CHALLENGES TO INTEGRATED NUTRIENT MANAGEMENT FOR SUSTAINABLE CITRUS PRODUCTION IN SOUTH-WEST NIGERIA

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ABSTRACT

Integrated nutrient management (INM) is a global practice aimed at achieving optimum plant nutrient supply for sustaining crop productivity in a holistic manner. It also aims at assuring higher yields, improved soil health, and sustainable environments. However, INM is not yet a popular practice among Nigerian farmers, particularly citrus producers, as they mostly rely on native soil nutrients, which result in yields that are below the optimum level and world average. The study therefore ascertained challenges associated with integrated fertilizer nutrient sources used among citrus farmers in the south-west zone of Nigeria. A questionnaire and Focus Group Discussion (FGD) guide were used to collect data from eighty respondents, which were analyzed using descriptive statistics. The majority of respondents were male (78.8%), married (100%), within 31-50 years (60.0%), and the majority (73.8%) had a primary education. One third (33.75%) had between 10-20 years' experience, and only 3.75% cultivated citrus using budded seedlings; the majority (83.75%) did not apply fertilizers on their citrus farms, and only very few (14.8%) were aware of integrated nutrient fertilizer use. Pest and disease infestation (85.2%), fluctuating weather conditions (77.8%), grazing animals (59.3%), and inadequate extension contact (48.1%) were the most predominant constraints to citrus production. Awareness and capacity building of citrus farmers should be provided by relevant stakeholders to promote the potentialities of integrated nutrient management for sustainable and profitable citrus production.

Keywords: ***Citrus, Constraints, Integrated Nutrient Management, Nigeria***

INTRODUCTION

Citrus is globally considered one of the premier fruit crops, both in terms of area and production. It is a large group of fruits that includes oranges, tangerines, limes, lemons, and grapefruits. They are widely cultivated for fresh consumption and industrial processing as they are both permanent and cash crops with a lot of economic potential. Nigeria is the 9th major citrus fruit-producing country in the world and the largest growing region in Africa, with about 3.9 million metric tonnes of fruits produced annually from about 8.0 hundred thousand hectares of land (FAO, 2012). Presently, Nigeria is not noted for the exportation of citrus fruits, but it has the potential to produce for both local and international markets. Citrus fruits are usually eaten fresh, but they possess other industrial, medicinal, and pharmaceutical uses.

As reported by Olife et al. (2015), there are two main markets for citrus fruits: the fresh fruit and processed citrus fruits markets, particularly orange juice. Also, there are several by-products from citrus, as well as several value-added products. By-products include citrus peel residue and seeds from which industrial products such as citrus fruit powders, orange fruit flour are derived. Pressed peel, citrus pulp and meal, peel oil, brandy spirit, feed yeast, vinegar, marmalade, and citric pomade are also derivatives of citrus peel, while seed oil and meal are

derived from citrus seeds. Value-added products from citrus include fruit pulp from which fruit juice has been extracted, which is used as livestock feed. Naringin, a flavonoid, is an artificial sweetener that is 1000 times sweeter than sugar and is obtained from grapefruit. The dried bark of citrus is a raw material in the production of insecticides. Due to these varied and diverse uses, citrus production in Nigeria is still below capacity. Inadequate agronomic management practices and technological knowledge on citrus production result in low production levels. There is a strong need to increase production and productivity through the use of best horticultural practices.

Nutrition plays a major role in maintaining vigor, productivity, and quality fruit production in citrus, as improper and inadequate nutrition is a key cause of decline in citrus production (Tarai and Gosh, 2016). Citrus is a perennial crop that requires constant management for continuous productivity. Citrus contributes significantly to agricultural development in Nigeria's economy and faces a lot of challenges in its development and maximization of potential by smallholder farmers. Sub-optimum production due to the prevalence of nutrient constraints is well established in citrus, like in other crops (Srivastava *et al*. 2008). It has been established that continuous fertilization has failed to sustain yield expectancy on a long-term basis due to depletion of soil carbon, and this has resulted in multiple nutrient deficiencies that are common in citrus orchards all over the world. Integrated nutrient management (INM), a concept that involves the combined use of chemical fertilizers, microbial inoculation, and organic manures, is better than other strategies of fertilization in citrus. INM aims for optimal soil fertility and plant nutrition, increasing fertilizer input efficiency, decreasing environmental risks, and improving crop productivity through root/rhizosphere management (Murillo *et al*., 2015). Citrus production can be increased by proper supply of nutrients, as it has been revealed that farmers undersupply some nutrients and oversupply some, resulting in nutrient imbalances that negatively influence crop yield (Tan *et al*., 2005). With integrated nutrient management, soil fertility is maintained and plant nutrient supply is at optimum levels, resulting in sustainable productivity as benefits from diverse sources of plant nutrients are optimized (Singh *et al*., 2020).

The conventional farming system involves enormous use of chemical fertilizers, which have been found to cause soil degradation in terms of soil fertility and also cause soil pollution. Maximum fruit yield is attainable through the combined use of organics, inorganic, or bio-fertilizers, as they provide a healthy soil environment for plant roots to uptake the soil nutrients efficiently. Integrated plant nutrient supply is the best approach to attaining a good quality yield of citrus; however, this integrated method of fertilizer management and use is not popular among many citrus farmers. This study was therefore conducted to ascertain the challenges to integrated nutrient management for sustainable citrus production in south-west Nigeria. Specifically, the study described the socio-demographic characteristics of citrus farmers; identified citrus farmers' production characteristics, assessed citrus farmers' knowledge levels in integrated nutrient management, and ascertained constraints that challenge the use of INM in citrus production.

METHODOLOGY

The study used a multi-stage sampling procedure to select respondents; the first stage involved a purposive selection of the southwest zone of Nigeria. This zone is reputed for the comparative advantage it has in fruit tree production, particularly citrus.

The second stage involved a random selection of 50% of the states in the zone. Therefore, Oyo, Ondo, and Osun states were randomly selected. The third stage involved a proportionate and purposive selection of citrus-producing Local Government Areas (LGAs) from each state. Ogbomosho South, Orire, Afijio in Oyo state; Ejigbo in Osun state, and Ifedore in Ondo state were selected. The fourth stage involved a random selection of communities within each LGA. Eegbe-Fiditi, Abule Odu, Ogbomosho, and Lagai were selected in Oyo State; Osinmo, Ife Odan, and Olodo Marun were selected in Osun State, while Igbara Oke and Bolorunduro communities were selected in Ondo State.

The final stage involved the selection of 80 citrus farmers in these communities based on probability proportionate to size. Information was elicited from these farmers with well-structured questionnaires and Focus Group Discussions. Six FGDs were held in total, one FGD each was held for male and female citrus farmers in Eegbe-Fifiti, Oyo state; Bolorunduro in Ondo state, and Olodo Marun in Osun state, respectively.

The data collected were then statistically analyzed with frequency counts, percentages, and mean scores.

RESULTS AND DISCUSSION

Socio-demographic Characteristics of Citrus farmers

Socio-demographic characteristics of respondents are summarized in Table 1. The majority (78.8%) of citrus farmers in the south-west zone of Nigeria were male, and 21.2% female. Age distribution revealed the mean age as 54 years, revealing that 15% were less than 18 years, 30.0% were between 18 and 41 years, while 50.0% were between 42 and 64 years, with only 5.0% above 65 years. With a mean age of 54 years, it showed that the farmers were in their economically active age, which could positively influence their standard of living. As reported by Akura et al. (2019), the majority of actors in Nigerian citrus value chains are young farmers who are very active at work, innovative, and energetic enough to withstand the rigorous activities involved in the enterprise. They, therefore, would be able to make a meaningful impact in citrus production with adequate information and motivation.

All respondents (100.0%) were married, implying that citrus production is a significant contributor to the well-being of citrus-producing families. The three major religions in Nigeria were practiced in the zone, as the majority (65.0%) were of the Christian faith; 30.0% were of the Islamic faith, while only 5.0% practiced traditional religion. While 13.7% had no formal education, the majority (73.8%) of respondents had primary education, and only 12.5% had secondary education. The high literacy level has favorable implications for extension and technology transfer, as educated farmers are more prone to adopt new or improved technologies.

The result further revealed that 33.8% of farmers had less than 5 persons in their households, while the majority (66.2%) had more than 5 persons in their households. The mean household size of 6 persons/household is an indication that large household size is favored by farming communities, usually as members produce diversified and appropriate crops without the need to employ additional labor for on and off-farm activities. Social organizations are accessible avenues where farmers can focus on common interests. Citrus farmers belonged to diverse social networks, as the majority (82.5%) were members of farmers' associations and religious respectively, while 65.0% belonged to cooperative groups. Membership of these organizations could assist these farmers to

pool their resources together to attract external intervention, as opined by Oyedele and Yahaya (2011).

Table 1: Socio-demographic Characteristics of Citrus Farmers (n=80)

Socio-demographic Characteristics	Categories	Frequency	Percent
Sex	Male	63	78.8
	Female	17	21.2
Age (Years)	≤18	12	15.0
	19 – 41	24	30.0
	42- 64	40	50.0
Mean=54	65 and above	4	5.0
Marital status	Married	80	100.0
Religion	Christianity	52	65.0
	Islam	24	30.0
	Traditional	4	5.0
Educational attainment	Non formal	11	13.7
	Primary	59	73.8
	Secondary	10	12.5
Household size	Less than 5	27	33.8
	5 – 10	40	50.0
Mean=6	Above 10	13	16.2
Social network*	Farmers association	66	82.5
	Cooperative association	52	65.0
	Religious group	66	82.5

Source: Field survey, 2022

Characteristics of Citrus Farming

Table 2 reveals that above half (51.25%) of the farmers had citrus farms that ranged between 1.6 and 2.4 hectares of land; 15.0% had less than 1.6 hectares, and 26.75% had between 2.5 and 3.6 hectares of citrus farms, while only 3.75% had between 3.7 and 4.8 hectares of citrus farms. With an average

farm size of 2.0 hectares, it revealed that citrus farmers in south-west Nigeria are smallholder farmers, which is peculiar to rural farmers in Nigeria.

Experience of respondents in citrus farming revealed that 48.75% had been in citrus farming for more than 40 years, 3.75% had been engaged in citrus farming for less than 10 years, while 15.0% and 18.75% had been in the enterprise between 21–30 years and 31–40 years respectively. With an average of 46 years, this long duration of involvement in citrus farming showed that these farmers had vast experience in citrus production. The majority (88.75%) used seedlings to establish their citrus farms, while only 3.75% used budded citrus seedlings, indicating that the use of budded seedlings is not yet common among citrus farmers in the study area. Table 2 shows different varieties of citrus cultivated in the zone such as sweet orange (77.5%), tangerine (74.0%), and tangelo (52.5%) were predominantly cultivated.

Furthermore, sweet orange and tangerine were preferred by 50.0% and 35.0% of farmers, respectively. Only 3.7% of citrus farmers indicated their preference for *Agege 1, Ajadi,* as well and *tangelo*. Many (55.0%) of farmers indicated marketability as the reason for preference for sweet orange production. This is in line with the position of Fakayode *et al*., (2010) that sweet orange was highly marketed not only for the fruits that are eaten fresh, but they are also useful as sweetening agent for flavoring foods, in canned orange juice, rind oil, pectin for jams and marmalade, and jelly pulp residue for livestock feed. The majority (67.5%) of farmers earned less than ₦500,000 annually, while 18.75% earned between ₦500,000 and ₦1,000,000 per annum, with 13.75% earning above one million naira per annum from citrus production, with an average income of ₦313,333.00. This further shows that with improvement in production practices such as INM, which aims at an adjustment in soil fertility and of optimal plant nutrient supply from all possible sources of nutrients, an increase in crop productivity is assured, which would result in higher incomes that could be generated from citrus production. This also confirms the opinion of Lamessa 2016, that the INM system holds promise of sustaining higher crop yields that can generate higher incomes besides improvement in soil health.

As reported by Karna et al. (2022), INM use in coconut production resulted in increased economic income. Cropping patterns of citrus farmers in the zone showed that only 26.25% practiced sole citrus cropping, while the majority (73.75%) practiced intercropping. This confirms the position of Okafor (2020) that intercropping is commonly practiced among citrus farmers in Nigeria to generate income before the economic yield and maturity of citrus is attained. This quantitative result was further buttressed by the FGD session conducted -

> "*We usually intercrop our citrus with other crops such as vegetables, maize, cassava, so that we can get additional crops for market and home subsistence before the citrus fruits are ready for sale.*" FGD with female citrus farmers in Eegbe-fiditi, Oyo state.

The findings of this study show that citrus orchards were not popular in the zone because only 26.25% of respondents practiced sole cropping.

Table 2: Citrus Production Characteristics (n=80)

Variables	Categories	Frequency	Percentage
Farm size (hectares)	Less than1.6	12	15.0
	1.6 – 2.4	41	51.25
	2.5 – 3.6	21	26.25
	3.7 – 4.8	3	3.75
Mean=2.0	Above 4.8	3	3.75
Citrus farming experience (Years)	< 10	3	3.75
	10 – 20	11	13.75
	21 – 30	12	15.0
	31 – 40	15	18.75
Mean=46	➢ 40	39	48.75
Type of propagating material	Budded seedling	3	3.75
	Seedling	77	96.25
Varieties cultivated*	Sweet orange	62	77.5
	Tangerine	59	74.0
	Tangelo	42	52.5
	Lemon	24	30.0
	Grape fruit	24	30.0
	Lime	6	7.5
	Sour orange	3	3.75
Preferred variety	Sweet orange	40	50.0
	Tangerine	28	35.0
	Agege 1	3	3.75
	Ajadi	3	3.75
	Tangelo	3	3.75
	Grape	3	3.75
Reason for preference*	Marketability	44	55.0
	Taste	33	33.75
	Yield	15	18.75
	Storability	11	13.75
	Size	9	11.25
Annual income (Naira)	<500,000	54	67.5
	500,000-1,000,000	15	18.75
	>1,000,000	11	13.75
Type of cropping pattern	Sole orange cropping	21	26.25
	Intercropping	59	73.75

Source: Field survey, 2022 *Multiple responses

Level of Knowledge in Integrated Nutrient Management

Citrus farmers' knowledge of integrated nutrient management is presented in Table 3. The majority (83.75%) of citrus farmers did not apply fertilizers to their citrus trees; only a few (11.25%) used inorganic fertilizers. This could be attributed to inorganic fertilizers being major contributors to enhancing crop production and maintaining soil productivity as easy and quick sources of plant nutrients, containing higher concentrations compared to other sources of plant nutrients. Only very few respondents

(2.5%) used integrated (combined) fertilizer, affirming the position of Abera and Belachew (2011) that farmers usually do not apply fertilizers as they believe that crop yields cannot be increased through fertilizer application.

According to Jat, Kumar, Jat et al. (2020), integrated nutrient management (INM) is a method by which plant nutrients are holistically supplied to improve and maintain soil physicochemical properties in order to sustain crop productivity and optimum yield. It is a simple system that can create a favorable soil condition and provide plants with sufficient, efficient, and sustainable nutrient supply. Only 11.25% use inorganic fertilizers; other components of INM, such as microbial fertilization, live mulch, and organo-mineral fertilizers, were unknown to citrus farmers. As revealed by this study, there was no specified time for harvesting citrus as fruits were harvested at different stages of maturity. While the majority (70.0%) of farmers harvested fully ripe citrus fruits, 26.25% of farmers harvested partially ripe citrus fruits. Only a few (17.5%) of citrus farmers indicated interest in building their capacity on INM components and methods. Also, during FGD, it was revealed that-

> "*if this integrated nutrient management will benefit us, resulting in higher yields with more income, we will like to be trained in how to practice it*" FGD with male citrus farmers in Bolorunduro, Ondo State.

Table 3: Citrus farmers' Knowledge Level of INM (n=80)

Variables	Categories	Frequency	Percent
Fertilizer application time	Never	67	83.75
	Once a year	9	11.25
	More than once a year	4	5.0
Type of fertilizer used	Organic fertilizer e.g., poultry/animal dropping, kitchen waste	2	2.5
	Inorganic	9	11.25
	Organo-mineral	0	0.0
	Microbial	0	0.0
	Live mulch, e.g. mucuna	0	0.0
	Integrated (combined)	2	2.5
Harvesting	Harvesting fully ripe fruits	56	70.0
	Harvest partially ripe fruits	21	26.25
	Harvest unripe fruits	3	3.75
Integrated Nutrient/Fertilizer	Desire for capacity development on integrated fertilizer use	14	17.5

Source: Field survey, 2022

Constraints associated with Citrus production

Several factors constrained the optimum production of citrus in the south-west zone of Nigeria. Some of these factors are shown in Table 4. Results in the table show that a large number of middlemen (92.6%) ranked as the 1st of constraints to citrus production in the

study area. This is as reported by Ouma (2008) that market linkages are usually incomplete, as farmers and their produce are at the mercy of middlemen who access markets directly and sell produce on their behalf. Pest and disease infestation (85.2%) ranked as the 2nd constraint.

As reported by Ibeawuchi et al. (2015), pests and diseases affect fruits in the field and, as a result, reduce their shelf lives as well as affect their physical appearance, an important factor in horticultural crops. Fluctuating weather conditions occasioned by climate change are the third constraint to citrus farming in south-west Nigeria. As reported by Abou Seeda et al. (2021), climate extremes have the potential to alter physiological stages of plants, thereby compromising food security and nutrition, because yields decline as a large expanse of cultivatable lands has become unsuitable for cultivation. Also, temperature instability provides favorable conditions for insects, pests of crops, to boost their capacity to stay alive in areas that were previously not amenable to them, which is capable of resulting in outbreaks. Furthermore, it places pressure on the growth and circulation of income.

Grazing animals is also one of the limiting constraints identified by 59.3% of farmers and ranked as the 4th constraint in this study. Another constraint identified by 48.1% of citrus farmers in the zone was inadequate extension contact, which ranked as the 5th. As reported by Baruwa (2013), low frequency of contact with extension personnel could be attributed to the presently limited number of extension agents (1:400 farmers) in Nigeria, which makes it almost impossible for EAs to reach all farmers with research findings by interpersonal means. Unavailability of budded seedlings was reported as a constraint to citrus production by 44.4% of farmers, confirming the report of Oyedele *et al*. (2022) that non-availability of improved planting materials is one of the key constraints to citrus production in North-central and South-west Nigeria. The use of un-budded seedlings results in lower yields with reduced economic returns, thereby compromising farmers' livelihoods. Other constraints were a lack of credit facilities, as reported by 44.4% of respondents.

Agricultural productivity is linked to access to agricultural credit, which is not available and accessible to all smallholder farmers, as they usually do not have the required collateral required and the high interest rates further make it inaccessible for them. Furthermore, a shortage of expansion capital was revealed as a constraint by 40.7% of farmers, as they did not have collateral to secure loans and credit facilities. Low-interest borrowing should be facilitated to encourage the expansion of existing farms. An inadequate transportation system was revealed as a constraint by 40.7%; as reported by Ibeawuchi et al. (2015), necessary infrastructures, such as adequate transportation facilities coupled with inaccessible roads, are lacking for Nigerian farmers. An inefficient, expensive transport system negatively affects input and output costs, supply, and reduces farmers' potential income from their enterprise. Insufficiency of funds for input supply was a challenge to 37.0% of farmers, as they were unable to finance the equipment and inputs required for citrus farming.

Also, 37.0% of farmers disclosed that land use tenure and pattern challenged their citrus production. This might be attributed to traditional land use among farmers in rural areas, which results in a shortage of land as farm holdings are subdivided for inheritance. The small allotted portions of land are subjected to intensive cultivation of multiple crops, which are usually detrimental to the optimum production of citrus. The absence

of a clear title to land also constrains farmers in Nigeria. It reduces incentives to invest in land quality maintenance and improvement, which discourages farmers from carrying out fruit management practices that can enhance their productivity and yield.

Inadequate marketing information was revealed as a constraint by 33.3% of the farmers, which could be attributed to the fact that all agricultural production, including citrus is weather-dependent and production activities cannot be planned, leading to glut as other produce floods the markets at the same time and competes with the same market outlets. This not only constrains citrus production, but it also challenges agricultural productivity and food security. Other constraints that impede optimal production of citrus in the zone were labour shortages, high tolls, and unfavourable government policies.

Table 4: Constraints to Citrus production (n=80)

Constraints	Percent	Rank
Large number of middlemen	92.6	1st
Pest and disease infestation	85.2	2nd
Fluctuating weather conditions	77.8	3rd
Grazing animals	59.3	4th
Inadequate extension contact	48.1	5th
Unavailability of budded seedlings	44.4	6th
Lack of credit facilities	44.4	6th
Inadequate transportation systems	40.7	8th
Shortage of start-up capital	40.7	8th
Insufficiency of funds for inputs such as fertilizers, root stock	37.0	10th
Land use tenure	37.0	10th
Inadequate market information	33.3	12th
Labor shortage	25.9	13th
High tolls	18.5	14th
Unfavorable government policies	11.1	15th

Source: Field survey, 2022

CONCLUSION AND RECOMMENDATIONS

Based on the results obtained from this study, the majority of citrus farmers in south-west Nigeria are male, with some level of formal educational attainment. From the study, it was also revealed that the majority of farmers established their citrus farms with un-budded citrus seedlings; the use of budded seedlings was not a common practice in the south-west zone of Nigeria. Citrus is mainly planted as an intercrop with other crops; citrus orchard systems are not popular in the zone, resulting in low-quality citrus fruits. Establishment of large orchards by farmers in the zone is encouraged to enhance the capacity in the zone as well as provide opportunities to introduce research technologies that could increase productivity. To facilitate this, provision and use of improved production technologies, such as budded seedlings of improved cultivars, is recommended. INM, a technique that is able to minimize environmental degradation and ensure food security, is also not yet popular among citrus farmers in the zone. Farmers in the different communities in the south-west zone, Nigeria however, indicated interest in capacity development on INM.

A range of constraints challenge the optimum production of citrus in the zone. Unviable land sizes, poor use of fertilizers, use of un-budded and unimproved varieties of citrus, a large number of middlemen, pest and disease infestation, fluctuating weather conditions, menace of grazing animals were major constraints to optimum citrus production in the zone. All these have to be addressed alongside infrastructural limitations in the zone. In light of these, research-extension linkages should be improved, and capacity-building programs that enhance farmers' knowledge of the components and benefits of INM in citrus production are recommended as a strategy to enhance production as well as harness the potential of citrus in the south-west zone of Nigeria.

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