American-Eurasian J. Agric. & Environ. Sci., 15 (5): 733-743, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.5.12611

Growth Response of Hot Pepper Varieties to Different Mulch Types at Jimma, South Western 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]Department of Postharvest Management, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box. 307, Jimma, Ethiopia
[3]Department of Horticulture and Plant Science, College of Agriculture and Veterinary Medicine, Jimma University, P.O.Box. 307, Jimma, Ethiopia

Abstract: Hot pepper 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 t mulch types on growth 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 growth of hot pepper varieties. The results indicated that the combined effects of mulching and varieties showed significant variation on growth of hot pepper. The interaction between Bako Local variety with dry coffee husk produced higher total leaf area (9089.94cm^2/plant), larger leaf area index (4.33), longer fruit length (13.10cm) and higher fruit shape index value (6.24). Bako Local with dry vetiver grass produced the longer fruit length (13.89cm) and higher fruit shape index. Variety Melka Awaze mulched with dry coffee husk produced maximum number of leaf per plant, higher number of fruit per plant. Melka Awaze with dry vetiver grass also gave higher number of fruit per plant. From this study it can be concluded that dry coffee husk and dry vetiver grass mulches combined with Melka Awaze variety have potential to increase the growth hot pepper under Jimma condition.

Key words: Hot Pepper · Varieties · Mulches · Growth

INTRODUCTION

Hot pepper (*Capsicum species*) is a new world crop that 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]. Even though no documented information is available, it was introduced to Ethiopia probably by the Portuguese in the 17th century [2]. It is a dicotyledonous woody perennial small shrub in suitable climatic conditions, living for a decade or more in the tropics 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].

Hot pepper 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

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

very important crop for spice extraction since it has a lot of Oleoresin for dying of food items [6]. In addition to its export value, the powder form of the dried pod is the main component in the daily diet of Ethiopians.

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, vertiver 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 [7-11] 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 [12,13]. 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 [14,15].

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 [13,16,17].

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 [18]. 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 [19]. 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 [20].

However, under Ethiopian conditions, very little information is available regarding comparative benefits and influences of different types of organic mulches on the growth and yield 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 Abeba 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 26.80C and 11.40C, 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 [21].

Experimental Materials: The experiment consisted of three types of mulches, which were dry coffee husk (M1), dry vetiver grass (M2) and dry banana leaves (M3) with a control (M0) where no mulch was used. Three hot pepper (Capsicum species) varieties vis-à-vis Bako local, Melka Awaze and Dube Medium were used as indicated in 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. The vetiver (*Vetiveria zizaniodes* (L.) Nash) grass and banana leaves were collected from

Table 1: Soil physical and chemical properties of the experimental site before planting

Soil depth	pH (H2O)	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 [22]; MARC [23]; MoARD [24]

Table 3: Details of treatment combinations

Treatments	Varieties	Mulches
1	V1 (Bako Local)	M0 (Control /with out mulch)
2		M1 (Dry coffee husk)
3		M2 (Dry vetiver grass)
4		M3 (Dry banana leaves)
5	V2 (Melka Awaze)	M0 (Control /with out mulch)
6		M1 (Dry coffee husk)
7		M2 (Dry vetiver grass)
8		M3 (Dry banana leaves)
9	V3 (Dube Medium)	M0 (Control /with out mulch)
10		M1 (Dry coffee husk)
11		M2 (Dry vetiver grass)
12		M3 (Dry banana leaves)

Jimma Agricultural Research Center and Jimma University College of Agriculture and Veterinary Medicine demonstration sites, respectively.

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 indicated in Table 3.

The whole experimental field was divided into three blocks each containing 12 plots. The size of each plot was 6.3 m^2 (3.5 m x 1.8 m). Then, the12 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 18th November, 2009 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 [25].

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 4th December, 2009 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 (126g/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 [22]. All the recommended rate of DAP was applied during final land preparation. Mancozeb (2.3kg/100 liters/ha) was applied once to prevent the potential damage by fungal diseases.

The respective mulch treatments vis-à-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 (24th January, 2010 G.C.) at a rate of 5cm thick. Application rates corresponded to 2, 8 and 2.5 kg/m2 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 growth response of hot pepper were collected from the three middle rows by excluding the borders. These include: plant height (cm), number of primary branches, canopy diameter (cm), number of leaves per plant, total leaf area (cm^2/plant): leaf area index, tap root length (cm): root volume (ml): number of days to 50% flowering and number of days to 50% fruit maturity.

Data Analysis: The data on different growth, yield and soil parameters were first checked for all assumptions and subjected to the Analysis of Variance (ANOVA) and correlation by using SAS version 9.2. [26]. Finally, significant treatment means were separated using LSD (Least Significance Difference) at 5% level of significance.

RESULTS AND DISCUSSIONS

Plant Height: Even though, the interaction effects due to mulch types and varieties was observed to be non-significant (P>0.05), however, plant height measured at 50 and 100% flowering and final harvest as influenced by mulching types and variety of hot pepper revealed very highly significant (P<0.001) variations in response to mulches and varieties (Table 4). On this plant response variable, plant height taken at fifty percent flowering revealed that the tallest plants were obtained as a result of treatment with dry vetiver grass mulch followed by dry coffee husk and dry banana leaves mulches; whereas the shortest plants were observed from the control. Dry vetiver grass mulch showed 54.29%, 26.79% and 17.39% taller plant height than the control, dry banana leaves and dry coffee husk mulch, respectively at 50% flowering. Among the varieties the tallest plants at 50% flowering were found to be from Melka Awaze followed by Bako Local and Dube Medium.

Subsequent measurement of plant height at hundred percent flowering revealed that mulching with dry coffee husk produced a significantly tallest plant which however was significantly at par with dry vetiver grass. Poor performance of plants as manifested by the shortest height was found to be the influence of no mulching (control) treatment. At 100% flowering the plant height from dry coffee husk mulched plot showed 58.16%, 19.20% and 0.76% taller height than the control, dry banana leaves and dry coffee husk, respectively. At final harvest, the tallest plant height was recorded from plots that received dry coffee husk, this nevertheless was statically similar with the value registered from dry vetiver grass treatment, while the control showed the shorter plant height. Plant height of dry coffee husk mulch was 49.87%, 21.12% and 6.68% taller plant height than the control, dry banana leaves and dry vetiver grass, respectively at final harvest.

Table 4: Effects of various mulch types and varieties on plant height of hot pepper

	Plant height (cm)		
Treatments	50% flowering	100% flowering	Final harvest
Mulch types			
Control	27.22c	35.09c	43.53c
Dry coffee husk	37.18b	55.50a	65.24a
Dry vetiver grass	42.00a	55.08a	61.15a
Dry banana leaves	32.95b	46.56b	53.86b
SE(+)	1.55	1.95	1.82
LSD (0.05)	4.56***	5.82***	5.37***
Variety			
Bako Local	27.63b	37.51 b	44.91b
Melka Awaze	48.22a	70.34a	83.31a
Dube Medium	28.66b	36.33b	39.61c
SE(+)	1.34	1.69	1.58
LSD (0.05)	3.95***	5.04***	4.64***
CV (%)	13.40	12.35	9.81

The tallest plant height at different growth and reproductive stages were obtained from the plot covered with mulches, these could be due to the fact that mulching conserved optimum soil moisture, maintained uniform soil temperature and suppressed weeds growth and also modified the soil properties in general. This result is in agreement with the findings of Aiyelaagbe and Fawusi [27] on pepper and Kayum *et al.* [28] on tomato. The mulch trial involving different organic mulches resulted taller plants in mulched plots over the control (un-mulched). Similar results were reported by Islam *et al.* [11] on garlic, Moniruzzaman [9] on lettuce, Jalil *et al.* [29] on potato, which showed that mulching significantly increased plant height (cm) and mulched plots produced the tallest plant over the control (bare plot). Wicks *et al.* [30], Gill *et al.* [31] and Khurshid *et al.* ([32] pointed out that maize grew taller under mulch, because of availability of more soil moisture contents for plant growth.

Regardless of the mulch types used, plant height at fifty and hundred percent flowering and at final harvesting showed very highly significant (p<0.001) variation due to different varieties. The taller plant heights at 50% flowering, 100% flowering and at final harvest, respectively were recorded from Melka Awaze. While the shortest plant heights were recorded from Bako local at

Table 5: Effects of various mulching types and varieties on number of primary branches and canopy diameter (cm) of hot pepper

Treatments	No. of primary branches	Canopy diameter (cm)
Mulch Type		
Control	4.90 c	21.72 c
Dry coffee husk	8.34 ab	39.55 a
Dry vetiver grass	8.95 a	34.37 a
Dry banana leaves	7.87 b	28.88 b
SE(+)	0.29	1.81
LSD(0.05)	0.85***	5.31***
Variety		
Bako Local	7.63ab	26.41b
Melka Awaze	7.90a	40.97a
Dube Medium	7.01b	25.25b
SE(+)	0.25	1.56
LSD (0.05)	0.74*	4.60***
CV (%)	11.66	17.60

50% flowering though statistically similar with Dube Medium. At 100% flowering the shortest plants were obtained from Dube Medium and Bako Local. At final harvest Dube Medium gave the shorter plant height at final harvest. According to MARC [23] the plant heights of Bako local and Dube Medium were 46.2 cm and 59 cm tall at full bloom, respectively. Whereas, the variety Melka Awaze can grow up to 61cm [24]. The possible reason for the variation in plant height among the varieties could be due to differences genetic makeup.

Number of Primary Branches and Canopy Diameter: Results pertaining to number of primary branches are depicted in Table 5. Though no significant interaction (P>0.05) effects were observed between varieties and mulch types, the findings of this experiment indicated that both mulch types and varieties independently and significantly affected the number of primary branches per plant. Significantly maximum numbers of primary branches were observed as a result of mulching hot pepper plants with dry vetiver grass which however, was not significantly different from the effect observed due to mulching with dry coffee husk. On the other hand, significantly the minimum number of primary branches was obtained from the control treatment. Of all mulch types applied in the experiment dry vetiver grass showed 82.65%, 13.72 % and 7.31% more number of branches increments than the control, dry banana leaves and dry coffee husk, respectively. The positive effects of mulching could probably be associated with the reduction in nutrient loss due to leaching, reduction of soil heat, suppression of weed and conservation of moisture by the mulch materials.

The results are in accordance with the findings of Tan *et al.* [33], who observed higher number of primary branches in bottle gourd cultivated under straw mulch relative to the bare plot. The authors substantiated their findings with the fact that mulch treatment would be superior to no-mulch for improving soil conditions and plant production.

Irrespective of the mulch type applied, performance of hot pepper varieties showed a significant ($p< 0.05$) difference with respect to the number of primary branches they produced (Table 5). Significantly more numbers of primary branches were observed from Melka Awaze which however was at par with Bako Local and significantly the least number of primary branches was recorded from Dube Medium. The possible reason for the variation in number of primary branches among the varieties could be due to differences genetic makeup.

As illustrated in Table 5, the application of different types of mulch materials to hot pepper plants grown under irrigation brought about very highly significant ($p< 0.001$) differences in terms of canopy diameter (cm). Plants that received dry coffee husk as mulch gave significantly the widest canopy diameter which however, was not significantly different from the effect observed due to mulching with dry vetiver grass followed by with the outcome of mulching with dry banana leaves while absence of mulching significantly reduced the number of primary branches to the lowest. Plots amended with dry coffee husk mulch gave 82.09%, 36.94% and 15.07% wider canopy diameters than the control, dry banana leaves and dry vetiver grass mulch, respectively. It is very apparent that mulched hot pepper plants were significantly larger in size than plants from bare plot (control), due mainly to high soil water content, uniform soil temperature and less weed infestation achieved with application of mulch.

Similar results were reported by Aiyelaagbe and Fawusi [27] based on their mulching experiment on pepper that revealed the superiority of sawdust, dry grass and maize cob over the control (without mulch). Furthermore, the result of this study corroborates with the findings of Moniruzzaman [9], who observed mulching with rice straw increased the average canopy width on lettuce. Similarly, Igbokwe [34] indicated that canopy width of cayenne hot pepper was increased by pine needle mulch compared to the control.

The results in Table 5 also depicted that irrespective of the mulch material applied, there were very highly significant ($P < 0.001$) differences among the varieties in terms of canopy diameter. Among the varieties Melka Awaze gave significantly the maximum canopy diameter

Table 6: Interaction effects of different mulch types and varieties on leaves response of hot pepper

Treatments				
Variety	Mulch types	No. of leaves per plant	Total leaf area (cm^2/plant)	Leaf area index
Bako Local	Control	137.83cd	840.28fg	0.39d
	Dry coffee husk	542.33a	9089.94a	4.33a
	Dry vetiver grass	520.00a	6515.66b	3.11ab
	Dry banana leaves	487.17a	4057.68c	1.93bc
Melka Awaze	Control	241.33bc	1315.47def	0.62cd
	Dry coffee husk	463.83a	2498.90de	1.18cd
	Dry vetiver grass	264.33bc	2485.97de	1.20cd
	Dry banana leaves	264.89bc	2102.43def	1.01cd
Dube Medium	Control	11.17d	1006.60ef	0.48d
	Dry coffee husk	478.33a	5631.37b	2.68b
	Dry vetiver grass	211.17bc	2312.36ed	1.10cd
	Dry banana leaves	298.00b	2599.15d	1.08cd
SE(+)		33.22	424.99	0.20
LSD (0.05)		132.4***	1246.5***	1.36***
CV (%)		17.17	21.83	21.83

followed by Bako Local which however happened to be statistically similar with Dube Medium that produced the narrowest canopy diameter (26.01cm). MoARD [6] reported the canopy diameter of Melka Awaze variety is 61 cm.

Number of Leaves per Plant, Total Leaf Area and Leaf Area Index: The performance of hot pepper in terms of the number of leaves per plant, total leaf area per plant (cm^2) and leaf area index were significantly ($P< 0.001$) influenced by the interaction effects between mulch types and varieties (Table 6). Significantly the highest number of leaves per plant was obtained when the variety Bako Local was grown under dry coffee husk which was statistically at par with Bako Local mulching with dry vetiver grass and dry banana leaves. Statistically similar results were also observed from plots of Melka Awaze plants mulched with dry coffee husk and Dube Medium variety grown under dry coffee husk. On the other hand, the lowest number of leaves was recorded when the variety Dube Medium and Bako Local without mulch (control).

As depicted in Table 6, the maximum leaf area was obtained from the cultivation of the variety Bako Local under dry coffee husk mulch followed by Bako Local grown under vetiver grass and Dube Medium with dry coffee husk. While the minimum leave area per plant was recorded from Bako Local grown with no mulch (control).

Regarding leaf area index the higher was observed from the cultivation of the variety Bako Local under dry coffee husk mulch, which was statistically at par with Bako Local mulching with dry vetiver grass. On the other hand, the lowest leaf area index was obtained from Bako local variety grown under bare plot (control). Statistically similar results were also observed from plots of Melka Awaze and Dube Medium with the control (no mulch) and also from Melka Awaze and Dube Medium grown under dry vetiver grass and dry banana leaves. In addition, Melka Awaze mulched with dry coffee husk also scored the lowest leaf area index. The observed increase in number of leaves per plant, total leaf area per plant and leaf area index as a result of application of different types of mulches to the varieties could probably be explained by the maintenance of uniform soil temperature, optimum soil moisture content, weed suppression and improved soil properties in general. These positive effects in turn might have improved the growth and yield of hot pepper by providing optimum growing environmental conditions.

The positive effect of mulching on the number of leaves per plant observed in this study agreed with the findings of Umar *et al.* [35] who reported significant effect of mulching on leaf number/plant in onions. Similar observation were given by Islam *et al.* [11] and Karaye and Yakubu [36], who reported higher number of leaves on mulched plot over the bare plot in Garlic, but disagreed with that of Ibrahim [37], who reported non-significant effect of mulching on leaf number/plant in garlic. Singh *et al.* [38] observed higher leaf area in mulched strawberry. As per the result of the experiment conducted on wheat, leaf area index was reported to be greater with straw mulch than without mulch [10].

Table 7: Effects of different mulching types and varieties on tap root length and volume of hot pepper

Treatment	Tap root length (cm)	Root volume (ml)
Mulch Type		
Control	23.00a	13.88c
Dry coffee husk	18.52b	28.08a
Dry vetiver grass	18.22b	25.86ab
Dry banana leaves	17.53b	23.69b
SE(+)	0.80	1.06
LSD (0.05)	2.37***	3.11***
Variety		
Bako Local	20.22	22.25b
Melka Awaze	18.56	28.70a
Dube Medium	19.18	17.68c
SE(+)	0.70	0.92
LSD (0.05)	2.05NS	2.70***
CV (%)	12.56	13.93

Tap Root Length and Root Volume: Analysis of variance showed there is no significance difference between the interactions of varieties with mulch types on tap root length. However, a very highly significant variation ($P<0.001$) in the tap root length (cm) was observed among the different mulching treatments (Table 7). However, there was no significant difference ($P>0.05$) in the tap root length among the varieties. Hence, the longest tap root length (23.00cm) was obtained from the control. The shortest tap root length was recorded from plants mulched with dry banana leaves which were at par with values obtained from mulching with dry vetiver grass and dry coffee husk. Consequently, the control (un-mulched plot) showed 24.19, 26.23 and 31.20% longer tap root length than plots mulched with dry coffee husk, dry vetiver grass and dry banana leaves, respectively. The observed increase in tap root length in the control could probably be a response of hot pepper plant to drought due to lack of moisture in upper layers. Under such circumstances roots grew to deeper layers in search of water, leading to longer root growth in lower layers, showing that the plant suffer from water deficit. A similar result was put forwarded by Rathore *et al.* [39] on Mustard and Chickpea experiment using rice straw mulch. These findings are in line with the work of Gill *et al.* [31], who indicated an increase of 40cm in rooting depth in the absence of mulch on corn experiment. Better availability of soil moisture in straw mulching reduced evaporation losses [40] and increase root density by lateral spread of roots [39,41].

Though significantly more root volume was recorded from the application of dry coffee husk statistically similar result was obtained from plots that received dry vetiver grass mulch (Table 7). In sharp contrast, the control showed statistically the lowest root volume. The high soil temperature regime of midday (1:00 p.m.) (22.59 °C) and afternoon at 6:00p.m. (24.53 °C) in bare plots (control) might have retarded root growth and impaired water and nutrient uptake and consequently the photosynthates required for plant growth were not adequate to prevent the stunted plant sizes (Table 7). Herrera [42] reported that the root distribution of the Puya pepper cultivar in the soil was modified by mulch than bare plot. Rathore *et al.* [39] reported rice straw mulch increased 3 to 5% root weight in mustard and 13 to 15% root weight in chickpea. Among the varieties Melka Awaze produced the highest root volume (28.70 ml) followed by Bako local (22.25 ml) and Dube medium which gave the lowest root volume (17.68 ml).

Days to 50% Flowering and Fruit Maturity: The results of this experiment indicated that the interaction between the different types of mulches and hot pepper varieties had a significant ($P<0.05$) effect on the numbers of days to 50% flowering (Fig. 1). Hence, the mulching of different hot pepper varieties with different mulch materials resulted in a significant variation with respect to the number of days taken to 50% flowering. Furthermore, it is vivid that the earliest flowering was recorded from mulching of Dube Medium with dry coffee husk which of course was not significantly different from the response of mulching Melka Awaze with dry coffee husk and dry vetiver grass. In contrast, the latest flowering was observed when the variety Bako Local was grown under the control. The apparent positive effect of mulching could probably be attributed to the conservation of soil moisture, maintenance of optimum soil temperature and reduction of competition from weeds, all of which are very critical at flowering stage of hot pepper.

In general, mulch application during dry season reduced the number of days required to reach 50% flowering by providing optimum growing environment for the crop. This result is in conformity with the findings of Singh *et al.* [38], who reported that strawberry plants mulched with black polyethylene, clear polyethylene and paddy straw took less number of days to flower over the bare plot (un-mulched).

Although there was no significant ($P>0.05$) interaction effects observed, the results of this study indicated that both mulch types and varieties independently and significantly ($P< 0.001$) affected the number of days to attain 50% fruit maturity either by enhancing or delaying the time required for 50% fruit

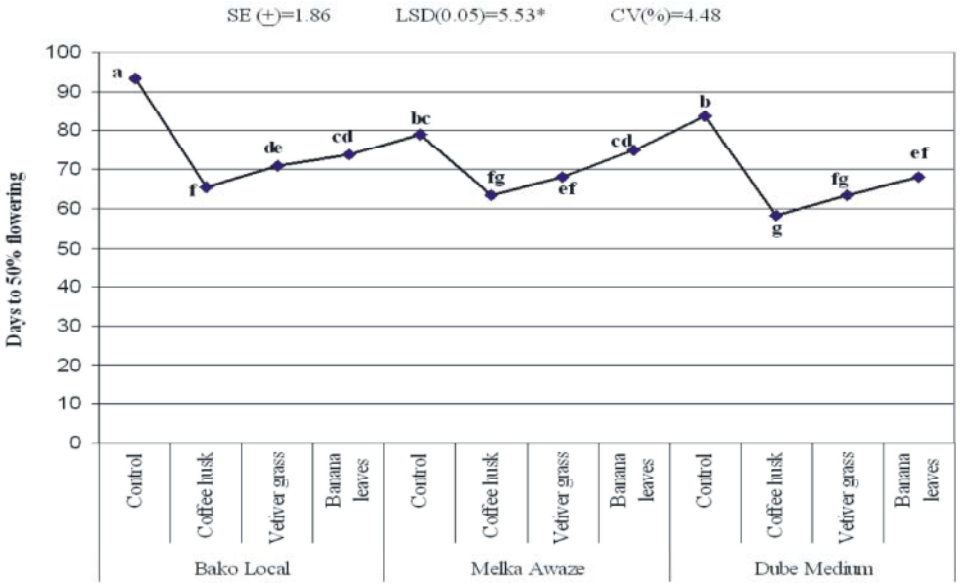

Fig. 1: Interaction effects of different mulch types and varieties on days to 50% flowering of hot pepper

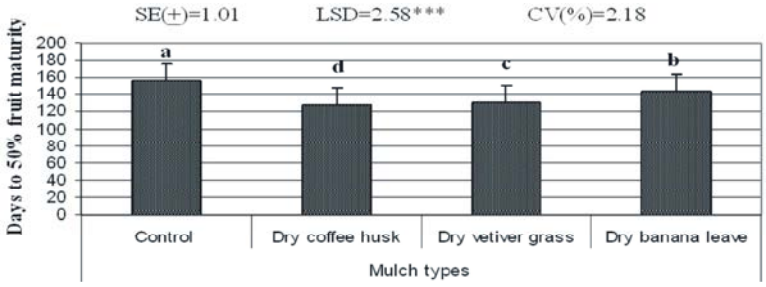

Fig. 2: Effects of various mulch types on days to 50% fruit maturity

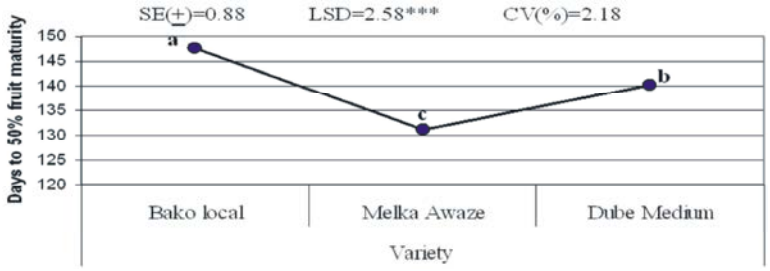

Fig. 3: Varietal difference on days to 50% fruit maturity.

maturity per plot (Fig. 2). Among the mulch types tested, dry coffee husk resulted in the earliest maturity followed by dry vetiver grass and dry banana leaves mulch. Whereas, plants in the control took the maximum time to reach fruit maturity, perhaps due to lack of soil moisture and fluctuation of soil temperature, which in turn play very crucial role during flowering. The early maturity of hot pepper plants mulched with dry coffee husk could be associated with the observed better weed controlling efficiency, retention of optimum soil temperature and relatively higher nutrient adding properties of the mulch material

The varietal differences in respect to 50% fruit maturity were very highly significant ($p< 0.001$) as shown in Fig. 3. Among the varieties, Melka Awaze was the earliest to mature while Bako Local took the maximum number of days to reach 50% fruit maturity. The varietal differences could be due to the inherent genetic variability of the crop.

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 (domestic, recreation, environmental and industrial uses). 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. Hot pepper being a high value and labour-intensive cash crop, with high production costs, it is necessary to devise means of decreasing the cost of production. Organic mulching is recommended as a tactical tool to 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. Ultimately it increases yield of the crop. To this end, understanding the variability of varietal response to different organic mulch types is crucial in improving the water use efficiency of hot pepper.

With these backgrounds, the present study was conducted to assess the growth response of hot pepper species to various mulch types at Jimma, Southwest Ethiopia. In order to pursue the research work, three hot pepper varieties namely Bako Local, Melka Awaze and Dube Medium were grown on plots treated with four types of mulches viz. dry coffee husk, dry vetiver grass, dry banana leaves and bare soil considered as control during the year 2009/10 under irrigation. The field experiment was conducted at JUCAVM using factorial in RCBD.

The results of the experiment indicated that the combined effects of mulching and varieties showed significant variation on growth attributes of hot pepper. The interaction of Bako Local variety grown under dry coffee husk produced maximum number of leaves per plant, higher total leaf area per plant, larger leaf area index, longer fruit length, higher fruit shape index value and; similarly, Bako Local variety cultivated with dry vetiver grass gave maximum number of leaves, longer fruit length and higher fruit shape index value. Variety Melka Awaze combined with dry coffee husk scored maximum number of leaves, higher number of fruits per plant. Whereas, Melka Awaze with dry vetiver grass also gave higher score for number of fruits per plant. On one hand the minimum number of days to 50% flowering, maximum number of leaves per plant were obtained from interaction effect of Dube Medium variety with dry coffee husk. On the other hand minimum number of days to attain 50% flowering, were recorded from treatment combinations of Dube Medium with dry vetiver grass.

Growth of hot pepper was significantly affected by various organic mulches materials. Among the various mulch materials, dry coffee husk had given the minimum numbers of days to reach 50% flowering, maximum numbers of primary branches, wider canopy diameter, tallest plant height at 100% flowering and highest root volume, wider fruit diameter. In addition, dry vetiver grass also scored highest and statistically similar results on numbers of primary branches, longer plant height at 50% flowering, 100% flowering and highest root volume. Among the varieties Melka Awaze gave the highest number of primary branches, wider canopy diameter, tallest plant height at 50 and 100% flowering, final harvest, higher root volume. While Bako Local and Dube Medium scored the highest number of primary branches.

Therefore, the result of this study has shown that various mulching types, varieties and their interaction have sound and promising impact on growth attributes of hot pepper.

Generally, dry coffee husk mulch material combined with Melka Awaze variety which significantly increased growth attributes 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 growth 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.
2. Hafnagel, H.P., 1961. Agriculture in Ethiopia. Food and Agricultural Organization of United Nations, Rome, Italy.
3. Bosland, P.W. and E.J. Votava, 1999. Peppers: Vegetables and Spice Capsicums. Crop Production in horticulture, Series No. 12 CBI Publishing, UK., pp: 204.

4. FAO, 2009. Production year book. Food and Agriculture Organization of the United Nations, Rome, Italy.
5. MoARD, 2009. Animal and Plant Health Regulatory Directorate: Crop VarietyR. Issue No. 12. Ministry of Agriculture and Rural Development, Addis Abeba, Ethiopia.
6. MoARD, 2007. Crop Variety Register, Crop Development Department: Issue No. 10, June 2007. Ministry of Agriculture and Rural Development, Addis Abeba, Ethiopia.
7. 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.
8. Kumar, S., I.P. Sharmaand 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.
9. 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.
10. 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.
11. 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.
12. USDA, 1998. U.S. Backyard Conservation: Mulching. Department of Agriculture, National Association of Conservation, USA., pp: 1-4.
13. Whiting, D., C. Moravec and C. Wilson, 2008. Mulching with Wood/Bark Chips, Grass Clippings and Rock. Colorado State University.
14. Gimenez, C., R.F. Otto and N. Castilla, 2002. Productivity of leaf and root vegetable crops under direct cover. Scientia Horticulturae, 94: 1-11.
16. Westerfield, R.R., 2005. Mulching Vegetables. The University of Georgia College of Agricultural and Environmental Sciences, Georgia, USA.
17. International Society of Arboriculture (ISA), 2009. Proper Mulching Techniques. USA.
18. 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.
19. 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.
20. Chomchalow, N. and K. Chapman, 2008. Other Uses and Utilization of Vetiver. Bangkok, Thailand.
21. 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.
22. EARO, 2004. Directory of Released Crop Varieties and their Recommended Cultural Practices. Ethiopian Agricultural Research Organization, Addis Abeba, Ethiopia.
23. MARC, 2005. Progress Report on Completed Activities. Melkassa Agricultural Research Center, Nazret, Ethiopia.
24. MoARD, 2006. Crop Variety Register, Crop Development Department: Issue No. 9, June 2006. Ministry of Agriculture and Rural Development, Addis Abeba, Ethiopia.
25. 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.
26. SAS (Statistical Analysis System) Institute Inc., 2008. SAS/STAT® 9.2 User's Guide. Cary, NC: SAS Institute Inc.
27. Aiyelaagbe, I.O.O. and M.O.A. Fawusi, 1986. Growth and Yield Response of Pepper to Mulching. Biotronics, 15: 25-29.
28. Kayum, M.A., M. Asaduzzaman and M.Z. Haque, 2008. Effects of Indigenous Mulches on Growth and Yield of Tomato. Agric Rural Dev., 6(1 and 2): 1-6.
29. Jalil, M.A., M.A.K. Azad and A.M. Farooque, 2004. Effect of Different Mulches on the Growth and Yield of Two Potato Varieties. J. Biological Sci., 4(3): 331-333.

31. Gill, K.S., P.R. Gajri, M.R. Chaudhary and B. Singh, 1996. Tillage, mulch and irrigation effects on corn (Zea mays L.) in relation to evaporative demand. Soil and Tillage Research, 39: 213-227.
32. Khurshid, K., M. Iqbal, M.S. Arif and A. Nawaz, 2006. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agric. Biol., 8: 593-596.
33. Tan, Y., J. Lai, K.R. Adhikari, S.M. Shakya, A.K. Shukla and K.R. Sharma, 2009. Efficacy of mulching, irrigation and nitrogen applications on bottle gourd and okra for yield improvement and crop diversification. Irrig. Drainage Syst., 23: 25-41.
34. Igbokwe, P.E., 1996. Mulching for Nutsedge Control in Field-Grown Peppers. J. Vegetable Crop Production, 2(1): 47-53.
35. Umar, M.S., C.O. Muoneke and M.D. Magaji, 2000. Influence of intra-row spacing and mulch material on some soil physical properties, weed control, growth and yield of irrigated onion (Allium cepa L.). J. Agric. Environ., 2: 81-91.
36. Karaye, A.K. and A.I. Yakubu, 2006. Influence of intra-row spacing and mulching on weed growth and bulb yield of garlic (Allium sativum L.) in Sokoto. Nigeria. African J. Biotechnology, 5(3): 260-264.
37. Ibrahim, A.I., 1994. Effect of grass mulch and plant spacing on growth and yield of garlic (Allium sativum L.). Department of Agronomy, ABU Zaria.
38. Singh, R., R.R. Sharma and R.K. Goyal, 2007. Interactive effects of planting time and mulching on 'Chandler' strawberry (Fragaria ananassa Duch.). Scientia Horticulturae, 111: 344-351.
39. Rathore, A.L., A.R. Pal and K.K. Sahu, 1998. Tillage and Mulching Effects on Water Use, Root Growth and Yield of Rainfed Mustard and Chickpea Grown after Lowland Rice. J. Sci. Food Agric., 78: 149-161.
40. Prihar, S.S., B. Singh and B.S. Sandhu, 1968. Influence of soil and deviate environments on evaporating from mulched and un mulched plots. J. Research (Punjab Agric. Univ. Ludhiana), 5: 320-328.
41. Chaudhary, M.R. and S.S. Prihar, 1978. Rooting development and growth response of corn following mulching, cultivation or inter-row compaction. Agron. J., 66: 350-355.
42. Herrera, L., 2002. Root distribution of the Puya pepper cultivar in the soil volume was modified by mulch.