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Studies on different mulching technology for improving hydrothermal regime of soil in capsicum (*Capsicum annum*) production at high altitude of Uttarakhand*

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Capsicum (*Capsicum annum* L.) is an important and high-value vegetable crop for many parts of the world. Low temperature is unfavourable for this crop as it affects growth and development and limits their ability to survive under hill condition of Uttarakhand. To make the cultivation successful, polyhouse, poly-tunnel and poly mulching are available solution. Poly-mulching is beneficial for vegetable production. It increases water-use efficiency, improves hydrothermal requirement of soil, reduces water evaporation, checks weed growth and improves the aerial environment around plant which facilitates congenial growth and yield. The information is very scanty on growing capsicum through poly-mulching under Uttarakhand hill condition during spring to get early summer crop. The present study was conducted with an objective to evaluate feasibility of poly-mulching technology to protect crop against hill environment stress as well as to get better plant performance, maximum yield and economic gain from capsicum cultivation in Uttarakhand hill during summer (off-season).

Experiments were conducted during second week of March and April of 2007 to 2009 at Krishi Vigyan Kendra, Jakhdhar, Rudraprayag and Lohaghat, Champawat (an altitude of 1718 m to 1850 m and northern latitude of 30° 19', average rainfall 900–1200 mm (June to Sept), sandy loam soil with gravel having *p*H 5.0 with low organic carbon. Both KVKs are under the administrative control of GBPUA&T, Pantnagar, Uttarakhand.

The size of beds 15.0 m long and 1.25 m wide were prepared for mulching treatments. Two types of mulches, i e bio-mulch (M_1) (7–8 cm thickness dry grasses mulch) and plastics mulch (M_2) UV stabilized, 50 micron black polyethylene were used. Total 18 plots were developed (6 mulch plots in each replication) according to treatment combinations. The experiment was laid out in factorial randomized block design (FRBD) with three replications. Forty days old nursery of hybrid Tanvi was transplanted during March and April in all the years. Full doses of farmyard manure (FYM) @ 25 tonnes /hectare and 50 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2O/ha were applied before laying the bio and plastic mulch on the bed. The black polyethylene mulch was laid in plots after the final land preparation and holes of 5 cm diameter using 50 cm × 50 cm spacing (double row planting method) were made over the polyethylene films for planting the capsicum, whereas the dry grasses mulch (bio-mulch), 7–8 cm thick was applied after transplanting. After one month of planting, 10 kg of N/ha was applied as top dressing by dividing into four equal dose during plant growth. All the recommended cultural and plant protection practices were followed to raise healthy crop. The observation of plant height (cm), number of branches/plant, days to flowering, fruit size (cm), total number of fruits/plant, marketable fruits/plant, total fruit yield and marketable fruit yield (tonnes/ha) were recorded at fortnight interval. Capsicum fruits were harvested after 55 days of transplanting in every 7–10 days interval at fully matured stage. Early fruit production was defined as the days to flowering and getting fruit yield of capsicum transplanted on each of the two transplanting dates. Weeds were collected time to time from 1 m^2 area of the centre of each plot and their dry weights were determined. Soil temperature and soil moisture were determined daily at 10 cm depth in each plot by using soil thermometer and tensiometer. The three years pooled data were analyzed by

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Table 1 Growth, development, yield attributes, quality yield and economics of capsicum and dry weight of weeds, in relation to soil environment influenced by mulching technology

Type of mulching technology (g/m^2)	Transplanting month	Three year pooled data at two locations of Uttarakhand hill (2007–09)										
		Plant height (cm)	No. of branches/ plant	Days to flowering	Fruits size (cm)	Weeds dry weight	Fruit weight (g)	Total no. of fruits/m^2	No. of marke- table fruits/m^2	Total fruit yield (tonnes/ ha)	Marke- table fruit yield (tonnes/ha)	Net income (₹/ha)
Without mulch (M_0)	2nd week of March	63.6	4.1	52	2.85	241	85.0	11.40	8.50	10.03	7.31	53 050.0
	2nd week of April	63.2	4.1	45	2.95	278	93.0	11.80	8.60	10.60	7.91	63 675.0
	Average	63.4	4.1	48.5	2.9	259.5	89.0	11.6	8.55	10.31	7.61	58 362.5
Bio-mulch (M_1)	2nd week of March	69.3	4.6	48	3.45	142	94.0	13.80	9.70	13.25	9.31	83 160.0
	2nd week of April	67.4	4.5	44	3.73	157	96.0	14.90	10.60	14.01	9.96	139 260.0
	Average	68.35	4.55	46.0	3.59	149.5	95.0	14.35	10.15	13.63	9.63	111 210
Plastics mulch (M_2)	2nd week of March	78.7	5.3	40	3.98	26	96.0	15.90	13.50	15.58	13.23	130 750.0
	2nd week of April	70.6	5.2	39	4.20	37	98.0	16.80	14.40	16.13	13.82	139 680.0
	Average	74.65	5.25	39.5	4.09	31.5	97.0	16.35	13.95	15.85	13.52	135 215
CD (P = 0.05)		4.1	0.3	3.6	0.4	12.8	2.6	8.2	13.4	1.13	1.06	

the statistical methods as described by Panse and Sukhatme (1989).

Black polyethylene plastic mulch had more beneficial effect on vegetative growth of capsicum plants followed by bio-mulching and without mulching (Table 1). The flowering was advanced by 4 to 12 days; and 1 to 6 days in both timely and late transplanted crop, respectively in dry grasses and black polyethylene mulch. Among the different mulching treatments, maximum average plant height (74.65 cm), number of branches/plant (5.25), size of individual fruit (4.09 cm), weight of fruit (97.0 g), total and marketable number of fruits per m^2 (16.35 and 13.95) were obtained in plastic mulch treatment. This might be black plastic mulch which created microenvironment, i e optimum moisture, optimum nutrient supply and optimum soil temperature, which resulted in better plant performance. It also helps to increase microbial activity for optimum nutrient/water uptake from the soil (Mehta *et al.* 2010).

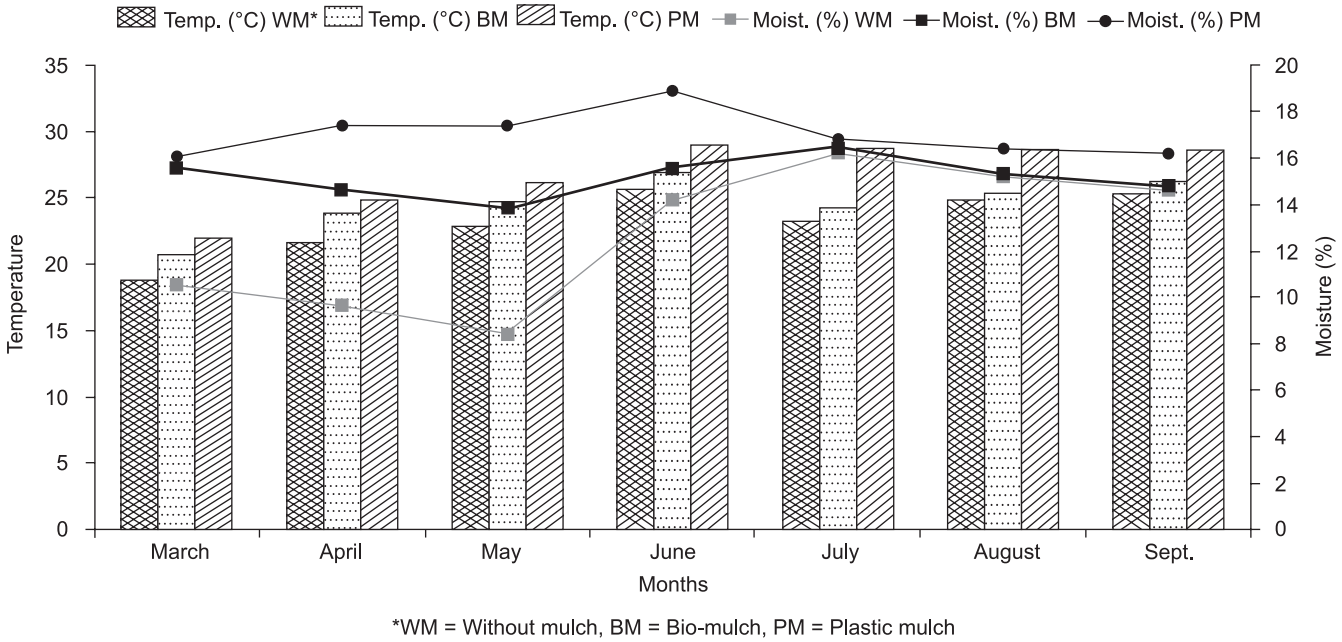

Fig 1 Influence of different type mulching technology on soil temperature and moisture

The average dry weight of weeds was minimum in plastic mulch treated plots (31.5 g/m^2), whereas maximum average dry weight of weeds (259.5 g/m^2) was recorded in without mulching treatment (Table 1). It indicates black colour plastic mulch inhibit the photosynthetic activity of the weeds, limit weeds growth and development, whereas without mulching enhanced photosynthetic activity and weeds performed well. Mulches are effective in weed control by improving the crop growing environment which resulted in increased growth and fruit yield (Awodoyin *et al.* 2007).

The plastic mulch performed better with maximum number of total fruits (16.35/m^2), marketable fruits (13.95/m^2) and fruit size (4.09 cm), maximum total fruit yield (15.85 t/ha) and marketable fruit yield (13.52 tonnes/ha) and was followed by the bio-mulch and without mulch treatment (Table 1). Higher yield in plastic mulched plots may be attributed to regular supply of water, nutrients, less weed competition, optimum soil temperature and more number of days of flowering which results heavy fruiting in mulched plots. The net profit from the mulched treatments was much higher than without mulched (Table 1). The maximum net return (₹ 135 215/ha) was recorded with black plastics mulch followed by bio-mulching (₹ 111 210/ha.) and minimum in without mulch (₹ 58 362.5/ha). Rashidi *et al*. (2009) reported that black plastic mulch has pronounced effect in increasing yield and yield components in tomato in timely and late transplanted crop in comparison to without mulch (bare soil) and other mulches.

The black plastic mulch showed temperature variation from 21.9 ^{o}C to 28.9 ^{o}C, favourable for the optimum growth of capsicum crop (Fig 1). However, without mulching, temperature range was comparatively lower (18.8 ^{o}C to 25.6 ^{o}C). The low soil temperature affects the growth of plants. Black plastic mulch plots had higher moisture content (16.1 to 18.9 %) followed by without mulch (8.4 to 16.2 %). The black polythene mulch reduces the evaporation rate and retains the soil moisture. Similar trends were also reported by Singh and Mir (2005).

SUMMARY

The experiment was conducted during 2007-09 at high altitude of Uttarakhand to evaluate the effect of different mulching technology on soil environment, growth and yield of capsicum (*Capsicum annum* L.). Two different mulch materials (black polyethylene and dry grass) were tested with two off-season planting dates (March and April month) in a factorial randomized block design. The maximum growth, flowering, yield and yield attributing characters were recorded with black plastic mulch, due to soil temperature regulation and soil moisture conservation followed by bio-mulch and poor plant performance in without mulch, however bio-mulch also fetched an appreciable profit as compared to without mulch.

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