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Evaluation and Demonstration of Irrigation Regime on Cotton: Evidence from Small Plot Adaptive Research in Katsina State, Nigeria

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Abstract **Original Research Article**

Cotton production output in Nigeria, is far below on-station potential yields owing to poor seeds, adulterated fertilizers, unimproved cultural practices, and soil infertility. Small plot adaptive demonstration technology transfer mechanisms under irrigated conditions were organized in 2021, in collaborations with the Institute for Agricultural Research. The recommended packages disseminated were the use of improved varieties SAMCOT 9, SAMCOT 11 and SAMCOT 13, herbicide application, land preparation, watering, planting, gap filling, weeding, fertilizer application, pest control, harvesting and processing. The result reveled that all the participants were male, and more than two-third were in productive age. Also, majority had adequate household size and adequate farming experiences. However, low literacy constitutes the larger majority. The results of the demonstration revealed that farmers obtained a yield of (1,401.3kg), less than on-station potential yield (1,600kg to 2000kg). Further result on cost and return revealed that farmers' production expenses rose to N410, 700:00, while the revenue generated is N420, 800:00, having a net profit of N9, 690:00. Additionally, aphid infestation and late demonstrations were ranked as the top amongst the production constraints; others were irrigation water drying in the dam, livestock encroachment, climatic stress, and inconsistence seed germination. Conclusively, improved farm technology has great potential in enhancing the cotton productivity and profitability through small plot adaptive demonstration trials in Batagarawa, Mai'aduwa, Dutsinma, Kafur, Malumfashi and Faskari Local Government Areas of Katsina State, Nigeria. It is recommended that farmers' literacy level need to be enhanced via adult literacy initiatives and other production constraints require utmost solutions.

Keywords: Cotton production, Irrigation scheme, small plot adaptive research, Katsina State Nigeria.

INTRODUCTION

Cotton is a significant cash crop to a considerable number of developed and third world countries, and it has been noted to strongly curtail the impact of poverty and increased small holders' per capita income [1]. The lint and seeds gotten from cotton plant are converted into fiber in textile, edible oil, about 28% used for home furnishings, and 8% for industrial applications [2] As documented by [3] enumerated a wide range of cotton seed usages as a source oil cholesterol-free, cosmetics ingredient, pharmaceuticals, and personal care products, in feed formulation of livestock and poultry. Affirmatively, [4] documented that in the year 2016 alone, the sum of USD 748 billion and 786 billion were generated from cotton supports to global market of textile mills and the world apparel manufacturing market that is making garments for extensive use.

Sub-Saharan Africa (SSA) produced fifteen percent of world cotton lint exports because of its significances in giving high economic returns; it is projected to expand by 14% by 2025. The major beneficiaries of the proceeds were China and Southeast Asia, extended to consumer markets in North America and the European Union (EU) (OECD and FAO, (2016) cited in [5]. In Nigeria, before the advent of oil boom, cotton used to be the major sources of foreign exchange and occupied the second largest creator of work force after the public sector [6]. Cotton is produced widely, in 19 out of the 35 states of the federation, even though, it

is dominant around the Savannah belts of Nigeria. Geographically, cotton-producing areas in Nigeria are divided into three ecological zones, namely, the Northern cotton zone provides 60 to 65%, while the Eastern cotton zone produce 30 to 35%. The Southern cotton is the third zone, contributes 5% CBN, (2011) quoted in [7]. Katsina is the largest producer of cotton in Nigeria, in conjunction with other potential northern producing areas meets the nations' human and industrial requirements [8]. However, Nigeria, which is notably considered as a leading cotton producer in Africa and occupied 12th position amongst the largest in the world, is envisaged to witness an insignificant production drawback of 20.29% of Africa's cotton production by 2029, based on the antecedents of dwindling outputs performance. According to OECD-FAO Agricultural outlook 2020 report, it is estimated that by the end of 2020, the Nation quota within share of African's cotton production stood at 27.89%, when equated with projected Africa's cotton production share in 2029, is expected to decline by about 7.60% [9]. This concurred with [10] pointed that the average yield obtained by peasant cotton grower per unit area in the country is far below on-station potential yields owing to; poor use of seed varieties, adulterated chemical fertilizers, unimproved cultural practices, and poor fertility of the soil.

Efforts to salvage the deplorable production situation commenced in 2015, the Raw Materials Research and Development Council (RMRDC) in partnership with the Institute of Agricultural Research (IAR), under the patronages of the National Cotton Association of Nigeria (NACOTAN) distributed cotton seed varieties to farmers; SAMCOT 7' 8' 9' 10' 11' 21' and 13', estimated to the tune of 5.82 tons and it has yielded to an uptake of 5% cotton production between 2015 and 2017 in the country [11]. Additionally, the crop became a focus commodity under the Anchor Borrower Program initiatives of the Central Bank of Nigeria (CBN). The program provides small-scale farmers with necessary inputs in cash and in-kind services to enhance productivity, also, Katsina state, being the leading cotton-producing state in the country, in the year 2019, the Governor of the CBN launched the distribution of cottonseeds to 150,000 cotton farmers in the state, accompanied with inputs such as (fertilizers, pesticides, and knapsack sprayers) with the expectation of yields improvement per hectare, from 1 to 4 metric tons [12]. Equally, the Apex Bank in 2021 has further aimed to reach out to more farmers and provides the necessary assistance to cultivate 80,000 hectares with a projection of an average yield 120,000 tons at 1.5 metric tons per hectare [13].

Evidently, these interventions have prompted the Katsina State Government to renew its effort in revamping cotton production to its previous levels and have collaborated with the Institute for Agricultural Research (IAR) Zaria that has the National mandate for genetic improvement and development of cotton varieties in Nigeria. The partnership involves the trail of three cotton varieties and the promotion of farmers' adoption of the tree varieties: Samcot-9, Samcot- 11, and Samcot-13, employing Small-plot Adaptive Research Technology Transfer Mechanisms under irrigation farming in six (6) different multi-locational trails covering the State three agricultural zones [14]. Empirical studies done in cotton production in the state found in the works of [15] evaluated foliar blend micronutrient fertilizer on cotton production. While [16] made a comparative analysis of cost and returns in cotton production with and without contract farming scheme. Whereas [17] dwelled on cotton value chain analysis, with [18] focus on determinants of allocative efficiency of non-contract cotton farming. None of the research that evaluates the status of farmers' adoption of cotton technology under the current revitalization initiatives via irrigated practices. Thus, empirical evidence justifies the study.

The main research objective is to evaluate improved cotton production practices disseminated through small plot adaptive research under irrigation regime. Specifically, this study is undertaken to:

a. Describe socio economic characteristics of respondents in the study area.
b. Examine cotton production recommendations extended to farmers under irrigation demonstration trials.
c. Determine cost and return of cotton production.
d. Ascertain constraints to cotton production in the study area.

RESEARCH METHODOLOGY

Study Area

This study was conducted in Katsina State, North-western Nigeria. The state has a total land area of 23,938 square kilometers located between longitudes 110 and 130 East: and latitudes 60 and 90 North. The projected population of the state was put at 7,452,629 and has 34 Local Government Areas (LGAs) [19]. The climate is semi-arid with average annual rainfall of about 689 mm falling between May and September. The state lies within three agro-ecological zones: Sahel Savanna, Sudan Savannah, and Northern Guinea Savannah [20]. The research was conducted in 6 irrigation sites, in six (6) LGAs of Dustina, Batagarawa, Malumfashi, Kafur, Faskari and Mai'adua that covers three agricultural zones of the state.

Sampling Techniques

Based on the lists of the existing dams and prospective cotton producers obtained from Agricultural Development Programmes (ADPs). Purposive sampling was used to select six irrigation areas as a pilot that covers three agricultural zones belonging to six (6) Local Government areas (LGAs) of

the State namely, Sabke (Mai'aduwa LGA), Ajiwa (Batagarawa LGA), Zobe (Dutsinma LGA), Mai'ruwa Faskari LGA), Ruwan Sanyi (Malumfashi LGA), and Sulma (Kafur LGA) respectively. More so, purposive sampling was adopted to select five (5) progressive farmers each from the six irrigation demonstration's locations that bring the total number of thirty (30) respondents. Since the mission of the state is to restore previous high cotton production pedigree through irrigation, in addition, to rainfed production using the aforementioned approach and the use of the use of innovators within members of the community, otherwise known as progressive/lead farmers became imperative due to their nature of risk taking and accept innovation. In addition, the method is a trickle-down technology diffusion approach, being well progressive farmers will play a greater role in transferring and persuading their fellow colleagues to use the practices.

Data Collection

The data was obtained from primary and secondary sources with the aid of well-structured questionnaires administered to the respondents. Data were collected based on the respondents' socio-economic variables, cotton agronomic practices, as well as cost and returns and problem encountered by the respondents.

Analytical Technique

The analytical tools that were used for this study include descriptive statistics and gross margin analysis.

Descriptive Statistics

The descriptive statistics that used includes percentage and frequencies. This was used to analyze the socio- economic characteristic of respondents, recommended agronomic, as well as the problem association with cotton production to achieve specific objectives (i), (ii) and (iv).

Gross margin Analysis

Gross margin analysis was utilized to determine the costs and net profit generated from cotton production to achieve objective (iii). Following the works of [21] and [22], it is expressed as follows:

GM = TR-TVC

Where:
GM = Gross margin of cotton farmers in (₦).
TVC = Total variable Cost (₦).
TR = Total Revenue (₦).

Respondents' Age, Household Size, Education, Farming Experience and Farm Size

The result in Table 1 on farmers' socio-economic shows that respondents' ages ranged from 25 to above 50 years, and were categorized into three, such as young age (up to 35 years), middle age (36-50 years) and old age (above 50 years). The result further indicates that farmers' household size ranged from 5 to above 8 members. Farming families were classified into three distinctions. Those sizes of (up to 5 members) were considered as small family, while (6-8 members) fall under medium family and large family contains (above 8 members) respectively. It revealed that majority (47%) of the farmer had medium sized family, followed by large sized family (30%) and the least (23%) small sized family. More so, educational level of cotton farmers indicates that more than two-third (80%) falls within no formal to primary education, respectively. In addition, result in Table 1 on experience in irrigation farming documented that the proportion of respondents who had 11-15 years of farming experiences was greater (56.7%) than those who had either 1- 5, 6-10 or 16-20 years of experience. The study further showed that all the respondents (100%) utilized 0.20 hectare of land, respectively.

Table 1: Distribution of cotton farmers according to age, sex, family size, level of education, farming experience and farm size (n=30)

Parameters	Categories	Frequency	Percentage
Sex	Male	30	100
	Female	0	0
Age	Young age (up to 35 years	04	13.3
	Middle age (36-50 years)	24	80.0
	Old age (above 50 years)	02	6.7
Household size	Small family (up to 5 members)	7	23.0
	Medium family (6-8 members)	14	47.0
	Large family (above 8 members)	9	30.0
Educational level	No formal education	14	46.7
	Primary	10	33.3
	Post primary	04	13.3
	Graduate	02	6.7
Years of experience	1-5	03	0.9
	6-10	17	56.7
	11-15	08	26.7
	16-20	02	6.7
Farm size	Marginal (0.00-0.20 hectare)	30	100

Source: Field survey data, 2021

Cotton Production Recommendations Extended to Farmers

For the extension agents to be much acquainted with technical aspects and other challenges to diffusion and farmers' uptake of the technology, the Institute for Agricultural Research (IAR), Ahmadu Bello University Zaria has provided technical expertise via capacity building trainings to ADPs extension agents. In addition, during the production period, several monitoring visits were conducted by representatives of the State Ministry of Agriculture and Natural Resources (MANR), Katsina State Agricultural and Rural Development Authority (KTARDA), IAR and Commodity Associations (CA). Also, a field day was conducted at Sulma irrigation area that has the attendance of different stakeholders in the production circle.

On the other hand, Small Plot Adaptive Demonstration Trials (SPADTs) were undertaken by the experts from the IAR and five (5) progressive farmers, each were allocated with 0.20 hectares in each of the 6 irrigation areas namely, Sabke, Ajiwa, Zobe, Mai'ruwa, Ruwan Sanyi and Sulma, making sample of 30 respondents that cut across of the three agricultural zones belonging to the state. Apparently, extension agents demonstrated the practices to farmers after which were replicated, while observations and comments on grey areas were made by resource persons in attendance. The agronomic practices extended to farmers' in cotton production includes; the use improved cotton varieties SAMCOT 9, SAMCOT 11 and SAMCOT 13, herbicide application, land preparation, watering, planting, gap filling, weeding, fertilizer application (NPK (20:10:10) and Urea (42:0:0) fertilizers at the rate of one bag (50kg) and half bag (25kg), pest control the use of insecticide Pymetrozine or Chlorantraniliprole 10 to 13 times at the rate of 2 sprays per a liter (approximately 39 liters), harvesting and processing. The yield of the three cotton varieties under trials were documented, which revealed that, in all the six (6) different multi-locational demonstration trials, farmers obtained a total output of**(**1,401.3kg), as against the research station potential yield of (1,600kg to 2,000kg). Indeed, this is a remarkable and a milestone production performance recorded, being a pilot test of the crop that has not been in extensive cultivation for more than a decade. It is pertinent to note that, if other production challenges are ameliorated, the attainment of potential yield and beyond can be possible. The finding corroborates with other empirical research that proved the efficacy of field demonstration techniques of technology transfer on farmers' uptake and yield of crop [25, 26].

Costs and Returns of Small Plot Adaptive Trials of the Six Irrigation Schemes

Input-output information from the smallholder farmers' cotton growers of the six demonstration trials were used to compute gross margins. Gross margin is the total revenue (TV) obtained from individual enterprise (gross value of production), whereas the total variable costs (TVC) are the production cost incurred within production period. Normally it is obtained by removing total production costs from the total amount of money realized from the sales of the produce, and the remaining balance represent gross margin or net profit of the investment [27]. The findings in Table 4 elucidated the expenditures made for the entire cotton growing period and the total amount of cash generated. The variable costs were seed N1,500, land clearing N1,500, watering, and harrow N6,500, land preparation N3,000, planting N3,000, weeding N12,000, fertilizer and applications N14,000, pesticide and applications N12,000, watering and labour N10,000, harvesting N3,000 and purchase of bags at N450. On the other hand, the gross margin otherwise known as net revenue from the three cotton varieties yield obtained from the 6 demonstration locations are as follows SAMCOT 9: produced 435.6kg, SAMCOT 11: yielded 441.1kg and SAMCOT 13 generated 524.6kg. The total outputs were (1,401.3kg) respectively. While the prevailing market price of cotton as at the time of the research was N300/kg.

The gross margin relationship is stated as follows:

Gross margin = (TR –TVC)

The total revenue accrued to the farmers' coffers were determined by obtaining the total value of product sold based on current market prices, minus production costs to arrive at the net income, as illustrated as follows.

Thus, the total outputs of the three (3) varieties planted in each of the six (6) demonstration centers were as follows 435.6kg + 441.1kg + 524.6kg = (1,401.3kg), while the prevailing market price of cotton as at the time of the study stood at N300/kg:

Then, 1,401.3kg x N300 = N420, 480:00
Minus production costs N410, 700:00
Net profit per farmers **N9, 690:00**

Consequently, each farmer made a net profit of Nine Thousand, Six Hundred and Ninety Naira (N9, 690:00) only. This corroborates with empirical studies of [28, 29]. In the same note, [30] claimed that popularized improved cowpea variety promoted through frontline demonstrations gave a higher gross return, net returns with higher benefits cost ratio comparable to farmers' conventional practices.

Table 3: Revenues, variable costs, and gross margins of cotton farmers under six irrigation schemes

Farm type	Gross value (cotton)	TVC (Production costs)	Gross margin (Net profit)
6 Cotton farms	SAMCOT 9: 435.6kg. x N300 = N130,680	Seed N1,500	
		Land clearance N1,500	
	SAMCOT 11: 441.1kg. x N300 = N132,330	Watering & harrow N6,500	
		Land preparation N4,000	
	SSMCOT 13: 524.6kg x N300 = N157.380	Planting N3,000	
		Weeding N12,000	
		Fertilizer & labor N14,000	
		Pesticide & labor N12,000	
		Watering & labor N10,000	
		Picking N3,000	
	130,680+132,330+157,380	Empty bags N450	
Total revenue	N420.390	**Total expenditures:** N68,450 x 6 = N410,700.00	**Net profit** N9.690

Source: Field survey data, 2021

Constraints to Cotton Production

Data analysis in Table 4 disclosed that farmers were facing challenges related to cotton production, prominent among which is the aphid infestation and late production commencement that recorded (100%) each, respectively. More so, (47%) complaints on early drying of water from their irrigation dams due to effect of climate change. Whereas (57%) witnessed livestock encroachment in their farms. The results of the analysis further revealed that (80%) lamented of cold periods stress especially in the months of December to January. Consequently, (73%) of the respondents experienced inconsistent seed germination.

Table 4: Constraints to cotton production

Parameters	Frequency	Percentage
High aphid infestation	30	100%
Late commencement of demonstration	30	100%
Early drying of source of water supply	14	47%
Livestock encroachment	17	57%
Climatic stress	24	80%
Inconsistent seed germination	22	73%

Source: Field survey data, 2021

DISCUSSION OF THE FINDINGS

The findings of respondents' socioeconomic characteristics in Table 1 designated that the highest farmers' proportion (80%) were in the middle-aged group (36-50 years), and it presumes that farmers under such group were more active, enthusiastic in execution of cotton recommended practices. The outcome of this study concurred with [23] research in Bangladesh where they reported that majority (47%) of farmers were in the middle age grade. Also, result of family size revealed that the higher (47%) had medium sized (6-8). This corroborate with the empirical research conducted, in Mymensingh District of Bangladesh discovered the sizable proportion (56.7%) of cattle fattening farmers were in medium sized [24]. Result of the analysis in Table 1 further indicated respondents had low literacy level, as more than two-third (80%) fall within no formal to primary education, respectively. It infers that their literacy level could not cope with the technological demands, and this need urgent attention towards attaining full production capacity that will cater for human and industrial demands of the product. More so, substantial number (56.7%) had (11-15) experience in irrigation farming, which gives them greater impetus to enhance their production efficiency in cotton production. Consequently, all the respondents (100%) have utilized 0.20 hectare of land specified for the demonstration trials, respectively.

The result in Table 2 revealed that 11 recommended production practices were extended to farmers within the six (6) demonstration trials, and farmers obtained a total output of **(**1,401.3kg), as against the research station potential yield of (1,600kg to 2,000kg). Nevertheless, the production had not attained the expected yield potential, but was a remarkable performance, taking into cognizance that, it is the first pilot demonstration trials being implemented towards resuscitating previous production pedigree. The finding corroborates with other empirical research that proved the efficacy of field demonstration techniques of

technology transfer on farmers' uptake and yield of crop [25, 26].

The findings in Table 3 illuminated the expenditures incurred for the season and total revenue generated. Respondents spent the sum of Four Hundred and ten Thousand, Seven Hundred (N410, 700:00), in the purchase of; seed and bags, land clearing, watering and harrow, land preparation, planting, weeding, fertilizer and applications, pesticide and applications, watering and harvesting. On the other hand, the net revenue generated from cotton sales rose to Four Hundred and Twenty Thousand, Four Hundred and Eighty Naira (N420,480:00), and each farmer realized a net profit of Nine Thousand, Six Hundred and Ninety Naira (N9,690:00). This corroborates with empirical studies of [28, 29]. In the same note, [30] claimed that popularized improved cowpea variety promoted through front line demonstrations gave a higher gross return, net returns with higher benefits cost ratio comparable to farmers' conventional practices

Accordingly, data analysis on production constraints in Table 4 documented that all farmers (100) suffered from aphid invasion that resulted into monumental yield losses, in addition, to production costs increase. This is similar to [31] reported that pest attack occupied sixth position amongst the foremost constraint bedeviling cotton production enterprise that significantly reduces yield. Furthermore, 100% of the respondents lamented on late commencement of the demonstration trails, which affect plants to attain a reasonable growth to withstand the scarcity of water occasioned at certain period, when the water from the irrigation source reduces drastically, which posed additional production cost in supplying water to meet plant requirements, in order to escape winter stress. This might have a connection with the bureaucratic process involved in the release of funds that deterred early commencement of the scheduled programme. Consonance to this, [32] affirmed that the bulk of operating budget of the (ADPs) is insufficient causing untold suffering of effective extension service delivery. More so, (47%) complaints on early drying of their irrigation dams due to impact of climate change, thereby constraining the yield potential. In the same vein [33, 34] confirmed that owing to the influence of cumulative climate change due to industrialization and water pollution, the irrigation water shortage is projected to become scarcer. Also, (57%) affirmed that they witnessed livestock encroachment in their farms that lead to severe plants destruction, which drastically affect the expected output and increase production cost due to undue expenses in fencing the land. The results of the analysis further revealed that (80%) lamented of cold periods stress especially in the months of December to January, had severely retarded the morphological process of crop development, as elevated temperature to greater magnitude is needed for appropriate cotton nourishment. Almost similar problems were stated by research conducted in India by [35] postulated that unfavorable weather condition has monumentally cause cotton failure by impeding growth and reproductive aspect. Consequently, (73%) of the respondents experienced inconsistent seed germination that reduced plant population leading to low yield. In the same context [36] pointed that in the third world countries, there is a predominance utilization of poor cotton seed of unknown pedigree and is the one of the principal reasons of major crop failure.

CONCLUSION

The monumental satisfaction level in relation to services executed, synergy with farmers' and technologies demonstrated among others, have portrayed stronger belief, physical and mental involvement in the small plot adoption demonstration trials (SPADTs) which in turn would lead to higher adoption. The current study conclusively showed that even though, farmers had adequate household size and production experience, however, there exists a wide gap in their Literacy levels that need urgent attention for successful adoption to emanate. This study also infers that the outcome of (SPADTs) on improved cotton agronomic Practice brought through collaborative initiative had generated yield and net profit, and these technologies can be extended through enhanced diffusion via large scale/cluster multi-locational demonstration trials of improved crop agronomic recommendations with proven high yielding potentials to the farming community. Further research findings acknowledged production constraints attributed to climate change, human and animal activities.

RECOMMENDATIONS

The following recommendations were sought out to facilitate towards broader cotton production efficiency:

a. An assessment should be conducted amongst the progressive farmers' non-participants that exhibit high enthusiasms for intensive cotton production under the scheme, with a view of providing them with maximum support in all ramifications, to boost mass production.
b. Synergies should be created amongst other stakeholders to enable farmers have access to institutional/organizational interventions in terms of provision of loans facilities, training, and other logistic support
c. There is the need for the development of improved seeds that is resistant to major cotton pests and adaptable to the prevailing climatic condition of the three ecological zones of the State.
d. Keeping in view its prominence in technology transfer, (SPADTs) should be designed and steadily articulated, and provisions should be made to cater for other complimentary extension activities such as result demonstration, field days, group meeting, etc.

for speedy propagation of the technology among farming families.

e. Farmer's knowledge of western education demands massive improvement through not only demonstration but also through various capacity building programmes in form of adult education session, exposure visit, field visits and mass media channels.

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