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Volume 2 | Issue 1 | January 2020 | Page1-25
NASS Journal of Agricultural Sciences

Contents

ARTICLE

REVIEW

NASS Journal of Agricultural Science
http://ojs.nassg.org/index.php/NJAS

ARTICLE

Subsistence Farming Towards Sustainable Economic Agriculture of Small Farmers in the Developing Countries

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ABSTRACT

Subsistence farming, a form of cultivation in which almost all crops or livestock are used to maintain farms and the farm family, leaving little, surplus for sale and trade. Pre-industrial farming peoples all over the countries of the worldwide apply subsistence agriculture system and take advantage of the possibilities available to them from land and water resources in all locations of agriculture sites. The agricultural production has become more specialized and developed in the subsistence farming system, and farmers have produced abundant production from many horticulture crops that are traded among them and achieve their self-sufficiency from those crops.

1. Introduction

Subsistence farming is self-sustaining farming, in which these farmers focus on growing foods that are sufficient for them to give an adequate amount of food themselves and other peoples. A regular subsistence farm includes a set of crops and animals the family needs to feed itself during the year. The decisions of agriculture are taken into account what the family will need during the next year in the first place, then market prices in the second place [1].

The truth is that farmers of the so-called subsistence farming method are farmers who grow whatever their family needs; they build their homes and do not depend on purchasing the needs of their crops on the market permanently. Despite this, the priority that self-sufficiency imposes on subsistence agriculture, most subsistence farmers now participate primarily in trade with each other, but this is achieved relatively little. Most subsistence farmers now live in developing countries and some rural areas in many countries of the world. Although their trade volume, if measured in monetary terms, is relatively less than the size of consumer trade in countries with modern complex markets. Many of these farmers have essential business contacts and commercial goods that they can produce with their skills or in special access to valuable resources in their local markets [2].

2. Subsistence Farming System as a Review

The subsistence farming system now continues in many developing countries, such as some rural areas in Africa, Asia and also Latin America. The use of the subsistence farming system has significantly decreased in Europe with the start of the First World War, and in North America as well, with farmers and their partners moving from the

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south and central-western America during the 1930s and 1940s. Until around the 1950s, it was still customary that rural farmers in North America and Europe had most of the family food that met their needs. The extent of subsistence cultivation varies from one country to another in the economies that it passes from one stage to another transitional stage, but what is noticeable is its global presence to the present day in many rural areas. Indeed, it isn't easy to provide a complete picture of the situation in some regions of Europe. Still, it is worth noting that the relative size of subsistence agriculture is enormous and is growing day by day. More than half of the consumption of major agricultural products in some countries of the world, such as Bulgaria, is provided by small independent production units [3,4,5].

The authors argue that even if the farmers of small and semi-subsistence subsistence farming systems are less technically efficient and the effects of their existence in general, and that compared to traditional commercial farming completely they are very positive in terms of production and sustainable consumption and that achieve their self-sufficiency [5].

Farmers in those densely populated countries like China and India use their small land holdings to produce enough of their needs. In contrast, they use little mutual production to barter for other goods for self-sufficiency. These farmers are trying to maximize the productivity of their available crops by intensifying farming methods and adopting modern agricultural practices, including preparing rice fields and some other crops that can be used year after year. In more severe cases, farmers may establish terraces on the steep areas for planting rice seedlings. These fields are found in populated areas in some countries such as the Philippines. Also, they can intensify agriculture using compost, modern industrial irrigation and animal waste as organic fertilizer.

3. Primitive Subsistence or Strolling Cultivation has the Following Advantages

Experienced older adults usually choose 1-Ladang locations in pristine forests. Hill slopes are preferred due to the better drainage. Many degrees are located in remote inland areas, away from major population centers.

There are three advantages to a sustainable livelihoods approach, in terms of focus Agency and methodology. First of all, livelihood strategies are usually diverse, with the drawing carries a range of profitable activities. In an agricultural context focused on consequently, the cash income generated by agriculture is very restricted; Researchers must consider the role of non-market production and family participation in the non-farm rural economy. Therefore, the focus should not be on specific sectors like agriculture or manufacturing in isolation, but rather people and families [6].

Second, the literature on sustainable livelihoods recognizes that the results are based not only on structures but also on agency factors in the form of their livelihood [7]. In this context, the role of rural development is empowerment low-income families improve their welfare rather than the state current cash transfers or act as guarantors of specific social welfare outcomes [8,9].

Third, researchers should use methods that embody the heterogeneity of the poor documenting of the various sources of profitable activity and asset portfolios [10]. Consequently, researchers usually study in a specific area of a geographical area, a cross-section of poor and relatively affluent families in both the most disadvantaged and least disadvantaged villages [11,12]. Cluster analysis may be usefully used to determine family heterogeneity profiles [13].

It is partly due to historical reasons as most itinerant farmers have been forced into less fortunate regions by expanding more advanced farmers to less and better land. Their isolation impedes their progress and makes the spread of new ideas more difficult.

(2) Deforestation is usually caused by fire and ash, and this increases soil fertility and, consequently, increases the productivity of crops grown there. Unturned trees are broken to spoil naturally. Hence, these crops are also called mobile agriculture.

(3) A few crops are raised in nurseries. The major are those of starchy crops, such as tapioca, potatoes, cassava, beans, bananas, rice, and other vegetables. These crops are grown at calculated intervals, often among other plants, so that these crops can be harvested to provide food throughout the year for farmers and their families. The same types and varieties of crops are grown on all farms.

(4) Crops are rotated for cultivation in the same plot of land. When crop productivity no longer supports society due to poor agricultural soils or weeds growing significantly, fields are abandoned, and new areas are cleared. "Field rotation" is practiced instead of "crop rotation".

(5) This system, from "migratory agriculture" to now, is considered supportive of many indigenous tribes from the tropical rainforests, despite efforts by local governments to resettle them. Indeed, this system led to the depletion of nutrients in the soil and attack from insect pests, bacterial, and fungal diseases.

Another more developed and effective model of subsistence cultivation is "stable subsistence cultivation"

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in the tropical lowlands. In this system of agriculture, non-fertile and weak lands are constantly reused, and society stays permanently in one place. In this agricultural system, crops are rotated in some areas, and more attention is given to lands and crops grown.

In the absence or weakness of technology in some regions, the amount of land that farmers can grow in each season of subsistence crops is limited by many factors such as available potential, quality and fertility of agricultural soils. The equipment and capabilities that subsistence farmer's use is often effortless. Many farmers do not have access to large domesticated working animals. Consequently, they perform agricultural service operations from growing crops, cultural practices, and harvesting using pointed sticks, primitive machines, or by hand.

Subsistence cultivation methods include "cutting and burning" disinfection as farmers clear their agricultural land by cutting all the brush, allowing debris to dry, and then burning the fallen waste. It makes the fields clean and more prepared for cultivation and abundant production, while the residue ash is an excellent organic fertilizer for the lands. Sub-tropical societies often use this clearing technology throughout the fertile regions of some parts of South America.

If subsistence farmers are not given enough food for farmers, due to the lack or weak fertility of soils, climatic conditions, and the lack of capabilities and modern agricultural tools, or types of high-yield crops, the farmer cannot do more than adapt to live. Under these conditions, the few years of harvest often lead to less food and may eventually lead to starvation.

Not all subsistence farmers can get as much land as possible. Often, socio-economic conditions prevent the expansion of agricultural plots and any increase in production levels. If the traditions of inheritance require that the plot be divided between the children of the owner upon the death of the owner, then the sizes of the land decrease steadily.

4. Conclusion

Subsistence farming means producing enough food and fibre for the needs of the farmer and his family. And this agricultural system was prevalent in many rural areas of the world, especially in many tropical regions. Where farmers work for a relatively few hours each week, they produce only enough and achieve self-sufficiency in cereal, oil and fibre crops. They played a fundamental role in the monetary economy of relatively low-income rural families, whether in developed or developing countries, and they must work to help them in achieving sustainability in achieving self-sufficiency in crops.

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ARTICLE

Constraints of Women Farmer's Access to Information and Communication Technologies (ICTs) for Agricultural Information in Oyo State, Nigeria

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ABSTRACT

The study investigated constraints of women farmers access to ICTs for agricultural information in Oyo State. A total of 120 respondents were sampled. Data were retrieved using interview schedule and were analysed using descriptive and inferential statistics. Statistics reveal respondents average age, average household size and average monthly income as x =45.8, x =10.6 and x = ₦7,800.34 respectively, majority (86.7%) were married, 58.3 % representing respondents with primary education. Mobile phone (x=0.98) was the most available among the respondents while poor ICTs infrastructure (x=1.55) and difficulty in the utilization of ICTs gadgets (x=1.62) ranked highest as constraints access to ICTs for agricultural information. Significant relationship existed between respondents average monthly income (r= 0.492, p=0.000), educational level (x^2= 4.726, p= 0.021) and the constraints access to ICTs for agricultural information. Scaling up the ICTs infrastructure base around farming clusters and capacity building like training on ICTs to access agricultural information retrieval is advocated for women farmers.

1. Introduction

Agriculture is an important sector with the majority of the rural population in developing countries depending on it for their livelihoods. Agricultural sector in Nigeria depends upon the women farmers who constituted the farming population and even responsible for farm work. According to the United Nations Report on status of the world's women, women are twice as likely to be involved in agricultural related activities as men [9]. Several studies have indicated that women in agriculture contributed some 60-80% of the labour input in African Agriculture, this is especially so for the production, processing and trade in food commodities [7,10]. Women farmers in their own right growing several crops and keeping livestock and what constitutes development in agriculture is the extent to which these farmers have access to accurate and reliable information. Information is an essential ingredient in agricultural development that every individual engaged in agriculture should have access to. Information access

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is a pre-requisite and a valuable resource for agricultural development [8]. Therefore, agricultural information access remains pertinent at which agricultural productivity can be attained. Agricultural information is a key component in improving small-scale agricultural production and linking increased production to remunerative markets, thus leading to improved rural livelihoods and food security [4]. Through agricultural information, women farmers can adopt new technologies or farming systems, know when to plant and harvest, which crop to produce and which animal to rear and where to sell, know where to acquire bank loans and other farming inputs, as well as how to control pests and diseases. Also, agricultural information is considered as one of the most important resources in agricultural and rural development that assists the women farmers to make decisions and take appropriate actions for further farming-related development. Adequate and relevant information is one of the key requirements for increased productivity and increased income which could ultimately lead to poverty reduction among the food producers [5]. Agricultural information access remains a promising strategy for increasing agricultural output and information and communication technologies (ICTs) have been considered as the tools where information can be obtained for rapid development in agriculture. Information and communication technologies (ICTs) play vital role in enhancing agricultural development, thus, they constitute a method of notifying farmers of new developments regarding their agricultural production activities which lead to better methods of farming and increase in food and cash crop production [3]. ICTs play important roles in the circulation of knowledge; teach ideas and skills that are essential for the creation of a better life for the farmers.

Among other sources of agricultural information, ICTs like radio and television constitute the highest preference for information access and they are regarded as critical resources for agricultural development because it empowers people to make informed choices for attaining better livelihoods [6]. According to Adeniyi and Yekinni [1], ICTs like radio, television and mobile phone are the most available and accessible in the rural communities.

ICTs are capable of capturing, coordinated, and processing and disseminate developmental information to larger percentage of population including women farmers at a given period of time. Despite the significant contribution of women farmers to agricultural production in rural area of Oyo state, they are not considered productive due to their limited access to information communication technologies (ICTs) for agricultural information . The study conducted by Olowu *et al* [7] revealed that despite the capacity of ICTs to assemble, process and share information among agricultural information providers, seekers and users in an interactive manner, women farmers who perform most of the agricultural tasks have limited access to ICTs which further widens their information gap It is difficult for women farmers to access ICTs for agricultural information probably because of their poor technical know-how on the use of ICTs, poor rural infrastructural base, illiteracy and poor economic conditions. It is against this background that the study investigated constraints of women farmers access to ICTs for agricultural information. Also, the study ascertained the socioeconomic characteristics of the respondents, examined the available ICTs and hypothesized that no significant relationship existed between the selected socioeconomic characteristics of the respondents and constraints access to ICTs.

2. Methodology

The study was conducted in Oyo State. The climate is equatorial, notable with dry and wet seasons and relatively high humidity, average daily temperature ranges between 25°c (77.0°F) and 350c (95.0°F) almost throughout the year. It is located between latitude 7045N and longitude 4015E which covers a total area of 28.454 square kilometers. The area is comprises of different ICTs with majority located in urban centre. The population of the study comprises of women farmers and two stage sampling procedures were used to determine the sample size. The first stage involved the purposive selection of all Agricultural development zone in Oyo State which were Ibadan/Ibarapa ADP Zone, Saki ADP Zone, Oyo ADP Zone, Ogbomosho ADP Zone while the second stage involved the selection of registered women farmers using proportionate random sampling technique which resulted to 120 women farmers.

Table 1. Registered Women Farmers, ADP Zones, and 15% of WomenFarmers in each Zones

ADP Zones	Registered Women Farmers	15% of Registered Farmers
Ibadan/Ibarapa	300	45
Saki	150	23
Oyo	196	29
Ogbomosho	150	23
Total		120

3. Data Analysis

Data were analyzed with the use of descriptive statistics such as frequency, percentage and inferential statistics

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such as Chi-square and Pearson Product Moment Correlation (PPMC) at 5% level of significance.

4. Result and Discussion

4.1 Respondents Socioeconomic Characteristics

The result of analysis in Table 2 below shows that 2.5% of the respondents are between ages of 20 to 30 years and 67 to 70 years respectively, 10.0% of them are between ages of 31 and 40 years, 13.3% of them are between ages of 51 and 60 years while 71.7% of them are between ages of 41 and 50 years. The implication of this result is that majority (71.7%) of the respondents are in their productive ages. This finding is similar to the research finding of Akinbile [2] that reported that most of the female farmers are more than 40 years and that only a few farmers are older than 50 years of age On the respondent's religious affiliations, the result showed that 47.5% of the respondents were Christians, 46.7% of the respondents were Muslim and 5.8% of them practice traditional religion. This means that the Christianity is popular than any other religion among the respondents. As shown in Table 2, majority (86.7%) of the respondents were married, 3.3% of them were divorced while 10.0% of them were widowed. Available data revealed that 8.3% of the respondents have between 1 and 4 persons in their families, 60.9% of them have between 5 and 8 persons in the families while 30.8% of the respondents have between 9 and 12 persons in their families. This implies that women farmers have larger families to cater for. Also, 16.7% of the respondents involved in crop cultivation, 20.0% of them involved in animal husbandry while 63.3% of them involved in both crop and animal husbandry. In terms of income earning, the study revealed that 13.3% o f them were earning below N5000, 17.5% of the respondents were earning between N5000 and N7000, 25.0% of them were earning between N7001 and N9000 while 44.2% of them were earning above N9000. The implication is that majority of the respondents are of low income. Respondents level of education indicated that 33.3% of the respondents had no formal education, 58.3% of them had primary education, and 1.7% of them had secondary education while 6.7% of the respondents had tertiary education. The implication is that educational level of the women are very low. Findings also show that 6.7% of them engaged in civil service besides farming, 80.0% of them engaged in trading, 10.8% involved in hair dressing while 2.5% of them were employed in private business besides farming. Farming as a business is not a major activities of women farmers in the study area

Table 2. Distribution of respondents by socioeconomic characteristics

Variables	Frequency	Percentage	Mean
Age (years)			
20-30	3	2.5	45.8
31-40	12	10.0	
41-50	86	71.7	
51-60	16	13.3	
61-70	3	2.5	
Religion			
Islam	56	46.7	
Christianity	57	47.5	
Traditional	7	5.8	
Marital status			
Married	104	86.7	
Divorced	4	3.3	
Widowed	12	10.0	
Household size			
1-4	10	8.3	10.6
5-8	73	60.9	
9-12	37	30.8	
Type of Agriculture involved			
Crop cultivation	20	16.7	
Animal husbandry	24	20.0	
Both crop and Animal husbandry	76	63.3	
Income/Month (Amount in N)			
< 5,000	16	13.3	
5000-7000	21	17.5	
7001-9000	30	25.0	7,800.34
>9000	53	44.2	
Other occupation			
Civil service	8	6.7	
Trading	96	80.0	
Hairdressing	13	10.8	
Private employed	3	25	
Education Level			
No formal education	40	33.3	
Primary education	70	58.3	
Secondary education	2	1.7	
Tertiary education	8	6.7	

4.2 Availability of ICTs Among the Respondents

Table 3 shows that 97.5% of the respondents indicated the availability of radio, 98.3% of them indicated the availability of mobile phone, 85.0% of them indicated the availability of television. Also, Extension bulletin poster (55.0%), newspaper (23.3%), computer and CD-

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ROMs (3.3%) respectively, internet (1.7%) were the ICTs available among the respondents in the study area. The implication of this findings is that mobile phone is the most popular ICTs among the respondents in the study area.

Table 3. Distributions of respondents according to the availability of ICTs

ICTs tools	Frequency	Percentage	Mean
Radio	117	97.5	0.97
Television	102	85.0	0.85
Mobile phone	118	98.3	0.98
Extension bulletins/posters	66	55.0	0.45
Computer	4	3.3	0.02
Internet	2	1.7	0.01
Newspaper	28	23.3	0.19
CD-ROM	4	3.3	0.02

4.3 Respondents Constraints to ICTs to Access Agricultural Information

Table 4 reveals that majority of the women farmers 70.0%, 66.7%, 65.0%, 60.0% indicated that they experienced serious constraints on high cost of ICTs gadgets, poor ICTs infrastructure, inability to read and comprehend English Language, high cost of electricity while most of the respondents 35.8%, 32.5%, 27.5%, 25.0% indicated no constraints to ICTs in terms of inability to understand the language of presentation, faulty equipment, inappropriate program schedule, loss of signals from sources during program and lack of local content.

Table 4. Distribution of respondents by constraints to ICTs to access agricultural information

Constraints	Serious constraints	Mild constraints	not a constraint	mean
High cost of ICTs gadgets	84(70.0)	26(21.7)	10(8.3)	1.62
High cost of electricity	72(60.0)	30(25.0)	18(15.0)	1.45
Difficulty in operating ICTs gadgets	63(52.5)	50(41.7)	7(5.8)	1.47
Faulty equipment	41(34.2)	40(33.3)	39(32.5)	1.02
Loss of signals from source	52(43.3)	38(31.7)	30(25.0)	1.18
during program Inappropriate programme schedule	40(33.3)	47(39.2)	33(27.5)	1.06
Shortage of time allotted to Agricultural programme	32(26.7)	60(50.0)	28(23.3)	1.03
Inability to understand the language of presentation	47(39.2)	30(25.0)	43(35.8)	1.03
Lack of local content	28(23.3)	62(51.7)	30(25.0)	0.98
Inability to read and comprehend	78(65.0)	26(21.7)	16(13.3)	1.52
English language Poor ICTs infrastructure	80(66.7)	26(21.7)	14(11.6)	1.55

4.4 Relationship between Respondents Socioeconomic Characteristics and Constraints Access to ICTs

The result of correlation analysis and chi-square in table 5 shows that there was significant relationship between the women farmers income and the constraints access to ICTs (r=0.492; p=0.000) which implies that income determines the accessibility of ICTs that is the higher the income the greater the access to ICTs for relevant information. Respondents with higher income will have more access to ICTs compared with the respondents with the lower income. Also, chi-square results shows that there was significant relationship between the educational level of the respondents and their access to ICTs for agricultural information (x^2=4.726; p=0.021).The implication of this result reveals that educational level of respondents determine their access to ICTs for agricultural information. Respondents education influence ICTs connectivity for agricultural information

Table 5. Result of correlation analysis and chi-square result of socioeconomic characteristics of the respondents and their constraints to ICTs for agricultural information

Variables	$x2$	DF	r-value	p- value	Decision
Age			0.045	0.211	NS
Religion	2.486	2		0.248	NS
Marital status	3.026	2		0.227	NS
Household size			0.066	0.376	NS
Type of Agriculture Involved	2.061	2		0.303	NS
Income			0.492	0.000	S
Other Occupation	3.446	3		0.134	NS
Educational level	4.726	3		0.021	S

5. Conclusion and Recommendations

This study attempted to assess the constraints of women farmers access to ICTs for agricultural information in Oyo state and it was revealed that majority of the respondents are in their productive years, married, had household size between 5 and 8 persons in their families, engaged in both crop production and animal husbandry. Majority of the respondents had formal education at different level and other occupations respondents engaged with besides farming was trading. The most available ICTs in the study area among the respondents were radio and mobile phone, however, high cost of ICTs gadgets and poor ICTs infrastructure were revealed as the major constraints to access ICTs for agricultural information in the study area. Significant relationship exists between the respondent's income, educational level and constraints access to ICTs. It is recommended that there should be an improvement in the provision of ICTs infrastructure in the study area by the government at all level, stakeholders in extension communication should expose the women farmers to the new ICTs tools and capacity building like training on ICTs to access agricultural information retrieval is advocated for women farmers.

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REVIEW

Opportunities of Doubling Indian Farmers Income by Post Harvest Value Addition to Agricultural Produce

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Agricultural entrepreneurship

ABSTRACT

The governments across the developing countries are facing a challenge of steadily increasing population, maintaining balance in demand and supply of food and upliftment in socio-economic status of farming community. Among the leading developing countries, India has successfully increased agricultural crop production by fourfold, thus having at most potential for adoption of secondary agriculture practices after harvest of farm produce. Post-harvest processing of agricultural produce like milling of cereals and pulses, extraction of oil from oilseed crops, development of value added ready to eat and ready to serve food product etc. not only facilitate efficient utilization of crop produce but also check losses fetching better returns to the farmers/entrepreneurs. Post-harvest processing operations at the production catchment area helps in minimizing post harvest losses, helps in generating employment opportunities in rural areas, purity assured products in turn open window for the developed products to qualify for wider market.

1. Introduction

The total population of India is expected to reach up to 1.55 billion by 2031 to become most populous country of the world [1]. Since Green Revolution, India's agricultural production hasincreased fourfold, at the same time India's demand for agriculture has continued to rise. India is leading producer as well as exporter of many fresh fruits and vegetables, spices, milk and second largest producer of wheat and rice. However, food security has been threatening problem for millions of people, with children, becoming the future youth have been severely affected.According to FAO, almost one-third of all food produced was lost and the amount is estimated to 1.3 billion tonnes per year [2]. These wastages and losses occur at each stage of food supply chain (FSC) from production to end consumers and at each stage of transition from freshly harvested to the storage, postharvest processing, retail and consumption. Eradication this chronic and pervasive problem and to meet sustainable development requires prompt action to process; value addition and preserve agriculture produce till it reach to the consumers table [3].

Agriculture has been considered the hallmark of the first stage of development, while the degree of mechanization has been taken to be the most relevant indicator of the country's progress along the development path. The mechanization of agriculture and development of agro- processing industries is thus a joint process which is generating an entirely new type of industrial sector. The vibrant agriculture sector offers various opportunities

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for the successful establishment of potentially profitable agro- processing units [4]. The potential for agro-industrial development in the developing countries is largely linked to the relative abundance of agricultural raw materials and low-cost labour in most of them. The most suitable industries in such conditions make relatively intensive use of these abundant raw materials and unskilled labour and relatively less intensive use of presumably scarce capital and skilled labour.

The problem of rural unemployment and low income has its own dynamic, since there is no money available for investing in highly input responsive agriculture. Hence there is a vicious circle of low input- low productivity – low income which needs to be changed to virtuous circle of judicious input- high productivity –high income, in order to sustain our agriculture. Many models to deal with serious situation are working with varying degree of success. One of the ways to create avenues for income and employment generation is to promote rural entrepreneurship based on agro-processing and value addition [5].

2. National Development through Post Harvest Processing

Food processing sector has tremendous potential to turnaround the whole economy right from farmer's field to national level as it directly targets farming sector by its characteristic ability of multiple product development from a single crop. This will increase demand for farming, farmers and hence impressive prices to produce.

Processing of raw food into primary, secondary and tertiary products reduce the contamination and spoilage by micro-organisms, fungus and disease and make it safe for human consumption as well as reduce storage losses and make it available for consumer's enjoyment round the year. Apart from this, left over part of crop such as risk husk can also be processed to get some useful product for e.g. rice bran oil; cattle feed; sugarcane bagasse can be used level power cogeneration at community level electrification to make villages self-reliant. Another advantage of localized food industry cluster is that, processing of fresh harvested food commodities at farm and local area level and value addition helps to increase income and livelihood of the primary sector employed population [6].

Localized processing of perishable food commodities can reduce volume of food in transportation, increases the scope of food packaging techniques, reduces food damage and wastage and preserve quality attributes. In addition to that it also reduces the burden on food logistic and ultimately to overall transport infrastructure of nation, reduces congestion of rail and roadways and reduces the fuel energy and power involved in the transportation that directly and indirectly contributes to the national Gross Domestic Product (GDP).

India'sdemographic dividend is much talked about and generating employment to this workforce is major challenge in front of the policy maker before it turns to demographic disaster. Food processing sector plays significant role in seizing this opportunity to convert demographic dividend to national power due to its potential to generate the plenty of direct and indirect employment opportunities. Installation of crop based micro, small and medium food processing infrastructure at localized level also absorbs skilled as well as unskilled workforce in rural areas and will have multiple impacts on socio-economic and political problems. Planed proliferation of food processing industries in countryside also reduce the economic exploitation of farmers by middleman, checks rural-urban migration that created slum/hygiene/health/social and infrastructural problem in mega cities and strengthen therural economy.Also contract processing based house hold cottage industries ensures income and security to poor women's, reduces their exploitation and increases there say and dignity in the family. Apart from all this, most of the post-harvest food processing industries are least environment pollutant unlike heavy industries that maintains the healthy rural livelihood. In short, it helps to bridge the gap between rural and urban to fulfill the Mahatma Gandhi's dream of making Indian villages self-sufficient.

3. Governments Participation and Enforcement

Due to the wider nature and robust potential of post-harvest food processing sector, government has never been lacking in grasping this opportunity and taken every possible action for the encouragement of this sector. A nodal Ministry of Food Processing Industries formulating and implementingpolicies and plans for creation of world class infrastructure, promotion of R&D in food processing, human resource development, setting analytical and testing laboratories and active participation in food standardization. To make strong consultative relationship between industries, R&D laboratories and academia two national level institutes of international standards such as National Institute of Food Technology Entrepreneurship and Management (NIFTEM) and Indian Institute of Food Processing Technology (IICPT) were established as "One Step Solution Provider" for any problem associated with this sector. Recent launch of *Pradhan Mantri Krishi Sampada Yojana* is single window umbrella scheme for establishment of Mega Food Park, development of integrated cold chain and value addition

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infrastructure etc targeted to supplement agriculture, modernise food processing and decrease agro-waste [7]. National Bank for Agriculture and Rural Development (NABARD) is also empowered with Special Fund for providing direct load for Mega Food Parks.

Scope of Indian food processing industry is not confined within territories of India but also opened its market overseas. Due to continuous intervention, encouragement, financial assistance, joint venture and other subsidies by Agricultural and Processed Food Products Export Development Authority (APEDA), India's food processing sector ranks fifth in the world in export, product and consumption. Food processing sector is 100% opened for FDI with single window application system to facilitate ease of doing business and attract foreign investors under Make in India initiative for generation of employment opportunities and inclusive development.

4. Augmenting Rural Prosperity through Food Processing

Government is successful in achieving 8.41% average annual growth rate between 2014-18 for food processing sector, above the overall agricultural growth [8]. However, most technologies developed by R&D institutes restricted in laboratories due to less extension activities. Development of small scale, farmer friendly, easy to handle, power efficient technologies and initiation of schemes such as "Scientist to Firms Door" can attract farmer's interest towards entrepreneurship and creation of stronger economic base. Rural farmers are unskilled labor of food processing sector, so skill development of farmers through hands on training and certificate courses in localized research stations, universities, KVKs is the key solution for their involvement for processing sector. Spatial crop based processing cluster development under the supervision and guidance of experts can helps to confidence building among farmers.

Creation of "Food Expert" portal under Digital India initiative for online supportentrepreneurs' problem can ensures time bound solution at free consultancy throughout the value chain. Development of custom hiring based food processing facilities can create scope to entrepreneurs for experimentation and market assessment before going for large scale production. "Contract Processing" on the basis of "Contract Farming" can reduce the farmers risk in the entrepreneurship, economic investment as well as storage and marketing strategies. Creation of "Minimum Support Price for Processed Foods" above the processing cost in line with the "MSP" can ensures market vulnerability of farmers and ensures fixed returns.

Cooperative business success as seen at AMUL and Lijjat Papad managed by cooperative named Shri Mahila Griha Udyog Lijjat Papad not only contribute for food processing sector but further extends to organize women for creation of Self Help Groups, to reduce poor-rich income gap, and helps to improve rural livelihood and self-sufficiency.

As said by Norman Borlaug "Without food man can live at most but few weeks, without it, all other component of social justice are meaningless", and this job of food production is solely done by farmers. So the mechanism should be developed where farmer can tract their produce during further value addition and 1% of the value added should be transferred in the farmers' account as an incentive under direct beneficiary transfer. Reorganisation of this *Rambaan* solution not ensures rural augmentation but also helps to achieve target to double the farmer's income as well as all the seventeen sustainable development goals.

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ARTICLE

Superabsorbent Polymer and Rabbit Manure Improve Soil Moisture, Growth and Yield of Eggplant (*Solanum melongena L.*)

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ABSTRACT

Production of eggplant (*Solanum melongena* L.) is influenced by limited soil water and fertility conditions that affect its growth and yield. The use of superabsorbent polymer (SAP), also known as slush powder and rabbit manure are among the strategies that can improve soil conditions, hence growth and yield of crops. The objective of the study was to evaluate the effects of SAP and rabbit manure on soil moisture, growth and yield of eggplant. The study was conducted at Pwani University, Kilifi, Kenya. A randomized complete block design with three replications was used. The treatments were SAP, rabbit manure, SAP plus rabbit manure and control (without SAP or rabbit manure). Soil moisture, growth and yield parameters were determined. Superabsorbent polymer and/or rabbit manure improved soil moisture, growth and yield of eggplant compared with the control. Use of SAP had a better soil moisture retention, growth and yield comparable to SAP combined with rabbit manure. The finding demonstrates that use of SAP and/or rabbit manure may help in better soil water and nutrient management, particularly in arid and semi-arid areas to improve growth and yield of eggplant.

1. Introduction

Eggplant (*Solanum melongena* L.) also known as aubergine is one of the important vegetables grown in Kenya for export and local demand. It is grown as an annual plant and is one of the most consumed fruit vegetables in tropical Africa; probably the third after tomato (*Solanum lycopersicum* L.) and onion (*Allium cepa* L.), and before okra [*Abelmoschus esculentus* (L.) *Moench*] [12]. Eggplant fruit is associated with high nutritional value and for its therapeutic properties [7]. Ripe mature eggplant vegetables contain high amounts of vitamin C, whose concentration increases progressively as the plant advances in maturity [7]. Eggplant production tends to be confined to warm and semi-arid areas where water is more often a limiting factor in production [10]. Therefore, there is a need to optimize water and nutrient management for eggplant production. Eggplant has also been reported to be amongst the most sensitive horticultural plants to drought stress because of its high transpiration rates aided by large leaf surface area, high stomatal conductance and a shallow root system[10]. The negative effects of soil moisture stress on both yield and quality such as reduced leaf size, photosynthetic area, fruit size and yields of eggplant

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fruits have been reported by Díaz-Pérez and Eaton [10].

Kilifi County is a hot and dry area for most parts of the year with most regions being arid and semi-arid, due to low annual rainfall [17]. The spatial and temporal distribution of this rainfall is inadequate and insufficient for commercial eggplant production. Thus, soil moisture conservation and nutrient management are essential practices; if sustainable vegetable production is to be realized in the region. One method of water conservation and reduction of irrigation costs is the use of superabsorbent polymer (SAP), also known as slush powder as soil improvement strategies. Superabsorbent polymer (SAP) is a group of new water-saving materials and soil conditioners that have been widely adopted in agriculture [8]. They are hydro-gels that can absorb and hold considerable amounts of water and slowly release them on demand around the root zone [8]. Superabsorbent polymer (SAP) has been considered as water-managing materials for horticultural purposes in the desert and drought-prone areas[24]. Use of SAP has been shown to increase soil water retention capacity, aeration in the soil, reduce soil bulk density, improve soil structure and increase crop production [8,11].

Superabsorbent polymer (SAP) is credited for being inert and do not have adverse effects on humans, plants, soil and the general environment [21]. They have abilities to absorb about 200 to 500 times as much water as their weight, and in 5 to 12 years gradually biodegrading to water, carbon dioxide and ammonia due to the microbial activity or sunray effect [9,22]. Use of adequate amounts of SAP under irrigation and water stress conditions can compensate for its purchase costs, leading to profitable yield. Fernando et al. [11] found that addition of 3 g L^{-1} of SAP to tomato cultivation beds resulted in increased water storage by 35% and reduced leaching of nutrient elements by 15%, in addition to enhancing soil nutrient storage capacity.

Currently, in Kenya, there is declining soil fertility resulting from continuous cultivation of smallholder farms. On the other hand, the cost of synthetic fertilizers is escalating and therefore, unfordable to the majority of smallholder farmers. There is also a need to conserve and build natural resource capital and biodiversity, which has led to renewed interest in the use of locally available organic nutrient resources for soil fertility management. As a result of health risks associated with red meat, consumers are resorting to eating white meat. This has resulted in high demand for such meat from the rabbit. Therefore, many smallholder farmers are keeping rabbits. Besides, rabbit requires only a small farm area and are also reported to have excellent manure rich in nutrients, hence a good source of organic fertilizer for crop production [1]. Rabbit manure is reported to improve soil chemical properties by enhancing cation exchange capacity, and are also a source of micronutrients [1]. Uzun et al. [25] reported that when organic manure such as rabbit manure is incorporated into the soil, observed benefits to eggplant production have been attributed to improved soil physical properties, due to increased organic matter concentration as well as the increased nutrient availability. Unlike other manures which have to be well composted before they are used, rabbit manure can be immediately applied to the soil. It contains a much more considerable amount of nutrients compared with other animal manure [3]. Rabbit manure is rich in potassium, nitrogen, zinc, and calcium, and it's one of the most nitrogen-rich manures [5]. Studies have shown that rabbit manure is rich in potassium which resulted in better quality eggplant fruit [1]. Studies have shown that the effect of soil conditioners like SAP and rabbit manure on crops is dependent on various factors like prevailing weather conditions as well as nature and type of soil [2,4,8,11,23]. As such, this study seeks to evaluate the use of SAP and rabbit manure in managing soil water and nutrient requirement and assessing its effects on growth and yield of eggplant to improve farmer's productivity, especially in water-limited and poor soil conditions.

2. Materials and Methods

2.1 Site of the Study

The study was conducted in two seasons at Pwani University farm from April to July 2018 and 2019. Pwani University farm is located at about 30 m above sea level, and at latitude 3.6° S and longitude 39.8° E. The temperature in the region ranges between 21 °C and 32 °C and receives the bimodal type of rainfall, where long rains occur during March to July, and short rains in September to December, with annual totals of 1100 mm [15]. The soils in the region are predominantly sandy loam with pockets of clayey soil [19].

2.2 Plant Materials

Eggplant 'Black Beauty' (Amiran (K) Limited, Nairobi, Kenya) was used in the study. The variety was chosen because of its good adaptability to the study area. It is also widely grown and consumed in the region. 'Black Beauty' is an open-pollinated eggplant. It is a hardy crop that grows best in warm areas. The fruit is oval to heart-shaped glossy purple to almost black. Fruit size is about 10 x 8 cm. It has a meaty white flesh, big in size, an attractive purple colour. It also has a good shelf life [14].

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2.3 Superabsorbent Polymer

The SAP (Belsap®, Bell Industries Limited, P.O. Box 18603-00500 Nairobi, Kenya). The active ingredient includes 80% w/w cross-linked potassium acrylate polymer. The SAP used is non-tonic and environmentally safe. It has no residual toxicity in the soil. It biodegrades into base components parts of ammonia, carbon dioxide and water. Due to its potassium base structure, it does not increase salinity levels in the soil. It has a neutral pH (6-6.8) [22].

2.4. Rabbit Manure

Decomposed rabbit manure obtained from Pwani University farm, rabbitry section was used in the study.

2.5 Experimental Design and Treatment Application

A randomized complete block design with three replications was used in the study. The treatments were SAP, rabbit manure, SAP plus rabbit manure and the control (no SAP or rabbit manure). The plot sizes were 3 m × 4.5 m. Each block measured 47 m × 4.5 m, separated by 1 m path. The entire plot measured 47 m × 15.5 m. Rabbit manure was applied at a rate of 1 kg per hole by mixing with the soil, two weeks before transplanting [14]. The superabsorbent polymer was applied at a rate of 5 g per hole (hill) or per plant during transplanting. This was done by mixing the SAP with soil [22].

2.6. Planting and Agronomic Practices

Nursery beds of 1 m by 2 m were prepared to a fine tilth. Eggplant 'Black Beauty' seeds were drilled at a spacing 10 cm between rows. Mulching was done using dry grass to conserve moisture and later removed after seedling emergence. Weeding was done manually every week. Watering was done manually in the evening using 10-litre watering can daily. Hardening-off seedlings were done two weeks before transplanting when the seedlings are 15 cm tall or had four true leaves by reducing watering to once after two days.

The field was prepared two weeks before transplanting to a fine tilth manually. Planting holes were dug up to 15 cm at, a spacing of 60 cm by 45 cm. One healthy seedling was transplanted in each hole. Gapping was done within the first week of transplanting. Three weedings were done during the first three weeks to maintain plots weed-free. All other acceptable agricultural practices were done when deemed necessary.

2.7 Data Collection and Methods of Their Determination

2.7.1 Rabbit Manure and Pre-plant Soil Analysis

Pre-plant samples of rabbit manure and soil were analyzed for total nitrogen contents using the Kjeldahl method as described by Okalebo et al. [18]. Phosphorus (P) was analyzed calorimetrically with a Jemway 6100 spectrophotometer following standard procedures [6]. Potassium (K) was analyzed by flame photometer following standard procedures [6]. The calcium (Ca), magnesium (Mg), Zinc (Zn) and iron (Fe) contents were analyzed after wet digestion with a mix of nitric, sulphuric and hydrochloric acids using atomic absorption spectro-photometer[18]. Organic matter and carbon (C) were analyzed by wet oxidation using a modified method of Walkley-Black [18]. Rabbit manure and soil pH content was determined in water using a pH meter (Hanna precision pH meter, Model pH 213, Merck KGaA, Darmstadt, Germany) [18]. Electrical conductivity (EC) was analyzed using an electrical conductivity meter (HI 993310, PCE Instrument, Southampton, UK). Moisture content was determined by the gravimetric method where a subsample of a fresh, sieved, composite sample of a soil or rabbit manure core was weighed, oven-dried until there was no further mass loss, and then reweighed [18]. The same method was also used to determine soil moisture in the experimental plots.

2.7.2 Weather Conditions

Weather data on rainfall, temperature, relative humidity and solar radiation were collected from Pwani University weather station. Data was collected during the entire production season and reported as a monthly average.

2.7.3 Growth and Yield Parameters

Data collection started two weeks after transplanting and continued on a weekly basis until harvesting. Ten plants in the middle rows were randomly selected and tagged for data collection. Growth parameters measured were; plant height, leaf number, stem thickness, number of branches, shoot fresh and dry weight, root fresh and dry weight, leaf area, leaf chlorophyll content, time to 50% flowering, fruit number, fruit length, fruit diameter, and fruit fresh and dry weight.

Plant height was measured from the ground to the tip of eggplant using a meter tape (5 m long with an accuracy of ± 1 mm). The number of leaves and branches was determined by counting. Vernier calipers was used to determine stem thickness of the main stem. Three plants were uprooted from each plot on a monthly basis and used to determine shoot fresh and dry weight. Fresh weight

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was determined by weighing the roots and shoots in a weighing machine and their weight recorded. Dry weight was determined by oven drying at 105 °C until constant weight. Leaf area was determined by measuring the length and width of leaves and their area computed. Leaf chlorophyll content was measured using chlorophyll meter (CCM-200, Opti-sciences, Inc. Tyngsboro, MA, USA) with a precision of ± 1.0 SPAD readings. Days to 50% flowering was determined based on days after transplanting. Mature fruit number was determined by counting. Mature fruit length and thickness was determined using a measuring tape and vernier calipers, respectively. Fruit fresh and dry weight was determined, applying a similar method for shoot and root.

2.8. Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using SAS software (version 10), and significant means at F-test compared using Tukey's test, at 5% level of significance. Data for the two seasons were pooled and presented in tables and graphs.

3. Results

3.1. Weather Conditions during Production of Eggplant

Mean monthly temperature ranged between 24.9 to 28.8 °C in season one and 27.5 to 29.8 °C in season two. The temperature was higher in season two except in May compared with season one (Figure 1A). Mean monthly relative humidity ranged between 78.5 to 88.9% in season one and between 76.3 to 80.9% in season season two (Figure1B). Relative humidity was higher in season one than in season two except in July. Rainfall ranged between 59.5 to 516.4 mm/month in season one and 22.4 to 292.6 mm/month in season two (Figure 1C). Rainfall was higher in season one than in season two throughout the study. Mean monthly solar radiation ranged between 16.7 t0 20.5 MJ m^{-2} and 28.4 to 39.2 MJ m^{-2} in the first and the second season respectively. Solar radiation was higher in season two than season one throughout the study (Figure 1D).

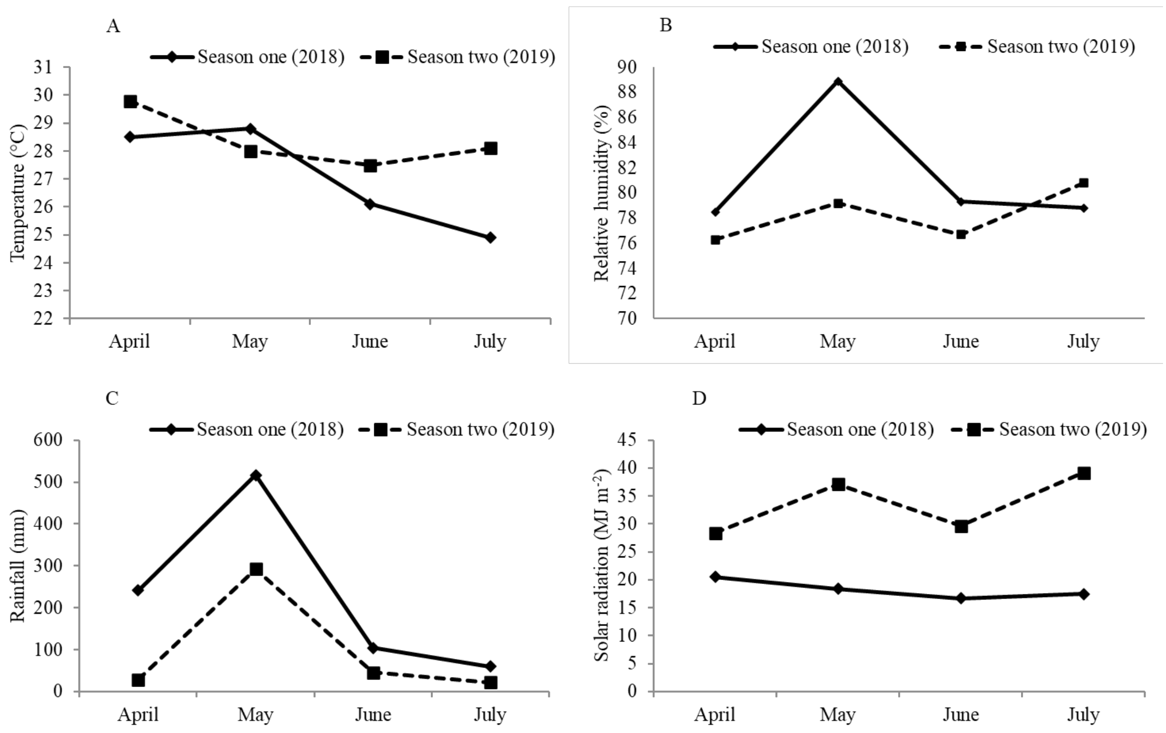

Figure 1. Mean monthly weather conditions during the production period of eggplant

3.2 Physico-chemical Properties of Rabbit Manure and Pre-plant Soil

Rabbit manure had higher electrical conductivity (7.9%), organic matter (4.6%), C (6.7%), moisture (78.2%), N (63.2%), P (20%), K (50%), Ca (37.5%), Mg (60%), Fe (64.5%), and Zn (72.1%) than pre-plant soil. Pre-plant soil on the other hand had only higher pH content (6.9) than rabbit manure (6.1) (Table 1).

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Table 1. Soil and rabbit manure composition used during production of eggplant

Variables	Rabbit manure	Pre-plant soil
pH	6.1 ± 0.3*	6.9 ± 0.4
Electrical conductivity (mS m^{-1})	210.1 ± 5.7	194.8 ± 6.0
Organic matter (mg kg^{-1})	120.7 ± 2.4	115.4 ± 3.5
Moisture (%)	23.7 ± 2.9	12.4 ± 0.3
C (mg kg^{-1})	213.6 ± 6.4	200.2 ± 6.9
N (g kg^{-1})	28.4 ± 3.2	17.4 ± 1.4
P (g kg^{-1})	0.6 ± 0.0	0.5 ± 0.0
K (g kg^{-1})	0.2 ± 0.0	0.1 ± 0.0
Ca (g kg^{-1})	2.2 ± 0.1	1.6 ± 0.0
Mg (g kg^{-1})	0.8 ± 0.0	0.5 ± 0.0
Fe (µg kg^{-1})	10.2 ± 0.4	6.2 ± 0.0
Zn (µg kg^{-1})	7.4 ± 0.2	4.3 ± 0.0

Note:
** Values represent means ± standard deviations*

3.3 Summary Statistics of the Analysis of Growth and Yield Variables during Eggplant Production

Analysis of variance indicated that all measured variables were affected by the treatments (Table 2).

Table 2. Analysis of variance for effects of rabbit manure and superabsorbent polymer (treatment) on measured variables

Variables	Treatment (*p* value)	R^2	CV	Mean
Soil moisture (%)	<0.0001 *	80.9	13.2	28.8
Plant height (cm)	<0.0001 *	91.5	6.9	66.0
Leaf number/plant	<0.0001 *	75.5	8.1	98.1
Stem thickness (cm)	<0.0001 *	79.2	20.1	2.5
Branch number/plant	0.0012 *	80.8	16.7	7.3
Shoot fresh weight (g)	<0.0001 *	80.3	4.8	925.6
Root fresh weight (g)	<0.0001 *	68.6	4.4	127.1
Shoot dry weight (g)	<0.0001 *	89.1	2.2	298.5
Root dry weight (g)	<0.0001 *	80.7	9.9	41.0
Leaf area (cm^2)	<0.0001 *	87.6	11.5	954.3
Leaf chlorophyll (SPAD reading)	0.0056 *	65.2	9.5	51.3
Days to flowering	0.0017 *	63.4	16.4	39.8
Fruit number	<0.0001 *	86.2	16.3	21.2
Fruit length (cm)	<0.0001 *	73.3	4.7	12.3
Fruit diameter (cm)	<0.0001 *	83.8	5.2	10.9
Fruit fresh weight (kg/plant)	<0.0001 *	91.1	8.9	2.7
Fruit dry weight (g/plant)	<0.0001 *	92.0	10.3	529.3

Note:
*ns, * not significant or significant at p ≤ 0.05, ANOVA*

3.4 Effect of Superabsorbent Polymer and Rabbit Manure on Soil Moisture

Plots, where SAP or rabbit manure + SAP was applied, had the highest soil moisture content compared with where no SAP or rabbit manure was applied (control), which had the lowest soil moisture, followed by plots where rabbit manure was applied alone (Figure 2).

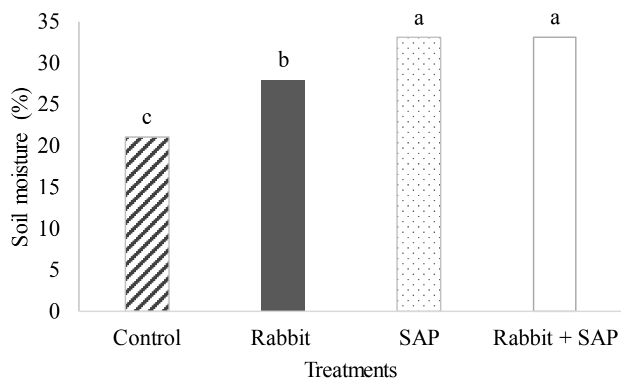

Figure 2. Effect of superabsorbent polymer and rabbit manure on soil moisture during production of eggplant. *Means followed by the same letter are not significantly different according to Tukey's honestly significant difference test at *p* ≤ 0.05. Rabbit = Rabbit manure, SAP = Superabsorbent polymer

3.5 Effect of Superabsorbent Polymer and Rabbit Manure on Growth and Yield of Eggplant

Use of SAP alone or in combination with rabbit manure resulted in tallest plants, most leaves, thickest stems and most branches. This was followed by the use of rabbit manure alone, while where no SAP or rabbit manure was applied had the shortest plants, fewest leaves, thinnest stems and most occasional branches (Table 3).

Table 3. Effect of superabsorbent polymer and rabbit manure on plant height, leaf number, stem diameter and number of branches of eggplant

Treatment	Plant height (cm)	Leaf number/ plant	Stem diameter (cm)	Branch number/ plant
Control	53.4 c*	82.3 c	1.7 c	5.9 c
Rabbit	62.4 b	97.4 b	2.3 bc	7.1 ab
SAP	72.3 a	104.5 ab	2.8 ab	7.4 ab
Rabbit + SAP	76.0 a	108.3 ab	3.1 a	8.6 a

Note:
**Means within a column followed by the same letter are not significantly different according to Tukey's honestly significant difference test at p ≤ 0.05. Rabbit = Rabbit manure, SAP = Superabsorbent polymer.*

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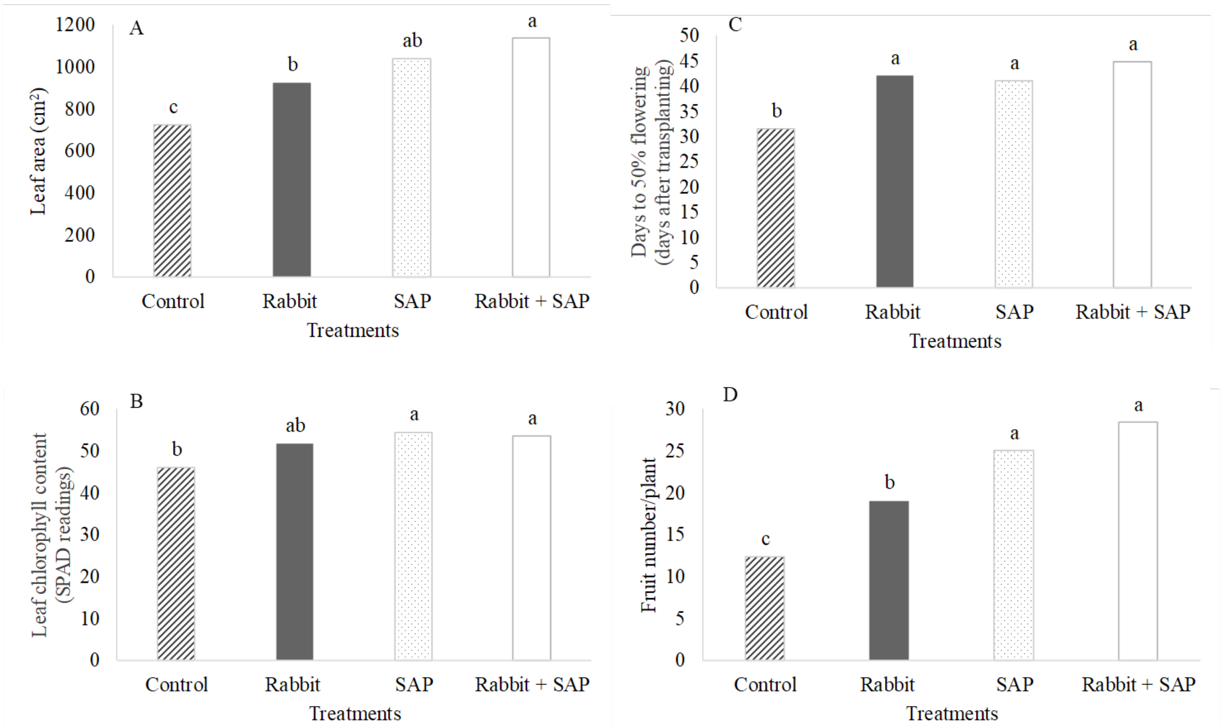

Figure 3. Effect of rabbit manure (rabbit) and superabsorbent polymer (SAP) on leaf area, chlorophyll content, days to flowering and fruit number of eggplants. Means followed by the same letter within a production season are not significantly different according to Tukey's honestly significant difference test at $p \leq 0.05$. Rabbit = Rabbit manure, SAP = Superabsorbent polymer

Use of SAP alone or in combination with rabbit manure resulted in highest shoot fresh weight, root fresh weight, shoot dry weight and root dry weight of eggplant, followed by use of rabbit manure alone. Control treatments, where no SAP or rabbit manure was applied had the lowest shoot fresh weight, root fresh weight, shoot dry weight and root dry weight of eggplant (Table 4).

Table 4. Effect of superabsorbent polymer and rabbit manure on fresh and dry weight of eggplant during production in season one (2018) and two (2019)

	Fresh weight (g)		**Dry weight (g)**	
Treatment	Shoot	Root	Shoot	Root
Control	848.1 c*	118.4 c	281.0 c	31.4 c
Rabbit	919.0 b	124.2 bc	298.7 b	40.6 b
SAP	954.0 ab	131.1 ab	305.6 ab	45.5 ab
Rabbit + SAP	981.2 a	134.8 a	308.9 a	46.5 a

Note:
**Means within a column followed by the same letter are not significantly different according to Tukey's honestly significant difference test at $p \leq 0.05$. Rabbit = Rabbit manure, SAP = Superabsorbent polymer.*

Superabsorbent polymer (SAP) and rabbit manure had effect on eggplant leaf area (Figure 3A), leaf chlorophyll content (Figure 3B), days to 50% flowering (Figure 3C), and fruit number (Figure 3D). Generally, use of SAP alone and/or rabbit manure had the highest leaf area, leaf chlorophyll content, days to 50% flowering, and fruit number compared with where no SAP or rabbit manure was used (control).

Superabsorbent polymer (SAP) and rabbit manure had effect on eggplant fruit length (Figure 4A), diameter (Figure 4B), fresh (Figure 4C) and dry weight (Figure 4D). Use of SAP alone or in combination with rabbit manure resulted in longest and thickest fruit as well as fruit the highest fresh and dry weight while the control, where no SAP and/or rabbit manure was used had the lowest of the mentioned parameters, followed by rabbit manure alone.

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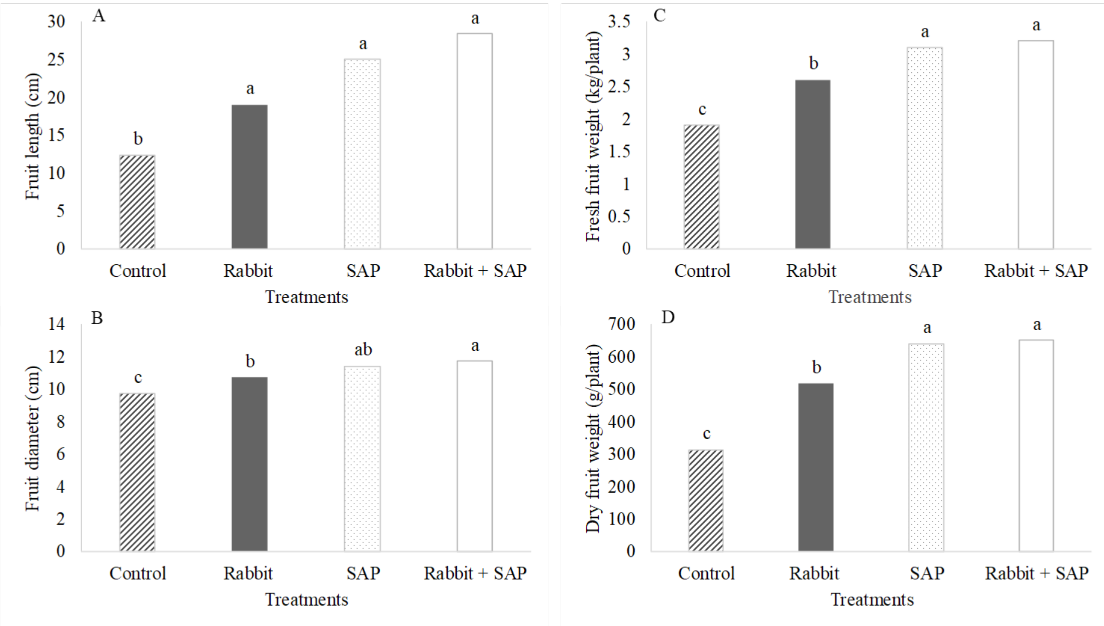

Figure 4. Effect of rabbit manure (rabbit) and superabsorbent polymer (SAP) on fresh and dry fruit weight of eggplant. Means followed by the same letter within a production season are not significantly different according to Tukey's honestly significant difference test at $p \leq 0.05$. Rabbit = Rabbit manure, SAP = Superabsorbent polymer

4. Discussion

Ideal soil condition is critical for the growth of crops such as eggplant. Water plays a vital role for the physiological development of eggplants [20]. Water is essential in maintaining cell turgidity, transportation of nutrients and organic compounds throughout the plant, serving as a raw material for various plant metabolic processes, including photosynthesis, and through transpiration, buffering the plant against wide temperature fluctuations as well as comprising much of the living protoplasm in the cells [16].

Use of superabsorbent polymer (SAP) and/or rabbit manure helped to conserve soil moisture compared with where they were not applied. Studies have shown that SAP is able to absorb large amounts of water during irrigation or rain to between 200 to 500 times their original weight or volume in relatively short periods[9, 22]. After irrigation or rain has stopped, SAP act as water reservoirs and gradually release water into the soil near the root zone and therefore helping to extend soil moisture availability[4]. Rabbit manure has also been shown to improve soil water holding capacity through changes in soil physical, chemical and biological properties[1]. Therefore, this explains why soil moisture content was higher, where SAP and/or rabbit manure was applied. Abrisham et al. [2] observed that SAP enhanced soil and plant properties, including soil water retention capacity. Abuarab et al. [3] observed that rabbit manure had a better water holding capacity than chicken, cow and compost manure.

Use of SAP and/or rabbit manure improved growth and yield of eggplant compared with when they were not applied. The effect was much better when SAP was used alone, similar to when it was combined with rabbit manure compared with rabbit manure alone. Superabsorbent polymers have been reported to act as water reservoirs by absorbing excess water during irrigation or rain and releasing it slowing into the root zone on demand [8]. Rop [22] observed that SAP upon biodegradation release nutrient to the soil making them available for plant uptake. Rabbit manure is reported to improve soil physical, chemical and biological properties which result in better plant nutrient uptake and therefore improved physiological growth and development. Rabbit manure was observed to improve vegetative growth and yield of pepper (*Capsicum annuum* L.) and eggplant (*Solanum melongena* L.) grown in pot culture [1]. This was attributed to enhanced water holding capacity and nutrients that were gradually released to the soil which resulted in better nutrient uptake and physiological development.

5. Conclusion

Soil water and nutrient management are essential for the growth of crops, including eggplant. This is even more

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critical in arid and semi-arid areas where water shortage is of great concern. SAP and/or rabbit manure helped to improve soil moisture, growth and yield of eggplant compared with the control. Use of SAP had a better soil moisture retention effect comparable to SAP combined with rabbit manure. The finding demonstrates that SAP and/or rabbit manure may help in better soil water and nutrient management, particularly in arid and semi-arid areas, thus improving growth and yield of eggplant.

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ARTICLE

On-farm Evaluation and Demonstration of Different Feeding Treatment for Beef Cattle Fattening in Adami Tulu Jidokombolcha District, East Shoa Zone

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ABSTRACT

Evaluation and demonstration study was conducted at Kemo-Gerbi kebele of Adami Tulu Jidokombolcha district on two to three year old Borana bulls with the objectives of evaluation and demonstration of bulls fattening technologies at on-farm level. One farmer's research extension group (FREG) was formed for fattening the bulls. Twenty bulls were purchased from Borana zone by farmers for the fattening trials. Two feeding treatments (T1= crushed maize grain (20%) + wheat bran (45%) + 35% Noug cake and T2 = wheat bran (65%) + cotton seed cake (35%)) were evaluated at on- farm. Eight hour grazing was common for both treatments. The animals were randomly assigned for dietary rations and data on live weight change of the animals were taken using weight chart tape (developed by JICA project). Finishing weights, total weight gain and daily weight gain of the bulls were not different (P>0.05) between the treatments. Bulls fed on treatment one attained an average daily weight gain of 0.83 kg per bull; while bulls fed on treatment two gained 0.76 kg per bull per day. Total gross margin of treatment one (53,154.5 ETB) was higher than treatment two (49,467.75 ETB). Cost-benefit analysis showed that feeding option number one (T1) is more profitable than feeding option number two (T2). However, fatteners can use any of the feeding options depending on availability of the ingredients in their area.

1. Background and Justification

Ethiopia has large livestock population in Africa. Its cattle, sheep and goat population are estimated above 59.5, 30.7 and 30.2 million heads, respectively [1]. The livestock sector contributes about 15% of the total export income and 30% of agricultural employment [2]. In spite of the importance, this sector has remained undeveloped and in many cases underutilized [3].

The average Ethiopian beef yield per animal of 108.4kg is by far less than 119 kg for Sudan, 146 for Africa and 205 kg for whole world [4-6]. Ethiopian people meat consumption per-capita is 13.9 kg/year which lower than the Africa (27 kg/year) and the world averages (100 kg/year) [7]. This is due to fact that livestock production in Ethiopia is subsistence oriented and characterized by low

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production performances.

The total amount of meat presently produced from cattle production in the Ethiopia could not promise the increasing demand of people. On the other hand, the traditional livestock farming practices are not mostly market oriented [8]. Farmer cattle fattening practices are frequently dependents on natural grazing land and crop residues with few or no supplements. The traditional practices did not also consider for the animal nutrient requirement, the level of feeding being either above or below the animal requirements.

The government of Ethiopia is trying to expand the sector to meet the increased demand from both export and domestic markets. Inline to this, some fattening feed treatment options are generated at Adami Tulu Agriculture Research Center. Recent reports indicated that growth performance of two years old Borana bulls evaluated on different dietary ration managed to attain 300 kg have promising results [9]. Evaluation and demonstration of such technology is a way to promote to farmers and users. Therefore, the study was designed to evaluate and demonstrate beef fattening technologies at on-farm level.

Objectives

(1) To evaluate and demonstrate fattening technologies for young Borana bulls at on-farm level

(2) To identify most economical feeding option for young Borana bulls at on farm level

2. Methodology

2.1 Demonstration Site

The study was conducted in East Shoa Zone. East Shoa Zone is belongs to the administrative zone of Oromia regional state, Ethiopia. The zone has an area of 10421 km^2. There are 10 districts within this zone and Adami Tulu JidoKombolcha (ATJK) is one of the districts, where the demonstration was undertaken. ATJK is found in mid-rift valley of Oromia Regional State at 167 km from Addis Ababa, Ethiopia at an altitude of 1650 meter above sea level, along the main road to Hawassa town. The district is geographically located at latitude of 70 50’ North and longitude of 380 42’East [10]. Kemo-Gerbi kebele was purposely selected together with livestock expert of ATJK district livestock agency having farmers with cattle fattening experience and access to market and transport. Cattle fattener primary selection criteria are willingness, history and accessibility to market.

2.2 Farmers’ Selection and Capacity Building

The activity was conducted using the farmers’ research extension group (FREG) approaches. One FREG was organized. Farmers were selected based on their willingness to participate and previous experience with cattle fattening. Farmers contributed money to purchase bulls, grazing land, construct fattening shade and labor for the fattening purpose. Adami Tulu Agriculture Research Center provided dietary ration (concentrate feeds) and technical aids during the fattening period. The theoretical and practical training were given to farmers, district livestock development experts and development agents on mixed ration preparation, feeding management, animals’ health keeping, bulls fattening and marketing the finished bulls.

2.3 Experimentalanimals’ Selection and Feeding Management

Ages of the bulls were determined by dentition techniques. Accordingly, the bulls were two to three years old with an average initial live weight of 216.6 ± 12.9 kg. A total of 20 bulls were purchased from Borana Zone of Oromia Regional State, Ethiopia. They were transported by truck to the study site. The experimental bulls were injected anti-parasites before the beginning of the actual feeding. All experimental bulls were randomly assigned to one of the two dietary treatments as indicated below in the next section. The dietary ration was prepared and provided in individually feeding bases. The concentrates were supplemented to the bulls at a rate of 2.5% of their life weights and readjusted on every 15 days weight recorded. The animals were kept on grazing for eight hours a day plus few tinning of maize crop whenever available and watering was freely or adlib during the whole day.

2.4 Experimental Ration Formulation

Dietary rations were formulated from different feed ingredients; wheat bran, Noug seed cake (NSC), crushed maize grain and cotton seed cake (CSC). Two dietary rations ((Treatment 1: Eight hour grazing + crushed maize grain (20%) + wheat bran (45%) + 35% NSC and (Treatment 2: Eight hour grazing + 35% (CSC) + 65% wheat bran)) were formulated in such a way that they contain similar amounts of energy and protein as compared to the traditional one, which is usually mixed at random (not in proportion manner) or fed separately and as being available; also mostly not depends agro-products that use only natural pasture.

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2.5 Chemicals Composition of Experimental feeds

Table 1. Feeds composition (%)

Dietary ration	Ingredient	Dry Matter	CP	TDN
T_1	Crushed maize grain (10, 85)	20	2.00	17.00
	Wheat bran (13, 67)	45	5.85	30.15
	Noug cake (29.75, 66)	35	10.41	23.10
	Total	**100**	**18.26**	**70.25**
T_2	Wheat bran (13, 67)	65	8.45	43.55
	Cottonseed cake (28, 75)	35	9.80	18.25
	Total	**100**		**69.8**

Notes:

T_1= Treatment one, T_2= treatment two, CP = Crude protein, TDN = Total digestible nutrient

2.6 Growth Performance Assessment

Record sheets and check lists were prepared to collect data on the amount of feed offered and fortnightly live weight changes in kg. Growth performance of young bulls was assessed as below:

$$DW=\frac{(FBW-IBW)}{TD}$$

$$TWG = FBW – IBW$$

Where: DG = Daily gain, TWG = Total weight gain, FBW = Finished body weight, IBW = Initial body weight and TD = Total feeding days

2.7 Cost-benefit Ratio Analysis

The variable costs incurred during conducting the evaluation and demonstration the beef fattening technologies were properly recorded. Thus costs like bulls purchase, transportation, concentrate purchase, wage and veterinary costs were considered in the financial analysis. The gross revenues were obtained from prices of the finished bulls sold at market. Fixed costs incurred for feeding the animals were excluded in financial analyses.

2.8 Data Analysis

The collected data was entered to computer. Growth performances and financial parameters incurred during evaluation and demonstration of different feeding options for young Borana bulls were analyzed using t-test of R software 3.5.2 version.

3. Result and Discussion

3.1 Effect of Feeding Different Options on Growth Performance

Effect of feeding different options on growth performances of the two to three years old Borana bulls were analyzed after finishing. The final body weight, total body weight and daily weight gains of the bulls were as listed in Table 2.

Table 2. Body weight change during bulls fattening period

Weight (Kg)	T_1	T_2	Overall
Initial body weight	214.3 ±10.9	218.8±14.7	216.6± 12.9
Final body weight	301.6±7.8	298.1±10.9	300.3±9.4
Total weight gain	87.3±5.2	79.3±8.4	83.8±7.7
Average daily gain	0.83±0.07	0.76±0.08	0.79±0.07

Note:

Values are not significant across raw at P<0.05

The study results indicate that there is no significance difference in final body weight between the two treatments. The current finding is related with the report of Mieso [11] who conducted similar study on the yearling Borana bulls. Similarly, Girma [9] reported that dietary rations have similar effect on final body weight of two years old Borana bulls.

The total and average daily weight gains for the experimental bulls didn't also showed significant difference between the two treatments at 105 days of fattening. Different authors [9,11-15] conducted studies at on-station on yearling Borana bulls, two years old Borana bulls, yearling Kereyu bulls, two years old Kereyu bulls, yearling Arsi bulls and two years old Arsi bulls fed on similar dietary ration reported as no significant differences in total weight gains between the treatments. The current average daily weight gains of the bulls was found to be similar to the reports of Girma [9] who indicated that 0.801 and 0.753 kg for two years old Borana bulls. Furthermore, this study indicated that the Borana bulls can attain export market body weight demand in 105 days of feeding.

Figure 1. Bulls at fattening shade

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Figure 2. Farmers field-day

3.2 Cost-benefit Analysis

The financial analysis of young Borana bulls after fattening period is listed in the Table 3. Even though, there was no significance difference between both treatments. The finding results indicated higher total gross margin for experimental bulls fed dietary feed (T_1) than those fed dietary ration (T_2). The study result was similar to Mieso [11] where the Borana bulls, which taken crushed maize grain, provided better profit than those received cotton seed cake.

Table 3. Economic return from Borana bulls fattening at on-farm level

List of items (ETB)	T_1	T_2	Overall
Feeds costs per bull	4,635.05	4,798.43	4,716.74
Purchasing price per bull	8,500	8,500	8,500
Transport cost per bull	700	700	700
Labor cost per bull	150	150	150
Veterinary cost per bull	55	45	50
Total variable cost per bull	**14,040.05**	**14,193.43**	**14,116.74**
Total gross output per bull	19,355.50	19,140.20	19,247.85
Gross margin per bull	5,315.45	4,946.77	5,131.11
Total gross margin	**53,154.5**	**49,467.75**	**51,311.13**

Note:
ETB: Ethiopia Birr; Values are not significant across raw at P<0.05

3.3 Farmers' Opinion on the Treatments

Farmers have their own opinion on the cattle fattening technologies. They have own observation on difference between their traditional fattening experience and the current fattening. In this study, participant farmers have appreciated the efficiency of the fattening ration in changing body condition of the animals. They also loved the processes involved in animal selection criteria, feeding management, dietary ration preparation and the house construction. The fattening treatments were as also found to be profitable and easily manageable by farmers.

4. Conclusion and Recommendation

Twenty Borana bulls were randomly assigned in to two dietary ration groups and kept on feeding for 105 days to observe their growth performance. Both dietary rations have similar effect on growth performance of the young Borana bulls, which may be attributed to the similarity of the CP and TDN of the ration provided to the experimental bulls as well as the similarity of the breed. Numerically bulls fed on dietary T_1 were more profitable than bulls fed on dietary T_2. The two - three years age Borana bulls have potential to reach three hundred kilogram using the treatments within fifteen weeks of feeding. Therefore, we recommend that any one of the dietary rations can be used based on the availability of the feed ingredients in the fattening locations as there were no significant variations in major parameters between the treatments.

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Author Guidelines

This document provides some guidelines to authors for submission in order to work towards a seamless submission process. While complete adherence to the following guidelines is not enforced, authors should note that following through with the guidelines will be helpful in expediting the copyediting and proofreading processes, and allow for improved readability during the review process.

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- Program: Microsoft Word (preferred)
- Font: Times New Roman
- Size: 12
- Style: Normal
- Paragraph: Justified
- Required Documents

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All articles should include a cover letter as a separate document.

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- A brief description of the novelty and importance of the findings detailed in the paper

Declaration

v Conflict of Interest

Examples of conflicts of interest include (but are not limited to):

- Research grants
- Honoria
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This section confirms that written consent was obtained from all participants prior to the study.

- Ethical Approval

Eg. The paper received the ethical approval of XXX Ethics Committee.

- Trial Registration

Eg. Name of Trial Registry: Trial Registration Number

- Contributorship

The role(s) that each author undertook should be reflected in this section. This section affirms that each credited author has had a significant contribution to the article.

1. Main Manuscript
2. Reference List
3. Supplementary Data/Information

Supplementary figures, small tables, text etc.

As supplementary data/information is not copyedited/proofread, kindly ensure that the section is free from errors, and is presented clearly.

Ⅲ. Abstract

A general introduction to the research topic of the paper should be provided, along with a brief summary of its main results and implications. Kindly ensure the abstract is self-contained and remains readable to a wider audience. The abstract should also be kept to a maximum of 200 words.

Authors should also include 5-8 keywords after the abstract, separated by a semi-colon, avoiding the words already used in the title of the article.

Abstract and keywords should be reflected as font size 14.

Ⅳ. Title

The title should not exceed 50 words. Authors are encouraged to keep their titles succinct and relevant.

Titles should be reflected as font size 26, and in bold type.

Ⅳ. Section Headings

Section headings, sub-headings, and sub-subheadings should be differentiated by font size.

Section Headings: Font size 22, bold type

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Main Manuscript Outline

Ⅴ. Introduction

The introduction should highlight the significance of the research conducted, in particular, in relation to current state of research in the field. A clear research objective should be conveyed within a single sentence.

Ⅵ. Methodology/Methods

In this section, the methods used to obtain the results in the paper should be clearly elucidated. This allows readers to be able to replicate the study in the future. Authors should ensure that any references made to other research or experiments should be clearly cited.

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In this section, the results of experiments conducted should be detailed. The results should not be discussed at length in this section. Alternatively, Results and Discussion can also be combined to a single section.

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In this section, the results of the experiments conducted can be discussed in detail. Authors should discuss the direct and indirect implications of their findings, and also discuss if the results obtain reflect the current state of research in the field. Applications for the research should be discussed in this section. Suggestions for future research can also be discussed in this section.

Ⅸ. Conclusion

This section offers closure for the paper. An effective conclusion will need to sum up the principal findings of the papers, and its implications for further research.

Ⅹ. References

References should be included as a separate page from the main manuscript. For parts of the manuscript that have referenced a particular source, a superscript (ie. [x]) should be included next to the referenced text.
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Ⅺ. Glossary of Publication Type

J = Journal/Magazine

M = Monograph/Book

C = (Article) Collection

D = Dissertation/Thesis

P = Patent

S = Standards

N = Newspapers

R = Reports

Kindly note that the order of appearance of the referenced source should follow its order of appearance in the main manuscript.

Graphs, Figures, Tables, and Equations

Graphs, figures and tables should be labelled closely below it and aligned to the center. Each data presentation type should be labelled as Graph, Figure, or Table, and its sequence should be in running order, separate from each other.

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Ⅻ. Others

Conflicts of interest, acknowledgements, and publication ethics should also be declared in the final version of the manuscript. Instructions have been provided as its counterpart under Cover Letter.

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