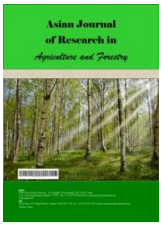

Asian Journal of Research in Agriculture and Forestry

5(4): 1-10, 2020; Article no.AJRAF.54996
ISSN: 2581-7418

Impact of Climate Change on Arable Crops among Farmers in Akko Local Government, Gombe State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors ISO and MAM designed the study, wrote the protocol and managed the analyses of the study. Author NGN wrote the first draft and managed the literature searches. Author OOA performed the statistical analysis. Authors NKD and OBK managed the literature searches of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2020/v5i430089
Editor(s):
(1) Dr. Hamid El Bilali, International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) and Mediterranean Agronomic Institute of Bari (CIHEAM-Bari), Italy.
Reviewers:
(1) Ali Raza, Chinese Academy of Agricultural Sciences, China.
(2) Agu Eensaar, Tallinn University of Applied Sciences, Estonia.
(3) Pradeep Mishra, College of Agriculture, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/54996

Original Research Article

Received 01 January 2020
Accepted 03 March 2020
Published 12 May 2020

ABSTRACT

The study was conducted on the impact of climate change on arable crops production among farmers in Akko Local Government Area of Gombe State, Nigeria. A multistage sampling method was adopted selecting one hundred and fifty respondents. Both primary and secondary data were collected covering a period of five years. The data collected were subjected to descriptive statistics. The research found that male farmers within the age bracket of 20-40 years dominate the farming system, with 62.2% being married and having one form of formal education or the other. The result indicated that 92.9% of the respondents are aware of climate change and are predominantly small land holders. The farmers highlighted increased in drought period, higher temperature, erosion,

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desert encroachment, loss of vegetation and reduced vegetation as effects of climate change. It was revealed that 92.9% of the respondents' cropping patterns have been affected by climate change. To cope with these effects, farmers diversify their enterprises. The findings show that farming activities such as deforestation, clean clearing, bush burning, open grazing contributes to climate change. The amount of rainfall experienced from 2015-2019 in the area was moderate. The respondents use farmers' saved seed as planting materials with 62.2% comprising of improved seed. The result indicates that over 95% of the sampled population uses synthetic and organic fertilizers in soil management. From the result, 52.0% of the respondents obtained good yield during the period under study. However, farmers engaged in different cropping systems to mitigate the effect of climate change. It is recommended that extension services should be improved to educate farmers more on adaptation strategies to increase output; Research Institutes should develop more advance or improved seeds as well as disseminate same to farmers timely and adequately.

Keywords: Climate change; arable crops; deforestation; bush-burning.

1. INTRODUCTION

The global impact of climate change on socio-economic sector includes water resources, agriculture, food security, forestry, fisheries, ecological systems, human health and settlements [1,2]. The projected impact of climate change centers on earth's environmental uncertainties and hence changes in weather would include disruption of temperature distribution, precipitation, evapo-transpiration, clouds, air-currents and consequential shifts in the vegetation belts, melting of polar ice-caps in the temperate, rise in sea level that could adversely affect low-lying areas and much more [3,4,5]. These changes by extension affect crop production in many ways, among which are; uncertainty and variations in the pattern of rainfall and flood, increased temperature, high relative humidity among others [2,6,5]. These result into erosion of top soil, reduction of arable land, irregularity in planting date, cropping system, temperature and water stress, and an increase incidence of pests and diseases infestation [7,8].

More so, climate change has been reported to affect yield of most staple crops such as maize, cassava, melon, sorghum and yam by about 2.5% per annum [9]. Likewise, cash crops such as cocoa, cashew, orange, kola-nut, oil palm, rubber, cotton and coffee suffer severe setback under reduced photoperiods with flower and fruit abortion trends that reduce yield by 5.5metrictons per hectares [1]. Climate change also has impact on forest resources through losses of medicinal plants, mushrooms and bush meat [10,11].

The impact of climate change on the population and livelihood of Nigeria's farming communities include floods, sand deposition, mud accumulation, salination of irrigated farmlands, poor health condition of farmers and ocean surges [12,13]. According to [13], ocean surge cause erosion of farm land and landslide of between 250 –270m2/ year. However, studies on adaptation to environmental changes are not new to mankind. Societies have demonstrated strong capacity for adapting to different climatic and environmental changes [1,2,6]. The adaptation mechanisms of notice include altering the time of planting dates to adapt to changing growing conditions as described by [14] in pulses, altering cropping mix and forest species that are better suited to the changing climatic conditions was reported by [15,6]. While, [16,17,2] showed other methods such as breeding new plant species and crops that are more tolerant to changed climate condition, promoting fire suppression practices in the event of increased fire risk due to temperature increases, controlling insect out breaks, ecosystems and Wildlife, protecting and enhancing migration corridors to allow species to migrate as the climate changes, identifying management practices that will ensure the successful attainment of conservation and management goals in-line with promoting management practices that confer resilience to the ecosystem water resources. More so, [6,2] reported improving water use efficiency, planning for alternative water sources (such as treated wastewater or desalinated seawater), and making changes to water allocation/irrigation, conserving soil moisture through mulching and other means and much more. This study is therefore important as it aims at identifying and articulating the impact of these constraints and adaptation strategies among arable crops

farmers in Akko Local Government Area of Gombe State, Nigeria.

1.1 Objectives

i. To assess the impact of climate change on soil fertility and productivity in Akko Local Government Area.
ii. To assess farmers' perception on rainfall and its impact on crop production in the study area

2. MATERIALS AND METHODS

This study was conducted in Akko Local Government Area of Gombe State, Nigeria. It is located at latitude 9° 46'N, longitude 10° 57' E. A descriptive survey design was used for this study to obtain information about various variables from a representative sample of farmers. Multistage sampling procedure was carried out in this study to select one hundred and fifty (150) farmers within Akko Local Government Area of Gombe State. Primary data were obtained from the farmers through administration of questionnaire which covered a period of Five (5) years, 2015-2019. The secondary data was obtained on rainfall and relative humidity from the Meteorological station of Federal University of Kashere. The data serve as prove to change in climate of the study area and link it with the data obtain from the field. One hundred and thirty-eight questionnaires were retrieved and information analyzed. The data collected from the field was analyzed using descriptive statistics.

3. RESULTS AND DISCUSSION

Table 1 shows the secondary data obtained on rainfall and relative humidity from the meteorological station of Federal University of Kashere. The data serve as prove to change in climate of the study area in connection with the data obtain from the field.

3.1 Demographic Information of the Respondents

From the results in Table 2, male respondents were 82% as females were 17.3% which reflect the dominance of male farmers in the study area. Studies have shown that women are marginalized in most societies in developing countries [18,19] and these limits their access to natural recourses such as land, thereby reducing their involvement in agriculture and access to extension services [20]. Similarly, 62.2% were married which implies they receive supply of cheap and readily available family labor. More so, marriage enhances sharing of information and knowledge among households. This could promote adaptation among farmers. Majority of the farmers falls within the age bracket of 20-30 years with 32.7%, while those between 40-50 years were 27.6%. These imply that most of the farmers are still within the productive age of youths with viability of energy in agricultural production. The result revealed that 60.2% of the farmers had one form of formal education or the other while the remaining 39.8% had no formal education. It could be inferred from this that literate farmers dominate the study area though the level of literacy differed. Hence, acquisition of formal education would increase the receipt of information on climate, leading to broader knowledge and adaptability.

Table 1. Mean values of Meteorological Report from the Department of Geography, Federal University of Kashere (2015 – 2019)

Year	Rainfall (mm)	Relative humidity (%)
2015	1006.00	10665.40
2016	2183.23	16160.20
2017	1258.00	14253.00
2018	1147.00	1641.40
2019	978.20	21532.60

Source: Meteorological report from the Department of Geography, Federal University of Kashere (2015 – 2019)

Table 2. Bio-data of respondents

Bio-data	Frequency	Percentage
Sex		
Male	114	82.70
Female	24	17.30
Age (years)		
20-30	45	32.70
30-40	35	25.50
40-50	38	27.60
50 and Above	20	14.30
Marital Status		
Married	86	62.20
Single	52	37.80
Education		
Formal	83	60.20
Informal	55	39.80
Total	138	100.00

Source: Field survey, 2019

3.2 Effects of Climate Change on Crop Production

The result in Table 3 shows that 42.9% of the respondents cultivates one hectare of land or less, implying that majority of the farmers are subsistence farmers with small scale farm sizes. Meanwhile, 37.8% cultivates 2-3 hectares of farm land and 19.4% farmers cultivate 4-5 hectares of land. This shows that the farmers were predominantly small land holders which are in conformity with the assertion of [21] that small holder farmers cultivate between 0.8 to1.2 ha of land. This could be attributed to the declining availability of land for agriculture due to climate change, urbanization and increasing population which consequently lower farmers' productivity. From the result, it indicates that most (58%) of the respondents have farmed for over 10 years in their life time. This is a good and long time enough to dictate changes in climate. As noticed by [22] that those with the greatest experience of farming are more likely to notice climate change. According to [1] evidence has shown that climate change is already affecting crop yields in many countries. This is particularly true in low-income countries, where climate is the primary determinant of agricultural productivity and adaptive capacities are low [23,24].

Consequently, a greater proportion, 92.9%, of farmers knew about climate change. These changes have caused effect in diverse ways. The result indicates that the effect of climate change in the study area is noticed in increased in drought period (29.6%), higher temperature (43.9%) and erosion (18.4%). Climate change remains a source of concern among farmers as drought due to low rainfall destroys their crops and reduce yield. Both the atmospheric and soil temperature increased drastically thereby affecting arable crop growth and yield. Erosion affects many areas thereby made them unsuitable for cultivating arable crops. These damages cause significant economic loss directly or indirectly [25]. According to [26], climate change with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture and food. Hence, increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security.

About 75% of the respondents have noticed desert encroachment in the study area. This collaborate the assertion of [27] who stated that desertification phenomenon has been reported in the northern Nigeria, with Gombe State having a moderate rate of desertification. Loss of vegetation in some areas due to accumulation of sand deposited by wind has rendered some areas uncultivable. The signs of desert encroachment noticed were heavy wind accompanied with sand, high temperature, change in relative humidity and reduced vegetation with a record of 37.8%, 7.1%, 25.5% and 25.5% respectively (Table 4). Accordingly, this encroachment has resulted to change in cropping pattern of the respondents. It was revealed that 92.9% of the respondents' cropping patterns have been affected by climate change in one way or the other. Thus, this leads to diversification of enterprises to counter the shortfall experienced from the cultivation of arable crops. In response to the cropping methods adopted among the respondents, 4.1% are into sole cropping, 71.4% of the farmers' practices mixed cropping, whereas 17.3% engaged in intercropping. As observed by [28], farmers in rural Kenya integrate crop and livestock production as a measure to cope with the changing climate. The finding indicates that 98.0% of the respondents' have recorded positive impact due to the cropping method practiced against climate change.

Table 3. Effects of climate change on crop production

Farm size (Hectare)	Frequency	Percentage
0.1-1	59	42.90
2 – 3	52	37.80
4 – 5	27	19.40
Experience (Years)		
1 – 5	31	22.60
6 – 10	26	18.50
11 – 15	29	21.30
Above 15	52	37.60
Awareness of climate change		
Yes	128	92.90
No	10	7.10
Effect of climate change		
Increased	41	29.60
drought period	61	43.90
Higher	25	18.40
temperature	11	8.10
Erosion		
Others		
Total	138	100

Source: Field survey, 2019

Table 4. Climate change and adapted cropping systems among respondents

Awareness and adaptation	Frequency	Percentage
Notification of desert encroachment		
Yes	104	75
No	35	25
Signs of desert encroachment		
Heavy wind accompanied with sand	52	37.8
High temperature	10	7.1
Reduced vegetation	35	25.5
Relative humidity	35	25.5
Others	6	4.1
If climate change affects cropping system		
Yes	127	92
No	11	8
Adapted cropping systems		
Sole cropping	6	4.1
Mixed cropping	99	71.4
Intercropping	24	17.3
Others	10	7.2
If cropping method is beneficial		
Yes	135	98
No	3	2
Contributions of farming activities to climate change		
Deforestation	33	24
Bush burning	56	40.6
Clean clearing	33	23.7
Others	16	11.7
Change in rainfall pattern	138	100
Yes	121	87.8
No	17	12.2
If rainfall decides when farming activities should be carried out		
Yes	123	89
No	15	11
If rainfall affects choice of crop		
Yes	116	84.4
No	21	15.5
How does rainfall affects choice of crop		
Early rainfall	86	62.2
Late rainfall	52	37.8
Total	138	100

Source: Field survey, 2019

The result exposes that 88.3% of farmers' activities such as deforestation, clean clearing, bush burning, grazing contributes to climate change. Deforestation exposes soil to danger and affects water cycle. Other effects of deforestation as mentioned by [29] include increase in temperature, decrease in rainfall, destruction of biodiversity, low agricultural yield, air pollution and degradation of landscape. All these effects culminate into climate change. Bush burning causes pollution and destroys soil beneficial organisms. The rainfall pattern in the study area has changed to the notice of 87.8% of the respondents. Rainfall is the major source of soil moisture for arable crop production. All crops need adequate moisture for efficient growth, hence, inadequate or excessive rainfall can lead to low productivity in crop. Over 80% of agriculture (both crop cultivation and animal production) in Gombe State depends mainly of rain fed [30], which is to a large extent conditioned by the patterns of rainfall in terms of amount, duration, intensity and distribution. This pattern in rainfall determines the choice of crop to cultivate.

3.3 Respondents' Perception on Amount of Rainfall in the Study Area

Fig. 1 show that in 2015, respondents viewed rainfall to be moderately distributed. This was highlighted by 66% of the total population of the sample. This implies that rainfall did not pose any harm on the yield in 2015; hence, it was adequate for most arable crops. In 2016, rainfall was perceived to be moderate (58.2%), thus, encourage better output at harvest. For the years 2017, 2018 and 2019, respondents perceived that rainfall was mostly moderate as it recorded 61.2%, 51.1% and 63.3% respectively. Both the atmospheric and soil temperature, and relative humidity required by crops were perceived to be favorable and supportive for arable crop production when the rainfall is not too high or too low. This findings support the report from the meteorological station which gave the average rainfall of 1314.48 mm for the period under study (2015-2019). This shows that the rainfall within the study area was moderate, collaborating the perception of the respondents. According to [1], the published results from many different models and on the basis of the evidence had estimated that by the year 2100, the global average surface warming (surface air temperature change) will increase by 1.1 – 6.4°C., the sea level would rise between 18 and 59 cm. It is very likely that hot extremes, heat waves and heavy precipitation events would continue to become more frequent.

3.4 Agronomic Practices

3.4.1 Tillage practices

Table 5 shows that 66.3% farmers practiced ploughing as method of tilling the soil before planting, most farmers used mould board plough drawn by animals in preparing a good seed bed for planting. The reason behind using mould board plough by majority of the farmers is that the nature of the soil, soil type, availability of the implement, financial strength of the farmer are all considered before choosing the appropriate method of tillage. A small proportion of 17.3% farmers do harrow their farms directly using tractor drawn implement. This has to do with financial capacity of a farmer as only few farmers can afford tractor for farm labour. Harrowing breaks the soil clods, improved soil aeration, increase water infiltration rate, easy penetration of root into the soil. However, it loses the soil and makes it prone to erosion. Considering effect of climate on soil and destruction of soil structure by machines, zero/no till or minimal tillage is encourage so as to help the soil regain its depleted properties.

3.4.2 Planting materials

The findings in Table 5 indicate that most (70.4%) of the respondents uses farmers' saved seed as planting materials while 20% and 9% source for planting materials from the open market and the Research Institutes respectively. On improved seed as planting materials, 62.2% of the respondents used improved seed. The improve seed being the product of research is now available for farmers use as certified seed. The seed posses all the qualities needed to withstand climate change, the seed passed from breeder seed or genetic seed to foundation seed stages. Looking at the effect of climate change and how to adapt to it, improved crop varieties possess qualities like early mature crops, pest and disease resistance, drought tolerance among others. If crops were resistant to the climate change, farmers can be able to obtain and sustain their livelihood. High proportion of farmers selects the best seed from their yield and used as planting material for next season. Quality seed, seed vigour, germination percentage, seed size, structure, viability are some of the characters observed by farmers before they select and save the seed for multiplication. For those farmers using the improved seed, 69.40% observe difference yield in using improved seed.

3.5 Soil Management

3.5.1 Type, time and method of fertilizer application

Among the respondents, the result indicates that 95.9% of the sampled population uses chemical fertilizer as a method of managing the soil. Accordingly, 38.80%, 55.10%, 3.0% and 6.10% of the respondents adopts Urea, NPK, SSP and other forms of synthetic fertilization respectively. This result could be attributed to the many constituents of NPK. The fertilizer quantity depends on farm size, crop type, nature of soil and the capacity of the farmer. Fertilizers are good for crop production but the negative impact should also be considered. On the other hand, organic fertilizer is used by 96.9% of the respondents. This shows that respondents combine both synthetic and organic fertilizers in their arable crop production. This use of organic fertilizer could be as a result of the short supply and high cost of synthetic fertilizers. Although,

organic fertilizer is known not be readily available, requiring large quantity and has slow mineralization of nutrients. Yet, it is used for sustainable soil conservation. The result also reveals that 27.5% of the farmers apply fertilizer at ploughing, 73.5% of the farmers apply fertilizer after sowing. The methods used in fertilizer application among farmers are: drilling (19.4%), broadcasting (35.7%), basal (40.8%), while others methods (4.1%). Fertilizer application is more effective and useful when buried in the soil. As most farmers use basal method of application, the fertilizers are washed away. Hence, drill method of application is most conservative and efficient. Meanwhile, majority (91.83%) of the respondents apply organic fertilizer, before ploughing. Organic fertilizers are applied before the setting in of rain so that it can remain in the soil and decompose gradually hence incorporated at ploughing.

Table 5. Tillage operations and soil management practices

Management practices	Frequency	Percentage
Tillage method practiced		
Ploughing	91	66.30
Harrowing	24	17.30
Both Ploughing and Harrowing	22	16.30
Source of planting materials		
Farmers' saved seed	97	70.40
Market	28	20.40
Research institute	13	9.20
If improved seed is used		
Yes	86	62.20
No	52	37.80
If there is difference in using improved seed		
Yes	96	69.40
No	42	30.60
If chemical fertilizer is applied		
Yes	132	95.90
No	6	4.10
Type of fertilizer		
Urea	54	38.80
NPK	76	55.10
Others	8	6.10
Time of fertilizer application		
At ploughing	34	24.50
After sowing	101	73.50
Others	3	2.00
Method of fertilizer application		
Drilling	27	19.40
Broadcasting	49	35.70
Basal dressing	56	40.80
Others	6	4.10
Use of organic fertilizer		
Yes	134	
No	4	3.10
Time of application of organic fertilizer		
Before ploughing	127	91.83
At ploughing	3	2.00
At sowing	7	5.10
during crop growth	1	1.00
Total	138	100.00

Source: Field survey, 2019

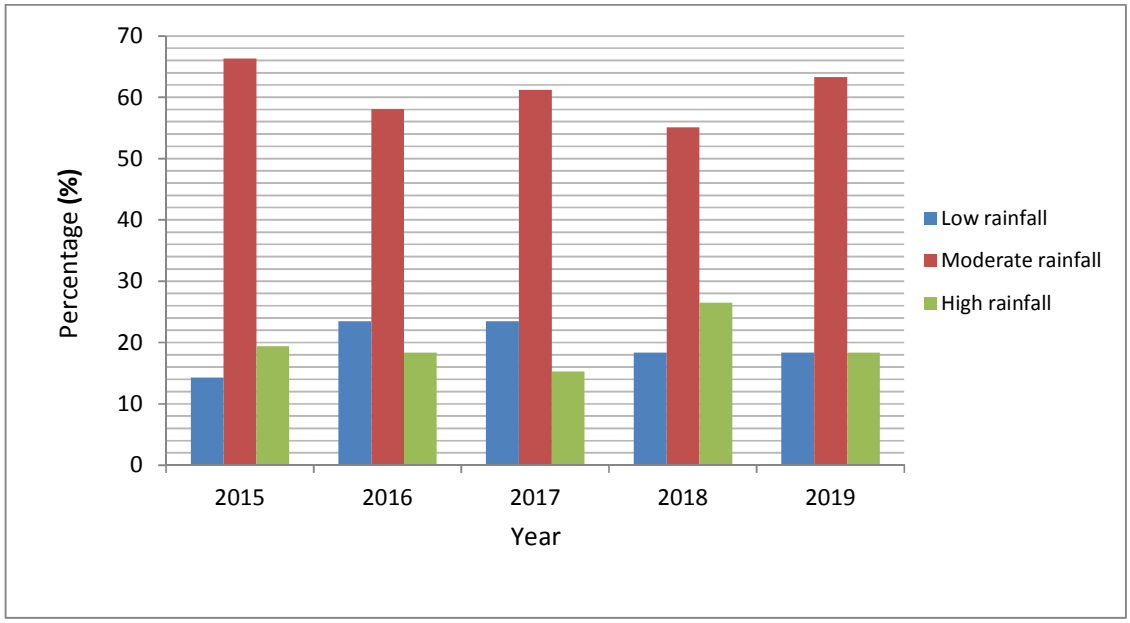
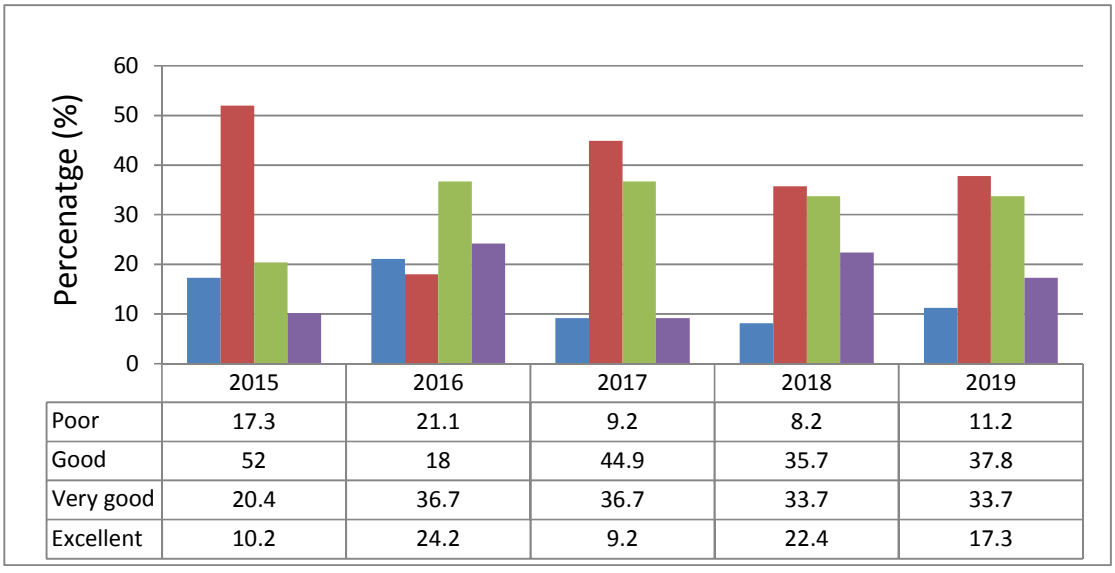


Fig. 1. Respondents' perception on rainfall

3.6 Yield Assessment from the Year 2015 – 2019

For 2015 cropping season, 52.0% of the respondents obtained good yield (Fig. 2), while 20.4% had very good yield. This could be attributed to the moderate rainfall experienced in the study area. In 2016, the year with the highest quantity of rainfall (2,183.23mm), good yield (8%) was recorded whereas 32.7% had very good yield while excellent yield was recorded by 11.2%. Nevertheless it was revealed that 44.9% of the respondents had good yield. Farmers output depends on the level of input and investment by farmers. Farmers that invest much on inputs and labor stand a better chance of bumper harvests. In 2017, 2018 and 2019, the respondents had good output.



	2015	2016	2017	2018	2019
Poor	17.3	21.1	9.2	8.2	11.2
Good	52	18	44.9	35.7	37.8
Very good	20.4	36.7	36.7	33.7	33.7
Excellent	10.2	24.2	9.2	22.4	17.3

Fig. 2. Assessment of respondents' yield from the year 2015 – 2019

4. CONCLUSION

Climate change has created serious concern and alteration in the abiotic components of agriculture, hence, affected farmers' practices and yield in crop production in the guinea savannah agro ecological zone of northeast, Nigeria. Consequently, the variation in rainfall pattern, increase in atmospheric and soil temperature, long drought period, desert encroachment and other effects of climate that affect productivity made farmers to engaged in different cropping systems to mitigate the effect of climate change. It is therefore recommended that extension services should be improved to increase awareness and educate farmers more on adaptation strategies to improve crop performance and yield; farmers should form cooperatives to enable them raise funds for bulk input purchase; the Research Institutes should develop more advance or improved seeds as well as disseminate same to the farmers timely and adequately.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/54996