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Rice seed quality as influenced by storage duration and package type in Cameroon

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ABSTRACT

The study aimed at evaluating the changes in rice seed quality as a function of storage duration and package type through characterization of seed quality determinants. Two rice varieties NERICA8 and NERICAL56) were measured into four package types (nylon bag, polyethylene bag, jute bag, and paper bag) and stored in a storage room of average relative humidity and temperature of 80% and 26 °C respectively. Standard methods of evaluating seed quality applicable to paddy were used. The quality parameters showed variability across the package types and storage duration. Remarkable changes were observed in the germination rate and insect damaged grains with slight changes in the number of colored grains, moisture content, and grain weight during the sampling intervals. The quantity of insect damage grains increased while germination rate decreased continuously during the entire experimental period. At three months of storage, the quantity of insect damage grains increased in all the bags for NERICA8 (0.1 g - 3.73 g) and was so for NERICAL56 only in the jute (0.15 g - 3.43 g) and paper (0.1 g - 3.13 g) bags at $p<0.05$ level of significance. Germination rate had reduced in all the bags below the minimum seed certification standard (MSCS) of 85%, reaching values of 53% and 51% for NERICA8 and NERICAL56 respectively in the polyethylene bag. Insect damage was least in the polyethylene bag (1.73 g) and highest in the jute (3.73 g) and paper (3.43 g) bags. NERICA8 was more pruned to insect damage as high values were observed at one month of storage but observed for NERICAL56 only at two months of storage. In addition, the number of colored grains was higher in the polyethylene and nylon bags compared to the jute and paper bags. From these results, a huge decrease in the quality of rice seeds occurred in the nylon and polyethylene bags. The observed high germination rate associated with insect infestation in the jute and paper bags suggest that if seeds in these bags are treated with insecticides, germination rate could improve to values around the MSCS even after three months of storage.

Keywords: Seed quality, NERICA, germination, insect damage.

INTRODUCTION

Rice is fast becoming a major cereal crop in Cameroon and is largely produced by subsistent smallholder farmers, mostly women on small plots. Rice is widely grown in the Ndop and Mbaw plains of the Northwest region; the Western region around Foumbot, Tonga, and Santchou ; the Central region extending to Makenene, and most importantly in the North (Lagdo area) and Far North

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(Yagua) regions of the country (MINADER, 2009). The agro-ecological environments in the country include rainfed lowland, rainfed upland, and irrigated ecosystems. Rice used to be a luxurious food in households but, it is already a staple foodstuff for a greater part of the population (Goufo, 2008). According to the Food sovereignty report (ACDIC, 2006), rice consumption has increased than that of most other food crops and is predicted to be so for quite sometime. Today, the national strategy for rice growing in Cameroon estimates consumption rate at 25.7 kg per person and growing at annual rate of 4 percent per year (MINADER, 2009). This program placed rice as the priority crop for food security in Cameroon and this concept is common throughout Africa following the lessons from the rice crisis of 2008 (AfricaRice, 2011). Despite being grown in most of these areas and recognized as a significant food component of the Cameroonian population, 87% of the rice consumed in Cameroon is imported (FAO, 2006; AfricaRice 2010). This has a negative impact on local farmers in terms of competitiveness with imported rice in the local markets. This effect can be minimized through enhancement of local production both quantitatively and qualitatively. Rice production and productivity in Cameroon is faced with several constraints including: inappropriate technologies for production, inconsistent agricultural inputs, poor marketing systems, lack of sufficient quantities of improved rice seeds (Guei et al., 2011; AfricaRice 2010) , and environmental constraints. In addition to these, farmers still face problems with maintaining the quality of their selected seed from one farming season to another. The quality of seed used for planting is an important factor that affects rice yield and the quality of milled grains (NaCRRI and CABI Africa, 2010). Most of these smallholder farmers produce and store their seeds because they have limited accessibility to seed producing enterprises or structures. In the course of storage, seed quality greatly deteriorate and this may be linked to a number of factors such as temperature, moisture content of seeds, relative humidity, insect infestation, grain discoloration and other physico-chemical changes like weight loss or gain and nutrient depletion (Bailly, 2004; Neelesh et al., 2011). Most of these factors are influenced by packaging type and storage duration. Thus, the designation of an appropriate packaging material capable of maintaining seed quality from one cropping season to another will positively contribute to the enhancement of rice seed quality and hence production by smallholder farmers. The objective of this work was to assess the influence of alternate package type on the quality of seeds of two rice varieties for a given storage duration in Cameroon.

MATERIALS AND METHODS

Study site and design

The study was conducted at the Institute of Agricultural Research for Development (IRAD, Yaounde) from October to December 2014. The storage room about 16 m^2 large, well plastered and aerated was treated with pesticide powder (Antoukar Super; Perimiphos-Methyl 16 g/kg, Permethrine 3 g/kg: DP) to ensure that the room was free from rodents. The average relative humidity and temperature of the room recorded over the storage period with a temperature/humidity data logger was 80% and 26 °C. The paddy seeds used were NERICA8; a rainfed upland rice variety and NERICAL56; a rainfed lowland rice variety. The seeds were obtained from the ERI (Emergency Rice Initiative) Project at IRAD one month after harvesting. The experimental design was a completely randomized design including 2 rice varieties (NERICA8 and NERICAL56) and 4 bag types (nylon, paper, polyethylene, and jute); two bags per bag type per rice variety (giving a total of 16 bags).

Four storage durations were evaluated: 0, 1, 2, and 3 months.

Bag types used

Nylon fiber bags

Farmers remove fertilizers from these bags and usually store their seeds in the bags;

Paper bags

These bags are obtained from bakeries following removal of wheat flour for storage of seeds;

Low density polyethylene bags

Water-tight bags used by farmers to store seeds;

Jute bags

Thick woolen bags commonly used to handle cocoa beans, are used by rice farmers to store paddy seeds.

Data collection

Standard methods of evaluating seed quality applicable to paddy as described in the IRRI 2011 rice quality training manual were used with slight modifications.

Moisture content

Paddy seed moisture content was measured using a Satake Rice moisture meter (Satake Co. Ltd., Tokyo, Japan). For each of the two bags per bag type, moisture content of seeds randomly collected was measured three times and only the average value recorded.

Weight changes

Five (5) kilograms of each of the two varieties was weighed into the different bags at the start of the experiment. At storage intervals of one month during the three months, the bags were weighed using a sensitive scale balance (Gibertini® Italy) before and after the collection of samples for analysis and the difference calculated and recorded.

Germination test

The sandwich method using cotton wool while respecting the ISTA (1999) standards was used for the germination test. After sterilization of the Petri dishes and the surface on which the test was conducted using 95% ethanol, 100 grains counted from random samples from the different bags was embedded between the cotton wool in the Petri dishes and moisten with distil water. The Petri dishes were kept at room temperature (≈25 °C) and verified on daily basis to ensure that the cotton was constantly wet. After 5 days, the first count was carried out and the second count on the 14th day. The total number of germinated seeds counted was then used to express germination rate as a percentage.

1000-weight grains

The weight of 1000 whole paddy seeds counted from each bag was weighed with the sensitive scale balance and recorded.

Immature grains

Immature grains are incompletely filled grains that will not normally be viable after germination. Samples of 200 g from each bag were used for this evaluation. The weighed 200 g was put in 1litre jar of clean water, stirred and allowed to settle. The floating grains (considered as immature grains) were skimmed and dried to the initial moisture content. The weight of the dried floated grains was measured and the percentage of immature grains reported.

The following parameters were characterized using random samples of 100 g measured from the different bags at each storage interval. It is worth noting that, all characterizations were done in triplicates.

Spotted and colored grains

A grain was considered colored when its surface was streaked or had a color different from the characteristic paddy color. The colored grains through careful observation were separated from the sample and weighed. The weight since obtained from a 100g sample was directly recorded as percentage colored grains.

Insect Damage Grains

The number of seeds damaged by insects was characterized by careful observation. The selected grains damaged by insects were then weighed and directly reported as insect damaged grains in grams (g).

Weed and other crop seeds

Weed seeds and other crop seeds were manually removed and weighed and the value recorded as a percentage.

The weight of inert matter obtained in the same manner was also used to denote percentage inert matter.

Statistical analysis

All data collected were subjected to analysis of variance (ANOVA) using SPSS statistical software version 17 for windows. Mean separation was done using Tukey (P<0.05) and the results were expressed as Means ± Standard deviation.

RESULTS AND DISCUSSION

The means of physical quality determinants of the seeds assessed at the start of the study are shown in Table 1. Both seeds of varietal type NERICA (New Rice for Africa), with NERICA8 as the rainfed upland variety and NERICAL56 as the rainfed lowland variety have potential average yields of 5000 kg/ha (AfricaRice, 2008). Varietal purity of seeds checked through measurement of 1000-grains weight had average values around the documented values of 29.0 g for NERICA8 and 27.0 g for NERICAL56 (AfricaRice, 2008). Physical seed purity as shown by the presence of weed seeds (0.1%), inert matter (1.4%), immature grains (0.80 g/200 g), and colored grains (0.15%) (at P<0.05 level of significance) in the two varieties was poor. Moisture content values were high for storage, around 14.5% (recommended moisture content for storage of paddy is 12-13%) and percentage germination good as all values were above 80%. As observed, grains were already affected by insects though the damaged grains were few.

At one month after storage (Table 2), the moisture content of the rice seeds in all the bag types tended to increase significantly (p<0.05) with time as observed in the polyethylene (PE) (watertight) bag for NERICA8 variety and in the nylon bag for the NERICAL56 variety. Moisture content of the NERICAL56 variety increased up to 15.35% in the nylon bag. The overall weight of grains in three of the bag types showed no significant difference as a significant increase was only observed in the polyethylene bag. The number of insect damaged grains varied significantly (P<0.05) across all the bag types for the two varieties with high infestation in the jute bag for NERICA8 and in the paper bag for NERICAL56. NERICA8 was pruned to high insect infestation than NERICAL56 as observed. The increase in the number of insect damage grains was irrespective of the variety but dependent on package type. Insect infestation during storage reduces grain quality causing grains to be classified as “infested” (USDA FGIS, 2002) and so not suitable for use as seeds. The percentage of colored grains increased in all the bags but higher values were recorded in the polyethylene and nylon bags for all the varieties. The increase in the number of colored grains (contaminated grains) is probably due to high grain moisture contents that promote fungal development (Reuss et al., 1994). The germination rate, though good for three of the bag types decreased significantly (turk test at P<0.05) in the polyethylene bag, reaching values of 77% for NERICA8 and 81% for NERICAL56. This decrease germination is in contrast to the report by Ratanaporn et al. (2005) who worked at controlled temperatures of 16 °C and relative humidity of 65%. Samples assessed for physical purity showed poor quality as high values of inert matter, immature grains and weed seeds were still recorded (FAO, 2007).

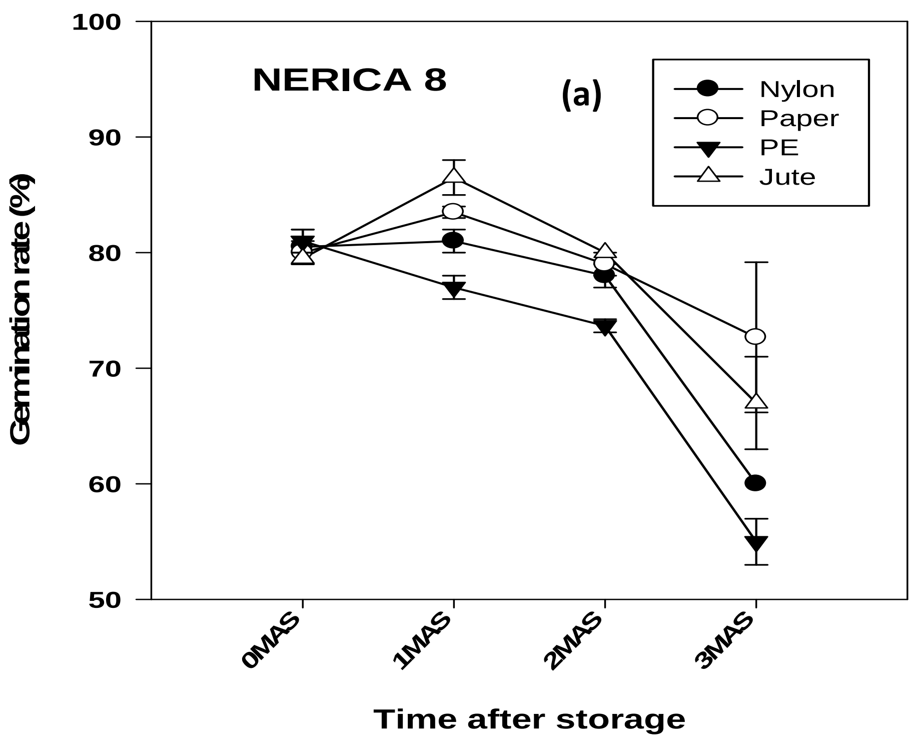
The means of physical quality determinants of seeds presented in Table 3 were assessed at two months of storage. The results show remarkable changes in germination rate and insect damage grains and slight changes in the rice seed moisture content, grain weight, and percentage colored grains. Percentage germination had reduced in all the bags for the two varieties and this reduction was significant (P<0.05) in the polyethylene bag. Higher germination rates were observed in the Jute and nylon bags for the NERICAL56 variety and in the jute and paper bag for the NERICA8 variety. The quantity of insect damage grains from NERICA8 had increased significantly ($P<0.05$) in all the bags with larger values recorded for the jute and paper bags. The slight increase in the quantity of insect damage grains for NERICAL56 was also important in the jute and paper bags though no significant difference was observed between paper and nylon bags. Only a few seeds were damaged by insects in the polyethylene bag for both varieties. The moisture content of seeds though highly dependent on the relative humidity of the storage room reduced just a little in three of the bags for both varieties and was almost stable in the polyethylene bag. The same pattern as in the variation of moisture content was observed for the weights of the bags. The percentage of colored grains increased remarkably for the NERICAL56 variety in all the bags with significant ($P<0.05$) increases in the polyethylene (4.7%) and nylon (4.6%) bags.

Results presented in Table 4 indicated extreme decline in the germination rate of the two rice seed varieties in all the bags. The decline was greatest in the polyethylene and nylon bags and both recorded values below 65%. These values were significantly different ($P<0.05$) to the germination rates seen in the jute and paper bags. Seed germination for both varieties dropped drastically at three months of storage in the polyethylene bags and nylon bags for all the two varieties but the drop was more visible for NERICA8 than for NERICAL56. Higher germination rates were thus observed in the jute and paper bags for both varieties and these values were significantly different ($P<0.05$) to those observed in the nylon and paper bags. Although with significant differences in the analyzed values, grains in the paper and jute bags were highly damaged by insects compared to damage in the nylon and polyethylene bags. Insect infestation has been reported as a major biotic constraint to stored grains in Cameroon (Ngamo et al., 2007). Moisture content of the grains in the paper bags significantly reduced to 13. 93% for NERICA8 variety and as with NERICAL56 variety, this was not significantly different to the values recorded for seeds in the jute bags. The weight of grains and percentage colored grains was high and constant in the polyethylene bags in the second and third months of storage. This observation was alike with moisture content variation for all the two varieties. The interactive effect of abiotic factors (temperature and moisture content) on biotic factors (insects and molds) was pointed out by Hayma. (2003) in his paper on the storage of tropical agricultural products; high temperature and moisture content values of grains favor fungus and insect development and a decline in the germination capacity of the grains. This statement is clearly confirmed by our results for the three months storage in all the different bags but more evidently in the polyethylene and nylon bags. Again, the presence of weed seeds (0.03 - 1.0%), inert matter (0.26 - 0.6%) and immature grains (1.73 - 2.36 g/200 g) was recorded and these values are important as they tend to reduce the quality of the seeds (FAO, 2007).

Trends in germination rate and insect damage grains over the storage period

The patterns of germination rate over the storage period in the nylon bag, paper bag, polyethylene (PE) and jute bags is shown in Figure 1. At the start, the germination rate of the seeds was good for both NERICA 8 (≈ 81%) and NERICA L56 (≈ 94%) but during the three months storage, it declined remarkably to 26% for NERICA8, and 40.67% for NERICAL56 in the polyethylene bag. A decline in rice seed germination with time is in conformity with the results discussed by Huynh Van Nghiep et al. (2005), who worked on seed treatment to improve seed quality in rice. The germination percentage of NERICA8 and NERICAL56 dropped drastically to about 53% and 51% respectively in the polyethylene bag. At one month after storage, the germination percentage of both NERICA8 and NERICA L56 was still good for three of the four bags types used but was already decreasing for the polyethylene bag. The nylon bag and polyethylene bags at two months and three months after storage presented very low germination rates when compared to that in the paper and jute bags. This was more visible in NERICA8 than in NERICAL56 whose germination significantly decreased only after two months of storage. Its germination rate was well above the Minimum Seed Certification Standard (85%) in the jute bag at three months after storage (MAS) compared to less than 70% (already very much below the MSCS) in the paper, polyethylene, and nylon bags.

The number of grains damaged by insects continuously increased during the entire experimental period. As seen in Figure 2, there was least damaged of the two varieties in polyethylene bag after the first month of storage and a slower increase compared to the other bags during the last two months. The increase in the number of insect damaged grains was high and constant for the three months in the jute (0.15 - 3.43 g) and paper (0.1 - 3.4 g) bags. This was very important in NERICA8 from the first month but only observed in NERICAL56 from the second month of storage. As earlier explained, the conditions including high temperature and raised humidity levels are responsible for growth and development of insects inside the stored grains (Murdolelono and Hosang, 2009; Weinberg et al., 2008). Ilelejia et al. (2007) stated the range 25 °C – 33 °C as the optimum growth temperature range for insects inside stored grains. Our average room temperature of 26 °C recorded during the entire storage duration falls in this range, confirming the constant increase in the weight of insect damaged grains observed during our study.



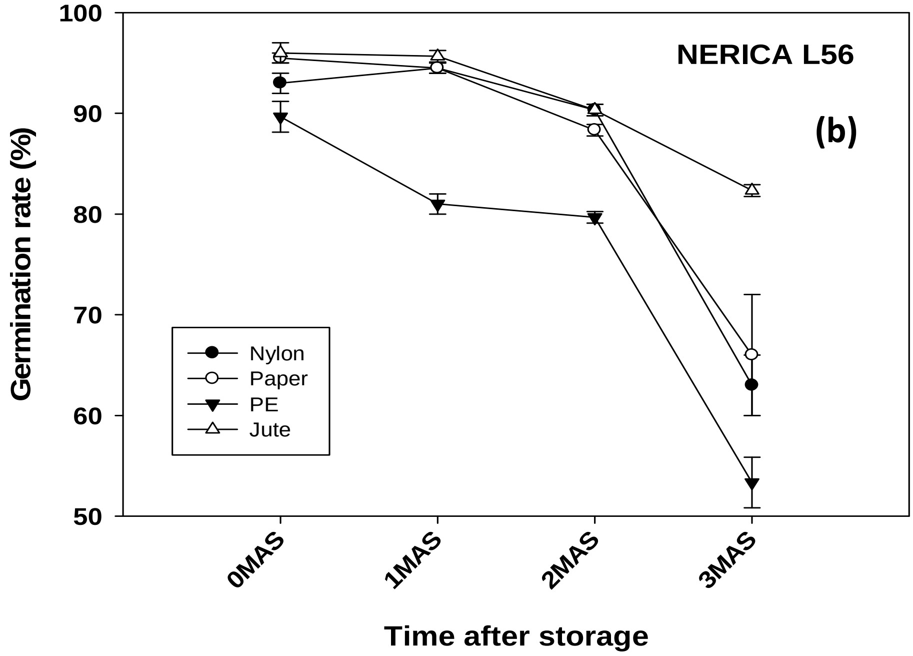
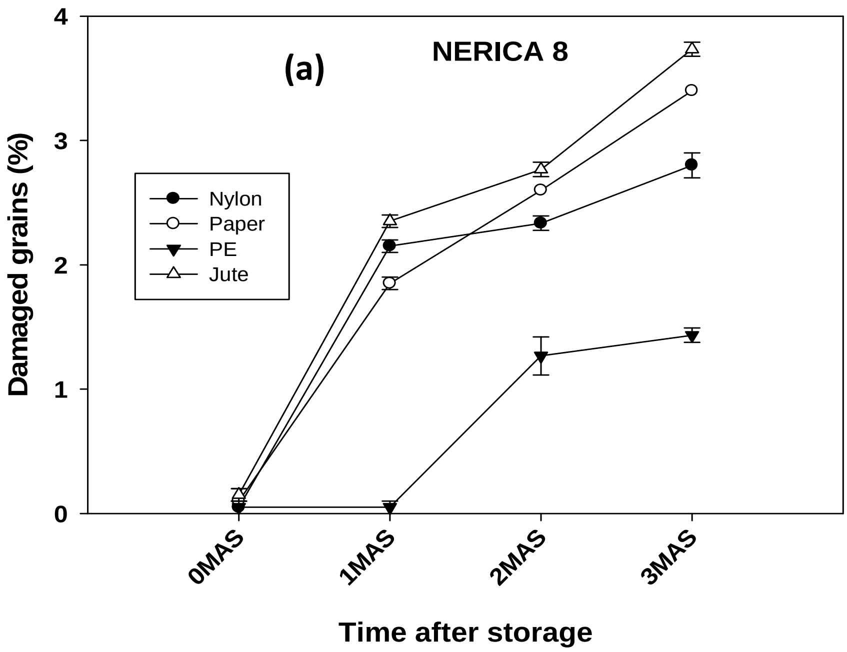


Figure 1: Germination rate pattern per bag type with storage duration for NERICAL8 (a) and NERICAL56 (b). PE=Polyethylene, MAS= months after storage.



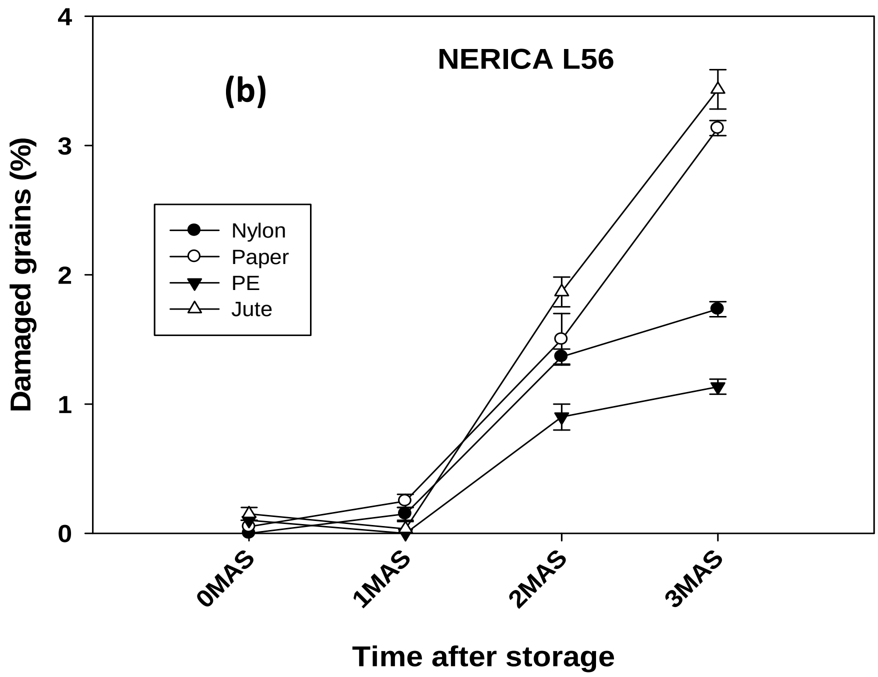


Figure 2: Patterns of insect damage grains per bag type with storage duration for NERICA8 (a) and NERICA L56 (b). PE= Polyethylene, MAS= Month(s) after storage.

Conclusion

In this study, the pattern of rice seed quality determinants was evaluated in order to determine the evolution of seed quality in different package types with time. Insect damage increased continuously, accompanied by a decrease in germination rate for all the package types and varieties. Moisture content fluctuations were not important even though slight increases in the number of colored grains (mold infested grains) were observed in the nylon and polyethylene bags. High insect infestation and highest germination rates were observed in the jute and paper bags. With these results, it appears that rice seed quality deteriorates more in the polythene and nylon bags.

Therefore, we recommend jute and/or paper bags accompanied by treatment with insecticides to limit insect infestation while improving germination rate. Quality determinants such as presence of weed seeds, impurities and immature grains are generally linked to farmer practices. To keep rice seed clean, weeding and harvesting should be done at the right time, threshing done on clean surfaces and winnowing properly done to eliminate immature grains and inert matter. Thus, in addition to storage practices and conditions, farmer agricultural practices also affect rice seed quality. If these agricultural practices are done hygienically and properly, their contribution in boosting the rice sector in the country will be felt.

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Table 1: physical quality determinants of seeds at the start of the study.

Bag type	Moisture content (%)	Grain weight (Kg)	1000-Grain Weight(g)	Weed seeds (%)	Inert matter (%)	Colored grains (%)	Immature grains (g/200g)	Insect Damage Grains (g)	Germination Rate (%)
NERICA8 (Rainfed Upland Variety)									
Paper	14.75	5.0	29.05b	0.10a	1.03b	0.05	0.35	0.10	80.0
PE	14.80	5.0	29.20ab	0.00b	0.95b	0.10	0.80	0.05	81.0
Nylon	14.85	5.0	29.25a	0.00b	1.40a	0.15	0.45	0.05	80.5
Jute	14.85	5.0	29.20ab	0.05ab	0.65c	0.10	0.60	0.15	79.5
NERICAL56 (Rainfed Lowland Variety)									
Paper	14.75	5.0	27.05b	0.10a	1.03b	0.05	0.35	0.10	93.0
PE	14.80	5.0	27.20ab	0.00b	0.95b	0.10	0.80	0.05	94.0
Nylon	14.85	5.0	27.25a	0.00b	1.40a	0.15	0.45	0.05	91.5
Jute	14.85	5.0	27.20ab	0.05ab	0.65c	0.10	0.60	0.15	92.5

Mean with the same letter indicates no significant difference (Turk test at 5% level of significance) (values are expressed as Means ± SD) PE=Polyethylene

Table 2: Physical quality determinants of seeds at one month of storage.

Bag type	Moisture content (%)	Grain weight (Kg)	1000- Grain weight (g)	Weed seeds (%)	Inert matter (%)	Color grains (%)	Immature grains (g/200g)	Insect Damage grains (g)	Germination rate (%)
Nerica 8 (Rainfed Upland Variety)									
Paper	14.85b	4.90b	29.53ab	0.05	0.55b	0.65c	1.50a	1.85c	83.5b
PE	15.10a	5.20a	28.15b	0.00	1.45a	1.05a	0.70b	0.05d	77.0c
Nylon	14.95ab	5.00b	29.25ab	0.05	1.85a	0.25d	0.80b	2.15b	81.0b
Jute	14.90b	4.93b	30.60a	0.05	1.93a	0.85b	1.60a	2.35a	86.5a
NERICA L56 (Rainfed Lowland Variety)									
Paper	15.00b	4.91b	27.70a	0.05	1.15a	1.70b	2.05a	0.25a	94.5a
PE	15.13b	5.10a	27.73a	0.05	0.45b	2.15a	1.20b	0.00c	81.0b
Nylon	15.35a	5.00b	27.50b	0.05	0.15c	2.15a	1.90a	0.15ab	94.5a
Jute	15.00b	4.92b	27.50b	0.15	0.20c	0.96c	1.30b	0.03bc	95.6a

Mean with the same letter indicates no significant difference (Turk test at 5% level of significance) (value are expressed as Means ± SD) PE=Polyethylene.

Table 3: Physical quality determinants of seeds at two months of storage.

Bag type	Moisture content (%)	Grain weight (Kg)	1000-Grain weight (g)	Weed seeds (%)	Inert matter (%)	Color grains (%)	Immature grains (g/200g)	Insect Damage grains (g)	Germination rate (%)
NERICA 8 (Rainfed Upland Variety)									
Paper	14.63b	4.76c	29.10ab	0.03	0.20	0.73b	1.50a	2.60a	79.00ab
PE	15.03a	5.00a	28.96b	0.06	0.53	1.40a	0.85b	1.26c	73.66c
Nylon	14.8b	4.83bc	29.70a	0.00	0.80	0.73b	0.93b	2.33b	78.00b
Jute	14.73b	4.90ab	29.00b	0.03	0.90	1.23a	1.40a	2.76a	80.00a
NERICA L56 (Rainfed Lowland Variety)									
Paper	14.83b	4.73b	27.20b	0.1	0.53a	3.90b	2.86a	1.50b	88.33b
PE	15.10a	5.00a	27.40a	0.2	0.35ab	4.70a	1.35c	0.90c	79.66c
Nylon	15.03a	4.80b	27.40a	0.1	0.16b	4.63a	2.43b	1.36b	90.33a
Jute	14.73b	4.83bc	27.23b	0.15	0.36ab	1.20c	2.70b	1.86a	90.33a

Mean with the same letter indicates no significant difference (Turk test at 5% level of significance) (value are expressed as Means ± SD) PE=Polyethylene.

Table 4: Physical quality determinants of seeds at three months of storage.

Bag type	Moisture content (%)	Grain weight (Kg)	1000-Grain weight (g)	Weed seeds (%)	Inert matter (%)	Color grains (%)	Immature grains (g/200g)	Insect Damage grains (g)	Germination rate (%)
NERICA 8 (Rainfed Upland Variety)									
Paper	13.93c	4.76b	29.1ab	0.03	0.33	2.20b	2.06c	3.40b	72.66a
PE	15.13a	5.00a	28.96b	0.06	0.26	3.00a	1.73d	1.43d	55.00c
Nylon	14.16b	4.80b	29.70a	0.00	0.40	1.36c	2.20b	2.80c	60.00bc
Jute	14.00bc	4.76b	29.00b	0.03	0.50	2.16b	2.36a	3.73a	67.00ab
NERICA L56 (Rainfed Lowland Variety)									
Paper	14.23bc	4.70b	27.00b	0.03	0.50	2.23b	2.30a	3.13b	66.00b
PE	15.10a	4.96a	27.30a	0.03	0.63	3.00a	1.93b	1.13d	53.33c
Nylon	14.70ab	4.80b	27.43d	0.03	0.50	1.40c	1.93b	1.73c	63.00b
Jute	13.83c	4.73b	27.13c	0.10	0.60	2.20b	2.40a	3.43a	82.30a

Mean with the same letter indicates no significant difference (Turk test at 5% level of significance) (value are expressed as Means ± SD) PE=Polyethylene

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