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Original Research Article

PROFITABILITY OF NITROGEN AND PHOSPHORUS FERTILIZER MICRO-DOSES ON MAIZE PRODUCTION IN SUB-HUMID FARMING SYSTEMS OF TANZANIA

ABSTRACT

Despite a high productivity potential for many best bet agricultural technologies there is a low adoption. Recommendations of improved technologies such as fertilizer use basing on agronomic data without economic analysis contributes to low adoption. The purpose of this study was to evaluate the profitability of selected fertilizer types and rates in maize production in a sub humid farming system. A field experiment was conducted to investigate costs and revenue of fertilizer types and rates on maize. The phosphate fertilizers were local Minjingu mazao (MM), di-ammonium phosphate (DAP) and triple super phosphate (TSP), urea was used to supply nitrogen. Fertilizer rates were micro-doses at 12.5, 25, 50 and 75% compared to control and recommended. Local MM at 75% micro-dosing produced the highest net benefit 3.0 – 3.5 million Tanzanian Shillings per hectare (TSH/ha) followed by 2.7 – 2.9 million TSH/ha from TSP at recommended and DAP at 75% micro-dose rate under subsistence farming. Micro-dosing fertilizer at 25 and 50% produced the highest benefit cost ratio under both commercial and subsistence farming conditions. Micro-dosing rate at 12.5% was more profitable than control and the profitability increased towards 25% and 50% and thereafter, decreased at recommended rate. Adoption of micro-dosing fertilizer at 12.5% could be an entry point to fertilizer use and later on advance to 25% and 50% micro-dosing rates which are more profitable under smallholder farming systems in sub-humid tropics.

Key words: Benefit/Cost ratio, Fertilizer use, Gross margin, Revenue

1.0 INTRODUCTION

UNDER PEER REVIEW

Agriculture is the backbone of country's economy in most of developing countries in the world as it provides the main source of food, feed, employment, raw materials for industry and foreign exchange earnings (1). In Tanzania, agriculture employs 65.5% of people, contributes 100% to the national food supply when there is adequate rainfall and 29.1% of gross domestic product (2) and (3). Cereals such as maize and rice are most important crops grown for food and cash in sub-Saharan Africa (SSA) countries, including Tanzania (4); (5) and (6). Maize accounts for 50% of the calories and protein in Eastern and Southern Africa and generates about 50% of rural cash income in Sub Saharan Africa (7).

Despite a high productivity potential for many best bet agricultural technologies there is a low adoption. This results into low productivity of most food and cash crops about 30% of potential yield (8). Low maize yields, for instance 1.0 – 1.7 t/ha in SSA compared to potential 7.5 – 8.2 t/ha (9) is attributed mainly to declining soil fertility caused by very low fertilizer application averaging 19 kg/ha in Tanzania (2), that is 38% of African Union's Abuja Declaration (10). Nitrogen and P fertilizers have been recommended for various parts of Tanzania (11). Fertilizer micro-dosing a technology of a reduced application by 25 – 33% of recommended rate (12) and (13) has been reported to increase crop yields in semi-arid conditions of West Africa (14) and (15). In Sub Saharan sub-humid and semi-arid agro-climates the maize yield increase with micro-dosing was found to attain twice the amount compared with no fertilizer application (16) and (17). Recommendations of improved fertilizer application technologies normally target on an optimum production rate while fertilizer purchase economically may not be feasible to poor farmers.

Economic analysis therefore is very important and enhances the usefulness of biophysical research results (18). Smallholder farmers are much aware on the prices of labour, inputs such as seeds, fertilizers and pesticides. Hayashi *et al* (19) reported more profit from farmers applying inorganic fertilizers than without fertilizer in millet cropping. However, (20)

UNDER PEER REVIEW

reported that lower net profit of micro-dosing fertilizer as compared to recommended rates in maize production might limit its adoption. Lessons on the economy of the fertilizer micro-dosing technology can further be drawn from the different countries (12); (19) and (15) as more contributions are still needed to the debate on how soil fertility can be revitalized (21). Therefore, study of cost components of micro-dose based maize production under agronomic experiments will help understand costs and can increase profitability. Thus, the objective of this paper is to evaluate the profitability (gross margin, return to labor and benefit/cost ratio) of selected fertilizer types and their micro-dose rates in maize production in a sub humid farming system.

2.0 MATERIALS AND METHODS

2.1 Study Area and Experimental Treatments

Field experiments were carried out in Ilakala and Changarawe villages of Kilosa District, Morogoro Region in Tanzania during the 2015 and 2016 cropping seasons. Three phosphate fertilizers namely Di-ammonium Phosphate (DAP), Minjingu Mazao (MM) and triple super phosphate (TSP) were applied at planting and urea fertilizer was applied at vegetative growth of maize to supplement nitrogen (11). Different fertilizer micro-dose rates at 12.5, 25, 50 and 75% were applied and compared with no fertilizer application and recommended rates (100%) in maize (17), whereby, a TMV-1 variety was used as test crop (22).

2.2 Data Collection

Costs of inputs such as seeds and fertilizers were collected from agro-shops during procurement of these materials. Labor costs for commercial farming and number of human labor (man-days per ha) under subsistence farming for land preparation, planting, fertilizer application, weeding, harvesting, shelling, transport and storage of produce were collected

UNDER PEER REVIEW

during execution of the entire experimentation, respectively (Table 1). Commercial and subsistence farming have been distinguished by Waceke and Kimenju (23). Subsistence farming is a form of farming in which crops or livestock are raised to sustain the farm family, farmers are not endowed with financial resources to buy inputs and very rare to hire labour as most of activities are done by family labour. Commercial farming is a type of farming which farmers maximize crop production, endowed with financial resources to buy inputs and use hired labour or implements to perform farm activities.

Table 1: Costs of inputs and labour in field activities under commercial and subsistence farming

Item/ Activity	Unit	Cost or Labour power
Seeds	TZS per ha	62,500.00
Fertilizer- DAP	TZS per 50 kg bag	75,000.00 – 80,000.00
Fertilizer- MM	TZS per 50 kg bag	35,000.00
Fertilizer- TSP	TZS per 50 kg bag	60,000.00
Fertilizer- Urea	TZS per 50 kg bag	55,000.00- 60,000.00
Cultivation (Non- family labour)	TZS per ha	125,000.00
Cultivation (family labour)	Man-days per ha	35.00
Planting (Non- family labour)	TZS per ha	75,000.00
Planting (family labour)	Man-days per ha	7.81
Fertilizer application (Non- family labour)	TZS per ha	75,000.00
Fertilizer application (family labour)	Man-days per ha	6.25
Weeding twice (Non- family labour)	TZS per ha	200,000.00
Weeding twice (family labour)	Man-days per ha	33.75
Harvesting (Non- family labour)	TZS per ha	87,500.00
Harvesting (family labour)	Man-days per ha	6.56

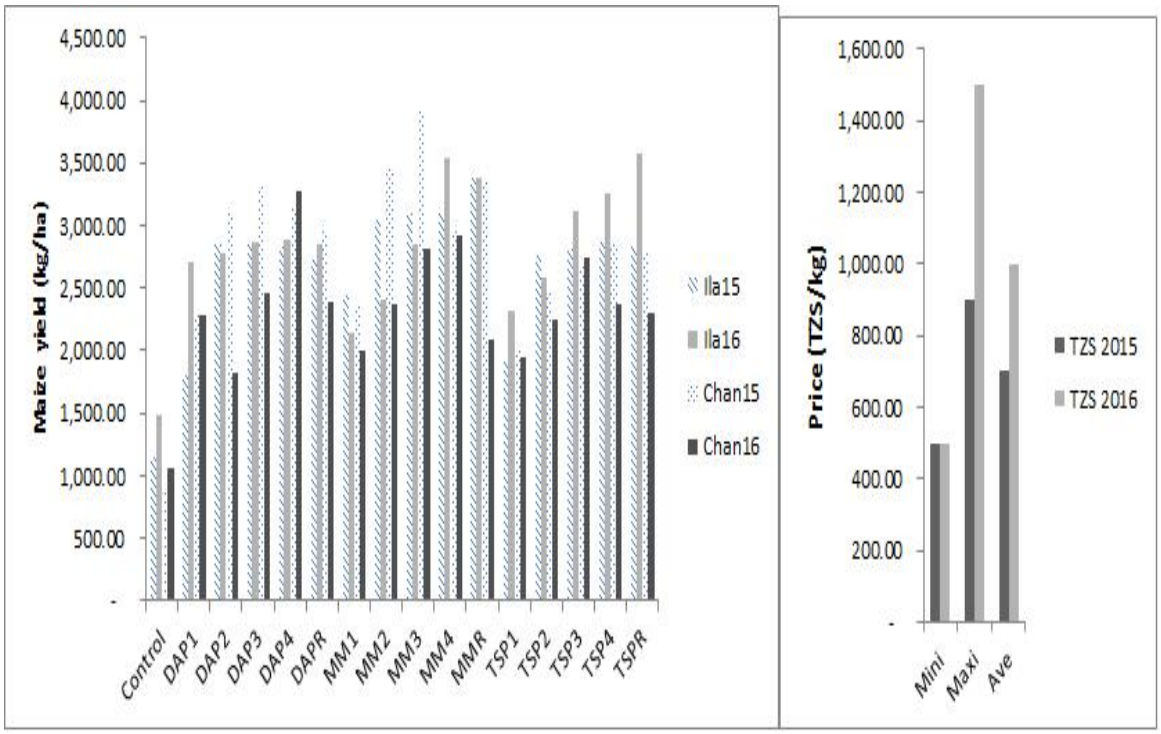
UNDER PEER REVIEW

Shelling (Non- family labour)	TZS per ha	60,000.00
Shelling (family labour)	Man-days per ha	7.50
Storage bags (woven/ polythene)	TZS per bag	1,200.00
Transportation of produce to home	TZS per bag	1,500.00

Yield of produce (kg/ha) was obtained from a split-block designed farm trial (17) and corresponding results are presented using Figure 1. Moreover, prices of produce in case study sites were collected during harvest and sowing from a total of 15 local key informants involving project research assistants, village agriculture extension officers and, in particularly, subsistence farmers. Minimum price was collected during harvest and the maximum at sowing period, the average price is a reflection of the overall prices combining all prices during both cropping seasons (Figure 1).

Figure 1: Maize grain yield (kg/ha) and prices (TZS/kg) during 2015 and 2016 cropping seasons

UNDER PEER REVIEW



Key: DAP, MM and TSP are Di-ammonium phosphate, Minjingu mazao and Triple super phosphate fertilizers;
Numbers 1 to 4 are micro-dose rates 12.5, 25, 50 and 75% of recommended nitrogen and phosphorus;
R is a recommended rate 40 kg P and 80 kg N/ha in maize.
Ila is Ilakala and Chan is Changarawe site, 15 and 16 are cropping years 2015 and 2016
TZS is Tanzani Shillings, Mini is minimum, Maxi is maximum, and Ave is average

Then, from these data gross return (GR), total variable cost (TVC) gross margin (GM) or net profit, return from labor and benefit- cost (C/B) ratios were calculated using the following equations (24):

$$Gross\ Return = Yield\ of\ produce\ x\ its\ market\ price \quad \ldots\ldots (1)$$

$$Gross\ Margin = Gross\ Return - Total\ Variable\ Costs \quad \ldots\ldots (2)$$

$$Return\ to\ labor = \frac{(Goss\ Return - Total\ Variable\ Costs)per\ ha}{Number\ of\ persondays\ per\ ha} \quad \ldots\ldots (3)$$

$$Benefit - Cost\ ratio = \frac{Gross\ Return}{Total\ Variable\ Cost} \quad \ldots\ldots (4)$$

UNDER PEER REVIEW

3.0 RESULTS

3.1 Revenue and Costs of Fertilizer Use in Maize Production

The lowest gross return was noted in control plots while the highest returns were due to fertilizer application from Ilakala and Changarawe study areas during 2015 and 2016 (Table 2). A gross return increased from control to micro-dose rates in DAP and thereafter decreased towards recommended rate DAP5. The trend of DAP was similar with Minjingu mazao (MM) and triple super phosphate (TSP) with few exceptions at Ilakala where gross return increased up to recommended rates in MM during 2015 and TSP during 2016 as shown in Table 2. The highest gross return in both sites was recorded from MM3 (2.7 million TZS/ha) and MM5 (2.3 million TZS) during 2015 while, MM4and TSP 5 (3.5 million TZS/ha) during 2016 at Ilakala and DAP4 (3.2 million TZS/ha) at Changarawe during 2016.

Total variable costs in both commercial and subsistence farming increased with fertilizer application rates and types (Table 2). Fertilizers TSP and DAP had more total variable cost than MM in both commercial and subsistence, however, commercial farming costs 500,000 Tanzanian shillings (TZS/ha) more compared to subsistence as far as fertilizer application is concerned. Fertilizer application had more labor demand than control but fertilizer micro-doses and recommended rate had equal labor (man-days) demand in spot application (Table 2).

Table 2 Gross return, total variable costs and labor in maize fertilizer micro-dosing technology

	Gross Return (1000'TZS/ha)				TVC (1000'TZS/ha)		Labor
Treatment	GR Ilakala 2015	GR Ilakala 2016	GR Changarawe 2015	GR Changarawe 2016	TVC-Commercial	TVC-Subsistence	Person days/ha
Control	806.4	1492.0	611.8	1059.0	639.5	149.5	91
DAP1	1263.5	2715.0	1599.5	2277.0	819.9	223.9	97
DAP2	1997.1	2776.0	2184.0	1824.0	883.5	278.3	97
DAP3	2009.0	2864.0	2323.3	2466.0	997.1	372.3	97
DAP4	1983.8	2886.0	2197.3	**3270.0**	1107.5	473.7	97
DAP5	1904.7	2846.0	2067.8	2389.0	1206.0	575.1	97

UNDER PEER REVIEW

MM1	1716.4	2146.0	1646.4	2003.0	817.6	221.1	97
MM2	2136.4	2415.0	2433.9	2379.0	883.4	270.9	97
MM3	2172.8	2844.0	**2737.0**	2805.0	991.8	371.2	97
MM4	2175.6	**3543.0**	2070.6	2924.0	1092.5	471.9	97
MM5	**2363.9**	3373.0	2340.1	2089.0	1191.8	573.3	97
TSP1	1354.5	2319.0	1406.3	1940.0	815.2	223.7	97
TSP2	1932.0	2579.0	1731.1	2253.0	882.3	277.9	97
TSP3	1971.2	3106.0	1887.9	2747.0	997.7	385.2	97
TSP4	2010.4	3258.0	2015.3	2372.0	1106.7	493.6	97
TSP5	1988.7	**3573.0**	1952.3	2300.0	1214.0	600.9	97

DAP, MM and TSP are fertilizer types namely Di-ammonium phosphate, Minjingu Mazao and triple super phosphate. Numbers 1, 2, 3, 4 and 5 are fertilizer rates as 7.5 kg P and 10 kg N, 10kg P and 20, 20 kg P and 40kg N/ha, 30 kg P and 60 kg N, and 40kg P and 80 kg N/ha. GR is gross return, and TVC is a total variable costs. Number bolded are highest GR.

3.2 Gross Margin of Fertilizer Rates in Maize Production

Gross margin that is also a net profit from fertilizer types and rates was very high under subsistence farming compared to commercial farming with the highest profit in Minjingu Mazao (MM4) as presented in Figure 2. Under commercial farming, control had the lowest gross margin and during 2015 Changarawe had a net loss or negative profit. Plots with DAP2 and DAP4, MM2, MM3 and MM4, TSP2, TSP3 and TSP5 had the highest gross margin (Figure 2).

Figure 2: Gross margin of maize under fertilizer micro-dosing application

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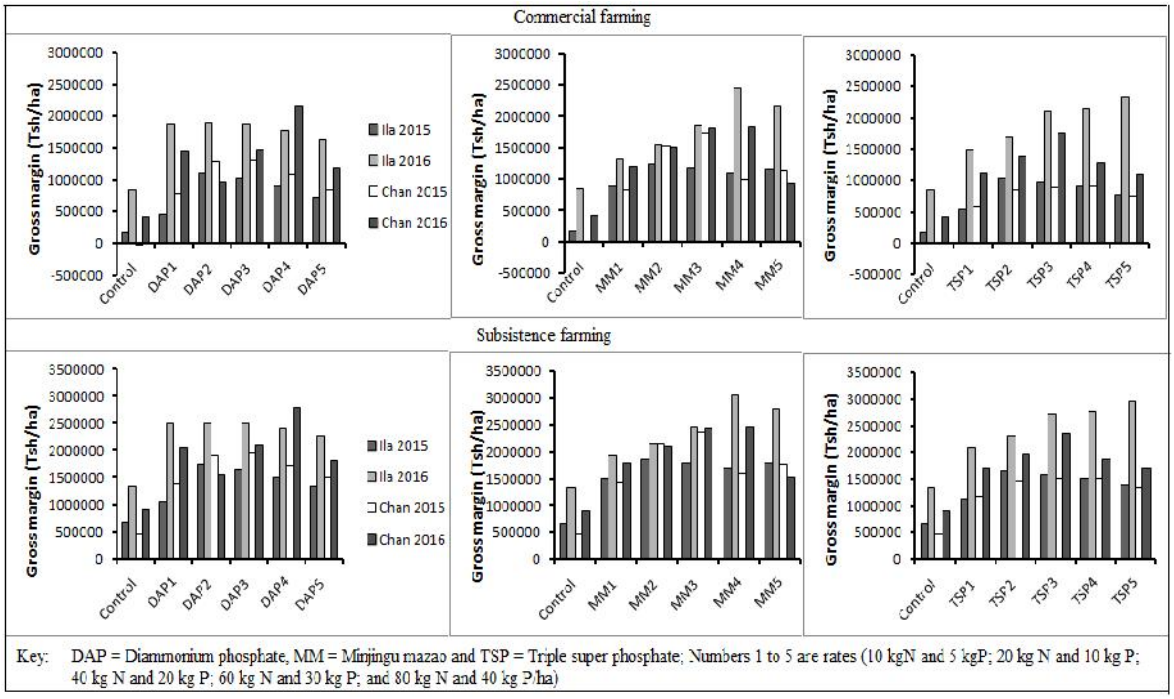
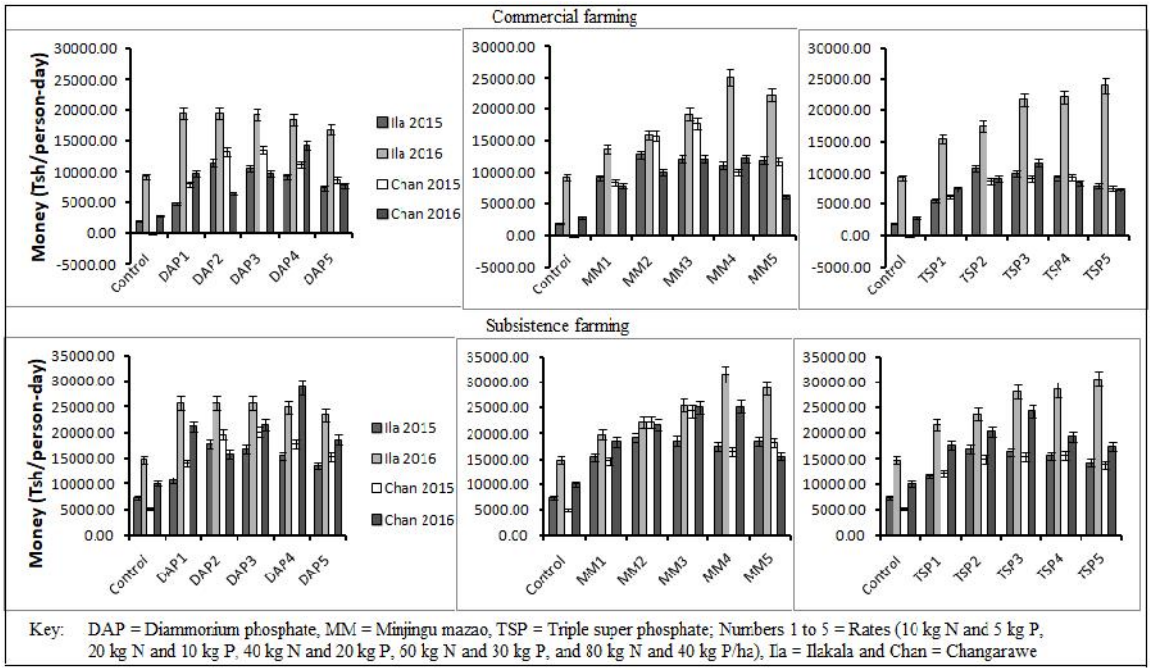


3.3 Return to Labor in Maize under Fertilizer Application

Return to labor was higher in subsistence farming than commercial with the highest amount of money saved with Minjingu mazao (MM4) as shown in Figure 3. Control had the lowest value, with negative return to labor at Changarawe during 2015 in commercial farming. There was increase in costs per person-day from control to micro-dose rates and it decreased towards recommended rates (Figure 3).

Figure 3: Return to labor in maize fertilizer micro-dosing technologies for 2015 and 2016 in Ilakala and Changarawe

UNDER PEER REVIEW



3.4 Benefit and Cost Ratio of Fertilizer Micro-dose Rates in Maize Production

Commercial farming had lower benefit cost ratios (B/C) than subsistence. Maize commercial farming had the highest B/C in DAP2, DAP4 and MM2 with the lowest values in control plots (Table 3). Subsistence maize farming had the highest values in DAP1 and MM2 with different trend compared to commercial farming.

Table 3 Benefit cost ratio of maize from fertilizer micro-dosing

	B/C- commercial				B/C- subsistence			
Treatment	Ilakala 2015	Ilakala 2016	Changarawe 2015	Changarawe 2016	Ilakala 2015	Ilakala 2016	Changarawe 2015	Changarawe 2016
Control	1.27	2.30	0.96	1.66	5.39	9.98	4.09	7.08
DAP1	1.57	3.26	1.95	2.77	5.74	12.13	7.14	10.17
DAP2	2.26	3.12	2.43	2.12	7.37	9.97	7.85	6.55
DAP3	2.04	2.86	2.30	2.49	5.40	7.69	6.24	6.62
DAP4	1.83	2.60	1.97	2.92	4.19	6.09	4.64	6.90
DAP5	1.61	2.34	1.70	1.98	3.31	4.95	3.60	4.15
MM1	2.09	2.63	2.00	2.47	7.76	9.71	7.45	9.06
MM2	2.40	2.77	2.70	2.73	7.89	8.91	8.98	8.78
MM3	2.19	2.90	2.70	2.86	5.85	7.66	7.37	7.56
MM4	1.99	3.22	1.90	2.69	4.61	7.51	4.39	6.20
MM5	1.97	2.81	1.95	1.79	4.12	5.88	4.08	3.64
TSP1	1.67	2.82	1.73	2.39	6.05	10.37	6.29	8.67

UNDER PEER REVIEW

TSP2	2.17	2.92	1.97	2.57	6.95	9.28	6.23	8.11
TSP3	1.98	3.09	1.90	2.76	5.12	8.06	4.90	7.13
TSP4	1.82	2.91	1.82	2.17	4.07	6.60	4.08	4.81
TSP5	1.64	2.90	1.61	1.92	3.31	5.95	3.25	3.83

DAP, MM and TSP are fertilizer types namely Di-ammonium phosphate, Minjingu Mazao and triple super phosphate. Numbers 1, 2, 3, 4 and 5 are fertilizer rates as 7.5 kg P and 10 kg N, 10kg P and 20, 20 kg P and 40kg N/ha, 30 kg P and 60 kg N, and 40kg P and 80 kg N/ha. GR is gross return, and TVC is a total variable costs

4.0 DISCUSSION

Gross return was influenced by the cost of resources invested (labour and inputs); quantity of crop produced and price fluctuation. Amount of maize crop produced per unit area varied among fertilizer types and levels applied as well as cropping year. These variations among treatments reflected the importance of fertilizer application to increase crop yield. Maize Prices fluctuated between seasons, during harvest the supply of maize was very high that resulted into low price. At sowing, maize supply was very low to most of smallholder farmers so that their value increased extremely. Fluctuation of maize prices reported in this study followed a trend reported by (25) confirming the supply and demand theory described by (24). Total production costs increased in plots treated with fertilizers due to extra expenses incurred for purchasing fertilizers, costs of transportation and labor needed to apply fertilizers (26). Subsistence farming required some extra field activities such as cultivation, sowing, weeding, and fertilizer application and harvesting to family labor which generally is considered as routine responsibility in family farming as many other examples show (27). Family labour often included self-exploitation not striving for a regular minimum salary and social benefits; but in exchange includes higher flexibility, self-determination, and more or less transparent profit-sharing (28). That resulted into lower production costs than commercial farming where everything was charged for the activity performed.

UNDER PEER REVIEW

Net loss in control plots under commercial farming was caused by increased production costs in land which is not productive without fertilizer application. This indicates that whenever farmer is shifting from subsistence to commercial production especially fertilizers should be used more intensively, as experienced also by other authors such as (29) and (23). Fertilizer micro-dose rates of only 25, 50 and 75% from the recommended nitrogen and phosphorus rates produced the highest net profit. This can be considered a strategy for coping with low rainfall periods or harsh weather conditions (30), declining soil fertility (31) and reducing fertilizer costs due to lower amount purchased (12). Results of net return reported in this study are different from those reported by Bachmann *et al.* (2016) who found 16.9% lower net return in fertilizer micro-dosing rates of 55.3 % compared to the recommended rate of NPK fertilizer. This difference can be attributed to differences in better weather conditions such as 800 – 1100 mm rainfall. The result of profitability is in similar trend with those reported by Camara *et al* (12) showing that micro-dosing had higher investment return compared to recommended fertilizer. Profitability analysis in terms of net profit, return to labor and benefit-cost ratio indicated that MM fertilizer was more profitable followed by DAP and TSP. This is mainly due to lower market price of MM fertilizer. Also, MM fertilizer had relatively more yield compared to DAP and TSP that increased revenues. Fertilizer micro-dosing at 12.5, 25 and 50% of recommended nitrogen and phosphorus were more profitable than recommended rate due to increasing yields with still lower amount of fertilizer usage. Hence, these lower rates, for instance 223,900 TSH/ha for 12.5% fertilizer micro-dose rates are economically more viable for poor smallholder farmers in sub-humid tropical conditions.

CONCLUSION AND RECOMMENDATION

Market prices of maize fluctuated over the year, with the price during harvest being low and increasing towards field operations of next cropping seasons. Minjingu Mazao fertilizer had

UNDER PEER REVIEW

the highest return among the phosphate fertilizer types under this study. Micro-dosing rate of 12.5% was more profitable than no fertilizer application and the profitability increased towards 25% and 50% and decreased at recommended rate (100% N and P) in subsistence and commercial farming. Subsistence farming was more profitable than commercial farming due to high labour charges. Therefore, smallholder farmers should first adopt for 12.5% as a low cost entry point to fertilizer use and later on advance to 25% and 50% micro-dosing rates which are even more profitable. These micro-fertilization techniques can easily offset fertilizer costs and bring fairly higher yields, profits and increase return on investment under the current changing of weather conditions affecting crop production in sub humid tropics.

REFERENCE

Works Cited

1. **FAO.** *The role of agriculture in the development of Least-Developed Countries and their integration into the World economy.* Rome : Commodities and Trade Division, Food and Agriculture Organization of the United Nations, 2002. p. 190.

2. **MALF.** *Budget Speech of the Ministry of Agriculture Livestock and Fisheries 2017/18.* Dodoma : Parliament of the United Republic of Tanzania, 2017. p. 255.

3. *Contribution of agriculture sector to the Tanzanian Economy.* **Chongela, J.** 7, 2015, American Journal of Research and Communication, Vol. 3, pp. 57-70.

4. **NAP.** *National Agricultural Policy.* Dar es salaam : Ministry of Agriculture Food Security and Cooperatives, 2013. p. 51.

5. **Smale, M, Byerlee, D and Jayne, T.** *Maize Revolution in Sub-Saharan Africa: The Policy Research Working.* s.l. : World Bank, 2011. p. 34.

6. *Chemical and nutritional value of maize and maize products obtained from selected markets in Kaduna State, Nigeria.* **Sule, E I, et al.** 4, s.l. : African Journal of Food Science and Technology , 2014, Vol. 5, pp. 100-104.

7. **Macauley, H and Ramadjita, T.** *Cereal crops: Rice, maize, millet, sorghum and wheat.* 2015. p. 36.

8. **Shao, F M.** *Analysis of the Agricultural Technologies Development and Dissemination Situation in Tanzania.* s.l. : SADC, 2007. p. 111.

9. *Can sub-Saharan Africa feed itself?* **van Ittersum, M K, et al.** 52, s.l. : PNAS, 2016, Vol. 113, pp. 14964-14969.

UNDER PEER REVIEW

10. **Cameron, A, Derlagen, C and Pauw, K.** *Options for reducing fertilizer prices for smallholder farmers in Tanzania.* Rome : MAFAP-FAO, 2017. p. 34.

11. **Marandu, A E, Mbogoni, J D and Ley, G J.** *Revised Fertilizer Recommendations for Maize and Rice in the Eastern, Southern Highlands and Lake Zones of Tanzania.* Dar es salaam : Department of Research and Development- Ministry of Agriculture Food Security and Cooperatives, 2014. p. 40.

12. *Micro-dosing of fertilizer- a technology for farmers' needs and resources.* **Camara, B S, et al.** 5, s.l. : International Journal of Agri Science, 2013, Vol. 3, pp. 387-399.

13. *Maize response to fertilizer dosing at three sites in the Central Rift Valley of Ethiopia.* **Sime, G and Aune, J B.** s.l. : Agronomy, 2014, Vol. 4, pp. 436-451.

14. *Long term effects of reduced fertilizer rates on millet yields and soil properties in the West-African Sahel.* **Adams, A M, et al.** s.l. : Nutr Cycl Agroecosyst, 2016, Vol. 106, pp. 17-29.

15. *Fertilizer micro-dosing in West African low-input cerealscropping: Benefits, challenges and improvement strategies.* **Okelabama, B C, et al.** 14, s.l. : African Journal of Agricultural Research, 2017, Vol. 12, pp. 1169-1176.

16. **Germer, J, et al.** *Fertilizer micro-dosing for increasing yields under sole and intercropping systems for rural stakeholders.* s.l. : Trans-SEC, 2017.

17. *Effects of Nitrogen and Phosphorus Micro-Doses on Maize Growth and Yield in a Sub-Humid Tropical Climate.* **Saidia, P S, et al.** 2, s.l. : Annals of Biological Research, 2018, Vol. 9, pp. 20-35.

18. **Kirway, T N, et al.** *Farming Systems Approaches Training Manual.* Dar es salaam : DRD-MAFS, 2003. p. 255. Vol. 2.

19. *Evaluation of application timing in fertilizer micro-dosing technology on millet production in Niger, West Africa.* **Hayashi, K, Abdoulaye, T and Gerard, B.** s.l. : Nutr Cycl Agroecosyst, 2008, Vol. 80, pp. 257-265.

20. *Profitability and institutional constraints to the adoption of fertilizer microdosing in Northwest Benin.* **Bachmann, E, et al.** 3, 2016, Sustainable Agriculture Research, Vol. 5, pp. 11-23.

21. *African agriculture: dirt poor.* **Gilbert, N.** Nature, Vol. 483, pp. 525-527.

22. *The use of improved maize varieties in Tanzania.* **Lyimo, S, Mduruma, Z and De Groote, H.** 7, 2014, African Journal of Agricultural Research, Vol. 9, pp. 643-657.

23. *Intensive Subsistence Agriculture: Impacts, Challenges and Possible Interventions.* **Waceke, J W and Kimenju, J W.** 1, 2007, Dynamic Soil, Dynamic Plant , Vol. 1, pp. 43-53.

24. **Debertin, D L.** *Agricultural Production Economics.* Upper Saddle River, N.J. : Macmillan Publishing Company, 2012. p. 431. Vol. 2.

25. *Impact of mineral fertilizer microdosing on the yield of sorghum in adoption fields of women trained in farmers' field school of Niako in South Sudan area of Mali.* **Sodogo, D, et al.** 4, 2016, International Journal of Current Microbiology and Applied Sciences , Vol. 5, pp. 698-704.

UNDER PEER REVIEW

26. *Agricultural household effects of fertilizer price changes for smallholder farmers in central Malawi.* **Komarek, A M, et al.** 2017, Agricultural Systems , Vol. 154, pp. 168-178.

27. *Indigenous labour sourcing: Subsistence farming and poverty status among farmers in Nigeria.* **Oladele, O I.** 3, 2008, Indian Journal of Traditional Knowledge , Vol. 7, pp. 478-484.

28. *"Why is the Agriculture of Advanced Western Countries still Organized by Family Farms? Will this Continue to be so in the Future?".* **Schmitt, G.** 3, 1991, European Review of Agricultural Economics , Vol. 18, pp. 443-458.

29. *From Subsistence to Commercial Production Systems: The Transformation of Asian Agriculture.* **Pingali, P L.** 1997, American Journal of Agriculture Economics , Vol. 79, pp. 628-634.

30. **Murendo, C and Wollni, M.** *Ex-post impact assessment of fertilizer microdosing as a climate-smart technology in Sub-Saharan Africa.* s.l. : ICRISAT. p. 27.

31. **Montpellier Panel Report.** *Sustainable Intensification: A new paradigm for African agriculture.* London : s.n., 2013. p. 36.