Full Length Research Paper

On farm partial budget analysis of pepper (*Capsicum Annuum* L.) to the application of NP fertilizer and farmyard manure in Raya Azebo District, Northern Ethiopia

Kassa Melese[1*], Wassu Mohammed[2] and Gebre Hadgu[3]

[1]Horticulture Researcher, Alamata Agricultural Research Center, Alamata, Ethiopia.
[2]Plant Breeding Instructor and Researcher, School of Plant Sciences, Haramaya University, Dire Dawa, Ethiopia.
[3]Plant Agronomy Researcher, Tigray Agricultural Research Institute, P. O. Box 492 Mekelle, Ethiopia.

This research was conducted to assess the economic feasibility of inorganic fertilizer application and farmyard manure on Marako Fana pepper variety in Raya Azebo district, Northern Ethiopia. The combination of 25, 50, 75 and 100% of nationally recommended inorganic fertilizers and 10 t ha^{-1} farmyard manure as well as four control treatments (unfertilized, 100% farmyard manure, 100% and blended fertilizer/NPS) were used in this study. The experiment was laid out in a randomized complete block design with three replications. The application of half rate recommended inorganic fertilizer in combination with 5 t ha^{-1} farmyard manure produced significantly, the maximum total and marketable dry fruit yield of 2.495 and 2.375 t ha^{-1}. Moreover, this treatment was also better than other treatments and generated above the minimum acceptable marginal rate of return. Therefore, it could be concluded that this fertilizer rate could be used in the study area for the production of the variety under irrigation. Hence, to obtain optimum economic return from the production of pepper at the study area, it is recommended to apply an integrated fertilizer management approach.

Key words: Blender fertilizer, marginal rate of return, NP, partial budget.

INTRODUCTION

Partial budget analysis (PBA) provides useful information for making decisions. Partial budget analysis can be used for comparing the impact of a technological change on farm costs and returns (International Potato Center, 1982). The partial budget measures the positive and negative effects of a change in the business. The left side

of partial budget shows the positive effects on net income including additional income and reduced costs. To counter balance this positive effect, the right side includes reduced income and additional costs or the negative effects of the proposed change (Lessley et al., 1991). New technology can be evaluated in terms of its impact on the productivity, profitability, acceptability and sustainability of farming systems (Herdt, 1987). The profitability of hot pepper production is partly related with the right type of input (fertilizer and improved variety) usage and the cost incurred for these inputs (Amare, 2010).

Partial budget analysis is a simple but effective technique for assessing the profitability of new technology for an existing enterprise. It also provides the foundation for comparing the relative profitability of alternative treatments, evaluating their riskiness, and testing how robust profits are in the event of changing product or input prices. Economic analysis is conducted to assess the feasibility of the treatments using partial budget, dominance and marginal analysis of each treatment. Partial budget analysis is used to organize experimental data and information on the costs and benefits of various alternative treatments. The partial budget included the average yields for each treatment, the adjusted yields, the gross field benefit and the total costs that vary. The total costs which vary are the sum of all cost for alternative treatments. The increased production of the crop due to the application of inputs might or might not be beneficiary to farmers. Therefore, partial budget analysis (CIMMYT, 1988) should be employed to estimate the net benefit and marginal rate of return that could be obtained from various alternative treatments.

Summer chilling is the major problem in Raya Azebo district. Due to this, rain-fed pepper production in the study area is impossible. Once chilling occurs, it affects the pepper plant at any stage of growth. Consequently, both dry and green pod pepper in the area is produced in irrigation season. Not only this, most of the pepper research done in the study area has focused on production issues, but almost none on other pepper economic aspects. Therefore, the purpose of this study was to identify the best pepper production option from different technological package alternatives and recommend those that would meet socio-economic conditions of farmers. It is indeed assumed that some of the pepper technological packages are more profitable than the current farmer pepper production practices. The specific objectives of the study are:

1. To assess the economic feasibility of NP and farmyard manure fertilizers application on *Marako Fana* pepper variety.
2. To identify the profitable hot pepper production package among alternative treatments

MATERIALS AND METHODS

Description of the study area

This study was conducted in Raya Azebo Wereda, northern Ethiopia. The specific site of the research was in lowland area of Raya Azebo Wereda, particularly at Kara Kebele (Figure 1). Raya Azebo Wereda is located in 12°3'-13°7'N latitude and 39°5'-39°8'E longitude. Agro-climatically, the area is characterized as dry semi-arid climate (Araya et al., 2010). The mean annual temperature and mean annual rain fall ranges from 16 to 28°C and from 446 to 830 mm, respectively. Various soil types commonly found in the area include verti soils, nitisoil, combisols and luvisols. Vertisoil (black soil with swalling characteristics) is the dominant soil types, which cover over 70% of the study area (Raya Azebo Wereda ARD Office, 2016).

Treatments and experimental design

The study was executed under irrigation using a pepper variety known as *Marako Fana*. This variety is widely adapted and recommended hot pepper in the study area. The seeds of *Marako Fana* were obtained from Alamata Agricultural Research Center and sown in 15 cm rows in a nursery established on well prepared seed bed. Sufficient numbers of seedlings were raised for the field experiment. The national recommended inorganic fertilizer application rates of 82 kg N ha^{-1} + 92 kg P$_2$O$_5$ ha^{-1} for the crop and 10 t ha^{-1} FYM, considered as optimum organic fertilizer rate for vegetables, were the basis for arranging the combined fertilizer treatments. Taking the application of the inorganic and organic fertilizers rates in combination as maximum, the treatments were arranged as 100, 75, 50 and 25% of these rates in all possible combinations. Application of the national recommended inorganic fertilizer rates, 10 t ha^{-1} FYM, blended fertilizer recently recommended for DAP with recommended urea (200 kg NPS ha^{-1} + 100 kg urea or 84 kg N ha^{-1} + 76 kg P$_2$O$_5$ ha^{-1} + 14 kg sulfur ha^{-1}) and no fertilizer application, were considered as control treatments. The blended fertilizer was used as control treatment since Bureau of Agriculture and Rural Development (BoARD) is distributing NPS in place of DAP. In this study, TSP and urea were used as source of P$_2$O$_5$ and N, respectively. The field experiment was laid out as randomized complete block design (RCBD) with three replications. A spacing of 30 and 70 cm between intra and inter-row, respectively, was maintained. There were six rows per plot and 15 plants per row with a total of 90 plants per plot in a plot size of 4.5 m × 4.2 m in length and width, respectively. Plants in the two rows at the extreme end of both sides of each plot and the two plants at the end of each row were not considered as experimental plants. This gave the net plot size of 3.9 m × 2.8 m (10.92 m^2) with a total of 52 plants per net plot. The spacing between blocks and plots was 1.5 and 1 m, respectively.

Experimental procedures

The farmyard manure (FYM) was produced in a trench under shade to avoid evaporation loss of nutrients. The FYM was decomposed for about six months following standard procedures. All available litter and refuse was mixed with dung then placed in the trench. A section of the trench from one end was used for filling with daily collection of three consecutive days. When the section is filled enough, the top of the heap was made into a dome and plastered with dung earth slurry. After two months of decomposition, the FYM was transferred into other well prepared trench early in the morning. Then later, it was left for decomposition for about four extra months.
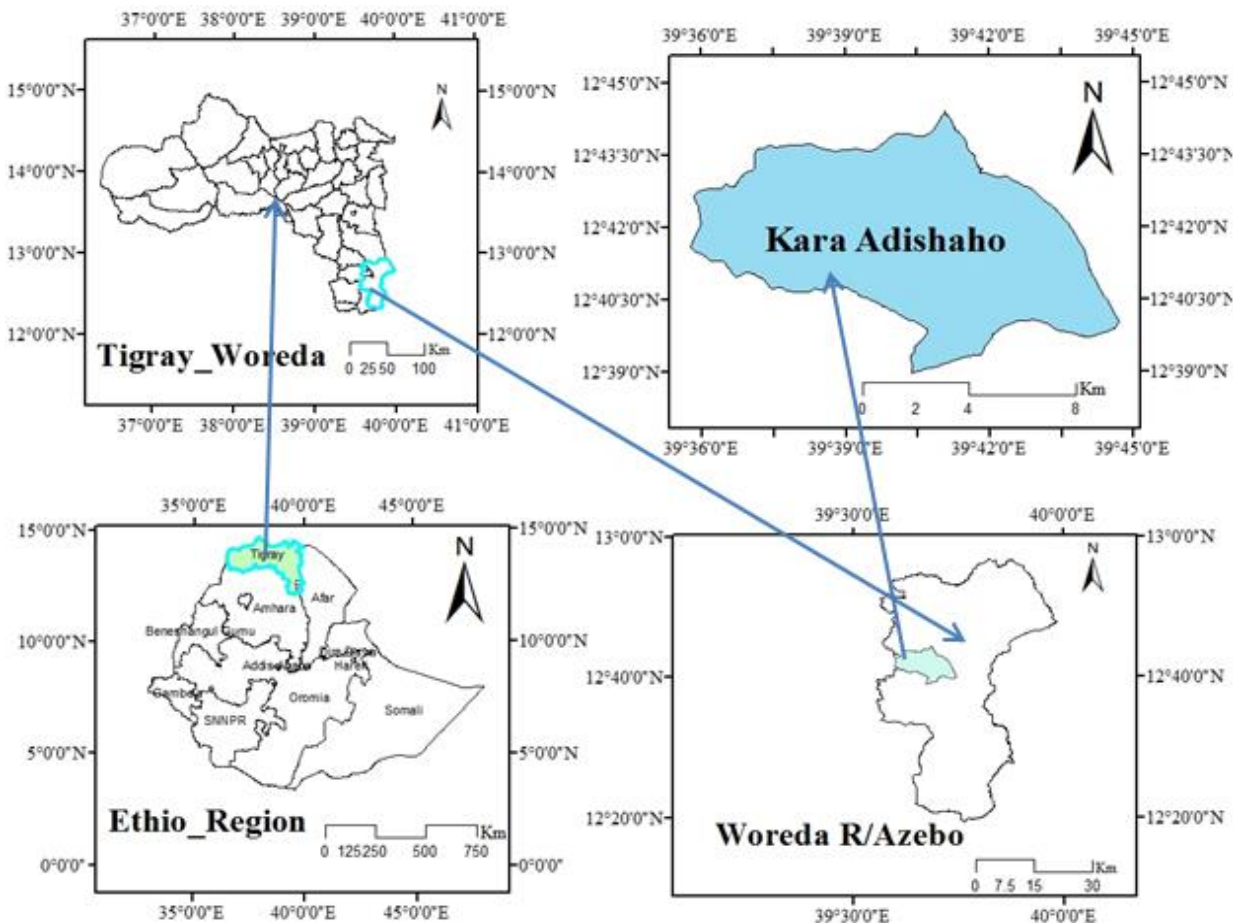
Figure 1. Map of the study area.

Seeds of *Marako Fana* were sown in November 01, 2015 on a seedbed size of 1 m × 10 m. In the nursery, 92 g/bed based P_2O_5 was applied in a bed during sowing time. The beds were then covered with dry grass mulch until emergence and watered using watering cane as needed. After seedlings emergence, the mulch was removed and then beds were covered by raised shade to protect the seedling from strong sunshine until eight days remained for transplanting. During hoeing and thinning of the seedlings, 82 g/bed based urea was applied in order to maintain optimum plant population and to keep seedlings vigorous. Watering was done with a fine watering cane in which the frequency was different depending on the seedling stages and seed bed was hand weeded. Other pertinent agronomic and horticultural practices were applied. The seedlings were transplanted to the field when the seedlings attained 20 to 25 cm height. The layout of experimental units was done before a month (30 days) before seedlings were transplanted in November 15, 2015. Then later, the applications of FYM to experimental units was done on plots that received FYM as sole or in combination of inorganic fertilizers depending on the treatments and randomization made by lottery method. During farmyard manure (FYM) application, they were broadcasted in plots one month (30 days) before seedlings were transplanted. The FYM was mixed with soil by hand hoeing of each experimental unit. Transplanting was done in December 16, 2015. Refilling of dead seedlings in the field was done one week after transplanting on the place where the first seedlings were planted. All rates of P_2O_5 and

half rates of nitrogen of the treatments were applied during transplanting, while half of nitrogen rates were applied after 30 days of transplanting.

Experimental units were irrigated using boarder irrigation method in each plot and row in plots received water from the source without passing any of the experimental plot to prevent mixing of fertilizer given to different plots. Irrigation water application was at field capacity every four days for 15 days after transplanting and every week and 15 days depending on the growth stage of the plants and weather conditions. Other agronomic practices such as weeding, hoeing, etc were applied based on the crop's requirement. Therefore, pods were harvested when they started drying and looked leathery (subjectively) in appearance on the plant. All treatments except unfertilized plot (2.33 times) were harvested three times. After harvesting, pods were further dried in partial shade until delectation.

Methods of partial budget analysis

Three analytical tools were used to identify the technological packages that are not only profitable but also exhibit good margin and remain profitable in different situations of input and output prices, respectively. Partial budget analysis was first carried out and generated the net benefits of the alternatives under study. It was then followed by marginal analysis which compares net benefits

with partial budget by considering the magnitude of corresponding variable costs.

Data collection

Data were collected for the following parameters:

Gross average fruit yield (t/ha) (AvY): An average yield of each treatment converted in hectare base.
Adjusted yield (AjY): Average yield adjusted downward by 10% to reflect the difference between the experimental yield and yield of farmers thus: jY (t/ha) = AvY × (1-0.1).
Gross field benefit (GFB) (ETB/ha): Computed by multiplying field/farm gate price (quintal/ha) by adjusted yield thus: GFB = AjY × field/farm gate price for the crop.
Total variable cost; cost of fertilizers and FYM preparation used for the experiment. The costs of other inputs and production practices such as labor cost for land preparation, planting, weeding, crop protection, and harvesting was considered to remain the same or will be insignificant among treatments.
Net benefit (NB) (ETB/ha): Calculated by subtracting the total costs from gross field benefits for each treatment thus: NB = GFB - total cost.
Marginal rate of return (MRR %); calculated by dividing change in net benefit by change in cost (CIMMYT, 1988) thus: $MRR = \frac{\Delta NB}{\Delta TVC}$ or

$$MRR \ (\%) = \frac{\text{Marginal benefit} \times 100}{\text{Marginal cost}}$$

RESULTS AND DISCUSSION

Material costs, farmyard manure preparation costs as well as other input and transportation costs that vary are presented in Table 1. Adjusted yield of the crop is considered for partial budget related things as indicated by CIMMYT (1988) that adjustments between 5 and 30% are appropriate for partial budget analysis. The dry pod yield of pepper was reduced to 10% for agronomic recommendation for farmers.

Partial budget analysis

This economic analysis is based on the average yield of each treatment across all repetitions (Duncan et al., 1990). Therefore, the net benefit estimate for 20 treatments is presented in Table 2. The application of 41 kg N ha^{-1} + 46 kg P$_2$O$_5$ ha^{-1} in combination with 5 t FYM ha^{-1} had a total net benefit of 161,547 ETB followed by 82 kg N + 92 kg P$_2$O$_5$ ha^{-1} and 61.5 kg N + 69 kg P$_2$O$_5$ ha^{-1} both in combination with 2.5 t FYM ha^{-1} which also had a total of 149,505 and 148,805ETB net benefit, respectively. Furthermore, the later inorganic fertilizers combination with 5 t FYM ha^{-1} also had higher net benefit of 145,967 ETB. The lowest net benefit was obtained by the application of the highest rates of fertilizers application (82 kg Nha^{-1} + 92 kg P$_2$O$_5$ha^{-1} + 10 t FYM ha^{-1}) with a total of 86,180 ETB followed by the net benefit obtained from production of pepper without fertilizer and

by application of 20.5 kg N ha^{-1} + 23 kg P$_2$O$_5$ ha^{-1} + 7.5 t FYM ha^{-1} with net benefit of 87,427 and 89,090.6 ETB, respectively. The low net benefit obtained might be due to low yield coupled with high cost prevailing treatment combinations.

The profitability study showed that application of 41 kg N ha^{-1} + 46 kg P$_2$O$_5$ ha^{-1} in combination with 5 t ha^{-1} FYM which provided the highest net benefit (161,547 ETB), was the peak to apply fertilizers. This indicated that the total costs increased until a certain level, and the net benefit obtained increased. However, as the total costs that vary increased over the optimum level, the net benefit obtained reduced as a result of higher variable costs associated with lower earnings. Similarly, the result of nitrogen experiment in maize presented by CIMMYT (1988) with application of 40, 80, 120 and 160 kg N ha^{-1} showed increase of net benefit until increase in the level of investment of up to 80 kg N ha^{-1} and reduced net benefit after application.

Dominance analysis and net-benefit curve

In most cases, farmers prefer the highest profit (low cost with high income). For this purpose, it is necessary to conduct dominated treatment analysis. A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary (Stephen and Nicky, 2007). The dominance analysis procedure as detailed in CIMMYT (1998) was used to select potentially profitable treatments from the range that was tested and serve to eliminate some of the treatments from further consideration and thereby simplify the analysis. The dominant (undominated) treatments were ranked from lowest to highest costs that vary. The net benefit curve also clarifies the reasoning behind the calculation of marginal rates of return, which compare the increments in costs and benefits between such pairs of treatments. The net benefit curve indicated that as the cost increases from lowest to small increase of 5000 ETB, the net benefit also increased linearly and attained peak at 5178 ETB. Thereafter, the net benefit reduced as the cost increased. The dominant analysis showed that the net benefit of all treatments were dominated except unfertilized plot and application of 20.5 kg N ha^{-1} + 23 kg P$_2$O$_5$ ha^{-1} + 2.5 t FYM ha^{-1} and nationally recommended inorganic fertilizers, application of blended fertilizer (84 kg N ha^{-1} + 76 kg P$_2$O$_5$ ha^{-1} + 14 kg sulfur ha^{-1}), the two higher rates of inorganic fertilizers (82 kg N+92 kg P$_2$O$_5$ and 61.5 kg N + 69 kg P$_2$O$_5$ ha^{-1}) both combined with low rate of 2.5 t FYM ha^{-1} and 41 kg N + 46 kg P$_2$O$_5$ + 5 t FYM ha^{-1} (Table 3). This result indicated that the net benefit decreased as the total cost that varies increased beyond undominated fertilizer treatments application. Therefore, no farmer may choose other dominated treatments in comparison with the undominated treatments. This also helps in avoiding the dominated

Table 1. Cost of input fertilizers, FYM production, transportation and materials used.

Treatment	MC	FYMP	N	P₂O₅	S	AP	ITVC	MKTC	TVC
82:92 +10	300	6600	898	1056	0	600	515	25	9994
82:92+2.5	300	1650	898	1056	0	150	140	39	4233
61.5:69+2.5	300	1650	673	792	0	150	136	39	3740
41:46+2.5	300	1650	449	528	0	150	133	26	3236
20.5:23 + 2.5	300	1650	224	264	0	150	129	25	2742
82:92 + 5	300	3300	898	1056	0	300	265	37	6156
61.5:69 + 5	300	3300	673	792	0	300	261	39	5665
41:46 + 5	300	3300	449	528	0	300	258	43	5178
20.5:23 + 5	300	3300	224	264	0	300	254	25	4667
82:92+ 7.5	300	4950	898	1056	0	450	390	33	8077
61.5:69 + 7.5	300	4950	673	792	0	450	386	36	7587
41:46 + 7.5	300	4950	449	528	0	450	383	28	7088
20.5:23 + 7.5	300	4950	224	264	0	450	379	25	6592
61.5:69 + 10	300	6600	673	792	0	600	511	30	9506
41:46 + 10	300	6600	449	528	0	600	508	26	9011
20.5:23 + 10	300	6600	224	264	0	600	504	26	8518
82:92	300	0	898	1056	0	600	15	32	2901
0:00:10	300	6600	0	0	0	600	500	26	8026
Unfertilized	300	0	0	0	0	0	0	23	323
84:76 : 14 S	300	0	920	872	108	600	15	31	2846

Treatment = N + P₂O₅ + FYM); MC = Material variable cost (12 ETB/sack), FYMP = cost of FYM preparation (660 ETB t⁻¹), price of N (10.95 ETB kg⁻¹), P₂O₅ = price of P₂O₅ (11.48 ETB kg⁻¹), S = price of sulfur (7.74ETB kg⁻¹), Ap = application cost (60 ETB t⁻¹), ITVC = input transportation variable cost (5 ETB qt⁻¹), MKTC = market transportation cost (2 ETB qt⁻¹).

treatment for further estimation of marginal rates of return.

Marginal rate of return

The net benefit-cost ratio showed that as the cost is one birr, the net benefit ranged from 31.2 to 41.6 birr for the dominant treatments. For each pair of ranked treatments, a % marginal rate of return (MRR %) was calculated. The % MRR between any pair of dominant treatments denotes the return per unit of investment in fertilizer expressed as a percentage. This analysis was conducted and presented in Table 4 and Figure 2. As shown in Table 4, the result of analysis of dominant treatments indicated that for each one birr invested in purchase or production of fertilizers, it was possible to recover one birr plus an extra 2.48, 230.53, 58.99, 33.56, 1.42 and 12.74 birr/ha as the fertilizer application changed from unfertilized plot until supplementation of 41 kg N ha⁻¹ + 46 kg P₂O₅ ha⁻¹+5 t ha⁻¹ FYM, respectively.

From the time of the first treatment that had the lowest costs to the end of the treatment which had the highest cost, that varies, the marginal rate of return obtained was above the minimum acceptable marginal rate of return. Accordingly, the study revealed that application of 41 kg N ha⁻¹ + 46 kg P₂O₅ ha⁻¹ + 5 t ha⁻¹ FYM was the best

recommendation. The best recommendation for treatments subjected to marginal rate of return is not (necessarily) based on the highest marginal rate of return, rather, based on the minimum acceptable marginal rate of return, and the treatment with the highest net benefit together with an acceptable MRR becomes the tentative recommendation (CIMMYT, 1988).

The process of calculating the marginal rates of return of alternative treatments, proceeds in steps from the least costly treatment to the most costly, and resolves if they are acceptable to farmers, which is called marginal analysis (CIMMYT, 1988). One way of assessing this change is to divide the difference in net benefits by the difference in costs that vary (CIMMYT, 1988). Marginal rate of return is marginal net benefit (Stephen and Nicky, 2007). In this study, 100% was considered as minimum acceptable rate of return for farmers' recommendation. It is important to note that the acceptable minimum rate of return for farmers' recommendation is 50 to 100% (CIMMYT, 1988).

Conclusion

Pepper (*Capsicum annuum* L.) is the world's most important vegetable after tomato. Both sweet and hot peppers are processed into many types of sauces,

Table 2. Net benefit estimate of the combined application of FYM and NP fertilizers on pepper Marako Fana variety in Raya Azebo district during 2015/16.

Treatment	AY (Q/ha)	ADY (Q/ha)	FP/Q (00 ETB)	GFB (ETB/ha)	TVC (ETB/ha)	NB (ETB/ha)
82:92 +10	13.7	12.3	78	96174	9994	86180
82:92+2.5	21.9	19.7	78	153738	4233	149505
61.5:69+2.5	21.73	19.6	78	152544.6	3740	148804.6
41:46+2.5	14.3	12.9	78	100386	3236	97150
20.5:23 + 2.5	13.7	12.3	78	96174	2742	93432
82:92 + 5	20.4	18.4	78	143208	6156	137052
61.5:69 + 5	21.6	19.4	78	151632	5665	145967
41:46 + 5	23.75	21.4	78	166725	5178	161547
20.5:23 + 5	14.16	12.7	78	99403.2	4667	94736.2
82:92+ 7.5	18.1	16.3	78	127062	8077	118985
61.5:69 + 7.5	20.1	18.1	78	141102	7587	133515
41:46 + 7.5	15.7	14.1	78	110214	7088	103126
20.5:23 + 7.5	13.63	12.3	78	95682.6	6592	89090.6
61.5:69 + 10	16.7	15	78	117234	9506	107728
41:46 + 10	14.37	12.9	78	100877.4	9011	91866.4
20.5:23 + 10	14.43	13	78	101298.6	8518	92780.6
82 : 92	17.6	15.8	78	123552	2901	120651
0:00:10	14.43	13	78	101298.6	8026	93272.6
Unfertilized	12.5	11.3	78	87750	323	87427
84:76:14 sulfur	17.13	15.4	78	120252.6	2846	117406.6

Treatment = N:P kg ha^{-1} + FYM t ha^{-1}); AY = average yield, ADY = adjusted yield, FP = field price, GFB = gross field benefit, TVC = total variable cost, Q = quintal and NB = net benefit.

Table 3. Dominance analysis of FYM by NP combination application in Raya Azebo district during 2015/16.

Treatment	TVC (ETB/ha)	NB (ETB/ha)	B:C ratio
Unfertilized	323	87427	
20.5:23 + 2.5	2742	93432	34.0744
84:76:14 Sulfur	2846	117406.6	41.25
82:92	2901	120651	41.58945
41:46+2.5	3236	97150D	30.02163
61.5:69+2.5	3740	148804.6	39.78733
82:92+2.5	4233	149505	35.31892
20.5:23 + 5	4667	94736.2D	20.29916
41:46 + 5	5178	161547	31.19873
61.5:69 + 5	5665	145967D	25.76646
82:92 + 5	6156	137052D	22.26316
20.5:23 + 7.5	6592	89090.6D	13.51496
41:46 + 7.5	7088	103126D	14.54938
61.5:69 + 7.5	7587	133515D	17.59786
0:00:10	8026	93272.6D	11.62131
82:92+ 7.5	8077	118985D	14.73134
20.5:23 + 10	8518	92780.6D	10.8923
41:46 + 10	9011	91866.4D	10.19492
61.5:69 + 10	9506	107728D	11.33263
82:92 +10	9994	86180D	8.623174

Treatment = N:P kg ha^{-1}+ FYM t ha^{-1}; D = Dominated treatments, TVC = total variable cost, NB = net benefit, B : C ratio = benefit cost ratio.

Table 4. Marginal rate of return of FYM and NP fertilizers application in combination for dry fruit production of Marako Fana pepper variety in Raya Azebo district during 2015/16.

Treatment	TVC (ETB ha⁻¹)	MC (ETB ha⁻¹)	NB (ETB ha⁻¹)	MB (ETB ha⁻¹)	MRR (%)
Unfertilized	323		87427		
20.5:23 + 2.5	2742	2419	93432	6005	248
84:76:14 Sulfur	2846	104	117406.6	23974.6	23053
82:92	2901	55	120651	3244.4	5899
61.5:69+2.5	3740	839	148805	28154	3356
82:92+2.5	4233	493	149505	700	142
41:46 + 5	5178	945	161547	12042	1274

Treatment = N:P kg ha⁻¹+FYM t ha⁻¹; TVC=Total variable cost, MC = marginal cost, NB = net benefit, MRR = marginal rate of return.
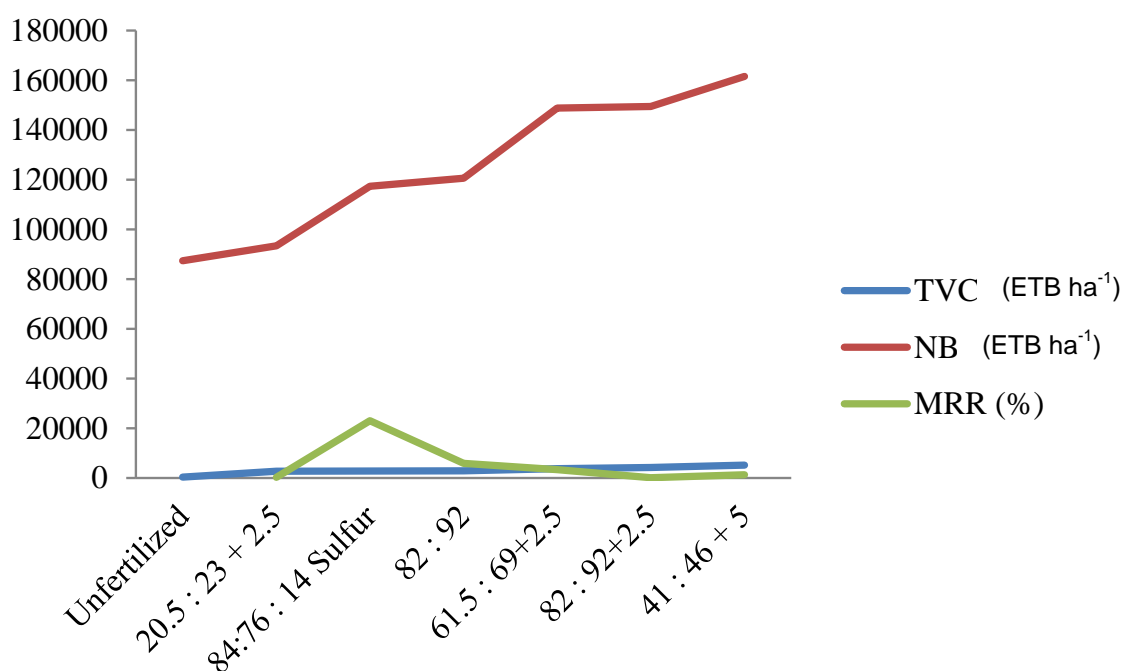
Figure 2. Net benefit curve of dominant organic and inorganic fertilizers application.

pickles, relishes and canned products. This study was conducted in Raya Azebo Wereda of Northern Ethiopia; specifically, Kara Kebele in 2015/16. It was executed under irrigation to assess the economic feasibility of NP and farmyard manure fertilizers application on *Marako Fana* pepper variety. The experiment was laid out as a randomized complete block design with three replications and treatments consisting of the combined application of four levels each for nitrogen, phosphorus and FYM. In this study, no fertilizer application, application of nationally recommended nitrogen and phosphorus rates, 10 t ha⁻¹ FYM as well as NPS fertilizers were considered as control.

The highest total dry fruit yield t ha⁻¹ was obtained from plots that received inorganic and organic fertilizers combination. Similarly, the highest marketable yield (2.375 t ha⁻¹) of *Marako Fana* was obtained on combined application of FYM which consisted of 50% of the blanket recommendation of inorganic fertilizers and 5 t ha⁻¹ FYM. The application of this treatment showed that about 1.125 t ha⁻¹ more marketable yield than unfertilized plot. Most of the treatment combinations of inorganic and organic fertilizers produced almost thesame amount of unmarketable dry fruit yield except the highest and the lowest unmarketable dry fruit yield obtained from blended fertilizer and 41 kg N + 46 kg P_2O_5 + 2.5 t FYM ha⁻¹ applications, respectively.

In this study, partial budget analysis was also employed by considering total variable cost and net benefit, dominated and dominant treatments using dominance

analysis, cost-benefit curve and marginal rate of return. The result indicated that the net benefit of all treatments except in the unfertilized plot. The combined application of half the nationally recommended rates of nitrogen, phosphorus and 5 t ha^{-1} FYM fertilizers was economically acceptable as compared to the other dominant treatments, although the marginal rate of return obtained from all dominant treatments was above the minimum acceptable marginal rate of return. Hence, to obtain optimum economic return from pepper production in the study area, it is recommended that 5 t ha^{-1} of FYM with half the rate of nationally recommended nitrogen and phosphorus fertilizers be applied. This recommendation is made based on varying total costs and marginal rate of return for alternative treatments.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ABBREVIATIONS

FYM, Farmyard manure; **RNPR,** recommended nitrogen and P$_2$O$_5$ rate; **NP,** recommended NPS rate; **RCBD,** randomized complete block design.

ACKNOWLEDGEMENTS

REFFERENCES

Amare T (2010). Determinants of Red Pepper Market Supply: The case of Jabitehinan Woreda, West Gojjam Zone of the Amhara National Regional State, Ethiopia. MSc Thesis Submitted to the Department of Agricultural Economics, Haramaya University, Ethiopia.

CIMMYT Economics program (1988). From agronomic data to farmer recommendations: An economics training manual. 27: CIMMYT.

Duncan B, Eric C, Mark K, Bruno H (1990). Economic analysis of on-farm trials: A review of approaches and omplications for research program design. Michigan State University, Senegal.

Herdt R (1987). Whither farming systems? In: how systems work. Proceedings of farming systems research symposium, University of Arkansas pp. 3-7.

International Potato Center (1982). Partial Budget Analysis for on-farm potato research. Lima, Peru.

Lessley B, Johnson D, Hanson J (1991). Using the partial budget to Analyze farm change. University of Maryland System 7:1990-1991.

Stephen K, Nicky M (2007). In service training on partial budgeting techniques. Mount Makulu, Lusaka, Zambia. http://fsg.afre.msu.edu/zambia/fsrp_gart_partial_budgeting.pdf