International Journal of Plant & Soil Science

27(5): 1-15, 2019; Article no.IJPSS.48221
ISSN: 2320-7035

Effects of Nitrogen Fertilizer and Mulch Application on Growth Performance and Pod Yields of Hot Pepper (*Capsicum annuum* L.) under Irrigated Condition

Temesgen Molla[1], Girma Abera[2*] and Sheleme Beyene[2]

[1]*Alage Agricultural Technical and Vocational Education Training College, Ethiopia.*
[2]*School of Plant and Horticulture Science, College of Agriculture, Hawassa University, Ethiopia.*

Authors' contributions

This work was carried out in collaboration among all authors. Author TM designed the study, performed the statistical analysis wrote the first draft of the manuscript. Authors GA and SB revised and edited the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2019/v27i530089
Editor(s):
(1) Dr. Marco Trevisan, Professor, Institute of Agricultural Chemistry and Environmental Research Centre BIOMASS, Faculty of Agriculture, Catholic University of the Sacred Heart, Italy.
Reviewers:
(1) Toungos, Mohammed Dahiru, Adamawa State University Mubi, Nigeria.
(2) Paul Kweku Tandoh, Kwame Nkrumah University of Science and Technology, Ghana.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48221

Original Research Article

Received 11 January 2019
Accepted 25 March 2019
Published 20 April 2019

ABSTRACT

Hot pepper is an important vegetable and spice crop in Ethiopia. However, the productivity of hot pepper is limited by poor soil fertility and lack of proper soil and water conservation measures under irrigated condition. Therefore, hot pepper crop response to nitrogen (N) fertilizer and mulching experiment was conducted at Alage ATVET College. The treatments consisted of three mulch types (no mulch, transparent plastic mulch, and dry banana leaves mulch) and four levels of N (0, 50, 100 and 150 kg N ha^{-1}) factorial arranged in a randomized complete block design with four replications. A hot pepper cultivar commonly known as "MarekoFana" was used for the study. Days to 50% flowering, 50% fruit set, maturity and harvest were significantly prolonged in response to increasing N application. The delays were about 7, 19, 23 and 12 days at the N levels of 50, 100 and 150 kg N ha^{-1}respectively compared to the control. The analysis of variance revealed that plant height, number of branches per plant, number of pods per plant, dry weight of seeds per pod, total weight of dried pods per plant, weight of individual dry pods and width were significantly (P = .001)

**Corresponding author: E-mail: girmajibat2006@yahoo.com;*

increased by the main effect of mulching. Generally, the results revealed that nitrogen application significantly (P = .001) influenced all growth parameters, pod yield, and yield components of the crop. Nitrogen application at 100 kg ha^{-1} resulted in the highest total dried pod yield (4.5 tha^{-1}), marketable yield (3.76 t ha^{-1}), pod length (13.3 cm), pod width (3.2 cm), mean dry weight of pod (3.85 g), and seed number per pod (108.4). The interaction of N and mulching also significantly (*P* = .05) affected marketable and total pod yields. In conclusion, based on agronomic performance and partial budget analyses results we recommend a combined application of dry banana leaves mulch and 100 kg N ha^{-1} for economically feasible and sustainable hot pepper production in Alage areas of Central Rift Valley of Ethiopia.

Keywords: Banana leaves; hot pepper; mulch; nitrogen rates; transparent plastic.

1. INTRODUCTION

Hot pepper (*Capsicum annuum*L.) belongs to the *Solanaceae* family and is related to eggplant, potatoes and tomatoes. It is consumed both as fresh and dehydrated spices [1]. Hot pepper is the world's third most important vegetable after potatoes and tomatoes in terms of quantity of production. It is grown as an annual crop and produced for its fruits. It is one of the most important processing crops as a spice. The world average productivity of chili and pepper is 8.5 t ha^{-1} while Africa's is 8.65 t ha^{-1} both as dry and green fruit [2].

In Ethiopia, hot pepper is an important cash and spice crop, and hence an economically and traditionally important crop. It is therefore a very important crop for Spice Extraction Company, since it has a lot of oleoresin for dying of food items [3].It is a major spice and vegetable crop produced by the majority of farmers in Oromia, Amhara and Southern Nations Nationalities and Peoples Regional of States [4].The powder from the dried pod is the main component in the daily diet of Ethiopians. The nutritional value of hot pepper, rich as source of vitamin A, C and E merits special attention. Both hot and sweet peppers contain more vitamin C than any other vegetable crops [1].

Hot pepper is largely produced under rain fed conditions for dry pods, however, as green vegetables, it is mainly produced under irrigated conditions in Ethiopia. The producers of hot pepper are mainly consumed domestically as a national spice in the traditional dishes. Despite its importance, hot pepper productivity remained low in the country with national average yields of 5.3 t ha^{-1} for green pods and 1.1 t ha^{-1}forthe dry pods [5].

The low productivity of hot pepper production is attributed to lack of improved varieties, poor cultural practices, low production inputs, inadequate knowledge on production and management (processing) systems, poor extension services, poor marketing system and the prevalence of fungal and bacterial as well as viral diseases [6]. Among these, soil fertility management is one of the most yield limiting factors for hot pepper production in Ethiopia [7]. Furthermore, there are limited studies on soil fertility management, particularly on the influence of nitrogen fertilizers and mulching, for hot pepper production in the country [8]. The soils of the country are diverse in terms types, fertility and properties such as pH and organic matter content, and moisture holding capacity. The use of nitrogen fertilizer in pepper to increase the overall performance of cropping systems through providing economically optimum nourishment to the crop and thereby get optimum yield should also be considered [9].

The yield of hot pepper is low in Alage area, Ethiopian rift valley system, due to poor cultural practices, low rainfall and high evapo-transpiration, and soil moisture stress. It was reported that yield of hot pepper is highly dependent on the moisture available in soil [10] and soil fertility management [11]. The use of supplementary irrigation along with proper soil and moisture conservation practices such as application of mulches could alleviate the soil moisture stress in Alage area. However, there was no study conducted on the use of mulches to alleviate the moisture stress problems in the study area. Although the farmers producing local hot pepper use plant residue as mulch, the practice is limited to mainly nursery bed. Additionally, the farmers do not apply recommended rates of chemical fertilizers.

The study was therefore initiated to determine the effects of mulching and increasing levels of N fertilizer on growth performance, and yield and yield components of hot pepper under irrigated conditions at Alage, central rift valley of Ethiopia.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted at Alage Agricultural Technical and Vocational Educational and Training College, Ethiopia. The college is located at 217 km south of Addis Ababa and 32 km west of Bulbula town in the vicinity of Abidjata and Shalla lakes. The study site is situated at 7˚65' N latitude and 38˚56'E longitudes, an altitude of 1600 meters above sea level. The site has mean annual rainfall of 800 mm, mean annual temperature of 20˚C and the soil of the site is clayey in texture with alkaline reaction.

2.2 Description of the Experimental Materials

Hot pepper (*Capsicum annuum* L.) variety, Marekofana, released by Melkasa Agricultural Research Centre in 197l, was used as a test crop. It grows to the height of 45 to 60 cm with an erect and good branching habit and matures in 120-135 days after transplanting [12]. It has dark-red colored large pods with pod yielding ability of 1.5 – 2.0tha^{-1}. The plant grows best at places having mean temperature of 20 – 29˚C and receiving uniform mean annual rainfall of 600 - 1337 mm and altitude of 1400-2200 meters above sea level [12].

White (transparent) plastic film that allows sunlight to pass through and having atypical characteristic of 20-25 microns or 0.2-0.25 mm thick, and 100 cm wide was used. Transparent plastic mulch was selected as it provides good micro climate for the soil and the plants, and is transparent for sun light as compared to the black plastic mulch [13]. Dry banana leaves that are easily available in the area were used as organic mulch.

2.3 Experimental Design and Treatments

The treatments consisted of a factorial combination of four levels of nitrogen(0, 50, 100 and150kg Nha^{-1}) and three mulching materials (no mulching, transparent white plastic mulch, dry banana leaves) in Randomized Complete Block Design (RCBD). The 4 x 3 factorial arrangements had a total of twelve treatment combinations (N0M0, N0M1, N0M2, N1M0, N1M1, N1M2, N2M0, N2M1, N2M2, N3M0, N3M1 and N3M2) replicated four times. The experiment was set at spacings of 30 and 70cm between plants and 70 cm between rows respectively, having 5.25 m^{2}plot area (3.5 m width 1.5 m length).The distances between plots and blocks were kept at 1 and 1.5 m, respectively.

2.4 Land Preparation and Raising Seedlings in the Nursery

A 5 x 3 m seed bed was prepared by ploughed and harrowed to make a fine tilth. Seeds were drilled by hand into the nursery beds at the inter-row spacing of 15 cm. Di-ammonium phosphate (DAP, 18-46-0) was applied at 43.5 kg Pha^{-1}at sowing as recommended by Cottenie [14]. After sowing, the beds were covered with dry grass mulch until emergence and watered using a watering can. Ten to fifteen days before transplanting, water supply to the nursery seed bed was reduced to harden the seedlings to reduce transplanting shock. Before transplanting, the seedlings were watered to enhance easy uprooting and prevent root damage.

2.5 Transplanting, Mulching and Other Agronomic Managements

Uniform, healthy and vigorous seedlings (standard seedlings) having a height of 20-25 cm were transplanted after about 6 to 7 weeks in the nursery to the experimental field on ridged beds at the recommended spacing in the designated plots [14]. Plastic mulches were spread on the plots before transplanting the seedlings by making small holes at the desired intra row spacing. For banana leaf mulch treatments, banana leaves of approximately 12-15 cm in length and5cm thickness were applied immediately after transplanting the seedlings.

The entire dose of recommended phosphorus (40 kg Pha^{-1}) in the form of TSP and half rate of nitrogen fertilizers of the respective treatments were applied in band spots at the time of transplanting. The remaining half rate of nitrogen fertilizers were applied during active vegetative growth stage (4 weeks after transplant) [15]. Urea (46% N) was used as the source of N fertilizer.

2.6 Data Collection and Measurements

Data were collected from the four middle rows, leaving the plants in the border rows to avoid edge effects. The collected data include plant height, branch number, leaf number, total biological dry weight, harvest index, days to 50% flowering, days to 50% fruit set, days to maturity, days to harvest, marketable pod yield, unmarketable pod yield, total pod yield, pod number per plant, seed number per pod, seed dry weight per pod, average weight of individual dry pod, average weight of dry pods per plant, pod length and pod width.

2.7 Soil Sampling and Analysis

Twelve surface soil samples (0-30 cm) were random collected in a diagonal walk from the experimental field using an auger and a composite was made. The soil samples were air dried and ground to pass through 2 mm sieve for selected physicochemical analyses, except for determinations of organic carbon and total nitrogen where a 0.5 mm sieve was used. The bulk density (BD) was determined from undisturbed core samples. Particle size (soil texture) was determined by using Bouyoucos hydrometer method [20]. Soil pH was determined in 1:2.5 soils to water ratio using a glass electrode attached to a digital pH meter [16]. Organic carbon content of the soil was determined based on oxidation of organic carbon with acid dichromate medium following the Walkley and Black method as outlined by Dewis and Freitas [17]. Total nitrogen was determined by micro-kjeldahl method [17] and soil cation exchange capacity (CEC) was determined by ammonium acetate method [18]. Available phosphorus was determined using Olsen method as described by Olsen and Dean [19]. Exchangeable potassium was determined with a flame photometer after extracting K from the soil with 1M ammonium-acetate at pH 7 as described by Hesse [21].

2.8 Partial Budget Analysis

Simple partial budget analysis was employed for economic analysis of mulching types and fertilizer application were carried out separately for a given marketable yield. The potential response of the crop towards mulching types and the added fertilizer, and price of fertilizer and mulching types during planting ultimately determine the economic feasibility of mulching types and fertilizer application [22]. The economic analysis was based on the formula developed by Cimmyt [22] and given as follows:

Gross average pod yield (kg ha^{-1}) (AvY): Is an average yield of each treatment.

Adjusted yield (AjY): Is the average yield adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmers.

AjY = AvY- (AvY-0.1)

GFB = AjY*field/farm gate price for the crop

Total cost: Is the cost of fertilizers for the experiment. The costs of other inputs and production practices such as labour cost for land preparation, planting, weeding, and harvesting were considered remain the same or were insignificant among treatments.

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

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

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

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

NB = GFB – total cost

Marginal rate of return (MRR %): was calculated by dividing change in net benefit by change in cost. MRR (%) = ΔNB/ΔTC x100 i.e.MRR (%)= (MB/ MC)*100

2.9 Statistical Analysis

The data were analyzed using GLM procedures of SAS software version 9.2 [23]. Significant treatment means were separated using the Least Significant Difference (LSD) test at 5%.

3 RESULTS AND DISCUSSION

3.1 Selected Physicochemical Characteristics of the Experimental Soil

The experimental soil was slightly neutral in reaction (pH=7.33) and clayey in texture (Table 1). It was also well drained, which is consistent with the recommendation given for producing hot pepper [24] having a minimum depth of 30 cm. Clayey soils with slightly basic reaction (pH= 7.33) are generally preferred for hot pepper production [25]. The total nitrogen and organic carbon contents of the soil were 0.18 and 2.10%, respectively, and could be considered to be moderate [26]. The available phosphorus content of the soil is very low (Table 1), suggesting the requirement of P fertilizer application for profitable and optimum hot pepper production in Alage area. The cation exchange capacity of the soil is high [27], whereas the bulk density of the soil is optimum for crop production [28].

3.2 Effects of Mulching and Nitrogen on Growth Performance of Hot Pepper

Nitrogen fertilizer application and mulching significantly (P =.001) affected plant height (PH) and branch number (BN) (Table 2). Similarly, increasing nitrogen levels significantly (P =.05) affected leaf number (LN), whereas mulching had no significant effect on LN. In general, the interaction of mulching and nitrogen application did not significantly influence all the growth parameters.

Accordingly, higher PH and more BN were recorded from plants treated with plastic mulching, followed by dry banana leaves. The plastic mulches increased PH and BN by 11.58 and 7.21% respectively compared to the control treatment where the shortest and less numbers of branches were recorded (Table 2). These findings are in line with previous findings [33] where the use of transparent polyethylene mulch increased the plant height in chilli as compared to organic mulch and control. Similarly, [34] also observed increased plant height and more number of structural plants in chilli pepper with the use of plastic mulch. This might be due to better availability of soil moisture and optimum soil temperature since mulching conserves moisture and also better regulates temperature by eliminating extreme temperatures. The dry banana leaves mulch also improved hot pepper growth parameters, although it was not as effective as plastic mulch (Table 2). Similar result was also reported from a study on sweet pepper showing the use of mulch was better than control in improving growth parameters during dry season [35]. Higher number of branches and the taller hot pepper plants were obtained from organic mulches (vetiver grass, dry coffee husk and dry banana leaves mulches) application as compared to the control, non-mulched [30].

Nitrogen application significantly (P =.001) affected PH, BN and LN of hot pepper (Table 2). As the nitrogen level increased from 0 to 150 kg Nha^{-1}, PH, BN and LN increased significantly by 42.7, 37.7 and 63.5%, respectively (Table 2). In general, plants that received higher rates of nitrogen produced taller plants than the control or those with lower levels of nitrogen. This result is in agreement with previous finding [36] which reported that the vigorous increase in height and leaf number of pepper plants was attributable to the supply of nitrogen. The increases in PH, BN and LN with increasing N levels could be mainly due to the better availability of nitrogen at higher rates that might have stimulated the production of cytokines and gibberellins, which stimulate high rate of shoot growth perhaps due to more assimilate allocation. In line with this, [37] also reported that nitrogen application increased pepper PH and BN significantly at 10 weeks after transplanting when applied at a rate of 75 kg N ha^{-1}compared to the control treatment.

Table 1. Some physical and chemical properties of the soil in the experimental site

Soil characteristics	Unit	Result
Soil reaction (pH-H_2O)	-	7.33
Organic Carbon (OC)	%	3.6
Total Nitrogen TN	%	0.18
Carbon : Nitrogen (C/N)	-	11.75
Avail Phosphorus (P)	$mgkg^{-1}$	4.12
Avil Potassium (K)	$mgkg^{-1}$	1531.7
Cation Exchange Capacity (CEC)	$Cmolkg^{-1}$ soil	31.8
Bulk Density (BD)	$g^{-1}cm^{3}$	1.29
Sand	%	18
Silt	%	36
Clay	%	46
Textural Class	-	clay

Table 2. Main effects of mulch and nitrogen on plant height, branch number, leaf number, pod number per plant and seed number per pod under irrigated condition at Alage, rift valley of Ethiopia

Treatment	PH (cm)	BN	LN	PN	SN
Mulch type					
No mulch	63.84^{b}	7.21^{c}	311.17	49.58^{c}	96.78^{b}
Dry banana leaves	66.27^{b}	7.73^{b}	313.84	63.38^{b}	99.21^{ab}
White plastic mulch	71.23^{a}	8.29^{a}	315.21	75.16^{a}	102.23^{a}
LSD (0.05)	2.82	0.35	ns	9.12	4.00
Nitrogen applied (kg ha^{-1})					
0	55.45^{d}	6.37^{d}	239.72^{c}	43.85^{d}	90.90^{d}
50	62.62^{c}	7.58^{c}	283.43^{c}	57.63^{c}	96.75^{c}
100	70.27^{b}	8.26^{b}	338.28^{b}	69.15^{b}	108.42^{a}
150	79.12^{a}	8.77^{a}	392.20^{a}	80.18^{a}	101.55^{b}
LSD (0.05)	3.26	0.40	50.65	10.53	4.62
CV (%)	5.85	6.25	19.46	20.22	5.59

PH= plant height, BN= branch number of per plant, LN= leaf number per plant, PN =pod number per plant and SN = seed number per pod. Means followed by the same letter(s) in a column is/are not significantly different at P≤5

Table 3. Main effect of mulching and nitrogen on days to 50% flowering, days to 50% pod set, days to maturity and duration of harvest of hot pepper under irrigated condition of Alage, rift valley of Ethiopia

Treatment	Days to 50% flowering	Days to 50% pod set	Days to 50% maturity
Mulch type			
No mulch	54.63^{a}	82.31^{a}	130.56 ^{a}
Dry banana leaves	49.50^{b}	81.19^{a}	124.13 ^{b}
White plastic mulch	40.89^{c}	76.75^{b}	117.94 ^{c}
LSD(0.05)	3.50	4.27	4.31
N (kg ha^{-1})			
0	44.92^{c}	89.75^{d}	113.83 ^{d}
50	46.92^{bc}	82.67^{c}	120.25 ^{c}
100	49.50^{ab}	77.17^{b}	126.25 ^{b}
150	52.00^{a}	70.75^{a}	136.50 ^{a}
LSD(0.05)	3.67	4.92	4.97
CV (%)	9.14	7.40	4.82

Means followed by the same letter(s) in a column are not significantly different at P≤5

3.3 Phenology as Affected by Mulch and N Fertilizer

Mulching and nitrogen application rates significantly (P=.001) affected the number of days to 50% flowering, 50% pod setting and maturity (Table 3). However, there was no significant interaction effect of mulching and nitrogen on these parameters.

The results revealed that mulching hastened flowering, pod setting and maturity in hot pepper. The earliest dates to 50% flowering, 50% pod setting and maturity was attained with transparent plastic mulch followed by dry banana leaves mulch. Plants grown with without mulch on average took 33.6 and 10.4% more time to reach 50% flowering compared to those with mulching using transparent plastic and banana leaves mulches, respectively (Table 3). Similarly, days to 50% pod setting and maturity were delayed by 7.2 and 1.4% and by 10.7 and 5.2% in non-mulched plots as compared to those with transparent plastic and banana leaves mulches, respectively.

The present results are in agreement with earlier reports [29] that showed hot pepper plants grown by mulching with transparent plastic and vetiver grass took more time to reach 50% flowering, 50% pod setting and maturity compared to plants grown with no mulch. Others also reported that mulch application during dry season reduces the number of days required to reach 50% flowering by providing optimum growing environment for the crop [30]. The use of plastic mulch is effective in promoting rapid plant growth and early flowering because it creates favorable conditions of soil temperature, moisture, and nutrient availability, thereby resulting in better uptake of nutrients for enhanced plant growth and maturity [31].

Application of nitrogen fertilizer significantly (P =.001) prolonged the time required by the hot pepper crop to attain 50% flowering, 50%pod set and maturity (Table 3). The longer duration for pod setting and maturity could be due to favorable growth conditions and less interplant competition where higher levels of nitrogen prolonged the developmental stage. The result is in accordance with previous findings [32] which reported applying higher rates of nitrogen had negative effects on early pod setting through delaying flowering date.

3.4 Effects of Mulch and Nitrogen on Pod and Seed Number of Hot Pepper

The pods number (PN) per plant and seeds number (SN) per pod were significantly (P=.01) influenced due to mulch and nitrogen fertilizer application (Table 2). However, there was no significant interaction effect of mulching and nitrogen on these parameters.

Mulch application increased, the PN and SN of hot pepper produced under irrigation condition. The highest PN and SN of hot pepper were produced in plots treated with plastic mulch followed by dry banana leaves, while the lowest were recorded from non-mulched plots. Plants grown with transparent plastic and banana leaves mulches, on average, produced 51.6 and 27.8% more PN as compared to those with no mulch, respectively (Table 2). The increased number of fruits in transparent plastic and banana leaves mulches over the control may be explained by the conservation of more moisture and the reduction of temperature in the top soil. The increment might be due to better vegetative growth of pepper plants with mulch material, which results in higher number of flowers and branches per plant resulting in increased pods. This result is also in accordance with the earlier findings [38] which stated that transparent polyethylene mulch highly boosted up the pod number in pepper followed by organic mulch over the control. The highest SN per pod was also obtained from transparent plastic mulch treatment (by 5.6%) followed by the dry banana leaves, although the number of seeds per pod from dry banana leaves treatment was statistically at par with no mulch (Table 2). The increase in the PN per plant of mulched plot was probably associated with the conservation of moisture and improved microclimate both beneath and above the soil surface. The suitable condition enhanced the plant growth and development and thereby increased fruit bearing nodes compared to the control. Considering relationship between the soil moisture content and pod number, it was clear that pod number in chilli pepper was strongly related with soil moisture content [34]. Similar results were reported [39] indicating that the highest SN per pod was obtained from plants grown with plastic mulched pepper while the lowest was from the control plot. It is essential to note that the seed set affects development and subsequent growth of the pod. There is a direct linear relationship between the number of seeds per pod and final pod size. This is consistent with the report [40] showing pods with the biggest size also have the highest number of seeds per pod in hot pepper.

Nitrogen application highly and significantly (P =.001) increased PN per plant and SN per pod (Table 2). Plants that received nitrogen at the rates of 50, 100 and 150 kg Nha^{-1}produced 32.24, 58.05 and 83.47% higher PN, respectively, over the control (Table 2). The results obtained in the present investigation is in accord with earlier findings [41] which reported the total number of pods per plant in pepper increased by 28.6% with increasing nitrogen fertilizer level from 100 to 150 kgha^{-1}.Similarly, [42] reported that PN per plant of chili pepper was increased by 86.2 and 64.6%, at 180 and 120 kg N ha^{-1} supply, respectively as compared to the control plots. These results are also in conformity with the findings [43] which reported that higher doses of nutrients resulted in higher number of branches and more reproductive parts coupled with less flower drop and more fruit set through altering hormonal balance in the plant system. The pod setting response to increased nitrogen appeared to correlate with height increment and branch development leading to more vegetative development leading to increased number of pods. Similar result was obtained [44] when high nitrogen supply increased primary, secondary and tertiary branches that contributed to fruit set. Furthermore, the increase in pod number as nitrogen level increased is in agreement with earlier work [45] which reported that doubling the rate of nitrogen from 112 to 224 kg ha^{-1} resulted in increased flower buds of pepper by 21% per plant, which led to increased pod number per plant. [46] also reported that the number of pepper pods increased with increased nitrogen levels. The highest SN was obtained at 100 kg ha^{-1} nitrogen followed by 150 and 50 kg ha^{-1}, all exceeding the SN per pod obtained from the control plots by 19.27, 11.72 and 6.44%, respectively (Table 2). This could be attributed to the enhancing effect of nitrogen on vegetative growth that might have resulted in the production and partitioning of more photosynthate that increased pod dry matter as well as pod length and width of the crop. This may have led to the production of higher number of seeds. The results are in agreement with those [47] who reported that highest number of hot pepper seeds pod^{-1} was recorded where nitrogen was applied at the rate of 100 kg ha^{-1}followed by 50 kg N ha^{-1} while the minimum was recorded from control plots. The results from this investigation are also in agreement with other findings [40] which indicated pod size is the factor that determines number of seeds per pod in hot pepper. Similarly, [48] observed a positive relationship between the number of seeds per pod and pod size, where pod weight increased linearly with the number of seeds per pod in sweet pepper.

3.5 Effects of Mulch and Nitrogen on Hot Pepper Pod Width and Length (cm)

Pod width (PW) and pod length (PL) showed significant (P=.01) response to mulch and nitrogen fertilizer application under irrigated condition. However, there was no significant interaction effect of mulch and nitrogen on these parameters (Table 4).

The results showed that the highest hot pepper PW and PL were produced with transparent plastic mulch followed by dry banana leaves mulch and no mulch. Thus, plants grown mulched with transparent plastic and banana leaves, on average gave, produced 48.74 and 36.18% more PW and PL respectively as compared to plants grown with no mulch, although the average hot pepper PW and PL recorded from plastic mulch was statically at par with dry banana leaves (Table 4). This result is consistent with that of Tnidartit and Ban [49] who observed that both white and black plastic mulch systems in bell pepper gave significantly larger fruit diameter (86.7 and 85.2 mm respectively) against bare soil (74.3 mm). Furthermore, the increase in fruit length of pepper with different mulching materials may be due to their varying moisture conservation capacities in the soil [39]. Generally, mulches conserve more moisture due to lower evaporative losses than the un-mulched plots.

Nitrogen application significantly (P= .01) increased PW and PL of hot pepper (Table 4). Accordingly, increasing nitrogen level from 0 to 100 kg ha^{-1} led the highest increases in PW (75.27%) and PL (22.0%) over the control (no-mulch). Similarly, application of 150 and 50 kg N ha^{-1} resulted in PW increment by 53.30 and 32.97%, respectively as compared to the control treatment. The lower PW and PL at 150 than at 100 kg N ha^{-1} could be attributed to the phenomenon that higher levels of nitrogen beyond the optimum would usually lead to growth of more branches, increased plant height and number of pods, which could have increased competition for assimilate partitioning among the plant parts thereby reducing pod length and width. Siti et al. [45] also found small-sized pepper pods at higher levels of nitrogen. This result is also consistent with that of Mebratu et al. [50] who observed increasing nitrogen supply to 100 kg N ha^{-1} resulted in about 74 and 69% increases in PW and PL, respectively compared to the control treatment. The increase in PW and PL with increase in nitrogen level could be attributed to enhanced assimilates partitioning by plants grown on plots with adequate nitrogen levels. The result is also in agreement with earlier finding [46] that showed significant increases in lengths of pepper pods with the increase in nitrogen levels. This result also corroborated that of Bosland and Votava [1] who reported that applied N fertilizers resulted in partitioning of assimilates to pods in addition to partition to other biomass, thereby increasing pod length and width. Larger and wider hot pepper pods are considered to be the best in quality and have better demand for fresh as well as dry pod use in Ethiopian markets [44]. Therefore, the pod size and length attained at 100 kg N ha^{-1} are within the range of preference by consumers in the market in the country, and are, hence, likely to be picked up by consumers over the thinner and shorter pods.

3.6 Effects of Mulch and N Fertilizer Application on Dry Pod Yields of Hot Pepper

Mulching and nitrogen fertilizer supply significantly (P= 0.05) affected, marketable pod yield (MPY), unmarketable pod yield (UPY) and total pod yield (TPY) of hot pepper under irrigated condition. There was also significant interaction between mulching and nitrogen on these parameters except for the UPY (Table 4).

The highest UPY was observed from the control followed by dry banana leaves treatment, but the difference was non-significant (Table 4). The lowest UPY was recorded from plants mulched with transparent plastic. Accordingly, plants grown with no mulch and dry banana leaves mulch on average gave 17.95 and 12.82% more UPY respectively compared to plants grown mulched with transparent plastic. This finding is supported by earlier finding [51] that indicated the highest unmarketable fruit yield when straw mulch was used compared to plastic mulch in tomato. In present study, the dry banana leaves might have favored occurrence of insect pests and diseases that cause pod decay, leading to high UPY in pepper [52].

Increasing nitrogen level from 0 to 50,100 and 150 kg N ha^{-1} increased UPY by 50, 75 and 96.43%, respectively (Table 4). When N supply increases, the plants become succulent and susceptible to diseases and pests. The highest UPY was obtained at the highest level of nitrogen, which could be attributed to the production of more number of branches and other vegetative organs that might increase competition for photo assimilate between vegetative and reproductive phases, thereby resulted in higher number of small-sized pods. The increased UPY at the highest level of nitrogen application could be also attributed to the production of high proportion of pods affected with insect pest and disease incidence. This result is in conformity with earlier result [53] which showed increased disease incidence with more nitrogen fertilizer application, which was more pronounced in densely planted peppers due to shading effect. In line with this result, the highest UPY was observed at 150 kg N ha^{-1}, which was higher by about 88% over the control [50].

The highest MPY and TPY were observed under transparent plastic mulch treated plots followed by dry banana leaves, while the lowest yields recorded with no mulch. Thus, plants grown with transparent plastic and banana leaves mulches gave 64.08 and 37.38% more MPY compared to no mulch, respectively (Table 4). The present finding is in agreement with earlier results [51] which showed that the highest marketable yield (65.44 tha^{-1}) was obtained with black plastic mulch followed by straw mulch (50.02 tha^{-1}) in tomato crop. It was also reported that organic mulch gave the highest MPY of bell pepper over the control treatment [54].Plants mulched with transparent plastic and with banana leaves produced about 38.34 and 28.06% more TPY respectively as compared to those on no mulch (Table 4). In line with this study, [52] stated as plastic mulching might have advantages in maintaining soil temperature and humidity by preventing soil borne diseases and pests and thereby speed up crop growth. The increase in pod yields of pepper in response to mulching over non-mulching treatment could therefore be attributed to the synergistic effects of mulch, that improve absorption of nutrient by plant roots, control weeds, diseases and insects, and

Table 4. Effects of mulch and nitrogen application on pod width, pod length, marketable pod yield, unmarketable pod yield and total pod yield under irrigated condition at Alage, rift valley of Ethiopia

Treatment	PW (cm)	PL (cm)	MPY (t ha^{-1})	UPY (t ha^{-1})	TPY (t ha^{-1})
Mulch type					
No mulch	1.99^{b}	11.10^{b}	2.02^{c}	0.48^{a}	2.50^{b}
Banana leaves	2.71^{a}	12.12^{ab}	2.75^{b}	0.47^{a}	3.22^{a}
Plastic mulch	2.96^{a}	13.19^{a}	3.13^{a}	0.41^{b}	3.54^{a}
LSD (0.05)	0.31	1.17	0.31	0.05	0.65
Nitrogen applied (kg ha^{-1})					
0	1.82^{d}	10.89^{c}	1.65^{d}	0.34^{d}	1.99^{c}
50	2.42^{c}	$11.9b^{c}$	2.13^{c}	0.78^{c}	2.91^{b}
100	3.19^{a}	13.29^{a}	3.76^{a}	0.74^{b}	4.50^{a}
150	2.79^{b}	12.45^{ab}	3.00^{b}	0.96^{a}	2.96^{b}
LSD (0.05)	0.35	1.35	0.36	0.06	0.75
CV (%)	16.7	13.27	16.59	15.76	29.31

PW=Pod width, PL= pod length, MPY= Marketable pod yield, UPY= Unmarketable pod yield, TPY= Total pod yield. Means followed by the same letters in a column are not significantly different from each other regulate or adjusts soil temperature [55]. Similar result was also reported [56] indicating that the use of different mulches improved the performance of *Capsicum annuum* L. under water deficit. In line with this study, [34]reported that mulching produced higher pepper fruit yield than the control, indicating that mulch had positive effect in generating increased fruit yield.

Nitrogen supply significantly (P=0.05) influenced MPY and TPY of hot pepper under irrigation condition (Table 4). The highest MPY and TPY, 4.02 and 4.5.51 t ha^{-1}, respectively were produced at 100 kg N ha^{-1}, while the lowest MPY and TPY, 1.66 and 1.94 t ha^{-1} respectively were obtained from the control (no N application).It is important to note that N fertilizer application improved pod yields via enhancing plant growth, pod length, pod width, seed weight, seed number and total dry matter of hot pepper. In agreement with this result, Leghari and Oad [57] and Mebratu et al. [50] reported that pod length, width and total dry pod weight per plant were positively correlated with marketable green pod yield in pepper. Further increases in applied nitrogen from 100 to 150 kg N ha^{-1} reduced marketable yield by about 32.24% (Table 4). This result is in agreement with previous findings [45] which showed decrease in the marketable fruit weight per plant in pepper as N level increased from 112 to 448 kg ha^{-1}. Other findings showed significantly lower total and marketable yields of pepper plants grown in plots not fertilized than nitrogen fertilized plots [58].

Total and marketable pepper yields were also significantly (P=0.05) influenced by the interaction effect of mulching and nitrogen application (Fig. 1). The analysis of variance showed that the maximum TPY and MPY were obtained from the treatment with transparent mulch and received 100 kg ha^{-1} followed by those mulched with banana leaves and received 100 kg ha^{-1}. The minimum TPY and MPY were recorded at the combination of no mulching and the 0 kg ha^{-1} N (Figs. 1 and 2). The TPY and MPY obtained from mulching with transparent plastic at N application 100 kg ha^{-1} exceeded the TPY and MPY recorded at no mulching with100 kg ha^{-1} N by about 282 and 339% respectively. The result of the present experiment is in agreement with previous finding [59] which indicated that the maximum weight of fresh yield of lettuce per hectare was observed in response to the optimum rates of N application with mulch and the lowest fresh weight yield was found in response to lower N fertilizer rates without mulching.

This study is also consistent with the investigation of [56] who reported that plastic, lantana leaves and grass mulches significantly maintained higher growth and yield parameters as compared to unmulched treatments, and capsicum yield levels increased by 198% in plastic mulch, 164% in lantana leaves and 141% in grass mulched plants over non-mulched plants.

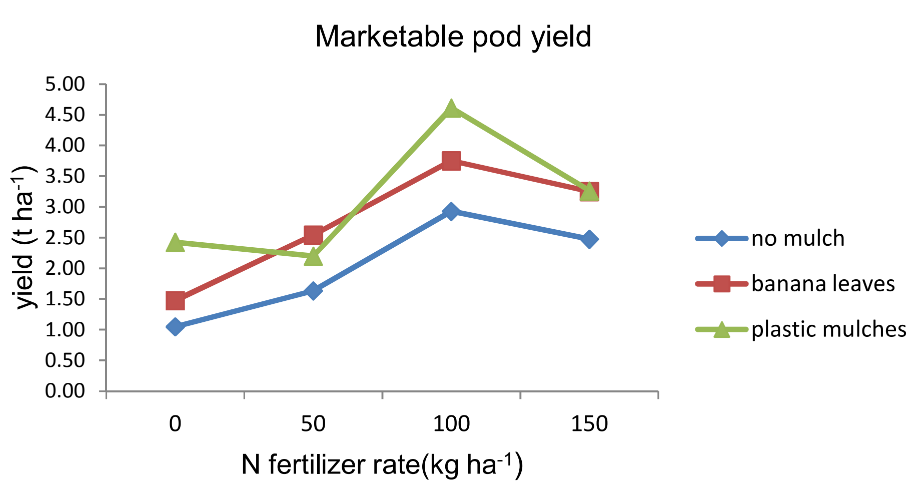

Fig. 1. Interaction effect of increasing nitrogen levels and mulching types on marketable pod yield at Alage, central rift valley of Ethiopia

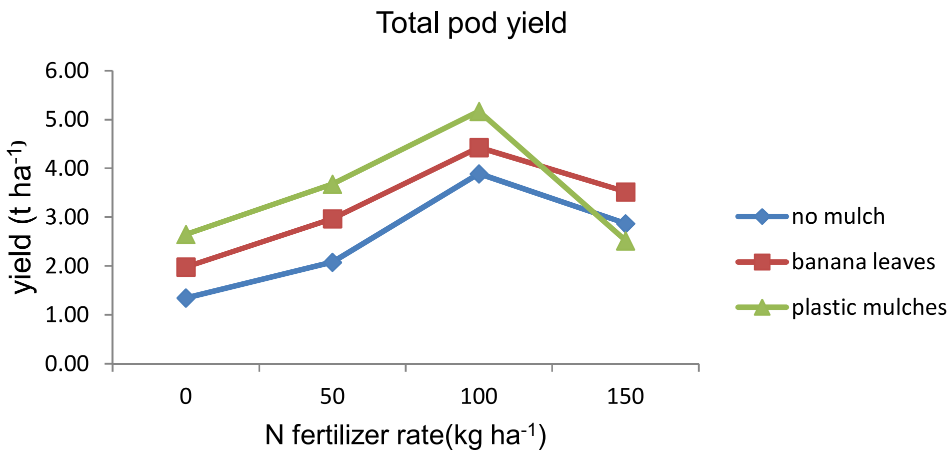

Fig. 2. Interaction effect of increasing nitrogen levels and mulching types on total pod yield at Alage, central rift valley of Ethiopia

Table 5. Main effects of mulching and nitrogen on economic benefit of hot pepper production in Alage irrigated condition, Central Rift Valley of Ethiopia

Treatments mulch + N(kg)	AVMTY (kg ha^{-1})	ADMTY (kg ha^{-1})	TCV (ETB ha^{-1})	GFB (ETB ha^{-1})	NB (ETB ha^{-1})	B:C
NM + 0	1050	945	0	30240	30240	-
NM + 50	1640	1476	978.3	47232	46253.7	47.28
NM + 100	2930	2637	1956.6	84384	82427.4	42.13
NM + 150	2480	2232	2934.9	71424	68489.1	23.34
DBL + 0	1480	1332	0	42624	42624	-
DBL + 50	2540	2286	978.3	50292	49313.7	50.41
DBL + 100	3750	3375	1956.6	108000	106043.4	54.20
DBL + 150	3250	2925	2934.9	93600	90665.1	30.89
WPM + 0	2430	2187	45977	69984	24007D	0.52
WPM + 50	2200	1980	46955.3	63360	16404.7D	0.35
WPM + 100	4610	4149	47933.6	132768	84834.4	1.77
WPM + 150	3260	2934	48911.9	93888	44976.1	0.92

NM=No mulch, DBL= Dry banana leaves, WPM= White plastic mulch, AVMTY kg ha^{-1} = Average marketable pod yield kg per hectare, ADMTY kg ha^{-1} =Adjusted marketable pod yield kg per hectare, TCV= Total cost that vary, GFB = Gross field benefit, NB=Net benefit and ETB= Ethiopian birr, B: C= Benefit cost ratio. During experimental period the price of Urea fertilizers were 9 Birr kg^{-1} and selling price of pod yield of 32 birr kg.$^{-1}$

3.7 Partial Budget Analysis of Mulch and Nitrogen Application

The results of the partial budget analyses revealed that maximum net benefit of Birr 106043.4 ha^{-1} with an acceptable marginal rate of returns (MRR) of 57.99 were recorded in the treatment combination of banana leaves and 100 kg ha^{-1} (Tables 5 and 6).

When the new technology surpassed the conventional practice, it is said to be undominated (22). MRR % measures the increase in the net income. MRR% become unnecessary when the treatment costs less than the existing practices. When the treatment yield gives lower benefit, then the treatment is said to be dominated. MRR is calculated by dividing the marginal increase in net benefit with the marginal increase in variable cost and multiplying the result by 100. In the present study, the treatment combination dry banana leaves and 100 kg N ha^{-1}was more profitable. The highest MRR % was 5799 for the best combination of mulch types and

Table 6. Marginal economic analysis of the non-dominated treatments of marketable pod yield of hot pepper

Treatments mulch+ N(kg)	TCV (ETB ha^{-1})	MC (ETB)	NB (ETB ha^{-1})	MB (ETB)	MRR	MRR (%)
NM + 0	0	-	30240	-	-	-
NM + 50	978.3	978.3	46253.7	16013.7	16.37	1637
NM + 100	1956.6	978.3	82427.4	36173.7	36.98	3698
NM + 150	2934.9	978.3	68489.1	-13938.3	-14.25	-1425
DBL + 0	0	-2934.9	42624	-25865.1	8.81	881
DBL + 50	978.3	978.3	49313.7	6689.7	6.84	684
DBL + 100	1956.6	978.3	106043.4	56729.7	57.99	5799
DBL + 150	2934.9	978.3	90665.1	-15378.3	-15.72	-1572
WPM + 100	47933.6	44998.7	84834.4	-5830.7	-0.13	-13
WPM + 150	48911.9	978.3	44976.1	-39858.3	-40.74	-4074

ETB= Ethiopian birr, NM=No mulch, DBL= Dry banana leaves, WPM= White plastic mulch TCV = Total cost that vary, MC=Marginal cost, NB = Net benefit, MB=Marginal benefit, MRR = Marginal rate of return and MRR (%) = Marginal rate of return in percent

N rates, the computed MRR % give an indication of what a producer can expect to receive by adopting technologies. Hence, high yield and low cost evidently leads to high income.

4. CONCLUSION

The results revealed that mulching and nitrogen fertilizer application resulted in high benefits for growth and productivity of hot pepper under irrigated condition of Alage, Central Rift Valley of Ethiopia. Application of mulch and N fertilizer improved most growth parameters and yield components of hot pepper such as PH, BN, P, SN, PW, PL and SN. It was observed that the combined application of 100 kg N ha^{-1} and transparent plastic mulch resulted in the highest MPY and TPY. Combined application of 100 kg N $ha^{-1}$and banana leaves mulch was also found to be an alternative for farmers to optimize hot pepper pod yields or improve hot pepper production under irrigated condition of semi arid areas. The results also showed that the use of dry banana leaves as mulching material could be recommended when the cost of transparent plastic is not affordable to farmers. The partial budget analyses estimated for both transparent plastic and dry banana leaves mulches also showed that the use of dry banana leaves along with 100 kg N ha^{-1} is preferred and economically acceptable as compared to the other mulching material when used in combination with nitrogen fertilizer. The partial budget analyses revealed that maximum net benefit of Birr 106043.4 ha^{-1} with an acceptable marginal rate of returns (MRR) of 57.99 were recorded in the treatment combination of banana leaves and 100 kg ha^{-1}.The next alternative approach could be application of 100 kg N ha^{-1}without mulch to obtain better profit (cost benefit ratio).

ACKNOWLEDGEMENTS

We would like to thank the Ministry of Agriculture of Ethiopia and Alage ATVT College for offering the opportunity to the first author to pursue his MSc study at Hawassa University. In addition, they are dully acknowledge for sponsoring the MSc thesis research undertakings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bosland PW, Votava EJ. Peppers: Vegetables and spice capsicums. Crop production science in horticulture, series No 12, CBI Publishing, UK. 2000;96-98.
2. FAO (Food and Agriculture Organization). Production year book. Food and Agriculture Organization of the United Nations. Rome, Italy; 2009.
3. Mo ARD. Crop variety register crop development department: Issue No. 10, June 2007. Ministry of Agriculture and Rural Development, Addis Abeba, Ethiopia; 2007.
4. EEPA (Ethiopian Export Promotion Agency). Spice potential and market study, Addis Ababa. 2003;103.
5. CSA. Agricultural sample survey of the year 2015/2016. Addis. Ababa, Ethiopia; 2016.

6. Delelegn S. Evaluation of elite hot pepper varieties (*Capsicum* species) for growth, dry pod yield and quality under Jimma condition, south west Ethiopia. M.Sc. thesis, Jimma University, Jimma. Ethiopia; 2009.
7. Alemu H, Ermias A. Horticultural crops production and associated constraints in northwest Ethiopia. Working paper. Agricultural Economics Research Division, Agricultural Research Centre, Adet. 2000; 18.
8. EIAR (Ethiopia Institute of Agricultural Research). Technology guideline for different crops. Amharic Version Addis Ababa, Ethiopia. 2007;121-124.
9. Mikkelsen R, Jensen CS, Tom WB. Nutrient management planning and accountability. International Plant Nutrition Institute. USA; 2012.
10. Friake NN, Bangal GB, Kenghe RN, More GM. Plastic tunnel and mulches for water conservation. Agricultural Engineering Today. 1990;14(3-4):35-39.
11. Yahaya RA, Aliyu L, Mahmud M. Effects of sheep manure and intra row spacing on yield and yield components of chilli pepper (*Capsicum annum* L.) at, Nigeria. Department of Agronomy, Ahmadu Bello University Zaria 6. 2010;2:45-50.
12. MARC (Melkasa Agricultural Research Center). Progress Report on Completed Activities. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia. 2005;1-7.
13. Hallidri M. Comparison of different mulching materials on growth, yield and quality of cucumber (*Cucumis sativus* L.). Act Horticulturae. 2001;559:49-53.
14. EARO (Ethiopian Agricultural Research Organization). Released crop varieties and their recommended cultural practices. Progress report. Addis Ababa, Ethiopia; 2004.
15. Lemma D, Shmelis A. Research achievement in Capsicum pepper. Research report. Addis Ababa, Ethiopia; 2008.
16. Page AL. Methods of soil analysis. Part II. Chemical and Microbiological properties. Madison. Publishing, USA. 1982;553-562.
17. Dewis J, Freitas P. Physical and chemical methods of soil and analysis. FAO Bulletin No. 10, Rome. 1970;275.
18. Cottenie I. Soil and plant testing as a base for fertilizer recommendation. FAO soils bulletin No. 38/2, FAO, Rome, Italy; 1980.
19. Olsen SR, Dean LA. Phosphorus. In: Methods of soil analysis. American Society of Agronomy. 1965;9:920-926.
20. Day PR. Hydrometer method of particle size analysis. In: Back CA (ed). Methods of soil analysis. America Society of Agronomy. Madison Winscowin. 1965;562-563.
21. Hesse PR. A text book of soil chemical analysis. John Murray, London. 1971;240.
22. CIMMYT. From agronomic data to farmer recommendations: An economic training manual, completely Revised edition. D.F. Maxico. 1988;79.
23. SAS Institute Inc. Cary, User's Guide. Version 9.2. NC. USA; 2008.
24. Weiss EA. Spice Crops. CABI publishing, UK. 2002;190-215.
25. Gervasius H. The effect of plant population and mulching on green pepper (*Capsicum annuum* L.) production under irrigation. MSc thesis submitted to the University of the Free State, South Africa. 2010;4-5.
26. Landon JR. Booker tropical soil manual. A hand book for soil survey and agricultural land evaluation in the tropics and subtropics. Longman Group Limited; 1991.
27. Tisdale SL, Nelson JD, Beaton R, Havlin JL. Soil fertility and fertilizers (7th ed.). Prentice-Hall of India, New Delhi; 2002.
28. Hazelton P, Murphy B. Interpreting soil test results: What do all the numbers mean? CSIRO Publishing, 150 Oxford Street (PO Box 1139), Collingwood VIC 3066, Australia. 2007;152.
29. Negera N. Response of hot pepper (*Capsicum annuum* L.) to mulching and plant spacing at Bako, west Shoa zone, Ethoipia. An MSc Thesis Presented to School of graduate Studies of Haramaya University. 2014;62.
30. Sintayehu M, Ali M, Derbew B, Essubalew G. Growth response of hot pepper varieties to different mulch types. American-Eurasian Journal of Agriculture & Environmental Science 2015;15(5):733-743.
31. Tindall JA, Beverly RB, Radcliffe DE. Mulch effect on soil properties and tomato growth using micro-irrigation. Agronomy Journal. 1990;83:1028-1034.
32. Decoteau RD. Vegetable crops. Prentice Hall upper Sadedle River, NJ. USA. 2000;292.
33. Ahmad I, Hussain Z, Raza S, Memon N, Naqvi SA. Response of vegetative and reproductive components of chilli to

inorganic and organic mulches. Pakistan Journal of Agricultural Sciences. 2011; 48(1):19-24.
34. Ashrafuzzaman M, Abdul halim RI, Mohd SM, d Alamgir MH. Effect of plastic mulch on growth and yield of chilli (*Capsicum annuum* l.). An International Journal of Brazilian Archives of Biology and Technology Crop botany 2011;54(2):321-330.
35. Komla AN. Effect of organic mulch on growth and yield of sweet pepper (*Capsicum annuum L.*). An MSc Thesis submitted to University of Ghana, Legon. 2013;78.
36. Akanbi WB, Togun AO, Adediran JA, Ilupeju EA. Growth, dry matter and fruit yield components of pepper under organic and inorganic sources of nutrients. American-Eurasian Journal of Sustainable Agriculture. 2010;4(1):1-13.
37. Ayodele OJ, Alabi EO, Aluko M. Nitrogen fertilizer effects on growth, yield and chemical composition of hot pepper (RODO). International Journal of Agriculture and Crop Sciences. 2015;8(5):666-673.
38. Iqbal Q. Biometric and biochemical studies on hot pepper. PhD Thesis in Horticulture Institute of Horticultural Sciences University of Agriculture. Faisalabad, Pakistan; 2009.
39. Edgar ON, Gweyi-Onyango JP, Nicholas KK. Influence of mulching materials on the growth and yield components of green pepper at Busia County in Kenya. Asian Research Journal of Agriculture. 2016;2(2): 1-10.
40. Mercelis LF, Baan LR. Effect of seed number on competition and dominance among fruits in *Capsicum annum* L. Annuals of Botany. 1997;79:687-693.
41. Balaraj R. Investigations on seed technologies aspects in pepper (*Capsicum annuum* L.). PhD Dissertation Presented to Dharwad University of Agricultural Science. 1999;129.
42. Khan A, Muhammad Shah SN, Rab A, Sajid M, Ali K, Ahmed A, Faisal S. Influence of nitrogen and potassium levels on growth and yield of chillies (*Capsicum annuum* L.). International Journal of Farming and Allied Sciences 2014;3(3): 260-264
43. Deshmukh AK. Response of pepper (*Capsicum annuum* L.) to Site Specific Nutrient Management. An MSc Thesis presented to Dharwad University of Agricultural Science. 2008;103.
44. Adugna Z. Effects of seed priming, planting method and fertilizers on yield and yield components of fresh hot pepper (*Capsicum annum* L.) in north-west Ethiopia. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University. 2008;74.
45. Siti AH, Gerber JM, Splittstoesser WE. Growth and yield potential of green pepper as affected by nitrogen at transplanting. Journal of Tropical Agriculture Science. 1993;16(2):101-105.
46. Roy SS, Khan MS, Pall KK. Nitrogen and phosphorus efficiency on the fruit size and yield of capsicum. Journal of Experimental Sciences. 2011;2(1):32-37.
47. Tibebu S, Bizuayehu T. Growth and productivity of hot pepper (*Capsicum frutscences L.)* as affected by variety, nitrogen and phosphorous at Jinka, Southern Ethiopia. Research Journal of Agriculture and Environmental Management. 2014;3(9):427-433.
48. Allemullah M, Haigh AM, Holford P. Anthesis, anther dehiscence, pistle receptivity and fruit development in the Longum group of pepper. Australian Journal of Experimental Agriculture. 2000; 40:755-762.
49. Tnidartit D, Ban D. Plant population and cultural practices on yield of bell peppers (*Capsicum annuum* L.). Vegetable Growing. Institute for Agriculture and Tourism. 2015;45:624-628
50. Mebratu A, Dechassa N, Mulualem T, Weldetsadik K. Effect of inorganic fertilizers on yield and physical quality parameters of hot pepper (*Capsicum annuum* l.) in South-Eastern Ethiopia*,* Journal of Plant and Pest Science. 2014; 1(3):138-145.
51. Baye B. Effect of mulching and amount of water on the yield of tomato under drip irrigation. Adet Agricultural Research Center, Bahir-Dar; 2011.
52. Sciortino A. Mulching, in what conditions. Colture Protette. 2001;30:39-43.
53. Aloni BL, Karni LR, Zaidman Z. The effect of nitrogen fertilization and shading on the incidence of 'Colour spots' in sweet pepper (*Capsicum annuum* L.) fruit. Journal of Horticultural Science. 1994;69(4):767-773.
54. Rose NE, Stoffella DJ, Bryan NH. Growth and yield of bell pepper and winter squash grown with organic and living mulches.

Journal of American Society of Horticultural Science. 1994;119:1193-1199.
55. Stapleton JJ. Reflective mulches for management of aphids and aphid-borne virus diseases in late-season cantaloupe (*Cucumis melo* L. var. cantalupensis). Crop Protection. 2002;21:891–898.
56. Thakur PS, Anju T, Kanaujia SP. Reversal of water stress effects. Mulching impact on the performance of *Capsicum annuum* under water deficit. Indian Journal of Horticulture. 2000;57(3):250-254.
57. Leghari GM, Oad FC. The effect of nitrogen fertilizer regimes on the growth and yield of pepper. Indus Journal of Plant Sciences. 2005;4(3):386-390.
58. Mavengahama S, Ogunlela VB, Mariga IK. Response of paprika (*Capsicum annuum* L.) to different basal fertilizers. Journal of African Crop Science Society. 2003;6:9-13.
59. Moniruzzaman M. Effects of plant spacing and mulching on yield and profitability of lettuce (*Lactuca sativa* L.). Journal of Agriculture and Rural Development, Bangladesh. 2006;4(1-2):107-111.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48221