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Effect of black polythene mulch on growth and yield of Winter Dawn strawberry (*Fragaria* × *ananassa*) by improving root zone temperature

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ABSTRACT

Root-zone temperature (RZT) plays important role in improving plant growth and development of strawberry (*Fragaria*×*ananassa* Duch) by influencing the uptake of water and mineral nutrients by roots. RZT attains greater prominence as roots are less adapted to fluctuations in temperature than shoots. The North-Indian plains are characterized by clear demarcation of seasons with extreme winter and summer. For effective root zone temperature, weed control and moisture regulation, mulching has been recommended. In the present study, we investigated the effect of different mulch materials on RZT, the root growth and its impact on plant performance. Mulching-induced improvement in RZT resulted in improved plant and root growth as evidenced by higher fresh and dry matter content. The beneficial effects of mulching on RZT, and subsequent impact on root and plant growth were reflected as increased number of fruit/plant and better-size fruit. Improvement in plant growth parameters led to almost 1.5-fold increase in yield over those grown on bare soil. Among the different mulches tested, black polythene outperformed the rest in terms of growth (plant fresh weight 187.31 g and dry weight 57.28 g) and yield parameters (fruit size length 54.00 mm and width 42.59 mm; fruit fresh weight 36.74 g, dry weight 2.88 g; no. of fruits/plant 33.55 and fruit yield/plant 536.55g).

Key words: Black polythene, Mulching, Root zone temperature, Strawberry

Strawberry (*Fragaria* × *ananassa* Duch) is basically a temperate fruit crop with short-day nature but due to the advent of day-neutral varieties, it is now widely grown in tropical and sub-tropical regions. The Panchgini-Mahabaleshwar region of Maharashtra grows more than 85% of country's strawberries because of mild low temperature. Strawberry fruits are delicate and rest on ground surface rendering them susceptible to infection with soil-borne pathogens. Hence, covering the bare soil with some litter material (mulch) becomes essential for clean and quality fruit production. Owing to herbaceous nature of plant mulching has strong influence on yield, quality and duration of harvesting in strawberry apart from weed control. This is primarily due to better soil and moisture conservation, soil temperature management, improved nutrient availability, suppression of weed, protection from frost injury and reduction in number of dirty and diseased berries. Strawberry is one of the crops that respond well to the increase in soil temperature/high reflectance produced with the use of mulches (Sonkar *et al.* 2012). Plastic mulches affect plant microclimate by modifying the soil energy balance and restricting soil water evaporation (Liakatas *et al.* 1986, Tarara 2000), affecting plant growth and yield. Root zone temperature is important for root formation, development, branching, and overall root growth and development because it affects physiological processes in roots such as uptake of water and mineral nutrients (Dodd *et al.* 2000, Tindall *et al.* 1990). Root zone temperature may also be critical for plant survival because roots have a lower temperature and are less adapted to extreme fluctuations than shoots. Under Indian sub-continent especially the areas with clear demarcation of seasons with extremes of winter and summer, the environmental temperature corresponding to root zone temperature plays a crucial role in successful strawberry production. Hence, the effect of temperature difference of soil and environment on root growth, plant growth, fruit yield and yield attributing characters of strawberry due to different mulches have been studied under this experiment.

MATERIALS AND METHODS

The study was conducted at College of Horticulture and Forestry (MPUAT), Jhalarapatan, Jhalawar, Rajasthan,during 2013-14. The soil of experimental plot was black with pH of 8.3, EC (0.56 dS/m at 25°C), OC (0.57%), available N (372.33 kg/ha), available P (28.01 kg/ha) and available K (276.67 kg/ha). The experiment was conducted in randomized complete block design with three replications comprising three mulches (black polythene, white polythene, rice husk) along with bare soil as control. Winter Dawn, a short day early bearing cultivar of strawberry was

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chosen for experimentation where tissue cultured plants were planted over raised beds of 15 cm height during the 1st fortnight of October. Between the two beds, 1.0m space was left for proper intercultural operations and crop management. On each bed two drip lines having in-line drippers at 30 cm distance were stretched parallel to each other. During the experimentation, all the beds uniformly comprised 30 plants in two rows (15 plants/row). Mulches were laid down before the planting. Recommended irrigation and fertilization scheduling was followed.

Root zone temperature (RZT) was measured by determining soil temperature in the middle of four plants 15 cm below the mulch and soil surface. RZT over the growing season was recorded using soil thermometer and compiled from four spots and averaged at fortnightly interval. Air temperature was measured with the help of thermo-hydrometer daily at 9:00 AM and 3:00 PM.

After the completion of fruiting period, randomly selected plants (top plus roots) from each replication were excavated from the soil, washed and subjected for recording plant growth parameters. Plant tops and roots were weighed for fresh weight and dried separately at 70 °C for dry weight.

Fruit length and fruit width of 20 assorted fruits were taken by digital vernier calliper at every harvest. The fruits were weighed on digital weighing balance for fresh weight and dried in oven at 70°C and weighed for dry weight. Number of fruits was counted from the tagged plant at every harvest and fruit yield/plant was recorded following standard methodology.

After completion of harvest, the tagged plants were excavated and washed properly. The roots were separated from the top portion and root length was measured with the help of meter scale. Root volume was determined by water displacement method, whereas fresh weight was taken by digital weighing balance. The roots were dried in oven at 70°C and weighed for dry weight. The root: shoot ratio was derived by dividing the fresh top weight by fresh root weight.

Daily difference in environmental and soil temperature gives a fair idea of the extent of congenial growing medium for strawberry. By working out the level of fluctuation in temperature the ideal temperature needed for better performance of strawberry plant can be suggested. This influence was created by different types of mulches. The temperature difference was postulated using standard procedures.

Data were analyzed using the analysis of mixed procedure of SAS (SAS Inst. Inc., 2000).Average, maximal and minimal RZTs for the season were calculated from daily values of mean, maximal and minimal RZTs for each of the mulches during the entire season. The means of RZTs, plant growth attributes and fruit yields were subjected to RBD test. The relationships of plant growth attributes with RTZ were worked out using the mean of the interaction of different mulches. Various models were evaluated to determine the differences in the relationship of plant growth and yield to RTZ and mulch types.

RESULTS AND DISCUSSION

Effect of mulches on root zone temperature

Ground cover provides warmth to soil when applied on the surface and saves the plant root from chilling or abrupt change in soil temperature. However, different mulches differed in their soil warming ability during the study (Fig 1). Among the different mulches used, mean RZT was highest under black polythene mulch and lowest in bare soil. The improvement in soil temperature under black polythene mulch might be attributed to the reduction in heat loss and conservation of warmth for longer duration (Lamont 1993). Fortnight mean values of RZT spread over the cropping season under different mulches were higher (–0.11 to 3.15°C) than those of bare soil (Fig 1). Ghosh *et al.* (2006) and Ramkrishna *et al.* (2006) also observed an increase of 4-6°C soil temperature in polythene mulch throughout the cropping season.

Effect of mulches on plant growth and yield

Plants mulched with black polythene had better growth than other mulched used (Table 1, 2 and Fig 2). It attributed to better soil hydrothermal regimes, better moisture conservation and suppression of weeds (Tarara 2000). Many researchers have reported better growth of strawberry plant under black polythene mulch (Singh and Asrey 2005, Singh *et al.* 2006). Plant under black polythene mulch had larger fruit length, fruit width, fresh fruit weight, dry fruit weight, number of fruits/plant and higher fruit yield mainly because of better plant growth owing to favorable hydrothermal regime of soil and complete weed free environment (Sharma and Sharma 2003, Singh *et al.* 2006). The higher fresh fruit weight might be attributed to vigorous growth of plants in black polythene mulch. Increase in dry weight might be due to the balancing of respiration by photosynthesis as explained by Salisbury and Ross (1986). The maximum number of fruits under black polythene mulch has also been reported by Nagalakshmi *et al*. (2002). It may be attributed to more number of flowers produced by vigorous plants.

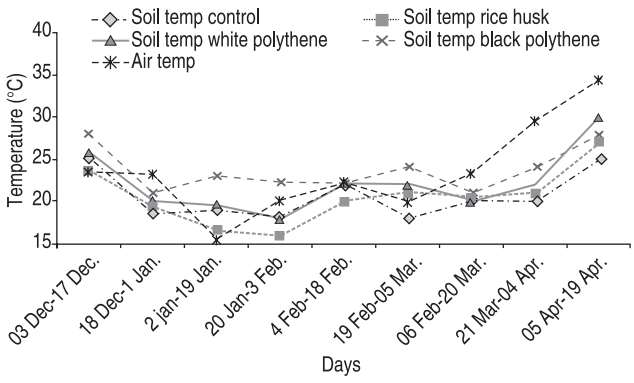

Fig 1 Rootzone soil temperature in different mulches during the peak growth and fruiting period of strawberry

Table 1 Yield attributing characters affected by temperature difference under different types of mulches

Treatment	Fruit size (mm)		Fruit weight (g)		No. of fruits/ plant	Fruit yield/ plant (g)
	Length	Width	Fresh	Dry		
Control	47.72 b	37.60 c	26.85 c	2.08 b	25.33 b	218.89 d
Rice husk	47.96 b	38.51bc	28.18bc	2.17 b	29.33ab	302.22 c
White polythene	48.19 b	40.67ab	31.67 b	2.14 b	32.78 a	478.11 b
Black polythene	54.00 a	42.59 a	36.74 a	2.88 a	33.55 a	536.55 a
CD (P=0.05)	2.08	2.48	3.80	0.49	4.46	53.83
SEm±	0.59	0.70	1.07	0.14	1.26	15.26

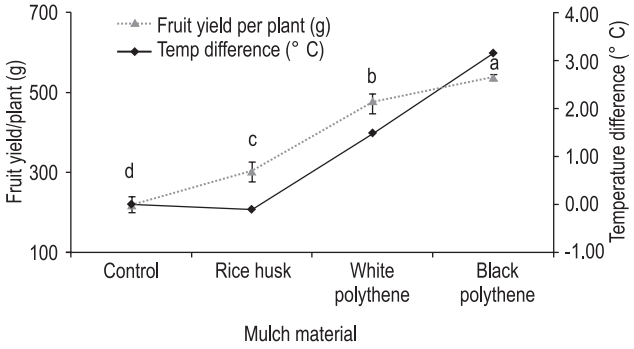

Fig 2 Influence of soil temperature difference on fruit yield of strawberry

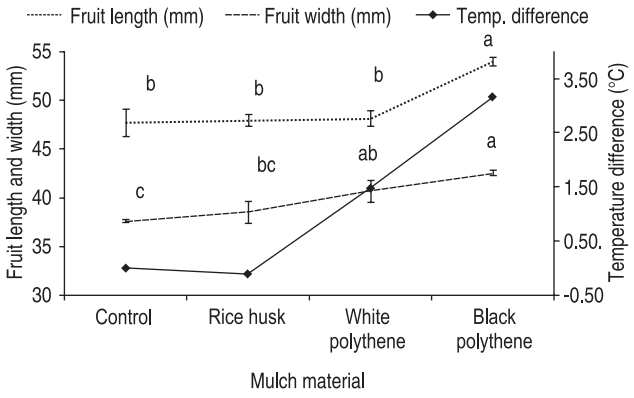

Fig 3 Effect of different mulches on length and width of strawberry fruit

Table 2 Temperature difference under different mulches affects plant weight of strawberry

Treatment	Plant weight (g)	
	Fresh weight	Dry weight
Control	90.03d	30.88d
Rice Husk	121.21c	33.78c
White polythene	126.15b	45.75 b
Black polythene	187.31a	57.28 a
CD (P=0.05)	3.16	1.37
SEm±	0.89	0.38

Effect of mulches on root growth

The maximum root weight (fresh weight and dry weight), volume, and length have been recorded under black polythene mulch (Table 3). Sandal *et al*. (2007) observed mulches as effective in increasing root growth owing to improved hydrothermal regimes. Black polythene mulch resulted in overall better root growth parameters. The more favourable effect of black polythene mulch in modifying the soil environment might be the reason for improved root length, volume and weight (fresh weight and dry weight) (Verma *et al.* 2005).

Effect of root zone temperature on growth and yield

The beneficial effects of mulching on root zone temperature and subsequent impact on root and plant growth were reflected as increased number of fruits/plant and better-size fruit. Ultimately, growing strawberry under

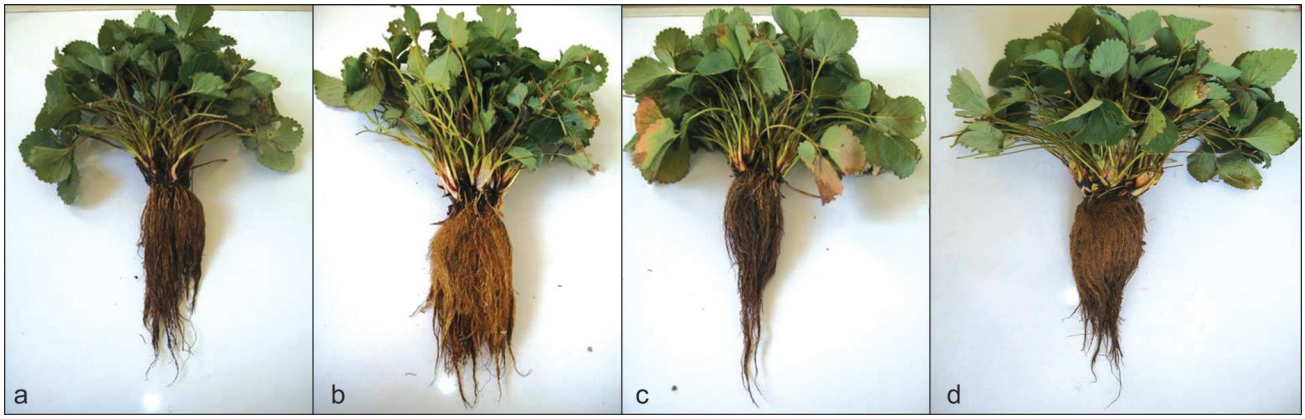

Fig 4 Effect of different mulches on root growth of strawberry cv. Winter Dawn. a-No mulch, b-Rice husk mulch, c- White polythene mulch, and d- Black polythene mulch

Table 3 Root characters of strawberry as affected by temperature differences under different mulches

Treatment	Root length (cm)	Root volume (cc)	Root weight (g)	
			Fresh weight	Dry weight
Control	20.55c	20c	18.52d	3.96c
Rice husk	22.22bc	40.66ab	32.84b	5.43b
White polythene	24.33b	35.44b	21.59c	4.74bc
Black polythene	28.22a	45.55a	37.76a	7.32a
CD (P=0.05)	2.58	8.74	1.84	0.93
SEm±	1.65	2.48	0.52	0.26

black polythene mulch resulted in almost 1.5-fold increase in yield over control. Mulching significantly improved plant growth as evidenced by accumulation of higher fresh and dry matter content as compared to control. In addition to more fruits/plant, the plants under polythene mulch bore bigger-sized and heavier fruits (Fig 3). On the contrary, plants grown under bare soil yielded fruit that were not only lesser in number but also smaller in size. Our finding is in agreement with published results (Dodd *et al*. 2000, Díaz-Pérez 2009). In similar studies on tomato as well as broccoli, plant growth and yield have been found highest as RZT approach optimal for the plants (Díaz-Pérez and Batal 2002), for which dark-coloured polythene mulches have been found more effective in achieving (Díaz-Pérez 2009). This increase in RZT is already known to strongly influence vegetative growth, nutrient uptake, and assimilate partitioning through its effect in creating favourable microclimate in the root-zone (Tindall *et al*. 1990). The benefits of plastic mulch on growth and yield are season-dependent (Díaz-Pérez 2009). The plants, in this study, being grown in the winter months appear to suggest the cause of black polythene mulch performing better than the rest by optimizing RZT.

In conclusion, mulching is already a commercial practice in strawberry production systems for optimum growth and yield. We found black polythene mulch to perform better among different mulch materials tested in optimizing plant and root growth in strawberry; this ultimately increased the yield and quality of fruit. Black polythene mulch exerted these beneficial effects through optimization of root zone temperature.

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