American-Eurasian J. Agric. & Environ. Sci., 15 (11): 2201-2210, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.11.12736

# Impact of Organic Mulch Materials on Yield and Yield Attributes of Hot Pepper Varieties at Jimma, Southwest Ethiopia

[1]*Sintayehu Musie,* [2]*Ali Mohammed,* [3]*Derbew Belew and* [4]*Essubalew Getachew*

[1]Department of Horticulture, Debre Markos University, P.O.Box. 269, Debre Markos, Ethiopia
[2]College of Agriculture and Veterinary Medicine Department of Postharvest Management, Jimma University, P.O. Box. 307, Jimma, Ethiopia
[3,4]Department of Horticulture and Plant Science, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box. 307, Jimma, Ethiopia

**Abstract:** Hot pepper (*Capsicum* species) is a national spice and vegetable of Ethiopia grown in both wet and dry seasons and fetches larger profit when cultivated during the dry season. The yield of the crop in the dry season is limited by soil moisture stress. Therefore, a field experiment was conducted in 2009/10 at Jimma University College of Agriculture and Veterinary Medicine under irrigation with the objective of determining the effects of different mulch types on yield and yield attributes of hot pepper varieties. The experiment consisted of three hot pepper varieties (Bako Local, Melka Awaze and Dube Medium) and three types of mulches (dry coffee husk, dry vetiver grass and dry banana leaves) laid out in Randomized Complete Block Design with three replications. Data were collected on yield and yield attributes of hot pepper varieties. The results indicated that the combined effects of mulching and varieties showed significant variation on yield and yield attributes of hot pepper. The interaction of Melka Awaze variety with dry coffee husk produced highest number of fruits per plant (64.05), highest dry marketable fruit yield and maximum total fresh (15.66 tons) and dry (3.09 tons) fruit yield per hectare. Bako local variety with dry coffee husk gave the longest fruit (13.10 cm) and highest fruit shape index (7.12). While, the height number of seeds per pod (143.08) was obtained from Dube Medium variety grown under coffee husk mulch. From this study it can be concluded that dry coffee husk and dry vetiver grass mulches combined with Melka Awaze variety have a potential to increase the yield of hot pepper under Jimma condition.

**Key words:** Hot Pepper · Varieties · Mulches · Yield and Yield Components

## INTRODUCTION

Hot pepper (*Capsicum species*) is a dicotyledonous woody perennial small shrub belongs to the *Solanaceae* family and originated in the new world tropics and subtropics (Mexico, Central America and Andes of South America) over 2000 years ago [1]. It was introduced to Ethiopia probably by the Portuguese in the 17th century [2]. Hot pepper species are diploid and have the same chromosome number of n=12, 2n=24. But, recent studies indicated that chromosome number for non pungent species is n=13 [3].

It is the world's third most important vegetable after potatoes and tomatoes in terms of quantity of production. World production of chili and pepper was 31.44 million tons both dry and green fruit from 3.70 million hectares [4]. Africa's production of chili and pepper was 7.70 million tons both dry and green fruit from 0.89 million hectares [4]. According to MoARD [5], the total area cultivated in Ethiopia with pepper (Green and peppers) were 118, 987 hectares and the total production was 0.25 million tons. It is a national spice of Ethiopia. It is an economically and traditionally important crop in the country. It is grown as an annual crop and produced for its fruits. It is one of the most important vegetable crops for fresh consumption (as chilies), for processing and as a spice (for making stew). It is also a very important crop for spice extraction since it has a lot of oleoresin for dying of food items [5]. In addition to its export value, the powder form of the dried pod is the main component in the daily diet of Ethiopians.

**Corresponding Author:** Sintayehu Musie, Department of Horticulture, Debre Markos University, P.O.Box. 269, Debre Markos, Ethiopia.

Soil moisture stress is the major bottleneck of pepper production in dry seasons. Full or supplementary irrigation could be used to alleviate soil moisture stress; however, the high cost of irrigation water necessitates its economy. Moreover, many of the farmers cannot afford the expenses of irrigation. Under this situation organic mulching could be a good complement for irrigation. Organic mulches like maize cobs, wheat straw, banana residues, coffee husk, vetiver grass and so on are generally practiced in the production of horticultural crops. Mulching has been used to obtain higher vegetative growth and yields in other crops [6-10] by exploiting one or a combination of its properties.

Mulching is a popular agronomic practice in agriculture. It is one of the simplest and most beneficial practices used in the garden. Mulch is simply a protective layer of a material that is spread on top of the soil. It can either be organic; such as grass clippings, straw, bark chips and similar materials or inorganic; such as stones, brick chips and plastic. Both organic and inorganic mulches have numerous benefits [11,12]. Mulching with plant residues and synthetic material is a well-established technique for increasing the profitability of many horticultural crops. A favorable soil-water-plant relation is created by placing mulch over the soil surface [13,14].

Mulch is an excellent insulator and prevents drastic fluctuations in soil temperature. It keeps the soil cooler in summer and warm in winter. In addition, mulch can improve both root growth and nutrient availability. At the end of the growing season, organic mulches can be tilled into the soil to further increase the organic matter content and the water-holding capacity of the soil. Organic mulches promote soil microorganism activity, which in turn, improves soil tilth and helps lessen soil compaction. It also control weeds by shading them and diseases by preventing soil contact with the plant foliage. It reduces labor required in cultivation, since emerging and small weeds perish under their dark barrier [12,15,16].

In spite of the economic importance of coffee, there is no reliable information on the utilization of coffee processing byproduct either from low input traditional small holdings or the large scale plantations [17]. Currently, huge amount of coffee husk from dry processing is burnt in Jimma area either deliberately or by spontaneous combustion. Thus, the availability of such coffee processing byproduct is advantageous resource to be reused in agricultural production. Nowadays, pollution because of disposal of the coffee husk is becoming a major concern in Jimma area [18]. Similar to other mulching materials, vetiver leaves provides shade to the plot, thereby decreasing the temperature and at the same time conserve moisture of the plot and keep weeds under control. Vetiver leaves are excellent materials for mulching; they are durable and long lasting. Vetiver mulch can be applied to vegetable plots, at the base of fruit trees and field crop plots [19].

However, under Ethiopian conditions, very little information is available regarding comparative benefits and influences of different types of organic mulches on the yield and yield components of hot pepper. The present study was, therefore, undertaken to investigate the effects of different mulches on the growth and yield of hot pepper in dry season.

## MATERIALS AND METHODS

**Description of the Experimental Site:** The experiment was conducted under field condition at Jimma University College of Agriculture and Veterinary Medicine research field in the year 2009/10 under irrigation. Jimma University College of Agriculture and Veterinary Medicine is geographically located at 346 km southwest of Addis Ababa at about 70, 33'N latitude, 360, 57' E longitude and at an altitude of 1710 meter above sea level. The analysis of soil samples from the top 30 cm depth of the experimental site before the experiment was conducted revealed that the soil contains 0.98% organic carbon, 0.04% total nitrogen, 30.63 ppm available phosphorus, 52.04 µS/cm electrical conductivity and a pH value of 5.20 (Table 1). The mean maximum and minimum temperatures are 26.8°C and 11.4°C, respectively and the mean maximum and minimum relative humidities are 91.4% and 39.92%, respectively. The mean annual rainfall of the area is 1500 mm [20].

**Experimental Materials:** The experiment consisted of three types of mulches, which were dry coffee husk ($M_1$), dry vetiver grass ($M_2$) and dry banana leaves ($M_3$) with a control ($M_0$) where no mulch was used. Three hot pepper (*Capsicum species*) varieties namely Bako local, Melka Awaze and Dube Medium were used as indicated on Table 2. Bako Local and Dube Medium were collected from Jimma Agricultural Research Center, while Melka Awaze was obtained from Melkassa Agricultural Research Center. The coffee husk byproduct of dry processing was obtained from the nearby coffee processing station of the town immediately after processing; this is to keep good quality of the mulch. Vetiver (*Vetiveria zizaniodes (L.) Nash*) grass and banana leaves were collected from Jimma Agricultural Research Center and Jimma University College of Agriculture and Veterinary Medicine demonstration sites, respectively.

Table 1: Physical and chemical properties of soil the experimental site before planting

| Soil depth | pH ($H_2O$) | Total nitrogen (%) | Available phosphorus (ppm) | Organic carbon (%) | Electrical conductivity (µS/cm) | Soil bulk density (g/cm$^3$) |
|---|---|---|---|---|---|---|
| 0-30 | 5.20 | 0.04 | 30.63 | 0.98 | 52.04 | 1.58 |

Table 2: Details of hot pepper varieties used in the study

| | Area of adaptation | | | |
|---|---|---|---|---|
| Variety name | Year of release | Altitude (m.a.s.l) | Rainfall (mm) | Maturity days |
| Bako Local | 1976 | 1200-1900 | 800-1300 | 130-145 |
| Melka Awaze | 2006 | 1000-2200 | 900-1300 | 100 |
| Dube Medium | Under study | 1000-1200 | 600-1237 | 96 |

Sources: - EARO [21]; MARC [22]; MoARD [5]

Table 3: Details of treatment combinations

| Treatments | Varieties | Mulches |
|---|---|---|
| 1 | $V_1$ (Bako Local) | M0 (Control /without mulch) |
| 2 | M1 (Dry coffee husk) | |
| 3 | M2 (Dry vetiver grass) | |
| 4 | M3 (Dry banana leaves) | |
| 5 | $V_2$ (Melka Awaze) | M0 (Control /without mulch) |
| 6 | M1 (Dry coffee husk) | |
| 7 | M2 (Dry vetiver grass) | |
| 8 | M3 (Dry banana leaves) | |
| 9 | $V_3$ (Dube Medium) | M0 (Control /without mulch) |
| 10 | M1 (Dry coffee husk) | |
| 11 | M2 (Dry vetiver grass) | |
| 12 | M3 (Dry banana leaves) | |

**Experimental Design and Management:** The experiment was laid out in a 3x4 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications. The treatments which consisted of three hot pepper varieties and three mulch types with one treatment without mulching were randomly assigned to the experimental plots. The details of the treatment combinations are presented in Table 3.

The whole experimental field was divided into three blocks each containing 12 plots. The area of each plot was 6.3 m$^2$ (3.5 m x 1.8 m). Then, the 12 treatment combinations were randomly assigned to the unit plot of each block so as to allot one treatment combinations only once in each block. There were 6 plants in each row and 30 plants per plot. A foot path of 0.5m and 1 m were left between plots and blocks, respectively. Hot pepper seedlings were raised on well prepared seedbeds whose dimension was 5mx1m. The seeds of each variety were sown on 18$^{th}$ November, 2009 G.C. in rows which were marked at 15cm interval across the length of the seedbed. Then, the beds were covered with dry grass mulch until emergence. Complete germination of the seeds took place within 10 to 15 days of sowing and seedlings were thinned out at 3-4 leaves stage in order to maintain optimum plant population and to keep them vigorous. Fertilizers were applied to the seedlings at a rate of 10 kg/ha $P_2O_5$ as DAP (46% $P_2O_5$ and 18% N) at sowing and 10 kg/ha N as urea (46% N) immediately after thinning [23].

The seedbeds were watered before uprooting the seedlings in order to minimize the potential damage that can be inflicted on the roots. Healthy, uniform and seven weeks old seedlings of the respective varieties were transplanted on 4$^{th}$ December, 2009 G.C. at a spacing of 70 cm between rows and 30cm between plants. Finally, the seedlings were watered after transplanting and provided with temporary shade using guava twigs for a week to protect them from direct sunlight. Fertilizers were applied to the experimental plots at a rate of 200 kg/ha DAP (126 g/plot) and 100 kg/ha Urea (63g/plot). Half of the recommended urea was applied at transplanting and the rest as side dressed half month later [21]. All the recommended rate of DAP was applied during final land preparation. Mancozeb (2.3kg/100liters/ha) was applied once to prevent the potential damage by fungal diseases.

The respective mulch treatments vis-α-vis banana leaves, dry coffee husk and dry vetiver grass mulches were dried in the sun for 7-15 days and applied three weeks after transplanting (24$^{th}$ January, 2010 G.C.) at a rate of 5cm thick. Application rates corresponded to 2, 8 and 2.5 kg/m$^2$ dry banana leaves, coffee husk and vetiver

grass, respectively. The banana mulch material was chopped to a small size for proper application. The recommended management practices were done equally for all the treatments.

**Data Collected:** Data on yield and yield attributes of hot pepper were collected from the three middle rows by excluding the borders. These include: number of fruits (pods) per plant, number of seeds per pod, fruit length (cm), fruit diameter (cm), fruit shape index, marketable and unmarketable dry fruit yield (tones/ha), total fresh and dry fruit yield (tones/ha).

**Data Analysis:** The data on different yield and yield components were first checked for all assumptions and subjected to the Analysis of Variance (ANOVA) by using SAS version 9.2. [24]. Finally, significant treatment means were separated using LSD (Least Significance Difference) at 5% level of significance.

## RESULTS AND DISCUSSION

There was a highly significance ($p \leq 0.001$) interaction effect between variety and mulch type on number of fruit per plant, fruit shape index and fruit length and there was also a significantly ($P \leq 0.05$) effect on seed numbers per pod. Mulch type highly significance ($p \leq 0.001$) affect fruit diameter of hot pepper (Table 4). There was a highly significance ($p \leq 0.001$) interaction effect between variety and mulch type total fresh fruit yield, dry marketable fruit yield and total dry fruit yield. Variety and mulch type independently highly significance ($p \leq 0.001$) affect dry unmarketable fruit yield pod yield of hot pepper (Table 5).

The results depicted in Tables 4 and 6 revealed that the interaction effect of various mulch types and varieties on the number of fruits per plant was very highly significance ($p \leq 0.001$). Among the different treatment combinations, the cultivation of the variety Melka Awaze under dry coffee husk mulch resulted in the highest number of fruits per plant which however was statistically at par with response observed when the same variety was mulched with dry vetiver grass followed by Melka Awaze variety with dry banana leaves.

Conversely, the least number of fruits per plant were recorded when the variety Bako Local was grown with no mulch (control). Statistically similar results were noted for Bako Local under dry coffee husk, dry vetiver grass and dry banana leaves and also for Dube Medium variety with dry coffee husk, dry vetiver grass, dry banana leaves and control. These results are in line with the findings of Liasu and Achakzai [25], who reported that higher number of fruits per plant in tomato mulched with *Tithonia diversifolia* leaf mulch than un-mulched bare plot. Also, Aiyelaagbe and Fawusi [26] reported organically mulched plants gave the maximum number of fruits per plant on pepper plot covered with maize cobs gave the maximum number of fruits per plant. According to Korir *et al.* [27] fruit numbers increased significantly due to mulch with increasing of between 15 to 27 % over un-mulched plots being observed on cucumber.

With respect to seed production, the application of different types of mulches and varieties significantly ($P \leq 0.05$) affected the number of seeds per pod (Table 4 and Table 6). The maximum number of seeds per pod was encountered from treatment combinations of Dube Medium variety grown under dry coffee husk mulch. Whereas, the minimum number of seeds was recorded from plots of Melka Awaze with no mulch (control).

These finding are in line with those obtained by Liasu and Achakzai [25], who fuund that number of fruits per plant was highest under *Tithonia diversifolia* leaf mulch than bare plot on tomato experiment. The highest number of fruits and seeds under plots covered with mulch might be due to the favorable soil micro-climate conditions created by organic mulch application which increased the growth of hot pepper this in turn increased the number of seeds per pod and fruits per plant.

**Fruit Length, Fruit Diameter and Fruit Shape Index:** The results pertaining to the interaction effects between mulch types and varieties on fruit length (cm), fruit diameter (cm) and fruit shape index are shown in Tables 4 and 7. As the results, fruit length and fruit shape index were significantly ($p<0.01$) were influenced due to the interaction effect of mulch types with varieties. However, for fruit diameter showed, non significant ($p<0.05$) two way interaction between mulch types and varieties was observed. The longest fruit was obtained from the variety Bako Local grown with dry vetiver grass which, however, was statistically at par with Bako Local under dry coffee husk and dry banana leaves mulch and also from Dube Medium under dry coffee husk.

While, the smallest fruit was obtained from Melka Awaze plants in the control and this value is not statistically different from the response recorded for Bako Local and Dube Medium grown in the control (without mulch). The smallest fruit was also recorded from Melka Awaze with dry vetiver grass and dry banana leaves, Dube Medium grown under dry vetiver grass.

Table 4: Means squares for fruit response variables

| Source of variation | Mean squares d.f | Number of fruits per plant | Seed numbers per pod | Fruit length | Fruit diameter | Fruit shape index |
|---|---|---|---|---|---|---|
| Replication | 2 | 61.39 | 133.43 | 0.49 | 0.047 | 0.97 |
| Variety | 2 | 4794.13*** | 1396.05*** | 24.84*** | 0.005$^{NS}$ | 7.56*** |
| Mulch | 3 | 864.65*** | 1481.44*** | 18.95*** | 0.44*** | 0.81$^{NS}$ |
| Variety X Mulch | 6 | 231.55*** | 257.19* | 3.96** | 0.009$^{NS}$ | 1.33** |
| Error | 22 | 38.57 | 72.03 | 0.87 | 0.006 | 0.33 |

***; ***= Highly significant, very highly significant at 1% and 0.1% probability levels, respectively.*

**; NS =Significant, non significant at 5% probability level.*

Table 5: Means squares for yield response variable

| Source of variation | Mean squares d.f | Total fresh fruit yield | Dry marketable fruit yield | Dry un marketable fruit yield | Total dry fruit yield |
|---|---|---|---|---|---|
| Replication | 2 | 1.3663 | 0.0901 | 0.00001 | 0.0913 |
| Variety | 2 | 111.278*** | 6.124*** | 0.0936*** | 7.7258*** |
| Mulch | 3 | 113.904*** | 1.681*** | 0.0364*** | 2.1386*** |
| Variety X Mulch | 6 | 6.0315*** | 0.382*** | 0.0027$^{NS}$ | 0.4222*** |
| Error | 22 | 0.5634 | 0.0733 | 0.0012 | 0.0774 |

*NS; *** =Non significant, very highly significant at 5% and 0.1% probability level, respectively.*

*Number of fruits (pods) per plant and number of seeds per pod*

Table 6: Interaction effects of mulch types and varieties on number of fruit per plant and seeds per pod of hot pepper

| Treatments Variety | Mulch Types | No. fruits per plant | No. seeds per pod |
|---|---|---|---|
| Bako Local | Control | 5.43$^{c}$ | 95.00$^{f}$ |
| | Dry coffee husk | 17.79$^{c}$ | 120.71$^{bc}$ |
| | Dry vetiver grass | 15.28$^{c}$ | 118.00$^{bcd}$ |
| | Dry banana leaves | 10.23$^{c}$ | 103.68$^{def}$ |
| Melka Awaze | Control | 19.46$^{c}$ | 79.25$^{g}$ |
| | Dry coffee husk | 64.05$^{a}$ | 110.48$^{cde}$ |
| | Dry vetiver grass | 58.47$^{ab}$ | 98.83$^{ef}$ |
| | Dry banana leaves | 46.27$^{b}$ | 118.10$^{bc}$ |
| Dube Medium | Control | 6.74$^{c}$ | 107.37$^{cdef}$ |
| | Dry coffee husk | 17.01$^{c}$ | 143.08$^{a}$ |
| | Dry vetiver grass | 13.69$^{c}$ | 125.00$^{b}$ |
| | Dry banana leaves | 13.44$^{c}$ | 116.39$^{bcd}$ |
| SE(±) | 3.58 | 4.89 | |
| LSD (0.05) | 14.29*** | 14.37* | |
| CV (%) | 25.89 | 7.62 | |

*, ***= Significant, very highly significant at P > 0.05 and 0.001, respectively. Means within a column followed by the same letter(s) are not significantly different according to least significance difference (LSD=0.05)

Although fruit shape index is largely a function of variety, the influence of environment is paramount. The results of this particular study with regard to the influence of mulch types and variety on fruit shape index depict that fruits from the variety Bako Local grown with dry vetiver grass mulch scored the highest fruit shape index value. Nonetheless, statistically similar results are recorded from the use of dry banana leaves and dry coffee husk as mulch for the variety Bako Local. This implies the fruits of the variety Bako Local grown under various types of mulches are more elongated than the rest. At the same time the lowest values of fruit shape index were observed when plots of the variety Melka Awaze mulched with dry vetiver grass which still was statistically similar with Dube Medium mulched with dry vetiver grass, Melka Awaze with no mulch, with dry banana leaves and with dry vetiver grass and Bako Local with bare plot. These results are in conformity with the findings of Korir *et al*. [27], where significant increases in fruit length were observed in straw mulch compared to no mulching on cucumber.

Table 7: Interaction effects of mulch types and varieties on fruit length and fruit shape index of hot pepper

| Treatments | | | |
|---|---|---|---|
| Variety | Mulch Types | Fruit length (cm) | Fruit shape index |
| Bako Local | Control | 8.50[de] | 5.49[cde] |
| | Dry coffee husk | 13.10[a] | 6.24[abc] |
| | Dry vetiver grass | 13.89[a] | 7.12[a] |
| | Dry banana leaves | 12.96[a] | 7.03[ab] |
| Melka Awaze | Control | 7.99[e] | 4.98[cde] |
| | Dry coffee husk | 10.27[bcd] | 5.19[cde] |
| | Dry vetiver grass | 9.28d[cde] | 4.18[e] |
| | Dry banana leaves | 9.57d[cde] | 5.23[cde] |
| Dube Medium | Control | 8.93[cde] | 5.94[abcd] |
| | Dry coffee husk | 12.13[ab] | 5.75[bcd] |
| | Dry vetiver grass | 9.37[cde] | 4.67[de] |
| | Dry banana leaves | 10.67[bc] | 5.76[bcd] |
| SE(±) | 0.53 | 0.33 | |
| LSD (0.05) | 2.14** | 1.32** | |
| CV (%) | 8.82 | 10.17 | |

*** = Highly Significant at P > 0.01. Means within a column followed by the same letter(s) are not significantly different according to least significance difference (LSD=0.05).*

Table 8: Effects of different mulch types and varieties on fruit diameter and dry unmarketable fruit yield of hot pepper

| Treatment | Fruit diameter (cm) | Dry unmarketable fruit yield (ton/ha) |
|---|---|---|
| Mulch Type | | |
| Control | 1.55[d] | 0.08[b] |
| Dry coffee husk | 2.07[a] | 0.19[a] |
| Dry vetiver grass | 1.96[b] | 0.21[a] |
| Dry banana leaves | 1.84[c] | 0.11[b] |
| SE(±) | 0.02 | 0.01 |
| LSD(0.05) | 0.07*** | 0.03*** |
| Variety | | |
| Bako Local | 1.86 | 0.10[b] |
| Melka Awaze | 1.83 | 0.25[a] |
| Dube Medium | 1.87 | 0.09[b] |
| SE(±) | 0.02 | 0.009 |
| LSD (0.05) | 0.06[NS] | 0.03*** |
| CV (%) | 4.17 | 23.12 |

*NS; ***= Non significant, very highly significant at P > 0.05 and 0.001, respectively. Means within a column followed by the same letter(s) are not significantly different according to least significance difference (LSD=0.05)*

Although there was no interaction effect between types of mulch and variety with reference to fruit diameter, main effect of mulch types significantly ($p<0.001$) influenced fruit diameter of hot pepper (Tables 4 and 8). Thus, irrespective of the type of hot pepper varieties tested, the widest fruit diameter was obtained from use of dry coffee husk as mulch while the control produced fruits with the narrowest diameter, however, statistically similar with dry vetiver grass mulch treatment.

With respect to the response of the varieties, there was no significance ($p>0.05$) difference in terms of fruit diameter. This finding was similar to that of Islam *et al.* [10], who observed higher garlic bulb diameter produced from water hyacinth mulch. Though the influence of various mulches was significant on fruit diameter of the crop, the effect of varieties on fruit diameter was not significant ($p>0.05$).

**Marketable and Unmarketable Dry Fruit Yield:** Interaction effects of mulch types and varieties on the yield of hot pepper are presented in Fig. 1 and Table 5. Among the parameters studied dry marketable fruit yield (tons) per hectare was significantly ($p<0.001$) affected due to the interaction between mulch types and varieties.

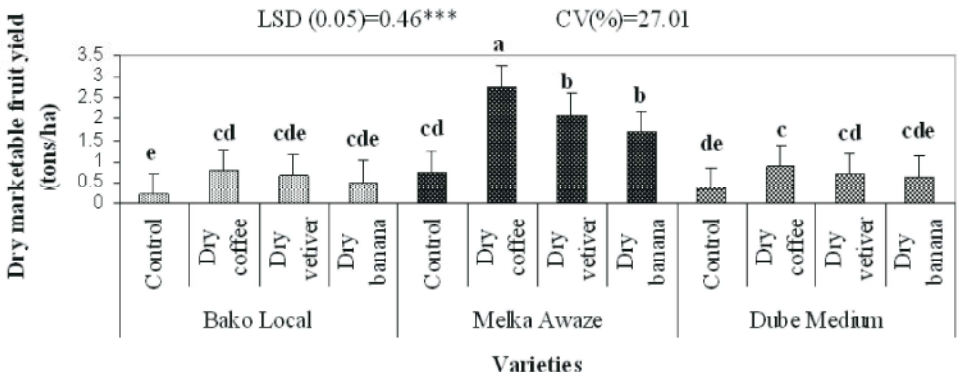


Fig. 1: Interaction effects of different mulch types and varieties on dry marketable fruit yield of hot peppervarieties
*** = Very highly Significant at P ≤ 0.001. Means followed by the same letter(s) are not significantly different according to least significance difference (LSD=0.05)

Thus, the highest dry marketable fruit yield per plant was observed from the treatment combinations of Melka Awaze variety grown under dry coffee husk mulch. The second highest yields were from Melka Awaze variety grown under both dry vetiver grass and banana leaves.

The lowest value for dry marketable yield per plant was recorded when the variety Bako Local was grown under no mulch (control) which was statistically similar with results obtained from Dube Medium with control, dry banana leaves and dry vetiver grass, Bako Local with dry banana leaves, dry vetiver grass and dry coffee husk. Melka Awaze variety grown without mulch (control) also showed the lowest dry marketable yield per plant. Mulching with various varieties increased marketable dry fruit yield of hot pepper through modification of the crop growing environment by reducing weed infestation, soil moisture depletion and ameliorating soil temperatures and also addition of nutrient to the soil through decomposition of organic mulch material under investigation.

Although the combined effect of various mulches and varieties showed non-significant ($p>0.05$) effect on unmarketable dry fruit yield per plant (Tables 5 and 8), mulch types and varieties were very highly significant ($p<0.001$). As a result, irrespective of the variety of hot pepper grown, the highest unmarketable dry fruit yield was also obtained from dry vetiver grass which was statistically similar with the result obtained from dry coffee husk, while the least unmarketable dry fruit yield per plant was observed in the control which is statistically similar with the response obtained by mulching hot pepper with dry banana leaves.

This could be probably due to the fact that dry fruit yield under dry coffee husk and vetiver grass were very high compared to control. In other words, the total dry yield from dry coffee husk and vetiver grass were 137.5% and 162.5% higher than the control, respectively. Therefore, the reason for higher unmarketable dry fruit yield per plant under mulched plot was probably due to lower total dry fruit yield under the control. Regardless of the mulch types used unmarketable dry fruit yield was found to be maximum in Melka Awaze variety while the least unmarketable dry fruit yield was observed from Bako Local variety, however, statistically similar with the variety Dube Medium.

**Total Fresh and Dry Fruit Yield:** The interaction between mulches and varieties had very highly significant ($p \leq 0.001$) effect on total fresh and dry fruit yield (ton/ha) as indicated in Tables 5 and 9. The maximum total fresh fruit yield per hectare was obtained from the treatment combinations of Melka Awaze variety with dry coffee husk mulch type followed by Melka Awaze with dry vetiver grass and Melka Awaze with dry banana leaves. The minimum total fresh fruit yields per hectare were scored from treatment combinations of Bako Local grown under the control and Dube Medium with the control. The highest yield regarding total dry fruit yield per plant was observed from the interaction of Melka Awaze with dry coffee husk followed by Melka Awaze with dry vetiver grass and dry banana leaves. Hot pepper varieties grown under mulched plots significantly out yielded the control plots because control/bare plot plants produced fewer flowers most of which abscised due to soil moisture stress. This is further supported by MoARD [5] in which it was reported that the dry fruit yield of Melka Awaze under research field were 2 to 2.8 tons per hectare.

The increase in total dry and fresh fruit yield per hectare could be due to positive effect of hot pepper varieties with various mulching material, which modified

Table 9: Interaction effect of different mulch types and varieties on total fresh and dry fruit yield (ton/ha) of hot pepper

| Treatments | | Total fresh fruit yield (ton/ha) | Total dry fruit yield (ton/ha) |
|---|---|---|---|
| Variety | Mulch Types | | |
| Bako Local | Control | 1.32[f] | 0.27[d] |
| | Dry coffee husk | 7.67[d] | 0.88[cd] |
| | Dry vetiver grass | 6.75[d] | 0.85[cd] |
| | Dry banana leaves | 3.61[e] | 0.58[cd] |
| Melka Awaze | Control | 3.45[e] | 0.93[c] |
| | Dry coffee husk | 15.66[a] | 3.09[a] |
| | Dry vetiver grass | 11.68[b] | 2.42[b] |
| | Dry banana leaves | 9.77[c] | 1.87[b] |
| Dube Medium | Control | 1.39[f] | 0.39[cd] |
| | Dry coffee husk | 7.73[d] | 1.02[c] |
| | Dry vetiver grass | 6.28[d] | 0.83[cd] |
| | Dry banana leaves | 4.19[e] | 0.69[cd] |
| SE(±) | | 0.53 | 0.43 |
| LSD (0.05) | | 2.14** | 1.72*** |
| CV (%) | | 8.82 | 11.33 |

**, *** = Highly significant, very highly Significant at P ≤ 0.01 or 0.00, respectively. Means within a column followed by the same letter(s) are not significantly different according to least significance difference (LSD=0.05)

the soil environment by conservation of soil moisture, maintenance of uniform soil temperature, suppression of weed growth and addition of nutrient to the soil due to decomposition of the organic mulch material under investigation better than the control which leads to higher vegetative and reproductive growth of hot pepper variety, these in turn increased yield ultimately.

These findings are in line with those reported by Schonbeck and Evanylo [6], who indicated hay, plastic and paper mulches considerably enhanced tomato yields compared to the un mulched treatment, Yang *et al.* [9] reported that wheat grain yield in straw and concrete mulch treatments were significantly higher than those in bare plot. Kumar *et al.* [7] reported both grass and polyethylene mulches increased strawberry yield over the un-mulched plots. Moniruzzaman [8] indicated that rice straw mulching produced maximum lettuce fresh weight and dry weight over bare plot. Aiyelaagbe and Fawusi [26] found that organically mulched plants significantly out yielded un-mulched plants on pepper; total dry fruit yield was higher under sawdust and Maize cobs. Highest garlic dry weight of bulb was produced from water hyacinth mulch compared to without mulch [10].

## SUMMERY AND CONCLUSION

Hot pepper is a warm season, high value cash crop, of which production is generally confined to areas where water is often limiting. Since the crop is sensitive to water stress, irrigation is standard practice in hot pepper production. However, the amount of water available for irrigation is declining consistently as a result of pressure from other competing sectors. Furthermore, excess water application of irrigation is one of the main reasons for degradation of agricultural land through salinization and erosion. Hence, there is a need to improve irrigation management and water use efficiency in crop production. Organic mulching is recommended as a tactical tool to manage irrigation and increase productivity of hot pepper because it improves growth and yield by improving all physical, chemical and biological properties of the soil and also lowering the production cost.

In this study, effect of mulch types and variety on yield and yield attributes of hot pepper were investigated. The findings of the study revealed the existence of apparently significant responses in terms of yield and yield related attributes. Generally, organic mulch materials and varieties used in the study significantly increased yield and yield components of hot pepper varieties.

Variety Melka Awaze combined with dry coffee husk scored higher number of fruit per plant, maximum dry marketable fruit yield, total dry and fresh fruit yield per hectare. Likewise, Melka Awaze with dry vetiver grass also gave higher score for number of fruit per plant. On the other hand Bako Local variety grown under dry coffee husk produced longer fruit length and higher fruit shape index value; correspondingly, Bako Local variety cultivated with dry vetiver grass gave longer fruit length and higher fruit shape index value.

Therefore, the results of this study has shown that various mulching types, varieties and their interaction have sound and promising impact on yield and yield attributes of hot pepper. Generally, dry coffee husk mulch material combined with Melka Awaze variety which

significantly increased yield and yield components of hot pepper would be preferred for dry season production followed by dry vetiver grass with Melka Awaze. It can be concluded from this study that dry coffee husk and dry vetiver grass mulches combined with Melka Awaze variety have potentiality to increase the yield of hot pepper under Jimma condition. Hence, farmers of Jimma and similar agro-ecological areas may possibly use those mulches which can increase the total production of hot pepper per unit area of land.

## REFERENCES


1. Walter, H., 1986. Green Leaf. Pepper Breeding. pp: 690. In: Breeding Vegetable crops. Westport, Connecticut: AVI Publishing, Co.
4. FAO, 2009. Production year book. Food and Agriculture Organization of the United Nations, Rome, Italy.
5. MoARD, 2006. Crop variety register, Crop development department: Issue No. 9, June 2006. Ministry of Agriculture and Rural Development, Addis Abeba, Ethiopia.
6. Schonbeck, M.W. and G.K. Evanylo, 1998. Effects of Mulches on Soil Properties and Tomato Production: Soil Temperature, Soil Moisture and Marketable Yield. J. Sustainable Agriculture, 13(1): 55-81.
7. Kumar, S., I.P. Sharma and J.N. Raina, 2005. Effect of Levels and Application Methods of Irrigation and Mulch Materials on Strawberry Production in North-West Himalayas. J. Indian Soc. Soil Sci., 53: 60-65.
8. Moniruzzaman, M., 2006. Effects of Plant Spacing and Mulching on Yield and Profitability of Lettuce (*Lactuca sativa* L.). J. Agric. Rural Dev., 4(1 and 2): 107-111.
9. Yang, Y., X. Liu, W. Li and C. LI, 2006. Effect of different mulch materials on winter wheat production in desalinized soil in Heilonggang region of North China. J. Zhejiang Univ. Sci., 7(11): 858-867.
10. Islam, M.J., A.K.M.M. Hossain, F. Khanam, U.K. Majumder, M.M. Rahman and S.M. Rahman, 2007. Effect of Mulching and Fertilization on Growth and Yield of Garlic at Dinajpur in Bangladesh. Asian J. Plant Sci., 6(1): 98-101.
11. USDA, 1998. U.S. Backyard Conservation: Mulching. Department of Agriculture, National Association of Conservation, USA., pp: 1-4.
12. Whiting, D., C. Moravec and C. Wilson, 2008. Mulching with Wood/Bark Chips, Grass Clippings and Rock. Colorado State University.
13. Gimenez, C., R.F. Otto and N. Castilla, 2002. Productivity of leaf and root vegetable crops under direct cover. Scientia Horticulturae, 94: 1-11.
14. Iqbal, Q., 2009. Biometric and Biochemical Studies On Hot Pepper. A PhD thesis submitted to Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan.
15. Westerfield, R.R., 2005. Mulching Vegetables. The University of Georgia College of Agricultural and Environmental Sciences, Georgia, USA.
16. International Society of Arboriculture (ISA), 2009. Proper Mulching Techniques. USA.
17. Chane Abate and S. Joachim, 2002. Management of coffee processing By-products: II. Effect of Coffee Husk and Pulp on Soil physical and Chemical Properties. Ethiopian J. Natural Resource, 4(2): 267-273.
18. Tadesse Eshetu, Wondyifraw Terefa and Tesfu Kebede, 2007. Effect of weed Management on Pineapple growth and Yield. Ethiopian J. Weed Mgt., 1(1): 29-40.
19. Chomchalow, N. and K. Chapman, 2008. Other Uses and Utilization of Vetiver. Bangkok, Thailand.
20. BPEDORS. 2000. Physical and socio economical profile of 180 District of Oromia Region. Bureau of Planning and Economic Development of Oromia Regional state, Physical planning Development. Finfinne, Ethiopia, pp: 248-251.
21. EARO, 2004. Directory of Released Crop Varieties and their Recommended Cultural Practices. Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.
22. MARC, 2005. Progress report on completed activities. Melkassa Agricultural Research Center, Nazret, Ethiopia.
23. Achenif Abe Hailu, 2006. Effect of Intercropping of Hot Pepper (*Capsicum annuum* L.) and Black Cumin (*Nigella sativa* L.) on Performance of Component Crops and Productivity of the System in Awi Zone, Amhara National Regional State. An M.Sc. Thesis Submitted to the School of Graduate Studies of Alemaya University, Ethiopia, pp: 26.
24. SAS (Statistical Analysis System) Institute Inc, 2008. SAS/STAT® 9.2 User's Guide. Cary, NC: SAS Institute Inc.
25. Liasu, M.O. and A.K.K. Achakzai, 2007. Influence of *Tithonia diversifolia* Leaf mulch and fertilizer Application on the Growth and Yield of Potted Tomato Plants. American-Eurasian J. Agric. and Environ. Sci., 2(4): 335-340.

26. Aiyelaagbe, I.O.O. and M.O.A. Fawusi, 1986. Growth and Yield Response of Pepper to Mulching. Biotronics, 15: 25-29.

27. Korir, N.K., J.N. Aguyoh and L. Gaoqiong, 2006. Enhanced Growth and Yield of Greenhouse Produced Cucumber under High Altitude Areas of Kenya. Agricultura Tropica Et Subtropica, 39(4): 249-254.