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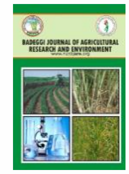

Research Article

Pre-Harvest Yield Loss and its Effect on Profitability of Upland Rice Production in Nigeria

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Abstract
Pre-harvest yield losses have been identified as major challenge to sustainable rice production. The objective of this study was to determine the effect of yield loss resulting from pests' damage on profitability of upland rice production. The study was based on the data collected on a naturally pest infested upland rice field in Southern Guinea Savannah zone of Nigeria. Descriptive statistics and partial budgeting techniques were used to analyse the data collected. Results indicated that physical yield loss was 17.9%. This loss reduced the gross margin per hectare by 9%. It was recommended that rice field should be monitored regularly and preventive measures taken as from milking stage to maturity stage. Improved pests control technologies should be disseminated to rice farmers for adoption. Farm survey should be carried out to ascertain severity of damage by pest' infestation on rice farms in the study area.

Keywords: Rice, Pre-harvest,Yield loss, Pests, Profitability

Introduction

Rice has become a staple food consumed on daily basis by a large proportion of Nigerian population. The crop is widely cultivated by farmers in various production systems including: rain-fed lowland, rain-fed upland and irrigated land, but the supply of rice produced within the country has not fully satisfied the demand of consumers resulting in huge import bill. The realization of the need to minimize rice importation makes self-sufficiency in rice production a prominent food policy of Nigeria government. Various measures have been taken in order to increase rice production to sufficiency level by various governments in the last three decades. Consequently, trend of rice production has increased over the years (FAO, 2013), but the average national yield of rice has been fluctuating around a mean of 2 tons/ha. This implies an urgent need for improvement of average yield of rice obtained on farmers' fields. In response to this need, promotion of yield enhancing technologies especially improved seed varieties was included in the rice transformation agenda of Nigeria government (ATA, 2011). Among improved seed varieties introduced to Nigeria farmers include: NERICA (New Rice for Africa), which has been found promising in upland ecologies in terms yield and resistance to stress.

As an attempt to investigate performance of the NERICA varieties under farmers' condition, a two hectare rice field was cultivated in 2017 and 2018 cropping seasons at the Research Out-Station of National Cereals Research Institute located at Mokwa, in the Southern Guinea Savanna zone of Nigeria. Various production constraints were

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identified on the rice field. One of such is the pests' damage which was observed in 2018 cropping season during panicle development stage of production. This paper presents the report of the crop losses caused by the birds and insect pests' damage as observed on the field. The specific objective was to determine the physical yield loss due to pests' damage and its effect on profitability of rice farming.

A lot of studies on crop yield losses have been carried out worldwide (Oerke, 2006, Basavaraja *et al*, 2007, Bright et al, 2007, IRRI *et al*., 2010, Dhaliwal *et al*., 2010, De Mey, *et al*. 2012, Savary and Willocquet, 2014, Kanan *et a*l., 2015, Nath *et al*, 2016, Cerda, 2017). Their findings indicated that biotic pests including birds and insects accounts for 15 to 37% of pre-harvest losses in rice production. Most of the past studies on pre-harvest losses focused on physical yield losses. According to Chambers *et al*., 2010, 'the estimates of physical losses, underestimate true economic losses as they do not account for costs entailed by the supply response adjustments that farmers make when faced with pests'. This observation is taken into account in this study by focusing on estimation of profit loss in addition to physical yield loss.

In estimating crop losses, most of the past studies have adopted experimental treatment approach (with or without pest attack through artificial infestation) or fields with natural infestation wherein half of the field is protected against the pest while the other half is not. The critics of these methods pointed out that the estimated crop losses under these conditions may not represent the actual field conditions of farmers (Groote, 2002). It was suggested that loss estimates should be collected directly from the farmers through sample survey for a reliable extrapolation in similar geographical settings (Kannan, 2014). According to Kannan, (2014), farmers' estimate are likely to be subjective and need to be validated with expert estimates of the agricultural research stations. At present, studies on the subject of crop loss validation by research experts under farmers' condition are very much limited. The current study is an attempt to fill the knowledge gap by estimating crop losses on a naturally pest infested research field under farmers' production practices. The study will guide researchers' decisions in designing appropriate programme aim at reducing the yield losses and will also provide policy makers with information on the best way to tackle the policy of self-sufficiency in rice.

Methodology

The site used for the study was the crop researchfield of the National Cereals Research Institute; Mokwa Station situated at elevation of 88 meters above sea level on geographical coordinates 9° 17' 0'' North, 5° 3' 0'' East. The Mokwa rice research station was established to conduct ecological specific research peculiar to Southern Guinea Savanna zone of the country. Rice production during 2017 and 2018 cropping seasons served as major source of data for this study. Primary data were collected through direct field observation and farm record. Yield loss data was estimated through direct field sampling procedure (Bright *et al*., 2007). The procedure for sampling involved random selection of representative samples of rice panicles. Four assessors were selected to perform the sampling procedure. The two-hectare farm was divided into two equal half. Two assessors each were assigned to one hectare of rice field. They were instructed to move through the two diagonals of one-hectare rice field on a straight path. At every five steps from beginning to the end of diagonals the whole rice plants per stand were uprooted. At the end, total of 110 samples of crop stands consisting of 1670 panicles were collected from the two hectares rice field. In each sample of crop stands, panicles were examined to assess presence of biotic pest damage. Each inspected panicles were cut and put in the appropriate bag marked damaged or undamaged. The two bags containing panicles were weighed separately. The weight of the empty bag was subtracted and the actual weight of panicles recorded. The panicles were separated out and the exact number in each bag counted. Percent pest damage losses (% DL) were calculated using equation (1) as adopted by Bright *et al*, 2007.

$$\%\ DL = \frac{\text{Mean wt. of damaged panicles}}{\text{Mean wt. of undamaged panicles}} \times \frac{\text{Number of damaged panicles}}{\text{Total number of panicles}} \times 100 \quad (1)$$

Profitability of rice production was determined using budgeting techniques to estimate gross margin as follow:

Gross margin (GM) = TR –TVC ------------- (2)

Where;

TR is the value of the rice output in Naira;
TVC is total costs of variable inputs used in rice production in Naira.
Percentage profit loss was estimated as:
$100(GM_1 – GM_2) / GM_2$ ----------------- (3)
Where:
GM_1 is the estimated gross margin using actual yield.
GM_2 is the estimated gross margin using attainable yield.
Actual yield is the yield obtained from the rice field used for the study. Attainable yield is the adjusted site-specific yield achieved under the environmental conditions of the site and with the best available production techniques required if biotic stress caused by pests is to be avoided (Nutter *et al*., 1993; Oerke *et al*., 1994).
Farmers' production practices adopted in this study include: cultivation of 2ha rice field (mean national rice farm size), wide and irregular plant spacing (ranging from 30 to 70cm as practiced by local farmers), manual hoe weeding (usually twice) and some widely adopted improved cropping practices in the area, such as: land preparation using tractor, seeds dressing with Apron plus before planting, use of improved seed varieties (NERICA 8) and inorganic fertilization of rice field at a rate adopted by rice farmers in Mokwa area.

Results and Discussion

Incidence of pests' damages

Infestation of pests including birds and insects was observed during panicle development stage of production. Insect pests observed were stem borers, panicle sucking bugs *(Mirperus spp.*) and grain sucking beetles (*Nemogratha nemorensis*). A few birds' were also seen attacking the rice panicles on the rice field. Infestation of pests was traced to presence of weeds especially wild grasses (*Digitaria spp*) which served as alternative food especially for *Nemogratha nemorensis,* even after rice was harvested. Presence of pests was traced to weedy condition of the field during panicle development stage. Based on farmers' practices, two weeding was carried out 35 days and 70 days after planting. The third supplementary weeding which is usually carried out under researcher managed rice field was not carried out.
Distribution of sampled rice stands according to number of panicles is presented in Table 1. Nearly half of (42%) of the panicles was attacked by pests indicating high incidence of pest attack. The pests attacked an average of six panicles out of fifteen panicles per stand. The high density of tillers per stand may be a contributing factor to the pest infestation. This finding corroborates Oecke, 2006 who reported that plant congestion lead to building up of pests. Insects accounted for larger percentage (35%) damage to the panicles. Birds accounted for 7% of the attacked on panicles at an average of one per stand which can be considered minimal because rice planted early in June and harvested before October are not usually suffer major birds attack in the study area due to presence of other alternative food sources. This result corroborates with De Mey and Demont, 2013 who similarly observed that birds attack is minimal during rainy season because of abundance of seeds from wild grasses available as alternative food sources.

Estimation of Yield losses

In this study, the weight of the dried rice paddy obtained was 825kg per hectare. This yield was considered too low compared with potential yield (NCRI, 2009) but within the range of 800 to 2000kg/ha for upland rice production in Nigeria (Bakare, *et al*., 2014). The estimated yield loss due to pests' damage based on equation 1 was 17.9%. It should be noted that insect pest infestation was detected about ten days before harvest and insecticide was applied within three days after the infestation was detected. The rate of damage would have been higher if infestation occurred at the early stage of panicle development stage. In a country where production cannot satisfy consumers' demand due to low national average yield, a pre-harvest loss of 17.9% within three days of insect infestation can be considered a substantial waste and should be avoided by taking precautionary measure or direct pest control whenever the need arise.
The attainable yield if such measure were taken was estimated using actual yield of 825kg/ha and 17.9% yield loss, and the result was 1005kg/ha. This yield is lower than the potential of the variety (NERICA 8) planted, but within the range obtainable under most of the upland ecologies in Nigeria (Bakare, *et al*., 2014). According to Bakare, *et al*., 2014, the nutrient content of the

soil in the upland is mostly low and water retention is low as well which explain the reason for generally low yield in the upland ecology.

Estimation of Profitability

Partial budget of rice production in one hectare of land under actual and attainable yield is presented in Table 2. Total cost of production was higher under attainable yield because extra inputs are required including pesticides as well as additional labour for pest control. The actual gross margin was lower than attainable gross margin. This implies that pest damage reduces profitability. The profit reduction was N27, 100.00 per hectare which is 9% of the attainable profit. However, an additional cost of N26, 900.00 will be needed to avoid this loss in order obtain attainable profit. Which implies that 99.3kobo will be spent in order to generate additional attainable profit of N1.00 (i.e. 100kobo) under attainable yield of 1005kg/ha obtained in this study. This result confirms the rationality of the notion that ‘it is not economically justifiable to reduce loss rates at low crop productivity, as the absolute yield gain from pest control is low’ (Oerke, 2006). The idea behind this notion is that preventive measures should always be taken to avoid pre-harvest losses due to pests’ damage as the cost of pest control may not be justifiable because of low productivity. This would entail such measures as cultivation of pest resistance varieties. This finding poses a challenge of developing insect pests resistant varieties by rice breeders. Entomologists also have a role to play in generating appropriate cost effective technologies for insect pest control.

Conclusion

The study presented assessment report of pre-harvest yield losses due to natural pests infestation on a two hectare upland rice field located at Mokwa in the Southern Guinea Savanna zone of Nigeria. The actual and attainable yields were lower than potential yield of the variety planted. It was established that biotic pests such as insects and birds were among major causes of reduction in yield and profitability of upland rice in the study area.

Based on the findings, the following policy recommendations were made:

1. Farmers should monitor rice field regularly and take preventive measures early as from milking stage to maturity stage.
2. Improved biotic pests control technologies should be disseminated to farmers for adoption.
3. Adoption of improved agronomic practices should be encouraged in order to improve productivity of upland rice production.
4. Farm survey of insect pests should be carried out to diagnose problems among farmers around the study area with a view to ascertain incidence and severity of damage cause by insects’ infestation on rice farms.
5. Reliable estimates of crop losses should be compiled and published regularly for use by different stakeholders to make proper planning for monitoring and controlling of pests.

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Table 1. Distribution of sample rice stands according to number of panicles

Panicles	Frequency	Mean per stand	Percentage
All	1670	15.18	100
Undamaged	969	8.81	58.0
Damaged	701	6.37	41.9
Birds damage	119	1.08	7.1
Insect damage	582	5.29	34.8

Source: Field data, 2018

Table 2: Partial budget of rice production in one hectare of land under actual and attainable yield

Budget items	**Actual (N/ha)**	**Attainable (N/ha)**
Land preparation	11,000	11,000
Seeds (50kg)	15,000	15,000
Seed dresser	1,250	1 250
Sacks	1,500	1,800*
Fertilizer: NPK (200kg)	28,000	28,000
Urea (150kg)	24,000	24,000
Insecticide 2L	-	5,000*
Labour: Planting	12,500	12,500
Weeding (2x)	26,000	-
Weeding (3x)	-	39,000*
Fertilizer application (2x)	10,000	10,000
Pesticide application	-	2,000*
Rogueing	3,000	3,000
Harvesting	10,000	12,000*
Threshing&Winowing	24,000	28,600*
Total Variable Costs	166,250	193,150
Value of actual yield (825kg)	247,500	-
Value of attainable yield (1005kg)	-	301,500
Gross margin	81,250	108,350
Return on investment	0.49	0.56

*Additional cost of recommended practices included