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Response of Hot Pepper (*Capsicum annuum* L.) as Affected by NP Fertilizer and Farmyard Manure Combined Application in Raya Azebo District, Northern Ethiopia

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ABSTRACT

Productivity of hot pepper in Ethiopia is low due to lack of improved varieties, poor cultural practices and the prevalence of diseases. This research is conducted to assess the effect of NP fertilizer application and Farmyard Manure on productivity and economic feasibility of Marako Fana pepper variety in Raya Azebo district, Northern Ethiopia. Thecombination of 25%, 50%, 75% and 100% of nationally recommended NP and 10 t ha^{-1} FYM as well as four control treatments (unfertilized, 100% FYM, 100% NP and blended fertilizer/NPS) were used in this study. The national recommendation of NP fertilizer was 82 kg N+92 kg P_2O_5 ha^{-1} while the highest FYM application as sole fertilizer was 10 t ha^{-1}. The experiment was laid out in randomized complete block design (RCBD) with three replications. All other management practices were implemented as per national recommendation for the variety. The crop phenology, growth and yield components were significantly influenced by treatment combinations and blended fertilizer application. More specifically, an application of 50 % of the recommended NP fertilizer combined with 5 t ha^{-1} FYM as well as the 75 and 100% NP rates in combinations with 2.5 and 5 t ha^{-1} FYM gave significantly maximum total dry fruit yield ranging from 2.25 to 2.50 t ha^{-1}. However, the application of half rates of recommended NP in combination with 5 t ha^{-1}FYM produced significantly the maximum total and marketable dry fruit yield of 2.495 and 2.375t ha^{-1}. It is recommended to apply an integrated fertilizer management approach. Furthermore, as the study had conducted at one location for a single season, it is also recommended to repeat the study across representative locations of the district both under rain fed and irrigation conditions.

Keywords: Pepper, Marako Fana, NP, FYM, blended fertilizer, inorganic fertilizer

INTRODUCTION

Pepper *(Capsicum annuum* L.*)* is the world's most important vegetable after tomato and used as fresh, dried or processed products, as vegetables and as spices or condiments (Acquaah, 2004). Though the introduction of pepper in Ethiopia not certainly known, its cultivation is an ancient practice (MARC, 2004; EEPA, 2003). Pepper is the main parts of the daily diet of most Ethiopian (Dennis, 2013).

Despite the benefits of pepper and the increasing demand in Ethiopia, the hot pepper production both in green and dry forms is low due to lack of improved varieties, poor cultural practices and the prevalence of fungal and bacterial as well as viral diseases (Fekadu and Dandena, 2006).

The supply of nutrients from organic fertilizers increases soil water retention, slow release of nutrients and contributes to the residual pool of organic nitrogen and phosphorus in the soil (Jen-Hshuan, 2006). However, the use of FYM alone as a substitute to inorganic fertilizer is not sufficient to maintain the present levels of crop productivity of high yielding varieties (Efthimiadou *et al*., 2010).

In Raya Valley, hot pepper is a major spice and vegetable crop produced by the majority of farmers. (Gebreyohan - nes *et al.,* 2010). However, the yield of hot pepper is low due to depletion of the soil nutrient in the area and failure of applying optimum amount of fertilizers by farmers. In Raya Azebo district, most of the crop nutria- ents such as nitrogen, phosphorus, sulfur and others are depleted (ATA, 2014). Therefore, it is necessary to conduct research that leads to make recommendation of economically feasible fertilizer application.

Objectives

1. To assess the effect of NP and farmyard manure fertilizers combination on growth and phenology characteristics of Marako Fana pepper variety and
1. To assess the effect of NP and farmyard manure fertilizers combined application on yield and yield related traits of Marako Fana pepper variety

MATERIALS AND METHODS

Description of the Study Area

This study was conducted in northern Ethiopia of Raya Azebo Woreda. The specific site of the research was in lowland area of Raya Azebo Woreda, particularly at Kara Kebele. Raya Azebo Woreda is located in $12^0$3'-$13^0$7'N latitude and $39^0$5'-$39^0$8'E longitude. Agro-climatically, the area is characterized as dry semi-arid climate (Araya *etal.,* 2010). The mean annual temperature and mean annual rain fall ranges from 16^0C to 28^0C and from 446 to 830 mm, respectively.

Treatments and Experimental Design

The study was executed under irrigation using a pepper variety known as Marako Fana was used. This variety is widely adapted and recommended hot pepper for the study area. The seeds of Marako Fana were obtained from Alamata Agricultural Research Center and sown in rows of 15 cm apart in nursery established on well prepared seed bed and sufficient number of seedlings were raised for the field experiment. The national recommended inorganic fertilizer application rates of 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1} for the crop and 10 t ha^{-1} FYM which was considered as optimum organic fertilizer rate for vegetables were the basis to arrange the combined fertilizer treatments. Taking the application of the whole inorganic and organic fertilizers rates in combination as maximum, the treatments were arranged as 100, 75, 50 and 25 percent 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_2O_5 ha^{-1}+14 kg sulfur ha^{-1}) and no fertilizer application were considered as control treatments. In this study, TSP and Urea were used as source of P_2O_5 and N, respectively. The field experiment was laid out as Randomized Complete Block (RCB) 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 x4.2 m in length and width, respectively. Plants in the two rows at the extreme end of both sides of each plot and plants the two plants at the end of each row were not considered as experimental plants. This gave the net plot size of 3.9 x2.8 m (10.92 m^2) with a total of 52 plants per net plot. The spacing between blocks and plots was 1.5 m and 1m, respectively.

Experimental Materials and Characteristics of Marako Fana Variety

In this study, cattle dung was used to produce FYM. TSP, Urea and NPS fertilizers were used as source of P_2O_5, nitrogen and sulfur fertilizers. An auger was also used to collect soil samples during soil sample collection. Marako Fana pepper variety released in 1976 was used for this experiment.Marako Fana pepper is characterized by larger and pungent pods with highly demanded dark-red colour. This variety is highly preferred by the local consumers due to the pungency level, attractive colour and high powder yield. Marako Fana variety is the only variety being used for a long time by the local factories for the extraction of *Capsicum* oleoresin for the export market (MARC, 2003).

The productivity of Marako Fana pepper is different for different agronomic practice and agro ecological condition of the environment in the country. MARC (2005) reported that the marketable yield potential of Marako Fana ranged between 1.5 t ha^{-1} to 2 t ha^{-1}. Addisalem (2011) who studied the response of pepper (*Capsicum annuum* L.) to application of nitrogen and potassium fertilizers at Agarfa,South-Eastern highland of Ethiopia also reported that the highest marketable yield of Marako Fana was about 2.72 t ha^{-1}from supply of 100 kg N ha^{-1}+115 kg P_2O_5 ha^{-1})in soil textural class of clay. Kassa (2015) also reported that Marako Fana pepper variety provided 2.83 t ha^{-1}of dry pod yield in Abergelle district. According to adaptation trial of Melaku *et al.* (2015), Marako Fana pepper variety also provided about 2.066 t ha^{-1}of marketable yield under Gedeo Zone of Dilla condition. It was also found that the green marketable yield of Marako Fana variety in Raya valley was 32.545 t ha^{-1} (Haileslassie *et al.*, 2015).

Experimental Procedures

The farmyard manure (FYM) was produced in a trench under shade to avoid evaporation loss of nutrients. The decomposition of FYM was done as recommended by Sankaranarayanan (2004) who reported that the manure becomes ready for use after four to five months after plastering. In this study, the FYM was decomposed for about six months following standard procedures. All available litter and refuse were 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 a dung earth slurry. After two months of decomposition, the FYM was transferred in to other well-prepared trench early in the morning. Then after, it was left for decomposition for about four extra months. Seeds of Marako Fana were sown in November 01, 2015 on a seed bed size of 1 x 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 sun shine until eight days remained for transplanting. During hoeing and thinning of the seedlings, 82 g/bed-based N from 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 after one and half month (46 days) after seeds were sown or at the stage when the seedlings attained 20 to 25 cm height. The layout of experimental units was done before a month (30 days) before seedlings transplanted in November 15, 2015. Then after, 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 was broadcasted in plots one month (30 days) before seedlings 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 each plot and row in plots received water from the source without passing any of the experimental plot to prevent mixing of fertilizer rates given to different plots. The 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 the recommendation for the crop. Therefore, pods were harvested when they started drying and looked leathery (subjectively) in appearance on the plant. After harvesting, pods were further dried in partial shade till delectation.

Data Analysis

Analysis of variance was performed following the procedure of Gomez and Gomez (1984) GENSTATE software program version 13. Treatments showed significant difference were subjected to Duncan's multiple range tests for mean separation at 5% level of significance.

RESULTS AND DISCUSSION

Soil Characteristics of Experimental Field

The pH of the soil for the experimental field is presented in Table 1.

Characteristics of Farmyard Manure

The FYM used in the experiment had pH of 7.82 and electrical conductivity (EC) of 3.58 (ms/cm).). It also contained 38.96 (%), 0.806 (%), 0.383 (%) and 2.34. (%) of organic matter, total nitrogen, phosphorus and potassium respectively. The source materials that were used to prepare the FYM were not visible in the form they were incorporated for decomposition in the final FYM indicating it was well decomposed.

Days to Flowering

Plants in plots treated with the two lowest rates of 20.5 kg N ha^{-1}+23 Kg P_2O_5 ha^{-1} and 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1} in combination with all rates of FYM except the former with 7.5 t ha^{-1} FYM and the later with 10 t ha^{-1} FYM showed earliness in 50% flowering (Appendix Table 1). However, the earliness of the variety for flowering due to these treatments had no significant difference with plots that did not receive fertilizers, treated with 10 t ha^{-1} FYM and 84 kg N ha^{-1}+76 kg P_2O_5 ha^{-1}+14 kg Sulfur ha^{-1}. Delayed flowering of plants was observed in plots treated with all other treatment combinations without significant difference and the most delayed plants in flowering was observed in plots treated with 82 kg N ha^{-1}+92 Kg P_2O_5 $ha^{-1}$and 20.5 kg N ha^{-1}+23 Kg P_2O_5 ha^{-1}+7.5 t ha^{-1} FYM. The lowest difference for 50% flowering of plants was 6 days between plots that did not receive fertilizer and plot received 20.5 kg N ha^{-1}+23 Kg P_2O_5 ha^{-1}+2.5 t ha^{-1}FYM,while the highest difference was 18 days. The delayed flowering was significant in plots that received fertilizer with higher rates of NP in combination with all levels of FYM.

The delayed flowering due to higher rates of fertilizers application could be due to the luxurious uptake of nutrients by plants that increased the vegetative growth and delayed the reproductive stage. Flowering might be delayed or inhibited by the continuous production of new leaves and stems. It is supported by Adhikari *et al.* (2016)who observed that chemical fertilizers tend to provide the plant nutrients readily and encourage vegetative growth, thereby, delaying the flowering phenomenon in sweet pepper.Higher nitrogen rates stimulated vegetative growth at the expense of flowering(Mills and Jones, 1979).This also agrees with Guohua *et al. (*2001) who suggested that flowering delayed with increase in nitrogen supply due to diversion of photosynthate to vegetative growth rather than towards reproductive growth of the plant.Similarly, Amare *et al.* (2013) also observed that the earliest days to flowering (66.33days) for Marako Fanavariety was recorded fromthe plottreatedwith 0 kg N ha^{-1} and 138kg P_2O_5 $ha^{-1}$and the delayed flowering (93.33 days) was observed in plots that received a combination of92 kg N ha^{-1} and 0kg P_2O_5 ha^{-1}.

Days to Green Pod Setting

Plants grown in plots without fertilizer application and treated with 20.5 kg N ha^{-1}+23 kg $P_2O_5$and 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1} both combined with2.5 t ha^{-1} FYM showed significant earliness to 50%green pod setting like that of unfertilized plot (Appendix Table 1).

Table 1. Soil chemical property of experimental site in cropping season

Soil chemical property	Experimental field	Rating	Reference Authors
Soil pH	7.95	Moderately alkaline	Murphy (1968) &Tekalign (1991)
OC (%)	1.46	Low	Tekalign (1991)
OM (%)	2.52	Medium to low	Murphy (1968) & Tekalign (1991)
TN (%)	0.115	Medium to low	Murphy (1968) & Tekalign (1991)
EXCH K cmol (+) kg^{-1}	0.73	Medium	Berhanu (1980)
EC ms/cm	0.33	Medium	Shaw (1999)
AV P (ppm)	15.92	Medium	Cottenie (1980)
CEC meq/100g	24.84	Medium	Hazelton and Murphy (2007)

OC (%) = organic carbon content in percent, OM (%) = organic matter content in percent, TN (%)=total nitrogen in percent, EXCH K=exchangeable potassium, EC=electrical conductivity, AVP=available phosphorus and CEC cation exchange capacity.

Plants in plots that received inorganic fertilizers with the rates and type of84 kg N ha^{-1}+76 kg P_2O_5 ha^{-1}+14 kg Sulfur ha^{-1} had significantly delayed days to 50% green pod setting. Other plants grown in plots that received most of the fertilizer treatment combinations showed statistically non-significant green pod setting (Table 3). The 50% green pod setting obtained from unfertilized plot was earlier by 27 days than the delayed 50% green pod setting from the plot that received 84 kg N ha^{-1}+76 kg P_2O_5 ha^{-1}+14 kg Sulfur ha^{-1}. This is an important element that farmers can understand pepper supplied optimum amount of the required fertilizer needs delayed time to produce good yield than lower fertilization.

The variety Marako Fana showed a trend of earliness in green pod setting when received lower rate combination of fertilizers; while it delayed in green pod setting towards the higher rate combination of NP and FYM fertilizers. This might be due to the effect of nitrogen from inorganic fertilizer and FYM fertilizersourcescould extend vegetative growth of plants that delayed green pod setting consequently. This finding is agreed withDecoteau (2000) that reported applying higher rates of nitrogen on pepper had negative effects on fruit earliness through delaying flowering. Similarly, Gardner *et al.* (2003) indicated that application of nitrogen fertilizer is beneficial to vegetative growth and prolongs flowering, fruiting and maturity period.The earlier green pod setting alsomight be due to that the phosphorus level supplied to the plots might cause earlier flowering so as green pod setting computing with nitrogen. This result is in conformity with Brady and Weil (2002) who stated that phosphorous enhances flowering and hastens maturity of crops. It is also observed by Blamey *et al*. (1987) that lower phosphorus in solution culture has sometimes been found to reduce plant growth without anycharacteristic symptoms.

Days to First Ripe Pod Harvest

The days to first ripe red pod harvest showed more or less similar trends with the days of 50% green pod setting. The early green pod setting were recorded in plots that did not receive fertilizer and received 20.5 kg N ha^{-1}+23 kg P_2O_5ha^{-1}and 41 kg Nha^{-1}+46 P_2O_5 kg ha^{-1} both combined with2.5 t ha^{-1} FYM (Appendix Table 1). These plots also allowed harvesting of the first ripe red pods early. However, these treatments did not show better early green pod setting than application of 10 t ha^{-1} of FYM and so as for first ripe red pod harvest. Whereas, plants in plots that received a combination of higher rates of fertilizers showed delayed first red pod harvest (Table 3). The highest difference to first ripe pod harvest was 26 days observed between the plot that received 61.5 kg N ha^{-1}+69 kg P_2O_5ha^{-1}+5 t ha^{-1} FYM and 20.5 kg N ha^{-1}+23 kg P_2O_5ha^{-1}+2.5 t ha^{-1} FYM. This significant difference among treatment combinations as well as unfertilized plot is practically important for farmers to schedule the type and time of planting for the next season crop. The significant difference might be attributed by the higher nutrient supply in delaying fruit setting.

This result is consistent with the findings of Lemma (2008) who reported that the nutrient supply is responsible for earliness or late start of blooming. Amare *et al.* (2013) also reported that the plot that received higher levels of nitrogen and phosphorus fertilizers exhibited prolonged time to commence blooming in Marako Fana variety. In pepper, fruit normally reaches the mature green stage 35 to 50 days after the flower is pollinated. The pods are harvested at immature and mature stages. The green stage is horticulturally ripe but physiologically immature. Early yield is determined by the first flowers setting fruits (Bosland and Votava, 2000). The current study result showed 33 to 51days differences between 50% flowering and green pod setting which was in agreement with the mean difference indicated by Bosland and Votava (2000).

Number and Duration of Harvest

The significantly different number of harvest in the analysis of variance was observed in the unfertilized plot. All other plots that received different combination of fertilizers had not showsignificant difference in response to number of harvestas well as the significantly different duration of harvest observed in application of 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM; while all other treatments were statistically similar (Appendix Table 1, Table 1). The non-significant differences of number and duration of harvest in Marako Fana due to different rates of fertilizers application could be suggested to the potential of the variety to be harvested at specified time duration which allows planned use of land under irrigation. It is supported by the finding of Seleshi (2011) who suggested that genetic make-up of pepper varieties were among reasons that could cause variations maturity. Therefore, the duration and repetitive harvest of consecutive fruit might most probably depend on the potential of the variety rather than other factors prevailing to the crop. The application of 61.5 kg N ha^{-1}+69 kg P_2O_5ha^{-1}in combination with 5 t ha^{-1} and 7.5 t ha^{-1} FYM showed statistically similar longest duration of harvest. The shortest duration of harvest was observed in plants grown in unfertilized plot. The difference between the shortest and longest duration of harvest was about 13 days.

Multiple picks of pepper are common because of sequential setting and ripening of fruits. This might be attributed to the positive effect of nitrogen and FYM on promoting increased vegetative growth, prolonged days of maturity, and subsequently delayed duration of harvest. The observed non-significant differences for number and duration of harvest among plots that received different rates of fertilizers in Marako Fanacould be due to the genetic potential of the variety in reaching maturity at definite period of time with application of different level of fertilizers.

Plant Height

Different fertilizer types and levels had revealed significant difference on the plant height of pepper (Appendix Table 2). The tallest (56.40 cm)and shortest (30 cm) plants were observed in plots that received 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM and unfertilized plot, respectively. However, the maximum plant height obtained was not statistically different with application of 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1}and 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1} fertilizers combined with 2.5 t ha^{-1} FYM,7.5 t ha^{-1} FYM,10 t ha^{-1} FYM and 5 t ha^{-1} FYM for the former treatment . Not only that, but also supply of 10 t ha^{-1} FYM and 84 kg N ha^{-1}+76 kg P_2O_5 ha^{-1}+14 kg Sulfur ha^{-1} produced significantly similar plant height from the tallest plants obtained by application of 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM. The two lowest inorganic fertilizer levels (41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1} and 20.5 kg N ha^{-1}+23 kg P_2O_5 ha^{-1}) combined with lowest organic fertilizer level (2.5 t ha^{-1} FYM) and the latter combined

Table 2. Effect of combined application of FYM and NP fertilizers on phenology parameters of Marako Fana pepper variety in 2015/16 in Raya Azebo district

Treatments (N:P kg ha^{-1}+FYM t ha^{-1})	DF	DGS	DFRPH	NH	DH
82 : 92 +10	76.00^{abc}	114.70^{abc}	144.00^{ab}	3.00^{a}	25.00^{b}
82 : 92+2.5	76.67^{abc}	115.00^{abc}	137.00^{bcd}	3.00^{a}	25.00^{b}
61.5 : 69+2.5	82.67^{ab}	114.00^{abc}	142.70^{ab}	3.33^{a}	26.00^{b}
41 : 46+2.5	75.00^{abcd}	95.00^{d}	129.70^{de}	3.00^{a}	25.00^{b}
20.5 : 23 + 2.5	65.00^{d}	95.00^{d}	123.30^{e}	3.00^{a}	25.00^{b}
82 : 92 + 5	82.67^{ab}	119.00^{ab}	141.30^{abc}	3.00^{a}	25.00^{b}
61.5 : 69 + 5	81.00^{abc}	120.00^{ab}	148.70^{a}	3.33^{a}	31.67^{a}
41 : 46 + 5	73.00^{abcd}	120.00^{ab}	139.00^{abcd}	3.00^{a}	25.00^{b}
20.5 : 23 + 5	72.00^{bcd}	113.00^{abc}	143.30^{ab}	3.00^{a}	25.00^{b}
82 : 92+ 7.5	81.00^{abc}	113.70^{abc}	140.00^{abc}	3.00^{a}	25.00^{b}
61.5 : 69 + 7.5	82.00^{ab}	114.30^{abc}	144.70^{ab}	3.00^{a}	28.33^{ab}
41 : 46 + 7.5	72.00^{bcd}	110.00^{bc}	144.00^{ab}	3.00^{a}	26.67^{b}
20.5 : 23 + 7.5	83.00^{a}	115.70^{abc}	143.00^{ab}	3.00^{a}	25.00^{b}
61.5 : 69 + 10	76.00^{abc}	111.00^{bc}	143.30^{ab}	3.00^{a}	25.00^{b}
41 : 46 + 10	77.00^{abc}	120.00^{ab}	138.30^{bcd}	3.00^{a}	25.00^{b}
20.5 : 23 + 10	74.00^{abcd}	107.30^{c}	140.00^{abc}	3.00^{a}	25.00^{b}
82 : 92	83.00^{a}	116.00^{abc}	142.70^{ab}	3.00^{a}	25.00^{b}
0:0:10	75.00^{abcd}	116.7^{abc}	132.0^{cde}	3.0000^{a}	25.00^{b}
Unfertilized	70.67^{cd}	95.0^{d}	125.0^{e}	2.3333^{b}	19.33^{c}
84:76 : 14 Sulfur	73.00^{abcd}	121.7^{a}	138.7^{abcd}	3.0000^{a}	27.00^{b}
LSD (5 %)	8.942	8.764	8.424	0.3696	4.063
CV (%)	7.1	4.7	3.7	7.5	9.7

Means with in columns followed by the same letter (s) are not significantly different at P< 0.05. DF=days to 50% flowering, DGS =days to 50% green pod setting, DFRFH=days to first red fruit harvest, NH=Number of harvest, and DH=Duration of harvest.

with 5 and 7.5 t ha^{-1} FYM also did not show significantly better plant height than that of the shortest plant height observed in the untreated plot.

The shortest plant height from unfertilized plot was 26.4 cm lower than the longest plant height obtained. This could be due to better nutrient supply might in turn better plant height. The result is in line with the finding of Gonzalez *et al.*(2001) who reported that application of organic manure and inorganic fertilizer has increased growth variables including plant height. They further noted thatboth organic and inorganic fertilizers supplied most of the essential nutrients at growth stage and it could be due to the occurrence this condition. Similarly, El-Tohamy *et al.* (2006) reported that the increase in plant height could be initiated due to better availability of soil nutrients in the growing areas, especially nitrogen and phosphorus, which have enhancing effect on the vegetative growth of plants by increasing cell division and elongation. The reason that sulfur contained inorganic fertilizer application was not significantly different with that of the highest plant height might be attributed to that sulfur plays an important role on nutrient activities of the soil. Application of sulfur might participate on the availability of other nutrients supplied to the crop in addition to its role. It is concurrent with the result of Hassaneen (1992) who found that sulfur application plays important roles in the soil that it is used as a soil amendment to improve the availability of nutrients such as P, K, Zn, Mn and Cu. The author also found that sulfur element reduced soil pH and converted the unavailable phosphorus to available form for plant tissues.

Canopy Diameter

The widest canopy diameter in plants was measured from the application of 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1}, 41 kg N ha^{-1}+ 46 kg P_2O_5 ha^{-1} and 82 kg N ha^{-1}+ 92 kg P_2O_5 ha^{-1} with the combination of 5 t ha^{-1} FYM fertilizer. However, the canopy diameter of plants that received 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1} with the combination of 7.5 t ha^{-1} FYM had no significant difference with the above treatment combinations. The narrowest canopy diameter was observed from the supply of 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+2.5 t ha^{-1} FYM fertilizers. There was about 27cm difference between the widest and narrowest canopy diameters. Application of 20.5 kg N ha^{-1}+23 kg P_2O_5 ha^{-1},41 kg P_2O_5 ha^{-1}+46 kg N ha^{-1},61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1} in combination with 7.5 (except the latter) and 10 t ha^{-1} FYM did not show better canopy diameter from unfertilized plot. In addition, application of 10 t ha^{-1} FYM and 20.5 kg N ha^{-1}+23 kg P_2O_5 ha^{-1} combined with 5 and 2.5 t ha^{-1} FYM were not significantly different from the unfertilized plot. This might indicate that optimum application of fertilizers could result better canopy diameter rather than excess or lower application of fertilizers. El-Tohamy *et al.* (2006) noted that nitrogen has positive effect on branching of pepper plants. Accordingly, the wider canopy diameter might be resulted due to higher branch number of Marako Fana variety. It also might be due to phosphorus supply which is supported by Gill *et al.* (1974) who studied the effect of nitrogen and phosphorus application rates on seed yield of sweet pepper and found that application of phosphorus fertilizer without nitrogen increased the number of branches per plant.

Number of Branches

The application of treatments exhibited highly significant ((P<0.01)) differences with regard to the number of primary, secondary and tertiary branches (Appendix Table 2).

The maximum number of primary branches (9.467) was observed from application of41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM. The unfertilized plot showed the lowest number of primary braches (2.133). However, the lowest number of primary branches obtained from unfertilized plot were not significantly different with other treatments except for plots treated with 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}, 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1} in combination with 5 t ha^{-1} FYM and the latter with 2.5 t ha^{-1} FYM as well as for the supply of 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1} without and with 2.5 t ha^{-1} FYM. Moreover, the application of 84 kg N ha^{-1}+76 kg ha^{-1} P_2O_5+14 kg Sulfur ha^{-1} and 20.5 kg N ha^{-1}+23 kg P_2O_5 ha^{-1}+10t ha^{-1} FYM provided significantly same lower primary branches. Supply of 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM produced 7.33 more primary branches than the lowest branches obtained (Table 3).

The greatest number of secondary branches (8.90) were obtained from application of 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1}+2.5 t ha^{-1} FYM which was statistically similar with supply of 41 kg N ha^{-1}+46 kg P_2O_5 $ha^{-1}$and 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1} in combination with 5 t ha^{-1} FYM. The lowest number of secondary branches was counted from plots that received 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+2.5 t ha^{-1} FYM. The highest number of secondary branches exhibited 4.67 secondary branches increment over the lowest number of secondary branches. The lowest numbers of secondary branches were not significantly different with most of other treatments except for plots that provided high count of secondary branches (Table 3). The application of RNPR and RNPSR fertilizers also produced statistically similar count of secondary branches.

Tertiary branches were also affected by combined application of FYM and NP fertilizers(Table 2). Accordingly, the greatest number of tertiary branches were attained from application of 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM followed by the combined fertilizer applications of 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM and 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1}+2.5 t ha^{-1} FYM without statistically significant differences. The lowest number of tertiary branches was attained from addition of 41 kg Nha^{-1}+46 kg P_2O_5 ha^{-1}+ 2.5 t ha^{-1} FYM. All other treatments except plots that received 82 kg N ha^{-1}+92 kg P_2O_5 ha^{-1} without and combined with 10 t ha^{-1} FYM, 5 t ha^{-1} FYM and 7.5 t ha^{-1} FYM and 61.5 kg N ha^{-1}+69 kg P_2O_5 ha^{-1}combined with 2.5 t ha^{-1} FYM and7.5 t ha^{-1} FYM produced statistically same number of tertiary branches with the plot to which lowest tertiary branches were obtained.The highest number of tertiary branches was 6.27 more than the lowest number of branches recorded.

The application of nitrogen, phosphorus and FYM fertilizers in appropriate proportion could enhance nutrient uptake of plants so as higher number of primary, secondary and tertiary branches. Organic manure and inorganic fertilizer supplied most of the essential nutrients at growth stage resulting in increase of growth variables (Gonzalez *et al.,*2001). Availability of soil nutrients in the growing areas, especially nitrogen and phosphorus have enhancing effect on the vegetative growth of plants by increasing cell division and elongation (El-Tohamy *et al.*, 2006). Similarly, Abd-El-Hakeem (2003) reported that application of 50% nitrogen requirements as organic form and the other 50% as mineral-N form was recommended to increase NPK uptake than supplying of all nitrogen fertilizer requirements in the organic or mineral form for high productivity of sweet pepper.

Table 3.Effect of combined application of FYM and NP fertilizers on growth of Marko pepper variety in 2015/16 in Raya Azebo district

Treatments (N:P kg ha^{-1}+FYM t ha^{-1})	PH (cm)	CDM (cm)	NPB	NSB	NTB
82 : 92 +10	48.77^{ab}	24.80^{fg}	3.43^{defg}	5.70^{cdef}	7.10^{bcd}
82 : 92+2.5	50.37^{ab}	36.30^{bc}	5.73^{b}	8.90^{a}	10.00^{a}
61.5 : 69+2.5	50.00^{ab}	33.80^{cd}	3.90^{cdef}	5.93^{cde}	7.67^{b}
41 : 46+2.5	36.00^{cde}	14.00^{i}	2.30^{fg}	4.23^{f}	5.17^{e}
20.5 : 23 + 2.5	32.33^{de}	23.30^{fgh}	3.53^{defg}	4.50^{ef}	6.67^{bcde}
82 : 92 + 5	50.60^{ab}	38.40^{ab}	3.73^{cdefg}	6.23^{cd}	7.70^{b}
61.5 : 69 + 5	42.13^{bcd}	41.00^{a}	5.23^{bc}	7.867^{ab}	10.40^{a}
41 : 46 + 5	56.40^{a}	39.80^{ab}	9.47^{a}	8.60^{a}	11.43^{a}
20.5 : 23 + 5	39.93^{bcde}	19.70^{h}	3.47^{defg}	4.90^{def}	5.93^{bcde}
82 : 92+ 7.5	50.17^{ab}	38.50^{ab}	3.50^{defg}	6.93^{bc}	7.70^{b}
61.5 : 69 + 7.5	50.43^{ab}	33.80^{cd}	3.33^{defg}	6.43^{cd}	7.43^{bc}
41 : 46 + 7.5	45.73^{abc}	23.30^{fgh}	3.20^{defg}	5.30^{def}	6.87^{bcde}
20.5 : 23 + 7.5	39.67^{bcde}	19.20^{h}	2.63^{efg}	5.13^{def}	5.73^{cde}
61.5 : 69 + 10	48.83^{ab}	20.50^{gh}	2.73^{efg}	5.40^{cdef}	6.53^{bcde}
41 : 46 + 10	42.33^{bcd}	20.50^{gh}	2.97^{defg}	5.93^{cde}	6.33^{bcde}
20.5 : 23 + 10	41.03^{bcd}	21.00^{gh}	4.03^{cde}	5.27^{def}	6.50^{bcde}
82 : 92	44.43^{bc}	31.60^{de}	4.03^{cde}	6.00^{cde}	7.30^{bcd}
0:0:10	46.57^{abc}	20.00^{h}	3.23^{defg}	6.00^{cde}	6.50^{bcde}
Unfertilized	30.00^{e}	18.80^{h}	2.133^{g}	4.833^{def}	5.53^{de}
84:76 : 14 Sulfur	45.16^{abc}	27.60^{ef}	4.600^{bcd}	6.067^{cde}	6.93^{bcde}
LSD (5%)	9.672	4.094	1.395	1.343	1.529
CV (%)	13.1	9.1	21.9	13.5	12.7

Means with in columns followed by the same letter (s) are not significantly different at P< 0.05.PH= plant height, CDM= Canopy diameter, NPB=Number of primary branches, NSB= Number of secondary branches and NTB= Number of tertiary branches.

Number of Red Fruits per Plant

The mean comparison of treatments revealed that significantly maximum number of red fruits per plant were obtained from the plot treated with supply of 41 kg Nha^{-1}+46 kg P_2O_5ha^{-1}+5 t ha^{-1} FYM followed by supply of 82 kg N ha^{-1}+92 kg P_2O_5ha^{-1} and 61.5 kg Nha^{-1}+69 kg P_2O_5 ha^{-1}both in combination of 2.5 and combination with 5 t ha^{-1}FYM for the latter treatment without significant difference among them (Table 4). On the contrary, the minimum number of red fruits per plant were counted from unfertilized plot followed by application of 20.5 kg Nha^{-1}+23 kg P_2O_5 ha^{-1} and 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}in combination with 2.5 and combined with 5 t ha^{-1}FYM for the latter treatment. The highest increase of red fruits (12.46)per plant were observed between fertilizer supply of 41 kg Nha^{-1}+46 kg P_2O_5ha^{-1}+5 t ha^{-1} FYM and unfertilized plot.

As a general trend, it was observed that number of fruits per plant were maximum in plots that received the combinations of highest inorganic fertilizer rates (82 and 61.5 kg Nha^{-1} and 92 & 69 kg P_2O_5 ha^{-1}) with relatively lower rates of inorganic fertilizer (2.5 & 5 t ha^{-1} FYM).It might be due to combination of higher rate inorganic fertilizers with relatively lower rate FYM might result easier nutrient release than higher rate FYM. The result indicated that inorganic fertilizers had more significant effect on fruit number of Marako Fana pepper variety. It is reported unless FYM is integrated with inorganic fertilizers, the use of farmyard manure alone may not fully satisfy crop nutrient demand, especially in the year of application (Patel *et al*., 2009). Supporting this result, Shuresh*et al.* (2013) who studied the productivity of sweet pepper using different nitrogen sources in subtropical climate and found that percentage of fruit set was highest on application of 50% FYM+50 UREA. This is in conformity with Aliyu (1997) who studied the effect of farmyard manure and poultry manure on growth of pepper and found that poultry manure at a rate of 9 t ha^{-1} significantly increased plant heights, number of fruits and fruit yield of pepper.

On the other hand, the minimum number of fruits was obtained from unfertilized plots followed by the combined application of lower rates of inorganic and organic fertilizer. Not only this but also application of all rates of inorganic fertilizers in combination with highest rate of organic fertilizer (10 t ha^{-1} FYM) also provided lower number of fruits. The minimum number of red fruits obtained from the combined application of lower rate inorganic and organic fertilizer might be due to insufficient nutrient supply. Bosland and Votava (2000) indicated that if the assimilates from leaves is limited it affects the pods of pepper. These authors also indicated that the rates of fruits set are negatively correlated with the number of fruits developing on plants. When the plant set several fruits, the rate of flower production decrease. Pepper benefits from some nitrogen, but too much nitrogen can over-stimulate growth resulting in large plants with few early fruits. This is because of the highest supply of nitrogen might have produced large plants with many fruit set at initial that decrease of subsequent flowers production and consequently decreases the total number of fruits. It also might be due to salinity effect. It is in line with Lunin *et al.* (1963) who demonstrated the age of pepper on susceptibility of salinity and found the leaf production dropped sharply when saline conditions were imposed at the early germination stage and as a result yield reduction.

Fruit Length and Width

The analysis of variance also revealed that a combined application of NP and FYM fertilizer has affected significantly ($P<0.01$) the average diameter and length of fruits (Appendix Table 3). The length of red fruits was significantly greatest in plots that received 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}followed by 61.5 kg Nha^{-1}+69 kg P_2O_5 ha^{-1} both in combination with 5 t ha^{-1} FYM. Plants grown in plots treated with 61.5 kg Nha^{-1}+69 kg P2O5ha^{-1} and 82 kg Nha^{-1}+92 kg P_2O_5 ha^{-1} both combined with 2.5 t ha^{-1} FYM as well as blended fertilizer (84 kg N ha^{-1}+76 kg P_2O_5ha^{-1}+14 sulfur kg ha^{-1}) also produced long fruits (Table 4). Plants in unfertilized plot produced fruits significantly short in length and most of the plots that received a combined inorganic and organic fertilizer at different rates also produced fruits statistically same length of fruits in plants grown without fertilizer application. The width of fruits were significantly more in plots that received highest rates of inorganic fertilizers (82 kg Nha^{-1}+92 kg P_2O_5ha^{-1} and 61.5 kg Nha^{-1}+69 kg P_2O_5 ha^{-1}) both combined with 2.5, 5 and 7.5 t ha^{-1} FYM, 41 kg N ha^{-1}+46 kg P_2O_5+5 t ha^{-1} FYM, highest rate of FYM (10 t ha^{-1}) and the blended fertilizer (84 kg N ha^{-1}+76 kgP_2O_5ha^{-1}+14 sulfur kg ha^{-1} (Table 4).

Optimum amount of nitrogen from inorganic and organic fertilizer sources might be important to obtain large size fruits. This might be due to nutrients supply until optimum level. Addisalem (2011) reported that increasing nitrogen to 100 kg ha^{-1} result the highest increase in pod length by about 69% over the control,

Table 4. Effect of FYM and NP fertilizers on number of red fruits, red fruit length and width of Marako Fana pepper variety in 2015/16 in Raya Azebo district

Treatments (N:P kg ha-1+FYM t ha-1)	NRF/P	RFL (cm)	RFW (cm)
82 : 92 +10	17.20fgh	6.77fgh	2.32cd
82 : 92+2.5	24.07ab	8.07bc	2.86a
61.5 : 69+2.5	23.97ab	7.67bcde	2.80a
41 : 46+2.5	15.40hi	6.47gh	1.75ef
20.5 : 23 + 2.5	15.38hi	6.47gh	1.89e
82 : 92 + 5	22.80bc	7.60cdef	2.77a
61.5 : 69 + 5	24.17ab	8.43ab	2.83a
41 : 46 + 5	26.13a	8.98a	2.84a
20.5 : 23 + 5	15.63ghi	6.77fgh	2.20d
82 : 92+ 7.5	21.00cd	7.37cdefg	2.61abc
61.5 : 69 + 7.5	21.73cd	7.57cdef	2.74ab
41 : 46 + 7.5	17.42 fgh	6.85efgh	2.37cd
20.5 : 23 + 7.5	16.37fgh	6.63gh	2.23d
61.5 : 69 + 10	19.87de	7.02defgh	2.50abcd
41 : 46 + 10	16.57fgh	6.967defgh	2.30cd
20.5 : 23 + 10	16.44fgh	6.90efgh	2.26cd
82 : 92	18.40ef	7.20defgh	2.53abcd
0:0:10	17.88efg	7.20defgh	2.41bcd
Unfertilized	13.67i	6.400h	1.50f
84:76 : 14 Sulfur	21.40cd	7.800bcd	2.72ab
LSD (5%)	2.095	0.7386	0.3132
CV(%))	6.6	6.2	7.8

Means with in columns followed by the same letter (s) are not significantly different at P< 0.05: NRF/P=Number of red fruits/ plant, RFL=Red fruit length and RFW=Red fruit width.

however, increasing nitrogen supply from 100 to 150 kg N ha^{-1}decreased pod length by about 21%. Shuresh *et al.* (2013) studied the productivity of sweet pepper using different nitrogen sources in subtropical climate and found that the highest fruit length, fruit diameter and fruit weight were obtained from application of 50% FYM+50% urea the recommended rates. The reason that supply of blended inorganic fertilizer (84 Kg N ha^{-1}+76 Kg P_2O_5 ha^{-1}+14 kg Sulfur ha^{-1}) had no significant difference with that of the highest fruit width obtained from combined inorganic and organic fertilizers applications produced higher fruit width might be attributed due to the presence of sulfur. 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.

Fresh and Dry Red Fruit Weight

The red fruit weight both at fresh and dry conditions were significantly maximum when plots supplied towards the highest combination of inorganic (41 kg Nha^{-1}+46 kg $P_2O_5ha^{-1}$, 61.5 kg Nha^{-1}+69 $P_2O_5ha^{-1}$ and 82 kg Nha^{-1}+92 kg P_2O_5 ha^{-1}) with combination of 5 t ha^{-1}FYM and 2.5 and 7.5 t ha^{-1} FYM for the two latter treatments. On the other hand, the minimum weight of fruit was obtained from unfertilized plot and most plots that received lower rates of inorganic and organic fertilizer combinations as well as in the combination of highest rates of inorganic and organic fertilizers (10 t ha^{-1}FYM). However, the maximum fresh and dry fruit weight was measured from the plot that received 41 kg Nha^{-1}+46 kg $P_2O_5ha^{-1}$+5 t ha^{-1}FYM. This showed that the optimum amount and combination of organic and inorganic fertilizers to attain the plateau of fresh and dry red fruits (peak/ highest weights) was 41 kg N ha-

^{1}+46 kg P_2O_5ha^{-1}+5 t ha^{-1} FYM though it did not show significant difference with some other lower or higher rates of inorganic and organic fertilizers combinations (Table 5). The maximum differences between minimum and maximum fresh and dry fruits weight were 2.07 and 0.96 g respectively. This showed that the maximum increase of 2.07 and 0.96 g fresh and dry fruit weight respectively in the optimum combination of fertilizers over unfertilized plots.

The maximum fresh and dry red fruits weights obtained from the balanced combinations of organic and inorganic fertilizers might be due to the optimum amount of nutrient uptake by the plants. It is in line with the findings of Hedge (1997) reported that pod dry matter content of peppers is directly related to the amount of nutrient taken from the soil, which is proportional to the nutrients present in the soil or the amount of organic and inorganic fertilizers applied to the soil and it is in agreement with the results of the current research. Combination of fertilizers might also provide balanced nutrients such as potassium. It is in conformity with Ozaki and Hamliton (1954) who suggested a bronzing condition of pepper leaves followed by, followed by necrosis and leaf drop associated with low level of potassium. Pundir and Porwal (1999) reported that supplying the plant with 100 kg N ha^{-1} resulted in the production of higher dry weight of pods per plant compared to the dry weight of pods obtained from the lower nitrogen treatments. Such increase might be attributed to the increased in assimilate partitioning towards the pod ultimately increasing the seed number, seed weight, length and width of individual dry pods at this level of nitrogen, resulting in increased weight of pods per plant.

The reason that lower fresh and dry fruit weight obtained from plots treated by higher rate combination of FYM and inorganic fertilizers might be as a result of nutrient toxicity. Toxicity of ammonium or nitrite occurs if the concentration of either raises above 50 mg N kg^{-1} in soil or in other media (Allen and David, 2007). When soil tests show very high or excess levels of a nutrient, yields may be reduced due to toxicity or imbalances of nutrients. Under this situation there is no need to apply fertilizers until levels drop back into the low range. In certain climates, green manure could have definite physicochemical advantages; in other climates, they face major constraints. For example, in temperate climates, low temperatures can hinder organic decomposition that could allow buildup of toxicity. In addition, fertilizer nitrogen is relatively easy to transport and apply, and farmers can readily adjust the timing and rate of application to meet crop requirements. Legume green manures, on the other hand, require careful management. This means that the use of green manures in crop production should be carefully evaluated for each situation (Nand et *al*., 2011).Dong *et al. (*1999) also reported that the probability of phosphorus toxicity increases at concentrations higher than 10 mg g^{-1} dry weight. Jen-. Hshuan (2006) also reported that heavy application of organic manure to agricultural soils may result in salt, nutrient or heavy metal accumulation and may adversely affect plant growth, soil organisms and water quality.

Total Fresh and Dry Red Fruit Yield

The maximum and significantly different total fresh and dry fruit yield t ha^{-1} was obtained from plots that received inorganic and FYM fertilizer combination of 41 kg Nha^{-1}+46 kg P_2O_5ha^{-1}+5 t ha^{-1} FYM. The maximum dry fruit yield obtained was higher by 1.145 t ha^{-1} than dry fruit yield obtained from unfertilized plot that produced significantly lowest yield. However, the combination of highest rates of inorganic fertilizers (61.5 kg Nha^{-1}+69 P_2O_5 ha^{-1}and 82 kg Nha^{-1}+92 kg P_2O_5 ha^{-1}) with 2.5 and 5 t ha^{-1} FYM and blended fertilizer produced statistically similar maximum total dry fruit yield to that of the uppermost dry fruit yield obtained. Similarly, most of the combinations of inorganic and FYM fertilizer at lower rates and at highest rates of FYM (10 t ha^{-1}) produced total dry fruit yield statistically same to unfertilized plot (Table 5). Most of highest and lowest total fresh fruit yields t ha^{-1} were obtained from plots that produced highest and lowest dry fruit yield though it was observed some differences of the fresh and dry fruit yields in same plots that received same fertilizers (Table 5).The low fresh and dry fruit yield observed in plots that received lower rates of inorganic and organic fertilizers in combination might be due to low availability and uptake of nutrient by plants to produce high yield. However, the low fruits yields obtained from plots with the application of combined inorganic and organic fertilizers at highest rates might be due to the toxic effect of nutrients supplied at highest rates.

Plants with excess nitrogen are usually dark green in colour, have abundant foliage, but usually with a restricted root system, flowering and seed production can be reduced(Anonymous, 1999). The author also reported that copper and zinc deficiencies may occur due to excessive phosphorus. Therefore, the application of 100% recommended rates of NP + highest rates of FYM (10 t ha^{-1}) might allow plants the excess uptake of nitrogen and phosphorus and with the combination of this slightly salinity problem of the experimental field resulted low fruit yield. Jen-Hshuan (2006) also reported that heavy application of organic manure to agricultural soils may result in salt, nutrient or heavy metal accumulation and may adversely affect plant growth, soil organisms and water quality. Pam and Brain (2007) reported that high levels of nitrate in ground water can become toxic to plants. According to Jen-Hshuan (2006) and WSU (2005) suggestion, the nutrient release rate of organic manure is too slow to meet crop requirements in a short time. High levels of nitrate in groundwater can become toxic. Therefore, excess organic fertilizer might not released nutrients more than other rates to increase fruit yield rather the negative effect of increasing salinity and toxic underground water might offset and to reduce fruit yields.

Amare *et al.* (2013) also reported that the highest dry pod yields (1.67 t ha^{-1}) were obtained from the variety Marako Fana with combined application of 92 kg N ha^{-1} and 69 kg P_2O_5 ha-^{1} fertilizers. Addisalem (2011) also reported the highest dry pod yield (3.1 t ha^{-1}) of Marako Fana pepper variety obtained from the application of 100 kg ha^{-1} nitrogen Siddesh, (2006) also observed greater yield of pepper (1.52t ha^{-1}) with application of farm yard manure (FYM) 9t/ha along with 50:50:50 kg of N, P2O5 and K_2O ha^{-1}. It is in line with Mallanagouda *et al.*(1995) who reported that integrated application of recommended dose of NPK+FYM improved the growth parameters as well as yield and yield components in pepper.

Table 5.Effect of FYM and NP fertilizers on red fruit weight and total red fruit yield of Marako Fana pepper variety in 2015/16 in Raya Azebo district

Treatments (N:P kg ha-^{1}+FYM t ha-^{1})	Red fruit weight (g)		Red fruit yield (t ha^{-1})	
	Fresh fruit	Dry fruit	Fresh fruit	Dry fruit
82 : 92 +10	3.98^{defg}	1.36^{efgh}	4.44^{g}	1.67^{fgh}
82 : 92+2.5	5.16^{ab}	1.90^{abc}	6.60^{b}	2.40^{ab}
61.5 : 69+2.5	5.15^{ab}	1.89^{abc}	6.47^{bc}	2.34^{abc}
41 : 46+2.5	3.69^{fg}	1.22^{gh}	4.10^{gh}	1.52^{hi}
20.5 : 23 + 2.5	3.69^{fg}	1.22^{gh}	4.27^{gh}	1.55^{hi}
82 : 92 + 5	4.960^{bc}	1.80^{abc}	6.24^{bcd}	2.27^{abc}
61.5 : 69 + 5	5.20^{ab}	1.91^{ab}	6.62^{b}	2.38^{ab}
41 : 46 + 5	5.42^{a}	2.06^{a}	7.51^{a}	2.50^{a}
20.5 : 23 + 5	3.32^{g}	1.23^{fgh}	4.25^{gh}	1.54^{hi}
82 : 92+ 7.5	4.65^{abcde}	1.66^{bcde}	5.72^{de}	2.07^{cde}
61.5 : 69 + 7.5	4.78^{abcd}	1.72^{bcd}	5.82^{cde}	2.14^{bcd}
41 : 46 + 7.5	4.08^{defg}	1.38^{efgh}	4.68^{fg}	1.70^{fgh}
20.5 : 23 + 7.5	3.83^{efg}	1.30^{fgh}	4.28^{gh}	1.65^{ghi}
61.5 : 69 + 10	4.45^{bcdef}	1.57^{cdef}	5.43^{e}	1.95^{def}
41 : 46 + 10	3.88^{efg}	1.31^{fgh}	4.44^{g}	1.62^{ghi}
20.5 : 23 + 10	3.85^{efg}	1.30^{fgh}	4.31^{gh}	1.61^{ghi}
82 : 92	4.18^{cdefg}	1.45^{defg}	5.31^{ef}	1.90^{defg}
0:00:10	4.10^{cdefg}	1.41^{defgh}	4.70^{fg}	1.80^{efgh}
Unfertilized	3.35^{g}	1.10^{h}	3.63^{h}	1.35^{i}
84:76 : 14 Sulfur	4.77^{abcd}	1.72^{bcd}	5.94^{bcde}	2.25^{abc}
LSD (5%)	0.755	0.2931	0.6705	0.2627
CV (%)	10.6	11.6	7.7	8.3

Means with in columns followed by the same letter (s) are not significantly different at $P< 0.05$

Marketable and Unmarketable Yield

The maximum and significantly different marketable dry fruit yield t ha^{-1} was obtained from plots fertilized 41 kg Nha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1}FYM closely followed by plots that received 61.5 kg Nha^{-1}+69 Kg P_2O_5ha^{-1} and 82 kg Nha^{-1}+92 kg P_2O_5 ha^{-1} in combination with 2.5 to both treatments and 5 t ha^{-1} FYM for the former treatment(Table 6, Appendix Table 4). The maximum marketable yield obtained might be attributed to the enhanced pod length, pod width, higher seed weight, seed number per pod and higher total dry pod weight per plant obtained at these levels of fertilizer rates. It is in conformity with Leghari and Oad (2005) who reported that pod length, width and total dry pod weight per plant were positively correlated with marketable green pod yield in pepper.Application of essential nutrients increases vegetative growth. This in turn had resulted in development of pods which are relatively healthy, attractive and acceptable in markets. Similarly Matta and Cotter (1994) pointed out that marketable pod yield increase in response to addition of nutrients in nutrient deficient soils.

The integrated application of FYM and inorganic fertilizers might also produce better yield. It is reported unless FYM is integrated with inorganic fertilizers, the use of farmyard manure alone may not fully satisfy crop nutrient demand, especially in the year of application (Patel *et al*., 2009). Tadila (2011) also studiedeffect of manure and nitrogen rates on yield and yield components of garlic (*Allium sativum L.*) at Haramaya, eastern Ethiopia and he found that the minimum bulb dry matter yield was recorded at the combined application of 50 kg N ha^{-1}+10 t ha^{-1}manure. It is supported by Siddesh (2006) who reported that the application of 150 kg Nha^{-1}and 10tha^{-1}FYM increased the green pepper yield by 60.42 % over the control.It is in line with Babli (2007) who reported that application of 50% recommended dose of chemical fertilizer and 50 % FYM (12.5 ha^{-1}with reduced level of recommended dose of fertilizer (50%) helps in higher vegetative growth and yield in tomato. Tisdale and Nelson (1993) suggested that organic fertilizers such as FYM, biogas, chicken manure, compost, Pigeon and green manure are good sources for macro and micronutrients essential for

Table 6. Effect of FYM and NP fertilizers on marketable and unmarketable red fruit yield, average number of seeds and weight of seeds per fruit of Marako Fana pepper variety in 2015/16 in Raya Azebo district

Treatments (N:P kg ha^{-1}+FYM t ha^{-1})	MKY (t ha^{-1})	UNMY (t ha^{-1})	AvNS/P	AvWS/P (g)/ p
82 : 92 +10	1.37^{hi}	0.30^{bc}	88.00^{g}	0.50^{g}
82 : 92+2.5	2.19^{ab}	0.21^{bcd}	130.30^{abc}	0.71^{b}
61.5 : 69+2.5	2.17^{ab}	0.17^{bcd}	129.70^{abc}	0.68^{bc}
41 : 46+2.5	1.43^{ghi}	0.09^{d}	77.70^{ghi}	0.38^{ij}
20.5 : 23 + 2.5	1.37^{hi}	0.18^{bcd}	75.30^{hi}	0.34^{jk}
82 : 92 + 5	2.04^{bc}	0.23^{bcd}	128.70^{abc}	0.68^{bcd}
61.5 : 69 + 5	2.16^{ab}	0.22^{bcd}	136.00^{ab}	0.72^{ab}
41 : 46 + 5	2.38^{a}	0.12^{cd}	138.00^{a}	0.77^{a}
20.5 : 23 + 5	1.42^{ghi}	0.13^{cd}	80.30^{ghi}	0.42^{i}
82 : 92+ 7.5	1.81^{cd}	0.26^{bcd}	121.30^{cd}	0.62^{cef}
61.5 : 69 + 7.5	2.01^{bcd}	0.13^{cd}	126.00^{abc}	0.66^{bcde}
41 : 46 + 7.5	1.57^{efghi}	0.13^{cd}	106.00^{f}	0.58^{f}
20.5 : 23 + 7.5	1.36^{hi}	0.28^{bcd}	83.00^{gh}	0.42^{i}
61.5 : 69 + 10	1.67^{efgh}	0.28^{bcd}	118.00^{cde}	0.62^{cdef}
41 : 46 + 10	1.44^{fghi}	0.19^{bcd}	87.00^{gh}	0.48^{gh}
20.5 : 23 + 10	1.44^{ghi}	0.16^{bcd}	85.30^{gh}	0.43^{hi}
82 : 92	1.76^{cdef}	0.14^{cd}	108.70^{ef}	0.60^{f}
0:0:10	1.44^{fghi}	0.35^{b}	113.30^{def}	0.61^{ef}
Unfertilized	1.25^{i}	0.10^{cd}	69.30^{i}	0.31^{k}
84:76 : 14 Sulfur	1.71^{defg}	0.53^{a}	124.30^{bcd}	0.62^{cdef}
LSD (5%)	0.2844	0.1670	10.926	0.05469
CV (%)	10.1	48.1	6.2	5.9

Means with in columns followed by the same letter (s) are not significantly different at P< 0.05. MY=Marketable yield,UNMY=unmarketable yield,AvNS/P=Average number of seeds per pod and Avws/P=Average weight of seeds per pod.

plant growth. It is also a good soil conditioner for both sandy and heavy clay soils. Organic matter increases the porosity of heavy soils, which in turn increases water absorption and lessens water run-off, leaching, and erosion (Ware and Mc-Collum, 1980).Beckman (1973) also reported that the use of organic manure application enhances soil productivity, increase soil micro organisms, improves soil crumb structure, improves nutrient status of the soil and enhances pepper yield. Addo-quaye, *et al.* (1993) also reported that phosphorus promotes root growth, flower, and fruit and seed development and stimulate stiffer stems.

The minimum and significantly different marketable dry fruit yield t ha^{-1} was obtained from the plot that did not received fertilizers. However, most of the plots that received combined organic and inorganic fertilizers at lower rates and combinations with highest rate FYM (10 t ha^{-1}) produced statistically same amount of low marketable dry fruit yield. It might be due to that either the nutrient release of FYM might be lower compared other treatments or there might be toxic effect for higher rate combinations.

Production of lower marketable yield from higher rate combination of inorganic and organic fertilizers could be due to toxic effect of over fertilization. Harmful effects to the young plants leading to retarded growth or death have been observed when organic matter in the form of compost or FYM is added at high rates in pot experiments under greenhouse conditions (Gupta *et al*., 1990). Bosland and Votava (2000) reported that high salt in the soil could result pinching off young leaves at the soil line and young seedling can die when light rain moves the salt to the younger tender roots. The authors also pointed out that high nitrogen fertilizer is unable to translocate adequate calcium to the pod and as the result the yield could be low. It is similar with the finding of Siti *et al.*(1993) who observed that total marketable fruit weight per plant decreased by 0.5 kg per plant as nitrogen level increased from 112 to 448 kg ha^{-1} in pepper. This result is also consistent withAddisalem (2011) who found that the marketable yield of Marako Fana reduced as nitrogen level increased from 100 Kg $ha^{-1}$to 150 kg ha^{-1}. The production of lower marketable yield from lower rate combinations might also bebecause of that the phosphorus level of FYM released to the crop might be lower in relative to other treatments.

On the other hand, significantly maximum and minimum unmarketable dry fruit yield were obtained from blended fertilizer and 41 kg N+46 kg P_2O_5+2. 5 t FYM ha^{-1} application respectively. The highest FYM (10 t ha^{-1}) application alone also produced the second maximum significantly different unmarketable dry fruit yield. Most of others combined applications of inorganic and organic fertilizers produced almost same amount of unmarketable dry fruit yield (Table 6, Appendix Table 4). Treatments with adequatelevel of phosphorus might initiate fruit setting development thereby producing acceptable pods in the market. Fruits harvested from plots treated with lower level of phosphorus could thus smaller in size, less firm, lesser in shininess and exhibit higher proportion of surface defects as compare with plots treated with high level of phosphorus. There also might be phosphorus deficiency on plots treated with blended fertilizer so as to produce high unmarketable yield due to improper pod colour. Pepper deficient in Phosphorus fertilizer produce weak plants with narrow, glossy and grayish green colour pod of pepper (Miller, 1961).

Number and Weight of Seed Per Fruit

The analysis of variance result revealed that number of seeds per fruit was highly significantly ($P<0.01$) influenced by treatments (Appendix Table 4). Plants that received 41 Kg N ha^{-1}+46 kg P_2O_5 ha^{-1} followed by 61.5 Kg N ha^{-1}+69 kg P_2O_5 ha^{-1} both in combination of 5 t FYM ha^{-1} produced significantly maximum number and weight of seeds per fruit without significant difference between the two treatments (Table 6). The inorganic fertilizer application at the rate of 61.5 kg Nha^{-1}+69 kg P_2O_5 ha^{-1}, 82 kg Nha^{-1}+92 kg P_2O_5 ha^{-1}in combination with 2.5 and with 7.5 t ha^{-1}FYM and5 t FYM $ha^{-1}$for the former and the latter treatments also produced significantly same highest number of seeds per fruit. Average number and weight of seeds per fruit was significantly low in plants that did not receive fertilizer. Conversely, the inorganic fertilizer application of 20.5 kg Nha^{-1}+23 kg P_2O_5 ha^{-1} and 41 kg Nha^{-1}+46 kg P_2O_5 ha^{-1}both in combination with lower rates of 2.5 and 5 t ha^{-1}FYM for the former treatment also produced low number and weight of seeds per fruit. The number of seeds and weight of seeds per fruit obtained from plants that did not receive fertilizer was lower by 50.23 and 40.08% than the highest number and weight of seeds per fruit, respectively, which was obtained from plants that received balanced fertilizer combination. The number and weight of seeds in dry fruit of pepper are the components that increase the weight fruit. The results indicated that the application of fertilizers both inorganic and organic in balanced combination produced fruits with highest number and weight of seeds and thereby high economic return for farmers. Most of the time number and weight of seeds per fruit are directly related.

Supporting this result, Bosland and Votava (2000) indicatedthe 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. The increase in seed weight could be related to the significant increase in seed number per pod. Similarly, Lemma (1998) reported that there was positive relationship between seed number per pod and pod size. It is also in conformity with Russo (2003) who reported that fruit weight increased linearly with seed number in sweet pepper. In this study, the lowest seed number and weight were obtained in plots that received high fertilizer combination. This might be due to negative effect of heavy fertilizers application. The use of chemical nitrogen and phosphorus fertilizers at high levels had an adverse effect on the accumulation of NH4+, NO3- and PO4- in fruit tissues (Abd El-Hakeem, 2003).

SUMMARY AND CONCLUSION

Pepper *(Capsicum annuum* L.*)* is the world's most important vegetable after tomato. Marako Fana pepper variety has large and pungent pods with highly demanded dark- red color. This variety is highly preferred by the local consumers in Raya Azebo Woreda of Northern Ethiopia. The production of this variety in the area is depending on either on the national recommendation of fertilizer rates or by farmers' decision. However, the application of fertilizer is necessary depending on the study results in the specific area and crop. In addition, currently blended fertilizer application is encouraging in the region even in the country as a whole. Therefore, the study was conducted in Raya Azebo Woreda of Northern Ethiopia; specifically Kara Kebele in 2015/16.

The crop phenology, growth, yield and yield components were considered. The highest and significantly different total dry fruit yield t ha^{-1} was obtained from plots that received inorganic and organic fertilizers combination of 41 kg N+46 kg P_2O_5+5 t FYM ha^{-1}. Similarly, the highest marketable yield (2.375 t ha^{-1}) of Marako Fana was obtained on combined application of 41 kg N ha^{-1}+46 kg P_2O_5 ha^{-1}+5 t ha^{-1} FYM which consisted of 50% the blanket recommendation inorganic fertilizers and 5 t ha^{-1}FYM. The application of this treatment showed about 1.125 t ha^{-1} more marketable yield than unfertilized plot. Most of treatment combinations of inorganic and organic fertilizers produced almost same 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.

Competing interests

Authors have declared that no competing interests exist.

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