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Combination effect of mulch and irrigation schedule on performance of Chilli under drip irrigation condition

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Abstract
The present investigation was carried out during Rabi season of 2017-2018 at the Horticulture complex, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The treatments consisting of two-coloured polyethylene mulch (black, silver/black) and with bare soil (without mulch) as controls. Results showed that soil temperature under the various coloured mulches was 2 to 4˚C warmer compared to bare soil. The highest soil temperature was recorded under black mulch (20.63). The plants grown on silver/black mulch produced Maximum plant heights (48.83 cm.), primary branches/plant (13.74), secondary branches/plant (21.13), early flowering (17.19), fruit length (8.74 cm), Fruit diameter (0.88 cm), average weight of fruit (4.49 g), number of fruits/plant (155.25), fruit yield/plant (744.14 g), Fruit yield per plot (11.82 kg), Ascorbic acid (269.07 mg/100 g), water use efficiency (4.96 kg ha -1 -mm), moisture depletion pattern % and soil temperature under different stages. Under without mulch condition, recorded maximum days taken to 50% flowering (24.58), maximum total soluble solids (2.38 º Brix), weeds fresh weight (41.49 g) and weeds dry weight (11.48 g).In an attempt to reducing chemical input for weed control and increase to yield of chilli black and silver/black plastic mulch may be a good alternative for conventional without mulch.

Keywords: Chilli, mulch: black, silver/black plastic, soil temperature, soil moisture, weed control, growth, fruit yield

Introduction
Chilli (*Capsicum annum* L.) is considered as one of the commercial spice crops. It is the most widely used universal spice, named as wonder spice. Different varieties are cultivated for various uses like vegetable, pickles, spice and condiments. In daily life, chillies are the most important ingredient in many different countries around the world as it adds pungency, taste, flavor and color to the dishes. India is the largest producer, consumer and exporter of chilli and contribute to 25% of total world's production. In India, chilli is grown in almost all the states across the length and breadth of the country. Andhra Pradesh the largest producer of chilli in India, contributes about 30% to the total area under chilli, followed by Karnataka (20%), Maharashtra (15%), Orissa (9%), Tamil Nadu (8%) and other states contributing 18%. In India, it occupies an area of 792 MH with a production of 1376 MT with an average productivity of 1643 kg/ha. (NHB 2015-2016). Madhya Pradesh is the producing Chilli Area 88000 H, production 70000 T and productivity 795 kg/h of Chilli (Anonymous, 2015-16) [1].
Chilli is increasing in its popularity for its pungent fruits and is highest in vitamins A, C, Iron and calcium. Chillies are used in making chilli vinegar, hot oil, tomato sauces, rice dishes, soups, hot condiments such as samber, beans, corn and curry powders. Chillies do well with several other spices including basil, ginger, oregano, cilantro, cinnamon, black pepper, fennel and cumin.
In general, the farmers raise chilli crop by adopting surface method of irrigation without any scientific basis in which appreciable quantity of water is lost due to evaporation and percolation resulting in low application and distribution efficiencies. Mulching is the practice of covering the soil around plants to make conditions more favourable for growth, development and efficient crop production (Nagalakshmi *et al.* 2002) [21]. Mulches are used for the moderation of soil temperature, through the effects were highly variable. Colour of mulch 2 affected soil temperatures. White (or) reflective plastic, decreased temperatures (Unger 1984) [36]. Use of straw and similar material mulches in different vegetable crops have greater insulating effect than pulverized soil mulch. Hot days, soil temperature under straw mulch was reduced as much as 17 °C (30°F) lower than unmulched plots (Yamaguchi, 1983) [38]. Mulches of plant material like straw, dry grass and leaves etc. reduced the soil temperatures (Dhesi *et al.* 1964; Bansal *et al.* 1971) [10].

Black polyethylene inducing soil temperature, more moisture conservation higher soil microbial activity resulting in more mineralization and availability of nutrients to the plant (Patil and Bansod 1972) [25].

Thus keeping all above factor in view the present investigation "Combination effect of mulch and irrigation schedule on performance of Chilli under trickle condition (*Capsicum annum* L.)*"*

Review of Literature

The literature on the effect of mulching and irrigation levels on chilli crop is scanty. Therefore, the information on other vegetable crops of Solanaceae family and other vegetable crops is reviewed and presented here under the following headings.

Effect of mulching and irrigation on growth

Goldberg (1971) [14] reported that the trickle irrigation method encourages the development of a shallow root system, as observed in pepper and other crops and this emphasizes the need for uniform distribution of water and nutrients. The concentration of soluble salts is high near the soil surface and especially at the midpoint between adjacent nozzles. This concentration will gradually increase if the salt content of the soil (or) water is high, and if the wetting fronts between the 2 nozzles meet at a greater depth.

Patil and Basad (1972) [25] reported that mulch regulates soil temperature, creates suitable condition for germination, improves soil moisture, suppresses weed growth, saves labour cost in tomato.

Beese *et al.* (1982) [7] conducted an experiment to determine growth and development bell pepper when irrigated by trickle irrigation at different levels of water application. Water application rates of 0.8, 1.2 and 1.4 times the control treatment were maintained, the results indicated that limiting the water applied to pepper during the period of rapid vegetative growth reduced the final yield. However, the water use efficiencies varied little were between 8.1 and 8.2 cm actual ET per tonnes of dry mass production.

Ayoub (1986) reported that 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.

Reddy *et al. (*1990) [30] conducted an experiment to study the performance of drip, furrow and check basin methods of irrigation under cauliflower production. The experimental field was divided into three blocks, each block having a particular irrigation method i.e. drip, furrow and check basin methods of irrigation. Drip irrigation resulted into 40 to 65 per cent saving of water. The field water use and consumptive use efficiency were found maximum in drip irrigation. The increase in yield of cauliflower under drip method was 48 per cent over furrow and check basin.

Duraisamy *et al.* (1992) [11] reported that the fruit yield was highest in the surface irrigation treatment (T1) i.e., 5 cm depth of water by surface irrigation at 1.0 IW/CPE ratio : the WUE was higher in sprinkler treatments T3 (3.75 cm depth of water through sprinkler irrigation at 0.75 IW/CPE ratio T4 (2.50 cm depth of water through sprinkler irrigation at 0.5 IW/CPE ratio) significantly higher fruit yield than was than T4 through sprinkler, 21% of irrigation water can be saved compared to surface irrigation in tomato.

Effect of mulching and irrigation on yield

Duraisamy *et al.* (1992) [11] reported that the fruit yield was highest in the surface irrigation treatment (T1) i.e., 5 cm depth of water by surface irrigation at 1.0 IW/CPE ratio : the WUE was higher in sprinkler treatments T3 (3.75 cm depth of water through sprinkler irrigation at 0.75 IW/CPE ratio T4 (2.50 cm depth of water through sprinkler irrigation at 0.5 IW/CPE ratio) significantly higher fruit yield than was than T4 through sprinkler, 21% of irrigation water can be saved compared to surface irrigation in tomato.

Mulching effectively manipulates crop growing environment leading to increased yield and improved product quality by suppressing weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Opara-Nadi, 1993; Hochmuth *et al.*, 2001; Awodoyin and Ogunyemi, 2005) [23, 16, 6].

Lourduraj *et al.* (1997) [18] found that mulching significantly increased okra yield, particularly the plastic mulch. Irrigation at IW/CPE ratio of 0.6 was the best irrigation regime to promote yield. The black plastic mulch was very effective in controlling weeds and increased net seasonal income by Rs. 14300/ha as compared with the unmulched control.

Chandra *et al* (2002) [9] found that potato yield increased with the use of mulches. Tuber weight was 0.23 kg per plant for no mulch but increased to 0.29 kg per plant when pine mulch was used. Similarly, number of tubers per plant increased to 6.5 from 5.4 with the use of pine mulch. Total yield was 165.0 q/ha for no mulch and 222.7 q/ha for pine mulching.

Nijamudeen and Dharamasena (2002) [22] reported a 32% increase in yield and 28% lower water consumption in chilli due to the application of mulch.

Alemayehu-Ambaye and Joseph (2002) [3] reported the significant influence of black LDPE mulch on increasing soil moisture retention, growth and yield of cucumber. Drip irrigations with 100 and 125% EP were superior to the lower levels of EP as well as farmer's practice of basin irrigation once in three days with 45 litres of water. Depending on the availability of water for irrigation, the cultivator was opt either 100 or 125% of EP for scheduling drip irrigation.

Sannigrahi and Borah (2002) [31] reported that mulching increased the number of tomato fruits per plant and had higher crop yield than the control. Water hyacinth mulch gave the highest increase in tomato yield (91%). The plant height, pod length and green pod weight of mulch-treated Okra were at par with those of the control. Maximum okra yield was recorded with black polyethylene mulch (121.2 q/ha) treatments, followed by water hyacinth (107.1 q/ha) and poultry waste (101.3 q/ha). Black polyethylene mulch increased Okra yield by 88% water hyacinth by 67%, poultry waste by 57%, spent straw by 53%, and rice straw by 41%. Stem yield (crop waste) after final harvesting was also higher with mulching than with no mulching. The rate of weed emergence was higher in Okra than in tomato plots, while black polyethylene mulch was the most effective treatment for weed control (83.5%).

Among various factors responsible for higher onion seed yield, the quantity of irrigation and fertilizer plays a pivotal role in enhancing the growth and productivity (Aklilu and Kataria, 2003; Pathak and Gowda, 1994; Tomar *et al*., 2004) [2, 26].

Ertek *et al*. (2004) [11] Reported that the optimum water quantity must be applied during the different crop growth periods in order to obtain a higher pepper yield.
Ertek *et al*. (2007) [13] Stated that the knowledge of water consumption in plants and the periods during which plants are susceptible to a lack of water, in addition to the irrigation intervals, is needed to increase crop yield.
Mahajan *et al* (2006) [19] conducted that a field experiment was conducted by in Ludhiana, Punjab on weed control in red chilli in relation to use of back polythene and rice straw mulch. All the weed control treatments showed significant effect on weeds in terms of dry matter accumulation by weeds and caused significant improvement in yield of red chilli. Black polyethylene mulch provided good weed control and resulted in the highest yield (241.9 q/ha), followed by sole plastic mulching treatment (219.4 q/ha). The un-effected weeded control treatment registered only 30.2 q/ha red chilli yield.
Moniruzzaman *et al.* (2007) [30] studied the effects of irrigation and different mulches on yield of cauliflower. (A field experiment on cauliflower var. Rupa) was conducted in two consecutive seasons (2000-01 and 2001-02) on sandy clay loam soil at the Agricultural Research Station, Raikhali, Rangamati Hill District. The intervals of irrigation were at 7, 14 and 21 days alone with five levels of mulching (non mulch, plastic mulch, rice straw mulch, sun grass mulch and mango leaves mulch). Irrigation at 7 days interval and plastic mulch independently as well as in combination produced maximum values for yield attributes and marketable yield of cauliflower. The highest curd yield of 30.38 and 29.40 t/ha were obtained from 7 days irrigation interval with plastic mulch respectively. Seven days interval irrigation and mulching with forest leaves (mango leaves) in combination gave the highest benefit cost ratio (6.51) closely followed by 14 days interval irrigation with the same mulch (6.48).
Vankar and Shinde (2007) [37] reported that white polythene mulch treatment recorded statistically higher yield of fruit (22.06t/ha), leaves and stem dry matter, number of fruits per plant, weight of fruits per plant, length of fruit and total biomass production in Okra than black, straw and no mulch treatments.
Gordon *et al* (2008) [15] conducted an experiment in which summer squash (*Cucurbita pepo* L.) cv. Prelude II, was grown on an Orangeburg sandy loam soil at Auburn. The summer squash was direct seeded in single rows. The experiment consisted of 12 treatments including: black plastic mulch in combination with spun bonded row cover, black polythene mulch alone, white plastic mulch in combination with row cover, White polythene mulch alone, red plastic mulch in combination with row cover, red plastic mulch alone, bare soil in combination with row cover, bare soil alone, silver plastic mulch in combination with row cover, silver plastic mulch alone, blue plastic mulch in combination with row cover and blue plastic mulch alone. Mulch colour x row cover interaction affected yield variables. Coloured plastic mulch with or without row covers increased early fruit yield in summer squash.
Rajablariani *et al*. (2010) [28] Studied the effect of polyethylene mulch films and bare soil on tomato evaluate and the effect of colored plastic mulches on weed and crop yield. The plastic mulches were blue, black, clear, red and silver on black coloured. Black and silver/black plastic mulches suppressed weeds which were encouraged under clear, blue and red mulches. Results also indicated that soil temperature increased under the various colored plastic mulches about 3 to 6 °C more than in bare soil. Number of branches and leaves were better for the plants grown in plastic mulch compared to bare soil. The highest early yield was obtained in clear plastic likely due to light entrance and raising soil temperature. Mulching increased marketable yield relative to bare soil as the plants grown on silver/black plastic mulch indicated a 65% increasing in marketable mulch compared to control treatment. The plastic mulches resulted in an 84-98% reduction in weed biomass.
Singh *et al.* (2010) [34] recorded that the plant height was improved by using the mulches. Weed density was always lower in plots having mulches and the plots sprayed with pendimethalin 30 EC or hand weeding. Pod length and pod diameter were often higher in mulch treated plots. Both black plastic mulch and wheat straw mulch were found to be helpful in conserving the moisture, controlling of weeds and produced higher yield.

Effect of mulching and irrigation on growth and yield
Sannigrahi and Borah (2002) [31] observed that the plant height, pod length and green pod weight of mulch-treated okra were on par with those of the control. Maximum okra yield was recorded with black polythene mulch (121.2q/ha) followed by water hyacinth (107.1q/h) and poultry waste (101.3q/ha). Black polythene mulch increased okra yield by 88%, water hyacinth 67% and poultry waste 57%, spent straw 53% and rice straw 41% stem yield (crop waste) after final harvesting with mulching than no mulch control.
Antony and Singandhupe (2004) [4] studied the effect of different irrigation methods and schedules on morphological, yield and water use efficiency of capsicum (*Capsicum annum* L.) var. California Wonder. They found that the plants grown under drip irrigation had more number of branches and plant heights compared to that of surface irrigated plants. Root mass was more in surface irrigated crop where as total root length was more in drip irrigated crop.
Salim *et al*. (2008) [32] studied the response of cauliflower to polyethylene mulch. The study was evaluated from September, 2003 to January, 2004 at Regional Agricultural Research Station (RARS), Ishurdi, Pabna to find out whether polyethylene mulch is suitable or not for cauliflower production in Bangladesh in Snow crown variety. The experimental design was Randomized Complete Block Design with 3 replications. The plot size was 9 m x 1.2 m. Fertilizer application was done at a dose of N (120), P205 (80) and K20 (100) kg/ha. Resulted a positive impact of mulch on growth and yield attributes of the crop varieties. The tallest plant (57.40 cm) was observed in snow crown variety in mulched condition and the shortest plant (38.90 cm) was observed in plots without mulch. It was also observed that mulching significantly influenced the curd diameter. In all the cases, curd diameter was higher (18.10 cm) in mulched plots and smallest (12.31) in plots without mulch. The highest marketable yield (31-32 t/ha) was obtained. The highest marketable yield was 35.16 per cent higher than those yields obtained from treatments without mulch.
Rathore (2009) [29] studied the optimization of nitrogen application and irrigation schedules in tuberose (*Polianthes tuberosa*). The study showed that irrigation applied at 0.8 IW/CPE ratio increased the number of florets per spike and bulb yield by 23 and 22 per cent over the control (flood irrigation) and by 30 and 44 per cent, respectively, compared to the treatment receiving minimum water at 0.4 IW/CPE. Water productivity based on consumptive use, irrigation water and total water applied through irrigation and rainfall

significantly improved the vegetative growth, spike and bulb yield with increasing ratio of water application from 0.4 to 0.8 IW/CPE ratio but failed to increase beyond 0.8 IW/CPE ratio which indicated that water application beyond 0.8 IW/CPE ratio is not being utilized the crop.

Ashrafuzzaman *et al*. (2011) [5] observed the Effect of plastic mulch on growth and yield of Chilli. Different mulches generated higher soil temperature and soil moisture under mulch over the control. Transparent and blue plastic mulches encouraged weed population which were suppressed under black plastic. Plant height, number of primary branches, stem base diameter, number of leaves and yield were better for the plants on plastic mulch. At the mature green stage, fruits had the highest vitamin-C content in the black plastic. Mulching produced the fruits with the highest chlorophyll-a, chlorophyll-b and total chlorophyll contents and also increased the number of fruits per plant and yield. However, mulching did not affect the length and diameter of the fruits and number of seeds per fruit. Plants on black plastic mulch had the maximum number of fruits and highest yield.

Effect of mulching and irrigation on quality

Irrigation, mulching and fertilizer nitrogen (N) rates are known to affect quality parameters (ascorbic acid and capsaicin content) of chilli fruit. Besides improvement in soil hydrothermal regime, mulching is known to check weed growth and thus, improve crop growth, yield and water use efficiency (Barker and Bhowmik 2001, Panchal *et al*.

Kirnak *et al* (2003) [17] observed that, use of polyethylene mulch mitigates effects of water stress, improves bell pepper yield and fruit of plants grown with black mulch had a thicker pericarp compared with plants grown in bare soil. When green infrared transmitted (IRT) mulch was used, plants produced significantly wider fruit (5%) with 13% more TSS compared with plants grown in bare soil.

Patel and Patel (2011) [27] recorded that significantly the highest pod yield (207.96 q/ha) was recorded under drip irrigation at 0.8 PEF and were higher 46.25% with 30.48 kg/ha-mm water use efficiency (WUE). Among mulching, black polyethylene mulch recorded significantly the highest plant height (110.71 cm), LAI (1.453), dry matter accumulation (68.94 g/plant), CGR,

(5.551 g/day/m2) and total chlorophyll content (10.75 mg/g) and was followed by organic mulch, while the lowest values were observed under no mulch treatment. Black polyethylene mulch increased pod yield by 29.65% over no mulch. N-fertigation @ 100% recommended dose was found significantly superior to 70% recommended dose and recorded higher values of all the growth parameters and registered higher pod yield of okra (169.72 q/ha).

Effect of mulching and irrigation on soil temperature

Sandal and Acharya (1997) [33] observed during 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. Mulching with plastic is a method by which soil moisture can be conserved.

Tiwari *et al*. (1997) [35] reported that trapping dry and moist soils with different colour plastic mulches resulted in a significant increase in soil temperature. The highest temperature was under red plastic mulches closely followed by under transparent mulch. Black plastic sheet had the least effect on increase in soil temperature.

Mohammed and Mamkagh (2009) reported that in Okra the soil moisture content (SMC) varied among the experimental treatments. At 30 and 60 days after planting, there was a significant interaction between tillage time and mulching for SMC at 30 cm depth. Bare plots (non-mulched plots) had the lowest SMC than black plastic mulched (BP mulch) plots. After 30 days of planting the highest SMC (25.94) was recorded in plots tilled three times (T1) and covered with BP mulch followed by plots tilled two times (T2) and covered with BP mulch (23.27). At 60 days after planting, SMC was significantly highest, when plots covered with BP mulch regardless of tillage times. In general, SMC at 90 and 120 days after planting were not significantly affected by different treatment combinations.

Conclusion

On the basis of Review investigation, it is concluded that the chilli responded well in terms of morphological, phonological, yield attributing character and quality parameters. Maximum yield the chilli crop can be drip irrigated at 0.8IW/CPE ratio.

Higher water productivity and yield can be obtained by application of silver/ black polythene mulch. To get maximum net profits, the chilli crop can be safely irrigated at 0.8 IW/CPE ratio with application of silver polythene mulch.

Suggestions for future work

On the basis of present investigation, the following suggestions are made for future line of work.

1. The present experiment should be repeated for two or three years to know the consistency of treatment effects.
2. Study should be conducted on scheduling of irrigation under constrains of irrigation water.
3. There is a need to conduct long-term investigation to ascertain the benefits of mulches on yield and quality of chilli and also its impact on physical, chemical and biological properties of soil.
4. Effect of mulching on temperature modulation, pest and disease changes, nutrient mineralization may be studied.

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