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Effect of Mulches on Growth, Yield and Economics of Chilli (*Capsicum annum* L.) in Eastern Hills and Plateau Region

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ABSTRACT

A trial at farmers field was conducted during rabi season at different villages in Ramgarh district of Jharkhand to study the effect of different types of mulching on growth and yield of chilli for two consecutive years 2019-2020 and 2020-2021, Mulching materials i.e. plastic mulch (double coated silver-black 30 micron), bio mulch (paddy straw) and no mulch (control) for chilli farming were taken for the study. The trial was laid out in randomized block design (RBD) with three treatments and eight replications. Data was recorded for weed population or weed density (m^3), soil moisture content, plant height, fruit weight, fruit numbers, number of structural branches, fruit length, number of leaves per plant, fruit yield/ plant (kg), fruit yield/ ha (q), days to flowering, days to first picking and fruiting span. Economics of various treatments were also worked out and BC ratio was calculated. The results revealed that plastic mulch (double coated) recorded the highest soil moisture retention (15.06 %), lowest weed population/ weed density (74.81), highest plant height (88.17 cm), maximum number of fruits/ plant (217.27), fruit length (8.66 cm) and fruit weight (9.99 g). Maximum number of leaves per plant (595.50) was also found with plastic mulch. Fruit yield/ plant (1.42 kg) and total fruit yield/ ha (463.08 q) with high cost benefit ratio (2.80) were recorded highest in plastic mulch followed by bio mulch and found lowest in plant with no mulch. Lowest soil moisture content (10.86 %), highest weed population (160 m2), minimum yield/ ha (134.0 q) and lowest benefit cost ratio (1.37) were recorded from without mulched plot. Therefore, mulching (organic as well as plastic) appears to be a viable tool to increase the chilli production and recommended for cultivation.

Keywords: Mungbean, Variety, Stress mitigating chemicals, Thiourea

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INTRODUCTION

Chilli (*Capsicum annum* L.) 2n=24 is the most important spice crop grown in the tropical and sub-tropical regions of world as an important vegetable and condiment crop. It is the most widely used universal spice, named as wonder spice. It belongs to the family Solanaceae. Mexico is considered as its primary centre of origin (Vavilov, 1926). Different varieties are cultivated for varied uses like vegetable, pickles, spice and condiments. In daily life, chillies are integral and the most important ingredient in many different cuisines around the world as it adds pungency, taste, flavour and colour to the dishes. Indian chilli is considered to be world famous for two important commercial qualities, its colour and pungency level. The fruits are good source of vitamin A (292 IU) and ascorbic acid (111 mg/ 100 g of edible matter). The composition of green chilli per 100 g of edible portion contains moisture (85.7g), protein (2.9 g), fat (0.6 g), minerals (1.0 g), fibre (6.8 g), carbohydrates (3.0 g), calcium (30 mg), magnesium (24 mg), riboflavin (0.39 mg), nicotinic acid (0.9 mg), phosphorous (80 mg), iron (1.2 mg), sodium (6.5 mg), potassium (217 mg), Vitamin A (292 IU) and Vitamin C (111 mg). Green chillies are rich in Vitamin A and C, minerals and protein. It is also used as medicinally, sauces, chutneys and pickles. The pungency is due to the oleoresin 'capsaicin (a condensation product of 3 hydoxy-4-methoxy benzylamine and decylenic acid). It is secreted by the outer walls of the fruit. The fruits are an excellent source of health-related phytochemical compounds, such as ascorbic acid, carotenoids, tocopherols, flavonoids and capsaicinoids that are very important in preventing chronic diseases such as cancer, asthma, coughs, sore throats, toothache, diabetes and cardiovascular diseases (El- Ghoraba *et al*., 2013). India is the largest producer of chillies in the world accounting for 11 lakh tons of production annually followed by China with a production of around 4 lakh tons, Mexico and Pakistan produce 3 lakhs tonnes each of chilli every year. In India, chilli is grown in an area of 8.82 lakh ha and annual production of 11.0 lakh tones with an average productivity of 1200 kg/ ha and export of chillies during the year 2001-02 has fetched a foreign exchange of Rs. 255.84 crores with production of 75,000 quintals (NHB, 2017). Major chillies growing states in the country are Andhra Pradesh, Karnataka, Maharashtra, Odhisa, Tamil Nadu, Madhya Pradesh and Rajasthan. Among chilli producing states in the country, Andhra Pradesh stands first and also constitutes the maximum acreage for chilli cultivation in the country. It occupies 49% share in the Indian total production and produces around 2.7 lakh tons of chillies

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followed by Odhisa (18%), Karnataka (15%), Maharashtra (6%), West Bengal (5%), Rajasthan (4%) and Tamil Nadu (3%) (www.ikisan.com). In Jharkhand it is cultivated in an area of about 0.015 million ha with an estimated production of 0.25 million tonnes and productivity of 12.27 tonnes ha (NHB, 2018). According to suitability different chilli varieties are grown all over the country which are vary from region to region such as F1 hybrids, Swarna Praphulya, Swarna Arohi, Swarna Apurva, Andhrajyoti, Pusa Sadabahar, Pusa Jwala, N.P. 46, A.K. 2, California Wonder, Chinese Giant, Yellow Wonder, Bharat etc. which are cultivated by farmers. Chilli is sensitive to water stress. Young chilli seedlings cannot withstand either water deficit or excess soil moisture while older plants can withstand deficit or excess water (Ayoub, 1986). Water deficit often limits the crop growth and development. Heavy rainfall is a problem for chilli cultivation because chilli cannot tolerate heavy rainfall. In the winter, production is hampered due to lack of irrigation as well as minimum rainfall. In the winter season, the conservation of soil moisture may help in preventing the loss of water through evaporation from the soil facilitating maximum utilization of moisture by the plants. Most determinate crops are sensitive to water stress especially at the time of floral initiation, during flowering, and to a lesser extent, during fruit development (Hegde, 1989). To improve the productivity of crops where water deficiency or excess frequently occurs, proper water management is necessary. Infestation of field with weeds is a limiting factor in the production of chilli causing a considerable reduction in yield by affecting the growth and yield parameters. Immediately after transplanting, chilli seedlings grow slowly whereas weeds emerge fast and grow rapidly competing with the crop severely for growth resources, viz. nutrients, moisture, sunlight and space during entire vegetative and early reproductive stages of chilli (Isik *et al*., 2009). Presence of weeds in the crop reduces the availability of nutrient, water, photosynthetic efficiency, dry matter production and its distribution to economical parts and there by reduces sink capacity of crop resulting in poor fruit yield. Thus, the extent of reduction in fruit yield of chilli by weeds has been reported to be in the range of 60-70% depending on the intensity and persistence of weed density in standing crop (Khan *et al*., 2012). It is well established that 30 to 60 days after transplanting is the most critical for crop- weed competition in chilli. Hence, managing weeds during this period is most critical for higher yields. But, the competing weeds pose problem greatly and need effective management to obtain higher yields. Mulching is an efficient method which can be used to conserve soil moisture, inhibit weed infestation, maintain soil moisture, repel insect and reflect back selective light wavelengths (Green and Dole, 2003) and increase yield and quality (Nagalakshmi *et al*., 2002). Mulching stimulates the microbial activity in soil, minimizes the use of N fertilizer, warms the soil, improves the soil physical condition & suppresses weed and increased yield (Nagalakshmi *et al*., 2002; Narayan *et al*., 2017). The mulching involves placing of a layer of material on the soil around the crop of interest to modify the micro environment to improve crop productivity. Mulches typically function by blocking light or creating environmental conditions, which can prevent germination or suppress weed growth shortly after germination. However, other benefits including earliness, moisture conservation, temperature regulation, reduce nutrient leaching, affect insect and disease pressures and some instances reduce soil compaction improved soil organic matter. The use of mulches typically, results in higher yield and quality in vegetable crop enhancing profitability for the growers (Narayan *et al*., 2017). Plastic for mulching is readily available in the market and has a relatively low cost. However, there are some disadvantages of mulching. These include greater initial cost of materials and the removal and disposal of mulch materials from the field. Keeping these points in view the present investigation was undertaken to ascertain the effect of different mulching materials on growth, yield and economics of chilli (*Capsicum annum* L.) in eastern hills and plateau region.

MATERIALS AND METHODS

The present investigation was conducted at farmers' field of the village at Ramgarh district in Jharkhand situated at 23° 38' N latitude and 85° 31° E longitude with a mean altitude of 337 meter above the sea level comes under eastern plateau and hills region, through on farm trials during rabi season of two consecutive years 2018-19 and 2019-20. Three treatments i.e. plastic mulch with silver-black polythene (double coated 30 Micron) and bio mulch with paddy straw (9 t/ ha) and a control or no mulch (bare soil) were used in variety of chilli named Swarna Praphulya, a dark green, turns dark red on ripened, long fruited, high yielding, resistant to bacterial wilt, pungent in smell, released from ICAR RCER Patna. Good agricultural practices like nursery raising, seed treatment, land preparation, transplantation of seedling, weed management, irrigation management, manure and fertilizers management, application of mulches, harvesting etc. were all applied well. The trial was laid out in Randomized Block Design (RBD) with three treatments and eight replications. Spacing of 45 x 60 cm was followed to raise the crop. The data was recorded for the effect of mulching on weed population (no.), soil moisture content (%), growth and yield parameters viz. plant height (cm), fruit weight (g), number of fruits/plant, fruit length (cm), number of leaves per plant, yield per plant (kg), marketable fruit yield (q/ha), phonological attributes (Days to flowering, Days to first picking, Fruiting span) and economic of the system. Weed population (nos.) were calculated by counting individual weed (no.) after 45 days after transplanting. The soil moisture content in various trial plots under different mulches was recorded in 0-10 cm depth. Soil moisture content was measured using gravimetric techniques/ method (oven drying), involves drying a soil sample and calculating the moisture content based on the weight difference before and after drying. Through this process soil samples were collected and its wet weight recorded thereafter dried the sample in an oven at a specific temperature (e.g., 105°C) until it reaches a constant weight, then its dry weight was recorded, at last the soil moisture content was calculated using the formula:

Soil Moisture Percentage (%) = [(Wet Soil Weight – Dry Soil Weight) / Dry Soil Weight] × 100.

Data obtained on various attributes were pooled and statistically analyses or critical differences using standard

procedure. The data was analyzed online by using OPSTAT Statistical Package (Sheoran *et al*., 1998).

RESULTS AND DISCUSSION

Effect of mulching on weed population

Weed populations were counted at 45 DAT as shown in Table 1. The weed number was minimum in silver-black polythene mulch (double coated 30 micron) (11.75) followed by bio mulch with paddy straw (110.38) and maximum in control or without mulch (160.13) which might be due to direct entrance of solar radiation through them (without mulch and bio mulched) and as well as due to higher soil temperature and soil moisture content, especially at the upper 5 cm depth. Silver-black plastic mulch produced weeds only through the punch and no weed was found under the plastic, which might be due to lack of penetration of light through black plastic. Black plastic mulch blocked the weeds, except a few, which emerged through the planting holes. The effectiveness of black polythene sheet as mulching material in restricting weed growth has been reported by Chirstopher *et al*. (1997) in brinjal and Agrawal *et al*. (2002) in banana.

Effect of mulching on soil moisture content

Results revealed that both plastic mulch and bio mulch retained higher moisture content as compared to the without mulched. There was significant soil moisture content difference among the mulching treatments. The silver-black polythene mulch (double coated 30 micron) showed higher soil moisture content (15.06%), followed by bio mulch with paddy straw (12.79%) and lowest in control (10.86%). Increase in moisture retention capacity due to plastic mulching could be attributed to less moisture evaporation from the soil. Moreover the water evaporated from the soil was again trapped beneath the mulches, resulting in vapours which again dropped into upper soil layer.

Effect of mulching on growth and yield attributes

Plant growth

Data regarding plant height is given in Table 1. The plant height varied significantly due to different mulching material at different growth stages and increased with plant age. Plastic mulches showed superior performance in plant height than control, indicating mulches had positive effect on the growth and development of chilli. Plastic mulch always showed superior performance than the others. At the maturity, the tallest plant (85.58 cm) was observed in silver black plastic mulch, followed by bio mulch (74.26 cm). The smallest plant (66.40 cm) was observed in with without mulched plot. The increased plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. Changes in the plant height of chilli have been observed by using different mulches and plastic mulch increased the plant height than other mulches (Shinde *et al*., 1999).

Fruit weight

The data relating weight of fruit is presented in Table 1. Shows that chili fruit weight was significantly affected by mulching materials. The effect of various mulching treatments on fruit weight was found statistically significant. Mulching resulted in higher fruit weight than in control, indicating that mulch had positive effect in generating increased fruit yield. Silver-black plastic mulch (double coated 30 micron) produced highest fruit weight of 19.50 g followed by with bio mulch (17.00 g) while minimum fruit weight (15.13 g) was recorded in control or without mulched plot. Fruit weight is one of the most important parameter in the yield component, due to which total yield may be increase or decrease. In mulching materials high soil moisture content, accumulation of nutrients in the root zone of plant and particularly in black plastic mulch weeds are almost absent which leads to maximum fruit weight. The above results are similar to the results of Kayum *et al*., (2008). They reported that mulching materials significantly affects individual fruit weight of tomato varieties. They observed maximum individual fruit weight from the plots mulched with water hyacinth followed by straw while, minimum was noted from without mulched plots. Ashrafuzzaman *et al*. (2011) reported that maximum fruit weight was noted in black plastic mulch followed by transparent and blue plastic mulch as compared to control. Similar results were also observed by Ahmad *et al*. (2011), they stated that maximum fruit weight was noted in black plastic mulch followed by transparent plastic mulch while minimum fruit weight was reported in control plots. Parmar *et al*. (2013) stated that mulching materials significantly increased the average fruit weight in water melon when compared with control plots.

Number of fruits/ plant

Perusal of the data revealed significant differences among various treatments for number of fruits per plant. Treatment silver-black plastic mulch (Double coated 30 micron) recorded highest number of fruits per plant (87.25) followed bio mulch with paddy straw (74.88) and minimum with control (65.75). The results are in accordance with the earlier report of Ashrafuzzaman *et al*. (2011) who reported that mulching significantly improved the number of fruits per plant and reduced the percentage fruit abortion compared to without mulched control. The increase in the number of fruits per plant associated with plastic mulching can probably be attributed to conservation of moisture, improved microclimate and less competition from weed growth. The suitable conditions enhanced the plant growth and development and produced increased fruit bearing nodes compared to the control (Ashrafuzzaman *et al*., 2011). Mulching materials especially black plastic mulch fully control weeds by inhibiting photosynthesis inside the plastic, which reduce the competition with plants as a result plant get maximum nutrients from soil which results in higher number of fruits plant. These results are similar with Nwokwu and Anickwe (2014) reported that mulching materials significantly affected number of fruits per plant of tomato varieties.

Number of structural branches

Data showing number of branches per plant is given in Table 1. Mean table shows that the mulches had a significant effect on the number of structural branches per plant. The number of

structural branches per plant continually increased with plant age. Mulches had the positive effect on generating and retaining higher number of branches per plant. The highest number of structural branches per plant was observed in silver- black plastic mulch, followed by bio mulch with paddy straw. Maximum numbers of branches (7.13) per plant were recorded where silver-black plastic was used for mulching followed by bio mulch with paddy straw (5.88) while minimum numbers of branches per plant (4.75) were noted in plants with no mulching. Favourable weather condition and moisture of the soil are the important parameters affecting the number of branches per plant. This may be attributed by sufficient soil moisture near root zone which is trapped under mulching material. The extended retention of moisture also leads to higher uptake of nutrient for proper growth and development of plants. The currents findings are in agreement with Ashrafuzzaman *et al*. (2011) and Kumara *et al*. (2016). They stated that mulching materials significantly affected structure branches of chilli plants particularly black plastic mulch produce maximum number of branches.

Fruit length

As per the data obtained from the trial, it was found that silver black plastic mulch (double coated. 30 micron) recorded highest mean fruit length (6.99 cm) followed by bio mulch with paddy straw (6.14 cm). Increase in fruit length when plastic mulches were used might be attributed by enhanced soil temperature and conserved soil moisture. The current results are similar with the findings of Ahmad *et al*. (2011) reported that maximum fruit length (8.85 cm) was found in black plastic mulch which was statistically similar to transparent plastic mulch followed by sugarcane bagasse.

Number of leaves per plant

Mulching produced significantly higher number of leaves per plant than that of control, throughout the whole growth period (Table 1). The number of leaves per plant increased gradually till through 60 DAT and there after increased rapidly up to 105 DAT. The maximum number of leaves per plant was found on the plants mulched with silver-black plastic (593.50) at all growth stages, followed by the bio mulch with paddy straw (469.88). Similar results were recorded in chilli by Ashrafuzzaman *et al*. (2011).

Yield per plant

The fruit yield per plant varied from 0.80 kg (without mulched, control) to 1.60 kg (plastic mulched) with overall mean of 1.20 kg. The maximum average fruits yield per plant was found in plant mulched with silver- black plastic (1.43 kg) followed by bio mulched with paddy straw (1.20 kg) while minimum average fruits yield per plant was found in no mulched or control (0.98 kg). These results were close to the earlier study of Sathiyamurthy *et al*. (2017) and Reddy *et al*. (2016).

Marketable fruit yield

Data on yield q/ha is given in Table 1. Mean table show that yield quintal per ha were affected significantly by mulching materials. The effect of mulching treatments on yield per plot was found statistically significant. Mulching resulted in higher yield per plot than in control, indicating that mulch had positive effect in generating increased fruit yield. Total fruit yield was found maximum (208.76 q/ha) in silver- black polythene mulch (Double coated) followed by bio mulch with paddy straw (171.20 q/ha) and lowest in control or without mulching (151.29 q/ha). Fruit yield increased in mulched plot because of increased number of fruit/plant and fruit weight which may be attributed to the better utilization of inputs due to lowest weed competition and better soil moisture. The results are in accordance with Ashrafuzzaman *et al*. (2011) who reported maximum fruit yield in case of black plastic mulch in chilli. Plastic mulch reduces evaporation, reduces fertilizer leaching, reduces soil compaction, increase soil temperature and have very few weeds in plastic mulch. These properties leads to well- developed root system of plant, high soil moisture and nutrients retention within root zone which ultimately result in higher crop yield.

Effect of mulching on Phenological parameters

Days to flowering

Data recorded on number of days to flowering is given in Table 1. Data shows that days to flowering in chili plant were affected significantly by mulching materials. Mean table shows that maximum days to flowering (72.88) were observed in non-mulched plots, while lowest days to flowering (66.13) were noted in plastic mulch. The early in flowering with the use of plastic mulch may be due to increase in soil temperature which promote rapid growth and early maturity of plant. Similar results were noted by Ahmad *et al*. (2011), they observed that minimum days to flowering were noted in plastic mulch then other mulch materials and control. High soil temperature under plastic mulch improves the plant micro climate leading to early growth and development which advanced the flowering. Similar kind of observation with respect to plant growth was also reported by Singh *et al*. (2005) in tomato. Nimah (2007) reported that plastic mulches improve the CO_2 availability in the plant which ultimately led to high rate of photosynthesis.

Days to first picking

Data showing first harvest time is presented in Table 1. Data shows that mulching materials significantly affected first harvest time in chili. Maximum days to first harvest time (94.00) were noted in non-mulched plots while minimum days to first harvest time (87.38) took in silver- black plastic mulch followed by bio mulch with paddy straw (90.25). The reduction in days to first harvest time in plastic mulch might be due to increased soil temperature, high soil moisture content and reduction in nutrients leaching. All these reasons result in rapid growth and early fruit maturity. Similar findings were noted by Ahmad *et al.* (2011), they stated that minimum days to harvesting were noted in plastic mulch, while maximum days to harvesting were observed in control.

Fruiting span

Data showing fruiting span of chilli plants is given in Table 1. Mean table shows that the plants with plastic mulch had

positive effect on fruit retention of plant and more number of fruiting span (56.13 days) than the control or non-mulch (52.25 days) one. This might be due to high soil moisture retention and low leaching of nutrients, less evaporation and very few numbers of weeds under plastic mulch than control. These results are in close conformity with the findings of Prajapati *et al*. (2017).

Effect of mulching on economic of the system

Higher money value and low cost of cultivation are desirable characters for higher returns. Hence, economics of the various treatments was worked out (Table 2), Gross returns were depending upon the yields, which are produced and sold. Maximum gross return (Rs. 6,31,500) and net return (Rs. 5,69,500) were obtained from silver- black plastic mulch followed by bio mulch with paddy straw (Rs. 4,42,260 and Rs. 3,87,260, respectively). Pooled data on cost benefit ratio reveals significant differences among different mulching treatments. Mulching with silver- black polythene double coated gave highest B:C ratio of 10.19 followed by mulching with bio mulch using paddy straw (8.04) which is significantly higher than control (non- mulch). The result is in close conformity with the findings of Prajapati *et al*. (2017) and Narayan *et al*. (2017).

Table 1: Effect of different mulches on growth, flowering, fruiting, yields and yield attributing traits of chili

Traits/ Treatments	Weed population (nos.)	Soil moisture content (%)	Plant height (cm)	Number of structural braches	Number of leaves / plant	Days to flowering	Number of fruit/ plant	Days to first picking	Fruit weight (g)	Fruit length (cm)	Fruiting span (Days)	Yield/ plant (kg)	Yield/ ha (q)
No Mulch	160.13	10.86	66.40	4.75	398.63	72.88	65.75	94.00	15.13	5.74	52.25	0.98	151.29
Bio Mulch	110.38	12.79	74.26	5.88	469.88	69.63	74.88	90.25	17.00	6.14	53.88	1.20	171.20
Plastic Mulch	11.75	15.06	85.58	7.13	593.50	66.13	87.25	87.38	19.50	6.99	56.13	1.43	208.76
C.D.	3.58	2.04	4.18	0.63	48.87	2.74	5.85	4.22	3.39	0.40	2.95	0.17	8.53
SE (m)	1.17	0.67	1.36	0.21	15.96	0.90	1.91	1.38	1.11	0.13	0.96	0.06	2.78

Table 2: Effect of different mulches on economics of chilli

Traits/ Treatments	Cost of Cultivation (Rs.)	Gross Returns (Rs.)	Net Returns (Rs.)	B:C Ratio
No Mulch	52000.00	335500	283500	6.45
Bio Mulch	55000.00	442260	387260	8.04
Plastic Mulch	62000.00	631500	569500	10.19

CONCLUSION

Based on the results from on farm trials at farmers' field, it could be concluded that plastic mulches can prove as a boon to enhance productivity in hills and plateau region of eastern India. Silver- black plastic mulch (double coated 30 micron) had tremendous effects on the growth and yield of chilli with high cost benefit ratio and showed superior performance among the treatments. A favourable soil conditions, water-plant relation is created by placing mulch over the soil surface. The microclimate surrounding the plant and soil is significantly affected by mulch. Mulches (poly mulch and bio mulch) could enhance soil moisture retention, suppress weed growth and enhanced crop yield. Moreover, using silver-black plastic mulch produced more vigorous plant, earlier flowering and fruiting, maximum number of branches, leaves and maximum number of fruits, highest fruit weight and size, earlier picking of marketable fruits, more fruiting days and higher yield as compared to non-mulched treatment. Light and temperature is trapped in polymulch which results increase in temperature of mulching area under plastic plus polymulch has better moisture conservation and availability results better root growth, root expansion and good plant growth. Plots under mulching have reduced labour costs and also less incidence of pests and diseases as compared to plots without mulching. Therefore, the cultivation of chilli using plastic mulch could bring an ample scope to enhanced yield in chilli.

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