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Research Article

Comparative Economic Analysis of Organic and Inorganic Fertilizers on Grain Yield of Tropical Maize Varieties

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Abstract
Increasing demand for maize in Nigeria has resulted in high use of inorganic fertilizers and these fertilizers are expensive for peasant farmers who dominate farming in the country. The use of inorganic fertilizers also results in hidden cost borne by man and the ecosystem. In a search for a cost-effective and safer alternative, six maize varieties were evaluated using moringa, banana-peel, maize-stalk fertilizer (MBM) both in solid and foliar forms. Gross benefit, net benefit and benefit-cost ratio (BCR) were used to determine enterprises with the highest economic returns. The results showed that maize varieties treated with 90 kg/ha of NPK had the highest grain yield which was significantly comparable with MBM. The application of 120N+50P+40K rate of MBM to single cross hybrid, SCH LY1312-1, resulted in the highest benefit-cost ratio (15.16). MBM is economically more viable than NPK Fertilizer and its application in the solid (powdered) form before planting produced double economic returns compared to foliar application. Single cross hybrids gave better economic returns when the fertilizer was applied in solid form.

Keywords: *Economic analysis, Grain yield, Inorganic fertilizer, Maize varieties, Organic fertilizer*

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Introduction
Maize *(Zea mays* L.) ranks third after wheat and rice in the world food grain production (Ort and Long, 2014). It is a food security crop in sub-Saharan Africa (SSA) (Muscat, 2013). Although Nigeria being the highest producer of maize in SSA, still imports maize to meet her domestic needs (Adeosun *et al*., 2019). In order to meet up with the increasing demand for maize, the use of fertilizer had been on the increase. Fertilizer is an organic or inorganic nutrient source, added to the soil to enhance plant growth (Daigneault *et al*., 2016). Inorganic fertilizers are chemical, synthetic nutrient sources while organic fertilizers are derived from biological origin either living or formerly living (dead) materials. However, inorganic fertilizer constitutes the single most expensive input incurred by peasant farmers (Bonilla-Cedrez *et al*., 2020). More so, the use of inorganic fertilizer has negative consequences on the ecosystem. This leads to land degradation, global warming and pollution of water bodies (Goulding, 2004). These negative consequences have necessitated the search for safer alternative natural sources of nutrient replenishment technology for improved productivity at a reduced cost. Hence, this research was initiated to explore the potential of moringa-banana peel-maize stalk organic fertilizer technology towards reducing the devastating consequences of inorganic fertiliser to the ecosystem, including man, crop output and the income of the farmers whose highest single input is fertilizer. Economic analysis was conducted to compare different levels of moringa-banana peel- maize stalk organic fertilizer with a standard national

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recommended NPK rate, using a partial budget, dominance and marginal analysis of each treatment. Partial budget analysis, as an analytic tool in economic analysis, employs average grain yield, gross benefit and the total costs in reaching a suitable decision required to adopt a technology or compare the impact of technological changes on the farm costs and returns. It is also valuable in assessing the relative profitability of the alternative treatments as it evaluates the riskiness, and profitability in changing a product or input prices (Dhakal *et al*., 2015; Melese *et al*., 2018). According to Olasoji and Egbelokun (2017), partial budget analysis is important in estimating the net benefit of a particular enterprise. Although literature abounds on the economic analysis of organic and inorganic fertiliser, there is a paucity of information on the economic analysis of moringa-banana peel-maize stalk technology, a new initiative, on different maize varieties.

Therefore, the objectives of the study were to:
i. Compare the gross and net benefits derivable from moringa-banana peel-maize stalk technology and inorganic NPK fertiliser;
ii. Identify the type of fertilizer and method of application with the highest gross and net benefit
iii. Identify the maize variety with the highest benefit cost ratio under the application of organic and inorganic fertilizers.

Materials and Methods

The field experiment was set up and laid out in randomized complete block design (RCBD) in three replicates at Teaching and Research Farms of Kwara State University. It was a three factor experiment, consisting of six maize varieties, two modes of fertiliser application (solid and spray) and four fertilizer levels (70N+30P+20K, 100N+40P+30K, 120N+50P+40K and 90 kg/ha NPK 15-15-15). The fertilizers included three levels of moringa-banana peel-maize stalk fertiliser namely: 70N+30P+20K, 100N+40P+30K and 120N+50P+40K and inorganic fertiliser (NPK 15-15-15) at the recommended rate of 90 kg/ha used as control (Table 1). Moringa leaves, banana peel and maize stalks were the primary sources of N, P and K respectively. These nutrient sources were air-dried to minimize nutrient loss, thereafter, ground with a blender to smaller sizes. 70, 100 and 120 kg of ground moringa leaves were measured to denote 70N, 100N and 120N respectively. Also, 30, 40 and 50 kg of ground banana peel denoted 30P, 40P and 50P while 20, 30 and 40 kg of maize stalk connoted 20, 30 and 40K respectively. Both organic and inorganic fertilizers were applied in both solid and spray form. The solid fertilizer was a mix of the ground nutrients which was incorporated into the soil a week before planting. The spray fertilizer was formed by dissolving each of the solid fertilizers in one litre of water in a jar and covered for three days, to allow the nutrient sources to dissolve. Thereafter, the filtrate was sieved and applied as foliar fertilizer on maize plants conventionally. The analytical techniques used in this study include Gross benefit (GB), Net Benefit (NB) and Benefit-Cost Ratio (BCR).

Gross benefits

Gross benefit (GB) calculation was done to estimate the difference between the gross return and variable costs. Gross benefit was calculated using the method described by (Olukosi, 2006; Egbetokun *et al*., 2018)
Gross benefit (N/ha) =Gross return (N/ha) - Total cost (N/ha).....(1)

Net benefits

Net Benefit (NB) was used to determine the overall positive impact of the treatments on monetary values. NB was calculated in the study as the difference between gross benefits (GB) and the total variable cost (TVC). The formula is given as:

NB (N/ha)=GB (N/ha) - TVC (N/ha).....(2)

Benefit-cost ratio

Benefit/cost analysis (BCR) determines the value of a project by dividing the incremental monetized benefits related to a project by the incremental costs of that project. It is the primary output of the analysis process. This output may either be expressed as a ratio (3:1) or a resultant value (3)**.** Benefit-Cost Ratio is an indicator used in the formal discipline of cost-benefit analysis, which attempts to summarize the overall value for money of a project (Olasoji and Egbetokun, 2017). In this research, the undiscounted benefit-

cost ratio was estimated as a ratio of gross return and total variable cost. Thus, the benefit-cost (BCR) analysis was carried out by using the formula

BCR=NB/TVC.....(3)

Note that the total cost comprises of cost of seeds, cost of fertilizer, cost of land preparation, cost of labour and cost of other inputs.

Results and Discussion

Economics of six varieties of maize treated with fertiliser incorporated into the soil in solid form

The result of the economics of the six maize varieties under the influence of organic and inorganic fertilizers applied in solid form is shown in Table 2. Application of 100N+40P+30K on OPV-STR gave a gross benefit of ₦255,440 with a net benefit and benefit-cost ratio of ₦222,880 and 6.84 respectively. Comparatively, the application of inorganic fertilizer (90 kg/ha NPK 15:15:15) to OPV-STR gave a gross benefit, net benefit and benefit-cost ratio of ₦272,250, ₦214,500 and 3.71 respectively indicating that the organic treatment (100N+40P+30K) has a better financial return compared to the inorganic treatment (90 kg/ha NPK 15:15:15) with regards to OPV-STR. Although the yield (1.10 ton/ha) from the (90 kg/ha NPK 15:15:15) was superior to that of 100N+40P+30K (0.96t/ha), the high cost of NPK 15:15:15 was the reason for the low returns. Also, 120N+50P+40K applied on SCH (check) resulted in a gross benefit, net benefit and benefit-cost ratio of ₦494,800, ₦461,600 and 13.90 while its corresponding 90 kg/ha NPK 15:15:15 applied on SCH (check) gave a gross benefit, net benefit and benefit-cost ratio of ₦502,800, ₦444,600 and 7.63 respectively. Thus, indicating that 120N+50P+40K has a higher return compared to 90 kg/ha NPK 15:15:15. Furthermore, 70N+30P+20K applied on SCH LY1312-1 gave a gross benefit, net benefit and benefit-cost ratio of ₦438,200, ₦405,400 and 12.35 while 90 kg/ha NPK 15:15:15, its inorganic counterpart, gave the same economic results of 553,800, 495,600 and 8.51 respectively. In the same vein, 100N+40P+30K applied on Doublecross hybrid (DCH) gave a gross benefit, net benefit and benefit-cost ratio of ₦293,225, ₦360,450 and 10.99 respectively while 90 kg/ha NPK 15:15:15 gave the same economic parameters of ₦383,025, ₦325,050 and 5.60 respectively. Concurrently, 120N+50P+40K applied to three-way hybrid under the same conditions attained a gross benefit, net benefit and a benefit-cost ratio of ₦306,025, ₦273,050 and 8.28 while its 90kg/ha NPK counterparts gave ₦329,025, ₦271,050 and 4.67 of the same economic parameters respectively. Finally, 70N+30P+20K applied to top cross hybrid BRTZL x 1368 gave a gross benefit, net benefit and a benefit-cost ratio of ₦246,525, ₦214,050 and 6.59 respectively while its corresponding 90kg/ha NPK gave the same economic parameters of ₦311,025, ₦253,050 and 4.36 respectively. From the foregoing, a single cross hybrid (SCH) LY1312-1 under 120N+50P+40K rate of moringa-banana peel maize stalk technology has the highest benefit-cost ratio (15.16). In all the treatments, moringa-banana peel maize stalk technology has a higher benefit-cost ratio than inorganic fertiliser (NPK 15:15:15) applied to the same maize varieties. Moringa-banana peel maize stalk technology is more economically viable than the inorganic fertiliser when applied as a solid. This agrees with the findings of Sekumade (2017) in Nigeria, and Jjagwe *et al*. (2020) in Uganda, who reported higher economic returns from maize fertilized with organic fertilizer over inorganic fertilizer. Although inorganic fertiliser, NPK 15:15:15 had a higher but significantly comparable yield to Moringa-banana peel maize stalk fertilizer, it had a lower economic return. This is a result of the exorbitant cost of inorganic fertilizer as it is usually the single input that takes the most cost in crop production (Bonilla-Cedrez *et al*., 2020). For single cross hybrid, both SCH LY1312-1 and SCH check had the highest economic returns for all the treatments be it organic or inorganic fertilizer application despite being more expensive than the seeds of other maize varieties, while the open pollinated variety, OPV-STR had the least benefit-cost ratio despite being the cheapest seed. Cultivating single cross hybrids of maize is most profitable under solid application of fertilizer at one week before planting. Similarly, Egbetokun and Oloyede-Kamiyo (2020) used partial budgeting, whose components are gross benefit, net benefit and benefit-cost ratio to choose the best maize variety under different planting densities. Also, Dhakal *et al*.

(2015) and Melese *et al*. (2018) concluded that benefit-cost ratio can be used in deciding as to which technology to adopt in an enterprise.

Economics of six varieties of maize under foliar fertilizer treatments

The result in Table 3 shows the economic parameters (gross benefit, net benefit and benefit-cost ratio) of maize yield under the influence of different levels of organic fertilizer and a recommended rate of inorganic fertilizers through foliar application. Application of 100N+40P+30K in the foliar form on OPV-STR amassed a gross benefit of ₦177,440, a net benefit of ₦144,880 and a benefit-cost ratio of 4.45 while 90 kg/ha NPK applied (check) resulted in a gross benefit, net benefit and benefit-cost ratio of ₦209,800, ₦176,600 and in the foliar form to OPV-STR gave a gross benefit, net benefits and benefit-cost ratio of ₦206,250, ₦148,500, and 2.57 respectively. Similarly, 120N+50P+40K applied in the foliar form on SCH 5.31 respectively while 90kg/ha NPK on the same SCH (check) gave the same economic parameters of ₦340,800, ₦282,600 and 4.85 respectively. Furthermore, 70N+30P+20K applied in the foliar form to SCH LY1312-1 gave a gross benefit, net benefit and benefit-cost ratio of ₦195,200, ₦162,400 and 4.95 while its inorganic counterparts gave the same economic results of ₦370,800, ₦312,600 and 5.37 respectively. This trend is similar to other fertilizer forms and varieties. However, single cross hybrids were not consistently giving better economic returns than the open pollinated variety and other varieties. A comparison of the benefit derived from solid and spray fertilizer applied in foliar form showed that solid fertilizer applied a week before planting consistently resulted in better economic returns per unit of investment irrespective of the fertilizer and maize varieties. Solid fertilizer gave twice the economic returns than foliar fertilizer. Besides, foliar fertilizer is more laborious to prepare and could require technicalities that farmers might not be comfortable adopting. This agrees with the results of Fageria *et al*. (2009) but contrary to the report of Ngosong *et al*. (2018) on cucumber.

Conclusion

Application of 120N+50P+40K rate of moringa-banana peel-maize stalk (MBM) fertilizer to single cross hybrids SCH LY1312-1 resulted in the highest benefit-cost ratio. This organic fertilizer consistently resulted in higher economic returns compared to the inorganic fertilizer (NPK). Hence, the use of organic fertilizer is economically more viable than inorganic fertilizer, in addition to the hidden cost borne by the environment when inorganic fertilizer is used. Fertilizer application in solid form at a week before planting has double economic returns compared to foliar application.

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Table 1: Six maize varieties, four fertilizer treatments and their codes

Treatments	Code
Maize varieties	
OPV-STR	1
Single cross hybrid (SCH) (check)	2
SCH LY1312-1	3
Double cross hybrid (DCH)	4
Three-way hybrid (TWH)	5
Top cross hybrid BRTZL x 1368	6
Fertilizer treatments	
100N+40P+30K	A
120N+50P+40K	B
70N+30P+20K	C
90kg/ha NPK	D

Table 2: Economic parameters of maize using solid inorganic and organic fertilizers

Treatment	Yield t/ha	Total revenue (₦)	Total cost (₦)	Gross benefit (₦)	Net benefit (₦)	Benefit-cost ratio
A+solid+1	0.96	288000	32560	255440	222880	6.84
A+ solid +2	1.53	459000	33000	426000	393000	11.90
A+ solid +3	1.81	543000	33000	510000	477000	14.45
A+ solid +4	1.42	426000	32775	393225	360450	10.99
A+ solid +5	1.10	330000	32775	297225	264450	8.06
A+ solid +6	1.02	306000	32775	273225	240450	7.33
B+ solid +1	1.00	300000	32750	267250	234500	7.16
B+ solid +2	1.76	528000	33200	494800	461600	13.90
B+ solid +3	1.90	570000	33200	536800	503600	15.16
B+ solid +4	1.29	387000	32975	354025	321050	9.73
B+ solid +5	1.13	339000	32975	306025	273050	8.28
B+ solid +6	1.07	321000	32975	288025	255050	7.73
C+ solid +1	0.89	267000	32250	234750	202500	6.27
C+ solid +2	1.43	429000	32800	396200	363400	11.07
C+ solid +3	1.57	471000	32800	438200	405400	12.35
C+ solid +4	1.28	384000	32475	351525	319050	9.82
C+ solid +5	0.93	279000	32475	246525	214050	6.59
C+ solid +6	0.93	279000	32475	246525	214050	6.59
D+ solid +1	1.10	330000	57,750	272250	214500	3.71
D+ solid +2	1.87	561000	58200	502800	444600	7.63
D+ solid +3	2.04	612000	58200	553800	495600	8.51
D+ solid +4	1.47	441000	57,975	383025	325050	5.60
D+ solid +5	1.29	387000	57,975	329025	271050	4.67
D+ solid +6	1.23	369000	57,975	311025	253050	4.36

Source: Field analysis, 2020

Ave.= Average, Nutrient levels: A= 100N+40P+30K, B= 120N+50P+40K, C= 70N+30P+20K, D=90kg/ha NPK Variety 1=OPV-STR, 2= Single cross hybrid (SCH) check, 3= SCH LY1312-11 4= Double cross hybrid, 5=Three-way hybrid 6=Top cross hybrid BRTZL x 1368

Table 3. Economic parameters of maize using liquid/spray organic and inorganic fertilizer

Treatment	Yield t/ha	Total revenue (₦)	Total cost (₦)	Gross benefit (₦)	Net benefit (₦)	Benefit-cost ratio	Benefit of Solid: Spray
A+spray+1	0.7	210000	32560	177440	144880	4.45	1.54
A+ spray +2	0.67	201000	33000	168000	135000	4.09	2.91
A+ spray +3	0.71	213000	33000	180000	147000	4.45	3.25
A+ spray +4	0.70	210000	32775	177225	144450	4.41	2.49
A+ spray+5	0.67	201000	32775	168225	135450	4.13	1.95
A+ spray +6	0.6	180000	32775	147225	114450	3.49	2.10
B+ spray +1	0.6	180000	32750	147250	114500	3.49	2.05
B+ spray +2	0.81	243000	33200	209800	176600	5.31	2.62
B+ spray +3	0.90	270000	33200	236800	203600	6.13	2.47
B+ spray +4	0.70	210000	32975	177025	144050	4.37	2.23
B+ spray +5	0.60	180000	32975	147025	114050	3.46	2.39
B+ spray +6	0.48	144000	32975	111025	78050	2.36	3.28
C+ spray +1	0.76	228000	32250	195750	163500	5.07	1.24
C+ spray +2	0.72	216000	32800	183200	150400	4.59	2.41
C+ spray +3	0.76	228000	32800	195200	162400	4.95	2.49
C+ spray +4	0.81	243000	32475	210525	178050	5.48	1.79
C+ spray +5	0.70	210000	32475	177525	145050	4.46	1.48
C+ spray +6	0.67	201000	32475	168525	136050	4.18	1.58
D+ spray+1	0.88	264000	57,750	206250	148500	2.57	1.44
D+ spray+2	1.33	399000	58200	340800	282600	4.85	1.57
D+ spray+3	1.43	429000	58200	370800	312600	5.37	1.58
D+ spray+4	1.03	309000	57,975	251025	193050	3.33	1.68
D+ spray+5	1.13	339000	57,975	281025	223050	3.85	1.21
D+ spray+6	1.00	300000	57,975	242025	184050	3.17	1.38
Ave. benefit							2.05

Source; field survey, 2020.

Ave.= Average, Nutrient levels: A= 100N+40P+30K, B= 120N+50P+40K, C= 70N+30P+20K, D=90kg/ha NPK Variety 1=OPV-STR, 2= Single cross hybrid (SCH) check, 3= SCH LY1312-11 4= Double cross hybrid, 5=Three-way hybrid 6=Top cross hybrid BRTZL x 1368