Fertilizer Use and Management Practices among Maize and Cowpea Smallholder Farmers in Ghana

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Summary

In most parts of West Africa, poverty contributes immensely to poor fertilizer adoption by smallholder farmers. Fertilizer adoption could be improved with micro-dosing technology. A socio-economic survey was conducted in the semi-deciduous forest zone of Ghana to assess the extent of fertilizer use and management among maize and cowpea smallholder farmers. Oral interview with structured questionnaire was used to interview one hundred farmers each at two locations. The results showed that farmers are aware of the use of fertilizer to increase crop yield. About 65% and 80% of maize and cowpea farmers respectively, identified high cost of fertilizer as a major constraint to fertilizer utilization. Consequently, only 32% maize farmers and 19% cowpea farmers were fertilizer users. In addition, the choice of fertilizer type to use was dependent on the type available on the market. As such, NPK 15:15:15 was mostly used for both maize and cowpea crops. Also, fertilizer application rate was mainly determined by the quantity farmer can purchase. On average, fertilizer application rate for maize and cowpea crops were 18.45 kg/ha and 9.05 kg/ha, respectively. The prevalent fertilizer application method on maize was mostly by point/side placement while ring application was largely used for cowpea. Awareness of fertilizer micro-dosing among the farmers was only 10%. Since the quantity of fertilizer used by the farmers as well as the fertilizer application methods were comparable to fertilizer micro-dosing, dissemination of micro-dosing technology to these farmers could promote fertilizer use and management among smallholder farmers, and ultimately sustain maize and cowpea production.

Résumé

Utilisation et pratiques de gestion des engrais minéraux chez les petits producteurs de maïs et de niébé au Ghana

Dans la plupart des régions d'Afrique de l'Ouest, la pauvreté contribue énormément à la mauvaise adoption de l'emploi d'engrais par les petits producteurs. Cette adoption pourrait être améliorée avec la technologie de micro- dosage d'engrais. Une enquête socio - économique a été réalisée dans la zone de forêt semi-décidue du Ghana pour évaluer l'étendue de l'utilisation et de la gestion des engrais chez les producteurs de maïs et de niébé. L'entretien par le biais d'un questionnaire structuré a été utilisé chez une centaine de paysans dans deux endroits différents. Les résultats ont montré que les agriculteurs sont conscients que l'usage des engrais permet d'augmenter le rendement des cultures. Environ 65% et 80% des producteurs de maïs et de niébé respectivement, identifient le coût élevé des engrais comme l'un des principaux obstacles à l'utilisation de ceux-ci. En conséquence, seulement 32% des producteurs de maïs et 19% des producteurs de niébé utilisent les engrais. En outre, le choix du type d'engrais dépend de sa disponibilité sur le marché. Le NPK 15:15:15 est utilisé principalement pour le maïs et le niébé. Le taux d'application des engrais a été principalement déterminé par la quantité que l'agriculteur peut acheter. Les taux d'application d'engrais étaient en moyenne, de 18,45 kg/ha et 9,05 kg/ha, respectivement pour le maïs et le niébé. La méthode courante d'application d'engrais sur le maïs est le placement en ligne à côté des plantes tandis que l'application en anneau autour de la plante est largement utilisée pour le niébé.

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Dix pourcent des agriculteurs maitrisent le micro-dosage d'engrais. Comme la quantité d'engrais utilisée par les agriculteurs et leurs méthodes d'application étaient comparables à celles du micro-dosage, la diffusion de la technologie de micro-dosage pourrait promouvoir l'utilisation et la gestion durable des engrais parmi les petits agriculteurs, et pourrait en conséquence améliorer la production du maïs et du niébé.

Introduction

Despite the poor inherent fertility and degrading nature of some soils, poor farming techniques and low fertilizer inputs still constitute a major challenge for many smallholder farmers. Though fertilizer has been identified as the main source of soil nutrients for agricultural production (24), its' use has not been widely adopted (1). Several factors have been reported to limit effective fertilizer utilization by farmers. Identified major constraint include: accessibility of fertilizer (22), availability of fertilizer (39), 'pan-territorial/blanket' recommendations that fail to take into account differences in resource endowment (6), high fertilizer cost, and high incidence of poverty in the farming communities. Among these factors, poverty seems to be the major constraint to effective fertilizer use. Compared to the developed countries, fertilizer costs in Africa are among the highest in the world. According to Bationo *et al.* (6), the cost of one metric ton of urea, for example is about US$ 90 in Europe, US$ 500 in Western Kenya and US$ 700 in Malawi.

On the other hand, high rates of fertilizer input have been recommended to farmers to maximize yields. For instance, the currently used blanket recommendation of NPK 90:60:60 kg/ha (maize) for semi-deciduous forest zone soils (12), is huge and beyond the reach of most smallholder farmers. This establishes the need for alternative lower but more efficient and cost-effective technologies/fertilizer recommendation for smallholder farmers. Since late 1990's fertilizer micro-dosing has been promoted as an appropriate technology for smallholder farmers in the Sahelian region of Africa.

It was developed in an attempt to increase the affordability of mineral fertilizer while giving plants enough nutrients for optimal growth (19). Fertilizer micro-dosing refers to the application of relatively low quantities of fertilizer (2 to 6 g/hill) through point placement to increasing cereal production. More reports have revealed the benefits associated with micro-dosing which include: increased crop yields (43 to 120%), income (50 to 130%), harvest index and nutrient use efficiency, better crop performance and increased food security (34, 37, 40).

While micro-dosing has been adopted for the production of cereals such as millet and sorghum, food security crops like maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) however, have received little attention. Maize and cowpea constitute the predominant staple food crops that are mainly produced by smallholder farmers in Ghana. While cowpea is the major legume grown in the semi-deciduous forest zone of Ghana (16), this zone is also among the leading maize producing areas.

Nonetheless, their production without inorganic fertilizers is characterized by soil nutrient depletion and low crop yields. Since micro-dosing has successfully worked in northern Ghana (34), similar performance is anticipated in the semi-deciduous forest zone of Ghana. Hence, for the introduction and dissemination of micro-dosing to this agro-ecological zone, it is fundamental to first ascertain its adaptability to the farmers' existing farming practices. This is very important because insufficient adaptation of technologies to farmers' condition among others has been recognized as a major constraint to adoption (33).

Besides, ICRISAT identified some major constraints to the widespread adoption of micro-dose technology include access to fertilizer; access to credit;insufficient flows of information and training tofarmers; and inappropriate policies (20).

Unlike other African countries such as Egypt, South Africa, Zimbabwe and Kenya with known average fertilizer utilization rate (21), there is difficulty in assessing the actual amount of fertilizer used by farmers in Ghana. It is often assumed that the quantity of imported fertilizers, less stock carryovers by dealers, is equivalent to fertilizer utilization rate (22). This makes it more difficult to ascertain the size of the contribution smallholder farmers make towards national food security through fertilizer use. Hence, there is limited information on the quantity of fertilizer input by smallholder farmers. The objectives of the study were: (a) to seek information on the fertilizer use and its management by smallholder maize and cowpea producers and (b) determine the farmers' practices likely to influence the adoption of fertilizer micro-dose technology in growing maize and cowpea crops.

Data on smallholder farmers' fertilizer use and management will help to prioritize the factors that constrain fertilizer adoption. This will inform researchers and agricultural extension workers on how to manage these factors and whether to demonstrate and disseminate fertilizer micro-dosing technology. It will also be useful for targeting better government policies that would benefits large percentage of smallholder farmers for better soil management and increased crop production.

Materials and methods

The study data were collected from Assin-Kushea, (6° 05' N and 1° 25' W) located in the Assin North Municipality of the Central region and from Twedie, (6° 39' N and 1° 44' W) situated in the Atwima-Kwanwoma District in Ashanti region of Ghana (Figure 1). The two locations fall within the Semi-deciduous forest zone of Ghana.

The study areas are characterized by bimodal rainfall pattern, with a mean annual rainfall of 1500 mm. The major season spans March to July and the minor, September to November with a short dry spell in August. The average monthly temperature ranges from 24 to 28 ^{0}C.

The study involved oral interview through the use of structured socio-economic questionnaire. Meetings were held with the extension officers and the 2011 best farmer Award winner of the areas, to inform and solicit their assistance in organizing the farmers for administering questionnaires. Only farmers growing maize and/or cowpea crops were interviewed. Accordingly, structured questionnaires which addressed the farmer's demography, farm size, cropping systems, fertilizer use/management practices and farmers' awareness of fertilizer micro-dose technology, were used to interview one hundred farmers at each location in 2012.

In addition, personal field observations and interviews with extension officers as key informants were conducted using a check list.

Soil samples for physical and chemical analysis were taken using soil auger at 0-20 cm soil depth from an uncultivated farmland at 7 spots along the Z-plane. The samples were bulked and a composite sample, representative of each location was used for laboratory analysis. The soil pH was determined in 1:2.5 soil and water suspension while soil texture was by the hydrometer method (15). Determination of soil organic carbon (SOC) was by modified Walkley and Black procedure (28), total nitrogen (N) by the Kjeldahl digestion and distillation procedure (7), and available phosphorus (P) was extracted with Bray's No. 1 solution (30). The exchangeable acidity (Al^{3+}, H^+), and exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+) were determined by McLean (25) and Thomas (38) methods, respectively. Effective cation exchange capacity (ECEC) and base saturation (BS) levels were calculated.

All the data collected were analysed using SPSS descriptive statistical package. Standard error bars were used to show differences in responses of the interviewed farmers.

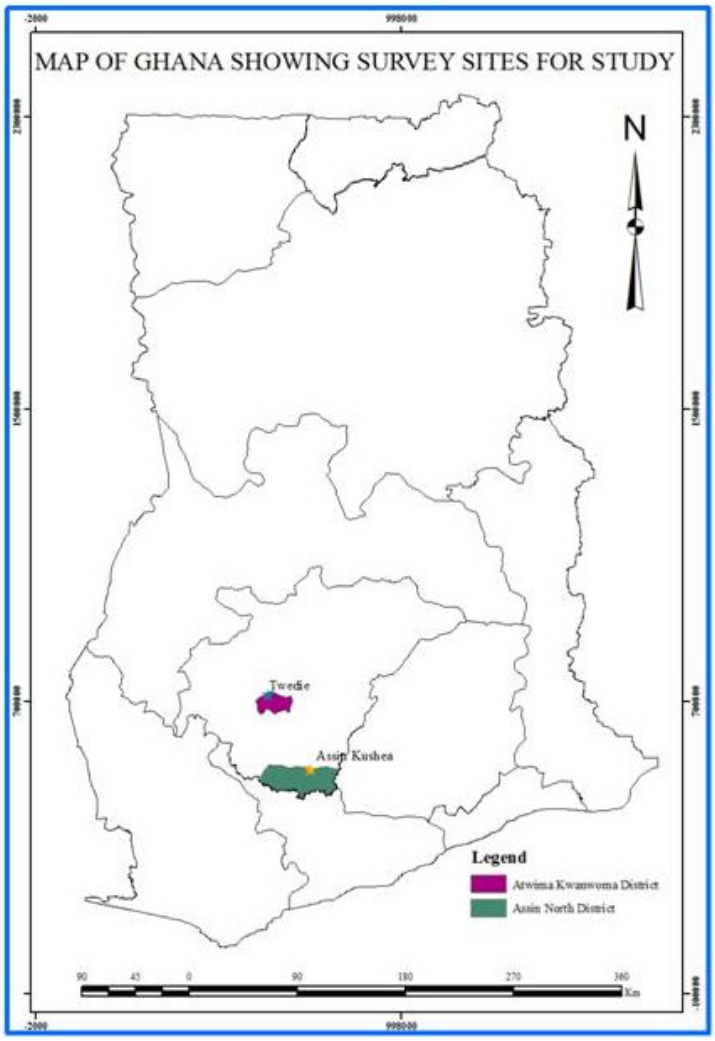

Figure 1: Map of Ghana showing Twedie and Assin-Kushea study locations.

Results

Soils of the study sites

The soils physico-chemical characteristics indicated higher sand proportion in Assin-Kushea (79%) than in Twedie (47%) soil. Hence, the soils were loam (Twedie) and loamy sand (Assin-Kushea). This confirms MoFA report (27) that Ghana soils have predominantly light textured surface horizons in which sandy loams and loams are common. The soil pH was moderately acid (5.90) to slightly acid (6.55). The SOC was moderately low (0.86 and 1.43 % for Assin-Kushea and Twedie, respectively) whilst low ECEC of 4.88 and 5.41 cmol/kg were determined for Assin-Kushea and Twedie, respectively. A medium BS level of 39.98 and 49.20 % were recorded at Assin-Kushea and Twedie, respectively.

Farmers' demographic characteristics

The basic demographic information of the survey respondents is shown in Table 1. Out of the 200 farmers interviewed; 45% were female, 72% were married farmers and only 9% were migrant settlers. The age of the farmers ranged from 18 to over 65 years, with 35% of them within the age bracket of 45-54 years. Most of the farmers attended Junior High school (40%), while 25% had no formal education. High proportions of the respondents had farming as their main occupation (89%), while 76% and 92% respondents cropped 0.2-1 ha maize and cowpea farm size, respectively. Among the interviewed farmers, 75% cultivated only maize while 21% cultivated both maize and cowpea with 4% engaging themselves in cowpea cultivation.

Table 1

Demographic characteristics of survey respondents at Assin-Kushea and Twedie.

Demography	Number of respondents	Male respondents (%)	Female respondents (%)
Gender	200	55	45
Age (years)			
18-24	3	67	33
25-34	24	71	29
35-44	42	45	55
45-54	70	50	50
55-64	41	63	37
Over 65	20	50	50
Marital status			
Single	8	100	-
Married	144	63	37
Separated	10	20	80
Divorced	17	35	65
Widowed	21	14	86
Level of education			
None	50	28	72
Primary	25	44	56
Junior High	80	61	39
Senior High	22	82	18
Apprenticeship/vocational training	20	75	25
Undergraduate	2	50	50
Postgraduate	1	100	-
Main occupation			
Farming	178	54	46
Trading	15	40	60
Formally employed	7	86	14
Residence status			
Native	183	55	45
Migrant	17	53	47
Farm size (ha)			
Maize			
0.2-1.0	144	53	47
1.1-2.0	41	51	49
2.1-3.0	2	50	50
3.1-6.0	2	-	100
Cowpea			
0.2-1.0	47	64	36
1.1-2.0	4	75	25
Crop cultivated			
Maize	150	53	47
Cowpea	8	75	25
Both maize and cowpea	42	55	45
Cropping system			
Continuous sole maize	39	77	23
Continuous sole cowpea	1	100	-
Maize/cowpea intercrop	3	-	100
Maize/cowpea rotation	9	67	33
Mixed cropping	135	47	53
Strip cropping	13	62	38

The semi-deciduous forest zone of Ghana which covers an area of 8,400 km^2 (27) is among the leading maize producing area. Under cropping system, less farmers were engaged in sole cowpea cropping (1%), cowpea intercropped with maize (2 %) and in maize/cowpea rotation (5%).

Fertilizer use by the crops

The data in Tables 2 provides clear evidence of low smallholder fertilizer adoption for maize (32%) and cowpea (19%) crops. This implies that 68% and 81% maize and cowpea smallholder farmers, respectively, have been farming unsustainably, mining the soil nutrients without inorganic fertilizer replenishment. The data further indicated the low participation of females (33%) than males (67%) in fertilizer utilization for cropping maize. In contrast, more female used fertilizer for growing cowpea (62%) as compared to the males (38%). Unfortunately, not all fertilizer adopters could access subsidized fertilizer. Only 48% benefited from fertilizer subsidy while about half of the fertilizer adopters (49%) got fertilizer input (unsubsidized) from the open market.

Types of fertilizer applied to crops

Information on the different types of fertilizer the interviewed farmers applied indicated that majority of them used more than one type of fertilizer. Generally, NPK 15:15:15 was mostly used by 61% farmers while 35% used ammonium sulphate. Other fertilizer types as TSP, MOP and urea received low patronage by the maize smallholder farmers. Similarly, NPK 15:15:15 dominated cowpea farms with 5 % users, followed by MOP with 25% users. Outstandingly, NPK 15:15:15, ammonium sulphate and urea which are among the subsidized fertilizer types could not be accessed by over 50% of targeted smallholder farmers for whom the subsidy programme was introduced. As such, the preference of a fertilizer type (Figure 2a) was mainly determined by fertilizer availability and fertilizer accessibility as reported by 33% and 28% farmers, respectively.

Quantity of fertilizer applied to crops

Table 2 compares the quantity of fertilizer applied to maize and cowpea crops. The fertilizer quantity reported here was calculated based on the commonly used type which is NPK 15:15:15. Generally, fertilizer application rate was within the range of 0.83 and 37.50 kg/ha. On the average, the smallholder farmers applied 18.45 kg/ha and 9.05 kg/ha of NPK 15:15:15 fertilizer for the cultivation of maize and cowpea, respectively. While 51% farmers used 25 kg/ha fertilizer, 19% farmers used about 8 kg/ha fertilizer for maize. The result also showed higher association of males to higher fertilizer utilization rate of 16.67 to 37.50 kg/ha, while more females were associated with the utilization of lower fertilizer rates (0.83 to 8.33 kg/ha). On the other hand, majority of the cowpea farmer respondents (57%) applied only 8 kg/ha fertilizer.

The differences in the choice of fertilizer quantity (Figure 2b) used by the smallholder farmers was mostly attributed to their purchasing power (40%) whereas 20% were guided by their personal decision. Strikingly were the 33% farmers who mentioned recommended rate as reason for choice of fertilizer quantity. However, available information (12) shows that the fertilizer quantity applied by the farmers is actually not the recommended fertilizer rate.

Methods of fertilizer application

The different methods of fertilizer application used by the farmers varied between the maize and cowpea crops (Figure 3). In general, prevalence of point/side fertilizer placement was significantly higher (79%) than band placement (3%), ring (9%), foliar (6%) and broadcast (3%) application methods for maize crop. For cowpea, the use of ring application method by 40% of the farmers was significantly higher than methods such as foliar, broadcast and point/side fertilizer placement (with 20% users each).

Table 2

Amount of fertilizer applied for maize and cowpea crops.

Fertilizer quantity (kg/ha)	Maize			Cowpea		
	Frequency	Male (%)	Female (%)	Frequency	Male (%)	Female (%)
0.83	3	33	67	1	-	100
4.17	1	-	100	1	-	100
8.33	12	33	67	4	50	50
12.5	4	100	-	-	-	-
16.67	9	78	22	-	-	-
25	32	75	25	1	-	100
37.5	1	100	-	-	-	-

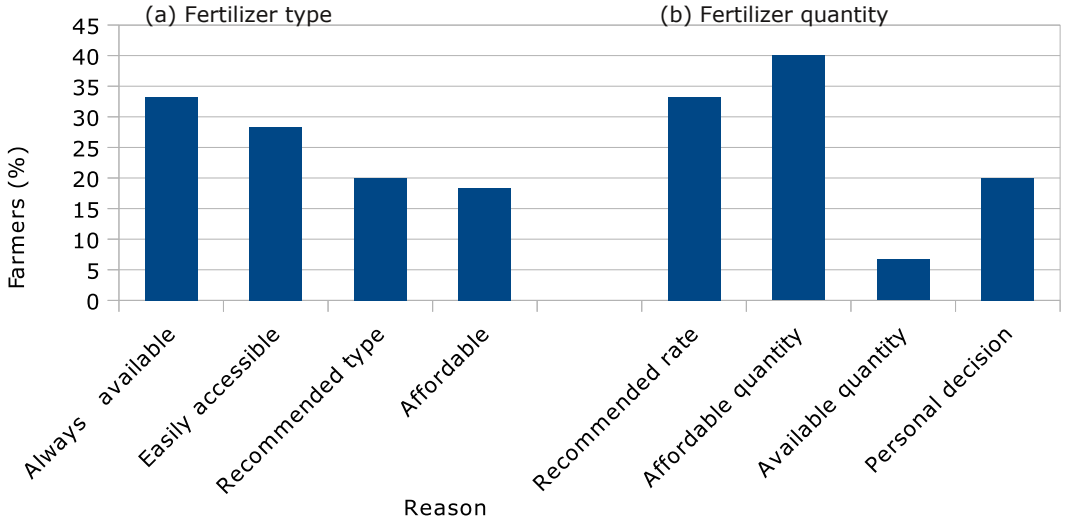

Figure 2: Reasons for choice of fertilizer type and fertilizer quantity.

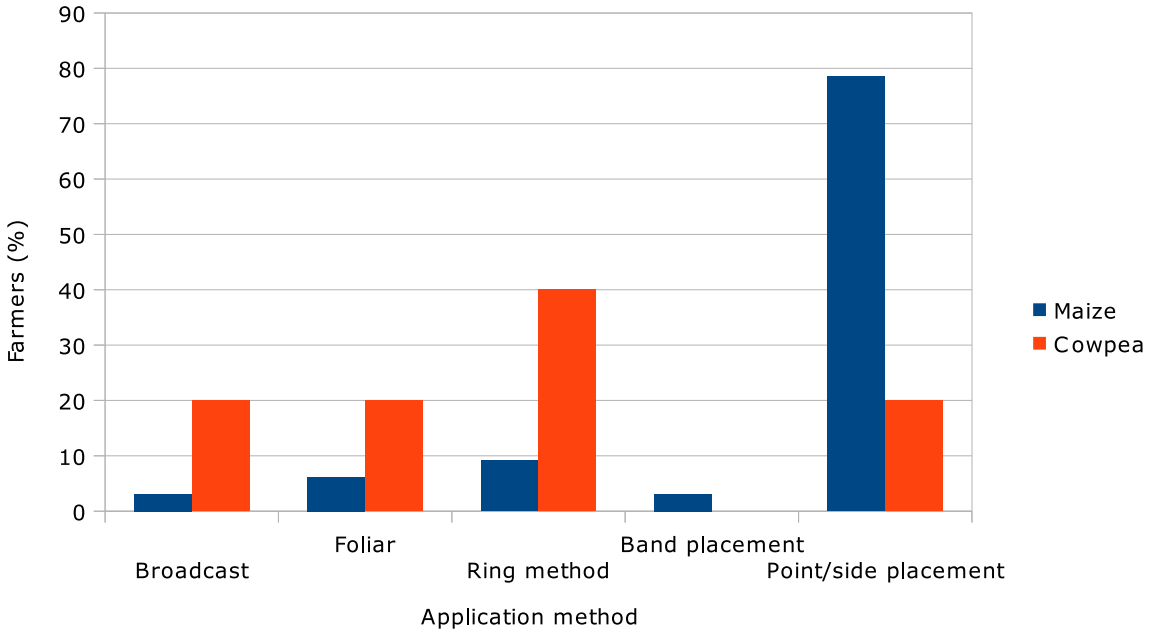

Figure 3: Method of fertilizer application on maize and cowpea crops.

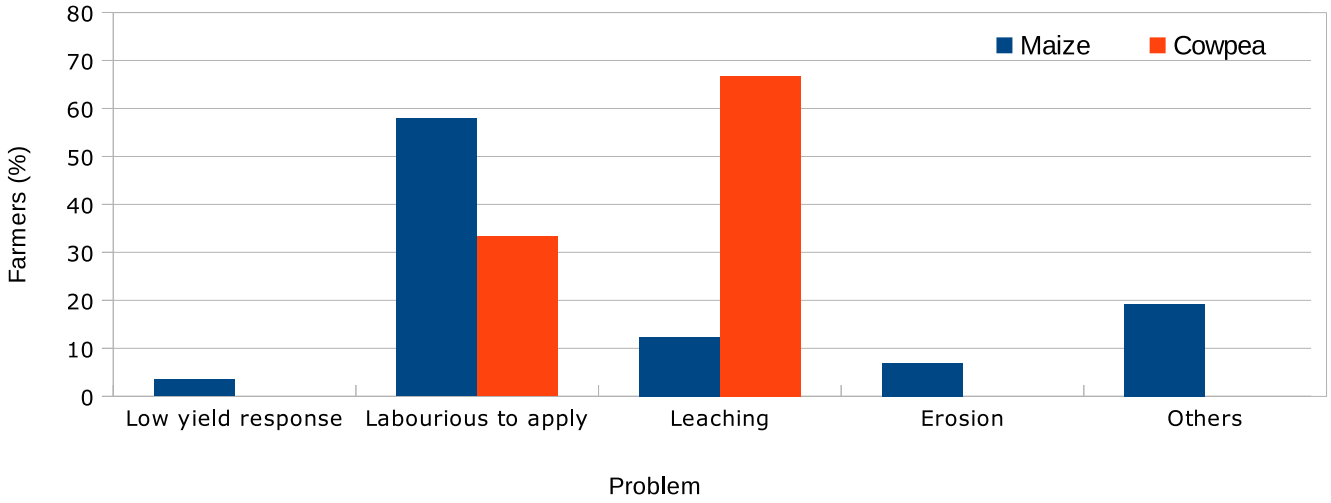

Figure 4: Problems encountered with fertilizer input on maize and cowpea field.

Table 3

Constraints to non-fertilizers input by smallholder farmers.

Issues raised	No of respondents	Percentage of respondents
High fertilizer cost	83	74.1
Unavailability of fertilizer to purchase	2	1.8
Inaccessibility of subsidized fertilizer	8	7.1
High recommended rate of application	2	1.8
Insufficient fertilizer recommendation	3	2.7
No knowledge about fertilizer	4	3.6
Labourious to apply	2	1.8
Others	8	7.1
% CV	15.57	
SD	2.18	

Time of fertilizer application

From the data obtained, fertilizer application time varied from 2 to 8 weeks after planting (WAP) for maize and from 1 to 4 WAP for cowpea crop. In general, fertilization at 2 WAP was commonly practiced as affirmed by 77% maize and 50% cowpea farmers. Higher percentage of farmers (82%) got information on fertilizer application time from the agricultural extension agents. Few farmers were informed from mass media (5%), 3% from other farmers/friends, and 10% were guided by their personal decision.

Some problems encountered with fertilizer use by the respondents are shown in Figure 4. The major problem encountered by the maize (58%) and cowpea (67%) smallholder farmers was associated with high labour demand.

Factors constraining fertilizer use

Table 3 shows that high fertilizer cost accounted for non-fertilizer utilization by 74% smallholder farmers, while few farmers attributed non-fertilizer utilization to the other issues listed in the table. It is noteworthy that only 4% of farmers claimed to have no knowledge about fertilizer. Other factors enumerated by the 7% interviewed non-fertilizer users included difficulty in accessing credit and low market price for surplus output.

Fertilizer micro-dosing

The data on micro-dosing awareness proved that out of the total respondents, only 8% was aware of the technology. The source of information was mainly from MoFA/extension officers (44%). Other information sources were gotten from researchers, mass media and friends/family/other farmers by 6%, 19% and 31% respondents, respectively. Remarkably, only one maize farmer had tested the performance of this technology with about 8 g of NPK 15:15:15 applied at one WAP. Though the trial was successful, the farmer however was not practicing it.

Discussion

The three major soil nutrients (NPK) at the study areas were generally low. Chemical limitations of soils in this agro-ecological zone as reported by Fosu and Tetteh (13) were P and K deficiencies, subsoil acidity, low OM, N and low CEC. In addition, the soils are known to be medium to high potentially productive. In this agro-ecological zone having a bi-modal rainfall pattern, farmers maximize their land resources by cultivating both during the major and minor rainy seasons. This suggests that intensive cropping without fertilizer input has contributed to the depletion of soil nutrients. With such critical soil fertility status, basal addition of NPK fertilizer should be targeted to synchronize with the crop needs. Also, split application of fertilizers such as urea with high N concentration will be ideal for sustained maize productivity. Alternatively, cowpea/maize rotation cropping would supply N need for the soil to attain its high productive potential.

Considering the farm size, the result indicated that the respondents are mostly smallholder maize and cowpea farmers. The area sown to maize and cowpea are generally small. Agriculture is predominantly on a smallholder basis in Ghana with about 90 % cultivating less than 2 ha of farm size (27).

Noteworthy among the data is the number of female respondents. The figure is relatively high, and suggests that the same number of women as men were maize/cowpea farmers. However, the relatively high proportion of women farmers probably stems from the fact that these crops are short season crops which are used to meet the immediate needs of the family both for consumption and income generation. With high native residence status of the respondents, it is expected that the farmers would farm sustainably unlike migrant farmers who over work the land to deplete the soil nutrients and abandon it. As such, high adoption of fertilizer micro-dosing is anticipated. More so, the educational level of the farmers will facilitate easy training and enhance the understanding and applicability of micro-dosing technology when disseminated. Nonetheless, the age characteristics of the farmers indicated that those who are actively involved in crop production are advanced. It thus implies that more youth are involved in other jobs than agriculture. Therefore, government policies on youth in agriculture should be promoted and extended across Ghana.

The survey results demonstrated that maize is an important crop for the majority of smallholder farmers in the surveyed area. Though cowpea constitutes the major legume grown in the semi-deciduous forest zone (16), it is mainly grown in the savanna and forest-savanna transitional agro-ecological zones of Ghana (11). Even in the surveyed communities, cowpea is cultivated mostly in the minor season in rotation with maize grown in the major cropping season. Mixed cropping involving cassava, maize, okra, garden egg, and cowpea crops predominates among the respondents. This result affirms the report of Fosu and Tetteh (13) that mixed cropping is typical to farmers in the semi-deciduous forest zone of Ghana. Moreover, maize and cowpea are important components of mixed cropping systems in many countries (29).

Low fertilizer use in Ghana has been a general problem over the years. The low adoption of mineral fertilizer contributes to the large difference between farmer's yields and potential yield (6).

Considering the poor nutrient status of the soils and the mixed cropping system that predominate the surveyed locations, the soil may become impoverished and unable to sustain crop production if farming without amendment is not halted and reversed.

The result findings agree with GOG study that reported even lower level of fertilizer adoption (10%) by smallholders with less than 1.0 ha of farm land (18). Also, Quinones and Diao reported of 15% fertilizer users in the forest agro-ecological zone of Ghana (31). The data raise the question as why the rate of fertilizer adoption by smallholder maize and cowpea farmers has been low even with the introduction of fertilizer subsidy. Of all the inputs used in crop production, none has received government intervention as fertilizer input that is clearly highlighted in national development plans. If farmers can access subsidized fertilizer and use it appropriately, it will ameliorate soil nutrient deficiencies while having a positive effect on crop productivity.

The low fertilizer use for cowpea could also be attributed to farmers' common knowledge that cowpea improves soil fertility. However, Chiezey reported that cowpea scarcely satisfies its N requirements in poor soils, and that the crop performance is improved with fertilizer addition (9). Also, Azarpour has shown the significance of applied fertilizer N to growth and yield of cowpea. Urea however was not used for growing cowpea (3). The use of correct type of fertilizer is of paramount importance as nutrients supplied through fertilizer must match crop needs for their efficient utilization (33). Inclusion of P fertilizer is needed for adequate growth of both maize and cowpea crops. In addition, knowledge of soil characteristics in relation to nutrient availability to crops is essential to raise production per unit of applied fertilizer nutrient. Considering the soil structure of the study sites, application of NPK fertilizer to maize would have greater chance of being utilized by the crops as compared to ammonium sulphate fertilizer which is extremely soluble in water and more prone to leaching losses due to high rainfall regime of the area. In addition, it contributes low N content per kg relative to NPK fertilizers, hence it is not economical.

Available data on average fertilizer import and sales in Ghana depict an increasing trend from 1999 to 2007 (12). Inadequate access to subsidized fertilizer such as NPK 15:15:15, ammonium sulphate and urea by smallholder farmers thus become a problem.

Even though NPK 15:15:15 is the most widely used fertilizer in Ghana (4), the prevailing fertilizer supply chain and its distribution become doubtful as whether large percentage of smallholder farmers does benefit from subsidized fertilizer. Hence, the preference of a fertilizer type by the farmers was highly dependent on its availability and accessibility. These two reasons though important are quite different from using the recommended fertilizer type which is by far more imperative to augmenting the nutrient needs of crop for increased productivity. Fertilizer affordability did not inform the choice of fertilizer type; rather it informed the choice of fertilizer quantity used by majority of the respondents. This attributes fertilizer cost (affordability) as the major constraint to fertilizer quantity used by smallholder farmers while fertilizer type is dependent on availability and accessibility. Among the recommended basic fertilizer types (NPK 15:15:15, ammonium sulphate and urea) (17), NPK 15:15:15 proved to be always available and accessible for use by over 50% of both maize and cowpea farmers. Therefore, the effectiveness and efficiency of fertilizer distribution to peasant farmers needs to be addressed. This will give an insight as to rate and time of fertilizer delivery to local agro-dealers for easy accessibility by smallholder farmers.

In Ghana, fertilizer consumption rate of about 7.2 kg/ha has been reported (22). Compared to other African countries, fertilizer application rates were 22 and 32 kg/ha in Malawi and Kenya, respectively (14). The low fertilizer application rates for maize and cowpea crops suggests that Ghana is still far from attaining to the targeted 50 kg/ha average fertilizer consumption by 2015 (2). Though the results showed that the choice of fertilizer quantity applied by the farmers was due to their purchasing power; women's poorer access to fertilizer, capital and credit may have contributed to the lower fertilizer utilization quantity for maize in particular. The predominance of farmers practicing point/side placement and ring methods could be attributed to the economics of the smallholder farmers and for efficient utilization of applied fertilizer. These methods involve the application of relatively small but equal amount of fertilizer to each individual crop.

Fertilizer precision placement is often exercised in order to reduce input cost, while enhancing nutrient use efficiency. These two methods are part of the strategic fertilizer application methods which are also similar to fertilizer micro-dosing technology (35). Also, fertilizer application at 2 WAP as practiced by majority of the maize and cowpea farmers is viewed as appropriate and in accordance with GAL recommendations (17). On the contrary, "basal dressing" at planting and "top dressing" at 4 to 6 WAP are recommended fertilizer application times across Ghana. However, depending on fertilizer type, sub-surface application is recommended for cowpea at 2 WAP. This will facilitate nutrient up take efficiency and hence enhance the nutrient use efficiency. Be that as it may, information on fertilizer application time was mostly disseminated to the farmers by agricultural extension agents. This finding affirms the indispensible role extension officers play in the dissemination of agricultural innovations to smallholder farmers as well as bridging the link between researchers and farmers. This implies that the dissemination of fertilizer micro-dosing in the study area would be more effective with the intervention of agricultural extension agents and other advisory service providers.

The labour intensive problem which ranked most highly among other problems was commonly associated with point/side placement and ring application methods. Nevertheless, efforts are being made at packaging the correct dose of fertilizer as a tablet that aids in application (20). Although fertilizer use is generally profitable, there are several constraints that limit its usage by most smallholder farmers. Our finding agrees with Sanchez who reported that the use of external inputs by resource-poor farmers is constrained by high costs (32).

Other reported major problems for effective utilization of fertilizers are availability of fertilizer (39), inappropriate fertilizer recommendations (6), and the distance from the farm to the nearest agro-dealer selling fertilizer (22). Generally, farm-level fertilizer prices in Africa are among the highest in the world. Although the NPK 15:15:15 fertilizer commonly used by smallholder farmers is subsidized, the cost of procuring it from the sales outlet to the farm will in the long run increase its total cost. Hence, forming co-operative group among smallholder farmers could help in bulk fertilizer purchase and transport in order to minimize cost. Again, warrantage or inventory credit has helped to resolve the farmers' capital constraint (6). The claimed of having no knowledge about fertilizer by very few farmers implies that majority of the smallholder farmers are well aware of the use of fertilizer to boost crop yield. Nonetheless, effort in helping smallholder farmers to understand the economics of fertilizer use through micro-dosing technology is vital for promoting fertilizer utilization. Moreover, adoption of micro-dosing techniques that utilizes small quantity of fertilizer entails minimizing the cost of fertilizer input needed to enhance crop yield.

Our findings suggest that majority of the farmers are not aware of fertilizer micro-dosing technology. For this reason, awareness creation of fertilizer micro-dosing is needed in the study areas. As majority of the farmers received information on fertilizer application time from the agricultural extension agents, it does imply that the effective dissemination of fertilizer micro-dosing technology to farmers in the two surveyed communities by both agricultural extension agents and MoFA field workers will facilitate its adoption. It is also promising to note that majority of the interviewed fertilizer users practiced similar fertilizer application method as micro-dosing. More so, the quantity of fertilizer utilized by the respondent farmers is comparable to micro-dose rate. Since, there will be no fundamental change in the farming system of the respondents; high adoption of micro-dosing technology is anticipated when demonstrated to the farmers in the study communities.

It must however be emphatically stated that understanding the techniques and profitability associated with micro-dosing is required to accentuate its adoption. With reference to the identified major constraint to fertilizer use (high cost), smallholder farmers will be much inclined to adopt micro-dosing since it involves using lower rates of fertilizer in more efficient ways that deliver high economic returns.

Conclusions and recommendations

Fertilizer usage by maize and cowpea smallholder farmers at the study areas is low, and is mainly because of high fertilizer cost. The quantity of fertilizer used by the smallholder farmers and the fertilizer application methods were comparable to fertilizer micro-dosing. Considering the little prevailing fertilizer micro-dosing awareness, and the poor soil nutrient status, the survey results suggest that awareness creation and dissemination of fertilizer micro-dose technology are needed to minimize fertilizer input costs and to sustain the soils chemical characteristics for efficient crop production. Moreover, introduction of the technology will not require any fundamental change in the farming system at the study areas.

In view of the significant contribution of extension agents/MoFA field workers in effective dissemination of information, it is recommended that agricultural extension agents and advisory service providers are actively engaged in the education of micro-dosing technology to smallholder farmers at Twedie and Assin-Kushea communities. This will facilitate adoption rate and hence, promote fertilizer use among smallholder farmers for sustained maize and cowpea production.

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