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Effect of Farmyard Manure and Blended Fertilizer Rates on Yield and Yield Components of Hot Pepper (*Capsicum annuum* L.) in East Wollega Zone, Ethiopia

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Abstract: Hot Pepper (Capsicum annuum L.) is an important spice and vegetable crop in Ethiopia. However, soil fertility depletion (nutrient deficiency) is one of the vital yield limiting factors in production. This experiment was conducted with the objective of determining the effects of combined use of different levels of Farmyard manure and blended fertilizer (NPSZnB) rate on yield and yield components of hot pepper and to identify the optimum combination of two fertilizers levels that give a higher yield of hot pepper. Mareko Fana variety was used for experiment. The treatments consisted of three levels of farmyard manure (0, 2, and 4 t/ha) and five levels of bended fertilizers (0, 25, 50, 75 and 100 kg/ha) combined factorially and arranged in a Randomized Complete Block Design with three replications. Analysis of the results showed that the interaction of farmyard manure and blended fertilizer significantly ($p<0.05$) affect most of the parameters studied. Application of 4t/ha farm yard manure and 100kg/ha blended fertilizers results showed that higher plant height 67.05cm, number of primary branches (7.82), number of leaf (331.72), number of fruit per plant (29.61), fruit length (10.49cm), total fresh fruit yield (5.60 t/ha), marketable yield (2.34 t/ha), total dry fruit yield (2.46 t/ha), biomass yield (4.96 t/ha) and harvest index (0.39) whereas lowest marketable yield (1.13 t/ha) and total dry fruit yield (1.25 t/ha), were recorded from unfertilized treatment. Therefore, the result of this study has showed that levels of farmyard manure and blended fertilizer in the study areas could be significantly enhances yield and yield components of hot pepper if 4 t/ha of Farmyard manure and 100 kg/ha of blended fertilizer are integrated and applied to hot pepper. Moreover, farmers in the study area should be encouraged to use integrated nutrient management system rather than inorganic fertilizer alone since such system helps not only supply nutrients but also improves physicochemical properties of the soil, thereby significantly enhances yield and yield component of hot pepper. Furthermore, as the study was conducted only 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 irrigated conditions.

Keywords: Mareko Fana Variety, Farmyard Manure, Blended Fertilizer, Marketable Yield

1. Introduction

Hot pepper (*Capsicum annuum* 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 [9]. It is originated from South and Central America where it is still under cultivation. *Capsicum spp.* is the most common crop in the countries of the tropics and subtropics with *Capsicum annuum* L. by far the most widespread species as spice and as a vegetable. The major center of diversity is Brazil where representatives at all cited levels are found [13].

Peppers are grown extensively under various environmental and climatic conditions. It is an important cash crop for smallholder farmers in developing countries such as Ethiopia, Nigeria, Ghana, China, India, Pakistan, Bhutan, Indonesia, Cambodia, and Thailand [23]. In many countries of the world, pepper is a cash crop with high domestic and export value. Peppers are widely grown in various parts of Ethiopia; small-scale farmers produce the largest proportion of hot pepper in the country [20]. In Ethiopia, hot pepper is commonly cultivated within an altitude ranges of 1400 to 1900 meter above sea level which receives mean annual rainfall of 600 to 1200 mm, and has mean annual temperature of 25 to 28°C [28]. The fruits are consumed as fresh and dried, row material for the processing industries, important cash crop for farmers, and source of employment to urban and rural populations [18]. Hot pepper is a high value and important cash crop for smallholder farmers in developing countries, which has potential for improving the livelihoods of thousands of smallholder farmers in Ethiopia [20, 21].

The average daily consumption of hot pepper by Ethiopian adult is estimated 15 gram, which is higher than tomatoes and most other vegetables [27]. However, pepper is the major ingredient in the daily diet of most Ethiopians, the supply of pepper is below the average demand. In addition to local consumption as a spice, it has export value for oleoresin extraction, which has been an exported different country by Ethiopian Spices Extracting Factory (ESEF). However, since 2004 there was a decrease in export of oleoresin due to shortage of raw material in the country for consumption and oleoresin extraction [17].

Despite enormous importance of pepper as vegetable, spice, medicine and ornamental, the production and productivity of hot pepper is low. Evidently, FAO revealed that world dry chilies and peppers covered an area of 1.8 million ha with total production of 3.9 million tonnes. While, green chilies and peppers occupied total area of 1.9 million ha and total production from this harvested area is 34.5 million tonnes. In terms of productivity, dry chilies and peppers produced yield ha^{-1} of 2.2 tonnes and that of green chilies and peppers 17.8 tonnes ha^{-1} [19].

In Ethiopia, green and red pepper covers an area of 190,533.74 hectare, which shares about 79.5% of the total area occupied by vegetable crops (239,609.76 hectares) at the national level [14]. In terms of production, green and red peppers share 48.2% of vegetable production whereby 391,598.6 tonnes of both peppers produced at the national level with yield per hectare of 1.83 and 6.3 t ha^{-1} for red and green peppers respectively [14].

Therefore, it can be concluded that Ethiopia's Capsicum productivity is far below the world average that strongly demands immediate improvement, aiming at increasing productivity. Low inputs, lack of improved pepper varieties, inadequate knowledge on production and management systems, poor extension services, poor marketing system and presence of diseases and insect pests are the major factors have contributed to the low yield of the crop in the country [16].

In Ethiopia, soil fertility depletion is one of the vital yield limiting factors in vegetable producing areas of the country owing to intensive cultivation, very low and unbalanced nutrient supply. On the other hand, the sources of plant nutrients for Ethiopian agriculture over the past five decades have been limited to urea, and Diammonium Phosphate (DAP) fertilizers, which contain only nitrogen and phosphorus that may not satisfy the nutrient requirements of crops including pepper. In this regard however, Ethiopian soils lack most of the macro and micronutrients that are required to sustain optimal growth and development of crops [32]. This is exacerbated especially by Ethiopian fertilizer rates that are below international and regional standards (Agriculture Growth Program, 2013). Integrated use of organic waste and N fertilizers significantly increase the uptake of the N. The combination of organic fertilizer and inorganic fertilizers promote plant growth the most [15]. Consequently, the yield and productivity of crops including pepper in Ethiopia are much lower than other countries. To narrow the yield gap a number of options can be taken by applying organic and newly introduced blended fertilizers and determining the optimum fertilizer rate.

Compost manure contains both micro and macro nutrients than inorganic fertilizer. This waste-to wealth technology is not only targeting private profit but also environmental benefit [22]. Organic manure can increase soil drainage, soil aeration, water holding capacity and the ability of the soil to hold nutrients. The beneficial effects of organic matter on soil structure can have a greater effect on plant growth than the fertilizer value of some of the organic materials. Adding organic manure to the soil not only fertilizes the soil but also improves soil structure and retention capacity. In more developing countries, there is a growing demand for organic foods driven primarily by consumer's perceptions of the quality and safety of such foods and to the position of environmental impact of organic agriculture practices. It was also reported from the same source that organically produced foods have lower levels of pesticides, hormonal residues and better storage quality than the conventional produce.

Increasing crops yields through the application of nitrogen and phosphorus alone can deplete other nutrients. Recent studies have indicated that elements like N, P, K, S and Zn levels as well as B and Cu are becoming depleted in most Ethiopian soils and deficiency symptoms are being observed on major crops in different areas of the country [7]. To avert the situation the Ministry of Agriculture of Ethiopia has been recently introduced blended fertilizer rate. However, little information is available on blended fertilizers requirement of hot pepper including macro and micronutrients this fertilizer has been currently substituted DAP in Ethiopian crop production system as main source of phosphorous (Ministry of Agriculture and Natural Resource [29].

Thus, this study was conducted to determine the effect of combined application of farmyard manure with newly introduced blended fertilizers rate on the yield and yield components of hot pepper in Guto Gida district of East Wollega zone.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Uke Research and Demonstration site of Wollega University, located in Guto Gida District of East Wollega zones of the Oromia regional state in western Ethiopia during the main cropping season of 2018/19. Uke is located in Guto Gida district of East Wollega zone on the main road from Nekemte to Bure. It is located about 365 km far away from Addis Ababa and around 40km far away from Nekemte town to north direction on main road Bure town. The topographical location of the area is between 1500-1700 m.a.s.l and it is an area with high temperature, sun light and rain fall condition.

2.2. Experimental Materials

Hot pepper (*Capsicum annuum* L.) variety Marako Fana which is released by Melkassa Agricultural Research Center through selection that has been widely produced in the experimental area was taken from Bako Agricultural Research Center (BARC) and used as planting material for the study.

2.3. Experimental Treatments and Design

The experiment was laid out in 5*3 (five level of NPSZnB and three levels of FYM fertilizers) factorial arrangement in Randomized Complete Block Design with three replications. The treatments consist of five NPSZnB levels (0, 25, 50, 75 and 100 kg ha^{-1}) and three FYM levels (0, 2, and 4 t ha^{-1}) fertilizers were randomly allocated to the experimental units within a replication in accordance with the design.

2.4. Experimental Producers

Hot pepper seedlings were raised in the nursery on a well-prepared seedbed of 5m in length and 1m in width. When the emerged seedlings attain 5 - 6 pair of true leaves (after 3-6 weeks from sowing) the seedbed was watered before uprooting the seedlings in order to minimize the damage of the seedlings root. Healthy, uniform and vigorous seedlings were transplanted into prepared field at spacing of 70 cm x 30 cm between rows and plants respectively on 650 m^2 area of experimental plots and each plot a size of 10.5 m^2 (3.5m * 3m). Each experimental plot has five rows and each row contains ten plants. Plots and blocks were separated by 0.5m and1m path road respectively.

2.5. Data Collection and Analysis

Data such as Number of days to 50% flowering, Number of days to 50% fruit maturity, Plant height, Canopy diameter, Number of primary branches per plant, Number of leaves per plant, Number of fruit per plant, Fruit length, Fruit diameter, Thousand seed weight, Total fresh fruit yield, Marketable dry pod yield, Unmarketable dry pod yield, Total dry fruit yield, Biomass yield, Harvest index were collected from the central three rows excluding the borders. Individual response parameters were recorded from six randomly selected plants in the middle rows on the net plot bases.

Soil samples were collected before planting and after harvesting from selected site at a depth of 0-30 cm in all sites following a zigzag fashion (W-shape) using an auger.

3. Results

3.1. Soil Physicochemical Properties

The soil sample collected from the experimental field before planting was analyzed for some selected soil properties and data were determined in the laboratory.

3.2. Soil Chemical Properties Analyzed After Harvesting

Chemical properties of the soil after harvest showed increase in contents of total nitrogen, available phosphorus, organic matter and organic carbon; but decreased in pH as the rates of applied blended fertilizer and farmyard manure rate increased (Table 1).

Table 1. *Physical and chemical properties of soil of the experimental area before and after transplanting.*

Before transplanting	**Parameters**					
	TN (%)	**P (Ppm)**	**OC (%)**	**CEC (cmol)**	**OM (%)**	**pH (H_2O)**
	0.22	4.64	2.53	22.6	4.36	5.7
Soil texture Class		Clay 34%	Sand 44%	Silt 22%	Soil texture=Clay loam	

After Harvesting

No	**FYM t/ha**	**NPSZnB kg/ ha**	**TN (%)**	**P (Ppm)**	**OC (%)**	**OM (%)**	**pH (H_2O)**
1	0	0	0.21	4.43	2.49	4.29	5.53
2	0	25	0.22	5.41	2.5	4.41	5.68
3	0	50	0.22	5.53	2.56	4.32	5.25
4	0	75	0.23	6.04	2.65	4.58	5.18
5	0	100	0.23	6.11	2.66	4.58	5.23
6	2	0	0.23	6.41	2.67	4.65	5.34
7	2	25	0.23	7.76	2.7	4.6	5.58
8	2	50	0.24	7.89	2.73	4.7	5.57
9	2	75	0.24	7.94	2.74	4.75	5.48
10	2	100	0.24	8.51	2.75	4.73	5.24
11	4	0	0.24	10.12	2.76	4.72	5.47

No	FYM t/ha	NPSZnB kg/ ha	TN (%)	P (Ppm)	OC (%)	OM (%)	pH (H_2O)
12	4	25	0.24	10.49	2.79	4.8	5.32
13	4	50	0.24	16.2	2.81	4.85	5.40
14	4	75	0.25	16.75	2.93	5.04	5.49
15	4	100	0.26	18.23	2.99	5.16	5.08

%TN=percent of total nitrogen, Av. P. Ppm=available phosphorus in parts per million, CEC (Cmolkg^{-1})=cation exchange capacity in cent mole, pH=hydrogen power, % OC=percent of organic carbon, %OM=percent of organic matter

4. Discussion

4.1. Effect of FYM and Blended Fertilizer on Phenology of Hot Pepper

4.1.1. Days to 50% Flowering

The analysis of variance showed that there was interaction effect of farmyard manure (FYM) and blended fertilizer rate on days to 50% flowering of hot pepper. Early flower formation was observed from the plot that received fertilizers as compared to the unfertilized plot or control (Table 4). Minimum days to flowering (69.79 days) was observed from the application of blended fertilizers 100 kg/ha of NPSZnB + 2 t/ha of FYM, while the maximum days to flowering of hot pepper (80.83days) was observed at the application of 100 kg/ha of NPSZnB + 4 t/ha of FYM. It was observed that days to 50% flowering stage delayed gradually with the increment level of farmyard manure from 0t/ha-4t/ha (Table 2).

Application of blended fertilizer (100kg/ha NPSBZn +2t/ha FYM) rate hastened days to flower by eleven days and nine days as compared to the plot that received 100 kg/ha + 4 t/ha and unfertilized plot respectively. The significant difference among the treatments might be attributed to the levels of farmyard manure and blended fertilizer, which enhanced vegetative growth of the crop and prolonged days required to attain 50% of flowering. Blooming was inhibited with fertilizer containing highest level of N and micro nutrient particularly Fe and Zn supply due to transformation of assimilates towards vegetative growth rather than reproductive growth [31]. Thus, increasing the levels of farmyard manure with blended fertilizer rates delayed days to flowering of hot pepper.

Table 2. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on days to flowering of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSZnB rate kg ha^{-1}				
FYM rate t ha^{-1}	0	25	50	75	100
0	78.16^{b}	77.00^{bc}	76.33^{cd}	74.66^{de}	72.75^{fg}
2	78.00^{bc}	74.33^{ef}	73.17^{efg}	72.33^{g}	69.73^{h}
4	76.50^{bc}	76.50^{bc}	77.33^{bc}	78.08^{b}	80.83^{a}
LSD (5%)	1.72				
CV %	1.32				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.1.2. Days to 50% Maturity

The number of days to 50% maturity was highly significantly (*P=0.01*) influenced by interaction of farmyard manure and blended fertilizer rate application. The maximum date required to attain days to 50% maturity (141.17days) was recorded from combined application of 4 t/ha of FYM with 100kg/ha of NPSZnB rate while (126.47 days) was recordedfrom unfertilized treatment. The result indicated that increasing rate of FYM delayed time of maturity of hot pepper, whichmay be attributed to the role that manure plays significant role in promoting vegetative growth as nitrogen promotes vegetative and lush growth thereby delaying plant maturity.

This finding agrees with the finding of who reported that increasing levels of N delayed the period required for fruit setting and fruit ripening [24]. Increasing of NPS fertilizer level increased days to maturity of potato cultivars in the way that as NPS fertilizer increased, duration of vegetative phase of potato also prolonged and in turn, maturity date delayed [5].

Table 3. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on days to fruit maturity of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSBZn rate kgha^{-1}				
FYM rate t ha^{-1}	0	25	50	75	100
0	138.83^{ab}	137.00^{bc}	136.17^{bc}	134.00^{cd}	131.67^{d}
2	137.33^{b}	132.00^{d}	128.50^{e}	126.47^{e}	127.66^{e}
4	136.50^{bc}	137.92^{b}	137.25^{b}	138.33^{ab}	141.17^{a}
LSD (5%)	3.06				
CV%	1.38				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.2. Effect of FYM and Blended Fertilizer on Growth Parameters of Hot Pepper

4.2.1. Plant Height

Plant height was significantly (*P<0.05*) affected by the interaction of farmyard manure and blended fertilizer rates (Table 4). The longest plant height (67.05 cm) was recorded from combination of FYM and NPSZnB 4 t/ha +100kg/ha respectively, while the shortest (42.99 cm) was recorded from unfertilized plot or control treatment (Table 4).

Increasing in plant height while FYM and NPSZnB rate increased might be attributed to nitrogen, which contributes for plant elongation and initiating growth-promoting hormones (IAA) similar to that of Zn and protein synthesis. Evidently, N is component of amino acids and chlorophyll, which is the primary light harvesting pigment for photosynthesis; plant height is positively responded to the application of this nutrient [11].

Table 4. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on plant height of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSZnB rate kgha^{-1}				
FYM rate t ha^{-1}	0	25	50	75	100
0	42.99^{g}	4767^{fg}	57.10^{d}	60.13^{bc}	59.88^{cbd}
2	47.22^{fg}	51.38^{ef}	58.06^{cd}	64.29^{ab}	65.55^{ab}
4	56.33^{de}	58.61^{cd}	59.22^{bcd}	65.16^{a}	67.05^{a}
LSD (5%)	5.20				
CV %	5.36				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.2.2. Canopy Diameter

Analysis of variances showed that Canopy diameter was not significantly (*P<0.05*) affected by the interaction of farmyard manure and blended fertilizers rates, but there is individually affect

4.2.3. Number of Branches Per Plant

The application of combined use of farmyard manure and blended fertilizers was significantly (P<0.05) differences with regard to the number of primary branches. The maximum number of primary branches (7.82) and the minimum number of primary branches (3.36) was observed from application of blended fertilizers rate of 100kg/ha NPSZnB + 4 t/ha FYM and 0kg/ha NPSZnB + 0t/ha FYM, respectively (Table 5).

The increase in the number of branches in response to the increases in the rates of fertilizers up to optimum could be attributed to the positive effect of NPSZnB and FYM nutrients on promotion of vegetative growth.

In agreement with this, found that branch numbers were highly significantly and positively influenced by N [26]. Application of NP + bioslurry increased the number of secondary branches of tomato cultivars [10]. The highest number of secondary branches through application of 82 kg N ha^{-1} + 92 kg P_2O_5 ha^{-1} + 2.5 t ha^{-1} FYM [6]. Similar result where high nitrogen increase primary, secondary and tertiary branches that contributed to fruit set [4].

Table 5. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on number of branches per plant of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSZnB kgha^{-1}				
FYM t ha^{-1}	0	25	50	75	100
0	3.36^{j}	4.61^{hi}	5.44^{efg}	5.86^{cdef}	6.07^{cde}
2	4.13^{i}	5.24^{fgh}	5.59^{defg}	6.19^{cbd}	6.37^{bc}
4	5.02^{gh}	5.28^{fg}	5.99^{cde}	6.75^{b}	7.82^{a}
LSD (5%)	0.64				
CV %	6.70				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3. Effect of FYM and Blended Fertilizer on Yield and Yield Attributes of Hot Pepper

4.3.1. Number of Fruits Per Plant

The analysis of variance for number of fruit per plant showed significant (p<0.05) differences due to interaction effect of farmyard manure and blended fertilizers. The highest number of pods (29.61) was recorded in treatment combination of Blended fertilizer and Farmyard manure application at the rate of 100kg/ha + 4 t/ha respectively, whereas the lowest number of pods (12.33) was recorded from control treatment (Table 6).

Sufficient availability of nutrients due to blended fertilizer and farmyard manure application enables the plant to acquire higher number of pods per plant and seeds per pod, through influencing photosynthetic activity and its proper partitioning. Nitrogen rates revealed positive association and highly significant variation on pod number per plant [8, 36].

Table 6. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on number of leaf per plant of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatment	NPSZnB rate kg ha^{-1}				
FYM t ha^{-1}	0	25	50	75	100
0	12.33^{i}	17.33^{h}	24.11^{efg}	27.74^{abcd}	28.44^{abc}
2	15.83^{h}	21.94^{fg}	25.39^{cde}	29.43^{ab}	28.78^{ab}
4	20.83^{g}	24.50^{def}	26.17^{bcde}	28.61^{abc}	29.61^{a}
LSD (5%)	3.29				
CV %	8.36				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.2. Fruit Length (cm)

Fruit length was measured after harvest and it showed statistically significant (P<0.05) difference due to interaction of farmyard manure and blended fertilizers application rates (Table 7). Increasing NPSZnB and FYM levels showed a consistent fruit length increment. The highest fruit length (10.49cm) was recorded from the application of 100kg/ha of NPSZnB + 4 t/ha of FYM. However, the lowest (6.51cm) was recorded from the control treatment or unfertilized plot.

Increasing nitrogen to 100 kg /ha result in the highest increase in pod length by about 69% over the control; however, increasing nitrogen supply from 100 to 150 kg N ha^{-1} decreased pod length by about 21% [2]. The possible reason for increased fruit length at the highest fertilizers rate might be due to plants that exhibit vigorous growth characteristics are those plants that acquired sufficient amount of essential nutrients. These nutrients in turn are translocated into the fruits and result in fruit enlargement, if not beyond the optimum level. The result also agreed with that higher levels of nitrogen beyond the optimum would usually lead to growth of more branches, increased plant height, more number of fruits, which could have increased competition for assimilate partitioning among the plant parts, thereby reducing pod length and width [26]. Plants sprayed with both Zn and B or Zn alone showed maximum pod diameter, pod length and individual fruit weight of hot pepper [34]. Therefore, subjectively this quality attribute, along with pod length and thickness could be of better preference to consumers over thinner and shorter pods.

Table 7. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on fruit length per plant of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSZnB rate kg ha^{-1}				
FYM t ha^{-1}	0	25	50	75	100
0	6.51^{g}	7.83^{e}	8.52^{d}	9.19^{c}	9.58^{bc}
2	7.21^{f}	8.32^{de}	9.22^{c}	10.03^{ab}	10.01^{ab}
4	8.53^{d}	9.57^{bc}	10.02^{ab}	10.07^{ab}	10.49^{a}
LSD (5%)	0.56				
CV %	3.8				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.3. Total Fresh Fruit Yield (t ha^{-1})

The analysis of variance showed that total fresh fruit yield of hot pepper was highly significantly (P<0.01) affected by application of blended fertilizers, farmyard manure and their interaction. The highest total fresh fruit yield (5.60 t/ha) was obtained at the highest levels of farmyard manure and blended fertilizer (4t/ha and 100kg/ha), respectively, while the lowest total fresh fruit yield of (3.74 t/ha) was obtained from control treatment.

Highest fruit yield with replacing of 60% UreaN by Poultry manure. The combined use of organic manures and nitrogen resulted in higher yields of tomato, eggplant, pepper and chilli than either N fertilizer or organic sources used alone. Zinc is effective in plant nutrition for the synthesis of plant hormones and balancing intake of P and K inside the plant cells, which in turn increases plant growth and yield [33].

Table 8. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on total fresh fruit yield of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSZnB rate kg ha^{-1}				
FYM t ha^{-1}	0	25	50	75	100
0	3.74^{f}	3.99^{ef}	4.13^{de}	4.24^{de}	4.38^{cd}
2	3.99^{ed}	4.16^{de}	4.24^{de}	4.41^{cd}	4.60^{bc}
4	4.24^{de}	4.82^{b}	5.47^{a}	5.58^{a}	5.60^{a}
LSD (5%)	0.32				
CV %	3.27				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.4. Marketable Dry Pod Yield (t ha^{-1})

Marketable dry pod yield (t/ha) was significantly (*P<0.05*) affected by the interaction of combined fertilizers rates NPSZnB and FYM. Similarly, it was highly significantly (*P<0.01*) influenced by main effect of blended fertilizer rates (NPSZnB) and farmyard manure (FYM).

The results showedthat the highest marketable dry pod yield (2.34 t/ha) was obtained from plots that received 100kg/ha of NPSBZnB + 4 t/ha of FYM while the minimum marketable dry pod yield (1.13 t/ha) was recordedfrom unfertilized plots. The variation in marketable pod yield might be due to varying levels of both organic and inorganic fertilizers treatment.

Lower total and marketable yields from pepper plants grown in plots not fertilized with nitrogen fertilizer [25]. Higher rates of NP fertilizers (150/50 kg/ha N/P_2O_5) had resulted in more plant height, canopy diameter, total and marketable dry pod yield of Mareko fana pepper variety [1].

Increasing yield at relatively higher rates of Zn may be due to the contribution of Zn in protein synthesis and energy production, nucleic acid synthesis, carbohydrate and lipid metabolisms which in turn helps to increases the yield and quality of vegetable crops. Regular application of organic amendments can sustain soil N fertility and increase marketable potato yields by 2.5 to 16.4 t ha^{-1}, compared to the unamended and unfertilized soil. The application of FYM substantially increased the total potato yield by 25.1% as compared to control [12].

Table 9. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on marketable dry fruit yield of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	NPSZnB rate kg ha^{-1}				
FYM rate t ha^{-1}	0	25	50	75	100
0	1.13^{i}	1.33^{gh}	1.40^{fgh}	1.52^{ef}	1.62^{e}
2	1.27^{hi}	1.47^{efg}	1.82^{d}	1.91^{cd}	2.05^{bc}
4	1.48^{efg}	1.62^{e}	2.02^{c}	2.22^{ab}	2.34^{a}
LSD (5%)	0.17				
CV%	6.50				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.5. Unmarketable Dry Pod Yield (t ha^{-1})

Unmarketable dry pod yieldwas non-significantly (P>0.05) influenced bythe application of blended fertilizers and farmyard manure. 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.

4.3.6. Total Dry Fruit Yield (t ha^{-1})

Total dry pod yield (marketable and unmarketable yield) was affected highly significantly *(P<0.05*) by the interaction effect of blended fertilizer and farmyard manure (Table 10). The highest total dry pod yield (2.46 t/ha) was obtained from 100 kg/ha of NPSZnB and 4t/ha of FYMand the lowest (1.25 t/ha) was recorded from unfertilized or control.

The highest total dry yield might be attributed to the production of more number of pods having marketable size, which is probably the function of supplied blended fertilizer and farmyard manure.

The positive impact of vegetative growth up on yield and yield components of hot pepper. Thus, compared with control, the higher concentrations of N, P and K gave significantly more yields per plant. An increased in yield of pepper up to a certain optimum level by increasing fertilizer level and then a decrease afterwards was reported by [30]. The lower yield obtained at the lower levels of fertilizers could be attributed to the decrease in yield and yield components leading to reduced total dry pod yield. 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 at Agarfa [2].

Table 10. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on total dry fruit yield of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	**NPSZnB rate kg ha^{-1}**				
FYM rate t ha^{-1}	**0**	**25**	**50**	**75**	**100**
0	1.25^{h}	1.46^{fg}	1.53^{fg}	1.65^{ef}	1.73^{e}
2	1.40^{gh}	1.59^{efg}	1.96^{d}	2.01^{cd}	2.17^{bc}
4	1.61^{ef}	1.73^{e}	2.15^{bcd}	2.33^{ab}	2.46^{a}
LSD (5%)	0.19				
CV%	6.42				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance differenceletter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.7. Biomass Yield (t ha^{-1})

The interaction effect of blended fertilizer and farmyard manure resulted highly significant (P<*0.01*) differences in dry biomass yield of hot pepper. The maximum dry biomass yield (4.96 t/ha) was obtained from in treatments that received 100 kg/ha NPSZnB and 4 t/ha of FYM respectively. On the other hand, the minimum dry biomass yield (3.95 t/ha) was recorded from control treatment (0 kg/ha NPSZnB and 0 t/ha of FYM).

A general increasing trend of dry biomass yield was observed with increasing level of blended fertilizer and Farmyard manure. A general increasing trend of total dry biomass yield was observed with increasing level of macro and micro fertilizers level. The higher nutrient fertilizers level resulted in significantly higher production of vegetative biomass including leaf area and leaf area index possibly due to the direct involvement of nitrogen on protein synthesis and meristematic growth through hormonal synthesis [35].

Table 11. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on biomass yield of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	**NPSZnB rate kg ha^{-1}**				
FYM rate t ha^{-1}	**0**	**25**	**50**	**75**	**100**
0	3.95^{l}	4.15^{j}	4.35^{h}	4.55^{f}	4.76^{d}
2	4.05^{k}	4.25^{i}	4.45^{g}	4.65^{e}	4.85^{c}
4	4.15^{j}	4.45^{g}	4.65^{e}	4.87^{b}	4.96^{a}
LSD (5%)	0.02				
CV %	0.27				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.8. Harvest Index

Harvest index (the partitioning efficiency of dry matter in to dry pod) was highly significantly (P<0.01) affected by the application of blended fertilizer and farmyard manure and their interaction. Increasing blended fertilizer from 0 to 100 kg/ha increased the harvest index. Similarly, increasing farmyard manure from 0 to 4 t/ha also showed consistent harvest index increment. Application of blended fertilizer in combination with farmyard manure showed linear and consistent harvest index increment over the control.

The highest harvest index at the highest rate of FYM may be suggested as manures like FYM are good enhancer of soil fertility by adding essential nutrients in available form for plant uptake for better vegetative growth the applying manure increased the uptake of N, P, K, Ca, and Mg by plants, indicating that organic fertilizers are good enhancer of soil fertility [3]. Besides furnishing plant nutrients, FYM provides decomposable organic matter and hence increases soil aggregation, which in turn improves physico-chemical condition of the soil like water holding capacity of light soil creates conducive environment for better root development in the tilth of heavy soil and improve soil fertility for increased yields.

Table 12. *Mean effect of Interaction of farmyard manure and blended fertilizer levels on harvest index of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments	**NPSZnB rate kg ha^{-1}**				
FYM rate t ha^{-1}	**0**	**25**	**50**	**75**	**100**
0	0.310^{i}	0.320^{h}	0.330^{g}	0.333^{fg}	0.350^{cde}
2	0.330^{g}	0.340^{ef}	0.350^{cd}	0.353^{bc}	0.360^{b}
4	0.343^{de}	0.346^{cde}	0.350^{cd}	0.360^{b}	0.390^{a}
LSD (5%)	0.0082				
CV %	1.39				

Means within a column and rows sharing common letter (s) are not significantly different, CV=coefficient variance; LSD=List significance difference

4.3.9. Partial Budget Analysis

Net Benefit Analysis

The net benefit was estimated for 15 treatments as illustrated in (Table 13). The results of the partial budget analyses revealed that maximum net benefit of birr 171,478 ETB ha^{-1} with an acceptable marginal rate of return (MRR) 58.67%was recorded from the treatment that received 100kg/ha blendedfertilizer combined with 4t/ha of FYM (Table 13). This combination generated birr 86,048.00 ETB ha^{-1} more compared to the control treatment. On the other hand, the next maximum net benefit of birr 162,618.50ETB ha^{-1} with an acceptable MRR of 44.20% was recorded from the treatment that received 75 kg ha^{-1} blended NPSZnB fertilizer combined with 4 t ha^{-1} FYM (Table 13). This combination generated birr 77,188.50 ETB ha^{-1} more compared to control treatment. Hence, the money generated from the combined application of 100kgha^{-1} blended NPSZnB fertilizer with 4t ha^{-1} FYM was more about birr 8,859.50 ETB ha^{-1} than the money generated from the combined application of 75 kg ha^{1} blended fertilizer with 4 t ha^{-1} FYM.

***Table 13** Partial budget analysis for combined use of farmyard manure and blended fertilizer levels of hot pepper growing at Guto gida district, during 2018/2019 cropping season, East Wollega zone.*

Treatments		MFY	AMY	GFB	TVC	NB	MRR %
FYM t ha^{-1}	NPSZnB kg ha^{-1}	(t ha^{-1})	(t ha^{-1})	(ETB ha^{-1})	(ETB ha^{-1})	(ETB ha^{-1})	
0	0	1.12	1.008	85680.00	250.00	85430.00	D
0	25	1.33	1.197	101745.00	570.50	101174.50	49.12
0	50	1.44	1.296	110160.00	890.00	109270.00	25.33
0	75	1.52	1.4	119000.00	1211.50	117788.50	26.49
0	100	1.62	1.458	123930.00	1532.00	122398.00	14.38
2	0	1.26	1.134	96390.00	3250.00	93140.00	D
2	25	1.46	1.314	111690.00	3570.50	108119.50	46.70
2	50	1.82	1.638	139230.00	3890.00	135340.00	85.19
2	75	1.91	1.719	150705.00	4211.50	146115.00	33.51
2	100	2.05	1.845	156825.00	4532.00	152293.00	19.27
4	0	1.38	1.332	113220.00	6250.00	106970.00	D
4	25	1.61	1.449	123165.00	6570.50	116594.50	30.02
4	50	2.03	1.827	155295.00	6890.00	148405.00	37.30
4	75	2.22	1.998	169830.00	7211.50	162618.50	44.20
4	100	2.34	2.106	179010.00	7532.00	171478.00	58.67

MFY=Marketable Fruit yield, AMY (10%)=Adjusted Marketable yield, GFB=Gross field benefit, TVC=Total variable cost, NB=Net benefit MRR=Marginal Rate of Return (%), ETB=Ethiopian Birr, D=Dominated. FYM=150/100kg ETB birr, NPSZnB=12.82 birr kg^{-1}, Price of dry pod=85 birr kg^{-1}, Labor cost 50 birr for one person day^{-1}

5. Conclusion

As a conclusion most of treatments that received fertilizers produced almost same amount of unmarketable dry fruit yield except the highest and the lowest unmarketable dry fruit yield obtained from unfertilized plot and at 100kg/ha NPSZnB + 4t/ha FYM or 4 t/ha of FYM and 75 kg/ha of NPSZnB. At this fertilizer rate was also noted that, among the yield components, increase in both pod width and length; number pods were responsible for the observed yield advantage. In general, this blended fertilizers, farmyard manure application improves hot pepper yield, and yield attributes as compared with unfertilized plot.

Therefore, the result of this study was shown that levels of farmyard manure and blended fertilizers used in the study areacould significantly enhance yield and yield components of hot pepper if 4 t/ha of FYM and 100 kg/ha of NPSZnB or 4 t/ha of FYM and 75 kg/ha of NPSZnB are integrated and applied for the hot pepper. Moreover, farmers in the study areas should be encouraged to use integrated nutrient management system rather than inorganic fertilizer alone since such system helps not only supply nutrients but also improves physicochemical properties of the soil, thereby significantly enhances yield and yield component of hot pepper. As recommendation this experiment was done for one season at one location, it is important to repeat the experiment on more locations and seasons with consideration of the long-term effect of FYM on the soil as well.

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