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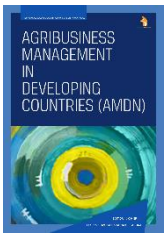

RESEARCH ARTICLE

MITIGATING RISKS IN SMALLHOLDER SORGHUM (*SORGHUM BICOLOR [L.] MOENCH*) PRODUCTION SYSTEMS

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ABSTRACT

Risks in agriculture include those related to the production, market, credit, technological, institutional, and human resource sectors; hence, low output in sorghum production is attributable to poor management practices among smallholders in Nigeria. Therefore, this study evaluated sorghum production risks and mitigation measures in small-scale farms in Toro, Bauchi State, Nigeria. Primary data collected via multi-stage sampling from 145 respondents was evaluated utilizing Descriptive Statistics and Adoption Index. The results showed the prevalent sorghum production risks include low farm output (80.7%), post-harvest losses and limited technology (69.7%), flood/drought (61.4%), damage by birds (57.2%) and commodity price volatility (53.8%). Most (98.2%) of the respondents adopted mixed cropping; this practice promotes agro-crop diversity in smallholder farming systems. Other critical mitigation measures include farm enterprise diversification (80.0%), improved technology adoption (72.4%), fertilizer application (67.6%); agrochemical application (55.9%) and improved agronomic practices (51.0%). Additionally, the adoption index of 64.8% of farmers is 0.33 or less; this index of adoption of measures of mitigating production risks was low and relatively inadequate. Furthermore, the major constraints of adoption of measures of mitigating production risks include inadequate capital (94.5%), poor access to agricultural technology and credit (73.1%), cost of adaptation strategy (69.7%) and poor input supply (51.7%). Improved access to agricultural credit and farm capital; adequate input supply and technology transfer, smallholder capacity building, improved extension and financial services; and effective policy modifications are strongly recommended.

KEYWORDS

Index of Adoption, Mitigation Measures, Production Risks, Sorghum, Smallholders.

1. INTRODUCTION

When compared to the other economic sectors, the agricultural sector has a higher level of risk exposure. Farming dangers incorporate production, market, credit, innovative, institutional and human asset risks. Furthermore, agricultural risks and the environment alter frequently and significantly (Almadani, 2014). These progressions can be partitioned into two fundamental groups; environmental change and market advancement. The environment in which farmers operate is becoming increasingly uncertain. Variable agricultural production outcomes and food insecurity directly result from climate change or natural disasters, particularly droughts. Liberalization of the agricultural market, which has an effect on the prices of inputs and outputs, makes natural disasters even worse. These elements undermine agrarian catchments. The recurrence and seriousness of agricultural risks, especially over the recent years has expanded by virtue of boundless environmental inconsistencies. Regional droughts have occurred in the past, according to FAO (2013), and the current droughts' spatial extent is broadly in line with anticipated changes in hydrologic cycles. Worldwide, droughts pose a threat to numerous regions (UNISDR, 2011). Sorghum (*Sorghum bicolor [L.] Moench*) is the fifth most significant grain crop after maize (*Zea mays L.*), wheat (*Triticum aestivum L.),* rice (*Oryza sativa L.*) and barley (*Hordeum vulgare L.*) (Shahbandeh, 2020; FAO, 2019). The United States of America produces the most sorghum worldwide, producing 8.7 million tons of grain annually from 2.0 million hectares; Nigeria produces 6.9 million tons annually from 5.4 million hectares; Ethiopia produces 5.3 million tons annually from 1.9 million hectares; and Sudan produces 3.7 million tons annually from 6.8 million hectares (FAO, 2019). Nigeria is the main sorghum producer, trailed by Ethiopia in Africa regarding gross production. Nigeria is the biggest producer of sorghum in West Africa representing around 71% of the gross regional sorghum yield. Sorghum production has declined over the course of the years because of the decrease in both cultivated areas and output (FAO, 2019). According to FAO (2019), the country's sorghum productivity is 1.23 t ha-1, which is relatively low in comparison to the world average of 2.45 t ha-1 and the United States' 4.58 t ha-1. Sorghum is moderately tolerant to drought, waterlogging and is widely adaptable to shifted soil conditions (Ajeigbe et al., 2018; Mrema et al., 2017). It is a coarse upstanding developing grass utilized as food, domesticated animals feeds and fencing houses (Gourichon, 2013). In many regions, sorghum has been utilized in different food items and products. This grain is used to make malted beverages, cakes, ethanol, bread, cookies, and breweries. Sorghum can be prepared in a variety of ways in traditional cooking. The entire grain might be crushed into a fine molecule item or flour, which is then, utilized in different traditional delicacies. Due to these characteristics, sorghum is the preferred staple crop in most African nations.

Sorghum is viewed as a customary food crop. Sorghum is consumed in a variety of ways in Northern Nigeria, such as in *Tuwo*, a thick porridge made from dry-milled, non-fermented grain flour that is eaten with soup; *Kunu* or *Ogi*, fermented pancakes, and roasted grain snacks (Ajeigbe et al., 2018). Sorghum grain is occasionally fermented and used to make products for

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local brewing. Sorghum is mostly used in industries to make beverages, breakfast cereals, and confections. A small amount of the grain is also used to feed animals. The stalks are utilized as raw materials for the biofuel industries, livestock feed, and to construct shelters or fences (GAIN, 2020). The yield's financial potential has not been completely acknowledged in Nigeria and sub-Saharan African (SSA) nations because of various production and efficiency requirements. The low sorghum production and product development can be attributed, among other things, to a lack of high-yielding varieties, declining soil fertility, drought stress, *Striga* infestation, restricted access to production inputs, agricultural credit and farm capital (Sani *et al*., 2013). According to Ajeigbe et al. (2018), Nigerian sorghum research programs were the first to develop and release varieties suited to specific agro-ecological zones for industrial use. Breeding drought-tolerant and environment versatile sorghum assortments can possibly counterbalance the yield deficits introduced by environmental change (Fedoroff et al., 2010). Ndjeunga et al. (2015) posited that just around 20% of gross sorghum production area is cultivated with developed cultivars in Nigeria. Mundia et al. (2019), posited a complex and highly variable set of factors, including the household's demographic characteristics, anticipated profitability, consumption preferences, availability, and cost of the improved variety's seed, influence farm-level decision to adopt a modern variety. Langyintuo et al. (2008) argued that farmers might not adopt the right technology because they might not have access to enough information. Smallholder's views of modern agricultural innovations are indispensable assuming it is to be embraced (Nto et al., 2013; Battisti and Naylor, 2009). Understanding smallholder impressions of the propriety of production innovation attributes can fortify the focal point of plant development and guides innovation advancement and uptake (Ajeigbe et al., 2018). However, there are a number of production constraints that contribute to the region's low sorghum productivity (≤1.0 t ha^{-1}) (Mrema et al., 2020). In Nigeria, the level of productivity is also influenced by socioeconomic factors like age, marital status, education, household size, farm size, and social participation, among other things. In Nigeria's sorghum-producing regions, a number of studies have evaluated farmer perceptions of modern technologies and production constraints (Ajeigbe et al., 2018; Sani et al., 2013; Baiyegunhi and Fraser, 2009). Nonetheless, not much accentuation is given to risk management practices by smallholders and strategy specialists in Nigeria (Okoro and Ujah, 2009). Nto et al. (2011) additionally revealed a re-occurrence of poor yield in crops like sorghum in Nigeria; taking into account the reliance of smallholders on climatic elements and conditions. Evaluation of risk mitigation measures in smallholder sorghum production systems is critical for rural development and helps policy makers to address appropriate methods compatible with the smallholders. In view of the background above, this study specifically identifies sources of sorghum production risks, measures of mitigating the production risks; evaluates the adoption index of mitigation measures and identifies the adoption constraints of risk mitigation measures

2. METHODOLOGY

2.1 Study Area

This study was conducted in Toro Local Government Area (LGA), Bauchi State, Nigeria. According to NBS (2019), the LGA has a population of 350,000 people and a land area of 6932 km^2 and is expected to grow by 3% annually to 499,586 people by 2020. Toro LGA is geologically uneven with height of 100m above ocean level. It is situated on longitude 9°N and 12°E and latitude 8°N and 11°E. It is in the Sudan Savannah zone of Nigeria with a typical precipitation going between 830mm to 1,100mm per annum beginning from April to October, with mean temperatures of 35°C and 31°C in lowland and highland areas, respectively (NBS, 2012).

2.2 Sampling Techniques

A multistage strategy was utilized to choose sorghum farmers in the area under study. At the initial stage, Toro LGA was chosen. The following stage included a purposive selection of three districts from the LGA (Toro, Lame and Jama'a). In the third stage, two villages from each district were selected at random. In the final stage, 145 respondents from the respective villages in the districts were chosen from a list of 2,965 sorghum farmers using a constant proportionality rate of 5% (0.05).

2.3 Method of Data Collection

Well-designed questionnaires were used to collect the primary data for this study.

2.4 Analytical Techniques

Collected data were examined utilizing descriptive statistics (frequency counts and percentages) and index of adoption.

2.5 Index of Adoption

The index of adoption of measures of mitigating production risks was estimated and presented in equation (1) as adapted from (Onuwa and Adedire, 2023):

$$Bi = \Sigma (R_i/R_T) \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

Bi = Index of adoption of mitigation measures by i^{th} smallholder; R_i = mitigation measures adopted by i^{th} smallholder; and R_T = mitigation measures available to i^{th} smallholders; and i = (1……..n).

Decision rule: ≤0.33 represents a low index of adoption, while ≥0.66 represents a high index of adoption. Some of the measures of mitigating sorghum production risks in the area under study include mixed cropping, farm enterprise diversification, improved technology adoption, fertilizer application, agrochemical application, improved agronomic practices, effective commodity pricing, irrigation farming and local guards.

3. RESULTS AND DISCUSSION

3.1 Sorghum Production Risks

Table 1 reveals the various risks associated with sorghum production in the area under study; these include low farm output (80.7%), attributable to poor adoption of improved production technologies. Post-harvest losses and limited technology (69.7%), attributable to poor harvesting techniques; processing and storage technology, and limited extension services for adequate technology transfer. Flood/drought (61.4%), due to erratic changes in climate and environmental factors. Damage by birds (57.2%), due to limited adaptation measures. Commodity price volatility (53.8%), attributable to several factors such as market forces (demand and supply), cost of agricultural production and availability of alternative products. Stem borer and *Striga* infestation (45.5%), attributable to poor farm management practices and application of agrochemicals. Fragmented lands (37.2%), attributable to the prevalent tenure policies in the area; resulting to small farm holdings. Poor credit access (31%), attributable to limited access to financial services and institutions. Farm theft (20.7%), due to prevailing insecurity challenges and ineffective security structures.

Table 1: Distribution according to Sorghum Production Risks

Production Risks	Frequency*	%
Low farm output	117	80.7
Post-harvest losses & limited technology	101	69.7
Flood/Drought	89	61.4
Damage by birds	83	57.2
Commodity price volatility	78	53.8
Stem borer and *Striga* infestation	66	45.5
Fragmented lands	54	37.2
Poor credit access	45	31
Farm theft	30	20.7

Source: Field survey (2019); * = Multiple responses

3.2 Mitigation Measures Adopted

According to Table 2, the majority of respondents (98.2%) used mixed cropping. This measure of mitigating production risks was very prevalent among respondents. It also promotes agro-crop diversity in smallholder farming systems. Farm enterprise diversification (80.0%); to mitigate production losses and serves as a buffer for agricultural production activities. Improved technology adoption (72.4%); required to optimize farm productivity and output. Fertilizer application (67.6%); to improve soil fertility and hence the quantity and quality of yield. Agrochemical application (55.9%); for effective weed management, disease and pest control. Improved agronomic practices (51.0%); enhances farm efficiency. Effective commodity pricing (43.4%); facilitates effective commodity price control. Irrigation farming (36.6%); mitigates risks of drought and erratic rainfall. Local guards (22.8%); to checkmate farm theft. This finding conforms to who in their respective studies on agricultural production risks proposed related results (Akosua, 2015; Kwesi and Henry de-Graft, 2012)

Table 2: Distribution of Respondents based on Mitigation Measures Adopted

Strategies	Frequency*	%
Mixed cropping	138	98.2
Farm enterprise diversification	116	80.0
Improved technology adoption	105	72.4
Fertilization application	98	67.6
Agrochemical application Improved	81	55.9
agronomic practices	74	51.0
Effective commodity pricing	63	43.4
Irrigation farming	50	34.5
Local guards	33	22.8

Source: Field survey (2019); * = Multiple responses

3.3 Index of Adoption of Mitigation Measures

According to Table 3, 64.8 percent of farmers have a low adoption index of 0.33 or less; while, 35.2% have high index of adoption of ≥0.66. As a result, it is evident that the area 3nder study offers a number of mitigation options. However, the index of these strategies' adoption was insufficient. This pattern is also a factor influencing low farm productivity as observed in previous studies (Maiangwa, 2008). Therefore, identification of barriers to adoption of production risk mitigation measures in smallholder grain production systems has become very germane (Bawa and Ani, 2014).

Table 3: Distribution according to the Adoption Index of Mitigation Measures

Adoption index	Frequency	Percentage (%)
Low adoption index	94	64.8
High adoption index	51	35.2

Source: Field survey (2019)

3.4 Adoption Constraints

Table 4 revealed the constraints of adoption of mitigation measures among smallholder sorghum farmers in the area under study. The Respondents pointed out some limitations of adoption of mitigation measures among smallholder sorghum farmers include inadequate capital (94.5%), poor access to agricultural technology and credit (73.1%), cost of adaptation strategy (69.7%), poor input supply (51.7%); lack of technical expertise (40.7%), inadequate extension contact (31.0%) and ineffective agricultural policies (22.8%). These constraints affected the adoption of mitigation measures among smallholder sorghum farmers in the study area. Similarly, Ali-Oluwanda *et al*., (2010) and Komolafe *et al*. (2010) in their respective studies observed that agricultural production in Nigeria is characterized by low adoption of production technology and practices, poor input supply, extension services, expensive and complex technologies.

Table 4: Distribution According to the Limitations on the Use of Mitigation Measures

	Constraints	**Frequency***	**%**
1.	Inadequate capital	137	94.5
2.	Poor access to agricultural technology and credit	106	73.1
3.	Cost of adaptation strategy	101	69.7
4.	Poor input supply	75	51.7
5.	Lack of technical expertise	59	40.7
6.	Inadequate extension contact	45	31.0
7.	Ineffective agricultural policies	33	22.8

Source: Field survey (2019); *Multiple Responses

4. Conclusion and Recommendations

This study evaluated production risk mitigation measures in smallholder sorghum production systems in Toro, Bauchi State, Nigeria. This study identified various risks associated with sorghum production in the area. In addition, different risk mitigation measures were available in the study area. However, indicators of acceptance and uptake of these strategies among smallholder farmers have been low and unsatisfactory. Additionally, the respondents identified several constraints of adoption of risk mitigation measures on their farms. In view of the background above, the following recommendations are suggested:

I. Policy formulation that provides agricultural credit and improves access to farm capital.

II. Adequate input supply and improved technology transfer.

III. Improved capacity building for sorghum farmers on production risk mitigation measures.

IV. Improved access to extension and financial services for effective technology transfer and adoption, by smallholders in mitigating production risks.

V. Agricultural policy modifications and development that suits the agrarian communities.

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