ranged between N300 and N174 across the seed companies (Figure 4.8). Company A recorded the highest price while company C recorded the lowest price in respect to the seed buyback from the seed company's outgrower (Figure 4.8).

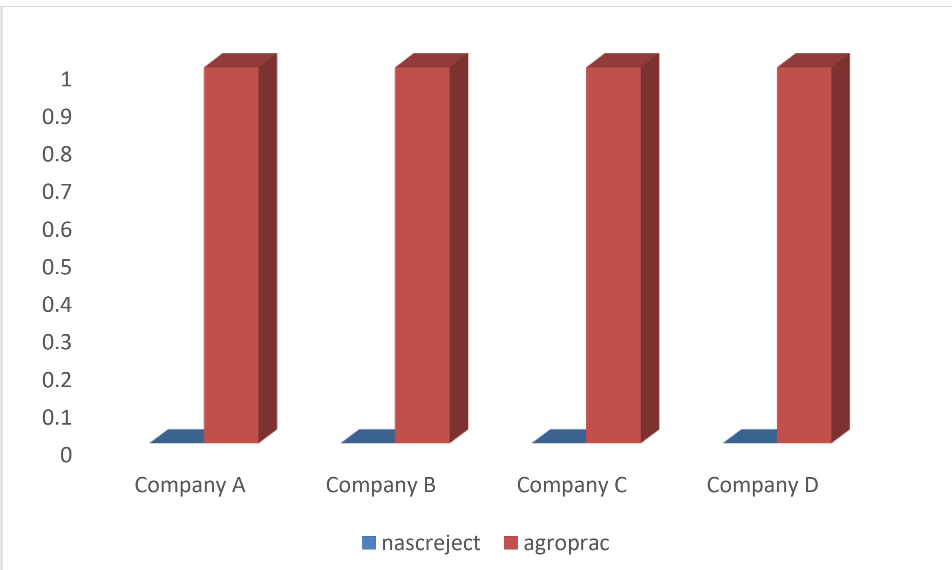


Figure 4.7: NASC field rejection and outgrower agronomic practices on the field

Figure 4.8: Quantity of seed buyback and Prices from the outgrower between year 2016 - 2018

4.8.6: Statistical analysis of questionnaires from Seed companies

The questionnaire was admitted to company A, B, C, and D respectively. The number of outgrowers that received foundation seed to multiply into certified seeds from the seed company between from 2016 to 2018 is shown in (Figure 4.9). The result showed that the number of outgrowers that received foundation seeds from the seed company ranged between 693 and 420 in company A from 2016 to 2018 (Figure 4.9). The highest number of outgrower was recorded in 2017 while the lowest number of outgrower was recorded in 2016 by company A.

At company B, the number of their outgrower ranged between 290 and 200 from 2016 to 2018 (Figure 4.9). Year 2018 recorded the highest number of outgrower while the lowest number of outgrower was recorded in 2016 by company B.

The number of outgrowers that received foundation seed in company C ranged between 500 and 360 from year 2016 to 2018 (Figure 4.9). The highest number of outgrower was recorded in 2018 while the lowest number of outgrower was recorded in 2016.

In company D, the number of outgrowers that received foundation seed from 2016 to 2018 ranged between 200 and 180. The highest number of outgrowers was recorded in 2016 while the lowest number of outgrower was recorded in the year 2017 (Figure 4.9).

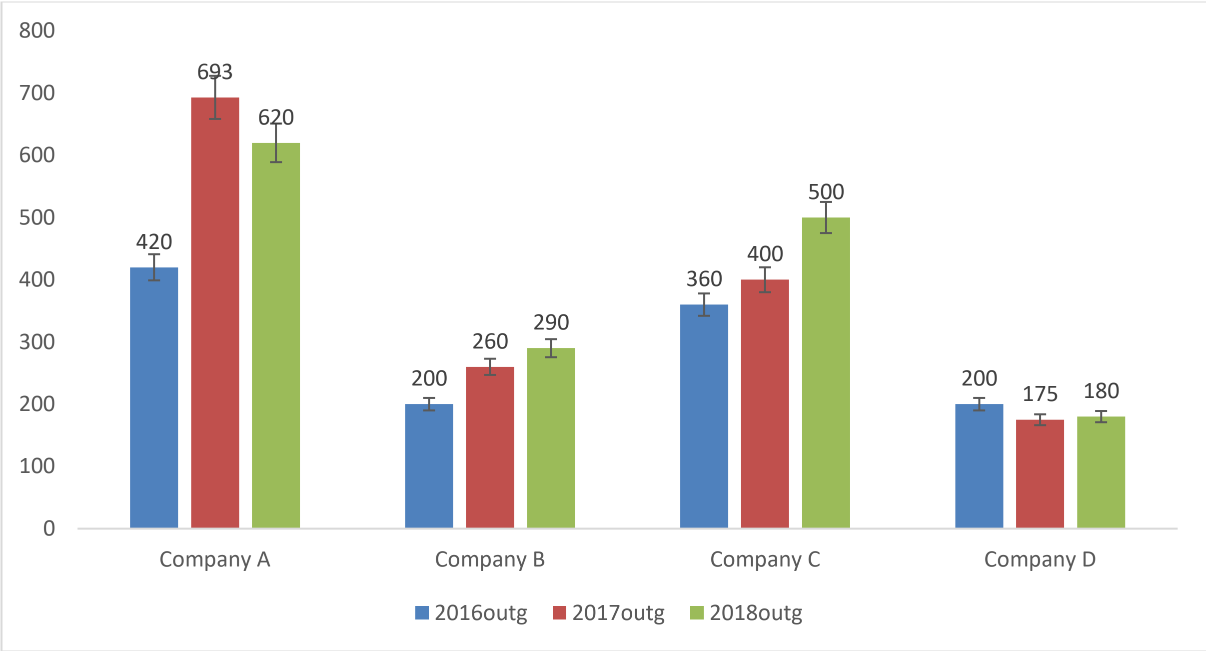


Figure 4.9: Number of outgrowers that received foundation seeds in 2016 – 2018 from seed company

4.8.7: Source of foundation seeds by the seed companies

Figure 4.10 showed where the foundation was obtained by the seed company, if the seed was obtained from other outgrowers than the selected ones, and methods of purity determination by the seed companies. The result showed that all the seed producing companies obtained their foundation seed from the National Cereal Research Institute (NCRI).

Company A, B, and D do not obtain seeds from other source aside from the outgrowers they supplied foundation seed while company C obtained seeds from other source aside the outgrowers they supply foundation seeds (Figure 4.10).

The purity level determination by all the seed producing companies were obtained through their field visits to the outgrowers field (Figure 4.10).

4.8.8: The quantity of foundation seeds given to the outgrowers and prices from 2016 to 2018

Figure 4.11 showed the quantity of foundation seeds given to the outgrowers and prices from 2016 to 2018 in for all the seed producing companies respectively. The result obtained showed that quantity of foundation seeds given to the outgrowers ranged between 60 kg and 59 kg from 2016 to 2018 across the seed companies (Figure 4.11). Company C had the highest quantity of foundation seed in year 2016, 2017, and 2018 respectively while company A, B, and D had similar lowest quantity of foundation seed in year 2016, 2017, and 2018 to their outgrowers (Figure 4.11).

The price in 2016 ranged between N450 and N250 among the seed companies. The highest price (450) was recorded in company A while the lowest price (250) was recorded in company C (Figure 4.11).

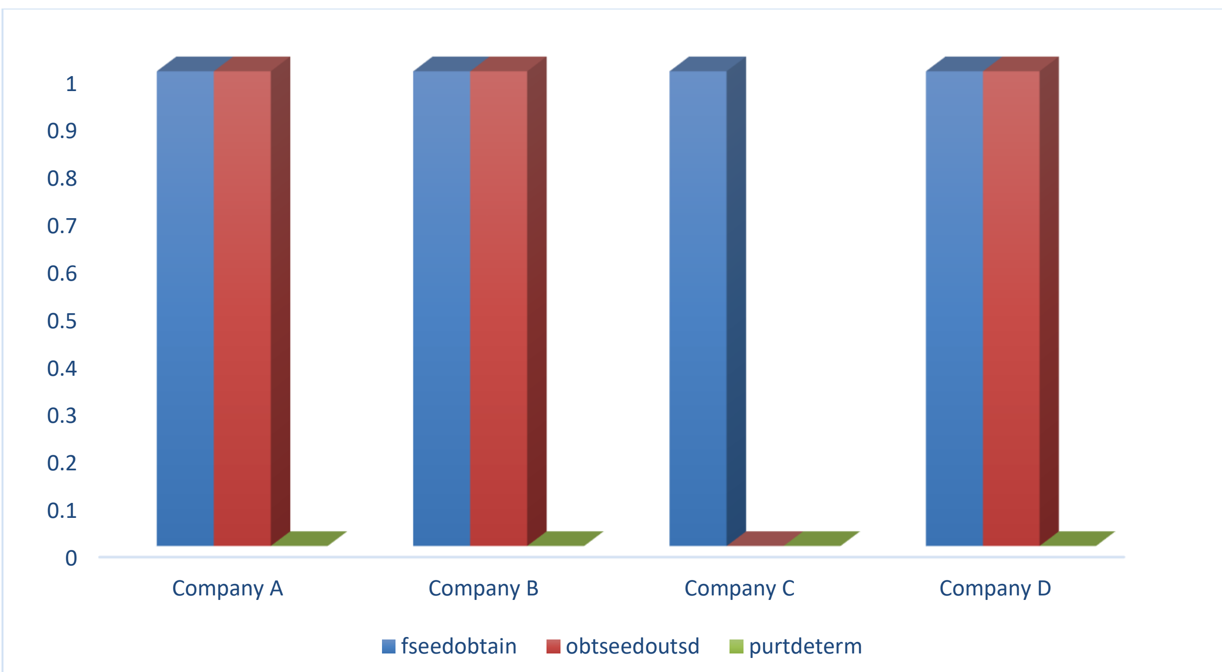


Figure 4.10: Source of foundation seed, Seed obtained from other outgrowers and purity determination by the seed company from field visit.

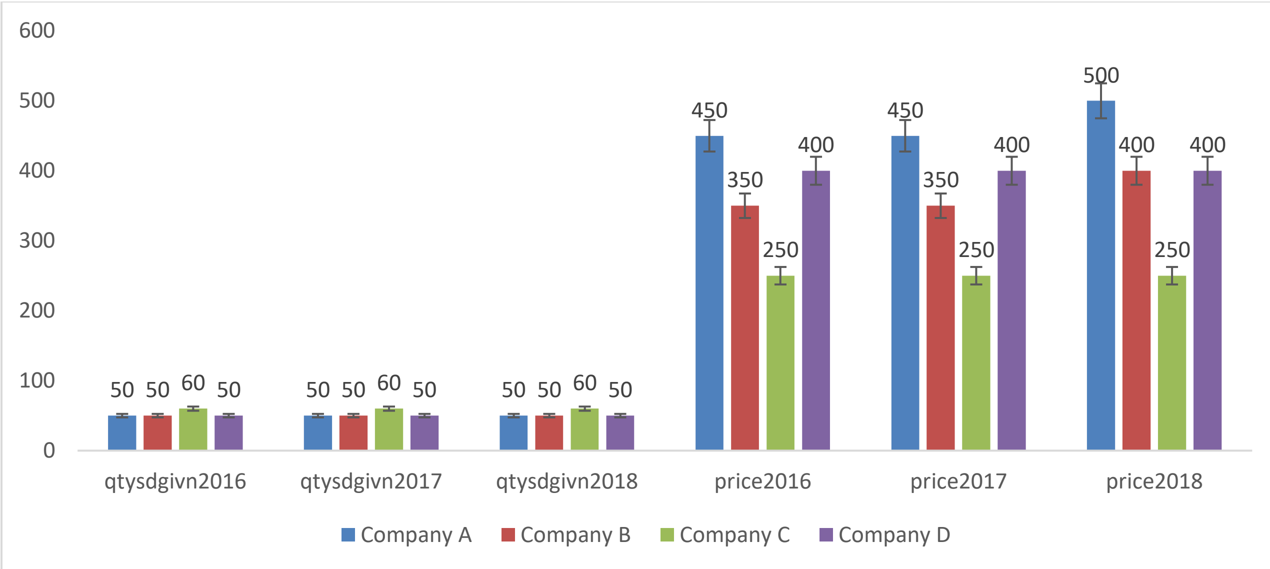


Figure 4.11: Quantity of foundation Seeds given to the outgrowers and Prices in 2016 - 2018

In 2017, the price ranged between N450 and N250 among the seed companies. Company A recorded the highest price while company C recorded the lowest price for foundation seed from the seed company.

The price of foundation seed in 2018 ranged between N500 and N250 among the seed companies. Company A recorded the highest price while company C recorded the lowest price in 2018 (Figure 4.11).

4.8.9: Seed buyback by the seed companies from their outgrowers and the price from 2016 to 2018 in by seed companies

Figure 4.12 showed the seed buyback by the seed companies from their outgrowers and the price from 2016 to 2018 by all the seed companies respectively. The seed buyback in 2016 by the seed company ranged between 4200 kg and 1750 kg among all the seed producing companies respectively. The highest buyback was recorded by company A while the lowest buyback was recorded by company C in 2016 (Figure 4.12). In 2017, buyback ranged between 5000 kg and 2800 kg across the four seed companies. Company D recorded the highest buyback while company C recorded the lowest buyback (Figure 4.12).Seed buyback from outgrowers by the seed company in 2018 ranged between 5000 kg and 2900 kg among all the seed producing companies respectively. The highest buyback was recorded by company A while the lowest buyback was recorded by company B (Figure 4.12).

The price in 2016 ranged between N250 and N143 across the seed companies. Seed companies B, C, and D recorded similar highest price while company A recorded the lowest price in 2016 (Figure 4.12). The price ranged between N300 and N157 across the seed companies in 2017, such that, company D recorded the highest price while company A recorded the lowest price in 2017 (Figure 4.12).In 2018, the price of the seed buyback from the outgrowers by the seed company ranged between N280 and N171 across the seed companies. The highest price was recorded by company D while the lowest price was recorded by company A in (Figure 4.12).

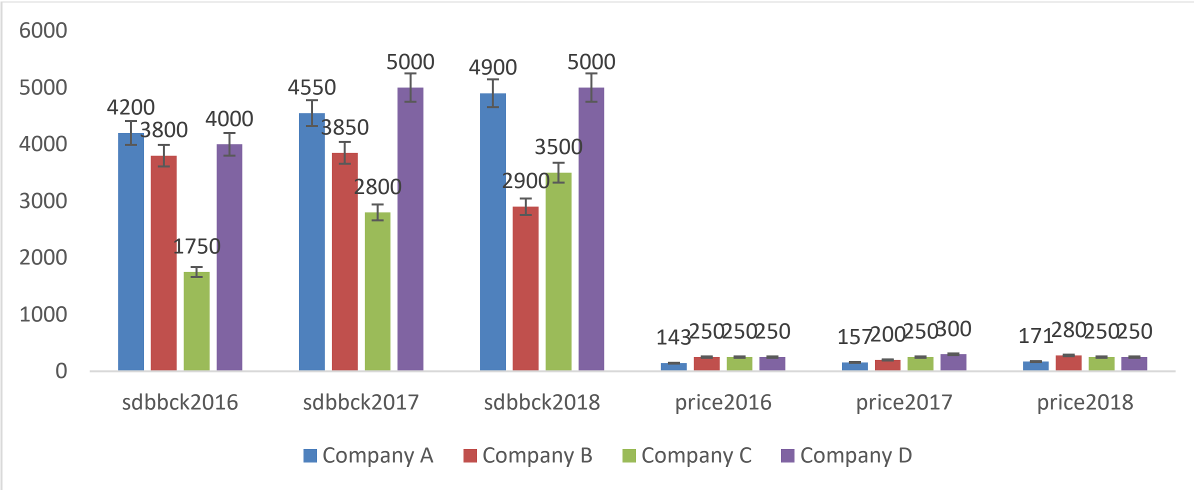


Figure 4.12: Seed buyback from outgrowers and price in 2016 – 2018

4.9 DISCUSSION

The results obtained showed high level of variation among varieties, companies and their interactions on the morphological characters of rice which revealed that variation exist among rice seeds and seed producing companies. This finding is similar with the work of Gana *et al*. (2013) who reported that mean square analysis had highly significant differences among the varieties which explains the variation existing among the rice cultivars.

The result of the principal component analysis substantially confirms the pattern of character co variation among the varieties and seed producing companies studied. It also identified the characters that contributed most to the variation within a group of entries. The biological meaning of the principal components can be accessed from contribution of the different variables to each principal component according to the Eigen values. Adebisi *et al*. (2013) had a similar finding with our result. The first three principal components were the most important in reflecting the variation patterns among accessions and the characters highly associated with this should be used in differentiating accessions. This result is in conformity with the work of Maji and Shaibu, 2012; Ashfaq *et al*., 2012; Adebisi *et al*., 2013; Gana *et al*., 2013; Nachimuthu *et al*., 2014; Placide *et al*., 2015; Mahendran *et al*., 2015; Mvuyekure *et al*., 2018; Kumari *et al*., 2019 and Ranjith *et al*., 2019 who stated that the first three axes of the PCA captured the total highest variation among the entries.

Plant height showed the highest level of differences among samples of the same varieties from different companies. Characters with high variability are expected to provide high level of gene transfer during breeding programs. Individual with genetic affinity will provide low gene transfer. Mean performance on the field performance of the sampled varieties from different companies' revealed variations for all the traits considered.

Performance Index shows that the yield reduction to the potential yield of the varieties considered revealed in this work is an indication of different quality of the seeds obtained from different companies. Quality of seeds has been reported to contribute 75 % to the better yield while agronomic practices contribute only 25 % (Adebisi, 2004). The least reduction which can be translated to the highest quality seed of FARO44 was obtained from company C. This may be as a result of the company's priority for the market of FARO44 in Nigeria and the highest monitoring and evaluation from National Agricultural Seed Council officials received by company C than the other seed companies in the result of our study. The use of high yielding varieties, responsive to fertilization and tolerance to major pest attacks has been shown to increase productivity (Nugraha, 2004).

The emergence test showed that the variability could be attributed to varietal superiority for this parameter. Similar result was obtained by Shiratsuchi *et al*. (2001), who recorded significant variability in emergence ability among rice cultivars subjected to the same growing medium.

Ruan *et al*. (2002) reported that the larger the energy of germination, the faster the rate of germination.

This is an indication of the possibility of seeds of the same variety but of different source significantly differing in quality and a number of factors could be responsible for this disparity. While poor seed production management could be a factor, it is also probable that a well-produced seed loses quality as a result of mishandling (exposure to unfavorable environmental condition on transit, dealer store, warehouses or in end user's custody) between the time/point of production and the time/point of used. Whatsoever the cause may be, the result of poor seedling emergence is not positive. Because missing stands would have to be supplied, there would be non-uniformity in plant growth which in turn would disrupt agronomic practices. Also, because desired plant population would not be achieved, obtaining optimum yield would be at stake. As a result, farmers may lose interest in certified seeds, thereby trusting their own saved seeds which have not been genetically improved upon. This would therefore negatively affect the farmer in particular and also the nation's food supply pool at large.

The survey questionnaire of the seed companies' outgrower scheme showed that the use of the farmers' own seeds can reduce the productivity of rice crops. Implication of other production input and means become less effective in the absence of qualified seeds of high yielding variety (Ansri, 2013).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

From the results of this study, it is concluded that the combined analysis indicated varieties had a significant effect on plant height at 2 WAT and at harvest while the companies had a significant effect on plant height at 2 and 4 WAT, seed weight, number of panicles and seed yield. The principal components (PC) showed variation individually among the seed companies and rice varieties for the specific traits under study. FARO 44 out yielded FARO 52 in terms of seedling emergence percentage (51.83 %), performance index (lowest yield reduction from the potential yield) and all the morphological characters measured. Company C consistently produced higher seedling emergence percentage (69.17 %), performance index (lowest yield reduction from the potential yield) 100 % and all the morphological characters measured. The highest qualitative seed was from the seeds obtained from company C. Company C also had the highest frequent monitoring and evaluation by the National Agricultural Seed Council, highest buyback (3950 kg) and lowest price of foundation seed N174 than company A, B, and D respectively.

5.2 RECOMMENDATIONS

Based on the context of this study, it is recommended that:

1. Farmer's should engage seed company C for increased growth, yield and seed quality of rice in this agro-ecological zone of Nigeria.
2. Timely evaluation of rice seeds obtained from seed producing companies should be carried out by breeders to evaluate the quality and performance of seeds to the farmer's across the agro-ecological zones of Nigeria.

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APPENDIX

ANOVA TABLE

Response Variable: PHT

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	4.6137	2.3069	9.04	0.0996
FactorB	1	67.9057	67.9057	266.07	0.0037
Error(a)	2	0.5104	0.2552		
FactorA	3	33.0844	11.0281	5.65	0.0119
FactorB:FactorA	3	44.8307	14.9436	7.66	0.0040
Error(b)	12	23.4101	1.9508		
Total	23	174.3551			

Response Variable: PHT

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	7.6158	3.8079	35.29	0.0276
FactorB	1	1.0417	1.0417	9.65	0.0899
Error(a)	2	0.2158	0.1079		
FactorA	3	2.5150	0.8383	0.60	0.6290
FactorB:FactorA	3	1.3817	0.4606	0.33	0.8052
Error(b)	12	16.8483	1.4040		
Total	23	29.6183			

ANOVA TABLE

Response Variable: PHT1

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	19.9100	9.9550	1.56	0.3908
FactorB	1	3.7763	3.7763	0.59	0.5223
Error(a)	2	12.7740	6.3870		
FactorA	3	1.9518	0.6506	0.18	0.9105
FactorB:FactorA	3	58.0215	19.3405	5.23	0.0153
Error(b)	12	44.3375	3.6948		
Total	23	140.7711			

ANOVA TABLE

Response Variable: PHT1

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.6358	0.3179	1.05	0.4879
FactorB	1	0.0417	0.0417	0.14	0.7463
Error(a)	2	0.6058	0.3029		
FactorA	3	5.7500	1.9167	1.08	0.3947
FactorB:FactorA	3	4.3950	1.4650	0.83	0.5049
Error(b)	12	21.3050	1.7754		
Total	23	32.7333			

ANOVA TABLE

Response Variable: FLOWERING

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	2.2500	1.1250	0.30	0.7712
FactorB	1	0.6667	0.6667	0.18	0.7157
Error(a)	2	7.5833	3.7917		
FactorA	3	4.8333	1.6111	1.06	0.4006
FactorB:FactorA	3	5.0000	1.6667	1.10	0.3866
Error(b)	12	18.1667	1.5139		
Total	23	38.5000			

ANOVA TABLE
Response Variable: FLOWERING

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.7500	0.3750	0.23	0.8125
FactorB	1	0.0000	0.0000	0.00	1.0000
Error(a)	2	3.2500	1.6250		
FactorA	3	0.0000	0.0000	0.00	1.0000
FactorB:FactorA	3	0.0000	0.0000	0.00	1.0000
Error(b)	12	12.0000	1.0000		
Total	23	16.0000			

ANOVA TABLE
Response Variable: PHTHAR

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	10.2342	5.1171	0.32	0.7582
FactorB	1	5368.5459	5368.5459	334.63	0.0030
Error(a)	2	32.0862	16.0431		
FactorA	3	29.1536	9.7179	1.42	0.2862
FactorB:FactorA	3	17.8811	5.9604	0.87	0.4841
Error(b)	12	82.3447	6.8621		
Total	23	5540.2459			

ANOVA TABLE
Response Variable: PHTHAR

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	3.3300	1.6650	5.52	0.1534
FactorB	1	4845.0417	4845.0417	16060.91	0.0001
Error(a)	2	0.6033	0.3017		
FactorA	3	24.8717	8.2906	5.29	0.0148
FactorB:FactorA	3	18.1650	6.0550	3.86	0.0381
Error(b)	12	18.8133	1.5678		
Total	23	4910.8250			

ANOVA TABLE
Response Variable: GW

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.3333	0.1667	1.00	0.5000
FactorB	1	1.0417	1.0417	6.25	0.1296
Error(a)	2	0.3333	0.1667		
FactorA	3	1.7917	0.5972	1.07	0.3964
FactorB:FactorA	3	7.7917	2.5972	4.68	0.0219
Error(b)	12	6.6667	0.5556		
Total	23	17.9583			

ANOVA TABLE
Response Variable: GW

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	1.0075	0.5038	1.17	0.4598
FactorB	1	5.7038	5.7038	13.30	0.0676
Error(a)	2	0.8575	0.4288		
FactorA	3	12.0946	4.0315	9.82	0.0015
FactorB:FactorA	3	19.4446	6.4815	15.78	0.0002
Error(b)	12	4.9283	0.4107		
Total	23	44.0363			

ANOVA TABLE
Response Variable: TILLERNO

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	1.0208	0.5104	0.86	0.5377
FactorB	1	1.5000	1.5000	2.53	0.2529
Error(a)	2	1.1875	0.5937		
FactorA	3	6.7500	2.2500	5.63	0.0120
FactorB:FactorA	3	5.0833	1.6944	4.24	0.0292
Error(b)	12	4.7917	0.3993		
Total	23	20.3333			

ANOVA TABLE
Response Variable: TILLERNO

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.2500	0.1250	0.05	0.9531
FactorB	1	5.0417	5.0417	1.98	0.2943
Error(a)	2	5.0833	2.5417		
FactorA	3	4.1250	1.3750	1.55	0.2533
FactorB:FactorA	3	0.4583	0.1528	0.17	0.9133
Error(b)	12	10.6667	0.8889		
Total	23	25.6250			

ANOVA TABLE
Response Variable: PANNO

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	6.2708	3.1354	1.92	0.3428
FactorB	1	3.0104	3.0104	1.84	0.3077
Error(a)	2	3.2708	1.6354		
FactorA	3	13.6146	4.5382	1.84	0.1939
FactorB:FactorA	3	29.1979	9.7326	3.94	0.0360
Error(b)	12	29.6250	2.4688		
Total	23	84.9896			

ANOVA TABLE
Response Variable: PANNO

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.7500	0.3750	1.00	0.5000
FactorB	1	0.0000	0.0000	0.00	1.0000
Error(a)	2	0.7500	0.3750		
FactorA	3	16.5000	5.5000	4.55	0.0237
FactorB:FactorA	3	24.0000	8.0000	6.62	0.0069
Error(b)	12	14.5000	1.2083		
Total	23	56.5000			

ANOVA TABLE
Response Variable: GrainYield

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.7751	0.3876	1.69	0.3721
FactorB	1	0.4579	0.4579	1.99	0.2935
Error(a)	2	0.4594	0.2297		
FactorA	3	1.2250	0.4083	1.49	0.2678
FactorB:FactorA	3	3.9735	1.3245	4.82	0.0199
Error(b)	12	3.2949	0.2746		
Total	23	10.1857			

ANOVA TABLE
Response Variable: GrainYield

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Block	2	0.0742	0.0371	1.05	0.4886
FactorB	1	0.2424	0.2424	6.84	0.1203
Error(a)	2	0.0709	0.0354		
FactorA	3	6.0859	2.0286	7.91	0.0036
FactorB:FactorA	3	8.8552	2.9517	11.50	0.0008
Error(b)	12	3.0791	0.2566		
Total	23	18.4076			

COMBINED ANOVA TABLE
ANOVA TABLE

Response Variable: PHT

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	4.9344	4.9344	1.61	0.2728
Block within Trial	4	12.2296	3.0574	16.84	0.0091
FactorB	1	42.8841	42.8841	236.19	0.0001
Trial:FactorB	1	26.0633	26.0633	143.55	0.0003
Pooled Error(a)	4	0.7263	0.1816		
FactorA	3	20.1131	6.7044	4.00	0.0193
FactorB:FactorA	3	15.2726	5.0909	3.03	0.0487
Trial:FactorA	3	15.4863	5.1621	3.08	0.0467
Trial:FactorB:FactorA	3	30.9398	10.3133	6.15	0.0030
Pooled Error(b)	24	40.2584	1.6774		
Total	47	208.9078			

ANOVA TABLE
Response Variable: PHT1

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	555.6963	555.6963	108.19	0.0005
Block within Trial	4	20.5459	5.1365	1.54	0.3439
FactorB	1	1.5123	1.5123	0.45	0.5382
Trial:FactorB	1	2.3056	2.3056	0.69	0.4531
Pooled Error(a)	4	13.3799	3.3450		
FactorA	3	3.5446	1.1815	0.43	0.7320
FactorB:FactorA	3	46.8412	15.6137	5.71	0.0043
Trial:FactorA	3	4.1572	1.3857	0.51	0.6814
Trial:FactorB:FactorA	3	15.5752	5.1917	1.90	0.1569
Pooled Error(b)	24	65.6425	2.7351		
Total	47	729.2008			

ANOVA TABLE
Response Variable: FLOWERING

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	6.7500	6.7500	9.00	0.0399
Block within Trial	4	3.0000	0.7500	0.28	0.8793
FactorB	1	0.3333	0.3333	0.12	0.7434
Trial:FactorB	1	0.3333	0.3333	0.12	0.7434
Pooled Error(a)	4	10.8333	2.7083		
FactorA	3	2.4167	0.8056	0.64	0.5962
FactorB:FactorA	3	2.5000	0.8333	0.66	0.5829
Trial:FactorA	3	2.4167	0.8056	0.64	0.5962
Trial:FactorB:FactorA	3	2.5000	0.8333	0.66	0.5829
Pooled Error(b)	24	30.1667	1.2569		
Total	47	61.2500			

ANOVA TABLE
Response Variable: PHTHAR

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	17.1005	17.1005	5.04	0.0881
Block within Trial	4	13.5642	3.3911	0.41	0.7924
FactorB	1	10206.8751	10206.8751	1248.95	0.0000
Trial:FactorB	1	6.7126	6.7126	0.82	0.4160
Pooled Error(a)	4	32.6896	8.1724		
FactorA	3	9.5389	3.1796	0.75	0.5306
FactorB:FactorA	3	19.2068	6.4023	1.52	0.2351
Trial:FactorA	3	44.4864	14.8288	3.52	0.0304
Trial:FactorB:FactorA	3	16.8393	5.6131	1.33	0.2874
Pooled Error(b)	24	101.1580	4.2149		
Total	47	10468.1713			

ANOVA TABLE
Response Variable: GW

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	1247.4602	1247.4602	3721.45	0.0000
Block within Trial	4	1.3408	0.3352	1.13	0.4556
FactorB	1	0.9352	0.9352	3.14	0.1510
Trial:FactorB	1	5.8102	5.8102	19.52	0.0115
Pooled Error(a)	4	1.1908	0.2977		
FactorA	3	4.2556	1.4185	2.94	0.0538
FactorB:FactorA	3	22.9556	7.6519	15.84	0.0000
Trial:FactorA	3	9.6306	3.2102	6.64	0.0020
Trial:FactorB:FactorA	3	4.2806	1.4269	2.95	0.0528
Pooled Error(b)	24	11.5950	0.4831		
Total	47	1309.4548			

ANOVA TABLE
Response Variable: TILLERNO

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	3.5208	3.5208	11.08	0.0291
Block within Trial	4	1.2708	0.3177	0.20	0.9244
FactorB	1	6.0208	6.0208	3.84	0.1216
Trial:FactorB	1	0.5208	0.5208	0.33	0.5952
Pooled Error(a)	4	6.2708	1.5677		
FactorA	3	10.5208	3.5069	5.44	0.0053
FactorB:FactorA	3	4.1875	1.3958	2.17	0.1182
Trial:FactorA	3	0.3542	0.1181	0.18	0.9067
Trial:FactorB:FactorA	3	1.3542	0.4514	0.70	0.5608
Pooled Error(b)	24	15.4583	0.6441		
Total	47	49.4792			

ANOVA TABLE
Response Variable: PANNO

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	8.7552	8.7552	4.99	0.0893
Block within Trial	4	7.0208	1.7552	1.75	0.3012
FactorB	1	1.5052	1.5052	1.50	0.2882
Trial:FactorB	1	1.5052	1.5052	1.50	0.2882
Pooled Error(a)	4	4.0208	1.0052		
FactorA	3	29.4323	9.8108	5.34	0.0058
FactorB:FactorA	3	49.0990	16.3663	8.90	0.0004
Trial:FactorA	3	0.6823	0.2274	0.12	0.9452
Trial:FactorB:FactorA	3	4.0990	1.3663	0.74	0.5368
Pooled Error(b)	24	44.1250	1.8385		
Total	47	150.2448			

ANOVA TABLE
Response Variable: GrainYield

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
Trial	1	51.2885	51.2885	241.55	0.0001
Block within Trial	4	0.8493	0.2123	1.60	0.3296
FactorB	1	0.0170	0.0170	0.13	0.7384
Trial:FactorB	1	0.6833	0.6833	5.15	0.0857
Pooled Error(a)	4	0.5302	0.1326		
FactorA	3	6.3717	2.1239	8.00	0.0007
FactorB:FactorA	3	11.6533	3.8844	14.63	0.0000
Trial:FactorA	3	0.9392	0.3131	1.18	0.3386
Trial:FactorB:FactorA	3	1.1753	0.3918	1.48	0.2464
Pooled Error(b)	24	6.3740	0.2656		
Total	47	79.8818			

SURVEY ON RICE SEED OUTGROWER SCHEME IN NIGERIA
QUESTIONNAIRE: TO SEED COMPANY

1. Do you have registered Rice Seed Outgrowers?

   Yes / No

2. If yes, How many registered Rice seed outgrowers?

   ____

3. Please fill the gap on the number of Outgrowers that received foundation seeds in the following year.

	2016	2017	2018
Number of Outgrowers			

4. Do you supply Foundation seed to your outgrowers?

   Yes / No

5. What percentage of requested Foundation seed do you supply averagely to your outgrowers?

   ____

6. How do you make sure that the Foundation seed is used by your outgrowers?

   ____

7. What is the average certified Rice seed yield?

   ____

8. How much certified seed do you receive from your outgrowers?

   I. Just as estimated per ha

   II. Below estimated per ha

   III. Above estimated per ha

9. How do you determine the maximum certified seeds expected from an outgrower?

____

10. What percentage of your outgrower:

    I. Supply below average estimate? ___________________

    II. Just estimated value? ________________

    III. Above estimated value? _____________

11. Where do you obtain your Foundation seeds?

    a. NCRI

    b. AfricaRice

    c. Company local breeding program

12. Do you obtain seed from other source beside the outgrowers you supplied Foundation seed to?

    Yes / No

13. How do you determine the purity level of the certified seeds coming from the outgrower?

    a. Field visits

    b. From seed stalk

14. What percentage of the seed you obtain comes from:

    I. Seed outgrower you supplied seed? _________________

    II. Seed outgrower you do not supply seed? _____________

15. Please fill the gap on the quantity of Foundation Seed given to the Outgrowers

	2016	2017	2018
Seed Company	Variety Qty(kg)/ha Price/Kg	Variety Qty(kg)/ha Price/kg	Variety Qty(kg)/ha Price/kg

16. Please fill the gap on the quantity of Certified Seed bought back from the outgrowers.

	2016		2017		2018	
Seed Company	Qty(kg)/ha Price/kg		Qty(kg)/ha Price/kg		Qty(kg)/ha Price/kg	

SURVEY ON RICE SEED OUTGROWER SCHEME IN NIGERIA
QUESTIONNAIRE: TO SEED OUTGROWERS

1. Do you always get foundation seeds from your seed company?

   Yes / No

2. What is the average quantity of foundation seeds do you always receive from your seed company?

   ____

3. What is the area of your seed farm?

   ____

4. What do you do when the quantity of seed you received from your seed company cannot cover your farm?

   ____

5. Do your seed company always tell you what quantity of seed they expect from you?

   ____

6. How often do your seed company field officers visit your field?

   I. Once

   II. Twice

   III. Thrice

   IV. More

7. Do NASC officers visit your seed field for certification purpose?

   Yes / No

8. If yes, how often?

   I. Once

   II. Twice

   III. Thrice

   IV. More

9. What quantity of seed do you usually supply your company?

   I. As expected

   II. Below expected

   III. Above expected

10. Do you supply seed to companies other than the one that gave you seed?

    Yes / No

11. If yes, how do such companies determine the purity of your seeds?

____

12. If you have excess seeds not recovered by your seed company, what do you do with such excess?

    I. Sell as seed to other farmers
    II. Sell as paddy
    III. Others: _______________________

13. Do your seed company always recover the seed you multiply for it?

    Yes/No

14. Have your seed field ever been rejected by:

    I. Seed company? _________
    II. NASC? __________

15. What are the Agronomic Practices you use in producing your seeds?

16. Certified Rice Seed (By back)

	2016		2017		2018	
Seed Company	Quantity	Price	Quantity	Price	Quantity	Price