

A Study on Use of Black Polythene Mulch as a Climate Smart Technology on Performance of Winter Cucumber and Resource Conservation In Terai Agro-climatic Zone of West Bengal

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript

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ABSTRACT

Though cucumber is mainly grown during *pre-kharif* and *kharif* season, but farmers of Teesta flood plains of Terai region prefer to grow this very crop during *rabi* season because of its high market demand and price during this period of year. This region experiences extreme cold during January and February, when maximum and minimum temperature falls below 22°C and 8°C respectively, average being around 13°C. As a result fruit setting and development is badly affected in cucumber. In order to cope with this problem of low temperature following study was conducted at Khagribari

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village (Latitude - 26.3504°N, Longitude - 89.4435°E) of Cooch Behar district of West Bengal, India during 2015-16 and 2016-17 under a National Network Project entitled 'National Innovations on Climate Resilient Agriculture (NICRA)' to assess effect of black polythene mulch on winter cucumber and on resource conservation with active participation of fourteen innovative and receptive farmers each having plot size of 0.13 ha. Performance of black polythene mulch was studied against conventional practice of growing winter cucumber without any mulch. Observations were taken on yield and yield attributing parameters of winter cucumber- like days taken to flower, flower drop percentage, fruiting period; net profit, soil temperature, irrigation water requirement etc. Two independent sample t- test were performed to compare two treatments for all parameters. Resulted showed that significantly higher yield (29.1 t/ha) and net return (Rs. 108100/ha) was obtained under black polythene mulch over conventional practice (26.2 t/ha and Rs. 80700/ha) as fruiting advanced by 5 days, fruiting period expanded by 20 days and fruit drop reduced to the extent of 10% due to higher night soil temperature and lesser fluctuation between day and night soil temperature under poly-mulching as against that of plots without mulch. The treatment also marked significant effect in conserving ground water and fuel by cutting down irrigation water requirement and diesel consumption in the tune of 5.38 ha-cm and 18.70 L/ha, respectively. Lower air pollution was also recorded due to 48.62 kg lower emission of CO₂ from irrigation pump during irrigation of 1 hectare area.

Keywords: *Cucumber; black polythene; mulch; irrigation; temperature; Terai region.*

1. INTRODUCTION

Cucumber responds like a semitropical plant. It grows best under conditions of high temperature, humidity and light intensity and with an uninterrupted supply of water and nutrients. Under favourable and stable environmental and nutritional conditions and when pest and diseases are under control, the plants grow rapidly and produce heavily [1,2,3]. Temperature is the main environmental component influencing vegetative growth, flower initiation, fruit growth and quality. Growth rate of the crop depends on the average 24 hour temperature, higher the average temperature faster the growth. Maximum fruit production is achieved with temperature of 20-22°C. Farmers of Teesta flood plains of Terai Region prefer to grow cucumber during winter months due to higher market demand and price. The region experiences extreme cold during January and February, when maximum and minimum temperature falls below 22°C and 8°C respectively, average being around 13°C. Cucumber is susceptible to low temperatures throughout its growth cycle [4,5]. Cucumber cultivators of the district Cooch Behar also have similar experiences *i.e.* poor plant growth, development, fruit setting and poor yield of cucumber during rabi season with their conventional practice of cucumber cultivation without mulch. It is also to be taken into account that rainfall received during winter months is *i.e.* from November to March is very scanty and annual rainfall of the region though high but

found to be depleting sharply when compared with annual average of last two decades leading to lower recharge of ground water. This along with continuously higher lifting of ground water for crop cultivation water saving and conservation has emerged as a burning issue to support agricultural activities. So, efficient use of irrigation water by introducing different agronomic practices is also considered very crucial now a day's [6]. On the other hand sandy and sandy loam soils suffer due to water deficiency for its less water retention capacity pointing out the need to cultivate the sandy soils with the least amount of irrigation [7].

Black, transparent, and white mulches are predominate in the commercial production of vegetable crops today over the world especially in developed countries during the winter season [8].

In light of above an effort was made to study the effectiveness of black polythene mulch in influencing the yield attributing parameters of winter cucumber; water conservation, fuel conservation and air pollution.

2. MATERIALS AND METHODS

Cucumber var. *Malini* was used for the study. The study was conducted on the farmers' field at Kharibari village (Latitude - 26.35°N, Longitude - 89.44°E, 43 m above mean sea level) of the district Cooch Behar, West Bengal, India. The

study was conducted during the year 2015-16 to 2016-17. The experiment was conducted at 28 numbers of farmers' field with 14 numbers in each year having average plot size of 0.13 ha at different location of the village. Adequate attention was paid while selecting farmer's field so that soil characteristics (Table 1) and micro-farming situation (medium to medium-upland and irrigated) remain nearly similar.

Raised beds of 120 cm wide and 15 cm height are prepared leaving 30 cm wide drainage channel in between two beds. Then raised beds are covered with black polythene mulch film. Adequate holes are made at specific distance of 110 cm x 30 cm, where basal fertilizers are placed. After 5-7 days treated cucumber seeds are sown at the hole. Recommended dose of fertilizer were applied and standard operational intercultural operations were followed. Irrigation was applied just before soil moisture level reached to the Permanent Wilting Point. Observations were taken on yield and yield parameters like fruiting period, fruit setting, days taken to flower etc., irrigation water requirement

and benefit cost ratio for plants raised on mulch and control. For all parameters two independent sample t-test were performed. Entire analysis was done in statistical Analysis System software (SAS, version: 9.2) using statement proct-test. The data were taken from 20 plants of each plot selected by random sampling method. Total numbers of sample plants were 560. Soil temperature at the depth of 10 cm was measured with soil digital thermometer. Data on number of irrigation applied during crop life, duration of each irrigation, fuel consumption per hour and irrigation costs were taken into account during the study. Water discharge capacity of 5 HP diesel pump (8 L per second) was calculated by recording the quantity of water discharge in 5 seconds (measured by stop watch) and dividing the quantity of water with the duration. Irrigation Water Requirement (IWR) expressed in ha-cm was calculated as: [Number of irrigation x duration per irrigation (seconds) x discharge rate (lit/second)] ÷ 10000 and Water Use Efficiency (WUE) was calculated according to FAO [9] as follows: yield (kg) ÷ IWR (ha-cm).

Table 1. Initial soil properties of experimental fields before cucumber cultivation

Physical properties	
Soil Texture	Sandy loam
Particle distribution	Sand – 72 to 78, Silt – 9 to 14, Clay – 12 to 17%
Bulk Density (g cc ⁻¹)	1.41 to 1.47
Maximum water holding capacity (%)	38.72
Field Capacity (%)	22.48
Permanent Wilting Point (%)	7.54
Chemical properties	
Ph	5.72 to 6.14
Electrical Conductivity (dsm ⁻¹)	0.10 to 0.42
Organic C (%)	0.89 to 1.11
Available N (kg N ha ⁻¹)	217 to 247
Available P (kg P ₂ O ₅ ha ⁻¹)	58 to 73
Available K (kg K ₂ O ha ⁻¹)	122 to 155
Available B (ppm)	0.60 to 0.87

Table 2. Average weather component of the experimental period (Agromet Field Unit, UBKV)

Month	Temperature (°C)			Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Average	Maximum	Minimum	
October	31.09	21.26	26.18	91.00	70.25	162.52
November	27.49	15.31	21.40	91.00	58.75	9.06
December	25.60	11.78	18.69	94.00	62.00	2.87
January	23.03	9.61	16.32	92.00	63.25	20.89
February	25.60	12.44	19.02	89.00	54.50	26.48
March	29.66	16.47	23.07	85.00	46.75	42.66

3. RESULTS AND DISCUSSION

3.1 Soil Temperature

Average soil temperature at 10 cm depth under each treatment at November, December, January and February are shown in Fig. 1. From the results as presented in Fig. 1 (a) it is seen that lowest and highest day soil temperature under both mulch and without mulch was recorded during January and November, respectively. Results further confirmed that average of monthly day soil temperature during growth period was significantly higher black polythene mulching that no mulch (1.5°C). Similar trends of results were also observed when day soil temperature at both treatment plots at each month of growth period (November to February) was compared separately. The obtained results are in agreement with those of [8,10,11,12,13,14,15].

It was also noticed from the recorded soil temperature at night during the growth period of cucumber that the soil temperature at night was nearly equal to the atmospheric temperature in bare soil where the same was much higher than the atmospheric temperature under black polythene cover. So it is imperative that average of monthly night soil temperature during growth period of cucumber was significantly higher (by 5°C) at plots covered with black polythene mulch that the plots where no cover was used. Similarly, significant differences between night soil temperature under poly mulch and no mulch were recorded at each month of growth period i.e. November, December, January and February. These findings of the study can be explained by the fact transparent and translucent black mulches promote a relatively large net radiation at the soil surface, increase soil heat flux and, as a consequence, the minimum and maximum soil temperature are increased [16].

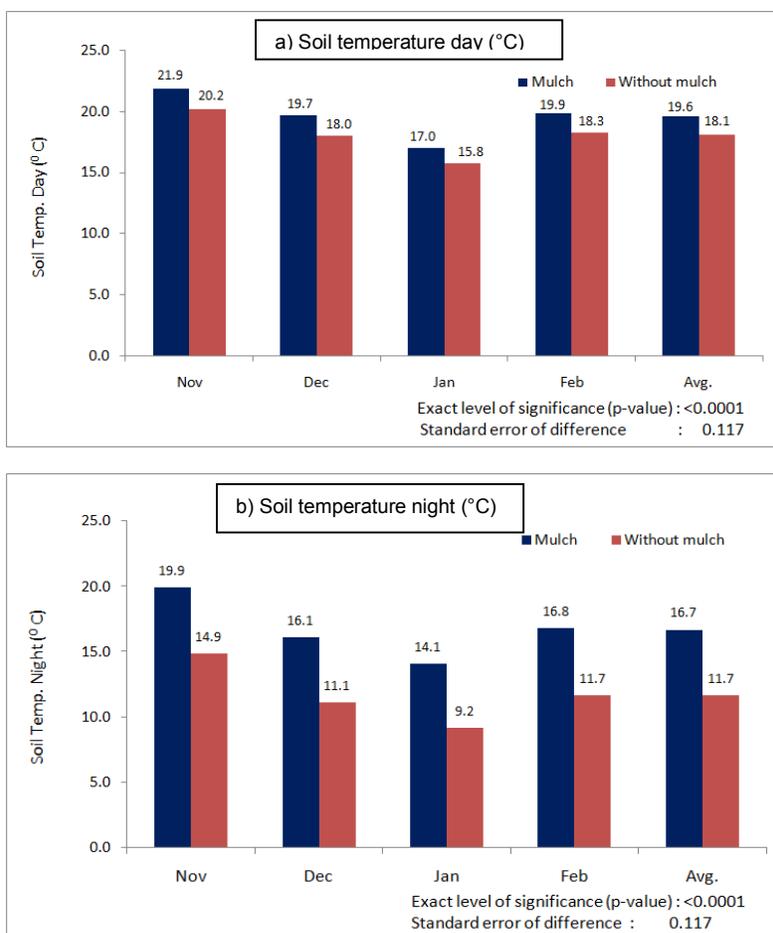


Fig. 1. Soil temperature under black polythene mulching and no mulching during growth period of winter cucumber

3.2 Yield and Economics

The obtained yield of winter cucumber as presented in Table 3 revealed that use of black polythene mulch to cover the soil of winter cucumber plots positively and significantly affected the yield (29.1 t/ ha) compared to growing winter cucumber in bare soil (26.2 t /ha). Results further explained that this was undoubtedly due to advancement of 1st flowering day by 5 days, increased in fruit setting percentage in the tune of 10% and expansion of fruiting period by 20 days which was in lines with the findings of Ngouajio and Ernest [17]. Several previous studies demonstrated that black polythene mulch increase crop yield and improve crop growth of many vegetables especially in cold season, where soil temperature is the limit factor for plant growth [10,11,12,18,19,20]. Polythene mulch modified root zone temperature, which has been shown to have an important role in plant growth and yield [21,22]. Higher yield and heavier fruit under black polythene mulch could be explained in light of beneficial effects of polythene mulch which enables retention of soil moisture and prevent soil temperature to raise high at the end of vegetative phase which enables increase in the CO₂ content resulting in increased photosynthesis [23].

While comparing economics of winter cucumber cultivation under black polythene mulch and at bare soil it was calculated that although gross cost was slightly higher while covering soil with mulch (Rs. 66500.00 ha⁻¹) than cucumber cultivation without mulch (Rs. 62700/ ha) but gross return was very significantly higher with poly-mulching technology (Rs. 174600 /ha) over that of control i.e. no mulching (Rs. 143400 /ha). Thus ultimately there has been considerable increase in net profit and benefit to cost ratio (Rs. 108100/ ha and 2.63) when black poly-mulching was used as soil cover as compared to that of normal practice of farmers without any mulching

material (Rs. 80700 /ha and 2.28). The finding was in conformity with the findings of Waterer [24] who also reported about higher gross return, increased net profit and benefit to cost ratio in case of winter cucumber cultivation covering soil with polythene mulch over that of cultivation without any soil cover.

3.3 Irrigation Parameter, Fuel Consumption and Carbon-di-oxide Consumption

Results presented in Table 4 on different irrigation parameters showed that total number of irrigation required for winter cucumber cultivation reduced from 9 numbers at uncovered soil to 7 numbers when soil was covered with black polythene mulch but the average duration per irrigation per hectare was 9 hours 23 minutes and same in both cases; thus resulting considerable reduction in total irrigation hours from 84.38 hours /ha at plots without mulch cover to 65.68 /ha at treatment plots where soil was covered with black polythene mulch. This led to significant reduction in IWR of cucumber from 24.30 ha-cm at uncovered soil to 18.92 ha-cm under black polythene mulch. Thus, significantly higher yield and lower IWR under black polythene mulch compared to no mulch plot resulted in increased WUE in the tune of 459.87 kg ha/cm. Higher WUE is an integral part of mulch cum drip irrigation [22]. All these can be explained by reduction in consumptive use of water and better retention of soil moisture under polythene mulch [23,24,25].

A comparison of fuel consumption under both treatments revealed considerable reduction (18.70 L/ha) in fuel consumption when soil was covered with poly-mulch compared to that of soil with no-mulch cover due to decrease in total irrigation hours per hectare area. As consequence of all above a considerable reduction in air pollution was also noted and this

Table 3. Effect of mulch film on yield attributing parameters and economics of winter cucumber

Parameter	Mulch	No-mulch	Exact level of significance (p-value)	Standard error of difference
Yield (t/ha)	29.1a	26.2b	0.0640	0.289
1 st flower (day)	31	36	< 0.0001	0.135
Fruit set (%)	55	45	< 0.0001	0.162
Crop duration (day)	130	110	< 0.0001	1.136
Gross cost (Rs./ha)	66500	62700	< 0.0001	0.716
Gross return (Rs./ha)	174600	143400	< 0.0001	0.114
Net profit (Rs./ha)	108100	80700	< 0.0001	124.11
BCR	2.63	2.28	< 0.0001	0.116

Table 4. Effect of mulch film on irrigation parameters, fuel consumption and carbon-di-oxide emission

Parameter	Mulch	No-mulch	Exact level of significance (p-value)	Standard error of difference
No. of irrigation required	7	9	< 0.0001	0.110
Duration/irrigation/ha (min)	563	563	< 0.0001	0.175
Total irrigation duration (hr/ha)	65.68	84.38	< 0.0001	0.142
Irrigation water requirement (ha-cm)	18.92	24.30	< 0.0001	0.113
Irrigation cost (Rs./ha)	5583	7172	< 0.0001	1.790
Water use efficiency (WUE) (kg/ha-cm)	1538.05	1078.18	< 0.0001	1.340
Diesel consumption (lit./ha)	65.68	84.38	< 0.0001	1.162
CO ₂ emission (kg/ha)	170.77	219.39	< 0.0001	0.399

is confirmed by calculated value of emitted CO₂ from diesel pump during the time required to irrigate one hectare winter cucumber - 170.77 kg/ha in poly-mulch covered soil against that 219.39 kg/ha in uncovered soil.

4. CONCLUSION

The present investigation revealed that cultivation of winter cucumber using black polythene mulch as soil cover is has high potential to increase crop yield by advancement and expansion of fruiting period, reduction in flower drop or increase in fruit setting due to rise in night soil temperature which is the main limiting factor of winter cucumber cultivation in the Terai Agro-climatic Region. Moreover, the technology has proved to have high potentiality in reducing IWR, increasing WUE, reducing diesel consumption for irrigation and thus results in reduction of irrigation cost and air pollution; significant conservation of natural resources in the form of ground water and fuel. Above all, from farmers view point the technology of using black polythene mulch has found to be economically viable as net profit and benefit to cost ratio increased to great extent. From the experiment it can be firmly concluded that the technology of covering soil with black polythene mulch during winter cucumber cultivation is very highly potent technology especially for the region where winter experiences very low temperature and where soil has low moisture holding capacity due to coarser texture of soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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