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Mathematics Applications for Agricultural Development: Implications for Agricultural Extension Delivery

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Abstract
This paper recognizes the fact that agriculture has been the mainstay of the nation's economy as it provides food for the teeming population and raw materials for the industries. The obvious remains that mathematics application for the development of agriculture becomes imperative and worthwhile. The paper therefore focuses on the concepts of mathematics and agricultural development, its requirements as well as some arrays of mathematics applications for agricultural development. Finally, it is suggested that the extension delivery of new technological packages should be participatory and democratic enough to allow farmers avail themselves the opportunities of identifying their needs and problems, prioritizing them, analyzing them, among other commitments.

Key words: Mathematics, Application, Agricultural development, Extension delivery

Introduction

Agriculture has been the mainstay of the nation's economy in Nigeria. It provides food for the ever rapidly increasing population and raw materials for the industries. People especially the rural dwellers are gainfully employed on their crop farms and small scale livestock farms for income earning. Realizing that the power of any nation lies in her ability to feed her citizenry, government has been making a lot of efforts to improve agriculture in the country in the past decades. These have been in the area of mounting different successive programmes such as Operation Feed the Nation (OFN) Green Revolution Programme(GRP) and Agricultural Development Programmes (ADPs). The success of any programme is hinged on how well developed and put in place such programme is as well as the commitment of its operators.

It is in the light of the above that the development of agriculture, a worldwide practice of raising crops and animals for satisfying human wants (Adedayo, 1999) becomes imperative and worthwhile. This is where science, technology and mathematics come in. Hence, Ochekliye (2004) in Enemali and Adah (2015a) maintained that no country in recent age can develop or even hope to maintain its existence without science, technology and mathematics. Agricultural development is one of such developments. It is on this premise that the paper focuses on the concepts of mathematics and agricultural development as well as applications of mathematics to agricultural development.

Concept of Mathematics

Johnson and Rising (1972) described mathematics as a creation of the human mind, concerned primarily with ideas, processes and reasoning. They view it as a way of thinking which makes it useful in the solution of all kinds of problems (including agricultural development), science and industry.

According to Onoja (1999), mathematics is therefore characterized with clarity and precision that enable us to perform computations, solve problems and complete proofs with ease. To Eredugba (1978) in Onoja (1999) mathematics is regarded as a 'tool subject' because it is useful in the breaking down of verbal arguments into concise and consistent forms. Supporting this, Idoko (1999) in a study maintains that mathematics provides a powerful technique of analysis which can be used to prove or disprove theories in economics; and by extension, agricultural development.

Ngoka (1993) observed that mathematics as well as science and technology is an important sphere in learning which greatly influence the level, nature, scope and direction of development of any nation. This is because the language of mathematics is regarded by many people as the life wire in the studies of various disciplines including agriculture.

From the foregoing, in all spheres of life, including agriculture, application of mathematics has been found to be key (Enemali and Adah, 2015a). Hence, Umaru (1995) conceptualized mathematics as a language which provides an indispensable means of investigating the nature of things particularly those which are dealt with in the field of science, technology, engineering and industry; and by extension agriculture and agricultural development.

Concept of Agricultural Development

Agriculture is an integral part of science. According to Nworah (2015) it involves the cultivation of land, raising and rearing of animals for the purpose of production of food for man, feed for animals and raw materials for industry. Aboyade in Adedayo(1999) defined development as a continuous process of generating and more efficiently allocating resources for achieving greater socially satisfying needs. Although a number of views abound on agricultural development, Adegeye and Dittoh (1985) taking cognizance of a purely subsistence economy, pointed out that agricultural development would mean enough food for the people and a marketable surplus produced to increase the income of the peasants and that the increased income so generated would provide means for them to purchase other necessities of life which they cannot produce for themselves. By this means the standard of living of the peasants will increase, and underemployment and unemployment will be reduced. They pointed out also that there would be an increase in the Gross Domestic Product (GDP) since a large proportion of the population depends on agriculture.

To Adedayo (1999) agricultural development could be viewed as:

a) Increased level of farm output where the benefits of such production are shared among those who work on the farm and those who otherwise contribute to the increased production.
b) Agricultural extension by way of additional lands, additional labour and additional capital.
c) Increases in income of people employed in the agricultural sector manifested by their acquisition of modern things.

From the foregoing the first view of Adedayo (1999) which centres on increased output is germane to this discourse. Hence, Adegeye and Dittoh (1985) had earlier viewed that for agricultural development to occur, the majority of farmers must experience significant improvement in their incomes and standard of living. This has underscored the significance of mathematics being a ‘tool subject’ for rapid development.

Requirements of Agricultural Development

According to Adedayo (1999), the following are requirements of agricultural development:

a) **Marketing**: There should be a high demand or consumption for agricultural product; marketing entails getting products from farmers to the consumers. It enlarges agricultural production as well as facilitating industrial growth and bringing greater wealth to the nation. Marketing involves transportation, storage, processing and packaging.
b) **New Farm Technology**: Agricultural development requires a research programme that is continuously generating new agricultural techniques.
c) **Purchasable Input**: Agricultural inputs like seeds, fertilizers, etc should be available at affordable prices to farmers, it should also be supplied at the right time and in the right place.
d) **Incentives to Farmers**: Farmers should be motivated towards producing more through the provision of price subsidy, fair sharing of farm produce in case of share cropping and the goods and services required by farmers should be made available for improving their standard of living.
e) **Production Credit**: Credit to farmers is necessary to be able to procure and adapt necessary technologies. A major source of credit to farmers is by government and commercial banks which are usually not available to farmers because of lack of collateral security and default in repayment.

These requirements demand one form of mathematics application or the other, especially in the area of new farm technology known to be the springboard of agricultural development. While acknowledging this fact, Ajayi and Imoko (2011) pointed out that without mathematics there is no science, without science there is no modern technology and without modern technology in our farms and farming activities, the society stands to suffer greatly (Enemali and Adah, 2015b).

Some Applications of Mathematics for Agricultural Development.

Ochekliye (2004) in Enemali and Adah (2015a) underscored the significant role of mathematics in various human endeavours when he stressed that it is the foundation of science and technology without which a nation can never be prosperous and economically independent. In line with this, farm mathematics encompasses all forms of measurements on the farm, farm forecasts, farm accounts and record keeping, all forms of business that have to do with farm and farm products (Enemali and Adah, 2015b).

Field experimentation is another core area where mathematics applications are used. According to Adedayo (1999) it is a systematic and logical process of comparing two or more factors on the field to identify the best in certain characteristics. It is an organized agricultural research endeavour aimed at gaining new facts and knowledge which will bring about increased productivity and agricultural development. It involves the conduct of field experiment where the field work is actually carried out and the application of statistical method for collecting; organizing, presenting, analyzing and interpreting data are employed. Here different fertilizers' effects on crops for optimum yields as well as plant population implications are studied. Soil suitability for crops and other various soil tests are carried out using field experimentation. All these are realizable through full mathematics applications.

More recent advances in the mathematical sciences have helped improve our ability to predict the weather, to measure the effects of environmental hazards and to study the origin of the universe (Aguele and Usman, 2007). This is very important in the current trend of climate change phenomena in the entire world today.

Okeke (2007) in Ajai and Imoko (2011) pointed out that the applications of science and technology to agriculture, whose foundation is mathematics, have completely changed the face of agriculture through the introduction of mechanical devices for planting, tending, harvesting and processing of various food crops. Researches have not only through hybridization by plant/animal breeders resulted in improved varieties of food crops and animals and other food products, but has boosted yields through the use of fertilizers and pesticides. All these have been possible courtesy of mathematical modeling, an aspect of computational mathematics.

Agricultural development is majorly about optimal results. Application of optimum spacing within and between rows of crops results in optimum yields in crop production. Apart from the yield factor, optimum spacing encourages formation of foliage canopy which helps in suppressing weeds emergence. Too staggered/close spacings therefore affect optimum yield as well. For the realization of optimum yields in maize, rice, yam, cassava and cowpea for instance, the following spacings should adhered to:

Table 1: Recommended Crop Spacings for Optimum Yield.

Crop	Spacing
Maize	90cm x 30cm at one seed per hole or 75cm x 25cm at two seeds per hole
Rice	25cm – 30cm apart, depending on variety
Yam	90cm x 100cm, while yam mini-setts is 25cm x 100cm
Cassava	1m x 1m
Cowpea	25cm x 90cm for the spreading type; 30cm x 75cm for the erect type

Source: Iwena (2012).

Further to this, Akissani and Muntari(2015) pointed out that overpopulation on the farm causes overcrowding, poor ventilation and reduction in yield as a result of competition for the environmental resources; and that low population densities is not desirable as there is emergence of weeds. Plants population is calculated using the formula:

$$\text{Plant population} = \frac{\text{Area of land}}{\text{Feeding area}}$$

Feeding area = Intra x Inter row spacing.

In fertilizer compounding and applications, mathematics is involved. This is because the recommended proportion of the component elements of the chemical must be used to avoid any harmful effect on the crops when applied. Again, its application to the field must be calculated as under and over applications are counterproductive. For instance, if a farmer is applying 60kg N/ha, what quantity of sulphate of ammonia does he require for 6 hectares? The following is the solution to the problem: Ammonium sulphate has 21%N as active ingredient. This implies that 21kg of N is contained in 100kg of ammonium sulphate.

Therefore,

60kg of N = 100/21 X 60/1 of ammonium sulphate

=285.714kg/ha of ammonium sulphate per hectare

For 6 ha =285.714 x 6

= 1714.3kg

=1.71 tonnes of ammonium sulphate.

In animal or livestock feed formulation, mathematics is also applied. Table 2 shows the nutrient requirements of some farm animals which should be considered strictly in feed formulation.

Table 2: Nutrient Requirements of Farm Animals

	Animal species	Protein (%)	*ME kcal/kg	Fibre (%)	**Ca (%)	***P (%)
1.	Pullet chickens. a. 0-8 weeks b. 9-20 weeks	 20.0 15-16	 2640 2600	 6 6	 1.0 0.8	 0.50 0.50
2.	Layers> 20 weeks	16	2500	6	2.75	0.50
3.	Broilers a. starter b. finisher	 23.0 20.0	 3000 3000	 3-4 3-4	 1.0 1.0	 0.50 0.50
4.	Pigs a. growers b. breeders c. latching	 17.0 15.0 16.0	 3500 3300 35000	 NA NA NA	 0.80 0.60 0.90	 0.70 0.65 0.45
5.	Rabbits a. growers b. lactating c. pregnant doe d. buck (resting)	 16.0 18.0 16.0 13.0	 2400 2500 2400 2100	 14.0 12.0 14.0 16.0	 0.40 1.10 0.80 0.40	 0.30 0.80 0.50 0.30
6.	Ruminants	12-16	2700	33.0	-	-

*Metabolisable Energy **Calcium ***Phosphorus

Source: Babayemi et al (2014).

In chemical control of pests, diseases and weeds, a lot but simple mathematics is involved. This is to avoid loss of crops that might occur during preparation (mixing) and application of such chemicals. A wrongly mixed and applied chemical could cause damping-off, burning and killing of the crop foliage.

Increased yield of agricultural products for local consumption and export is associated with the application of mathematics in protection strategies, evaluation of retailer performance, application rates, finance division and piloting to explain for more efficient travel are ideas outlined by persons knowledgeable in mathematics (Malami, Ayyub and Halilu, 2013). The application of mathematics therefore, aids in enhancing efficient food supply for local and international appeal, thereby curtailing starvation to the teeming manpower that can enhance the development of other sectors of the economy with prospects of improvement in the standard of living being assured. Hence, Natasha in Akissani and Muntari(2015) stated that there are two very important elements within the broad concept of farming: time and money. At the root of both is mathematics. Mathematics has enabled farming to be more economically efficient and has increased productivity. Farmers use numbers everyday for a variety of tasks, from measuring and weighing, to land marking.

Amodu and Okpanachi (2015) underscore the relevance and usefulness of various mathematical models. For instance, the Malthusian model on population growth against growth in food production is still a guide for decisions on food security today. Likewise, mathematical model on economic growth against agricultural development can spur government policy and action on agriculture. Again, mathematical models on world population growth against food security have placed agriculture on the top list of global affairs. Crop and soil studies as well as pest life and disease control have found mathematical models to be very useful.

Fadare, Ayeni and Babatunde(2015) pointed out the use of mathematics for the following agricultural activities: plotting the demand and supply schedule and curve for decision making, amount of fertilizers to be applied per area of land and per stand of a crop, oestrus cycle, incubation period and gestation periods in livestock, loss and profit accounts and percentages, diameter of soil components, interest on agricultural loans and credit facilities, number of eggs laid by fowls, litres of honey harvested in a bee box, making of in-let and out-let in a fish pond and their correct depth and height, quantity of water to be used for vaccine(e.g. Lasota, Gumboro, Coccidiosis,etc.),the ratio of the weight of egg lobe to the whole fish so as to determine the amount of chemical to be applied on the female fish in the process of production of fingerlings. When to change fowls feed from growers feed to semi-layer finally to layers feed, is a measure of the percentage of egg collected in a poultry.

Farmers also estimate elements of time. According to Akissani and Muntari (2015) farmers know approximately how many hours they will need to seed and harvest and can plan accordingly. These estimates of time are based on crop types and machine availability, as well as human resources. They added that farmers consider past trends of weather and moisture conditions to decide when to start seeding. Furthermore, farmers can estimate the time remaining until harvest by calculating growing degree days. This is the measurement of heat units needed by the plant to reach its full maturity. It also accounts for the ripening of the crop. An approximation is made of how many days remain until the crop and can change numbers of growing degree days.

Concept of percentage is used by farmers to carry out seed germination test. To Akissani and Muntari (2015), this involves getting a uniform and representative sample of an entire seed lot, counting a more convenient sizeable number, 25, 50,100 or more seeds from the representative sample. The seeds are then sown in seed boxes, baskets or polythene bags filled with sterilized soil and kept at room temperature. The seeds are kept moist as often as possible. Account is taken as the seeds emerge. The principle is that viable seeds will sprout more or less at the same time while weak seeds usually sprout irregularly and they do not produce normal seedlings. The percentage emergence of the seeds is obtained as follows:

$$\text{Percentage emergence} = \frac{\text{Number of seedlings emerged}}{\text{Total number of seeds planted}} \times 100\%$$

Where a seed lot has less than 50% germination test, it is advisable that such seeds are not planted in order to avoid planting dead seeds. And if the seed lot will be used for planting, it is better to double such seed rates for example, if 2-3 seeds are required per planting hole, 5-6 seeds should be planted per hole.

Calculus which is an advanced system of calculation that deals with continually changing values is used for agricultural development. For instance, Nworah (2015) revealed that in agricultural mechanics, calculus is used when adjusting aircraft that apply spray material to crops. It can be used to calculate amounts when the application has multiple variables.

In measuring discharge in irrigation, mathematics is also applied. The discharge of water from a pipe or a channel according to Uguru (1996) is the volume of water flowing per second. It is measured in cubic metre per second (m^3/s). Discharge (m^3/s) = area (m^2) x velocity of flow (m/s).The simplest means to measure discharge from a pipe or a channel according to Uguru (1996) is to use a container (bucket) of known volume. The bucket is placed directly in the channel and water is allowed to flow into it. The time taken to fill the bucket is recorded and discharge is calculated thus:

$$\text{Discharge } (m^3/s) = \frac{\text{Volume of bucket } (m^3)}{\text{Time taken to fill the bucket(s)}}$$

These are just few specific examples of mathematics applications for agricultural development. A lot more instances of other mathematics applications abound.

Implications for Agricultural Extension Delivery

Agricultural extension is said to be the fulcrum upon which all other fields of agriculture rest and so has a huge responsibility in achieving the desired agricultural development. Agricultural extension education according to Agbarevo and Obinne (2010) is an informal or out-of-school educational programme for adult learners, rural people or farmers designed to help them and their families learn, accept, adapt and adopt improved agricultural practices. It is designed to change the farmers' way of thinking, his attitude and habits, so that he becomes receptive to change or innovations in agriculture, leading to a more productive farming, and consequently, a higher standard of living. It also includes general education and some supportive services. Agricultural extension has the objective of not only improving the farmers' farming methods and techniques, his production efficiency and income but, also, his social and educational standards leading to a higher standard of living.

In the light of the above and for the realization of the desired agricultural development, the extension practitioners through study and training programmes such as Fortnightly Training(FNT) and Monthly Technology Review Meeting(MTRM) should evolve pragmatic approaches for the dissemination of new farm technologies which might be beneficial to farmers. Success of any extension work depends on thorough training of extension workers and local leaders. Good intellectual training, technical skills and practical experience bring efficiency and effectiveness in the organization of local groups for attainment of groups goals. The extension staff should therefore be soundly trained to be able to cope with the latest research findings and technologies from various research stations and institutes aimed at developing agriculture. The delivery of new technological packages should therefore be participatory and democratic in approach to allow farmers avail themselves the opportunities of identifying their needs and problems, prioritizing them, analyzing them, seeking alternative means of solving them, choosing preferred alternatives, experimenting and implementing a chosen course of action, monitoring and evaluation of programmes. Since extension is essentially communication (Ogunbameru, Undiandeye and Ani, 2008), a process whereby various participants are linked and exchange information, which is a critical requirement for sustainable agricultural development, government and all other stakeholders should take its business a very serious one to achieve good result and sustain them. This includes proper funding of the services.

Conclusion

The paper has highlighted the fact that mathematics is key to agricultural development especially in every sphere of research in agriculture as already x-rayed. The various requirements of agricultural development such as good marketing, new farm technology, purchasable input, incentives to farmers and production credit are critical to the development and should be put in place and sustained. Finally, extension delivery system should be pragmatic enough to contribute positively to the desired agricultural development. This is by making it both participatory and democratic in approach. Further to this government at all levels should adequately fund extension component of the agencies saddled with agricultural matters to achieve successful as well as sustainable agricultural development.

References

Adedayo, R.O. (1999). Agricultural economics for colleges and secondary schools. Ado-Ekiti, Adedayo Printing Nigeria Limited. 65-171.

Adegeye, A.J. and Dittoh, J.S. (1985). Essentials of agricultural economics. Ibadan, Impact Publishers Nig. Ltd. 236 – 247.

Agbarevo, M.N.B. and Obinne, C.P.O. (2010). Elements of rural sociology and agricultural extension.Enugu, Teo Publishers. 49 – 63.

Aguele, L.I. and Usman, K.O. (2007). Mathematics education for dynamic economy in Nigeria in the 21st century. Retrieved on 09/10/14 from http://www.krepublishers. com/02 journals

Ajai, I.J. and Imoko, T.B. (2011). Mathamtics as a tool for sustainable national development and for addressing Nigerian challenges in the 21st century. Nasher Journal 9(2) 95-101.

Akissani, I. and Muntari,I. (2015). The role mathematics in agricultural development. In Sadiku, J.S (ed.) Proceedings of September 2015 Annual National Conference of Mathematical Association of Nigeria (M.A.N.). 317-324.

Amodu,A. and Okpanachi,D.(2015). Effect of mathematical applications on agricultural development in Kogi State, Nigeria. In Sadiku, J.S (ed.) Proceedings of September 2015 Annual National Conference of Mathematical Association of Nigeria (M.A.N.). 296-303.

Babayemi, O.J., Abu, O.A. and Opakunbi, A. (2014). Integrated animal husbandry for schools and colleges. Ibadan, Positive Press. 230-233.

Enemali, I.A. and Adah, O.C. (2015a). Empowering individuals and communities through agricultural education: The role of mathematics education. Journal of Vocational and Technical Educators. 4 (4) 46-50.

Enemali, I.A. and Adah,O.C.(2015b).Quality assurance in educational administration in the teaching of farm mathematics for national integration in Nigeria. Journal of Education and Practice. 6(23) 52-56.

Fadare,A.O. and Ayeni, A.A.(2015). Enhancing the teaching and learning of commercial mathematics for entrepreneurship skills development. A paper presented at the 5th Annual National Conference of School of Sciences, Federal College of Education (Special), Oyo,Oyo State.7th-10th April.

Idoko, C.U. (1999). Mathematical approach to effective teaching and learning economics in tertiary institutions. Ankpa Journal of Arts and Social Sciences (AJASS). 1(1) 23-28.

Iwena, O.A. (2012). Essential agricultural science for senior secondary schools._Ikeja, Tonad Publishers Ltd. 17-25.

Johnson, D.A. and Rising, G.R. (1972). Guidelines for teaching mathematics. (2nd_ed).Belmont, Wardsworth Publishing Company.

Malami,B.,Ayyub, M.H. and Halilu, A.(2013). Mathematics education as a tool for national development. A paper presented at the 50th Annual National Conference of Mathematical Association of Nigeria (M.A.N.) held at St. Patrick's College,Asaba, Delta State. 31st August -5th September.

Ngoka, G.N. (1993). The effects of educational materials for teaching pre-primary science in Nigeria. Teacher Education Journal (TEJ). 1(1) 7-21.

Nworah,F.C.(2015).Mathematics application for agricultural development in Nigeria. . In Sadiku, J.S (ed.) Proceedings of September 2015 Annual National Conference of Mathematical Association of Nigeria (M.A.N.).72-77.

Ogunbameru, B.O., Undiandeye, U.C. and Ani, A.O. (2008). Agricultural extension methodologies. Kaduna, Apani Publications 1-12.

Onoja, F.A. (1999). Translating some economics theories into mathematical relations. Ankpa Journal of Arts and Social Sciences (AJASS). 1(1) 18-22.

Uguru, M.I. (1996). Crop production: Tools, techniques and practice. Nsukka, Fulladu Publishing Company. 24-32.

Umaru, I.I. (1995). Science technology, mathematics, economic development education and national stability. Nsukka, Universal Trust Publishers.