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RESEARCH ARTICLE

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Plastic Mulch's Effect on Cauliflower Yield and Yield-attributing Traits in Protected Structures in Pithoragarh, Uttarakhand

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ABSTRACT

Background: Cauliflower, cultivated for its curd, an immature inflorescence, is a temperature-sensitive crop. Due to its need for very specific weather patterns for both the transition from vegetative to curd initiation phase and the growth of curd, this crop is highly susceptible to climate change. Due to the plant's sensitivity to environmental conditions, an experiment was conducted in the mid-hills of the western Himalayas during the rabi season of 2020/21 to assess the impacts of different plastic mulching on yield and its yield-attributing features under polycarbonate.

Methods: The experiment included three separate runs and was set up in a randomized block design. Cauliflowers of the ''Amazing'' type were subjected to five different treatments (T_1: black polythene mulch, T_2: red polythene mulch, T_3: silver polythene mulch, T_4: yellow polythene mulch and T_5: control).

Result: Red polythene mulch was the most efficient method of enhancing yield and yield-related traits.

Key words: Cauliflower, Mulching, Soil moisture, Soil temperature, Yield.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is harvested in the winter, is an excellent source of minerals and antioxidants (Moniruzzaman *et al*., 2007). Due to its high degree of environmental sensitivity and its need for more care than cabbage, broccoli and other winter vegetables, cauliflower is sometimes considered the ''royalty'' of the Brassicaceae family (Salim *et al*., 2008). It may be cultivated in a variety of climates, but when it is changing from its vegetative to its curd initiation and growth phase, it has certain requirements. Maintenance of temperature for better curd yield and quality is very important (Santosh *et al*. 2017). This plant thrives in Uttarakhand's district of Pithoragarh, where the mild daytime temperatures of 21°C to 29°C, abundant sunlight and wet soil provide ideal growing circumstances. There is great variation in agro-climatic conditions of this hilly region. Inclement weather conditions are a common feature of hill agro-climatic zones. During April-May and September-October, hail storms hit the middle hills in this area. Cauliflower can be grown outdoors during the winter, but the quality suffers. Protected cultivation not only improves productivity but also enhances the produce quality and ensures off-season availability. Mulch use in greenhouse buildings creates a favorable microclimate for the crop plants under these circumstances, promoting greater growth and development of cauliflower crops.

In earlier studies, it was found that due to a lack of enough soil moisture and very low-temperature cauliflower crops had very low yields (Angmo *et al*., 2020). It has been suggested that improved temperature and water management, namely *via* increased soil moisture conservation, might be the key to solving the low yield issue and cutting down on watering costs. According to research by Mannan and Rashid (1983) and Djigma and Diemkouma (1986), applying mulch efficiently stops soil moisture loss *via* evaporation. It has been shown that using polythene mulch increases fruit production compared to using a control (Quadir, 1992). Therefore, it is clear that mulching is a crucial component for increased cauliflower yields. Cauliflower and other winter crop production costs have decreased as a consequence of increased usage of polyethylene mulch to retain soil moisture and reduce weeding expenses (Salim *et al*., 2008). Plastic mulches disrupt the energy balance in the soil, which has a knock-on effect on the plant's microenvironment (Angrej and Gaur, 2007). Soil temperature may be altered by manipulating the crop's microclimate, which in turn can impact plant development and production (Lamont, 2005; Ibarra-Jimenez *et al*., 2008). The plastic's heating qualities directly

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affect the soil temperature under a plastic mulch, including its transmittance, reflectance and absorptivity and how these properties interact with solar radiation (Ddheech *et al*., 2018). Net radiation was greater in plastic mulch than in non-plastic mulch conditions (Bahadur *et al*., 2013). All of these factors are intimately linked to a rise in winter cauliflower yield and an improvement in its overall quality. Therefore, this study aimed to examine the impact of several factors, like temperature and moisture by the use of colored plastic mulches under protected structures on cauliflower yield.

MATERIALS AND METHODS

Experimental site and growing conditions

The DRDO experiment was carried out in a polycarbonate chamber at the DRDO's experimental farm in Pithoragarh, Uttarakhand. The experimental farm is situated in Pithoragarh at a height of 1532 m (above MSL) with coordinates of 29.5835°N and 80.2095°E. The farmland is located in the western Himalayan state of Uttarakhand, on the hilly middle ground. Mean monthly temperature (October 2020- January 2021) at 9.00 AM varied from 28.24°C to 18.93°C and 2.30 PM from 38.52°C to 24.00°C and Relative humidity at 9.00 AM varied from 24.52% to 18.25% and at 2.30 PM from 10.53% to 9.65%.

Experimental design and material

In this research, we used the ''Amazing'' variety of cauliflower. A Randomized Block Design (RBD) with three replicates and five treatments was used in this study. Black polythene mulch (T1), red polythene mulch (T2), silver polythene mulch (T3), yellow polythene mulch (T4) and no mulch (T5) were the experimental conditions. Four sets of each treatment were performed. According to treatment and replications, 20 plots were prepared for of 7.20×1.20 cm area. Each planting bed was given a 45 cm separation from its neighbor and was elevated 15 cm above ground level for better intercultural operations. Mulches of 50μ(200 gauge thickness) were applied in plots according to the treatment combinations. All the mulches used in the experiment were purchased from the open market.

After that holes were made at the spacing of 60×60 cm on the mulch. Seedlings were transplanted on 8th October (2020) on well-prepared plots, which accommodate 24 plants per plot.

Data collection

Plant growth and yield data

We successfully finished all intercultural procedures. Plant height at harvest (cm), number of leaves per plant, days until curd commencement (d), days until harvest (d), curd weight (g), curd length (cm), curd diameter (cm), biological yield per plant (kg) and yield per plot (kg) were all recorded for a random sample of five plants. The yield is then translated into tones as yield/hectare.

Air temperature

Air temperature minimum at 9:00 AM and maximum at 2:30 PM was recorded daily during the cropping period.

Soil temperature

Platinum resistance thermometers were installed in the centre of each plot of each treatment at 10-15 cm depth. The temperature in °C was recorded daily for a minimum of 7.30 hours and a maximum of 14.30 hours.

Soil moisture

For calculating soil moisture content, soil samples were drawn at fortnightly intervals. Soil moisture content was determined from 0-30 cm soil depth by gravimetric method. After taking the fresh weight of samples, these were dried in aluminium boxes in the oven at 105-120°C till constant weight and soil moisture percentage were achieved. Soil moisture content was then calculated on oven dry weight basis with the help of the formula below.

$$Mp = \frac{Fw\text{-}Dw}{Fw} \times 100$$

Where,

Mp= Moisture percentage on oven dry weight basis.

Fw= Fresh weight of soil sample.

Dw= Dry weight of soil sample.

Statistical analysis

Analysis of variance (ANOVA) for the experiment was done as per the model suggested by Panse and Sukhatme (2000). The data recorded was analyzed using MS-Excel, OPSTAT and SPSS 16.0 package as per the design of the experiment.

RESULTS AND DISCUSSION

Growth and yield parameters

Mulch composition was shown to have a substantial effect on yield and yield-related characteristics (Table 1).

Plant height at harvest was greatest in the plots covered with red polythene mulch (T_2) and least in the control plots (T_5). Similarly, more leaves were recorded in T_2 and fewer numbers were recorded in T_5. The superior performance under red polythene mulch was attributed to improved soil temperature and moisture content throughout the growing season compared to control treatments. These results are consistent with the earlier reports where higher soil temperature has been recorded under the red and black plastic mulch compared with the control. Plastic mulches enhance plant growth and development by modifying the local microclimate, lowering soil water loss and changing the surface radiation budget (Kasirajan and Ngouajio, 2012, Ityel *et al*., 2014, Dhaliwal *et al*. (2017), Shilpa *et al*., 2021).

Early curd initiation was recorded in T_2 which was statistically at par with T_1, whereas late curd initiation was

Table 1: Effect of different colored mulches on yield and yield attributing traits of cauliflower.

Treatment	Plant height at harvesting (cm)	No. of leaves/plant	Days taken to curd initiation	Days taken to harvest	Curd length (cm)	Curd diameter (cm)	Curd weight (kg)	Biological yield/ plant (kg)	Yield/ plot (kg)	Yield/ha (t)
T1- Black-colored polythene mulch	49.98	18.04	50.81	63.59	17.72	47.90	0.74	2.58	16.27	15.06
T2- Red-colored polythene mulch	53.31	19.63	50.47	61.98	19.69	49.35	0.85	2.83	17.10	15.83
T3-Silver colored polythene mulch	41.43	16.15	55.02	67.69	15.98	42.50	0.53	2.08	13.16	12.18
T4- Yellow-colored polythene mulch	43.82	17.24	53.55	67.12	17.03	45.35	0.63	2.28	15.00	13.98
T5- Control	30.83	14.72	65.59	75.06	13.64	40.10	0.42	1.76	10.28	9.57
SEm±	0.44	0.20	0.26	0.37	0.26	0.60	0.02	0.08	0.18	0.18
$CD_{0.05}$	1.36	0.63	0.80	1.15	0.79	1.88	0.05	0.25	0.56	0.57

recorded in T_5. A minimum of days taken to harvest was recorded in red polythene colored mulch (T_2) and a maximum of days in control (T_5). This may be because mulching reduces the soil's upper 20 to 30 cm temperature fluctuations. As a result, the planting bed's soil temperature rises, which is beneficial for the plant's base to grow (Sarolia and Bhardwaj, 2012; Bhardwaj *et al*., 2011; Bijalwan *et al*., 2022 and Shilpa *et al*., 2022).

Maximum curd length was noted in T_2 and minimum in T_5. Wider curd was recorded in red polythene mulch plots (T_2), which was statistically at par with black polythene mulched plots (T_1) and narrow curd was recorded in non-mulched plots (T_5). Heavy curd was recorded in T_2, whereas lower curd was in T_5. The plots with red polythene mulch (T_2) had the highest biological yield per plant, yield per plot and yield per hectare based on yield parameters, while T_5 had the lowest biological yield per plant, yield per plot and yield per hectare. The increased yield in red polythene mulched plots is because it has a more consistent effect on biomass accumulation (Bahadur *et al*., 2014). Reddy *et al*. (2020) and Bobby *et al*. (2017) came to the same conclusion that polythene mulch may help with nutrient retention in the root zone, which in turn improves nutrient utilization by the crop. Complete nitrification is ensured by greater microbial biomass in the soil, which is favored by stable moisture levels, higher temperatures and improved aeration (Bhatt *et al*., 2011; Ashrafuzzaman *et al*., 2011). Mulching, as was previously noted, increases soil temperature and as stated, higher soil temperatures are beneficial for N mineralization and plant N absorption (Liu *et al*., 2003; Mahadeen, 2014). All such factors are directly associated with better plant development and greater yield due to large size and heavy curd.

Air temperature, humidity, soil temperature and soil moisture

Mean monthly temperature (October 2020-January 2021) at 9.00 AM varied from 28.24°C to 18.93°C and at 2.30 PM from 38.52°C to 24.00°C (Table 2) and Relative humidity at 9.00 AM varied from 24.52% to 18.25% and at 2.30 PM from 12.48% to 9.65% (Table 2). Cauliflower's growth relies heavily on the soil temperature. Soil temperatures were highest in plots mulched with red polythene and lowest in unmulched plots throughout the cropping season (October-January). The soil temperature was greater at a depth of 5 cm at 9 a.m. and 2:30 p.m. than at a depth of 10 cm (Table 3 and 4). Trends in soil temperature that are rising or falling are influenced by the daily atmospheric temperature. Soil moisture was observed to be greater in the mulched plots than in the social change and social ones when comparing plots with and without red polythene mulch (Table 5). Ashrafuzzaman *et al*. (2011) reported that soil temperature at 5 to 10 cm depth was different due to the presence of mulch and mulch colour. Soil temperature varied significantly with the type of mulching, time of the day and the depth of soil. Soil temperature was low in the early morning and gradually increased until a peak at 15:00 hours

Table 2: Mean monthly temperature (°C) and relative humidity (%) during the cropping period (Year 2020-21).

Month	Soil temperature (°C)		Relative humidity (%)	
	Minimum	Maximum	Minimum	Maximum
October	28.24	38.52	24.52	10.53
November	22.51	30.18	22.68	10.00
December	20.33	28.09	19.86	12.48
January	18.93	24.00	18.25	9.65

Table 3: Effect of different colored mulches on soil temperature at 5 and 10 cm depth (9:00 AM).

Month	Black mulch		Red mulch		Silver mulch		Yellow mulch		No mulch	
	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm
Oct	26.75	24.5	26.82	24.61	24.03	23.11	25.00	23.52	22.30	21.18
Nov	21.48	19.46	21.58	19.59	18.50	17.49	19.64	18.25	17.44	16.86
Dec	15.21	13.57	15.33	13.76	12.95	12.03	13.35	11.00	10.25	10.21
Jan	11.67	10	11.95	10.28	9.71	9.44	10.00	9.05	7.08	8.46

Table 4: Effect of different colored mulches on soil temperature at 5 and 10 cm depth (2:30 PM).

Month	Black mulch		Red mulch		Silver mulch		Yellow mulch		No mulch	
	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm
Oct	31.20	31.02	32.00	31.59	30.11	30.00	30.42	30.25	28.55	28.29
Nov	24.61	24.59	24.98	24.31	23.18	23.05	23.69	23.48	23.12	23.00
Dec	18.26	18.22	18.95	18.26	16.59	16.25	17.32	17.12	15.89	15.46
Jan	16.82	16.35	17.01	16.95	15.00	14.63	15.22	15.11	14.44	14.25

Table 5: Effect of different colored mulches on soil moisture content during the cropping period (Year 2020-21).

Month	Black mulch	Red mulch	Silver mulch	Yellow mulch	No mulch
Oct	24.12	24.55	23.11	23.89	15.26
Nov	22.11	22.86	20.45	21.15	14.28
Dec	25.36	25.74	24.16	24.87	16.85
Jan	27.98	28.00	26.88	27.12	18.00

in all the treatments and then declined. Temperature under mulches was higher than that of the control plots for all the times.

CONCLUSION

Yield or productivity of any crop is the most important factor but the quality of the produce cannot be ignored. The optimum temperature is favorable for the growth of vegetables to get the maximum yield. The protected structures are economic structures that change the desired area's microclimate. Mulching promotes plant development by enhancing root activity and enhancing the root zone's access to moisture and nutrients. Despite the extreme cold, Cauliflower may be effectively cultivated beneath sheltered buildings in the winter using plastic mulches. Farmers of the hills can be motivated to use protected cultivation technology to get high yields of vegetables with good remuneration.

Conflicts of interest

Authors declare that no conflict of interest exists.

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