Pak. J. Agri. Sci., Vol. 46(2), 2009

VEGETATIVE AND REPRODUCTIVE EVALUATION OF HOT PEPPERS UNDER DIFFERENT PLASTIC MULCHES IN POLY/PLASTIC TUNNEL

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Since the beginning of civilization, the man has developed technologies to increase the efficiency of food production. The use of plastic mulch in commercial vegetable production is one of these traditional techniques that have been used for centuries. Studies were conducted to assess the efficacy of plastic mulch on growth and yield of two hot pepper hybrids, viz. Sky Red and Maha in poly/plastic tunnel. The treatments were black plastic mulch, clear plastic mulch and bare soil as control. Both hot pepper hybrids mulched with black plastic showed significantly better vegetative growth (plant height, leaf area etc) and fruit yield. Clear plastic mulch significantly increased soil temperature and reduced the number of days to first flower than black plastic mulch and bare soil. However, fruit yield was higher by 39.56 and 36.49% respectively in both hybrids when they were grown on black and clear plastic mulch as compared to bare soil. Overall results indicated that the use of plastic mulch is an ideal option to maximize hot pepper productivity as well as to extend their production season in poly/plastic tunnels.
Keywords: *Capsicum annuum* L., plastic mulch, soil temperature, reproductive growth

INTRODUCTION

Hot pepper is an important horticultural crop, not only because of its economic importance, but also due to nutritional and medicinal value of its fruit. These are the excellent source of natural colors and antioxidants (Howard *et al.*, 2000). A wide spectrum of antioxidant vitamins, carotenoids, capsaicinoids and phenolic compounds are present in hot pepper fruits. The intake of these compounds in food is an important health-protecting factor preventing widespread human diseases. The National Master Agriculture Research Plan 1996-2005 for Pakistan identified hot pepper as a crop requiring research to increase and stabilize yield and quality (PARC, 1996). Acreage under hot peppers is increasing particularly in Punjab due to a shift in production trend from cotton based farming to non-traditional crop production which in turn is due to a decline in income from cotton crop (Amjad *et al*., 2007). During the last decade, the area under protected cultivation (poly/plastic tunnels) of vegetables like hot pepper, tomato and cucumber is increasing steadily. Hot pepper is one of the potential crop to be grown in poly/plastic tunnels. The climate of Punjab is suitable for simple unheated poly/plastic tunnels for indoor vegetable production which is well suited for the purpose of over-bridging the gap in vegetable markets during cool months or to extend the season to be earlier in the market than the produce of the open field. Similarly, hot peppers for spice production gave advantage to be harvested and dried before the onset of rainy season. In poly/plastic tunnels, plastic mulches have been used in many regions of the world for commercial production of vegetables in order to maximize water use efficiency by the plant, to reduce weeds and to get early and quality produce. But in Pakistan, it is a new technique and area is growing up year after year. Mulching with plant residues and synthetic material is a well-established technique for increasing the profitability of many horticultural crops (Gimenez *et al*., 2002). A favorable soil-water-plant relation is created by placing mulch over the soil surface. Mulches create a microenvironment by retaining soil moisture and changing root-zone temperatures and the quantity and quality of light reflected back to the plants which alter plant growth and development (Csizinszky *et al*., 1995). Plastic mulches affect plant microclimate by modifying the soil energy balance and restricting soil water evaporation, thereby affecting plant growth and its yield (Tarara, 2000; Voorhees *et al*., 1981); modify the soil temperature regime according to their optical properties (Ham *et al*., 1993). Changes in root zone temperature can affect the uptake and translocation of essential nutrients, therefore influencing root and shoot growth (Tindall *et al*., 1990). Increased soil temperatures also affect the crop in other ways. Extreme solar heating of the soil can lead to improve plant health by controlling soil-borne pathogens (Katan *et al*., 1976). Vegetable crops grown under plastic

mulches have shown earlier (7 to 14 days) and increased yields (2 to 3 times) over bare soil (Lamont, 1993; Ibarra-Jimenez *et al*., 2004). So far little information is available for local farming community on hot pepper production in poly/plastic tunnels using plastic mulch. Therefore present study was designed to compare the vegetative and reproductive response of hot peppers using different plastic mulches in poly/plastic tunnels.

MATERIALS AND METHODS

Present research work was conducted at Vegetable Experimental Area, University of Agriculture, Faisalabad, Pakistan during the year 2005-06. Seeds of commercially cultivated hot pepper hybrids viz. Sky Red and Maha were obtained from Haji Sons (Pvt.) Seed Distributor, Lahore, Pakistan. The experiment was designed in randomized complete block (RCBD) under factorial arrangement with three replications. Hot pepper seedlings were raised in pots and transplanting was done on both sides of raised beds in simple poly/plastic tunnel. Plants were staggered at 60 x 60cm apart as well as seed beds were maintained 15cm high and 75cm spaced apart. Seed beds adorned with different plastic mulches such as (M_1) Bare Soil considered as control (M_2) Black plastic mulch and (M_3) Clear plastic mulch. Both black and clear plastic mulches used were 30µm thick and installed on pre-shaped beds manually with drip tape buried 6 cm deep in the center of beds. According to soil nutrient analysis report, fertilizers were applied @ 180, 200 and 180 kg ha^{-1} for nitrogen, phosphorus and potash respectively. One third of NPK was applied during bed preparation prior to applying plastic mulch and drip tape. This "starter" fertilizer provides some nutrition to the crop during its early growth while remaining NPK was applied throughout the season as needed by the crop through drip irrigation. Hoeing and weeding was practiced regularly on plants grown on bare soil. Plant protection measures followed standard recommendations as and when required.

Data Collection

Soil temperature was measured with thermometer at depth of 10cm daily between 12.00 to 1.00 solar hours up to 90 days after transplanting and average was calculated. Plant height and stem diameter were recorded at first harvest as well as number of days taken to first flowering were counted after transplanting. For leaf area, ten gram leaf samples from the top, middle and base of the canopy were randomly collected, weighed and their leaf area g^{-1} was calculated with the help of portable leaf area meter (CI-202 CID Inc.) and then converted into leaf area $plant^{-1}$ by taking fresh weight of leaves from each plant. Similarly fresh fruit weight at each harvest was recorded with the help of single pan digital balance and the data of each harvest was added to get cumulative yield per plant.

Harvest index was calculated by the following formula:

Harvest index = (*fruit yield/fruit yield + vegetative yield) x 100*

Analysis of variance of the data from each attribute was computed using the STATISTICA Computer Program. The Least Significant Difference test at 5% level of probability was used to test the differences among mean values (Steel *et al*., 1997).

RESULTS

Soil temperature (ºC)

Since color of the plastic mulch determined the degree of soil warming and generally light colored mulches maintained highest values of soil temperature than dark colored mulches due to light transmission. Data regarding soil temperature under different mulch treatments revealed that plastic mulches increased soil temperature significantly than un-mulched control (Figure 1). Clear plastic mulch maintained highest values of soil temperature and on an average it was 3.9 and 1.2ºC higher under clear and black plastic mulch respectively as compared to bare soil.

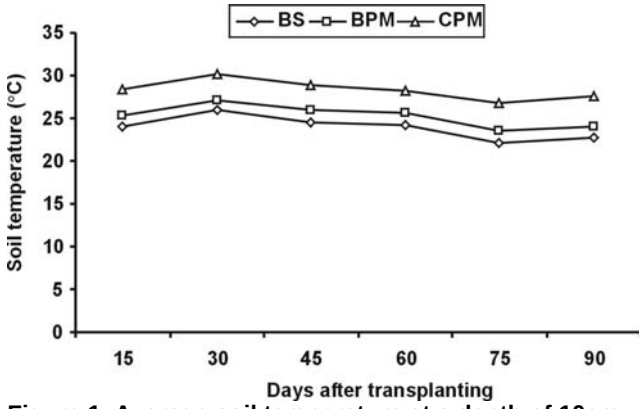

Figure 1. Average soil temperature at a depth of 10cm after transplanting over three months for 15-day period at 12.00-1.00 solar hour. (BS - Bare soil; BPM - Black plastic mulch and CPM - Clear plastic mulch)

Vegetative growth

Both hybrids differed significantly with respect to plant height, stem diameter and leaf area. Plant height was maximum in Maha (88.27 cm) while leaf area (6250.86 cm^2) and stem diameter (25.34 mm) were highest in Sky Red. Similarly, plastic mulches had significant effect on plant height and leaf area; however non-

significant results were observed in case of stem diameter (Table 1). Plants grown on black plastic un-mulched treatment. However, the interactive effect of mulch x hybrid was found non-significant (Table 1).

Table 1. Effect of plastic mulches on vegetative and reproductive characteristics of two hot pepper hybrids

Treatment	Plant height (cm)	Stem diameter (mm)	Leaf area (cm^2)	Days to first flower (days)	Fruit yield $plant^{-1}$ (kg)	Harvest index (%)
Mulch (M)						
Bare soil	77.35 c	23.56	4913.55 c	74.91 a	0.88 c	62 b
Black plastic	91.70 a	23.68	7200.08 a	72.10 b	1.42 a	66 a
Clear plastic	86.93 b	24.13 ^{NS}	6322.58 b	69.16 c	1.32 b	65 a
Hybrid (H)						
Sky Red	82.37 b	25.34 a	6250.86 a	68.25 b	1.15 b	63 b
Maha	88.27 a	22.24 b	6039.95 b	75.86 a	1.26 a	66 a
M x H	*	NS	**	**	NS	NS

Means separated within columns by Fisher's protected LSD test at $P = 0.05$.
*, ** = Significant at $P = 0.05$ and 0.01 respectively. NS = Non-significant

mulch produced taller plants (16%) and had more leaf area (32%) as compared to bare soil plants. However, plant height and leaf area were greater 12 and 23% respectively in plants from clear plastic mulch than bare soil plants. Further, the interactive effect of mulch x hybrid showed that plant height was highest in Maha (94.43 cm) while leaf area was more in Sky Red (7293.68 cm^2) when mulched with black plastic (Figure 2A & B); however, it was non-significant for stem diameter.

Reproductive growth

Irrespective of mulching, the hybrid Maha took 75.86 days to first flower while Sky Red start early flowering than Maha with 68.25 days (Table 1). This difference in days to first flower clearly shows that this attributes to the genetic ability of individual hybrid. Similarly, plastic mulches had significant effect on this variable and clear plastic mulch reduced the number of days to first flower. Plants grown on clear plastic mulch took 69.16 days to start flowering followed by black plastic mulch 72.10 days while plants grown without mulch took 74.91 days to start flowering. Further, the interactive effect of mulch x hybrid was significant as both Sky Red and Maha took 64.63 and 73.70 days to start flowering when mulched with clear plastic than bare soil plants which took 71.56 and 78.26 days respectively (Figure 2C).

Both hybrids differed significantly in terms of fruit yield $plant^{-1}$ with 1.26 kg in Maha and 1.15 kg Sky Red. Irrespective of hot pepper hybrids, plastic mulches had significant effect on fruit yield $plant^{-1}$ and when plants grown on black plastic mulch it was higher by 39.56 and 3.07% respectively than clear plastic mulch and Significant difference was observed among hybrids for harvest index (a measure of yield efficiency) and it was 66 and 63% respectively in Maha and Sky Red. As for as the effect of plastic mulches on harvest index is concerned, both the plastic mulches were statistically alike and gave greater harvest index than bare soil. Harvest index was 66 and 65% on black and clear plastic mulch treatments as compared to bare soil (62 %). However, the interactive effect of mulch x hybrid was found non-significant (Table 1).

DISCUSSION

In general, plastic mulches increase soil temperature in relation to bare soil and this increase is higher in clear and dark colors than in the reflective ones such as white or silver/aluminum (Rangarajan and Ingall, 2001). Different forms of plastic mulches varying from woven plastic to smooth plastic and embossed plastic films are available. Now-a-days 100% compostable and biodegradable mulches are also available in advanced countries and these are more environment friendly. Soil temperature is increased by 5 to 10°C by the application of plastic mulches as compared to bare soil (Elmer and Ferrandino, 1991). This well documented temperature rise is often used as an explanation for increased production of crops grown on plastic mulch (Grubinger *et al.*, 1993; Davis, 1994). Himelrick *et al*. (1993) found that soil temperatures were warmest with clear plastic mulch followed in order of decreasing temperatures by black-on-white, black, white on-black and bare ground. Results of present study are supported by the findings of Locher *et al*. (2005) that black plastic mulch caused 1.4ºC increase

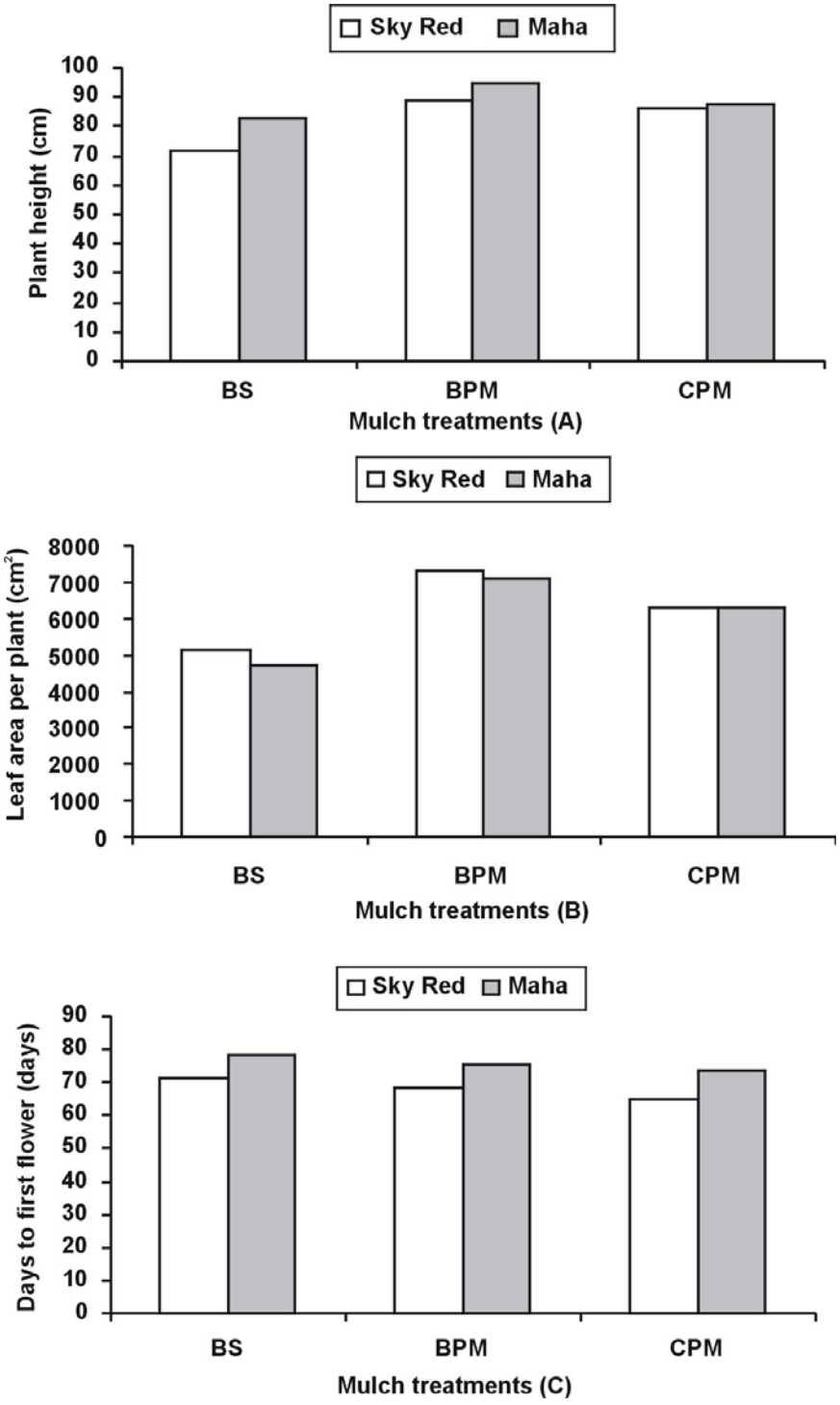

Figure 2. Interactive effect of mulch x hybrid on plant height (A); leaf area plant^{-1} (B) and days to first flower (C). BS - Bare soil; BPM - Black plastic mulch and CPM - Clear plastic mulch)

in soil temperature as compared to the un-mulched control. Similarly, they also reported that soil temperature under light colored plastic mulches (clear, violet, light green) was 2.5-2.9ºC higher when compared with bare soil.

Present studies indicate that plant growth parameters like plant height, stem diameter and leaf area were significantly influenced by hybrids and mulching treatments. The difference between two hybrids for plant height, leaf area and stem diameter was due to their genetic variability; however effect of plastic mulches on plant height and leaf area may be attributed to increase in soil temperature and moisture retention which changed plant microclimate as a result faster plant growth was observed. However, plants grown on black plastic mulch had better vegetative growth than either mulched with clear plastic or un-mulched. Similar results were reported by Hallidri (2001) that plant height was maximum in plants grown on black and transparent polythene mulch than control (bare soil) but stem diameter was not changed by the application of plastic mulch in cucumber. Similarly, Ibarra-Jimenez *et al*. (2002) found that black plastic mulch alone or combined with row covers had a positive effect on leaf area in bell peppers relative to the control. Since plant light environment and soil temperature was affected by mulch surface color so this increase in leaf area might be attributed to change in plant microclimate by black and clear plastic mulch. However, less leaf area under clear plastic mulch might be due to weed competition as compared to black plastic mulch with no weed growth.

Plants from both hybrids grown on clear plastic mulch took significantly less days to start flowering which might be due to higher soil temperature. Present results support the findings of Tuli and Yesilsoy (1997) that clear plastic mulch was found to be more efficient on first blossoming and harvesting time in squash while lowest plant growth and yield values were observed in bare soil. Similarly Ibarra-Jimenez *et al*. (2005) found that time to anthesis in water melon (appearance of perfect flowers) was 45 and 55 days after sowing for black plastic mulch and control plants respectively.

Fruit yield depends on size of the plant. Plants grown on either black or clear plastic mulch had significantly higher fruit yields than plants grown on bare soil. This difference between mulched and un-mulched treatments might be due to better vegetative growth of both hybrids which results in more number of flowers and branches per plant; as a result number of fruit set increased. Similarly, another possible reason for increased production in mulched plants is the potential for higher level of soil moisture contents as well as increase in soil temperature. However, lower yields on un-mulched plants were attributed to relatively poor growth when compared with mulched plant. As plastic mulches improved stand establishment and fruit yield as compared to un-mulched (control). Hassan *et al*. (1995) reported that mulching is practically beneficial in chilli production. They concluded that increased plant growth for mulched plants may be related to soil moisture contents because plant dry weight was positively correlated with soil temperature and moisture contents. The results of present study are in line with the findings of Locher *et al*. (2005) that higher yield of sweet peppers were achieved from mulched treatments due to higher soil temperatures than the un-mulched treatment. Similarly, the difference in spectral quality of light reflected from different color of mulches influenced yield through the regulatory affect of the phytochrome system (Decoteau *et al*., 1988).

CONCLUSION

From these results, it can be concluded that vegetative and reproductive traits of hot pepper hybrids significantly improved by the application of plastic mulches in poly/plastic tunnels. Complete inhibition of weed growth was also observed under black plastic mulch which could be helpful to boost hot pepper production in poly/plastic tunnels.

ACKNOWLEDGEMENTS

We acknowledge Higher Education Commission, Government of Pakistan, for providing financial support.

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