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Influence of Precursor Crops on Inorganic and Organic Fertilizers Response of Maize at Bako, Western Oromiya, Ethiopia

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Abstracts: The present research was conducted with the objective to determine the right precursor crop with integrated nutrient management is an approach to soil fertility management and play a significant influence on sustainable production of maize (*Zea mays*). Precursor crops showed significant effect on yield and yield components of maize. Higher grain yield of maize was observed from Niger seed precursor crop. All inorganic and organic nutrients gave better yield of maize on Niger seed precursor crop compared to *Mucuna pruriens* green manured fields. Maize following Niger seed gave grain yield advantage of 20.19% compared to maize following *Mucuna pruriens.* The use of Niger seed as precursor crop with 23-46 kg N-P ha^{-1} and 8 t FYM ha^{-1} produced better grain yield of maize. Higher grain yield with integrated nutrient management were realized from Niger seed precursor crop. Niger seed precursor crop with integrated nutrients application is the most successful management option for sustainable production of maize. Use of precursor crop and fertilizer enabled maize yield to be maintained at a fairly high level compared to continuous cropping. Thus, it is recommended that Niger seed precursor crop with integrated nutrients are agronomically profitable for sustainable maize production in Alfisols of Bako.

Key words: Integrated nutrient management, soil fertility Niger seed, *Mucuna pruriens*

INTRODUCTION

Soil nutrient depletion is a fundamental biophysical limiting factor responsible for slow growth of food production[1]. Maintaining or enhancing food security, environment and fragile ecosystems, to increase the quantity, quality and variety of food currently need urgent response. However, population growth has often outstripped the rather meager growth in economic and food security[2]. Nevertheless, for most of the African countries in generally and Ethiopia in particularly income per caput remains at subsistence level or below. Donovan and Casey[1] as agricultural production intensifies there shall be a need for more soil fertility management, which is a base for crop production. According to FAO[2] the most alarming perhaps is that the growth of agricultural outputs has remained stagnant over the last three decades, averaging less than 2% while population growth continues at 3%. Cereal production and productivity is reduced from time to time. This perhaps may be due to inadequate use or application of chemical fertilizers, low inherent soil fertility, monocropping, seldom use of integrated nutrient application.

Integrated nutrient management is an approach to soil fertility management that combines organic and mineral methods of soil fertilization with physical and biological measures of soil and water conservation[1], desirable soil physical and chemical properties[3]. It is indicated that half may reduce N fertilizer rates if high quality green manure rich in N fixed from atmosphere is applied. Organic fertilization enhances the responses to mineral fertilizers, thereby increasing the efficiency of fertilizer use. Kumwenda *et al.*[4] improving the efficiency of mineral fertilizers with SOM could expand the number of fertilizer users, hence reduced the cost of chemical fertilizers. Furthermore, use of inorganic soil ameliorants in conjunction with slow release minerals has the advantage of increasing the nutrient storage capacity of the soil[1]. In areas where, P limits legume production, may has a greater benefits in the longer run than just adding nitrogen fertilizers on very acid soils. Organic approaches have the additional advantage of ameliorating aluminum toxicity if managed correctly[1]. Besides green manures and other organic amendments can have significant effects with 1-2 years based on quantity and quality of SOM and fertility status.

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Hikwa and Mukurumbira[5] with the rise in mineral fertilizers prices and concern over the sustainability of current cropping systems, green manures have attracted new research interests for cereal production. Biological N fixation from legumes can sustain tropical agriculture at moderate levels of output, sometimes doubling production currently achieved. In additions, under favorable conditions green manure crops generate large amounts of OM and can accumulate up to 100-200 kg N ha^{-1} in 100 - 150 days in the tropics.

Mucuna pruriens is a promising legume, which has been used in Central America in hilli agriculture and is being introduced successfully in Africa[1]. Singh *et al.*[6] *Mucuna pruriens* grow in a wide range of range of soils from sands to clays and well on acidic soils which is true for the area. Generally legumes are the most promising routes for increasing soil organic matter, when used as green manure, crop rotation and intercropping. However, according Tadesse and Tolessa[7] Niger seed is the best precursor crop for maize with a yield advantage of 50% as compared to sole cropping followed by haricot bean. Including of oilseed crops in rotation with wheat may also increase soil productivity because of their deep root system, which enables them to scavenge nutrients from lower root depths and produces root channels, which may facilitate root development in subsequent cereal crop[8]. Integrated use of inorganic and organic fertilizers is essential to attain sustainable agricultural development. According Donovan and Casey[1] technologies that combines mineral fertilizers with organic resources are best of all, increasing fertilizer use efficiency, reducing risks of acidification and providing a more balanced supply of nutrients. To date no information is available regarding precursor crops integrated with mineral and organic fertilizers for sustainable maize production in the area. Therefore, the objective of this study was to determine the right precursor crops integrated with N/P and FYM rate for sustainable maize production.

MATERIALS AND METHODS

The experiment was conducted from 2001 to 2003 cropping seasons for three years at Bako Agricultural Research Center. The altitude of the area is 1650 m. The long-term (1961-2003) mean annual rainfall at BARC is 1239 mm with unimodal distribution. It has a warm humid climate with the mean minimum, mean maximum and average air temperatures of 13.2°C, 28°C and 21°C, respectively. Sixty percent of the soil (1400 ha), of Bako Research Center, is reddish brown in colour clay and loam in texture and acidic in nature[9]. The experiment was laid out in a Randomized Complete Block Design in factorial arrangement with precursor crops as factor A, Nitrogen as factor B, Phosphorous as factor C and farmyard manure as factor D rate as sub-factors. All factors were at two rates: precursor crops (Niger seed and *Mucuna pruriens*), Nitrogen (23 and 46 kg N ha^{-1}), Phosphorous (5 and 10 kg P ha^{-1}) and farmyard manure (4 and 8 t ha^{-1}) tested with 0 fertilizer rate after (Niger seed and *Mucuna pruriens*) for maize and recommended fertilizer rate (110/20 kg N-P ha^{-1}) for the area.
The treatment combinations were:

T_1 : Niger seed 23/5 kg N-P 4 t FYM ha^{-1}
T_2 : Niger seed 23/5 kg N-P 8 t FYM ha^{-1}
T_3 : Niger seed 23/10 kg N-P 4 t FYM ha^{-1}
T_4 : Niger seed 23/10 kg N-P 8 t FYM ha^{-1}
T_5 : Niger seed 46/5 kg N-P 4 t FYM ha^{-1}
T_6 : Niger seed 46/5 kg N-P 8 t FYM ha^{-1}
T_7 : Niger seed 46/10 kg N-P 4 t FYM ha^{-1}
T_8 : Niger seed 46/10 kg N-P 8 t FYM ha^{-1}
T_9 : *Mucuna pruriens* 23/5 kg N-P 4 t FYM ha^{-1}
T_1 : *Mucuna pruriens* 23/5 kg N-P 8 t FYM ha^{-1}
T_{11} : *Mucuna pruriens* 23/10 kg N-P 4 t FYM ha^{-1}
T_{12} : *Mucuna pruriens* 23/10 kg N-P 8 t FYM ha^{-1}
T_{13} : *Mucuna pruriens* 46/5 kg N-P 4 t FYM ha^{-1}
T_{14} : *Mucuna pruriens* 46/5 kg N-P 8 t FYM ha^{-1}
T_{15} : *Mucuna pruriens* 46/10 kg N-P 4 t FYM ha^{-1}
T_{16} : *Mucuna pruriens* 46/10 kg N-P 8 t FYM ha^{-1}
T_{17} : Niger seed 0/0 kg N/P 0 t FYM ha^{-1}
T_{18} : *Mucuna pruriens* 0/0 kg N/P 0 t FYM ha^{-1}
T_{19} : Control maize with 110/20 kg N/P ha^{-1}.

First year Niger seed was planted sole while *Mucuna pruriens* was intercropped with maize after one week of maize planting. Niger seed was planted at normal planting time (July 12-20). *Mucuna pruriens* were chopped add to the plot in December. Second and third years the main crop maize was planted with different fertilizer combinations. The plot size was 5.1×4.5 m. The spacing was 75×30 cm for maize. The maize variety used was BH-660 the most popular improved variety in the area. The seed rate used was 25 kg ha^{-1}. Sowing dates followed recommended date of planting for maize May 1-30. Full dose of phosphorus (as DAP) was applied once at planting, while nitrogen (as Urea) was applied in spilt doses, half at planting and the remaining half applied 30 to 40 days after planting for maize. Decomposed Farmyard manure was applied at planting. The maize grain yield was adjusted at 12% moisture level and converted from yield per plot to yield per hectare. The data were analyzed using MSTATC[10] and SAS [11] statistical packages. Mean separation was done using Least Significance Difference (LSD) at 5% probability level[12].

Table 1: Mean yield and yield components of Niger seed and maize and dry biomass of *Mucuna pruriens* intercropped with maize

	Niger seed		Maize			*Mucuna pruriens* dry biomass
Treatments	Plant height (cm)	Grain yield (kg ha^{-1})	Plant height (cm)	1000 seed weight (g)	Grain yield (kg ha^{-1})	(kg ha^{-1})
1	224	398				
2	217	282				
3	225	465				
4	217	442				
5	210	492				
6	226	281				
7	220	440				
8	214	421				
9			204	224	1815	777
10			226	308	1239	730
11			207	250	1588	600
12			219	255	1258	816
13			214	254	1274	794
14			238	258	1511	725
15			203	191	1373	596
16			198	254	1501	647
17	223	401				
18			210	280	1373	796
19			223	307	9508	

Table 2: Combined treatment effects of precursor crops, N-P and FYM fertilizer rate response on plant height, 1000 seed weight and grain yield of maize at Bako

	Plant height (cm)			1000 seed weight (g)			Grain yield (kg ha^{-1})		
Treatments	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
1	301	272	287	451	420	436	7815	6833	7324
2	310	254	282	390	451	420	7968	6726	7347
3	304	259	281	403	381	392	7723	6675	7199
4	309	277	293	398	430	414	8383	8040	8211
5	312	269	290	420	408	414	8138	7440	7789
6	320	282	301	397	406	401	9226	8705	8965
7	302	270	286	461	443	452	6585	7310	6947
8	315	286	301	444	401	423	8859	8046	8453
9	310	224	267	373	340	357	8077	4841	6459
10	318	250	284	357	423	390	8706	4982	6844
11	316	217	267	390	392	391	7694	3397	5546
12	308	236	272	388	382	385	8148	4289	6218
13	318	244	281	362	353	358	7852	4393	6122
14	319	253	286	383	382	383	9751	5305	7528
15	311	245	278	368	385	377	8131	4921	6526
16	331	261	296	377	392	385	8222	4854	6538
17	289	234	262	419	385	402	6173	5517	5845
18	291	182	236	337	375	356	7995	2225	5110
19	320	201	261	362	331	347	9639	7467	8553
LSD (5%)	Ns	20.36	14.73	Ns	Ns	Ns	Ns	1142	1069
CV (%)	4.28	4.95	4.58	12.86	14.44	13.67	13.70	11.70	13.22

For partial budget and marginal rate of return analysis, maize grain yield was valued at an average open market price of EB 82 per 100 kg for the last 10 years and maize seed price was EB 3.10 per kg. Labour cost 3.5 per man-day. Cost of Urea and DAP was EB 269.65 and 303.35 per 100 kg.

RESULTS AND DISCUSSION

Precursor crops yield and dry biomass: Grain yield of Niger seed and maize and dry matter of *Mucuna pruriens* crop are indicated in Table 1. Dry weight biomass ranged from 596 to 816 kg ha^{-1} for *Mucuna pruriens* and maize grain yield from 1274 to 1815 kg ha^{-1} were obtained from intercropping *Mucuna pruriens* with maize (Table 1). The dry weight biomass of *Mucuna pruriens* observed is similar to the report of Singh *et al.*[13] dry matter production of 6 to 7 t ha^{-1}. Mean grain yield (281 to 492 kg ha^{-1}) of Niger seed was harvested from sole planting. First year yield of both crops helps to overcome shortage of land and food crops. Furthermore, it reduces risks of food shortage due to fallowing. Thus producing green manure crops with food and Niger seed as sole contributes for fairly sustainable maize production follows it and maintains soil fertility.

Table 3: Mean square of plant height, 1000 seed weight and grain yield of maize due to precursor crops, N, P and FYM across years at Bako

Sources variations	Mean square DF	Plant height	1000 seed weight	Grain yield
Year	1	76840.0*	80.67*	111728986*
Pc	1	3060.0*	40262*.0	40986005*
N	1	2709.0*	18.37	5191669*
P	1	5.04	1320	2815439
FYM	1	2281.0*	228	14377391*
Year x Pc	1	8288.0*	551	57077377*
Year x N	1	417.0	1162	810543
Year x P	1	20.17	486	410589
Year x FYM	1	155.0	5221	418366
PC x N	1	92.0	864	68036
PC x P	1	15.0	610	855124
PC x FYM	1	73.0	3384	577685
N x P	1	40.0	3825	488288
N x FYM	1	121.0	693	1507930
P x FYM	1	181.0	468	16871
Year x PC x N	1	73.0	888	262747
Year x PC x P	1	150.0	651	314822
Year x PC x FYM	1	260.0	155	7473
Year x N x P	1	104.0	155	746345
Year x N x FYM	1	35.0	5192	788742
Year x P x FYM	1	108.0	3851	94586
PC x N X P	1	330.0	5163	3480322
PC x N X FYM	1	113.0	1121	621241
PC x P X FYM	1	131.0	2185	2203689
N x P x FYM	1	43.0	392	2055263
BC x N X P x FYM	2	327.0	2195	1297306
Year x PC x N x P	1	4.17	1291	463607
Year x PC x N x FYM	1	360.0	400	47554
Year x PC x P x FYM	1	155.0	100	587016
Year x N x P x FYM	1	360.0	737	723749
Year x PC x N X P x FYM	2	95.04	570	606177
Error	62	149.68	2776	975274

*Significant at 5% level of probability, respectively

Combined treatment effect: Combined yields across years were averaged 7027 kg ha^{-1} but 8162 and 5892 kg ha^{-1} in 2002 and 2003 cropping seasons (Table 2). Mean grain yield of 2002 was higher by 38.53% as compared to 2003 indicating better response of maize following precursor crops in the first year. This might be due to the residual effects of precursor crops. This indicates the residual effects of precursor crops was very high first year and gradually reduced in the second year.

The combined result compared to control treatments non-significantly ($p>0.05$) affected thousand seed weight but significantly ($p<0.05$) affected mean plant height and grain yield of maize 2001 and combined over two years (Table 2). Similarly Bajwa *et al.*[14] a significant increase in maize cob dry biomass was observed in NPK and green manure amended treatments. Higher mean grain yield of 8965, 8553, 8453 and 8211 kg ha^{-1} was observed from treatments combinations 46/5 kg N-P ha^{-1} and 8 t FYM ha^{-1} following Niger seed, recommended (110/20 kg N-P ha^{-1}), 46/10 kg N-P ha^{-1} and 8 t FYM ha^{-1} and 23/10 kg N/P ha^{-1} and 8 t FYM ha^{-1}, respectively following Niger seed precursor crop (Table 2). This was attributed due to efficiently utilization of nutrients in integrated fertilizer application following Niger seed precursor crops. The over all mean grain yield of maize was higher following Niger seed precursor crop compared to *Mucuna pruriens*. Maize following Niger seed and *Mucuna pruriens* without fertilizers produced lower grain yield compared to other treatments (Table 2). This indicates rotation without fertilizer amendments could not significantly increase grain yield of maize. This justifies a need inorganic or organic fertilizer amendments for sustainable maize production following precursor crops.

Cropping season: Cropping season significantly ($p<0.05$) affected mean plant height, 1000 seed weight and grain yield of maize (Table 3). This justifies that environmental factors play a significant role on productivity of maize. Thus considering the effects of a given environmental situation to maize production is too crucial in addition crop and soil management practices. Year x precursor crops interaction significantly ($p<0.05$) affected mean plant height and grain yield of maize (Table 3) indicating the significant contribution of crop rotation on the performance of maize.

Effects of Precursor crops: Precursor crops significantly ($p<0.05$) affected mean plant height, 1000 seed weight and grain yield of maize (Table 3-5). Maize following Niger seed produced grain yield advantage of 1307 kg ha^{-1} or 20.18% as compared to *Mucuna pruriens*. Similarly Tadesse and Tolessa[7] maize following Niger seed gave yield advantage of 50% as compared to continuous cropping. The low yield of maize following *Mucuna pruriens* was due low residual N because of poor N-fixation of *Mucuna pruriens* in acid soils. Niger seed precursor crop better than *Mucuna pruriens* for sustainable maize production. This might be due to deep root system of Niger seed, which facilitates more nutrients from deep soil depth to the top of the soil. It further stated Niger seed scavenge nutrients from the deeper depth of the soil to the topsoil where plant roots take available nutrients. The lower yield of maize following *Mucuna pruriens* might be due to volatilization of N during off-season with warm temperature.

Effects of N-P: Plant height and grain yield significantly ($p<0.05$) but 1000 seed weight non-significantly affected by nitrogen rates (Table 3 and 4). Nitrogen rates significantly increased grain yield of maize (Table 4). 46 kg ha^{-1} nitrogen gave mean grain yield advantage of 466 kg ha^{-1} over 23 kg ha^{-1}. Higher grain yield advantage (19.99 and 20.36%) of maize was recorded with 23 and 46 kg N ha^{-1} application following Niger seed as compared to following *Mucuna pruriens* (Table 4). Phosphorous was non-significantly affected all parameters of maize (Table 3 and 5). Grain yield of maize non-significantly increased with P rates. Grain yield of maize was increased by 16.59 and 24.10% with rates of P following Niger seed as compared to following *Mucuna pruriens*(Table 5).

Effects of FYM: Farmyard manure significantly ($p<0.05$) affected mean plant height and grain yield of maize but non-significant effect for 1000 seed weight (Table 3 and 6). Higher grain yield of maize obtained from 8 t ha^{-1} as compared to 4 t ha^{-1} showing grain yield advantage of 774 kg ha^{-1} or 11.48%. Thus 8 t ha^{-1} of FYM produced agronomically higher mean grain yield. Application of FYM produced 18.69 and 21.56% grain yield of maize following Niger seed compared to *Mucuna pruriens* (Table 6).

Interaction effects: All two-way interactions of all factors had non-significant effects on all parameters of maize (Table 3). Even though the statistical analysis showed non-significant difference for the interaction of precursor crops and N rate greater yield maize was obtained from Niger seed break with 46 kg N ha^{-1}. At both rates of N (23 and 46) kg ha^{-1} better grain yield of maize was recorded from Niger seed precursor crop field compared to *Mucuna pruriens* (Table 4). In addition from two-way interaction of precursor crops with phosphorous and farmyard manure higher grain yield of maize was observed from Niger seed precursor crop field than *Mucuna pruriens*. Higher mean grain yield of maize 7856 and 8244 kg ha^{-1} was obtained from the interaction of Niger seed with 5 kg P ha^{-1} and Niger seed with 8 t FYM ha^{-1}, respectively (Table 5 and 6). The interaction of N and P gave higher yield at the combination of 46/5 kg N/P ha^{-1} compared to other combinations (Table 7). This indicates better grain yield was obtained from reduced amount of N-P compared to the recommended fertilizer rate. This result may argue that precursor crops contributed to nutrient development of the topsoil or efficiently utilization of the applied nutrients. Further more, the

Table 4: Effects of precursor crop, N rate and their interaction on grain yield (kg ha^{-1}) of maize at Bako

Treatments	N fertilizer rate (kg ha^{-1})		Mean
Precursor crop	23	46	
Niger seed	7520	8039	7779a
Mucuna pruriens	6267	6679	6473b
Mean	6893b	7359a	
LSD (5%)	403		403
CV	13.86		

Ns=Non-significant

Table 5: Effects of precursor crop, P rate and their interaction on grain yield (kg ha^{-1}) of maize at Bako

Treatments	P fertilizer rate (kg ha^{-1})		Mean
Precursor crop	5	10	
Niger seed	7856	7703	7779a
Mucuna pruriens	6738	6207	6472b
Mean	7297	6955	
LSD (5%)	Ns		403
CV	13.86		

Ns=Non-significant

Table 6: Effects of precursor crop, FYM rate and their interaction on grain yield (kg ha^{-1}) of maize at Bako

Treatments	FYM rate (t ha^{-1})		
Precursor crop	4	8	
Niger seed	7315	8244	7779a
Mucuna pruriens	6163	6782	6472b
Mean	6739b	7513a	
LSD (5%)	403		403
CV	13.86		

Ns=Non-significant

Table 7: Effects of N, P rate and their interaction on grain yield (kg ha^{-1}) of maize at Bako

Treatments	P fertilizer rate (kg ha^{-1})		Mean
N fertilizer rate (kg ha^{-1})	5	10	
23	6993	6794	6893b
46	7601	7116	7359a
Mean	7297	6955	
LSD (5%)	Ns		403
CV	13.86		

Ns=Non-significant

Table 8: Effects of N, FYM rate and their interaction on grain yield (kg ha^{-1}) of maize at Bako

Treatments	FYM fertilizer rate (t ha^{-1})		Mean
N fertilizer rate (kg ha^{-1})	4	8	
23	6632	7155	6893b
46	6846	7871	7359a
Mean	6739b	7513a	
LSD (5%)	403		403
CV	13.86		

Ns=Non-significant

Table 9: Effects of P, FYM rate and their interaction on grain yield (kg ha^{-1}) of maize at Bako

Treatments	FYM fertilizer rate (t ha^{-1})		Mean
P fertilizer rate (kg ha^{-1})	4	8	
5	6924	7671	7297
10	6554	7355	6955
Mean	6739b	7513a	
LSD (5%)	403		Ns
CV	13.86		

Ns=Non-significant

Table 10: Partial budget and Marginal rate of return analyses for precursor crops on the mean grain yield of maize at Bako

	Precursor crops	
Items	Niger seed	*Mucuna pruriens*
Average yield (kg ha^{-1}) maize	7779	6472
Adjusted yield kg ha^{-1}) maize	6999.3	5824.8
Gross field benefit of maize	5739.43	4776.34
Costs of *Mucuna pruriens* chopping and application (EB ha^{-1})		140
Total costs that vary (EB ha^{-1})		140
Net benefit	5739.43	4636.34
Values to cost ratio		
Marginal Rate of Return (MRR)		

Note: Grain price = EB 0.82 kg^{-1}, Seed price = EB 3.10 kg^{-1}, Labour cost = EB 3.5 day^{-1} Yield was down adjusted with 10% coefficient

Table 11: Partial budget and marginal rate of return analyses for nitrogen rate on the mean grain yield of maize at Bako

	N fertilizer rate	
Items	50 kg ha^{-1}	100 kg ha^{-1}
Average yield (kg ha^{-1}) maize	6893.00	7359.00
Adjusted yield (kg ha^{-1}) maize	6203.70	6623.10
Gross field benefit of maize	5086.79	5430.94
Costs urea (EB ha^{-1})	134.825	269.65
Fertilizer application cost (EB ha^{-1})	3.50	5.00
Total costs that vary (EB ha^{-1})	138.325	274.65
Net benefit	4948.46	5156.29
Values to cost ratio	35.77	18.77
Marginal Rate of Return (MRR)		152.00%

Note: Grain price = EB 0.82 kg^{-1}, Seed price = EB 3.10 kg^{-1}, Labour cost = EB 3.5 day^{-1} Urea= EB 2.6965 kg^{-1}; Yield was down adjusted with 10% coefficient

interaction effects of Nitrogen and FYM produce higher grain yield (7871 kg ha^{-1}) at 46 kg N ha^{-1} with 8 t FYM ha^{-1} compared to other combinations (Table 8). Also interaction effects phosphorous and farmyard manure gave more yield (7671 kg ha^{-1}) at 5 kg P ha^{-1} and 8 t FYM ha^{-1} combination. This justifies that higher dose of FYM contributed to higher yield of maize with lower doses of Phosphorous, which may be due to higher nutrients compositions of FYM. This further stated that application organic with inorganic fertilizers helps for integrated nutrient management and sustainable production of maize. All three-way and four-way interaction non-significantly affected biological and grain yield of maize (Table 3).

Table 12: Partial budget and Net benefit analyses for farmyard manure rate on the mean grain yield of maize at Bako

	FYM rate	
Items	4 t ha^{-1}	8 t ha^{-1}
Average yield (kg ha^{-1}) maize	6739.00	7513.00
Adjusted yield (kg ha^{-1}) maize	6065.10	6761.70
Gross field benefit of maize	4973.38	5544.60
FYM collection and application cost (EB ha^{-1})	52.50	105.00
Total costs that vary (EB ha^{-1})	52.50	105.00
Net benefit	4920.88	5439.59
Values to cost ratio	93.73	51.81
Marginal Rate of Return (MRR)		988.00%

Note: Grain price = EB 0.82 kg^{-1}, Seed price = EB 3.10 kg^{-1}; Labour cost = EB 3.5 day^{-1} yield was down adjusted with 10% coefficient

The highest net benefit of EB 5,739 ha^{-1} was achieved from maize following Niger seed than *Mucuna pruriens* that was EB 4, 636 ha^{-1} (Table 10). Maize following Niger seed was gave advantage of EB 1,103 ha^{-1} or 23.79% as compared *Mucuna pruriens* precursor crop (Table 10). The result for N/P fertilizer rate indicted that the highest net benefit of EB 5,156 ha^{-1} and marginal rate of return of EB 152% was obtained from 100 kg N ha^{-1} than 50 kg N ha^{-1} that was EB 4,948 ha^{-1} net benefit (Table 11). The values to cost ratio was EB 35.77 and 18.77 per unit of investment from 50 and 100 kg N ha^{-1} (Table 11). The result for FYM indicated that the highest net benefit EB 5,440 ha^{-1} and marginal rate of return of 988% with EB 51.81 profit per unit of investment was achieved from 8 t FYM ha^{-1} (Table 12). The net benefit and values to cost ratio for 4 t FYM ha^{-1} was EB 4,921 and 93.73 profits per unit of investment (Table 12). It was found that yield and economic return from the Niger seed precursor crop, 100 kg N ha^{-1} and 8 t FYM ha^{-1} were significantly produce higher economic return for maize. Therefore rotating maize with precursor crops and integrated use of fertilizer improved profit for maize production.

Precursor crops significantly affect productivity of maize. It is beneficial in reducing use of chemical fertilizers while maintaining crop productivity and soil fertility in sustainable basis. Application inorganic and organic fertilizers sources enhance maize grain yield differently. Production of maize following Niger seed precursor crop with 46/5 kg N-P with 8 t FYM ha^{-1} or recommended fertilizer (110/20 kg N-P ha^{-1}) is recommended for Bako area.

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