Original Research Article

Agronomic and Economic Performance of Hot Pepper (*Capsicum annuum* L.) in Response to Blended Fertilizer Supplyat Asossa, Western Ethiopia

ABSTRACT

Hot pepper production is constrained bydeclining soil fertility and poor management practices in Assosa area, western Ethiopia.An experiment was conducted to evaluate different rates of blended fertilizerson agronomic performance and pod yield,and economic profitabilityof hot pepper production at Assosa. The treatments included were: control, recommended NP, three rates for each NPSB and NPSBZn (100, 150, 200 kg ha^{-1})arranged in a randomized complete block design, with three replications.In the blends since N proportion was low, supplementary N was applied from Urea to optimize N needs of the crop.The result of the study revealed that the growth parameters (plant height and number of branches), yieldcomponents(number of pod per plant, pod length and width) andmarketable pod yield were significantly ($p<0.05$) affected by fertilizer rates and types. The marketabledry pod yield was improved by 134.7% with the application of 150 kg NPSBZn +44kg ha^{-1}N as compared to the control.Moreover, this treatment generated the highest net benefit of168,070.2 ETB ha^{-1} with 5365% marginal rate of return (MRR). Nevertheless, application of 100 kg NPSBZn +29 kg N ha^{-1} had also resulted in 57% pod yield improvement, 8444%MRR, and net benefit of 138,315.7ETB ha^{-1}. In general, all blended fertilizer rates appliedwere superior over the recommended NP and the control implying that S, B and Zn added with blends might be deficient in Assosa area for crop production.Therefore,these two rates (150 kg NPSBZn +44 kg Nha^{-1}and100 kg NPSBZn + 29 kg Nha^{-1}) can be recommended forprofitable hot pepper production in Assosa areaas an alternative for the poor and wealthy groups of framers.

Keywords: *blended fertilizer, Mareko Fana, net benefit,pod yield*

1. INTRODUCTION

Hot pepper (*Capsicum annum* L.) is an important spice and vegetable crop in tropical areas of the world and it belongs to the *Solanaceae* family, and the genus *Capsicum.* The genus *Capsicum* is the second most important vegetable crop of the family after tomato in the world (Berhanu *et al.*, 2011). In Ethiopiathe total production share of pepper is high as compared with other vegetables such as lettuce, tomatoes, head cabbage, onion and others (CSA, 2016). However, in Ethiopia as general and in Assosa in particular,the productivity of pepper is still low attributed to lack of proper agronomic management practices, specially unbalanced nutrient supply, weed infestation, disease and other factors.

Soil fertility decline and a resultant nutrient deficiency is the most yield limiting factor for vegetable production in different agro-ecologiesof Ethiopia, of them the major limiting ones are N, P and other macro and micronutrientssuch as K S, B and Zn deficiencies (Alemu and Ermias, 2000). Previous fertilizer research work in Ethiopia as well as in Assosa area focused with N and P fertilizer management under different soil types and various climatic conditions.The blanket recommendation rate for these fertilizerswere is 100 kg DAP ha^{-1} and 100 kg Urea ha^{-1}, respectively are widely used for pepper production. In addition of these, different fertilizer rates were recommended for different parts of hot pepper production areas of Ethiopia. For instance Girma *et al.* (2001) reported that application of 200 kg ha^{-1} of DAP and 100 kg ha^{-1} of urea was found optimum for better yield at Abobo area. Whereas, application of 207 kg of DAP and 137 kg of urea per hectare gave optimum pods yield of hot pepper variety Oda Haro at Bako (MoARD, 2005).These rates vary as per the agro-ecological domains of the country; however, it is essential to determine the optimum fertilizers ratesand types specifically for Assosa area for profitable hot pepper production.Thus unbalanced application of plant nutrients may aggravate the depletion of other important nutrient elements in soils such as K, Mg, Ca, S and micronutrients (FAO, 2000;Wassie *et al.,* 2011). Recent soil inventory by EthioSIS (Ethiopian Soil Information System) also revealed that in addition to N and P, nutrients such as S, B, Zn are deficient in different areas of the country including Asossa area (ATA, 2013). On the other hand, hot pepper is a heavy feeder crop that extracts a lot of nutrients from the soil during their growing period and produces large amounts of pods in short seasons (Ejaz*et al*., 2011). Application of balanced fertilizers is the basis to produce more crop output from existing land under cultivation and nutrient supply of crops should be,according to their physiological requirements and expected yields (Ryan, 2008).Crop producers used to supply different nutrients for the crop as blend to the plants at once, this can save resources and economy of the farmers.

Sub heading required here:

Agronomic and economic analysis/partial budget analysis/ provides useful informationfor making decisions to recommend the result of the field experiment to the farmers. Partial budget analysis can be usedfor comparing the impact of a technological change onfarm costs and returns (CIP, 1982). New technology can be evaluated in terms of itsimpact on the productivity, profitability, acceptability andsustainability of farming systems (Herdt, 1987). Theprofitability of hot pepper production is partly related withthe 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 effectivetechnique for assessing the profitability of newtechnology for an existing enterprise. It also provides thefoundation for comparing the relative profitability ofalternative treatments, evaluating their riskiness, andtesting how robust profits are in the event of changingproduct or input prices(CIMMYT, 1988).The increasedproduction of the crop due to the application of inputsmight or might not be beneficiary to farmers. Therefore,the experiment was conducted toassess the agronomic performance and economic feasibility of blended fertilizers (NPSB and NPSBZn) rates on growth and dry pod yield of *Marako Fana* pepper variety at Assosa, western Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the Study area

The study was conducted at Assosa Agricultural Research Center (ASARC) farm, which is located in Assosa District of Benishangul-Gumuz Regional State, western Ethiopia. The ASARC is located at 10º 01' 25'' to 10º 02' 50'' north latitude and 34º 33' 50'' to 34º 34' 35'' east longitude in western part of Ethiopia.It is situated at an altitude of 1553 m a.s.l. The study area is characterized by hot to warm moist lowland plain with uni-modal rainfall pattern. The rainy season startsmiddleMarch and lasts to the end of October with maximum rainfall in the months of June to September. The total annual average rainfall is 1316 mm. The soil type of the study area was characterized as Nitisol. (EARO, 2004)

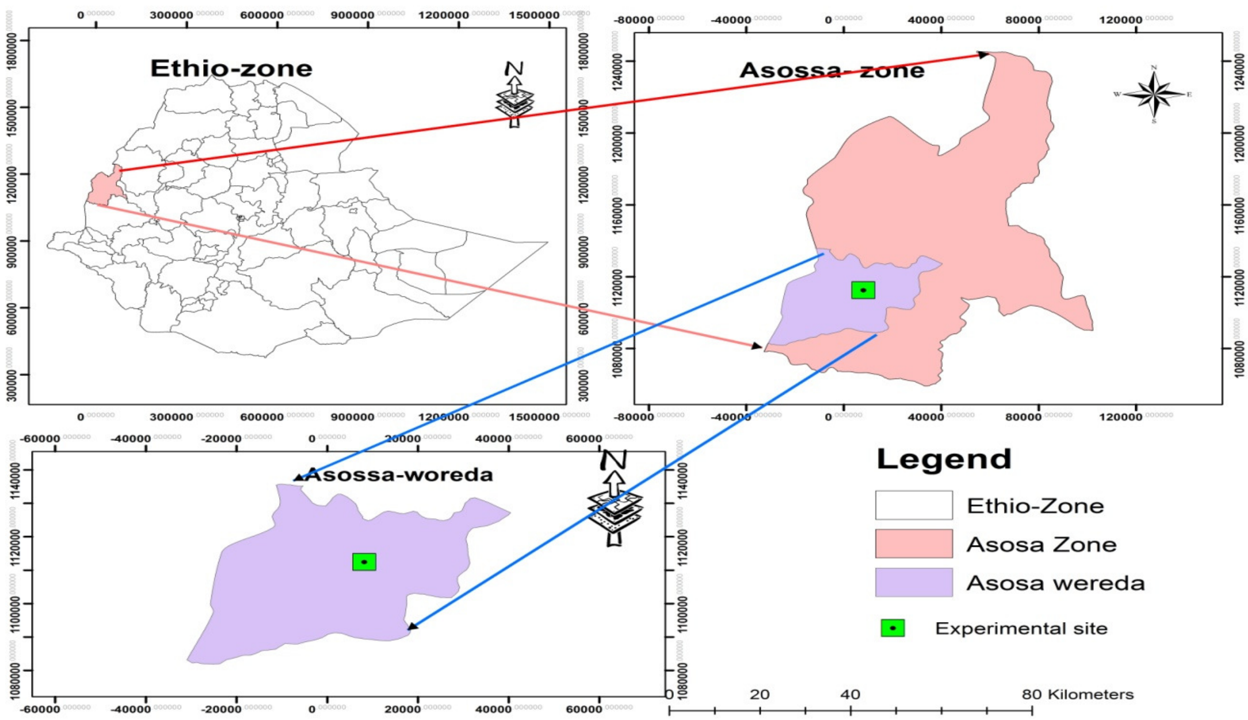
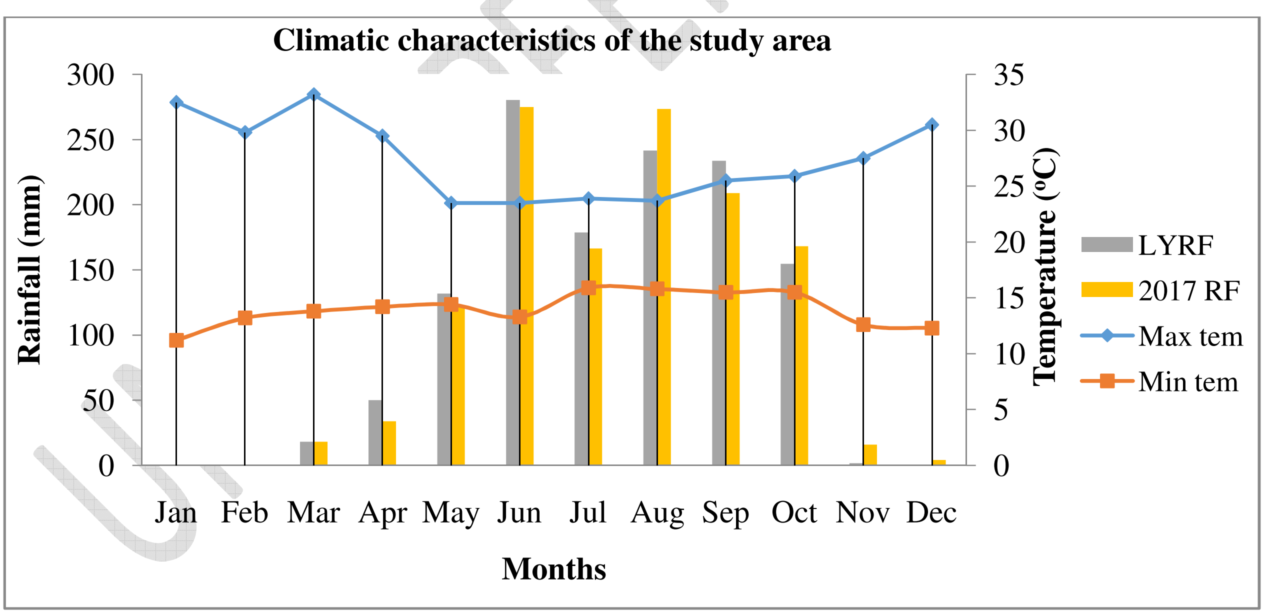


Figure 1. Location map of the study area



LYRF= Long year rainfall, Max tem= maximum temperature, Min tem= minimum temperature, RF = rain fall

Figure 2. Long term (2011-2017) average rainfall and temperature and one year (2017) rainfall of Assosa Agricultural Research Center

2.2 Experimental Designand Treatments

The fertilizer treatments considered for the study consists of control, three levels of NPSB (100, 150 and 200 kg ha^{-1}),three levels of NPSBZn (100,150 and 200 kg ha^{-1}) and recommended NP (100 kg Urea and 100 kg TSP ha^{-1}). In both blended fertilizersnitrogen proportion was low,how low hence adjustment were made to compensate for the shortfall of N in blended fertilizer.The experiment was laid out in a randomized complete block design (RCBD) with three replications. Marako Fana variety of hot pepper which is a high yielding and adapted to the agro-ecology of the area was used for the study.The experimental plot size was 12.6m^2(3m wide and 4.2m long), with 0.75m space between plots and 1m between blocks. There were six rows per plot and ten plants per row with a total of 60 plants per plot.

Table 1a.Fertilizer rates involved in treatments for the study includes

No.	Treatments (kg ha^{-1})	N : P_2O_5 : S : B : Zn (kg ha^{-1})
1	Control (no fertilizer)	0 : 0 : 0 : 0 : 0
2	100 Urea & 100 TSP	46 : 46: 0: 0: 0
3	100 NPSB + 28N	46.1 : 36.1 : 6.7 : 0.71: 0
4	150 NPSB + 42N	69.1 : 54.15 : 10.1 : 1.1: 0
5	200 NPSB + 56N	92.2 : 72.2 : 13.4 : 1.42: 0
6	100 NPSBZn + 29N	45.9 : 33.8 : 7.3 : 0.7 : 2.2
7	150 NPSBZn + 44N	69.4 : 50.7 : 10.9 : 3.4 : 1.0
8	200 NPSBZn + 58N	91.8 : 67.6 : 1.6 : 4.5 : 1.3

2.3 Soil sampling and analysisprior to the experiment

The composite soil samples were collected to identify the initial characteristics of the experimental soil, selected soil physico-chemical properties were analyzed at Soil and Plant

Analysis Laboratory of Holleta Agricultural Research Center, Ethiopia.The soil at experimental site was clay loam in textural classwhich was supposed to be suitable for hot pepper production and other major crop production. The site of soil was moderately acidic in reaction (pH = 5.5),the bulk density was moderate(1.36 gm cm^{-3}), low in total N (0.12%)Landon(1991),low in organic carbon (1.47%) and low to moderate in organic matter (2.53%) (Tekalign, 1991). Similarly, available P (5.0 mg kg^{-1} soil) was low (Olsen 1954).

2.4 Agronomic Data Collection and Measurements

The field agronomic data were collected at different stages of hot pepper growing period and after harvesting from the representative samples. These parameters include:growth parameters (plant height, number of primary and secondary branches), yield and yield components (number of pods per plant, marketable pod yield (t ha^{-1}), unmarketable pod yield (t ha^{-1}), average number of seeds per pods,seed dry weight (g), pod length and width (cm).

2.5 Partial Budget Analysis

To consolidate the analysis of variance of the agronomic data, economic analysis was performed for each treatment. For economic evaluation, cost and return, and benefit to cost ratio was calculated according to the procedure given by CIMMYT (1988). Actual marketable pod yield was adjusted downward by 10% to reflect the difference between the experimental pod yield and the pod yield that farmers would expect to get from the same treatment (CIMMYT, 1988).

Variable costs incurred for the production and the local market price of the dry marketable pod yield of hot pepper after harvest were recordedfor the economic analysis of blended fertilizer application.The marketable pod yield from the control plot was taken as a reference and the pod yield increment at different treatments that received different rates of fertilizer (increase over the control) was considered for evaluation. The field price of dry pod pepper in the local market of the area was 85.00 birr kg^{-1} of dry pod. The minimum acceptable marginal rate of return used in this study was assumed to be 100% for farmers' recommendation domain. Finally, the fertilizer levels that gave the maximum net benefit with acceptable marginal rate of return were selected. The economic analysis was based on the formula developed by CIMMYT (1988) and given as:

Gross average yield (GAY) (kg ha^{-1} or ton ha^{-1}): is an average yield of each treatment

Adjusted yield (AJY): is the average yield adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmer's field.

AJY = GAY - (GAY * 0.1)

Gross field benefit (GFB): was computed by multiplying field/farm gate price that farmers receive for the crop when they sale it as adjusted yield.

GFB = AJY * field/farm gate price of a crop

Total variable cost (TVC): is the cost of inputs that were used for the treatments as mean current prices of UREA, TSP, blended fertilizer, wage for fertilizers applicationand transport of fertilizers, were considered per hectare.

Net benefit (NB): was calculated by subtracting the total costs from the gross field benefit for each treatment. NB = GFB – TVC

Marginal cost (MC) = change in costs between treatments.

Marginal benefit (MB)= change in net benefits between treatments.

Marginal rate of return: is Percent marginal rate of return was calculated as changes in net benefit (raised benefit) divided by changes in cost (raised cost).

MRR (%)= (MB/ MC)*100

2.6 Statistical analysis

Analysis of variance was carried out for the growth, yield and yield components following the standard statistical procedures using SAS computer software version 9.2 (SAS Institute Inc. Cary NC, 2008). Whenever treatment effects were significant, the means differences were separated using the least significant difference (LSD) at 5% level of significance.

3. RESULTS ANDDISCUSSION

3.1 Effect of Blended Fertilizers on Growth Parameters

Application of blended fertilizer significantly ($p \leq 0.05$) increased plant height as compared to the recommended NP fertilizers and the control (unfertilized plot)(Table 1). The least plant height was recorded in unfertilized plots (49.47cm) and might be due to low soil fertility level in the study area. In conformity with the results obtained from this study, plant growth and development may be retarded significantly if any of nutrient elements is less than its threshold level in the soil (Landon, 1991). The increase in plant height could mainly be due to better availability of nutrients in blended fertilizers, especially N and P which have enhancing effect on the vegetative growth of plants by increasing cell division and elongation (El-Tohamy *et al*., 2006; Mebratu *et al.,*2014). Application of sulfur might participate on the availability of other nutrients supplied to the crop in addition to its role.It is in concurrent with the results of Hassaneen (1992) who found that sulfur application plays important roles as a soil amendment to improve the availability of nutrients such as P, K, Zn, Mn and Cu. In addition the presence of B and Zn in blended fertilizers mightstimulate the growth hormones such as IAA which is mostly responsible for plant growth(Ram and Katiyar, 2013).

Number of primary and secondary branches

The application of blended fertilizer treatments exhibited significant ($p<0.05$) differences with regard to the number of primary and secondary branches. Numerically the maximum number of primary (3.33) and secondary (6.93) branches was observed from application of blended fertilizers rate at 150kg NPSB + 42 kg N ha^{-1} and 150kg NPSBZn + 44 kg N ha^{-1} respectively. Both blended fertilizer types (NPSB and NPSBZn) improved number of primary and secondary branches up to 150 kg ha^{-1}, and afterwards declined (Table 1). The increase in the number of branches in response to the increases in the rates of fertilizer up to optimum could be attributed to the positive effect of nitrogen and other nutrients on promotion of vegetative growth due to its stimulative effect on protein synthesis and meristematic tissues through hormonal synthesis leading to more number of buds which may have resulted in the production of more number of branches per plant (Uchida, 2000).

In addition the presences of S,B and Zn in blended fertilizer improves various plant metabolic processes such as nitrogen uptake, photosynthetic activity, nitrogen metabolism, chlorophyll synthesis and proteinquality (Cakmak, 2008). The present results agreed with many research findings with hot pepper who indicated that increased nitrogen and other nutrient supply resulted in increased branches and biomass production (El-Tohamy *et al.,* 2006,Adugna, 2008).

Table 1. Effect of blended fertilizerstype and rates on plant height, number of primary and secondary branchesof hot pepper at Assosa, Western Ethiopia.

Treatment (kg ha^{-1})	PH	NPB	NSB
Control	49.47^{d}	2.47^{d}	4.27^{d}
Recommended NP	57.33^{c}	2.8^{c}	5.73^{c}
100 NPSB + 28 N	63.07^{ab}	3.07^{b}	5.87^{c}
150 NPSB + 42 N	66.4^{ab}	3.33^{a}	6.47^{ab}
200 NPSB + 56 N	62.13^{abc}	3.0^{bc}	5.93^{bc}
100 NPSBZn + 29N	61.07^{bc}	3.00^{bc}	5.87^{c}
150 NPSBZn + 44N	67.33^{a}	3.13^{ab}	6.93^{a}
200 NPSBZn + 58N	62.53^{abc}	3.07^{b}	6.07^{bc}
LSD (0.05)	5.591	0.204	0.5694
CV (%)	5.22	3.91	5.52

PH=Plant height; NPB=Number of primary branches; NSB=Number of secondary branches; NPSBZn are fertilizer that contains nitrogen, phosphorous, sulfur, boronand zinc;CV=Coefficient variance; LSD= List significance difference

3.2. Effect of Blended Fertilizers on Yield Attributes

Number of pods per plant and seed number per pod

The hot pepper response to blended fertilizers was significantly ($p \leq 0.05$) different in terms of number of pods per plant, but non-significant in seed number per pod. Blended fertilizers increased the number of pods per plant as compared with recommended NP and unfertilized plot (Table 2). Sufficient availability of these nutrients enables the plant to acquire higher number of pods per plant and seeds per pod, through influencing photosynthetic activity and its proper partitioning. On other hand the availability of B fertilizers improves the formation of pollen tube and seed formation.The application of boron in tomato increased the number of flower buds per plant and total number of fruits per plant than that of control (Suganiya *et al*., 2015).In contrast to the present findings, Lemma *et al*. (2008) and Russo (2003) reported increase in the number of seeds per pod in response to fertilizer supply. The results from this investigation was in agreement with the findings of Mercelis and Baan (1997) who reported that pod size is one factor that determines number of seeds per pod in capsicum annum. They observed a linear increase in individual fruit size with seed number.

Dry seed weight per pod (g)

Seed dry weight of pod was statically non-significantly ($p \leq 0.05$) affectdry application of blended fertilizer as compared to the recommended NP fertilizers and the control. Numerically the maximum weight was attained from blended fertilizer treatment of 150 kg NPSBZn + 44 kg N ha^{-1} and the least seed weight were registered from unfertilized plot (Table 2). Most of the time number and weight of seeds per fruit are directly related.Aleemulah *et al*. (2000) observed a positive relationship between the number of seeds per pod and pod size, where pod weight increased linearly with the number of seeds per pod in sweet pepper. In line with this result, Bosland and Votava (2000) indicated the seed of some pepper cultivars can contain up to 60% of the dry weight of the fruit that makes it an important economic part of the crop.

Pod length and width

The application of blended fertilizer was significantly ($P \leq 0.05$) affected the average length and width of pods. Plants in unfertilized plot produced fruits significantly short in length and narrow in width. As general trend, the fruit long in length and wide in width were produced in plots that received optimum amount of fertilizers. The reason that supply of blended fertilizer had higher response in terms of pod width than recommended NP fertilizers applications might be attributed due to the presence of sulfur and other micronutrients. It is in conformity with Randle and Bussard (1993) who reported that sulfur often ranked immediately behind nitrogen, phosphorus, and potassium in terms of importance to crop productivity.

The present result is in agreement with the finding of Sileshi (2014) who reported better fruit setting characteristics of the plant with larger sized fruits is directly related with the amount of nutrients taken from the soil. The result indicated that plots treated with relatively higher rates of nitrogen and phosphorus gave fruits with larger cross-sections. Larger and wider hot pepper pods are considered to be the best in quality and have better demand for fresh as well as dry pod use in markets (Adugna, 2008). When sufficient nutrient supply is available in the soil, fruits as other vegetative parts of the plant take part in assimilating portion of the nutrient and would acquire larger and thicker sizes (Hegde, 1997). Therefore, subjectively this quality attribute, along with pod length and thickness could be of better preference to consumers

3.3Effect of Blended Fertilizers on Yield of Hot Pepper

Marketable pod yield (t ha^{-1})

Marketable pod yield were significantly ($p \leq 0.05$) affected by blended fertilizer rate. The results showed that the highest marketable pod yield (2.22 t ha^{-1}) was obtained from plots treated with blended fertilizer rates of 150 kg NPSBZn + 44 kg N ha^{-1} (Table 2). The variation in marketable pod yield might be due to varying levels of fertilizers treatment and the nutrient status of the growing area. But, further increases in applied fertilizers from 150 to 200 kg ha^{-1} reduced marketable pod yield, implying that 150 kg N ha^{-1} could be optimum for hot pepper production.

The increase in marketable pod yield from 0 kg ha^{-1} to 150 kg ha^{-1}, followed by a decrease at 200 kg ha^{-1} were in agreement with the findings of Siti *et al.* (1993) who reported that total marketable fruit weight per plant decreased by 0.5 kg per plant as N level were increased from 112 to 448 kg ha^{-1} in pepper. Also, Leghari and Oad (2005) reported that higher seed weight, seed number per pod and total dry pod weight per plant were positively correlated with marketable pod yield in pepper. Marketable pod yield increased in response to addition of nutrients in nutrient deficient soils, and also significantly lower total and marketable yields from pepper plants grown in plots not fertilized with pepper(Mavengahama, 2003).

Unmarketable dry pod yield (t ha^{-1})

The application of blended fertilizers was non-significantly ($p \leq 0.05$) influenced unmarketable pod yield. The highest unmarketable pod yield was obtained from unfertilized plot while the least unmarketable pod yield recorded from blended fertilizers treatment at 150 kg NPSBZn + 44 kg N ha^{-1} (Table 2). This unmarketable yield was recorded through subjective judgment based on shrunken shaped fruits, small sized and discolored fruits that were estimated to be due to the differences in nutrients uses. In addition, those lacked uniformity when drying, and or due to physiological disorders (bleaching) during the fruit set or due to the climatic conditions of the growing environment during harvesting were considered as unmarketable pod yield.As Aloni *et al*. (1994) who reported that colour spot incidence increased with nitrogen application and was more pronounced in densely planted peppers due to shading effect.

Table 2. Effects of blended fertilizers types and rates onnumber of pods per plant, number of seed per pod, dry seed weight per pod, pod length and width, marketable and unmarketable pod yield of hot pepper at Assosa, western Ethiopia.

Treatment (kg ha^{-1})	NPP	NSP	DSW	PL	PW	MY	UMY
Control	17.27^{d}	119.8	1.08	8.01^{c}	1.59^{b}	0.95^{c}	0.24
Recommended NP	22.67^{c}	148.4	1.15	8.93^{b}	1.94^{a}	1.44^{bc}	0.23
100 NPSB + 28 N	25.13^{bc}	163.13	1.26	9.71^{ab}	2.0^{a}	1.72^{ab}	0.23
150 NPSB + 42 N	25.13^{bc}	165.73	1.28	9.87^{a}	2.01^{a}	2.12^{a}	0.23
200 NPSB + 56 N	26.73^{b}	165.47	1.27	9.38^{ab}	1.90^{a}	1.82^{ab}	0.22
100 NPSBZn + 29N	25.13^{bc}	151.4	1.24	9.96^{a}	2.0^{a}	1.83^{ab}	0.23
150 NPSBZn + 44N	30.47^{a}	168.93	1.37	10.16^{a}	2.14^{a}	2.23^{a}	0.22
200 NPSBZn + 58N	24.87^{bc}	152.4	1.23	9.58^{ab}	2.06^{a}	1.68^{ab}	0.23
LSD (0.05)	3.5746	NS	NS	0.8895	0.2403	0.621	NS
CV (%)	8.27	13.46	6.82	5.36	7.01	20.58	5.09

NPP= number of pods $plant^{-1}$, NSP=number of Seed pod^{-1}, DSWP= dry Seed weight pod^{-1} (g), PL= pod length, PW= pod width, MY= marketable pod yield, UMY= unmarketable pod yield, NS=not significantly different, CV=coefficient variance; LSD= list significance difference; NS= non-significance

3.4Partial Budget Analysis

Cost benefit analysis was undertaken with different blended fertilizer types and ratesto determine the highest net benefit with acceptable marginal rate of return. The results revealed that the maximum net benefit was obtained from 150 kg NPSBZn + 44 kg N ha^{-1}(Table 3). The results show that a general decrease in benefit cost ratio with increase in level of fertilizers. This showed that excess usage of fertilizers was increased cost and decreased marketable yield. This implies that profitability of hot pepper production is partly related with the right type and rate of input (fertilizer) usage and the cost incurred for these inputs (Amare, 2010).Thus, on the basis of marketable yield, net income and cost benefit ratio, it can be concluded that among the fertilizer rates tested 150 kg NPSBZn + 44 kg N $ha^{-1}$and 100 kg NPSBZn + 29 kg N ha^{-1} were the most economically feasible for hot pepper production which provided the net benefit of (168, 070.2 ETB) and (138, 315.7 ETB) respectively. This indicated that as the total costs that vary increased until certain level, the net benefit obtained also increased. However, as the total costs that vary increased over the optimum level, the net benefit obtained reduced as the result of higher variable costs associated with lower earnings.

Table 3. Net benefit analysis for the application of blended fertilizers type and rates on hot pepper production at Assosa, western Ethiopia.

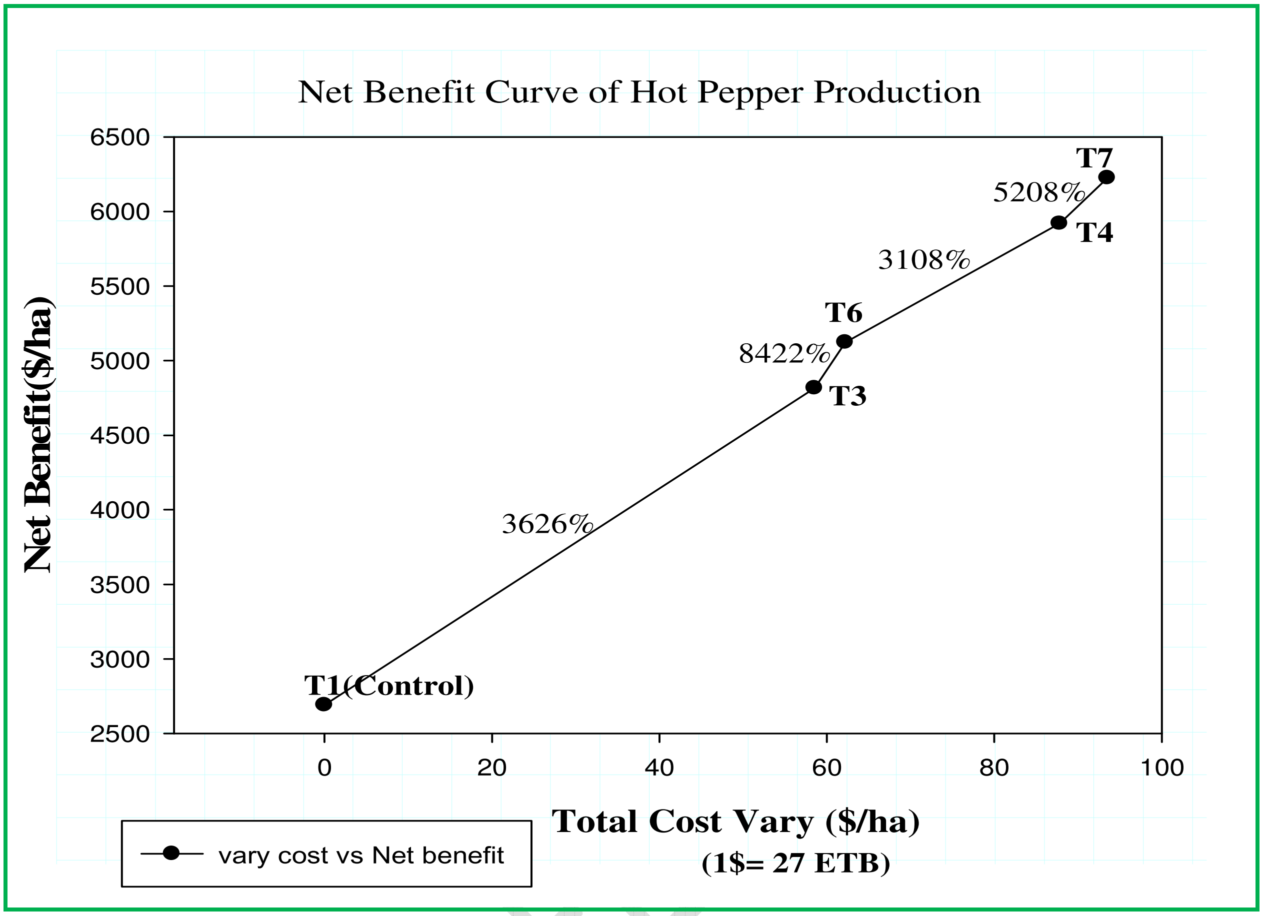
Treatment (kg ha^{-1})	AMPY (t ha^{-1})	AY (t ha^{-1})	TVC (ETB ha^{-1})	GFB (ETB ha^{-1})	NB (ETB ha^{-1})
Control	0.95	0.855	0	72675	72675
Recommended NP	1.44	1.296	2409	110160	107751
100 NPSB + 28 N	1.72	1.548	1580.56	131580	129999.44
150 NPSB + 42 N	2.12	1.908	2370.84	162180	159809.16
200 NPSB + 56 N	1.82	1.638	3161.12	139230	136068.88
100 NPSBZn + 29N	1.83	1.647	1679.3	139995	138315.7
150 NPSBZn + 44N	2.23	2.007	2524.8	170595	168070.2
200 NPSBZn + 58N	1.68	1.512	3358.6	128520	125161.4

AMY= Average marketable pod yield, AY= Adjusted yield, TVC= Total variable cost, GFB = +Gross field benefit, NB = Net benefit, ETB ha^{-1}= Ethiopian birr per hectare. The price of inputs: Urea = 8.24 birr kg^{-1}, TSP = 12.75 birr kg^{-1}, NPSB = 11.02 birr kg^{-1}, NPSBZn = 11.70 birr kg^{-1}, Price of dry pod = 85 birr kg^{-1}.

Dominance analysisand Net benefit curve

The highest net benefits from the application of inputs for the production of the crop might not be sufficient for the farmers to accept as good practices. In most cases, farmers prefer the highest profit with low cost(high income). For this purpose it is necessary to conduct dominated treatment analysis. The dominant (undominated) treatments were ranked from the lowest to the highest costs that vary. The dominant analysis showed that the net benefit of recommended NP, 200 kg NPSB + 52 kg N ha^{-1} and 200 kg NPSBZn + 58 kg N ha^{-1} treatments was dominated. This indicates that the net benefit was decreased as the total cost that varies increased beyond undominated fertilizer treatments application.

To compare treatments with net benefit curve only undominated treatments were listedin order of increasing costs that vary for the net benefit curve, 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, the net benefit also increase linearly and attained peak then after, the net benefit was reduced as the cost was increasing. The net benefit curve shown in (figure 3) was the relation between the costs that vary and net benefits for thenondominated treatments and allows to mark out an efficient set of technologies for recommendation.



T3- 100 NPSB +28N; **T4**- 150 NPSB + 42 N; **T6**- 100 NPSBZn + 29N; **T7**- 150 NPSBZn +44N

Figure 3. Net benefit curve of hot pepper as influenced by blended fertilizers application at Assosa, western Ethiopia.

Marginal rate of return

The percentagemarginal rate of return (%MRR) between any pair of dominant treatments denotes the return per unit of investment in fertilizer expressed as a percentage. Passing from the first treatment that had the lowest costs that vary to the end treatment which had the highest cost that vary, the marginal rate of return obtained was above the minimum acceptable marginal rate of return. The best recommendation for treatments not subjected to 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). In this study, 100% was considered as minimum acceptable rate of return for farmer's recommendation. For instance for every 1.00 Birr invested in application of blended fertilizer, farmers can expect to recover the 1.00 Birr, and obtain an additional 52.08 Birr $ha^{-1}$and also the second alternative recommendation with values to cost ratio of ETB 82.37 profit per unit investment for hot pepper production was obtained from application of 100 kg NPSBZn + 29 kg N(Tables 4).

Table4.Dominance analysis and marginal rate of return of the application of recommended blended fertilizers rates on hot pepper production at Assosa, western Ethiopia.

Treatment (kg ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	Dominance	B:C ratio	MRR%
Control	0	72675			
100 NPSB + 28 N	1580.56	129,999.44		82.25	3626
100 NPSBZn + 29N	1679.30	138,315.70		82.37	8422
150 NPSB + 42 N	2370.84	159,809.16		67.41	3108
Recommended NP	2409.00	107,751	Dominated		
150 NPSBZn + 44N	2524.80	168,070.20		66.57	5208
200 NPSB + 56 N	3161.12	136,068.88	Dominated		
200 NPSBZn + 58N	3358.60	125,161.4	Dominated		

TVC=Total variable cost; NB=Net benefit; B:C ratio=Benefit cost ratio; MRR% = marginal rate of return, MRR = change in net income / change in cost x 100 Costs and returns (income) are described in Birr ha^{-1}.

4. CONCLUSION AND RECOMMENDATIONS

The resultsof the study revealed that most of the agronomic parameters considered were significantly affected by the blended fertilizer treatments.Among the yield and yield components, the highest and significantly different marketable pod yield (2.37 t ha^{-1}) were obtained from plots that received blended fertilizers rate of 150 kg NPSBZn + 44 kg N ha^{-1}.The economic analysis indicated that the application of 150 kg NPSBZn + 44 kg N ha^{-1}blended fertilizer produce net benefitof 168,070.2ETB ha^{-1} with a MRR of 5208%, which was superior in most of growth and yield parameters. Furthermore, application of 100 kg NPSBZn + 29 kg N ha^{-1} also produced the net benefit of 138,315.7ETB $ha^{-1}$with the highest marginal rate of return 8422%. Hence, to obtain optimum economic return from the production of hot pepper at the study area, blended fertilizer rates of 100 kg NPSBZn + 29 kg N ha^{-1} and 150 kg NPSBZn + 44 kg N ha^{-1}could be recommended for different wealthy groups of framers.Thisrecommendation is supported by CIMMYT which stated that farmers should be willing to change from one treatment to another if the marginal rate of return of that change is greater than the minimum acceptable rate of return.

REFERENCES

Adugna Z. 2008. Effects of Seed Priming, Planting Method and Fertilizers on Yield and Yield Components of Fresh hot pepper (*Capsicum annuum* L.) in Northwest Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia. 36p.

Aleemullah M, Haigh AM, Holford P. 2000. Anthesis, anther dehiscence, pistil receptivity and fruit development in the Longum group of *Capsicum annum*. Austr. J. Exper. Agric. 40:755-762.

Alemu H and Ermias A. 2000. Horticultural crops production and associated constraints in North-west Ethiopia. Working paper. Agricultural Economics Research Division, Agricultural Research Centre, Adet. 18p.

Aloni B, Karni L, Rylski I and Zaidman Z (1994). The effect of nitrogen fertilization and shading on the incidence of 'Colour spots' in sweet pepper (*Capsicum annuum*L.) fruit. *Journal of HorticulturalScience*, 69 (4): 767-773.

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, Haramaya University, Ethiopia.

ATA (Agricultural Transformation Agency) 2013. Status of soil resources in Ethiopia and priorities for sustainable management. Ethiopian agricultural transformation agency In: Global Soil partnership (GSP) for eastern and southern Africa. March 25-27: 2013, Nairobi, Kenya.

Berhanu Y, Derbew B, Wosene G, and Fekadu M. 2011. Variability, heritability and genetic advance in hot pepper (Capsicum annuum L.) genotypes in west Shoa, Ethiopia. *American-Eurasian Journal of Agriculture and Environmental Science*, 10(4), 587 –592.

Bosland P.W. and Votava E.J. 2000. Peppers, Vegetables and Spices *Capsicum.* CABI Publishing. New York. 198p.

Cakmak I. 2008. Enrichment of cereal grains with zinc: Agronomic or genetic biofortification Plant and Soil, 302: 1-17**.**

CIMMYT 1988. From agronomic data to farmer recommendations. An economics-training manual. Completely revised edition. D.F, Mexico 51p

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

CSA (Central Statistical Agency) 2016. Agricultural sample survey report on Crop and livestock product utilization. 2015/2016. Addis Ababa, Ethiopia

EARO (Ethiopian Agricultural research Organization) 2004. Released crop varieties and their recommended cultural practices. Progress report. Addis Ababa, Ethiopia.

Ejaz, M., Rehman, S.U., Waqas, R., Manan, A., Imran M., and Bukhari M.A.,2011. Combined efficacy of macro-nutrients and micro-nutrients as foliar application on growth and yield of tomato grown by vegetable forcing. *International Journal for Agro-Veterinary and Medical Sciences*, 5(3): 327-335.

El-Tohamy W.A., Ghoname A. A. and Abou-Hussein S.D. 2006. Improvement of pepper growth and productivity in sandy soil by different fertilization treatments under protected cultivation. *Journal of applied Science Research,* 2: 8-12.

FAO (Food and Agriculture Organization) 2000. Guidelines for On-Farm Plant Nutrition and Soil Management Trials and Demonstrations, AGL/MISC26/2000.

Girma,T., Lidet, S., Damtrew, M., and Daniel,B. 2001. Berber production in Ethiopia.

Hassaneen M.N. 1992. Effect of sulfur application to calcareous soil on growth and certain metabolic changes in some crops. *Journal of Agriculture Science,* 17(10): 3184-3195.

Hedge D M. 1997. Nutrition requirement of solanacaous. Vegetable crops, All India Coordinated Safflowers Improvement Project. Solapur, Maharashtra, India. In: Food and Fertilizer Technology center. Taipie,10616 Taiwan, R. O.C. www.agent.org.

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

Landon J. R. 1991. Booker tropical soil manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York. 474p.

Leghari G and Oad. F. 2005. The effect of nitrogen fertilizer regimes on the growth and yield of pepper. *Indus Journal of Plant Sciences*, 4(3): 386-390.

Lemma D and Shimelis A. 2008. Achievement and research experience on capsicum crop Melkasa Agricultural Research center. EIAR. Un published report.

Marcelis I.F. M. and Baan Hofman-Eijer I. R. 1997. Effect of seed number on competition and dominance among fruits in *Capsicum annum* L. *Annals of botany* 79:687-693.

Mavengahama S, Ogunlela V.B. and Mariga I.2003. Response of pepper (*Capsicum annuum* L.) to different basal fertilizers application. *Journal of African Crop Science Society*,6: 9-13.

Mebratu A, Dechassa N, Mulualem T, Weldetsadik K. 2014. Effect of Inorganic Fertilizers on Yield and Physical Quality Parameters of Hot Pepper (*Capsicum annuum* l.) in South-Eastern Ethiopia. *Journal of Plant and Pest Science*,1(3): 138-145.

MoARD (Minstry of Agriculture and Rural Development). 2005. Crop Development department crop variety register.2005.Issue No 8. Adis ababa Ethiopia.

Olsen S.R., Cole C.V, Watanabe F.S and Deen L.A.1954. Estimation of available P in soils by extraction with sodium bicarbonate. USDA. Circ 939: 1-19.

Ram S. and Katiyar T.P.S. 2013. Effect of sulphur and zinc on the seed yield and protein content of summer mungbean under arid climate. International Journal of Science and Nature, 4(3): 563-566.

Ramakrishna T. 2002. Effect of plant geometry and fertilizer levels on growth, yield and quality of pepper (Cv. Vietman-2). An MSc Thesis Presented to University of Dharward Agricultural Science. 132p.

Randle W.M. and Bussard M.L. 1993. Pungency and sugars of short day onion as affected by sulfur nutrition. *Journal of American Society of Horticulture Science*, 118(6): 766-770.

Russo V.M. 2003. Planting date and plant density affect the yield of pungent and non-pungent jalapeno peppers. J. Hort. Sci. 38: 520-523.
SAS Institute Inc. Cray. 20008. Users Guide. Version 9.2. NC.USA.
Seleshi D, Derebew B, Ali M and Yehene G. 2014. Evaluation of Elite Hot Pepper Varieties (*Capsicum* spp.) for Growth, Dry pod yield and Quality under Jimma condition, South West Ethiopia. *Int. J. Agric. Res.*, 9(7): 364-374.
Siti A.H., Gerber, J.M. and Splittstoesser W.E. 1993. Growth and yield potential of green pepper as affected by nitrogen at transplanting. *Journal of Tropical Agriculture Science*, 16 (2): 101-105.
Suganiya, S., Kumuthini and Harris, D., 2015. Effect of boron on flower and fruit set and yield of ratoon brinjal crop. *International Journal of Scientific Research and Innovative Technology,* 2(1): 135-141.
Tekalign T.1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working document No.13. Int. Liv. Research Center for Africa, Addis Ababa, Ethiopia.
Uchid R. 2000. Essential nutrients for plant growth: nutrient functions and deficiency symptoms; Plant nutrient management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture; College of Tropical Agriculture and Human Resources, Univ of Hawaii.
Wassie H and Shiferaw B. 2011. Response of Irish Potato (*Solanum tuberosum*) to the Application of Potassium at Acidic Soils of Chencha, Southern Ethiopia.International Journal of Agriculture and Biology 13:595-598.