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Growth and yield response of cabbage (*Brassica oleracea* var. Capitata) under the influence of different types of inorganic polythene mulches

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Abstract

The present investigation entitled “Growth and yield response of cabbage (*Brassica oleracea* var. capitata) under the influence of different types of inorganic polythene mulches” was conducted at Vegetable Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand during September to December, 2023. The experiment was laid out in randomized complete block design in triplicates with eight treatments viz., T₁-Control, T₂-Black polythene mulch-30μ, T₃-Transparent polythene mulch-30μ, T₄-Silver on black polythene mulch-30μ, T₅-Pink Polythene mulch-30μ, T₆-Blue polythene mulch-30μ, T₇-Green polythene mulch-30μ, and T₈-Red polythene mulch-30μ. Soil hydro-physical parameters – saturated hydraulic conductivity, water holding capacity, bulk density, porosity, moisture content and soil temperature were estimated. Plant yield and quality parameters – whole plant weight, head weight, yield per plot, yield per hectare, TSS, vitamin c, dry matter contents were also being tested. The results revealed that plant height, leaf length, head circumference, head length, head diameter, whole plant weight, head weight, yield per plot and yield per hectare were recorded from the plants grown in the plots applied with black polythene mulch (30μ). The maximum TSS, vitamin C, dry matter, minimum weed population and the minimum fresh and dry weight of weeds were also recorded in same treatment. Economically feasible cost benefit ratio (1:5.78) was also recorded in black polythene mulch (30 μ).

Keywords: Cabbage, polythene mulches, soil parameters, quality, yield

Introduction

Cabbage, a leafy vegetable belonging to the Brassicaceae family with chromosome numbers having $2n=2x=18$ (Bauras *et al.*, 2011)^[1], locally known as bandh gobhi. The crop can tolerate significant cold and thrives best in a chilly, damp area and mostly cultivated during winter and early spring in warmer areas, although it is also grown as a spring or fall crop in cooler climates. Mulch is regarded as an essential component that might affect the production of cabbage. Mulching using plastic film can raise soil warmth, lower water usage in irrigation systems, decrease weed weight, use fewer herbicides, and increase crop yields. Mulching plays a vital role in maintaining soil health and enhancing crop productivity through various mechanisms. One of the key benefits of mulching is its ability to slow down soil deterioration by effectively suppressing weed growth, reducing water evaporation, and preventing soil runoff and erosion. This, in turn, helps in controlling soil temperature and preserving moisture content, creating a favourable environment for plant growth. Moreover, mulching enriches the soil by providing essential nutrients, thereby improving its physical, chemical, and biological properties (Kumar *et al.*, 2019)^[2]. The colour of mulch also plays a crucial role in influencing the energy it emits and its impact on the surrounding environment, particularly in relation to food plants.

Materials and Methods

The present investigation was carried out at Vegetable Research & Demonstration Block, VCSGUHF, Bharsar, Pauri Garhwal, Uttarakhand. The experiment was laid out in randomized complete block design with three replication and eight treatments viz., T₁-Control, T₂-Black polythene mulch-30μ, T₃-Transparent polythene mulch-30μ, T₄-Silver on black polythene

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mulch-30 μ , T₅-Pink Polythene mulch-30 μ , T₆-Blue polythene mulch-30 μ , T₇-Green polythene mulch-30 μ , and T₈-Red polythene mulch-30 μ . The location falls under cold and temperate region. The seedlings were transplanted at the spacing of 60×45 cm. The different polythene mulch films were cut in size of 1.2×0.9 m and laid between two rows of seedlings in such a way that it covers all the area between two rows. The both edge of polythene stripes were buried at either side of flat beds to protect the film against damage by wind. Cultural practices like irrigation, hoeing and weeding, plant protection measures were done as and required. Total amount of water given to the plants during their growth period was approximately 85 litre/plot.

Results and Discussion

Hydro-physical soil properties

Different mulches appeared to have considerable impacts on the various hydro-physical soil-properties. Bulk density and porosity of soil were measured at 30-, 60-, and 90-days interval in which the black polythene mulch was successful in maintaining the considerable range of bulk density (1.157 g/cc) and porosity (56.322%) (Table 1). According to (Mbah *et al.* (2004) [3] a high bulk density causes inadequate root penetration, less aeration,

and decreased water infiltration into the soil, all of which lower crop output. The increased porosity and decreased compaction in plastic film mulched plots may have improved microbial activities and aeration in the soil, increasing root penetration and cumulative feeding area, which in turn led to increased plant growth and yield (Mbah *et al.* 2010) [4]. The improved soil aggregation and porosity in mulched treatments compared to no mulch treatments may be the cause of the higher saturated hydraulic conductivity values at harvesting, which in turned to a considerable increase in saturated hydraulic conductivity. Bhagat and Acharya (1951) [5] and Zhang *et al.* (2005) [6] both observed higher saturated hydraulic conductivity under mulched treatments. Significant variation in soil moisture conservation was seen through different mulching materials (Figure 1). Treatments with higher moisture conserved plots were T₂ > T₄ > T₈ > T₇ > T₆ > T₃ > T₅ > T₁. The use of plastic mulch helped conserving water by reducing evaporation from soil surface, controlling weed growth and reducing soil compaction. The results of this study were in line with the findings of Albu-Goukh and El-Balla (2003) [7]; Ramakrishna *et al.* (2006) [8]; Ban *et al.* (2009) [9]; Wang *et al.* (2009) [10] and Kumar and Lal (2012) [11], in which they indicated that the main advantage of using plastic mulch is to retain soil moisture.

Table 1: Hydro-physical properties of soil of the experimental site owing to different mulch treatments

Treatments	Bulk density (g/cc)				Porosity (%)				Water holding capacity (%)		Saturated hydraulic conductivity (cm/min)	
	30 DAT	60 DAT	90 DAT	Average	30 DAT	60 DAT	90 DAT	Average	BT	AH	BT	AH
T ₁	1.19	1.24	1.25	1.23	54.92	53.03	52.90	53.62	42.20	43.50	0.488	0.345
T ₂	1.12	1.18	1.17	1.16	57.58	55.54	55.84	56.32	46.62	47.04	0.391	0.414
T ₃	1.16	1.22	1.23	1.20	56.12	53.99	53.60	54.57	43.68	44.07	0.401	0.388
T ₄	1.15	1.19	1.21	1.18	56.72	55.03	54.22	55.32	44.34	45.74	0.377	0.390
T ₅	1.16	1.20	1.22	1.19	56.27	54.53	54.13	54.98	45.72	43.80	0.411	0.380
T ₆	1.13	1.18	1.18	1.17	57.27	55.42	55.44	56.04	45.33	45.72	0.393	0.398
T ₇	1.13	1.19	1.20	1.17	57.49	54.92	54.84	55.75	43.62	45.50	0.381	0.411
T ₈	1.13	1.18	1.19	1.17	57.44	55.61	55.06	56.04	44.13	44.85	0.383	0.403

DAT – Days after transplanting; BT – Before transplanting; AH – After harvesting

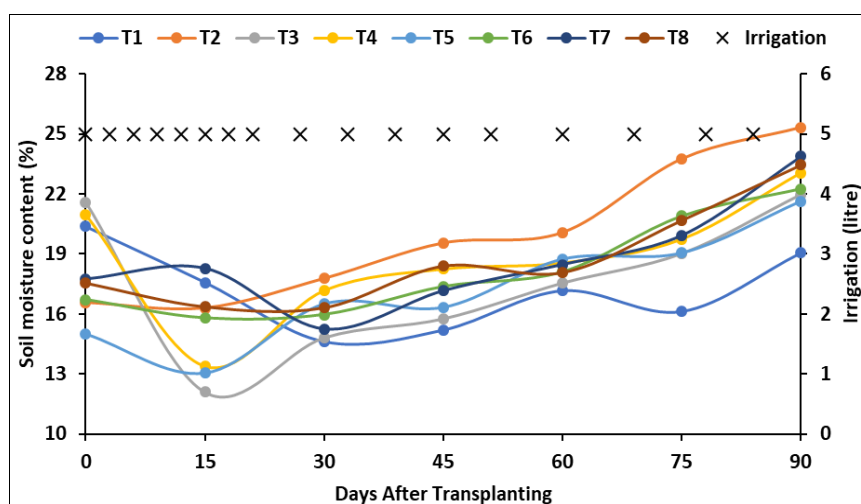


Fig 1: Soil moisture dynamics in the respective profiles owing to different types of plastic mulches

Soil temperature at the experimental site was recorded at 3 days interval at 5cm depth and found highest under black polythene mulch, and was relatively lower in control (Figure 2). The warming under plastic mulch is attributed to entrapment of long wave radiation from soil, reduction in conduction loss and cut off of convection loss under plastic mulch. Plastic mulch was more effective in reducing thermal loss than cutting incoming solar energy. The net effect is actually trade-off between mulch led reduction in incoming solar energy and reduction in heat loss

from the soil which may vary on different day depending on prevailing weather conditions. The temperature increase in the black polythene mulch condition might be because the black film absorbed incoming solar radiation and radiated much of this energy as sensible heat to the air (above) and soil (below). The results are similar to the findings of Suwwan *et al.* (1988) [12]; Decoteau *et al.* (1989) [13]; Hegde (1995) [14]; Vos and Sumarni (1997) [15] and Choudhary *et al.* (2012) [16].

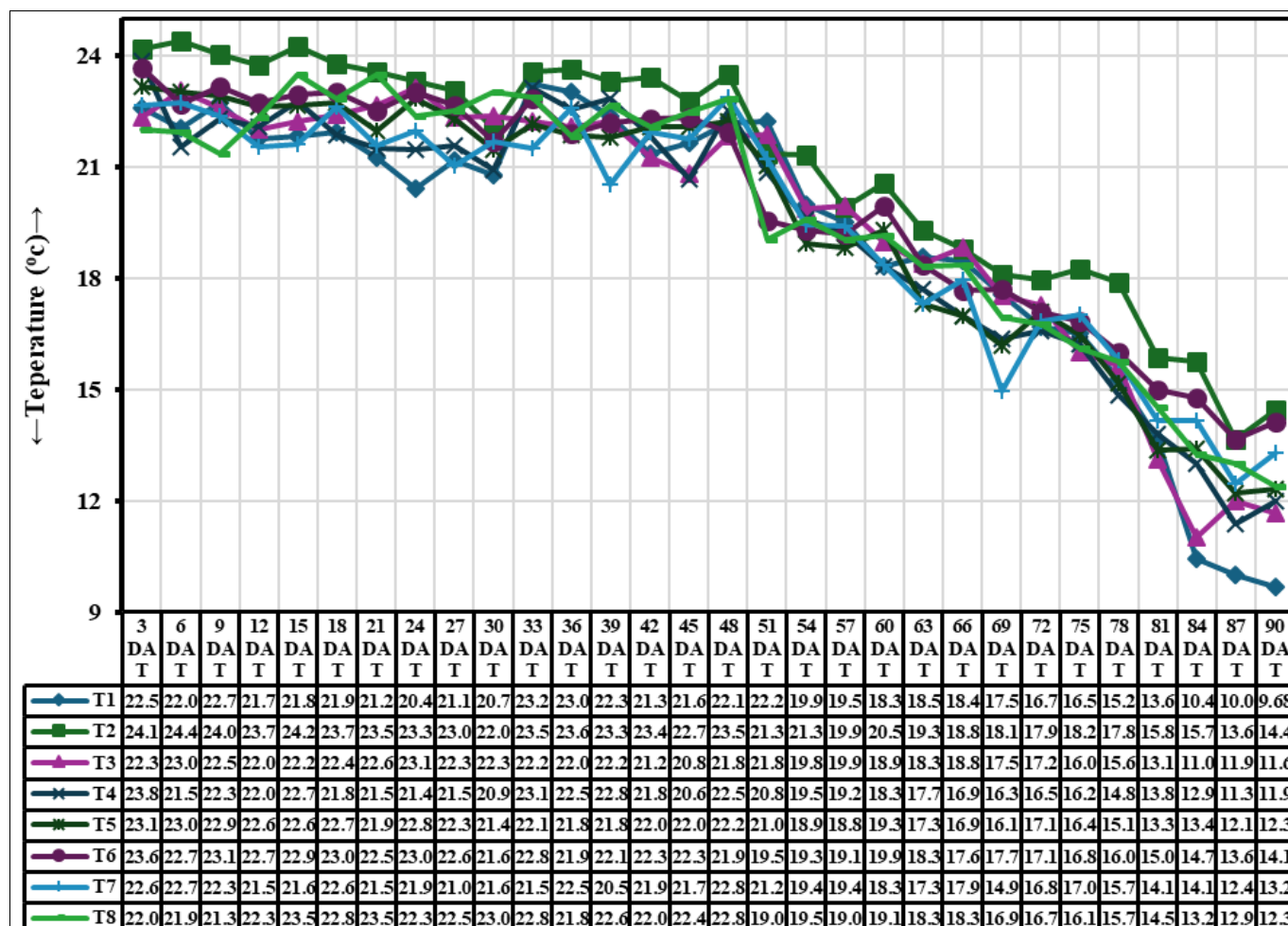


Fig 2: Soil temperature with respect to different treatments

Yield and quality attributes of cabbage

As per the findings the maximum whole plant weight (2.870 kg) was obtained in T_2 (Table 2). This increase in yield trait might be the result of improved rhizosphere soil moisture, improved nutrient consumption, increased photosynthesis, less weed development, and improved soil hydrothermal characteristics from black polythene mulching. T_2 produced the highest head weight (1.866 kg). The findings of Sarkar *et al.* (2003)^[17] and Trdan *et al.* (2008)^[18] support the statistically significant increase in cabbage head weight attributed to black polyethylene

mulch. This may be the beneficial result of the black mulch's ability to retain soil moisture and inhibit weed growth and reduce nutrient uptake, improve nutrient use efficiency, and increase yield potential (Saady *et al.*, 2021 and Admovic *et al.*, 2023)^[19, 20]. T_2 produced the highest yield (16.791 kg/m²) and (69.009 t/ha), and had 43.76% higher yield over T_1 (control) as per the investigation. Similar to our findings, Verma *et al.* (2017)^[21] reported a 22.4% increase in cabbage production due to black film mulch.

Table 2: Influence of different mulching materials on yield parameters of cabbage

Treatments	Whole plant weight (kg) ± S.E (m)	Head weight (kg) ± S.E (m)	Yield per plot (kg/2.43 m ²) ± S.E (m)	Estimated yield (t/ha) ± S.E (m)	Cost benefit ratio
T ₁	1.663 ± 0.082	0.816 ± 0.060	7.347 ± 0.542	30.235 ± 2.232	1: 3.01
T ₂	2.870* ± 0.044	1.866* ± 0.038	16.791* ± 0.343	69.099* ± 1.411	1: 5.78
T ₃	2.151* ± 0.095	1.758* ± 0.229	15.825* ± 2.058	65.123* ± 8.471	1: 5.39
T ₄	2.570* ± 0.112	1.552* ± 0.109	13.965* ± 0.982	57.469* ± 4.041	1: 4.23
T ₅	2.386* ± 0.227	1.267* ± 0.216	11.406* ± 1.948	46.938* ± 8.017	1: 3.43
T ₆	2.287* ± 0.087	1.227* ± 0.102	11.043* ± 0.918	45.444* ± 3.779	1: 3.42
T ₇	2.568* ± 0.116	1.780* ± 0.099	16.020* ± 0.891	65.926* ± 3.667	1: 5.47
T ₈	2.282* ± 0.170	1.628* ± 0.041	14.655* ± 0.368	60.309* ± 1.515	1: 4.11
S.E(d)	0.186	0.184	1.660	6.833	-
CD _(0.05)	0.403	0.400	3.596	14.797	-

*Significant at 5% level of significance as compared to T_1 (control)

Data shows significantly higher TSS content (8.133 °B) in T_2 over control (Table 3). This might have occurred due to the application of mulches, which contribute to an increased availability of essential nutrients for the plant. Highest ascorbic

acid content (93.533 mg/100g) was found in T_2 . This might have happened because application of black polythene mulch resulted in the creation of an optimal rhizosphere, a zone of soil that significantly benefits root development and overall plant growth.

By improving soil conditions, including moisture retention and temperature regulation, black plastic mulch facilitated an environment conducive to stronger and more vibrant cabbage plants. These favourable conditions are directly correlated with the production of higher-quality cabbage heads, rich in nutrients such as ascorbic acid. The strategic use of black polythene mulch mitigates these adverse effects and promotes a more

resilient and productive growing environment for the cabbage plants, leading to visibly superior outcomes in terms of both crop yield and nutritional content. In broccoli, Kosterna's (2014)^[22] and Saloom and AL-Sahaf's (2016)^[23] findings were comparable. T₂ provided highest dry matter content (20.047%). The observed benefits can be attributed to the implementation of black polythene mulch in agricultural practices.

Table 3: Influence of different mulching materials on qualitative traits of cabbage

Treatments	Total soluble solids (°Brix) ± S.E (m)	Vitamin C (mg/100g) ± S.E (m)	Dry matter (%) ± S.E (m)
T ₁	3.800 ± 0.361	47.400 ± 2.003	7.967 ± 0.384
T ₂	8.133* ± 0.441	93.533* ± 1.462	20.047* ± 0.956
T ₃	6.767* ± 0.318	72.600* ± 4.839	9.723 ± 0.323
T ₄	6.267* ± 0.536	92.133* ± 1.753	14.303* ± 0.837
T ₅	5.667* ± 0.186	63.533* ± 1.434	11.107* ± 1.234
T ₆	4.367 ± 0.145	65.267* ± 3.381	10.753* ± 0.541
T ₇	7.200* ± 0.153	91.133* ± 1.988	11.743* ± 0.251
T ₈	6.100* ± 0.551	67.867* ± 2.822	9.977* ± 0.823
S.E (d)	0.527	3.814	1.005
CD _(0.05)	1.140	8.259	2.176

*Significant at 5% level of significance as compared to T₁(control)

Conclusion

Results from the study indicate that black polythene mulch yielded the most favourable outcomes across various parameters including yield, quality, gross return, net return, and cost-benefit ratio. The use of black polythene mulch not only significantly boosted overall productivity but also enhanced crop quality, presenting a clear advantage over alternative treatments. Therefore, considering the comprehensive benefits demonstrated by mulching, with a specific focus on the effectiveness of black polythene mulch, it is undeniable that such approaches offer a pathway to maximizing agricultural success and should be strongly encouraged for sustainable and profitable farming endeavors.

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