Online ISSN : 2249-4626
Print ISSN : 0975-5896
DOI : 10.17406/GJSFR

Global Journal

of Science Frontier Research: D

Agriculture & Veterinary



Analysis of Risk Management

Integrated Nutrient Management

Highlights

Agronomic Parameters of Rice

Initial Growth of Sorghum Cultivars

Discovering Thoughts, Inventing Future

VOLUME 23 ISSUE 2 VERSION 1.0

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Volume 23 Issue 8 was originally issued as D2

Global Journal of Science Frontier Research: D
Agriculture & Veterinary

Volume 23 Issue 8
Originally issued as D2

Global Journal of Science Frontier Research: D
Agriculture & Veterinary

Volume 23 Issue 2 (Ver. 1.0)

Open Association of Research Society

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Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-587X

The Increase in Air Temperature and its Interference in the Emergence and Initial Growth of Sorghum Cultivars

By Glaucia Suêrda Gomes do Nascimento, Gilmara Moreira Oliveira, Elioenai Gomes Freire Silva, Juliane Rafaele Alves Barros, Miguel Julio Machado Guimarães, Anderson Ramos de Oliveira & Francislene Angelotti

Abstract- Plant establishment depends on the ability of seeds and seedlings to adapt to adverse environmental conditions. Thus, the objective of this study was to evaluate the influence of the increase in air temperature (with variations throughout the day) the emergence and initial growth of sorghum cultivars (Sorghum bicolor L. Moench). The experiment was conducted in growth chambers in a 7x3 factorial scheme with a completely randomized design using seven sorghum cultivars (AGRI 002E, BRS 506, BRS 716, SF15, IAC Santa Elisa, BRS Ponta Negra and, Volumax) and three temperatures: T1 (20.0-26.0-33.0°C); T2 (24.8-30.8-37.8°C); T3 (27.8-33.8-40.8°C), with four replications of ten seeds. The following aspects were evaluated: emergence percentage, emergence speed index, average emergence speed, average emergence time, length, and fresh and dry mass of seedlings.

Keywords: *seedlings; sorghum bicolor L. moench; heat stress.*

GJSFR-D Classification: *FOR Code: 070302*



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The Increase in Air Temperature and its Interference in the Emergence and Initial Growth of Sorghum Cultivars

Glaucia Suêrda Gomes do Nascimento [α], Gilmara Moreira Oliveira [σ], Elioenai Gomes Freire Silva [ρ], Juliane Rafaele Alves Barros [ω], Miguel Julio Machado Guimarães [¥], Anderson Ramos de Oliveira [§] & Francislene Angelotti [χ]

Abstract- Plant establishment depends on the ability of seeds and seedlings to adapt to adverse environmental conditions. Thus, the objective of this study was to evaluate the influence of the increase in air temperature (with variations throughout the day) the emergence and initial growth of sorghum cultivars (Sorghum bicolor L. Moench). The experiment was conducted in growth chambers in a 7x3 factorial scheme with a completely randomized design using seven sorghum cultivars (AGRI 002E, BRS 506, BRS 716, SF15, IAC Santa Elisa, BRS Ponta Negra and, Volumax) and three temperatures: T1 (20.0-26.0-33.0°C); T2 (24.8-30.8-37.8°C); T3 (27.8-33.8-40.8°C), with four replications of ten seeds. The following aspects were evaluated: emergence percentage, emergence speed index, average emergence speed, average emergence time, length, and fresh and dry mass of seedlings. The temperature x cultivar interaction was not significant for emergence, dry mass or length of sorghum seedlings. The speed index and the mean emergence velocity increased in the regime of 27.9-34.3-40.8°C, with means of 2.85 and 0.34 seeds days-1, respectively. The responses regarding the cultivars were different for the growth and emergence variables. The 24.8-30.8-37.8°C provided more significant seedling development with higher seedling length, and fresh and dry mass values. From the results, it appears that the increase of 4.8°C in air temperature favors the emergence and initial growth of sorghum seedlings.

Keywords: seedlings; sorghum bicolor L. moench; heat stress.

I. Introduction

Temperature is one of the climatic elements that most restrict agriculture (IPCC, 2018), and it can affect the emergence and initial growth of seedlings (Reis et al., 2017), thereby determining plant establishment in the field. According to climate projections by the Intergovernmental Panel on Climate Change (IPCC), an increase of up to 4.3°C in average air temperature could occur, with extreme weather events such as heat waves and prolonged droughts becoming frequent (IPCC, 2021). It is noteworthy that semi-arid regions are identified as being more vulnerable to changes in climate and extreme temperature events (Marengo et al., 2020). Thus, selecting plant specimens that present satisfactory performance in the initial development through vigorous seed germination and uniform establishment of seedlings can be considered a strategic step for maintaining agricultural production, especially in these regions (Parmoon et al., 2015; Barros et al., 2020).

Temperature directly interferes with seed germination, being able to hinder or boost the germination process (Barros et al., 2020). In addition, it affects the germination speed, which is an important parameter because the higher the seed germination speed, the faster the seedlings will grow, and the shorter the exposure time of the seeds to adverse environmental conditions, which can harm the germination process (Baskin e Baskin, 2014; Gazola et al., 2013).

Sorghum stands out among the most relevant crops in the Brazilian semi-arid region; which is grass used for multiple purposes, from fodder for animal feed to human consumption (Tabosa et al., 2020). It has recently become an alternative for generating energy by directly burning its biomass, in addition to being an alternative source in manufacturing second-generation ethanol (Pimentel et al., 2017; Silva et al., 2018). Sorghum shows better germination between 21 and 35°C (Peacock, 1982). Thus, it is of fundamental importance to evaluate how the increase in air temperature can influence seed germination and the growth of sorghum seedlings, since this step can significantly contribute to high crop yield in the field.

Thus, studies evaluating the initial development of sorghum under increased air temperature conditions are scarce in the literature. In addition, studies with sorghum evaluating this climatic element were carried out using only constant temperatures (Silva et al., 2016; Chopra et al., 2017; Chiluwal et al., 2018). Simulating temperature increases with variations throughout the

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day can represent a methodological advance in scientific research, allowing us to more accurately present results that represent environmental conditions (Barros et al., 2020; 2021). Thus, the objective of this study was to evaluate the influence of an increase in air temperature with variations throughout the day the emergence and initial growth of sorghum cultivars.

II. Material and Methods

The study was conducted at Embrapa Semi-arid located in the municipality of Petrolina, PE, Brazil. Fitotron growth chambers with temperature, humidity, and photoperiod control were used. The design was in a 7x3 factorial scheme (cultivars x temperature), with four replications. Seven sorghum cultivars were evaluated, of which five were of the dual purpose type (AGRI 002E, BRS 506, SF 15, BRS Ponta Negra, and Volumax) and two biomass sorghum cultivars (BRS 716 and IAC Santa Elisa) which were conserved in a cold chamber to reduce possible alterations in seed quality. The temperature regimes used were: 20.0-26.0-33.0°C; 24.8-30.8-37.8°C; 27.8-33.8-40.8°C (Table 1), simulating temperature variations throughout the day, with a photoperiod of 12 hours and relative humidity ranging from 50 to 70%.

Table 1: Temperature Regimes, with Minimum, Average, and Maximum Temperature Variation Throughout the Day

Temperature Regimes	Hour/Temperature (°C)			
	6h às 10h	10h às 15h	15h às 20h	20h às 6h
T1 (20,0 - 26,0 - 33,0°C)	26,0	33,0	26,0	20,0
T2 (24,8 - 30,8 - 37,8°C)	30,8	37,8	30,8	24,8
T3 (27,8 - 33,8 - 40,8°C)	33,8	40,8	33,8	27,8

The temperature regimes were determined from the average daily temperature of the Sub-medium region of the São Francisco Valley in the last 30 years, including the minimum, average, and maximum temperature of the day, ranging from 18-22, 25-27 and, 32-34°C, respectively. Temperature simulations increasing from the average temperature by 4.8°C and 7.8°C were performed.

First, ten seeds were sown in pots with a volumetric capacity of eight liters at a depth of two centimeters. The pots were filled with gravel at the base and completed the volume with Eutrophic Yellow Argisol. Seedling emergence was then evaluated daily for 12 days. The following parameters were assessed: emergence percentage (E%) (Brazil, 2009); mean emergence time (MET) and mean emergence speed (MES) (Labouriau, 1983); and emergence speed index (ESI) (Maguire, 1962).

The fresh and dry mass was evaluated 12 days after sowing, as well as the length of the seedlings. The seedling length was determined with a ruler, and then the weight of the fresh mass was obtained on an analytical scale (in grams). Then, the plant material was stored in paper bags in a forced air circulation oven at 65°C for drying. After reaching constant mass after ± 72 hours, the samples were weighed on an analytical scale to obtain the dry mass (expressed in grams).The obtained data were submitted to analysis of variance (ANOVA), and the means were compared using the Scott Knott test at 5% significance.

III. Results and Discussion

The temperature x cultivar interaction was insignificant for the emergence percentage, emergence speed index, mean emergence time or mean emergence speed (Table 2). However, the emergence percentage varied according to the sorghum cultivars (Tables 2 and 3). In addition, there was an isolated effect of temperature and cultivars on the emergence speed index (ESI), on the mean emergence time (MET), and the mean emergence speed (MES) of seeds (Tables 2 and 3).

Table 2: Summary of Analysis of Variance, by the Mean Square, of Seedling Emergence Parameters Evaluated in Different Sorghum Cultivars Submitted to Different Temperature Regimes

Source of Variation	Medium Square				
	GL	%E	ESI	MET	MES
Temperature (T)	2	122,619ns	4,499 **	9,183 **	0,056 **
cultivars(Ct)	6	1650,000 **	2,389 **	1,297 **	0,012 **
T x Ct	12	147,619ns	0,289ns	0,266ns	0,001ns
Residue	63	178,571	0,275	0,253	0,002
CV%		16,36	20,21	15,05	13,35

*DoF = degree of freedom; Emergence percentage (E%), emergence speed index (ESI), mean emergence time (MET), and mean emergence speed (MES); CV = coefficient of variation; ns = not significant, ** significant at the level of 1% probability by the F test*

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The emergence percentage of sorghum seedlings did not differ with increasing temperature, and only presented variation between cultivars. According to the Rules for Seed Analysis (RAS), the minimum commercial value established for seed germination is 80% (Brasil, 2009); thus, the AGRI 002E, BRS 506, and BRS Ponta Negra cultivars showed an emergence percentage below the minimum established value (Table 3). This result may be related to the physiological quality of the seeds, as according to Pádua et al. (2010), changes in physiological potential affect seed germination and vigor.

Genetic variability among cultivars can directly interfere with a seed's response to abiotic stresses (Maia et al., 2011). This was evidenced in this work, where the IAC Santa Elisa cultivar presented emergence percentage (E%) and emergence speed index (ESI) with values above 97% and 3.29, respectively (Table 3).

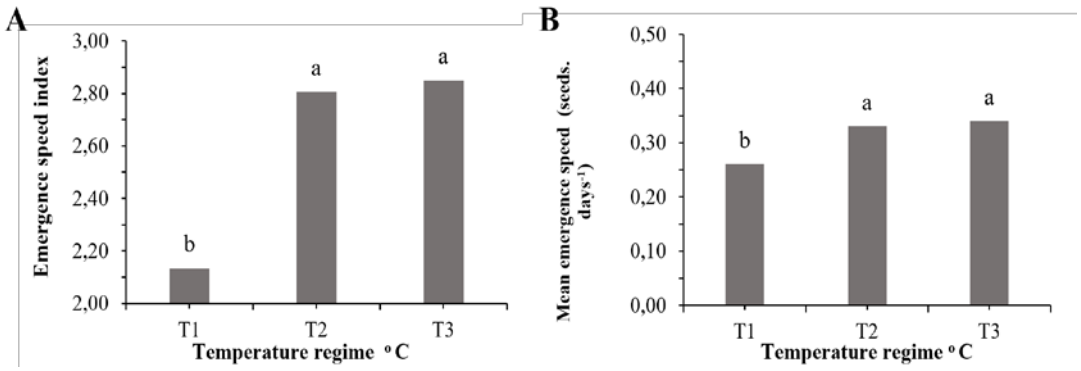
Table 3: The Emergence of Sorghum Cultivars

Cultivars	%E	ESI	MET	MES
AGRI 002E	75,83 c	2,46 c	3,27 b	0,31 b
BRS 506	70,00 c	2,11 d	3,63 a	0,29 c
BRS 716	84,17 b	2,94 b	2,83 b	0,37 a
SF 15	93,33 a	2,59 c	3,85 a	0,27 c
BRS Ponta Negra	65,83 c	2,04 d	3,42 a	0,30 c
IAC Santa Elisa	97,50 a	3,29 a	3,18 b	0,33 b
Volumax	85,00 b	2,75 b	3,23 b	0,32 b
CV%	16,36	20,21	15,05	13,35

Means followed by the same lowercase letter in the column do not differ from each other by the Scott Knott test at 5% probability. Emergence Percentage (E%), Emergence Speed Index (ESI), Mean Emergence Time (MET), and Mean Emergence Speed (MES).

High emergence percentage is an important parameter to be evaluated for the choice of a cultivar, as it favors its productivity by enabling fast fixation of the species in the environment, ensuring plant development even under adverse conditions (Melo et al., 2018). The highest emergence speed was observed in the BRS 716 cultivar seeds. As mentioned above, the germination speed is an important parameter in the choice of cultivar, since a delay in emergence can directly interfere with the uniformity of the final stand (Pádua et al., 2010).

The increase in temperature also accelerated the emergence speed index, with values ranging from 0.33 to 0.34 (Figures 1A and B). The lowest ESI values were observed in the temperature regime of 20.0-26.0-33.0°C, with an average of 0.26 (Figure 1A). The beginning of sorghum seedling emergence took two days in the temperature regimes of 24.8-30.8-37.8°C and 27.8-33.8-40.8°C, whileit was three days for the regime of 20.0-26.0-33.0°C (Figure 1C). It is observed that the increase in temperature promoted a reduction in the mean emergence time (Figure 1C) in 1 day.



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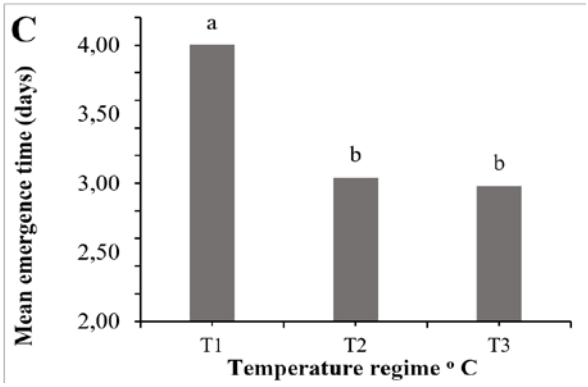


Figure 1: Emergence speed index (A), mean emergence speed (seeds. days^{-1}) (B), and Mean Emergence Time (Days) (C) of Sorghum Cultivars Sown in Three Temperature Regimes: T1: 20.0-26.0-33.0°C; T2: 24.8-30.8-37.8°C; T3: 27.8-33.8-40.8°C

The higher seed emergence speed in the regimes of 24.8-30.8-37.8°C and 27.8-33.8-40.8°C can be explained by the influence of the increase in temperature, since high temperatures favor an increase in the speed of water absorption and chemical reactions (Carvalho & Nakagawa, 2012). The germination process becomes more efficient in this scenario since the seeds that have a higher emergence speed will be more effective at initially establishing seedlings and therefore, capable of developing more vigorous plants and guaranteeing the harvest (NIMIR et al., 2015).

It was verified that the temperature of the installation affected the corn seed germination, presenting an increase in the germination percentage from 94.33% at (28-30 °C) to 98.33% at (31-33°C) (Wawo et al., 2020). However, temperatures above 35°C reduce in the germination percentage of six lots of corn seeds (Sbrussi e Zucarelli, 2015). It is worth noting that these studies were carried out using constant temperatures, while in natural conditions, there is variation in air temperature throughout the day. Thus, experiments using different temperature regimes can more accurately simulate temperature variations in the environment, allowing better evaluation of the interference of this element in the germination rate (Liu et al., 2013).

From the ESI, MES, and MET results for the temperature regimes of 24.8-30.8-37.8°C and 27.8-33.8-40.8°C, which represent an increase of 4.8 and 7.8°C in the average temperature of the semi-arid region, it was found that this increase did not negatively affect the seedling emergence process and may be related to the ecological adaptation of the species to air temperature fluctuations throughout the day.

The interaction between temperature and cultivar was significant for the fresh mass of sorghum seedlings. However, the isolated effect of temperature and cultivar was observed for dry mass and seedling length (Table4).

Table 4: Summary of Analysis of Variance by Mean Square to Evaluate Initial Growth in Different Sorghum Cultivars Submitted to Different Temperature Regimes

Source of Variation	Medium Square			
	GL	Freshmass(g)	Drymass(g)	Seedling length (cm)
Temperature (T)	2	0,2559 **	0,0021 **	260,6278 **
Cultivars (Ct)	6	0,1285 **	0,0032 **	124,5324 **
T x Ct	12	0,0145 **	0,0002^{ns}	17,0246^{ns}
Residue	63	0,0068	0,0001	23,0147
CV%		21,14	21,44	18,54

*DoF = degrees of freedom; CV = coefficient of variation; ns = not significant; ** significant at the 1% probability level by the F test*

The BRS 716 cultivar presented higher seedling fresh mass in the temperature regime of 20.0-26.0-33.0°C (Table 5). The AGRI 002E, BRS 716, and Volumax cultivars showed a higher fresh mass with an increase of 4.8°C in air temperature, corresponding to the regime of 24.8-30.8-37.8°C. The increase in the average air temperature above 4.8°C may reduce the fresh seedling mass of the BRS 716 cultivar (Table 5). Moreover, there was a reduction in the seedling fresh mass of the AGRI 002E, BRS Ponta Negra, IAC Santa Elisa and Volumax cultivars in the 27.8-33.8-40.8°C regime compared to the 24.8-30.8-37.8°C. However, compared to the 20.0-26.0-33.0°C regime, there was no significant difference in any of these cultivars, meaning that the fresh matter production was statistically similar

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in both the 20.0-26.0-33.0°C and 27.8-33.8-40.8°C regimes.

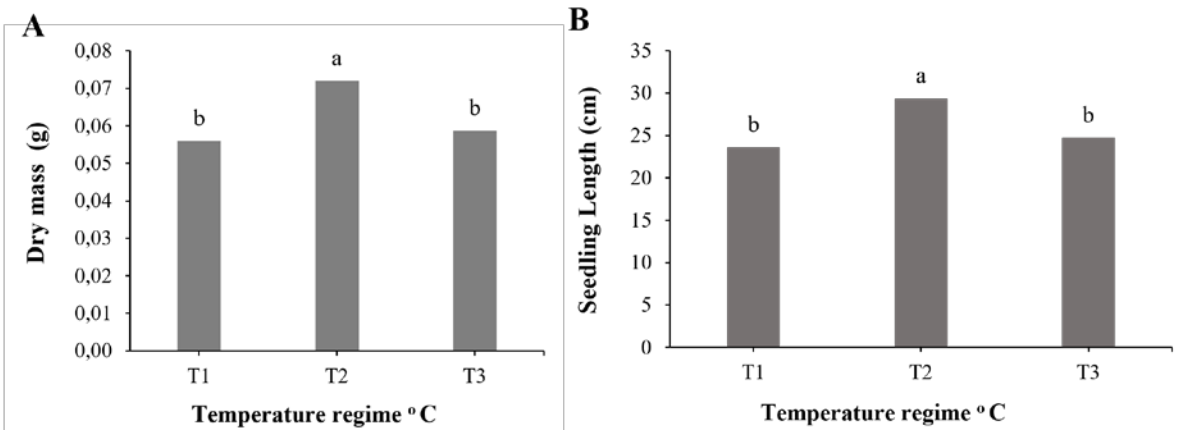
Table 5: Fresh Mass of Sorghum Cultivars Subjected to Different Temperature Regimes

Freshmass(g)							
Temperature regimes	AGRI 002E	BRS 506	BRS 716	SF 15	BRS Ponta Negra	IAC Santa Elisa	Volumax
20,0-26,0-33,0 °C	0,34 Cb	0,27 Ca	0,55 Aa	0,25 Ca	0,33 Cb	0,31 Cb	0,43 Bb
24,8-30,8-37,8 °C	0,59 Aa	0,33 Ca	0,67 Aa	0,29 Ca	0,51 Ba	0,41 Ca	0,65 Aa
27,8-33,8-40,8 °C	0,32 Ab	0,29 Aa	0,38 Ab	0,20 Ba	0,36 Ab	0,24 Bb	0,37 Ab
CV %	21,14						

Means followed by the same lowercase letter in the column and uppercase in the row do not differ from each other by the Scott-Knott test at 5% probability.

The fresh mass of BRS 506 and SF 15 cultivars did not show a statistical difference between the temperature regimes tested. This result may be related to the water adjustment of these cultivars to adapt to the conditions imposed by the thermal increase. According to Li et al. (2017), plants that present partial closure of the stomata have a greater ability to use water, and therefore have reduced water loss through transpiration. The transpiration through the stomata may play a crucial role in tolerance to warmer environments (Zhou et al., 2015; Feller, 2016).

The highest dry mass value found in the temperature regime of 24.8-30.8-37.8°C was 0.07 g (Figure 2A),with a 14% reduction in the dry mass of seedlings submitted to the regimes of 27.8-33.8-40.8°C and 20.0-26.0-33.0°C, with no statistical difference between them (Figure 2A). A similar result was observed for seedling length, with a reduction of 18% (Figure 2B).



**Equal Letters Do Not Differ by the Scott Knott Test at 5% Probability*

Figure 2: Dry Mass (A) and Seedling Length (B) of Sorghum Subjected to Different Temperature Regimes.

In evaluating the effect of air temperature on the initial phase of sugarcane growth, Guerra et al. (2014) observed that plants subjected to higher temperatures (33°C daytime and 27°C night) had the highest plant height compared to the treatment with a lower temperature regime (29°C during the day and 23°C at night). However, exposing seedlings to higher temperatures (30-40°C) can cause severe cell damage that limits the growth of sorghum seedlings (Yamasaki et al., 2002). The 20.0-26.0-33.0 and 27.8-33.8-40.8°C regimes provided a reduction in dry mass and seedling growth compared to the 24.8-30.8-37.8°C regime. Temperatures above the upper basal of the species in C4 plants cause a reduction in enzymatic activity and changes in the fluidity of thylakoid membranes (Bergamaschi e Bergonci, 2017). On the other hand, lower than optimal temperatures during planting can decrease the concentration of reserves and reduce the growth rate (Cruz et al., 2007). The nutrient reserves of seeds are stored in the cotyledons and the cell walls of the endosperm. After germination, these reserves are decomposed and carried to the growing seedling until it becomes autotrophic (Taiz et al., 2017).

It should be noted that the initial growth of sorghum varied with the cultivar analyzed (Table 6). The BRS 716 cultivar presented higher dry mass, while the lowest performance for seedling length occurred for the BRS 506 and SF 15 cultivars (Table 6).

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Table 6: Initial Growth Parameters of Sorghum Cultivars Subjected to Different Temperature Regimes

Cultivars	Drymass(g)	Seedling length(cm)
AGRI 002E	0,064 c	25,817 a
BRS 506	0,053 c	21,293 b
BRS 716	0,089 a	28,945 a
SF 15	0,040 d	21,908 b
BRS Ponta Negra	0,057 c	25,845 a
IAC Santa Elisa	0,053 c	29,130 a
Volumax	0,077 b	28,222 a
CV (%)	21,44	18,54

*CV = coefficient of variation; *means followed by the same lowercase letter in the column do not differ from each other by the Scott Knott test at 5% probability*

The emergence of seeds and the initial growth of seedlings are essential stages for the establishment of plants in the field, as they are periods dependent on environmental conditions, such as high temperatures. The 4.8°C increase in air temperature had a positive response in the emergence and initial growth of sorghum seedlings, while the 7.8°C increase in air temperature did not affect these parameters. Therefore, studies on the impacts of increased air temperature on the initial development of sorghum plants are essential.

IV. Conclusions

Temperature can interfere with the emergence and initial development of sorghum seedlings, with different responses among cultivars. The 4.8°C increase in air temperature results in a higher emergence speed index and mean emergence speed, favoring the dry mass and the length of the seedlings. The rise in air temperature by 7.8°C did not affect the dry mass response and the size of sorghum seedlings.

Acknowledgements

To the Foundation for Support to Science and Technology of the State of Pernambuco (FACEPE), for promoting it (PBPG-0640-5.01/20), and for funding the postdoctoral fellowship (BFP-0113- 5.01/21). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

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Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-587X

Comparative Study on Organic Calcium Diffusion and Content in Apples and their Influence on "Anna" Apple Fruits Quality

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Abstract- This study was conducted during the two successive seasons 2021 and 2022 using "Anna" apples. The trees were sprayed by using some organic calcium solution to compare their efficacy on providing the skin and flesh tissues with calcium which reflects on the fruit quality. The trees were sprayed twice at the rapid elongation and maturity stages in both seasons treatments included tap water as the control, calcium lignosulfonate (at 0.2%) and (at 0.4%), calcium foliate (at 0.2%) and (at 0.4%), calcium acetate (at 1%), calcium acetate (at 1%) plus urea (at 1%) and calcium acetate (at 1%) plus ethanol (at 2%). The non-ionic surfactant top film at 0.05% (v/v) was added to all treatments to reduce the surface tension and to increase the contact angle. Treatments resulted in increasing calcium content in the skin and the flesh of "Anna" apples the highest magnitude of increase was obtained in the skins and flesh of calcium acetate treated fruits plus ethanol as well as in the flesh.

Keywords: organic calcium, calcium lignosulfonate, calcium acetate, calcium foliate, calcium content, apple quality.

GJSFR-D Classification: FOR code: 0706



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Karim. M. Farag [α] & Raed. S. Shehata [σ]

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Keywords: organic calcium, calcium lignosulfonate, calcium acetate, calcium foliate, calcium content, apple quality.

I. Introduction

Calcium is very important essential element for plants as well as for living been. Its sufficiency is very crucial for the integrity of cell membranes and for the cell wall which prolong the shelf life of fruits and preserve the firmness of the plant tissue. No wonder, the deficiency of calcium results in many physiological disorders such as bitter pit of apples, internal breakdown of tissues spotted of lenticels, water core of apple fruits and superficial scorch or scald. Moreover, calcium increases the tolerance to many abiotic stresses (McAinsh and Pittman, 2009; Dodd *et al.,* 2010; Sarwat *et al.,* 2013; Liu *et al.,* 2018). There are variations in the ability of calcium compounds to diffuse across the cuticles. It was found that Ca absorption in the form of nitrate or formate was more active than its application as chloride or acetate across citrus leave (Song *et al.,* 2006). The mobility of various calcium compounds in another critical factor since calcium ions are immobile. However, the application of the organic form of calcium such as acetate, citrate, formate or lignosulfonate increase calcium mobility within the plant and enhances its efficacy and even the speed of its action (Wojcik 2013). It was reported that calcium acetate speed of action is very high and even described as immediate as compared with other form such as chloride (Borchert 1986 and Treesubsuntorn and Thiravetyan 2019). Furthermore, Ca lignosulfonate was reported as a beneficial compound that is mobile, water soluble, increases chlorophyll and sugar content. It is a nutrient based on lignin which affect its rate of break-down, slowing down the rate of release and non-volatile. Thus, it is an important component in the manufacturing of many fertilizers and pesticides especially slow release fertilizers. Even in the case calcium formate it was reported that calcium forms a complex with formate and it is completely soluble in water. Moreover, it was mentioned that calcium formate can be easily assimilated by the roots and trans-located in an acropetal sense (Hanger,1979). Aforementioned, it was reported that applying pre-harvest foliar calcium spray has been a standard practice to control fruit Ca concentrations in certain deciduous fruit trees. Conversely, the effects of foliar Ca spray on the Ca concentration in fruit and the incidence of disorder were inconsistent. Foliar Ca sprays reduced bitter pit, enhanced fruit firmness and storage time, and sometimes reduced the incidence of brown rot during storage of apples, reduced internal browning during storage and the incidence brown rot in peaches (Yamane, 2014). Three possible reasons were reported to explain the reasons for inconsistencies of foliar Ca replication. First, was the environmental conditions particularly air humidity in areas of high temperature and low relative air humidity. Second, the uneven distribution of Ca in fruit within the canopy especially fruit at the top. Third, the condition and management of a tree fruit Ca concentration is affected by fruit size. Thus, the objectives of this study were to provide some

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information about effect of spraying some organic calcium ability to diffuse and change internal Ca concentration in "Ann" apple fruit whether applied individually or along with ethanol or small concentration of urea as adjuvants and the accompanied change in main quality parameters at harvest.

II. Materials and Methods

The present study was conducted during the two successive seasons 2021 and 2022 on Anna apple cultivar (*Malus domestica*). The trees were 4-years-old spaced at 4×5 m and grown under drip irrigation system in a private orchard at Nubaria region, Beheira Governorate, Egypt. Trees had been under the standard agricultural practices throughout the season. Soil texture was sandy and drip irrigation system was adopted. Treatments were arranged in a completely randomized block design. Three replications were used for each treatment and one apple tree represented one replication, thus twenty four trees were employed to this study in each season. Twenty four standard "Anna" apple trees were randomly assigned to receive one of eight treatments and applied as spraying two times at rapid elongation and at maturity. The treatments included; tap water spray (as the control), Ca lignosulfonate at (0.2%), Ca Lignosulfonate at (0.4%) + Ca foliate at (0.2%), Ca foliate at (0.4 %) + Ca acetate at (1%), Ca acetate at (1%) + urea at (1%) and Ca acetate 1% + ethanol 2%. The non-ionic surfactant Top film at 0.05% (*V/V*) was added to all treatments to reduce the surface tension and to increase the contact angle of sprayed droplets. These treatments were arranged in Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD).

a) Physical Characteristics

Samples of five fruits per tree were collected randomly and the fruit weight was measured using an electronic balance and fruits diameters. Fruits diameter were measured by vernier caliper.

b) Chemical Characteristics

Acidity in the fruits juice was assayed as citric acid by titration with 0-1 N sodium hydroxide after adding a few drops of phenolphthalein as an indicator according to (A.O.A.C.; 1975).

Total soluble solids (TSS %) was estimated using Galli 110 Refractometer according to *(A. O. A. C.; 1975).*

Determination of Anthocyanins:

Extracts were prepared by the method described by (Onayemi *et al.* 2006). 1g fruit skin samples were pulverized with 20 ml of 85 Ethanol and 1.5 M HCL (by volume) solution. The samples were covered and kept overnight in the deep freeze. The extracts were completed to 50 ml of the solvent and then absorbance of the solution was measured at a wave length of 530 nm, using spectrophotometer (Unico 1200-USA). Result is expressed as mg/100 g of fresh fruit.

Total anthocyanin was calculated using the succeeding equation developed by (Lees and Franci 1971).

$$\text{Total anthocyanins (mg/100g)} = A_{530} \times V / 98.2 \times W$$

Where: A530 is the rate of absorption of the sample at the wavelength of the subtitle A. for example, A530 is the absorption at a wavelength of 530 nm, V= total volume of extract (ml), W= weight of fresh sample (g).

Ca content (skin) and (flesh) was determined photometrically using flame photometer as described by (peterburgski 1968).

Determination of vitamin C content is determined using UV spectroscopy. In this method according to (Desai and Desai, 2019). Bromine water is added which oxidizes the ascorbic acid into dehydroascorbic acid. 2, 4 dinitrophenyl hydrazine gives coupling reaction at 37°C temperature for 3 hours. After 3 hours solution is treated with 85% H2SO4 which gives coloured complex and the absorbance was measured at 491nm.

c) Statistical Analysis

Data of the first experiment was analyzed as a Randomized Complete Block Design (RCBD) with three replications. Comparisons among means were made *via* the least significant difference (LSD) at 0.05 level according to Snedecor and Cochran (1980). The data was analyzed using SAS (2009).

III. Results

a) Calcium Content in the Apple Skins

The influence of various calcium compounds on the skin and flesh contents of apples cv "Anna" at harvest was shown in table 1. The data indicated that the highest calcium content in the skin was found with the treatment of Ca Acetate at (1%) plus ethanol at 2% (v/v) as compared with the control and all other treatments. Meanwhile, the application of Ca Acetate (at 1%) alone resulted in lower calcium content than Ca Acetate plus urea (at 1%) which in turn gave less calcium in the apple skin when compared with Ca Acetate in the presence of ethanol (at 2%). These trends were consistent for both seasons. Moreover, Ca foliate at 0.2% or at 0.4% applications resulted in greater calcium content in apple skins than that obtained in the control in both seasons. In addition, calcium lignosulfonate resulted in greater calcium content than that found in the comparable concentration of Ca foliate in both seasons.

b) Calcium Content in the Apple Flesh

Changes in calcium content in the flesh of "Anna" apple inresponse to various used treatments were reported in table 1. The data indicated that using

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the same compound, namely Ca Acetate at the same concentration but with different enhancers of diffusion across the fruit cuticle showed that ethanol at 2 % (v/v) was more effective than urea at 1% on enhancing the diffusion of calcium, while both compound had greater Ca acetate diffusion than the individual use of Ca acetate in the absence of any included enhancers. Moreover, Ca foliate at 0.4 % had higher Ca diffusion in the flesh as compared with Ca foliate at 0.2%. Meanwhile, both compound concentrations (0.4 or 0.2 %) resulted in higher calcium content in the flesh as compared with the control. Moreover, that was the data trend when we compare calcium content in the apple flesh caused by Ca lignosulfate at 0.4 or at 0.2% compared with the control. Higher the calcium compound concentration, high the diffused amount of calcium in both seasons.

c) Fruit Weight and Diameter

With regard to the changes in some physical characteristics in response to various applications in both seasons. The data in table 2 showed that fruit weight at harvest showed similar trends to that obtained with calcium since the greatest fruit weight was found with calcium acetate treatment plus ethanol follow by Ca acetate treatment in the presence of urea. The same concentration of calcium acetate. However, when used alone without the incorporation of any enhancer resulted in lower fruitweight than that in the presence of ethanol or urea. In a similar manner ca foliate at 0.4% resulted in greater fruit weight as compared with Ca foliate treatment at 0.2% that was also the case with Ca lignosulfonate at 0.4% and 0.2% when their influence on fruit weight was compared with each other and with the control. However, each of the lignosulfonate compound was able to cause a greater fruit weight than that found was calcium foliate concentration at 0.2 % in a consistent manner in both seasons. Regarding the changes in fruit diameter at harvest in response to various applications. The data in table 2 showed that both Ca acetate treatments alone with ethanol or urea were equally effective on increasing fruit diameter in both seasons. However, the sole application of calcium acetate caused a significant increase in such diameter only in the first season only when compared with the control. On the other hand, calcium lignosulfonate at 0.2 and 0.4 and calcium foliate at 0.2 and at 0.4, all had similar influence on fruit diameter at harvest. Meanwhile, the diameter of the control fruit did not significantly vary from that of some treatments such as Ca foliate (0.2%), Caacetate (1%).

d) Chemical Characteristics

i. *Total Soluble Solids (TSS)*

The response of total soluble solids to various pre-harvest treatments was reported in table 3. The data revealed that Ca acetate either plus ethanol at (2%, v/v) or plus urea at (1% w/v) resulted in the highest TSS when compared with the control or with the rest of the treatments. Meanwhile, the control fruits had the lowest TSS as compared with all other treatments in both seasons. Moreover, calcium acetate at the same concentration but used alone resulted in significant change in TSS when compared with the control in both seasons. Meanwhile, Ca foliate at both applied concentrations resulted in a significant increase in the TSS as compared with the control. Furthermore, Ca lignisulfonate at 0.4% resulted in greater TSS than that obtained with Ca lignosulfonate at 0.2% in the two seasons.

ii. *Juice acidity*

The effect of pre-harvest treatments of "Anna" apples with various calcium compounds on juice acidity was reported in table 3. The data indicated that the least acidity in both seasons was found with calcium acetate treatments whether along with ethanol at (2%) or plus urea at (1% w/v) as compared with the control or with all other treatments. Meanwhile, the two mentioned calcium acetate was used alone, juice acidity was significantly higher the combinations in both seasons. Calcium foliate, on the other hand, either at 0.4% or at 0.2% was able to cause a significant reduction in fruit acidity as compared with the control. Similar trend was obtained with calcium lignosulfonate at the two used concentrations at (0.4% and 0.2%) since they resulted in a significant reduction in juice acidity when compared with the control.

iii. *TSS/Acidity Ratio*

The response of the TSS to acidity ratio to various used applications before harvest was shown in table 3. The data revealed that many treatments were able to increase TSS/ Acidity of "anna" apples when compared with the control such as calcium lignosulfonate at both used concentrations at (0.2% and 0.4%). In fact, the highest ratio was obtained with Ca actate plus ethanol at 2%. In a similar manner, Ca acetate at (1%) plus urea at (1%) did not vary significantly from the above lignosulfonate at (0.4%).Even Ca foliate at (0.4%) was able to cause a significant increase in the TSS to acidity ratio as compared with the control in both seasons but not at 0.2%. On the other hands, Ca acetate plus urea resulted in a significant increase in TSS/Acidity ratio as compared with Ca acetate at (1%) alone. Such individual treatment of Ca acetate did not vary from the control. Thus, the increase in the applied concentration resulted in a significant change in the TSS to acidity ratio especially with the treatment of lignosulfonate while with Ca acetate, the addition of the effectiveness of applied Ca acetate.

iv. *Vitamin C Content*

Changes in vitamin C content in "anna" apple fruits in response to various applications were shown in

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table3. The data revealed that Ca acetate at (1%) plus ethanol at (2%) resulted in the highest vitamin C content followed by Ca acetate at (1%) plus urea at (1%). In general, most treatments had higher vitamin C content when compared with the control except with Ca acetate at (1%) in the second season. The increase in lignosulfonate concentration from 0.2% to 0.4% resulted in a parallel increase in vitamin C content but this was not the case with Ca foliate since the magnitude of the increase was slight. It could be concluded that the ability to diffuse across the fruit cuticle was not the critical factor since lignosulfonate molecule has a much greater value as compared with Ca foliate.

v. *Anthocyanin Content In Fruit Skin*

The effect of pre-harvest applications of various calcium organic compounds on anthocyanin content in the skin of "Anna" apples was reported in table 3. The data indicated that some treatments were effective on increasing anthocyanin in apples skin such as lignosulfonate at (0.4%) in both seasons as compared with the control. In a similar manner, the application of Ca acetate at (1%) whether plus urea or ethanol at (2%) resulted in higher anthocyanin content than that obtained with the control in both season. The application of Ca foliate resulted in a non-significant increase in anthocyanin except with Ca foliate at (0.4%)in the second season. The individual application of Ca acetate at (1%) did not result in a significant change in anthocyanin as compared with the control in both seasons.

Average of initial value of Calcium before treatments was 12.23 mg/100g and 3.00 mg/100g for the skin and the flesh, respectively in 2021 season, while in the 2022 seasons, these value were 11.86 mg/100g, 3.13 mg/100g for the skin and the flesh, respectively.

Table 1: The Effect of Various Organic Calcium Solution on Calcium Content of the Skin and the Flesh of "Anna" Apples at Harvest During the Two Seasons 2021 and 2022

Treatments	Ca (skin) ($mg.100g^{-1}$)		Ca (flesh) ($mg.100g^{-1}$)	
	2021	2022	2021	2022
Control	16.47^{h}	14.82^{h}	3.15^{h}	2.80^{h}
Ca lignosulfonate 0.2%	20.24^{e}	18.86^{e}	4.90^{e}	4.26^{e}
CaLignosulfonate 0.4%	23.36^{c}	21.56^{c}	6.12^{c}	5.32^{c}
Ca foliate 0.2%	18.71^{f}	17.49^{f}	4.38^{f}	3.78^{f}
Ca foliate 0.4 %	21.71^{d}	20.17^{d}	5.51^{d}	4.79^{d}
Ca acetate 1%	17.15^{g}	16.10^{g}	3.73^{g}	3.24^{g}
Ca acetate 1% + urea 1%	24.75^{b}	22.80^{b}	6.65^{b}	5.81^{b}
Ca acetate 1% + ethanol 2%	26.30^{a}	24.15^{a}	7.22^{a}	6.36^{a}
$LSD_{at\ 0.05}$	0.51	0.64	0.24	0.30

Values in each column when accompanied with similar letters, were not significantly different by using the least Significant Difference at 0.05 for comparing the means

Table 2: The Effect of Various Organic Calcium Solution on Some Physical Characteristics of "Anna" Apples at Harvest During the Two Seasons 2021 and 2022

Treatments	Weight of Fruit (g)		Fruit Diameter (cm)	
	2021	2022	2021	2022
Control	119.74^{g}	105.21^{g}	5.67^{e}	5.23^{c}
Calignosulfonate 0.2%	139.09^{e}	123.52^{e}	6.47^{bcd}	5.73^{abc}
Ca Lignosulfonate 0.4%	152.98^{c}	137.22^{c}	6.83^{abc}	6.10^{ab}
Ca folic 0.2%	131.94^{f}	117.52^{f}	6.23^{cde}	5.60^{abc}
Ca folic 0.4 %	145.75^{d}	130.69^{d}	6.53^{ad}	5.93^{abc}
Ca acetate 1%	126.91^{f}	113.72^{f}	6.03^{de}	5.37^{bc}
Ca acetate 1% + urea 1%	159.11^{b}	143.59^{b}	7.03^{ab}	6.10^{ab}
Ca acetate 1% + ethanol 2%	166.21^{a}	151.27^{a}	7.17^{a}	6.33^{a}
$LSD_{at\ 0.05}$	5.35	4.90	0.68	0.77

Values in each column when accompanied with similar letters, were not significantly different by using the least Significant Difference at 0.05 for comparing the means

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Table 3: The Effect of Various Organic Calcium Solution on Some Chemical Characteristics of "Anna" Apples at Harvest During the Two Seasons 2021 and 2022

Treatments	TSS (%)		Acidity (%)		TSS/ Acidity (ratio)		Anthocyanin (mg.100g-1)		V.C (mg.100g-1)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
control	10.64^{g}	9.83^{e}	0.81^{a}	0.65^{a}	13.15^{f}	15.19^{e}	4.95^{c}	3.32^{e}	4.95^{f}	3.77^{g}
Ca lignosulfonate 0.2%	11.56^{e}	10.54^{c}	0.67^{bcd}	0.52^{bc}	17.38^{de}	20.35^{cde}	5.08^{abc}	3.53^{b-e}	5.57^{cd}	4.39^{de}
Ca Lignosulfonate	12.18^{c}	10.95^{b}	0.58^{de}	0.43^{de}	21.24^{bc}	25.55^{bc}	5.21^{ab}	3.67^{abc}	6.05^{b}	4.74^{bc}
Ca folic 0.2%	11.21^{f}	10.28^{d}	0.72^{abc}	0.57^{b}	15.70^{ef}	18.20^{de}	4.98^{bc}	3.46^{cde}	5.39^{de}	4.18^{ef}
Ca folic 0.4 %	11.84^{d}	10.73^{bc}	0.64^{cd}	0.48^{cd}	18.63^{cd}	22.45^{cd}	5.15^{abc}	3.63^{a-d}	5.80^{c}	4.54^{cd}
Ca acetate 1%	10.89^{g}	10.06^{de}	0.76^{ab}	0.60^{ab}	14.31^{f}	16.96^{e}	5.01^{bc}	3.43^{de}	5.19^{e}	3.97^{fg}
Ca acetate 1% + urea 1%	12.47^{b}	11.26^{a}	0.54^{e}	0.39^{e}	23.33^{b}	29.23^{ab}	5.25^{a}	3.76^{ab}	6.25^{ab}	4.95^{ab}
Ca acetate 1% + ethanol 2%	12.79^{a}	11.51^{a}	0.48^{e}	0.35^{e}	26.72^{a}	33.53^{a}	5.30^{a}	3.81^{a}	6.48^{a}	5.15^{a}
LSD $_{at\ 0.05}$	0.28	0.26	0.10	0.08	2.87	5.42	0.24	0.24	0.23	0.26

Values in each column when accompanied with similar letters, were not significantly different by using the least Significant Difference at 0.05 for comparing the means

IV. Discussion

Since calcium is one of the most important plant nutrients as it contributes to the integrity of plasma membrane and the firm structure of the cell wall. Providing fruits such as apple with calcium through foliar spray is an agricultural practice that is gaining more interest as field application that is more target oriented application especially in arid lands with relatively high soil PH and environmentally friendly fertilization method. It means directly delivering calcium to the target (the fruit) and reducing the needed amount. That means helping to reduce the environmental impact associated with soil fertilization. In spite of using organic calcium such as lignosulfonate, acetate or foliate that are highly water soluble. However, the response to foliar spray is variable that is because there are many factors that are involved in the diffusion process through the fruit cuticle of apples. The apple cuticle was found to contain many lenticels and many have some ultra-nutural cracks in addition to the stomata (Glenn *et al.,* 1985). Furthermore, it was proposed that there are "aqeous pores" (Schönherr, 2000), (Schönherr, and Schreiber, 2004) that are generated by the adsorption of water molecules to polar moieties located in the cuticlar membrane (Schreiber, 2005) such as an esterified carboxyl groups, ester and hydroxylic groups (chamel *et al .,* 1991) in the cutin network and carboxylic groups of pectic cell wall material (Schönherr and Huber, 1977). This hypothesis was supported by others on cuticular water sorption (luque *et al.,* 1995b). However, using adjuvants such as low concentration of urea or ethanol, in this study, helped increasing the penetration of calcium application in the form of calcium acetate. Thus, the individual application of calcium acetate was not as effective as its combinations. Enhancing the diffusion sprayed growth regulators such as ethephon was reported by other studies on the stomata's cuticle of the cranberry fruits and crimson seedless grapes (*farag et al.,*1985, 2012a and 2012b). Furthermore, the ability of lignosulfonate to function as a bio-stimulant dispersion material or bonding to fruit surface (Yang *et al.,* 2008, Elsawy*et al.,* 2022). On the other hand, calcium actate has the advantage of the high speed of action in plant tissues (Frizzell *et al.,* 2017). These organic salts of calcium are highly water soluble which enable calcium to translocate with in tissues and due to their safety, their use is allowed in organic agriculture. These organic calcium compounds have a high point of deliquescence (POD) which represent an obstacle against diffusion (Schönherr 2002). However, the mentioned pathways in the apple cuticle structure represent a major help to sprayed calcium solutions. In addition, sprayed droplets can be easily diffuse through the shoots and pedicles, then dissolved calcium in lignosulfonate, acetate or foliate move to various parts. Aforementioned, there has been an emphasis on the practical significance of foliar nutrition especially when applied at the right time as at the peak of nutrient demand times and to minimize the costs.

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Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-587X

Effect of Integrated Nutrient Management on Tuber Dry Matter Accumulation and Uptake of Nutrients by Potato (Solanum Tuberosum L.)

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Abstract- Potatoes have received a reputation as being a large consumer of nutrients such as nitrogen (N), phosphorus (P) and potassium (K). An experiment was conducted to study the effect of integrated nutrient management on the dry matter accumulation and uptake of nutrients in potato (Solanum tuberosum L.). Application of 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T7) recorded maximum total dry matter production (21.67%) which was on per with T3 (20.53%) and followed by T4 (19.79%), T5 (19.19%), T9 (18.55%) and T6 (18.42) during rabi 2011. Similarly the maximum uptake of N (97.17 kg/ha), P (21.76 kg/ha) and K (159.63 kg/ha) was found with plants provided with 50%RDF + 50%FYM + Azotobacter + PSB (T7) which was on par with T4, T3 and T5 during rabi 2011.

Keywords: potato, azotobacter, phosphobacteria, dry matter production, nutrient uptake, NPK concentration and vermicompost.

GJSFR-D Classification: FOR Code: 090803



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Effect of Integrated Nutrient Management on Tuber Dry Matter Accumulation and Uptake of Nutrients by Potato (*Solanum Tuberosum* L.)

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Abstract- Potatoes have received a reputation as being a large consumer of nutrients such as nitrogen (N), phosphorus (P) and potassium (K). An experiment was conducted to study the effect of integrated nutrient management on the dry matter accumulation and uptake of nutrients in potato (*Solanum tuberosum* L.). Application of 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T_7) recorded maximum total dry matter production (21.67%) which was on per with T_3 (20.53%) and followed by T_4 (19.79%), T_5 (19.19%), T_9 (18.55%) and T_6 (18.42) during *rabi* 2011. Similarly the maximum uptake of N (97.17 kg/ha), P (21.76 kg/ha) and K (159.63 kg/ha) was found with plants provided with 50%RDF + 50%FYM + Azotobacter + PSB (T_7) which was on par with T_4, T_3 and T_5 during *rabi* 2011. The minimum dry matter accumulation (15.32%) and N (83.40 kg/ha), P (16.13 kg/ha) and K (108.23 kg/ha) was registered with 100%FYM + 50% N supplied through neem cake + Azotobacter (T_8).

Keywords: potato, azotobacter, phosphobacteria, dry matter production, nutrient uptake, NPK concentration and vermicompost.

I. Introduction

Potato (*Solanum tuberosum* L.) constitutes staple food in many countries worldwide. It possesses inbuilt genetic potential to yield huge biomass in short time/unit land. In India, farmers have been regularly growing this crop even under acute price fluctuation and shortage of cold storage facilities. Potato allows the farmer to harvest up to 80% of dry matter as edible nutritious food, as compared to only 50% of the cereals as grain (Pandey *et al*., 2005). Besides being nutritionally superior and highly productive than most food crops, it has a relatively short duration and therefore amenable for inclusion in the intensive cropping system. Continuous use of inorganic fertilizers cause detrimental effects on soil physical health and thus reduces crop yields drastically (Guar 2002). A promising method to counteract these emerging threats is to switch on to organic farming practices which involves use of organic manures like FYM, vermicompost, poultry manure, neem cake, etc. and biofertilizers like *Azotobacter* and Phosphobacteria. Numerous works have been done on the integrated use of nutrients on potato, however, information regarding use of strictly organic manure alone and its effect on dry matter accumulation and nutrients uptake by potato is still lacking. Assessment of dry matter accumulation, uptake of nutrients and its distribution to various parts of the plant is essential for understanding the nutrient requirement also to estimate the nutrient removal by the crop. Accumulation and uptake of nutrients in a plant depends on many factors such as physico-chemical characteristics of soil, cultivar and agro-climatic situation. Therefore, a field experiment was conducted in Eastern Dry Zone of Karnataka to know the effect of integrated use of different organic and inorganic bio-fertilizer sources of nutrients on tuber dry matter accumulation and uptake of nutrient by potato variety Kufri jyoti.

II. Material and Methods

The field trail was carried out in sandy loam soil at Post Graduate Centre, University of Horticultural Sciences, Campus, Gandhi Krishi Vignana Kendra, Bangalore during *Rabi* 2011. There were 1o treatment combinations of organic, inorganic and biofertilizers *viz*., 100% recommended dose of fertiliser (125:100:125 kg NPK ha^{-1}) (T_1); 100% RDF + 100% FYM (25t ha^{-1}) ($T_{2)}$; Soil Test Crop Response targeted yield (155:150:129 kg NPK ha^{-1}) (T_3); 50% RDF + 100% FYM + Azotobacter (12 kg ha^{-1}) + Phosphobacteria (kg ha^{-1}) (T_4); 75% RDF + VC (1.5t ha^{-1}) + Azotobacter (12 kg ha^{-1})+ Phosphobacteria (12 kg ha^{-1}) (T_5); 50% RDF + Azotobacter (12 kg ha^{-1})+ Phosphobacteria (12 kg ha^{-1}) (T_6); 50% RDF + 50% FYM + VC (1.5t ha^{-1}) + Azotobacter (12 kg ha^{-1})+ Phosphobacteria (12 kg ha^{-1}) (T_7); 100% FYM + 50% Nitrogen supplied through neem cake (62.5 kg ha^{-1}) +Azotobacter (12 kg ha^{-1}) (T_8); 100% FYM + 50% nitrogen supplied through poultry manure (1.5t ha^{-1}) + Azotobacter (12 kg ha^{-1}) (T_9) and 100% FYM + 50 % FYM supplied through vermicompost (1.5 t ha^{-1}) + Azotobacter (12 kg ha^{-1}) (T_{10}). The experiment was laid out in RCBD and the treatments were replicated three times. The dry matter production was estimated on over dry weight basis on five randomly selected plants. Uptake of major nutrients

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and available NPK in the soil were also assessed. The content of nutrients was estimated by following standard procedures as outlined by Jackson (1973). The uptake of nutrients was calculated by multiplying their content with dry weight expressed as kg/ha.

III. Results and Discussion

Data pertaining to dry matter accumulation in different plant parts at harvest of potato differed significantly during *rabi* 2011 due to varying fertility levels (Table1). Application of 50% RDF + 50% FYM + Azotobacter + PSB (T_7) recorded significantly higher dry weight in shoot (50.7 g plant^{-1}), leaves (62.3 g plant^{-1}), roots (15.0 g plant^{-1}), tuber (127.3 g plant^{-1}) and total dry weight (255.3 g plant^{-1}) which was on par with the treatments T_3 and T_4.

Table 1: Effect of Integrated Nutrient Management on Dry Weight in Different Plant Parts at Harvest

Treatments	Dry weight (g/plant)				Total dry weight (g)
	Leaves	Shoots	Roots	Tubers	
T_1	31.7	24.3	10.7	86.3	153.0
T_2	34.0	27.7	11.3	95.3	168.3
T_3	51.0	46.0	14.3	121.7	233.0
T_4	51.3	44.0	14.0	118.3	227.6
T_5	43.0	32.3	13.3	111.3	199.9
T_6	40.3	31.0	12.7	104.0	188.0
T_7	62.3	50.7	15.0	127.3	255.3
T_8	24.7	22.3	9.7	83.3	140.0
T_9	36.7	29.3	12.0	101.0	179.0
T_{10}	27.0	25.3	11.0	92.3	155.6
SE m ±	1.88	2.16	0.73	5.17	6.54
CD at 5%	3.95	4.54	1.52	10.87	13.74
CV (%)	5.73	7.95	7.16	6.09	4.21

The increased dry weight could be attributed to better vegetative growth and also more of fresh weight. Increased dry weight is also related to better uptake of nutrients due to the influence chemical fertilizers (T_3). The better absorption and accumulation of nutrients promotes growth and metabolism. This in turn resulted in production of more dry weight accumulation. The growth attributes due to application of bio-fertilizer in conjunction with vermicompost (T_7) were enhanced by production of bio active substances having similar effects as that of growth regulators besides nitrogen fixation through bio-fertilizer leading to greater dry matter production. The higher dry matter production is attributed to the cumulative effect of progressive increase in growth attributes *viz*., plant height, number of stems per plant, stem girth and number of leaves per plant. Similar results were also reported by Kumar Manoj *et al.* (2011), Zaman *et al.* (2011), Sarkar et *al.* (2011) in potato, Ramanandam *et al.* (2008) in cassava (*Manihot esculenta* Crantz), Nedunchezhian and Srinivasulureddy (2002) in sweet potato.

Data pertaining to total nitrogen, phosphorus and potassium uptake as influenced by integrated nutrient management practices (Table 2). The plants provided with 50% RDF+ 50%FYM+AZT+PSB (T_7) recorded higher total nitrogen uptake (97.17 kg ha^{-1}) which was on par with T_3 (96.40 kg ha^{-1}), T_4 (95.20 kg ha^{-1}) and T_5 (94.47 kg ha^{-1}) during *rabi* 2011 respectively. This could be attributed to better availability of nutrients when plants received in combination of inorganic, organic and biofertilizers. It is also related to application of biofertilizers especially Azotobacter which helped in fixation of atmospheric nitrogen while the applied FYM improve the soil physical and chemical properties which aid in uptake of nitrogen. The increased uptake could be due to higher availability of nutrients and increased absorptive area, which resulted in higher tuber yield. Similar results were noticed by Parmar *et al.* (2007) in potato, Alfred Hartemink *et al.* (2000) in taro, Ramanandan *et al.* (2008) in cassava, Patil (1998) in chilli, Murukumar and Patil (1996) in capsicum.

Maximum total phosphorus uptake (21.76 kg ha^{-1}) during *rabi* 2011 was observed in the plants treated with 50% RDF+ 50%FYM+AZT+PSB (T_7) which was on par with T_3 (21.43 kg ha^{-1}) and T_4 (21.07 kg ha^{-1}) respectively. The maximum total phosphors uptake (21.767 kg ha^{-1}) was observed in plants fertilized with 50% RDF + 50% FYM + VC + AZT + PSB (T_7) and it was *on par* with the treatments of T_3 (21.43 kg ha^{-1}) and T_4 (21.07 kg ha^{-1}). This could be attributed to improved physical and chemical properties of soil due to applications of organic manures and biofertilizers especially phosophobateria which enhanced the inorganic phosphorus in available form. Increased phos-

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phorous uptake is also due to solubilization of insoluble form of phosphors into soluble form by phosphobateria there by increased uptake of phosphorus (Olsen *et al.,* 1999). These results are in the line of Mahendran *et al*. (1996) who have reported that application of NPK fertilizers with bio-fertilizers viz., Azospirillum and phosphobacterium significantly influenced N and P content and uptake of NPK by different plant parts. This is in conformity with the findings of Nandekar *et al.* (1992) in potato crop.

Total potassium uptake was also highest (159.63 kg ha^{-1}) during *rabi* 2011 with application of 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T_7) which was on par with T_4 (153.90 kg ha^{-1}) (Table 3). This could be attributed to the pronounced improvement in soil fertility through the addition of FYM and the substitution of NPK nutrients supplied through Azotobacter and PSB facilitated effective utilization of available nutrients. Hoda Habib *et al.* (2011) reported that uptake of nutrients NPK may be due to the increase of enzymatic activities which affect on absorption of mineral nutrients by plant and in turn increase its concentration in plant parts. The results are in the conformity with the findings of Parmar *et al.* (2007), Singh *et al.* (1996) and Shambhavi and Sharma (2008a) in potato.

Table 3: Effect of Integrated Nutrient Management on Total Nitrogen, Phosphorus and Potassium Uptake by Potato

Treatments	Nitrogen Uptake (kg ha^{-1})	Phosphorus Uptake (kg ha^{-1})	Potassium Uptake (kg ha^{-1})
T_1	90.50	18.80	138.33
T_2	93.33	19.13	147.30
T_3	96.40	21.43	147.30
T_4	95.20	21.07	153.90
T_5	94.47	20.13	145.06
T_6	91.56	19.33	149.83
T_7	97.17	21.76	159.63
T_8	83.40	16.13	108.23
T_9	93.10	19.97	144.53
T_{10}	89.00	18.53	127.36
SE m ±	1.53	0.52	4.18
CD at 5%	3.22	1.09	8.79
CV (%)	2.03	3.26	3.64

It can be concluded that application of 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T_7) recorded highest dry weight of shoot (50.7 g plant^{-1}) during *rabi* 2011 which was followed by T_3 (46.0 g plant^{-1}), T_4 (44.0 g plant^{-1}) and T_6 (32.3 g plant^{-1}); highest dry weight of leaves (62.3 46.0 g plant^{-1}) which was on par with T_4 (51.3 46.0 g plant^{-1}) and T_3 (51.0 46.0 g plant^{-1}) respectively. Application of 75% RDF + 75% FYM + Azotobacter + Phosphobacteria (T_7) recorded higher root dry weight (15.0 46.0 g plant^{-1}) which was on par with T_3 (14.3 g plant^{-1}) and T_4 (14.0 g plant^{-1}) respectively, highest tuber dry weight (127.3 46.0 g plant^{-1}) which was on par with T_3 (121.7 g plant^{-1}) and T_4 (118.3 g plant^{-1}) and total dry weight (255.3g plant^{-1}). Similarly the maximum N uptake (97.17 kg ha^{-1}), P (21.76 kg ha^{-1}) and K (159.63 kg ha^{-1}) was found with the plants provided with 50% RDF + 50% FYM + Azotobacter + Phosphobacteria (T_7) which was on par with T_3 and T_4 during *rabi* 2011.

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Table 2: Effect of Integrated Nutrient Management on Accumulation of Nitrogen, Phosphorus and Potassium in Different Plant Parts of Potato at Harvest

Treatments	Nitrogen Accumulation (%)			Phosphorus Accumulation (%)			Potassium Accumulation (%)		
	Stem	Leaf	Tuber	Stem	Leaf	Tuber	Stem	Leaf	Tuber
T_1	1.29	1.14	1.08	0.12	0.49	0.93	2.03	2.61	4.24
T_2	1.31	1.18	1.12	0.12	0.53	0.94	2.09	2.75	4.31
T_3	1.80	1.30	1.27	0.16	0.58	1.08	2.17	3.35	4.39
T_4	1.76	1.29	1.24	0.16	0.56	1.05	2.17	3.43	4.35
T_5	1.72	1.26	1.19	0.15	0.55	0.99	2.15	3.08	4.34
T_6	1.66	1.25	1.16	0.14	0.54	0.97	2.12	2.99	4.34
T_7	1.85	1.33	1.28	0.17	0.59	1.12	2.22	3.93	4.52
T_8	1.15	1.11	1.04	0.11	0.48	0.91	2.03	2.42	4.19
T_9	1.33	1.20	1.12	0.13	0.54	0.95	2.11	2.79	4.31
T_{10}	1.26	1.16	1.07	0.12	0.52	0.94	2.06	2.72	4.26
SE m ±	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.18	0.03
CD at 5%	0.04	0.04	0.04	0.02	0.02	0.06	0.04	0.39	0.06
CV (%)	4.67	1.65	1.64	6.40	3.06	3.26	1.43	7.31	0.99

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Global Journal of Science Frontier Research (D) Volume XXIII Issue II Version I Year 2023
22

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Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-587X

Extent, Levels and Suitability of ICT Usage for Agricultural Information Dissemination in Uganda: A Case of Rubanda, Mayuge Districts, and Mbarara City

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Abstract- The main source of livelihood in Uganda is smallholder farming. It is the most common type of agriculture practice supporting more than 70% of the population, thus a dire need to devise means to sustain and improve it towards poverty reduction and socio-economic development resulting from the agricultural sector. This study investigates the Level and Suitability of ICT Usage for Agricultural Information Dissemination in Rubanda, Mayuge Districts, and Mbarara City of Uganda. The study adopted the survey design of the cross-sectional and used structured questionnaires. Data collected were analysed using descriptive statistics of frequency counts and percentages.

Keywords: *ICT, agricultural information, dissemination, Uganda.*

GJSFR-D Classification: *FOR : 0701*



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Extent, Levels and Suitability of ICT Usage for Agricultural Information Dissemination in Uganda: A Case of Rubanda, Mayuge Districts, and Mbarara City

Byamukama Willbroad [α], Businge Phelix Mbabazi (PhD) [σ] & Kalibwani Rebecca (PhD) [ρ]

Abstract- The main source of livelihood in Uganda is smallholder farming. It is the most common type of agriculture practice supporting more than 70% of the population, thus a dire need to devise means to sustain and improve it towards poverty reduction and socio-economic development resulting from the agricultural sector. This study investigates the Level and Suitability of ICT Usage for Agricultural Information Dissemination in Rubanda, Mayuge Districts, and Mbarara City of Uganda. The study adopted the survey design of the cross-sectional and used structured questionnaires. Data collected were analysed using descriptive statistics of frequency counts and percentages. The study recommended that agricultural information dissemina- tion should always be disseminated and reiterated using newer and more complex ICT devices and platforms but the priority and emphasis must be placed on mobile phones and radio being the leading types of ICT used for agricultural information dissemination in Rubanda district, Mayuge district, and Mbarara city.

Keywords: ICT, agricultural information, dissemination, Uganda.

I. Introduction

The growth and development of the agriculture sector are achieved through the effective preparation of Information and Communication Technology (ICT). In line with the Food and Agriculture Organization (FAO, 2017), ICT has been a major contributor to the expansion and socio-economic development in countries and sectors wherever they're well deployed. The effective integration of ICT within the agriculture sector in developed and developing countries have done tremendous improvements in agriculture and its productivity. For example, traceability technologies like block chain, and frequency identify-cation (RFID) have enabled transparency and potency throughout the organic phenomenon through the pursuit and tracing of food from farm to fork. This makes it doable to spot the supply of any food-related incident just in case a food safety issue happens. Such transformation is however required in most African countries' agricultural systems.

In recent years, efforts to transform the sector have led to the propagation of many mobile-based applications and services. A recent digitization report by the Technical Centre for Agriculture and Rural Cooperation (Tsan *et al*., 2019) discovered that thirty-three million farmers are presently reached by digital applications as of 2019 and this is often projected to achieve two hundred million by 2030. These applications are varying and target information and data services, market linkages, money access, and provide chain management, with information and data service dominating the market. Nejadrezaei et al. (2018) assert that ICT-based innovations will improve rural livelihoods and empower farmers in developing counties by enhancing their capacity and increasing access to correct and timely agriculture information. For instance, Esoko which is a technology platform in most African countries uses a mixture of mobile and internet services to boost access to extension services and market data. This reduces the prices of sorting out market data and provides weather and extension recommendations to farmers. Innovative ICT starting from computers, radio, television, and mobile phones to advanced technologies like block chain, computer science, cloud computing, Internet of Things (IoT), and big data are among these trends (Obschonka & Audretsch, 2019). Nejadreza ei et al. (2018) argue that these ICT trends hold the potential to contribute to sustainability transitions in agriculture by increasing efficiency, enhancing transparency, and traceability. Patel & Sayyed (2014) indicated that remote sensing exploitation satellite technologies and geo-graphical data systems are opted to increase agricultural output. Furthermore, big data analytics can be used to provide predictive insights into farming operations, drive real-time operational decisions, and redesign business processes (Wolfert *et al.,* 2017; Ahoa *et al.,* 2020; Van Klompenburget al., 2020). With ICT

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recognized as a major contributor to the expansion and development of agriculture, its application in recent years has gained increasing attention in several developing countries.

a) ICT and Agriculture

Today's world is widely information-driven where Information and Communication Technologies (ICT) are increasingly becoming the underlying drivers of social and economic development including agriculture, not only in developed countries but across the globe (Sennuga et al., 2020). The role of ICTs in enhancing access and dissemination of agricultural information among smallholder farmers is paramount and it is also discovered that ICTs are usually very important tools for accessing relevant agricultural information if used effectively by targeted communities. The literature reviewed in this paper disclosed that there were varied ICT tools in agriculture but sadly, there was no clear proof of how the farmers significantly in rural settings were utilizing and gaining from these since most of these were found and set in urban areas with high internet penetration and usage(To & Trinh, 2021).

All in all, the approach which was employed in this study seeks to determine whether or not problems of adoption are the same as problems of information communication and persuasion. Aspects just like the inappropriateness of the innovation itself, or difficulties originating from the material conditions (as against temperament traits) of the potential adopter, were very little emphasized in previous studies. Also, the link that has been understood in previous studies between those striving to promote innovation and also the potential adopters is unequal and hierarchical; the adopters are considered as those having bigger information in the agricultural sector and the poor are seen as those that do not understand what's sensible for them (Morosan & DeFranco, 2016).

Various studies distinguish that the selections of users are oftentimes supported by rationality that is subject to economic, social as well as cultural specificities. These studies place major emphasis on the method by which the procedure itself is generated and developed, additionally on the demand to make sure of its appropriateness to the necessities of users. They highlight that the peculiarity between a generation of innovation and adoption could be a false one in which it is inconceivable to require innovation as exogenously given how it is to be developed/adapted within the field itself (Venkatesh et al., 2016). The foremost common feature of such studies is the emphasis that they place on the desirability of close interface with and participation of the ultimate user within the method of innovation itself. Where they vary is within the extent of involvement anticipated. This study was set to bring out confirmatory results to justify innovation adoption, implementation, and ICT usage among smallholder farmers in their localities. It is observed that sharing of agricultural information to and among the numerous smallholder farmers in remote areas does not adequately consider the necessary ICT tools that best suit the intended farmers for increased ICT adoption that can necessitate the actual, intended, and effective delivery of agricultural information in developing countries. There is therefore a need to investigate and understand the extent, levels, and suitability of ICT Usage for Agricultural Information Dissemination in Uganda using a case study of Rubanda, Mayuge Districts, and Mbarara City.

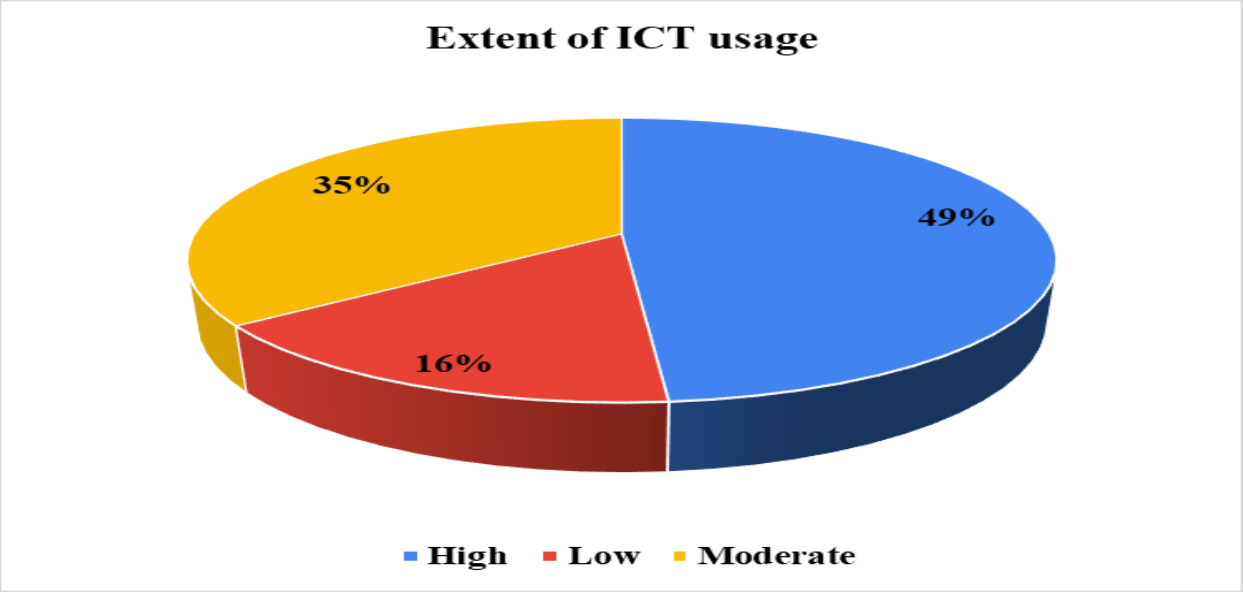
II. Methodology

The study adopted cross-sectional design of survey research type and the instrument for this study consisted of structured questionnaires. The questionnaire was subjected to face and content validity and reliability test. Data collected were analysed using descriptive statistics of frequency counts, percentages, and mean and standard deviation. The target population of this study comprised all farmers in Rubanda District, Mayuge District, and Mbarara City where 374 farmers were randomly selected and made to participate in the study. Copies of the questionnaire were distributed to them and collected for analysis after they were completely filled.

III. Result and Discussion

This section elaborates the findings of this study in relation to the extent of ICT usage, levels, and suitability of different types of ICT tools for agricultural information dissemination in developing countries particularly Uganda.

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Source: Field Survey, 2022

Figure 1: The extent of ICT usage for agricultural information dissemination

The results in Figure 1 show that a simple majority (49%) of the farmers moderately used ICT devices (Radios; Televisions, Mobile Phones, Computers) for agricultural information dissemination across all study areas. 35% of them only used the devices at a high rate and only 16% used the devices at a low rate. This finding further justifies how easily accessible the ICT devices are to farmers.

Farmers in Mayuge district used radios at the highest rate (80.35%) for agricultural information dissemination than farmers in the other two study areas. The majority (45.24%, 80.95%, and 56.86%) of the farmers in Mbarara city used Televisions, Mobile Phones, and Computers respectively for the dissemination of agricultural information as indicated in Table 1 below.

Generally, the ICT device that was mostly used in the three districts was the radio with a response rate of 73%. This is because it's cheaper to acquire and user-friendly among the common subsistence farmers and this conforms with the study by Oyeyinka and Bello (2013) who indicated that radio continues to possess very wide penetration and reach, notably in Africa, South America, and elements of Asia that have rural areas, to produce and interpret information in an exceedingly relevant manner for its listeners.

Table 1: The Extent of ICT Usage for Agricultural Information Dissemination in Rubanda District, Mayuge District, and Mbarara City

ICT Devices	CATEGORY											
	Mayuge District (%)			Mbarara City (%)			Rubanda District (%)			Overall (%)		
	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate
Radio	80.35	1.16	18.5	77.38	8.33	14.29	61.04	14.29	24.68	73	8	19
Television	11.79	17.28	70.93	45.24	5.95	48.81	32.69	28.85	38.46	30	17	53
Mobile Phone	52.63	12.5	34.87	80.95	3.81	15.24	75.31	11.11	13.58	70	9	21
Computer	2.94	52.94	44.12	56.86	17.65	25.49	19.57	43.48	36.96	26	38	36

Source: Field Survey, 2022

Results in Table 1 above indicate the findings of the study that Mayuge district had the highest percentage (80.35%) of radio usage for agricultural information dissemination, followed by 11.79% for television, 52.63% for mobile phones, and 2.94% for computer usage.

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Table 2: The Overall Extent of ICT Usage for Agricultural Information Dissemination In Rubanda District, Mayuge District, and Mbarara City

Type of ICT	Extent							
	Do not Use		Low		Moderate		High	
	f	%	f	%	f	%	f	%
Radio	25	6.7	13	3.5	69	25.4	241	64.4
Television	167	44.7	30	8.0	111	29.7	66	17.6
Mobile Phone	2	0.5	48	12.3	88	23.4	258	63.6
Computer	258	69.0	65	17.4	46	12.3	5	1.3

Source: Field Survey, 2022

Results in Table 2 reveal the overall extent of ICT usage for agricultural information dissemination in Rubanda District, Mayuge District, and Mbarara City according to their percentage. Most of the respondents revealed that; 64.4% have high usage of radio for agricultural information dissemination, followed by mobile phone (63.6%), then television (44.7%). Whilst, computer (1.3%) is the least type of ICT device used for agricultural information dissemination. This was justified by the nature of cost-effectiveness and affordability ranging from radio to computer respectively. Many of the respondents across the study areas reported that they always tune in to local radio stations particularly mornings before they leave for their farming activities and later on in the evenings after work which gives them ample time to attentively get the agricultural related information from the radio. These findings are in agreement with Galanakis (2020) who indicates how ICTs help to monitor the vehicles of agricultural transformation during restricted days of lockdown and issues of wider coverage and time saving by extension service providers versus the number of farmers in respective areas.

Table 3: Tabulation for the overall extent of ICT usage for agricultural information dissemination in Rubanda District, Mayuge District, and Mbarara City

District	
[Radio]	Pearson chi^2 (6) = 60.9387 Pr = 0.000
[Television]	Pearson chi^2 (6) = 72.554 Pr = 0.001
[Computer]	Pearson chi^2 (6) = 32.766 Pr = 0.001
[Mobile Phone]	Pearson chi^2 (6) = 30.632 Pr = 0.001
Gender	
[Television]	Pearson chi^2 (6) = 1.191 Pr = 0.75
[Computer]	Pearson chi^2 (6) = 10.124 Pr = 0.18
[Mobile Phone]	Pearson chi^2 (6) = 0.538 Pr = 0.910
[Radio]	Pearson chi^2 (6) = 17.814 Pr = 0.000
Marital Status	
[Television]	Pearson chi^2 (6) = 27.816 Pr = 0.001
[Computer]	Pearson chi^2 (6) = 8.471 Pr = 0.487
[Mobile Phone]	Pearson chi^2 (6) = 40.687 Pr = 0.000
[Radio]	Pearson chi^2 (6) = 36.529 Pr = 0.000
Education Level	
[Mobile Phone]	Pearson chi^2 (6) = 49.115 Pr = 0.000
[Television]	Pearson chi^2 (6) = 81.037 Pr = 0.000
[Computer]	Pearson chi^2 (6) = 61.712 Pr = 0.000
[Radio]	Pearson chi^2 (6) = 50.8386 Pr = 0.000
Age	
[Computer]	Pearson chi^2 (6) = 22.382 Pr = 0.098
[Mobile Phone]	Pearson chi^2 (6) = 50.433 Pr = 0.00
[Television]	Pearson chi^2 (6) = 38.050 Pr = 0.001
[Radio]	Pearson chi^2 (6) = 71.036 Pr = 0.001
Monthly Income	
[Television]	Pearson chi^2 (6) = 92.097 Pr = 0.000
[Computer]	Pearson chi^2 (6) = 72.385 Pr = 0.000
[Mobile Phone]	Pearson chi^2 (6) = 46.559 Pr = 0.000
[Radio]	Pearson chi^2 (6) = 51.027 Pr = 0.000

Source: Field Survey, 2022

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The tabulation tables run further report the overall extent of ICT usage for agricultural information dissemination in Rubanda District, Mayuge District, and Mbarara City, and the Chi-square tests across study areas and socio-economic factors for the extent of ICT adoption and usage for agricultural information dissemination show that at a 5% level of significance, $p<0.01$ implies that there is a significant association between the district of participants and their extent of use of radio. The vast majority (78.7%) of the people who have a high use of radio are domiciled in Mayuge district. Followed by Mbarara district (61.1%), followed by Rubanda (54.5%). The implication of this is that efforts aimed at improving agricultural information among farmers should consider the use of radio as the major ICT tool for Mayuge and Mbarara districts.

The highest percentage (35.2%) of the people who use television are from the Mbarara district, followed by those who are from the Rubanda district with 19.3% of farmers who were using television for agricultural information, while Mayuge accounted for the least 6.2% of farmers who were using television for agricultural information purposes. The implication is that any effort aimed at improving ICT usage among the farmers in these districts should first ensure accessibility to television with an enabling environment for its usage for agricultural information among farmers. Thus, a chi-square statistic shows that at a 5% level of significance, $p<0.00$ implies that there is a significant association between the district of participants and their extended use of television.

The highest percentage (3.4%) of the people who use a computer was from the Rubanda district, followed by those who are from the Mbarara district with 1.9% of farmers who were using a computer for agricultural information, while none of the farmers from Mayuge were using a computer for agricultural information purposes. The implication is that any initiative aimed at improving ICT usage among the farmers in these districts should first ensure training, re-training, and accessibility to a computer with an enabling environment for the application of computers for agricultural information among farmers. And at a 5% level of significance, $p<0.00$ implies that there is a significant association between the district of participants and their extended use of the computer.

The vast majority (78.7%) of the people who have a high use of mobile phones are domiciled in Mbarara district followed by those from Rubanda district (72.7%), followed Mayuge (50.0%). The implication of this is that efforts aimed at improving agricultural information among farmers should consider the use of the mobile phone as the major ICT tool for Mbarara and Rubanda districts. At a 5% level of significance, $p<0.00$ implies that there is a significant association between the district of participants and their extended use of the mobile phone.

The highest percentage of the farmers (44.7%) were not using Television for agricultural information purposes. However, out of the 17.6% of the total respondents who use Television, analysis shows that females had a higher percentage of 19.5% usage of television for agricultural information purposes. The implication of this is that any initiative towards improving agricultural information dissemination should be more targeted at female farmers as the said gender was more comfortable with the usage of Television than their male counterparts. At a 5% level of significance, $p<0.75$ implies that despite the higher percentage of female usage of television for agricultural information purposes; the Chi-Square result shows there is no significant association between the gender of participants and their extended use of Television for agricultural information purposes.

The highest percentage (69.0%) is not using computers for agricultural information purposes. However, out of the 1.3% of the people who use a computer, analysis shows that males had a higher percentage of 2.1% usage of computers for agricultural information purposes. The implication of this finding can be viewed in two ways; firstly, it is obvious that most of the farmers do not know how to operate the computer system. Secondly, the financial implication of having a personal computer may be on the high side for many poor farmers. Thus, any effort aimed at improving the use of computers among the farmers should first consider training and re-training in the use of computers and if possible, agricultural grants should be made available to encourage the farmers financially. At a 5% level of significance, $p<0.01$ implies that there is a significant association between the gender of participants and their extent of use of Computers for agricultural information purposes.

The highest percentage (63.6%) of the respondents were found using mobile phones for agricultural information purposes. The analysis also shows gender differences of a higher percentage (64.6%) of male farmers' usage of mobile phones for agricultural information purposes compared to a lesser percentage (61.8%) of their female counterparts. The implication of this is efforts to improve agricultural information dissemination should first identify the choice of ICT tools that are most suitable gender-wise and take better advantage of mobile phones to reach the male. Females had oftentimes been found dumping their phones inside their handbags for several hours and sometimes throughout the whole day, thus, missing several urgent and timely pieces of information, unlike their male counterparts who oftentimes held their mobile in their hands as they go about their daily activities. At a 5% level of significance, $p<0.75$ implies that despite the higher percentage of male usage of mobile phones for agricultural information purposes; the Chi-Square result shows there is no significant association between the

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gender of the participant farmers and their extended use of the mobile phones for agricultural information purposes.

The married farmers' respondents recorded a higher (32.2%) percentage usage of television for agricultural information purposes, followed by the single farmers who accounted for 28.6%, followed by the farmers who were divorced which accounted for 25.0%. The implication of this is that married people are more settled and stable, and they tend to have equipped the home with some electronics among which is television unlike their singles counterparts who are less settled and less stable and often time do not have a television set thus, efforts aimed at improving agricultural information disseminations should consider Television for a better reach of the married farmers with agricultural information. The chi-square test shows that at a 5% level of significance, $p<0.01$ implies that there is a significant association between the marital status of participants and their extended use of Television for agricultural information purposes.

The single farmers' respondents recorded a higher (19.7%) percentage usage of Computers for agricultural information purposes, followed by the farmers who were married which accounted for 11.7%, followed by the farmers who were widowed which accounted for 5.3%. The implication of this is that the younger farmers who were mostly singles were vaster in ICT-related skills and more comfortable with the use of computers for agricultural information thus, efforts aimed at better information dissemination on agricultural matters should consider the computer to reach the single/younger farmers. At a 5% level of significance, $p<0.48$ implies that despite the disparity in marital status towards the usage of Computers for agricultural information purposes; the Chi-Square result shows there is no significant association between the marital status of the participant farmers and their extended use of Computer for agricultural information purposes.

The single farmers' respondents recorded a higher (31.6%) percentage usage of the Mobile phone for agricultural information purposes, followed by the farmers who were married which accounted for 24.0%, followed by the farmers who were widowed which accounted for 19.6%. While the respondents' farmers who were divorced accounted for the remaining 18.8%. The implication of this is that the younger farmers who were mostly singles were more comfortable with the use of the mobile phone for agricultural information thus; efforts aimed at better information dissemination on agricultural matters should consider the mobile phone as one of the best platforms to reaching the single/younger farmers. Thus, at a 5% level of significance, $p<0.01$ implies that there is a significant association between the marital status of participants and their extended use of the mobile phone for agricultural information purposes.

That the farmers' respondents with Master's degrees recorded a higher (50.0%) percentage usage of television for agricultural information purposes, followed by the farmers who were bachelor's degree holders which accounted for 34.9%, followed by the farmers who were O 'level holders which accounted for 17.8%. The implication of this is that the more educated farmers were more comfortable with the use of television for agricultural information thus; efforts aimed at better information dissemination on agricultural matters should consider television to reach the advance and highly educated farmers. At a 5% level of significance, $p<0.00$ implies that there is a significant association between the educational level of participants and their extended use of television for agricultural information purposes.

The farmers' respondents with Master's degrees recorded higher (16.7%) percentage usage of computers for agricultural information purposes, followed by the farmers who were bachelor's degree holders which accounted for 34.9%, followed by the farmers who were O 'level holders which accounted for 17.8%. The implications of these are that the most educated farmers were vaster in ICT-related skills and more comfortable with the use of computers for agricultural information thus, efforts aimed at better information dissemination on agricultural issues should consider the computer to reach the more educated farmers. A chi-square was also run to further confirm the claims above and it reveals that at a 5% level of significance, $p<0.00$ implies that there is a significant association between the marital status of participants and their extended use of computer for agricultural information purposes.

The farmers' respondents who were Bachelor's degree holders recorded a higher (83.5%%) percentage usage of mobile phones for agricultural information purposes, followed by the farmers who were Master's degree holders which accounted for 83.3%, followed by the farmers who were O 'Level holder which accounted for 68.9%. Others were accounted for by farmers who primary schools were leaving certificate holders and others probably who do not have any formal educational qualification. The implication of this is that the well-educated farmers were also having better use of mobile phones resulting from their vastness in ICT-related skills and can comfortably use mobile phones for agricultural information thus; efforts aimed at better information dissemination on agricultural matters should also consider mobile phone to reaching the more educated farmers and at a 5% level of significance, $p<0.00$ implies that there was a significant association between the educational level of participants and their extended use of mobile phones for agricultural information purposes.

The farmers' respondents' age range of 34-44 recorded a higher (33.6%) percentage usage of television for agricultural information purposes, followed

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by farmers who were age range of 45-54 who accounted for 31.4%, followed by farmers who were below 25 which accounted for 27.3%, followed by the farmers who were 55-64 which accounted for 26.7%. The implication of this is that middle-aged to older farmers were more comfortable with the use of television for agricultural information thus; efforts aimed at better information dissemination on agricultural-related issues should consider television to reach the older farmers. At a 5% level of significance, $p<0.01$ implies that there is a significant association between the age range of participants and their extended use of television for agricultural information purposes.

The farmers respondent's age range of 25-34 recorded a higher (18.5%) percentage usage of computer for agricultural information purposes, followed by farmers who were age range of 35-44 which accounted for 15.5%, followed by the farmers who were 55 and above which accounted for 14.3%, followed by the farmers who were below 25 and those of 45-54 which accounted for 9.3% and 9.1% respectively. The implication of this is that middle-aged to younger farmers were more comfortable with the use of computers for agricultural information thus; efforts aimed at better information dissemination on agricultural-related issues should consider the computer to reach the younger farmers. More so, at a 5% level of significance, $p<0.09$ implies that despite the differences in age usage of Computers for agricultural information purposes; the Chi-Square result shows there is no significant association between the age of the participant farmers and their extended use of computers for agricultural information purposes.

The farmer's respondents age range 45-54 recorded higher (32.6%) percentage usage of mobile phones for agricultural information purposes, followed by farmers who were age range 65-54 which accounted for 28.0%, followed by the farmers who were below 25 years old which accounted for 27.3%, followed by the farmers who were 35-44 and those of 65 and above which accounted for 19.8% and 19.0% respectively. The implication of this is that middle-aged farmers to older farmers seem to be having better usage of the mobile phone thus; efforts aimed at better information dissemination on agricultural-related issues should consider reaching the older farmers via mobile phones. Furthermore, at a 5% level of significance, $p<0.00$ implies that there is a significant association between the range of participants and their extended use of the mobile phone for agricultural information purposes.

The farmers' respondents whose monthly income falls within 1.5-2M (million Uganda shillings) recorded higher (50.0%) percentage usage of television for agricultural information purposes, followed by the farmers whose monthly income was above 2M which accounted for 23.1%, followed by the farmers whose monthly income falls within 500k-1M which accounted for 22.8% usage of television for agricultural purposes. The implication of this is that the farmers with average to higher monthly income seem to be comfortable with television for catching up with agricultural information. At a 5% level of significance, $p<0.00$ implies that there is a significant association between the income level of participants and their extent of use of television for agricultural information purposes.

The farmers' respondents whose monthly income ranges from 1.5M-2M recorded higher (12.5%) percentage usage of computer for agricultural information purposes, followed by the farmers whose monthly incomes were above 2M which accounted for 7.7%, followed by the farmers whose monthly income were within 500K-1M which accounted for 2.1%. The implication of this is that the farmers with average to higher monthly income seem to be more conversant with computers for assessing agricultural information. And at a 5% level of significance, $p<0.00$ implies that there is a significant association between the income level of participants and their extent of use of computers for agricultural information purposes.

The farmers' respondents whose monthly income ranges from 1.5M-2M recorded higher (100.0%) percentage usage of mobile phone for agricultural information purposes, followed by the farmers whose monthly income were 1M-1.5M which accounted for 100.0%, followed by the farmers whose monthly income were above 2M which accounted for 76.9%, followed by those whose monthly income was within 500K-1M which accounted for 75.2% usage of mobile phone as ICT tool/s for information dissemination. The implication of this is that the farmers with average to higher monthly income seem to be more comfortable with the mobile phone for catching up with agricultural information. A chi-square confirmation further shows that at a 5% level of significance, $p<0.01$ implies that there is a significant association between the marital status of participants and their extent of use of Television for agricultural information purposes in the study areas since married couples tend to involve in agricultural activities more than the other categories of marital statuses.

IV. Conclusion and Recommendations

Mobile phone devices and Radio are the leading types of ICT usage for agricultural information dissemination in Rubanda district, Mayuge district, and Mbarara city. It is recommended that agricultural information dissemination can be reiterated using other newer and more complex ICT devices and platforms but the priority and emphasis must be placed on mobile phones and radio being the leading types of ICT used for agricultural information dissemination in Rubanda district, Mayuge district, and Mbarara city.

Efforts aimed at improving agricultural information among farmers should consider the use of

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radio as the major ICT tool for Mayuge and Mbarara districts. Efforts aimed at improving ICT usage among the farmers in these districts should first ensure accessibility to television with an enabling environment for its usage for agricultural information among farmers.

Initiatives aimed at improving ICT usage among the farmers in these districts should first ensure training, re-training, and accessibility to the computer with an enabling environment for the application of computers for agricultural information among farmers. Efforts aimed at improving agricultural information among farmers. Should consider the use of the mobile phone as the major ICT tool for Mbarara and Rubanda districts. Initiatives towards improving agricultural information dissemination should consider the use of Television for female farmers than their male counterparts

Efforts aimed at improving the use of computers among the farmers should first consider training and re-training in the use of computers and if possible, agricultural grants should be made available to encourage the farmers financially. Efforts to improve agricultural information dissemination should first identify the choice of ICT tools that are most suitable gender-wise and take better advantage of mobile phones to reach the male. Females had oftentimes been found dumping their phones inside their handbags for several hours and sometimes throughout the whole day, thus, missing several urgent and timely pieces of information, unlike their male counterparts who oftentimes held their mobile in their hands as they go about their daily activities.

Efforts aimed at improving agricultural information dissemination should consider Television for a better reach of married farmers with agricultural information. Efforts aimed at better information dissemination on agricultural matters should consider the computer to reach the single/younger farmers. Efforts aimed at better information dissemination on agricultural matters should consider mobile phones as one of the best platforms to reach single/younger farmers.

Efforts aimed at better information dissemination on agricultural matters should consider television to reach advanced and highly educated farmers. Efforts aimed at better information dissemination on agricultural issues should consider the computer to reach the more educated farmers. Efforts aimed at better information dissemination on agricultural matters should also consider the mobile phone to reach the more educated farmers.

Efforts aimed at better information dissemination on agricultural-related issues should consider television to reach older farmers. Efforts aimed at better information dissemination on agricultural-related issues should consider computers to reach younger farmers. Efforts aimed at better information dissemination on agricultural-related issues should consider reaching older farmers via mobile phone.

a) Conflict of Interest

The authors declare no conflict of interest in this publication and have the right for any changes and adjustments throughout the entire manuscript.

b) Source of Funds

This was self-sponsored research as one of the objectives for PhD research project.

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Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-587X

Combined Effect of Doses of Fertilizers and Different Densities on Agronomic Parameters of Rice (Oryza Sativa) Adapted on Humid Area on the Valley of Benoué-Cameroon

By Bertrand Wang-Bara, Philémon Kaouvon, Cyrille Woulbo Biyack & Yvonne Djeoufo

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Keywords: *planting density, rice, doses, mineral fertilizers, yields.*

GJSFR-D Classification: *LCC Code: GB701*



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Keywords: planting density, rice, doses, mineral fertilizers, yields.

I. Introduction

Rice (*Orysa sativa* (L)) culture represent the first cereal for human's food in the world and for around half of world populations (Courtois, 2007). Asiatic country remains dominant on economy of Rice with 90 % in terms of surfaces and production (Mendez, 2008). Countries which are more included are China, India and Indonesia which represent more than half of the world production. Latin America and Africa represent 10 % of the rest of the production (Mendez, 2008).

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In Africa, Rice culture is the third of sources of calories for the country (Adrao, 2009). Actual problems which Africa is confronted is that the local production does not never equal to the demand (Harold *et al.,* 2015). However, the production, estimated at 330.000 tons, is largely lower to the demand whose requirement is estimated to more than 600.000 tons. For satisfy this deficiency, Cameroon should refer to the importations. Rice takes the first place in the order of five principals food products of high consummation concerned by importation in Cameroon. Importations varies from 552.472 tons in 2000 for the values of 156.6 thousand billion of FCFA to 819.841 tons, equivalent of 212.6 thousand billion of FCFA in 2013, after decreasing from 728.443 tons for the values of 183.7 thousand billion milliards in 2017. Importation price has increased from 7.9 % (INS, 2017).

Cameroon has a biggest natural potentiality good for Rice culture on all national territory according to the land, resources in water and climate. Many governmental interventions were recorded, but the lower valorization of natural resources and public interventions on this culture remains few. In research domain, Institute of Agricultural Research and Development (IRAD) multiply research activities and solutions concerning productivities of Rice. Through their international partnership (Center of Africa Rice and International Rice Research Institute). IRAD has experimented high potential technologies for improving the productivity and the quality of local Rice like NERICA (New Rice for Africa). Varieties Nerica were experimented in 1990, by crossing between Asiatic Rice (*Oryza sativa*) and African Rice (*Oryza glaberrima*). Many varieties were tested, adopted and vulgarized by IRAD through the country. In a Northern part, variety Nerica L36 is the most used and most appreciated from all. These could be justified by the adaptability of these variety on humid area to irrigated zone. Considering the few irrigated perimeters, this variety response well for the producers which are satisfied by their production in humid area and disseminated to others zone on the valley of Bénoué. However, variety NL36 has a high yield (4.5 t/ha in rural zone and with potential yield around 6 t/ha), good and

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appreciable for their quality in term of gustation. These variety has short cycle compared to others traditional varieties, which is recommended for Sudano-area in a context of climate change.

In fact, for enhance yield, it is important to use improved varieties, but also recent agricultural strategies and fertilizers (Sallah *et al.,* 2009). Nowadays, agricultural practices used by the producers is endogens. However, the productivity of rice is low due to delay in nursery sowing and late transplanting, faulty methods of cultivation and little or no use of fertilizers. The secret of boosting its yields mainly lies in timely transplanting and proper fertilization the crop (Jagtap *et al.,* 2018). Also, the establishment of crop is very slow in drilling method result in low yields due to heavy weed infestation (Jagtap *et al.,* 2018). But, the introduction of news varieties not satisfy to increase the production of Rice. We could ask that if the quantity of fertilizers should be a factor for optimizing good growing of plants and yields of Rice on a humid area for the populations of rural zone. It is this context that, theses research was made in order to determine the recommended dose of fertilizers recommended for good products of Rice culture in a humid area of the valley of Benoué

II. Materials et Methods

a) Description of the Site

Study was realized at the experimental site of IRAD precisely on Kismatari near to valley of Benoué situated at 15 km of North of the town of Garoua, Cameroon. One site was chosen with geographical coordinates: 09°34'310'' N and 013°27'712'' E. Climate of this locality is Sudano-Sahelean types with two seasons: a short raining season beginning from May to September and long dry season beginning from October to April.

b) Vegetal Material

Vegetal material used is the variety adapted to humid area of type Nerica L36. The variety experimented is Nerica L36 and their characteristics is detailed on the table 1 below:

Table 1: Characteristics of the Variety Nerica L36

Denomination (synonyms)	NERICA L 36
Pedigree	WAS 161-B-6-B-1
Parent	TOG5681/4*IR64
Genetic nature	Pure descendant
Varietal type	*Oryza sativa* x *Oryza glaberrima*
Years of creation	ADRAO (2007)
Date of introduction	2008
Responsible of maintaining	IRAD
Cultural vocation	Humid area, irrigated
Cycle (days)	95-105 days
Seeds texture	long
Weight of 1000 seeds (g)	30 to 40
Potential yields (t/ha)	4 to 6 t/ha
Others characteristics	Tolerant to dryness, good resistance to diseases and insects' good aptitude to transformation: white seeds; organoleptic characteristics: culinary quality not stick.

Sources: Warda (2008)

c) Experimental Design and Treatments Applied

Experimental design was a split-plot with two factors: Factor 1 concerning dose of fertilizers and Factor 2 concerning variety of Rice (*Nerica* L36). Study started on July 2021, with preliminary works like clearing and treatments of experimental unit with herbicide (Momtaz (insecticide and fungicide for the seeds). The surface was 86.975 m^2 constituted of four treatments repeated three time. Two weeks after sowing, we proceeded to remove exceeding plants on pockets in order to have recommended density per pockets and transplanting non germinated pockets to two plants per pockets.

Density of plants is constituted of three levels for sowing: De1=20 cm x 20 cm; De2=25 cm x 25 cm; De3=30 cm x 30 cm. density used for sowing were 250.000 pockets/ha for the distance of 20 cm within lines and 20 cm among pockets of every line; 160.000 pockets/ha for the distance of 25 cm within line and 25 cm among pockets of every line and 111.111,111 pockets for the distance of 30 cm within line and 30 cm among pockets of every line. In every pocket approximatively 5 seeds were sowed.

d) Fertilization of plants

Uses of fertilizers are important in Rice culture because he permit good growing of plants, fructification and maturation process of panicles (padding). One type

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of fertilizers (mineral) was used with formula NPKSB 14-23-14-5-1 and treatments (doses) used is constituted to different levels of doses of fertilizers: T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha).

Table 2: Treatments Providing to the Combination of Mineral Fertilizers Doses and Urea

Treatments	Fertilizers types (Kg/ha) NPKSB (14-23-14-5-1)	Cover fertilizers (Kg/ha) Urea 46%N	Combination
T1	0	100	0kg/ha+100kg/ha urea
T2	150	100	150kg/ha+100kg/ha urea
T3	200	100	200kg/ha+100kg/ha urea
T4	250	100	250kg/ha+100kg/ha urea

e) Data Collection Procedure

Data were collected on 9 plants randomly chosen in order to sample phenological, agro-morphological and yields data the development of plants. Growing parameters obtained by counting are: heading date at 80 %, maturity date, the number of tillers, the height of plant, panicles length, the number of panicles/plant. Harvest data collected is constituted: the number grains/panicles, weight of 1000 grains, potential yields.

f) Statistical Analysis

Statistical analysis was done with the software R commander. Values are estimated in terms of average ± standard error. Means comparison was made using t-student test and ANOVA on the probability of 5 %.

III. Results

a) Agromorphological Aspects

i. *Height of Plants*

Effect of different doses per density on height of plants is presented in table 1. Comparatively within doses, dose 2, 3, 4 were significant (P≤0.05) on growth of height of plants for the three densities (1, 2, 3) considered (20 cm x 20 cm; 25 cm x 25 cm and 30 cm x 30 cm). According to different doses, the height of plants varies from 103 to 111 cm for the dose 2; 107 to 112 cm for the dose 3 and 105 to 115 cm for the dose 4. Which permit to deduce that the doses 2, 3, 4 are favorable on growing on height of plants for the three densities considered of the variety Nerica L36.

Table 3: Height of Plants According of Doses and the Densities

Treatments	Height (cm)		
	Density 1	Density 2	Density 3
T1	92.67±4.51b	102.33±7.57b	102.67±9.71b
T2	103±2.0a	110.33±3.51a	111±3.60a
T3	107.67±0.57a	115.33±2.08a	112.33±1.53a
T4	105.33±1.15a	110.67±2.52a	115.33±3.51a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

ii. *Number of Tillers*

Table 4 present the number of tillers for the different doses per density considered. Compared between the doses, the three doses (2, 3, 4) were significant (P≤0.05) on the number of tillers of plants for three densities (1, 2, 3) considered. Concerning the aspect dose per density, the number of tillers varied respectively of 12 to 22 for the dose 2, 14 to 21 for the dose 3 and 11 to 22 for the dose 4. We could deduce that dose 2, 3, 4 favor a good tillage of plants during growing for all the densities considered of the variety Nerica L36.

Table 4: Number of Tillers According to Doses and Densities

Treatments	Number of tillers		
	Density 1	Density 2	Density 3
T1	9.33±2.08b	14.00±1.73b	15.67±6.1b
T2	12±2.0ab	16.33±1.53ab	22±1.73a
T3	14.67±1.15a	18±1.0a	21.33±2.08a
T4	11.67±1.15ab	18±1.0a	22±1.73a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm).

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iii. *Number of panicles*

Table 5 shows the number of panicles per plants according to doses and different densities. Comparatively between the dose, the dose 2, 3, 4 were significant (P≤0.05) on the number of panicles per plants for the density 2 (25 cm x 25 cm). Considering the doses for the density 2, the number of panicles per plants varied from 16 to 18 compared to dose 1 (14). Contrary, the effect of different doses not influenced the number of panicles per plants for the density 1 and 3. However in comparison within doses, doses 2, 3, 4 increases the number of panicles per plants, deducing that the density 2 improve the number of panicles per plants of the variety Nerica L36.

Table 5: Number of Panicles According to Dose and Densities

Treatments	Number of panicles/plants		
	Density 1	Density 2	Density 3
T1	11±1.0a	14.67±1.15b	16.33±5.51a
T2	14±0.0a	18.33±2.88a	19.33±0.57a
T3	13±1.0a	16.67±0.57ab	19.33±0.57a
T4	12±1.0a	17±2.64ab	18±1.73a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

iv. *Length of Panicles*

Table 6, present the length of panicles for the different doses and per density. Compared among different doses, doses 2, 3, 4 were significant on length of panicles for the density 1 (20 cm x 20 cm) and 3 (30 cm x 30 cm). Effect of different doses not affect length of panicles for the density 2 (25 cm x 25 cm). However, in comparison among doses, the doses 2, 3, 4 increases the length of panicles and permit to deduce that the density 1 and 3 improves the length of panicles of the variety Nerica L36.

Table 6: Length of Panicles According to Doses and Densities

Treatments	Length of panicles		
	Density 1	Density 2	Density 3
T1	23±2.64b	26.33±2.52a	24.33±1.53b
T2	26±1.0a	26.67±0.57a	26.33±1.53ab
T3	26.33±0.57a	26.67±1.15a	26.67±0.57ab
T4	27±1.0a	25.67±2.31a	28±0.0a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

v. *Heading date at 80%*

Table 7 present the effect of different doses per density for sowing for the aspect of heading of plants at 80 %. Referred to different doses, the dose 1 and 2 was significant (P≤0.05) for the density 1 (20 cm x 20 cm) with the number of days varying respectively from 80 to 84 days after sowing. Followed by the dose 2 with 82 days after sowing for the density 2(25 cm x 25 cm). The dose 1 and 2 are favorable for a good heading of plants. Concerning the dose 1, the different densities considered are favorable to heading of plants, contrary for the dose 2, 3, 4, the density 1 and 3 are favorable for heading of plants of the variety L36.

Table 7: Heading Date at 80% According to Doses and Densities

Treatments	Heading date at 80 % (days)		
	Density 1	Density 2	Density 3
T1	84.67±3.05a	82.33±5.13ba	80±2.0a
T2	80.33±3.05ab	76.67±1.15b	78±2.0a
T3	78±1.0c	76.67±0.57b	77.67±0.57a
T4	79.33±1.15bc	77±1.0b	79±1.73a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

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vi. *Maturity Date at Harvest*

Table 8 present the maturity of plants at harvest for the different doses and densities. Comparatively within doses, dose 1 was significant (P≤0.05) to the date of maturity at harvest of plants for the density 1 (20 cm x 20 cm) and 2 (25 cm x 25 cm). However, the dose 1 is favorable for the good maturation of plants of the variety Nerica L36 at harvest for the density 1 and 2.

Table 8: Maturity Date at Harvest According to Doses and Densities

Treatments	Maturity date at harvest (days)		
	Density 1	Density 2	Density 3
T1	114.67±3.05a	112.33±5.13a	110±2.0a
T2	110.33±3.05b	106.67±1.15b	108±2.0a
T3	108±1.0b	106.67±0.57b	107.67±0.57a
T4	109.33±1.15b	107±1.0b	109±1.73a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

b) Yields Aspects

i. *Seeds Number/Panicles*

Table 9 present the number of seeds per panicles according to doses and density. Comparatively within doses, the dose 2, 3, 4 were significant (P≤0.05) on number of seeds per panicles of all densities considered. According to different doses, the number of grains per panicles varies from 130 to 174 for the dose 2, 150 to 174 for the dose 3 and 161 to 186 for the dose 4. However, we could deduce that the dose 2, 3, 4 increases the number of grains per panicles for all densities considered of the variety Nerica L36.

Table 9: Seeds Number Per Panicles According to Doses and Densities

Treatments	Seeds number/panicles		
	Density 1	Density 2	Density 3
T1	116.93±15.95c	131.13±17.58b	144.67±21.54b
T2	130.20±11.64bc	156.67±8.95ab	174.73±9.14a
T3	150.80±29.47ab	151.87±8.05ab	174.40±15.51a
T4	161.53±12.26a	163.53±14.05a	186.93±18.46a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

ii. *Weight of 1000 Seeds*

Table 10 show the weight of 1000 gains according to doses and densities. In comparison within different doses formulated, none significant (P≤0.05) difference was recorded between the doses for all the density considered of the variety Nerica L36.

Table 10: Weight of 1000 Seeds According to Doses and Densities

Treatments	Weight of 1000 seeds		
	Density 1	Density 2	Density 3
T1	26.67±0.85a	26.77±0.50a	26±0.88a
T2	26.43±0.51a	26.33±0.57a	26.70±1.0a
T3	26.33±0.35a	26.43±0.51a	26.67±0.35a
T4	26.10±0.17a	27.13±0.51a	26.77±0.68a

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

iii. *Potential Yields*

Table 11 present the potential yields according to doses and densities. In comparison among the different doses formulated, doses 2, 3, 4 were significant on potential yields of the variety Nerica L36 for all the densities 1, 2, 3 (20 cm x 20 cm; 25 cm x 25 cm and 30 cm x 30 cm). Which permit to deduce that the dose 2, 3, 4 increases the productivity for the three densities considered of the variety Nerica L36.

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Table 11: Potential Yields According to Doses and Densities

Treatments	Potential yields		
	Density 1	Density 2	Density 3
T1	3.83±0.50b	4.53±0.81b	4.30±1.58b
T2	6.57±1.30a	7.50±1.08a	5.60±0.36ab
T3	6.80±1.77a	7.43±0.30a	6.13±0.72a
T4	6.60±0.55a	6.83±0.57a	5.93±1.12ab

NB: Data of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P≤0.05). T1 (0 kg NPKSB+100 Kg Urea/ha); T2 (150 kg NPKSB+100 Kg Urea/ha); T3 (200 kg NPKSB+100 Kg Urea/ha); T4 (250 kg NPKSB+100 Kg Urea/ha). Density 1 (20 cm x 20 cm), Density 2 (25 cm x 25 cm), Density 3 (30 cm x 30 cm)

IV. Discussions

Results of our study showed that within different doses formulated on field, the doses 2, 3, 4 were affect significantly (P≤0.05) height of plant Rice of the variety Nerica L36 for the three densities (1, 2, 3) considered (20 cm x 20 cm; 25 cm x 25 cm and 30 cm x 30 cm). These different doses improve the growing of plants on field and height of plants were highest with the different doses formulated. Works of Amedep et al. (2022) showed that height of plants of the variety Nerica 60 responses well to fertilization with organic manure during their growing stages. Similarly works of Moussa et al. (2021) on mineral fertilization (cereals complex and urea) of Nerica Rice variety with different doses showed a highest height of plants Rice during their growing.

Numbers of tillers for the variety Nerica L36 were significantly (P≤0.05) highest with the uses of different doses of fertilizers formulated. Tillers number were improved with the doses 2, 3, 4 for all density considered. However, tillers stages of plants were good for the three densities considered. Works of Amedep et al. (2022) showed a highest number of tillers for the variety ITA 300 during the growing of plants with the dose of organic manure. Similarly, Moussa et al. (2021) found significant growing of tillers of the variety Nerica 4 and 8 with mineral fertilizers (cereals complex and urea). In the same, works of Raholimboahangy (2015) showed that uses of different NPK treatments were significant on the number of tillers. Soils of Riziculture are mostly deficient in Nitrogen element for good growing pf plants (Raholimboahangy, 2015).

Uses different doses of NPK fertilizers increased the number of panicles of the variety Nerica L36. The doses 2, 3, 4 significantly (P≤0.05) improve number of panicles for the density 2 (25 cm x 25 cm). Works of Moussa et al. (2021) on different doses of mineral fertilizers based on cereals complex and urea showed also a significant number of panicles of plants Rice. Our study corroborates with works of Lacharme et al. (2001) and Akintayo et al. (2008), founded that use of mineral fertilizers on variety Nerica 4 and 8 favor a good density of panicles during growing.

Results of study showed that the uses of different doses of mineral fertilizers were significantly (P≤0.05) highest on the length of panicles with the doses 2, 3, 4 of the variety Nerica L36, compared within the doses for the density 1 and 3. These different doses improve the length of panicles with the density 1 and 3. Works of Nadjilom et al. (2020) showed positive responses on length of panicles of two varieties of Rice with the mycorrhized than non-mycorrhized treatments in South-Chad.

Results on heading date at 80% of plants showed that for all the doses and densities considered, the dose 1 and 2 was important for the density 1 (20 cm x 20 cm). Followed by the dose 2 with density equal to 25 cm x 25 cm. The dose 1 and 2 are considered for good heading of plants, but the dose 2, 3, 4 responses well to heading of plants with the density 1 and 3, contrary to the dose 1 which responses well for all the densities considered of the variety Nerica L36. Maturity of plants at harvest was significant for the dose 1 (20 cm x 20 cm) and 2 (25 cmx 25 cm). which permit to deduce that the dose 1 is favorable for good maturation of plants of the variety Nerica L36 at the harvest for the two densities. Contrary, works of Asmamaw (2015) showed that plants density was not affect full heading at 74 DAT and physiological maturity (104 DAT) of Rice (*Oryza sativa*).

Our results of number of seeds per panicles with uses of different doses and density showed that number of seeds per panicles were significantly (P≤0.05) highest with the dose 2, 3, 4 with all the densities. The number of seeds per panicles of the variety Nerica L36 increased for all the densities considered. Same results were made by Nadjilom et al. (2020) which showed important seeds number per panicles of two varieties of Rice with the mycorrhized than non-mycorrhized treatments in South-Chad.

Weight of 1000 seeds for the variety Nerica L36 were not significantly (P≤0.05) affected by the uses of different doses of mineral fertilizers for all density considered. Contrary, works of Dieng (2021) showed a significant effect of doses of organo-mineral on the weight of 1000 seeds of Rice.

Potential yields recorded by the uses of different dose of mineral fertilizers and densities showed that doses 2, 3, 4 were significant highest (P≤0.05) on potential yields of the variety Nerica L36 for all densities considered. These different doses increase the productivity of plants for the three densities of Nerica

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L36. Same results were also found by Dieng (2021) on grains yields of Rice with uses of doses of organo-mineral on growing and yields of Rice. Works of Saidou et al. (2014) showed a significant difference among different forms of fertilizers applied concerning grains yields of the variety Rice IR841 et Nerica-L14.

V. Conclusion

Objective of this study was to determine the doses and densities which responses well on the degraded soil of the north, especially with the variety Nerica L36 on growing and yields parameters at the experimental site of the Institute of Agricultural Research for Development (IRAD), Cameroon. Concerning growing, the doses 2, 3, 4 are recommended for increase and improve the productivity of culture for all densities considered. Study permit to conclude that densities 1, 2, 3 are good for optimizes the yield of culture of the variety Nerica L36.

Acknowledgment

Authors are grateful Institute of Agricultural Research for Development (IRAD), Multipurpose Station of Agricultural Research of Garoua.

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Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 23 Issue 2 Version 1.0 Year 2023
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-587X

Analysis of Risk Management in Poultry Production Enterprises in AKWA IBOM State

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Abstract- The study analyses risk management strategies among poultry enterprises in Akwalbom State, Nigeria. Multistage sampling technique was to select 122 poultry farmers for the study. Data obtained were analyzed using descriptive, inferential statistics and maximum likelihood estimates. Results of the study revealed that majority 54.9% were male with a mean age of 49 years. All farmers had formal education, 23.2% were primarily farmers with 6 years mean farming experience. The farmers had average household size of 4-6 persons and mean off farm income of N70, 050. About 48.4% were members of cooperative societies and 41.8% had a farm size of 100-200 birds per production cycle. Major sources of risk associated with poultry enterprises in the area included financial/credit risk, health risk and market risk. Most adopted risk management strategies were avoidance measures of fencing and netting and use of foot dips at the entrance. The result of the Maximum Likelihood Estimates revealed that age, off farm income, farm size and medication cost were the factors affecting output of poultry farmers.

Keywords: risk management; risk, poultry; poultry production.

GJSFR-D Classification: DDC Code: E LCC Code: Z2002



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Analysis of Risk Management in Poultry Production Enterprises in AKWA IBOM State

Ebong, V. O [α] & Awatt, N. K [σ]

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Keywords: risk management; risk, poultry; poultry production.

I. Introduction

Across the globe, risk has a considerable influence on agricultural production and in some parts of the world has led to fundamental changes in production patterns and condition (Maurer, 2014). Risk is considered as an important aspect of farming business. The uncertainties inherent in weather, yields, prices, government policies, global markets and other factors that impact agricultural production can cause wide swings in farm income (USDA, 2006). Typically, farmers make decisions in a risky environment every day. The consequences of their decisions are generally not known when the decisions are made.

Following OECD (2011) production risks caused by weather, pest and diseases as well as market and price risks are more prevalent in agriculture. Risk arises from the high variability of production outcomes, farmers are unable to predict with certainty the amount of output their production will yield, because of external factors such as weather, pest, diseases and other natural calamities (Abimbola, 2013). On the other hand, marketing (price) risks are more pronounced in agribusiness than in other economic sectors (Maurer, 2014). Both inputs and outputs price volatility are sources of market risk in agribusiness. Prices of agricultural products are typically volatile and farmers face a considerable price uncertainty. The price is usually not known as at when production decisions are taken. Prices vary with levels of production and demand at the time of sale (Iheke and Igbelina, 2016). Inelastic demand for many agricultural products are often cited as the main explanation for agricultural price variability where small increases in production can result in large price swings (World Bank, 2004).

According to Anton (2009), risk management strategies start with decisions on the household; on the set of outputs to be produced, the allocation of the land, the use of other inputs and techniques including irrigation and the diversification of activities on and off farm. Farmers can also manage market risk with instrument which includes insurances and future markets. Following Harwood, Coble, Pery and Somwani (2000). Risk Management can be seen as choosing among alternatives to reduce the effects of risk. Effective risk management therefore involves anticipating outcomes and planning a strategy in advance given the likelihood and consequences of events not just reacting to those effects after its occurrence (Effiong, Enyenihi and George, 2014). Keeping poultry is a part of life in rural Africa (Sonaiya, 2005) and it accounts for 25% of local meat production in Nigeria (Okunlola and Olofinsawe, 2007).

Poultry is an important aspect of economic development in Nigeria economy because it serves as a source of food, income, employment and poverty alleviation (Adene and Oguntade, 2006). Poultry offers a range of uses to human which include provision of meat and egg, research and medicinal purpose, production of manure which helps to improve soil fertility and also feathers from poultry birds provides human with aesthetic value. Specifically the roles of poultry in providing the much needed animals protein for the increasing population cannot be over emphasized (Udoh and Etim, 2009).

According to Akpabio, Okon, Angba and Abu (2007), Poultry production is the second most important subsector of most developing countries. In Nigeria it is estimated to be above 140 million birds which make it to be well developed in poultry industry among West

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African Nations. Daily Independent report of 2014 shows that 14 million people are directly or indirectly engaged in commercial poultry while the rural family poultry with cumulative value of N320 billion are managed by 85million people.

Poultry industry in Nigeria has suffered a great deal of losses, which affects poultry farmers as well as poultry consumers (Ogeke, 2009). Nigeria presently produces above 550,000mt of poultry meat per annum and 700,000mt of eggs (FAO, 2014). Despite this, the country is far from meeting her domestic demand when compared with developed countries that are involved in poultry production due to high level of risk involved in poultry production activities (Atteh, 2004).

In Nigeria, factors that range from climatic variability, crop yield failure, input price variability, incidences of pest and diseases, environmental degradation, pollution from industrial sites, oil spillage, insecurity among others are the factors that make farmers inadequately equipped against risks and uncertainties (Ayinde, 2008). In developing countries, farmers also lack access to both modern instruments of risk management such as agricultural insurance, future contracts or guarantee funds and emergency government assistance as such farmers rely on different "traditional" coping strategies and risk management techniques which are mostly inefficient (Wenner, 2010). A general lack of accurate information on the risks sources and mitigation strategies in the livestock sector combined with insufficient veterinary and breeding services, non-existence or inadequate regulations concerning production, commerce and animals health control are also other important obstacles to the mitigation of risks in poultry production (FAO, 2008). These factors bring about uncertainty in poultry production and thus affects the supply of poultry products in the market.

The importance of risk management associated with poultry production will be better appreciated when it is realized that 70% of Nigerian population are farmers (Ekong, 2010) and 4 in every 10 Nigerian are involved in poultry farming (Saddiq, et al 2016). These farmers generally lack the understanding of risk as well as approaches to managing risk.

There is therefore a need for a thorough assessment of risk management strategies adopted by poultry farmers in the state and also, an understanding of the types of risk being faced by these farmers and how their businesses are affected by these risks. Specifically, the study examined the socio economic characteristics of poultry farmers, identified the major risks faced by poultry farmers in the area, examined the risk management factors in poultry production and determined factors affecting the output of poultry production enterprises.

II. Methodology

This study was conducted in Akwalbom State, Nigeria. Akwalbom State lies in the south -south geopolitical zone of the country. The state lies between Latitude 4°33' and 5° 33 North and Longitude 7°25' and 8°21 East. The 2006 census of the Nigeria Population Commission put the state's population at 3,920,208 out of which 2,044,510 are male while 1, 875,698 are female(NPC 2006). The state falls within the tropical zone. Its dominant vegetation is the green foliage of trees and shrubs and the oil palm tree belt which holds the highest density of the cash crop in the world. A multistage sampling technique was used to select 122 poultry farmers for the study. Data collection was through personal interviews and the use of well-structured questionnaire. Descriptive, inferential statistics with multiple regression models were used to analyze data collected.

The Model used is Specified in the Implicit form as:

$Y = F(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9) + e$

Y = Poultry output (annual sales in Naira)

X_i = Age (years)

X_2 = Educational qualification (Years of formal education)

X_3 = Farming experience (Years)

X_4 = Off farm income (₦)

X_5 = Cooperative membership (member = 1, non-member = 0)

X_6 = Farm size (number of birds stocked)

X_7 = Labour Cost (₦)

X_8 = Medication cost (₦)

X_9 = Feed cost (₦)

e = Error term

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a) Likert Scaling

On major risk faced in poultry production enterprises, a 3 point Likert scale was used to assess the level of severity of each risk encountered by respondents based on Not severe, Severe, Very severe. Rank 1 was considered the most severe risk and Rank 29 was the least severe risk.

A4 point Likert scale rating of Strongly agree, Agree, Disagree, and Strongly disagree was employed in examining the risk management strategies adopted in the study area by the respondents. In achieving this objective, a high mean score indicates a general high adoption rate of a risk management factor and a low mean score signifies a low adoption rate.

III. Results and Discussion

The distribution of respondents based on their socio economics characteristics is presented in table 1. The result showed that 54.9% were males with a mean age of 49 years. The result further reveals that young people were involved in poultry production in the study area as the industry is dominated with people who are able to tackle risks challenges that is associated with poultry farming. This finding is within range with the findings of Yusuf and Malomo (2007) who reported a mean age of 44 years for poultry farmers in Nigeria. All respondent had formal education as 41.8% of the respondents were HND/BSc holders and had spent an average of 16- 20 years obtaining formal education. It is seen that educational level of farmers is important in poultry management as this will afford them the opportunity to understand and adopt modern farming practices thereby increasing their responses to risk. Majority (82%) of the respondents were married, only 23% were engaged in farming as their primary occupation and about50.8% had 6 – 10 years poultry farming experience. This result implies that the farmers are well experienced in the business and possess risk bearing abilities. This finding was in line with Oladumi and Fatuase (2014) who reported that majority of poultry farmers have been in poultry business for at least 6 years.

The result further revealed that most (50%) of the respondents had household size within the range of 4-6 persons, A large household size will make family labour available to most poultry enterprises in the study area. This finding is in consonance with the National household average of 5.9 persons (NBS, 2016).

The monthly income range of farmers in the area was ₦30,000 – ₦180,000 with an average monthly off farm income of ₦70,500. 48.4% of the respondents were seen to be registered members of cooperative and 41.8% of the respondents had a flock size of 100 – 200 birds. This result agrees with Omalayo (2018) who stated that majority of poultry farmers have less than 500 birds in their farms and this may be attributed to high cost required to operate in large scale. Survey conducted on farmers nearness to market showed a mean distance of 938.11m which indicates that the respondents did not have markets quite close to their farms. Ogolla (2016), stated that a long distance to market will reduce the possibility of poultry farmers to increase their production because of the risk associated with high cost of transportation. It was also seen that (63.1%) of the respondents had water sources available in their farms thus making supply of clean water readily for farming purposes which in turn will minimize the spread of intestinal disease among birds (Lacy, 2002).

Table 1: Distribution of Poultry Farmers based on their Socio-Economic Characteristics

Item	Selected Variables	Frequency n – 122	Percentage %	Mean
1.	Sex			
	Male	67	54.9	
	Female	55	45.1	
2.	Age (years)			
	27 – 37	16	13.1	49
	38 – 48	50	41.1	
	49 – 59	32	26.2	
	60 – 70	24	19.7	
3.	Educational Qualification			
	No formal education	0	0	
	Primary	2	1.6	
	Secondary	19	15.6	
	ND/NCE	41	33.6	
	HND/BSc	51	41.8	
	Postgraduate	9	7.4	
4.	Years of formal education (years)			
	6 – 10	7	5.7	15
	11 – 15	57	46.7	
	16 – 20	58	47.6	
5.	Marital Status			

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	Single	7	5.7	
	Married	100	82.0	
	Separated	3	2.5	
	Widowed	12	9.8	
6.	Primary Occupation			
	Farming	28	23	
	Trading	18	14.8	
	Civil Servant	60	49.2	
	Artisans	3	2.5	
	Others	13	10.7	
7.	Farming experience (years)			
	< 1 – 5	56	45.9	6
	6 – 10	62	50.8	
	11 – 15	3	2.4	
	> 16	1	0.8	
8.	Household size			
	1 – 3	13	10.7	3
	4 – 6	61	50	
	7 – 9	35	28.7	
	> 10	13	10.7	
9	Off Farm Income (N)			
	< 10,000 - 50,000	26	21.3	70,500
	50,001 – 100,000	74	60.5	
	100,001 – 150,000	18	14.1	
	> 150,001	4	3.2	
10.	Membership to cooperative			
	Yes	59	48.4	
	No	63	51.6	
11.	Farm size (Number of birds)			
	100 – 200	51	41.8	
	201 – 400	44	36.9	306
	401 – 600	22	17.2	
	601 – 800	3	2.4	
	>801	2	1.6	
12.	Labour Type			
	Family	53	43.4	
	Hired	68	55.9	
	Family/Hired	1	0.8	
13	Distance to market(m)			
	100- 1000	91	74.6	938.11
	1001-2000	22	18	
	>2001	9	7.4	
14	Distance of source of water(m)			
	Sources of water at the farm	77	63.1	41.5
	100- 200	43	35.2	
	201- 400	2	1.6	

Source: Field Survey Data, 2022

a) Major Risk Faced in Poultry Production Enterprises

Results on table 2 reveals the major risks encountered by poultry entrepreneurs. These risk were categorized into environmental risks, human/personnel risk, financial/credit risk, production risk, market/price risks, legal/institutional risk and health risk. Twenty-nine (29) variables were selected based on the these major sources of risk and a 3 point Likert scale was used to assess the level of severity of each risk encountered by respondents. The most severe risk were: high interest rate with mean score of 2.61, failed vaccines with a mean score of 2.50 and disease outbreak with a mean score of 2.47.

Akanni (2007), considered poultry production as a high risk investment by most financial institutions due to high rate of poultry mortality, low productivity and low levels of loan repayments. This situation has led to skepticism on the part of financiers when considering financial request for poultry production hence, the high interest rate. This result reveals that poultry farmers are faced with limited credit facilities to purchase items and this limits productivity and expansion in the sector. In addition, Butcher and Yegeni (2009) listed the causes of

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vaccine failure to be improper administration/handling of vaccines, maternal antibodies, stress, poor timing, immune suppression, poor management practices, poor quality of vaccines and modifications in vaccines. He further stated that a well-designed, well timed and soundly executed vaccination coupled with good management, nutrition and bio security will decrease the probability of disease problems and increase the likelihood the flock will perform to its genetic potential. Saddiq*et al*. (2016), Identified outbreak of diseases as the highest source of risks in poultry businesses. This he attributed to the prevalence of widespread diseases such as Avain Influenza, Newcastle, Gomboroetc coupled with weather conditions. These diseases require reliable vaccines which are not often available (Lawal*et al.*, 2009). This result further agrees with Ihekeand Igbelina (2016) who maintained that disease outbreak was among the most severe risk faced by poultry farmers and those risks directly affects farmers' incomes and can be a threat to the future of their farms (Briner and Finger, 2012).

From the result, it can be deduced that the most prevalent sources of risks in the area are financial risk, health and marketing risks.

The survey revealed the least severe risk in the study area to be: rotting of eggs at storage, ill-health of farmers/worker, inadequate information to upgrade production technique, accumulation of drugs and technological failure. This indicates that poultry farmers in the area maintained good hygiene conditions. This may be attributed to the fact that the use of this measure is cost effective (Effiong *et al*., 2014).

Table 4.2: Distribution of Respondents Based on Major Risk Faced by the Poultry Production Enterprises

S/N	Factors	NS	S	VS	Mean	Rank
	Environmental Risk					
1	Fluctuation in weather	20(20.5)	66(54.1)	31(25.4)	2.05	14
2.	Shortage of feed	58(47.5)	52(42.6)	12(9.8)	1.62	22
3.	Shortage of water	38(31.1)	64(52.5)	20(16.4)	1.85	19
	Human and Personnel Risk					
4.	No brooding technical knowhow for mass production of chicks	66(54.1)	43(35.2)	13(10.7)	1.57	23
5.	Inadequate information to upgrade production technique	72(59.0)	41(33.6)	9(7.4)	1.48	27
6.	Poor personal management	18(14.8)	62(50.8)	42(34.4)	2.20	9
7.	Ill-health of farmer/worker	70(57.4)	47(38.5)	5(4.1)	1.48	28
	Financial/ credit risk					
8.	High interest rate	2(1.6)	43(35.2)	77(63.1)	2.61	1
9.	Unavailability of credit facilities	15(12.3)	51(64.7)	50(41.0)	2.29	7
	Production risk					
10.	Low output	34(27.9)	58(47.5)	30(24.6)	1.97	16
11.	Technological failure	62(50.8)	53(43.4)	7(5.7)	1.55	25
12.	Poor parent stock	42(34.4)	68(55.7)	12(9.8)	1.75	20
13.	Low quality of feed	57(46.7)	53(43.4)	12(9.8)	1.63	21
14.	Theft	22(18.0)	85.(69.7)	15(12.3)	1.94	17
15.	Death of birds	8(6.6)	72(59.0)	42(34.4)	2.28	8
16.	Inadequate stock	25(20.5)	54(44.3)	43(35.2)	2.15	11
17	Erratic power supply	18(14.8)	62(50.8)	42(34.4)	2.20	9
	Market/price risk					
18	Transportation problems	21(17.2)	79(64.8)	22(18)	2.01	15
19.	High cost of improved breed	13(10.7)	79(64.8)	30(24.6)	2.14	12
20.	High cost of feed	8(6.6)	69(56.6)	45(36.9)	2.30	6
21.	High cost of vaccines	7(5.7)	59(48.4)	56(45.9)	2.40	5
22.	Rotting of eggs at storage	83(68.0)	37(30.3)	2(1.6)	1.34	29
23.	Fluctuation in prices of output	2(1.6)	65(53.3)	55(45.1)	2.43	4
	Legal/ institutional risk					
24.	Un favourable government policies	27(22.1)	57(46.7)	38(31.1)	2.09	13
	Health risk					
25.	Accumulation of dungs	66(54.1)	48(39.3)	8(6.6)	1.53	26
26.	Failed vaccines	6(4.9)	49(40.2)	67(54.9)	2.50	2
27.	Disease outbreak	4(3.3)	57(46.7)	61(50.0)	2.47	3
28.	Accident	59(48.4)	58(47.5)	5(4.1)	1.56	24
29.	Inadequate veterinary services	27(22.1)	79(64.8)	16(13.1)	1.91	18

Source: Field Survey data, 2022

Note: figures in parenthesis are percentages and frequencies otherwise.
Rank 1 is considered the most severe risk.
Rank 29 is the least severe risk.
NS - Not severe, S – Severe, VS - Very severe.

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b) Risk Management factors in Poultry Production

Data from Table 3 showed that fencing/ netting was the most adopted risk management factor in the study area. This finding is synonymous with that of Effiong *et al.* (2014) who maintained that fencing and netting was the most utilized risk management practice adopted by poultry farmers as this is necessary to protect the farm against predators and theft. The second most adopted factor was the use of foot dips at entrances of pen. Respondents practiced the use of foot dips at entrances to prevent introduction of infection, incidence/spread of diseases and cross infection to stock on farms (Kaoud, 2016). Proper storage of input and poultry products ranked third from the survey. This strategy is adopted to cope with production risk as the stored product can increase liquidity of the farm by providing supplementary cash reserve in light of unexpected events.

The finding from table 3, agrees with Salman et al. (2013) who posited that farm insurance was the least utilized strategy in mitigating risk. Consequently, future markets are not usually adopted by poultry farmers because the contracts may not be honoured by both the traders and farmers and may further become a risk if the output is lower than expected (Kahan, 2013).

The result however showed that poultry farmers tend to rely solely on their poultry production enterprises and rarely practiced diversification. Salimonu and Falusi (2009) reports that diversification is not mostly adopted because it sometime requires increase capital and more management time. In this way, diversification while minimizing risk, often reduces potential farm income. Alderman (2008) stressed that diversification can reduce production risk by improving efficiency in resource use and enhance sustainability of the natural resource base. It was also observed that poultry farmers in the area operate in small scale. Hence, unavailability of space may hinder the practice of separation of birds by species as a reduction factor. The result revealed that poultry farmers tend to focus more on the management of production risk by employing various risk reduction factors because no single strategy can cover all the risk likely to be encountered by the farmers.

Table 3: Risk Management Factors in Poultry Production Enterprises

S/N	Factors	SD	D	A	SA	Mean	Rank
	Avoidance/Preventive measures						
1.	Ensuring proper and timely vaccination	-	2(1.6)	49(40.2)	71(58.2)	3.57	4
2.	Use of footdips at the entrance	-	2(1.6)	36(29.5)	84(68.9)	3.67	2
3.	Fencing and netting	-	2(1.6)	32(26.2)	88(72.1)	3.71	1
4.	Disinfecting of poultry house	-	23(18.9)	77(63.1)	22(18.0)	2.64	24
5.	No or controlled access to visitors	-	1(0.8)	71(58.2)	50(41.0)	3.40	8
6	Avoid overcrowding of birds	-	5(4.1)	81(66.4)	36(29.5)	3.25	10
7	Separation of birds by age	2(1.6)	42(34.4)	72(59.0)	6(4.9)	2.67	22
8	Proper ventilation of poultry house	-	18(14.8)	63(51.6)	41(33.6)	3.19	13
9	Control of rodent and pest	-	16(13.1)	78(63.9)	28(23.0)	3.10	16
10	Use of sawdust	3(2.5)	14(11.5)	77(63.1)	28(23.0)	3.07	17
11	Separation of birds by species	12(9.8)	46(37.7)	47(38.5)	17(13.9)	2.56	26
12	Use of disease tolerant breed	6(4.9)	43(35.2)	61(50.0)	12(9.80)	2.65	23
	Mitigation/reduction measures						
13	Diversifying into crop and other livestock activities	16(13.1)	43(35.2)	47(38.5)	16(13.1)	2.51	27
14	Buying input in advance	-	3(2.5)	85(69.7)	34(27.9)	3.25	10
15	Appropriate nutrition in feed	1(0.8)	32(26.2)	82(67.2)	7(5.7)	2.78	21
16	Producing the feed myself	34(27.9)	77(63.1)	10(8.2)	1(0.8)	0.56	30
17	Getting my feed from known source	6(4.9)	39(32.0)	70(57.4)	7(5.7)	2.63	25
18	Getting water from safe and known source	-	5(4.1)	62(50.8)	55(45.1)	3.41	7
19	Getting birds from known as safe sources	1(0.8)	3(2.5)	50(41.0)	68(55.7)	3.52	6
20	Use of preventive medical treatment	-	5(4.1)	78(63.9)	39(32.0)	3.27	9
21	Quarantine of sick birds	-	8(6.6)	78(63.9)	36(29.5)	3.22	12
22	Provision of constant power supply	2(1.6)	28(23.0)	76(62.3)	16(13.1)	2.87	18
23	Proper record keeping	2(1.6)	12(9.8)	73(59.8)	35(28.7)	3.16	14
24	Proper collection of eggs	1(0.8)	11(9.0)	77(63.1)	33(27.0)	3.16	14
	Retention/Coping measures						
25	Keeping extra cash at hand incase of emergency	-	4(3.3)	45(36.9)	73(59.8)	3.56	5
26	Off farm income	2(1.6)	34(27.9)	71(58.2)	15(12.3)	2.81	19
27	Attending extension workshops	6(4.9)	34(27.9)	60(49.2)	22(18.0)	2.80	20

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28	Proper storage of input and poultry products	-	6(4.9)	39(32.0)	77(63.1)	3.58	3
	Transfer measures						
29	Insuring my poultry birds	25(20.5)	58(47.5)	36(29.5)	3(2.5)	2.13	29
30	Taking future market	9(7.4)	54(44.3)	51(41.8)	8(6.6)	2.48	28

Source: Field Survey Data, 2022

Note: figures in parenthesis are percentages and frequencies are otherwise.
SA - Strongly agree, A - Agree, D - Disagree, SD - Strongly disagree

c) *Factors influencing the reduction of risk on the output of Poultry Farmers*

The maximum likelihood estimates using four functional forms in poultry production in Akwa Ibom State are presented in table 4. The exponential function was chosen as the lead equation based on number of significant variables, value of $R^2$and F- statistics. The R^2 value was 0.802 which indicates that 80.2% of the total observed variations in poultry output were explained by the variables included in the model while 19.8% of the variation was due to error. The result also shows that 4 variables were statistically significant and conform to a prior expectation. The F-ratio was 50.45 which was statistically significant at 1% indicating a high goodness of fit of the model.

The coefficient of age was statistically significant at 5% and was negatively related to output. This inverse relationship implies that the age of the farmer does not necessarily increase their output. The increase in the output of the farmer depend more on other factors than their age. This is in consonance with Effiong, *et al.* (2014) who found a negative relationship between age and the output of the farmers. The coefficient of off farm income was significant at 10% level and a positive regression coefficient of 0.478. This implies that a unit increase in off farm income of the respondents would lead to an increase in the reduction of risk on the output. Effiong, *et al.* (2014) in Iheke and Igbelina (2016) however reported that increased income will assist farmers in tackling additional risk on the farm without being risk averse. This will lead to an increase in output of the poultry products and will help farmers to generate income needed to manage other forms of risk. Iheke and Igbelina (2016) attributed it to the fact that an increase in income will enable the farmer to adopt proper risk management practices.

Number of birds was significant at 5% and earned a positive regression coefficient of 0.301 which implies that a unit increase in the number of birds by the respondents will lead to an increase in the reduction of risk on the output by 0.301. Ajieh (2010) in Effiong, *et al.* (2014) stated that in situations where farmers have increased farm size and engage in diversified practices, it will serve as a better way of managing risk and reduce impact on the output of farmers. The coefficient of medication cost was significant at 10% and it is positively related to the output. This implies that as the cost of medication increases, the output of the farmer increases by 0.198. Medication can be employed to reduce disease outbreak and mortality of birds. This result is consistent with Ihekeand Igbelina (2016) who noted that if medications administered are efficient, it will reduce the risk on the output of the farmers.

Table 4: Estimated Regression Results for the Effect of Risk Reduction Factor of Output

Variables	Linear model	Exponential Model	Double log model	Semi log model
Constant	29684.732 (1.171)	10.062 (51.941)	1.534 (1.461)	-459612.049 (-2.672)
Age	-0.121 (-2.023)**	-0.111 (-2.506)**	-0.102 (-2.447)**	-0.095 (-1.338)
Education Qualification	-0.001 (0.016)	0.057 (1.338)	0.039 (0.964)	0.013 (0.181)
Farming Experience	0.046 (0.787)	0.056 (1.290)	0.042 (1.034)	0.035 (0.507)
Off Farm Income	0.181 (1.870)*	0.418 (5.879)***	0.469 (6.208)***	0.293 (2.282)**
Cooperative Membership	0.046 (-0.766)	-0.012 (-0.282)	-0.024 (-0.577)	-0.060 (-0.862)
Farm Size	0.630 (3.075)***	0.301 (1.994)**	0.195 (1.268)	0.408 (1.556)
Labour Cost	-0.251 (-1.852)*	-0.038 (-0.382)	-0.028 (-0.289)	-0.064 (-0.397)
Medication Cost	-0.011 (-0.082)	0.198 (1.920)*	0.178 (1.528)	0.008 (0.042)
Feed Cost	0.257 (1.498)	0.096 (0.761)	0.169 (2.043)**	0.093 (0.660)

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R^2 AdjR2 F = ratio	0.635 0.606 21.658***	0.802 0.786 50.452***	0.823 0.808 57.691***	0.487 0.446 11.811***

Source: Field Survey Data, 2022

Note: The figures in brackets are the representative t – ratios
*, **, *** are significant at 10%, 5% and 1% probability

IV. Conclusion

From the result, it was observed that poultry industry the study area is made up of mainly small scale farmers who engage in farming on part-time basis, and had at least 6 years of farming experiences.

It could be concluded that most farmers were faced by various sources of risk and young male individuals who are married owned poultry production enterprises. The most severe farming risk associated in poultry production in the area were credit/ financial, health and marketing risk. Majority of the farmers employed avoidance and preventive measures as their major risk management strategies. Age of the farmer, off farm income, number of birds and medication cost were the major factors influencing the output of poultry production enterprises in the study area. Therefore efforts should be made at reducing interest rate and training of farmers on feed formulation. In conclusion, farmers should be encouraged to diversify into crops and other livestock related activities and purchase insurance as measures to help them manage risk in their poultry production enterprises.

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10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



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Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



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Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755896



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