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Short Communication

Evaluation of non-chemical weed management practices in chilli (*Capsicum annuum* L.)

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Abstract

An experiment was conducted at the Department of Agronomy, College of Agriculture, Thrissur, Kerala from June 2020 to September 2020 (*Kharif*) with the objective of evaluating non-chemical methods of weed management in chilli. Six different techniques including stale seed bed methods, mulching and hand weeding were evaluated against a weedy check in randomized block design replicated thrice. Black polythene mulch recorded the highest weed control efficiency and the lowest weed density, weed dry matter production and weed index, followed by straw mulch when applied alone and when followed by one hand weeding. At all stages of observation, chilli plants in polythene mulching were found to be the tallest, followed by straw mulching when done alone and when followed by one hand weeding. Chilli plants in polythene mulching recorded the highest number of fruits per plant (218) and fruit yield (22.44 t/ha), followed by straw mulching both when done alone (182 nos. and 18.89 t/ha respectively) and when followed by one hand weeding (177 nos. and 18.38 t/ha respectively). The organic carbon content in soil was highest in polythene mulching at 60 DAT and after the final harvest. At both stages of observation, straw mulching had highest values of available P and K, whereas available N was found higher in black polythene mulch at 60 DAT and in stale seed bed followed by one hand weeding after the final harvest. Black polythene mulch recorded the highest B:C ratio (1.84) and was followed by straw mulching (1.42).

Keywords: Black polythene mulch, Chilli fruit yield, Stale seed bed, Straw mulch.

One of the major problems in any crop production system is weed infestation, which causes reduction in both the yield and quality of produce. Although the use of herbicides provides effective and sustained weed control, it is not a preferred option because of environmental concerns (Tabaglio et al., 2008). The problems created by chemical herbicides include environmental pollution, herbicide residue and development of herbicide resistant weeds. Kropff and Walter (2000) reported that the overuse of chemical herbicides resulted in environmental issues because herbicides had negative effects on non-target organisms, could cause pollution to food and ground water with their residues, and resulted in mammalian toxicity. This is particularly true in the case of vegetables, some of which are consumed either partially cooked or raw. Hence non-chemical methods of weed control are gaining popularity among the vegetable farmers nowadays.

Non-chemical methods include all management practices to control weeds except the use of herbicides. The stale seed bed or false seed bed, with the principle of flushing out germinable weed seeds before cropping, in which soil cultivation may take place days or weeks before planting or transplanting a crop (Johnson and Mullinix, 1995) is one such technique. Mulching with loose

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materials like straw, bark and composted municipal green waste can provide effective weed control. A cut ryegrass (*Lolium* spp) mulch spread between planted rows of tomatoes (*Lycopersicon esculentum*) and peppers (*Capsicum annuum* L.) was more economic than cultivation in unmulched plots (Edwards et al., 1995).The use of polythene mulches was also found to be very effective in controlling weeds and increasing crop yields. Ashrafuzzaman et al. (2011) found that the use of black plastic mulch resulted in highest weed control efficiency and fruit yield in chilli as compared to other mulches.

Weed infestation reduces economic yield in chilli by 60 to 70 per cent (Patel et al., 2004). An efficient weed management strategy is essential to make chilli cultivation profitable. In this background, a study was conducted to evaluate various non-chemical methods for effective management of weeds in chilli. In addition to polythene mulching, the methods included straw mulching and stale seed bed technique, which were combined with manual removal of weeds at fixed intervals.

The field experiment was conducted from June 2020 to September 2020 (*Kharif* season), at Agronomy Farm, College of Agriculture, Vellanikkara, located at 10° 31' N latitude and 76°13' E longitude, at an altitude of 40.3 m above mean sea level. Warm humid climate is experienced in this region. The soil was acidic (pH 5.2) with sandy loam texture. The available N content of soil was 189 kg/ha, available P, 51 kg/ha and available K, 438 kg/ha. The treatments included T1: stale seed bed for 14 days followed by shallow digging and planting of chilli, followed by two hand weedings at 30 and 60 days after transplanting, T2: stale seed bed for 14 days followed by shallow digging and planting of chilli, followed by one hand weeding at 45 days after transplanting, T3: black polythene mulch, T4: straw mulch at 7.5 t/ha applied twice, at planting and one month after planting, T5: straw mulch at 7.5 t/ha applied twice, at planting and one month after planting followed by one hand weeding at 60 days after transplanting, T6: hand weeding at 30 and 60 days after transplanting and T7: unweeded control. The experiment was laid out in completely randomized block design with three replications. Anugraha, a high yielding, early maturing and bacterial wilt resistant chilli variety, was used in the experiment. The field was cleared, ploughed with a tractor and then leveled. The experiment was laid out and raised beds of length 3.6 m, width 2.25 m and height 30 cm were formed. Lime at the rate of 250 kg/ha was applied two weeks before transplanting, and farmyard manure was applied at the rate of 20 t/ha one week before transplanting.

In the treatments involving stale seed beds (T1 and T2), the beds were prepared two weeks before transplanting, and weeds were allowed to germinate. After 14 days, all the emerged weeds were removed by shallow digging and hoeing. Three treatments included mulching, one with black polythene mulch and the other two with straw mulch. Black polythene of 30 microns thickness was used for mulching in T3. Holes of approximately 5cm diameter at a spacing of 45 cm x 45 cm were made in the sheet to facilitate transplanting of chilli seedlings. Mulching with paddy straw at 7.5 t/ha was done in two splits, half at the time of planting and half one month after planting.

One-month old chilli seedlings were transplanted in the main field at a spacing of 45 cm x 45 cm. Gap filling was done one week after transplanting in order to maintain the plant population. The recommended dose of N,P_2O_5 and K_2O for chilli (75:40:25 kg per hectare) was applied with the fertilizers urea, Rajphos and muriate of potash. Half N, P and half K were applied basally, one fourth of N and half of K at 30, and the remaining one fourth N at 60 DAT.

Observations were recorded on weed dry matter production at 30, 60 and 90 DAT, number of chilli fruits per plant and chilli yield, and soil was analysed for pH, EC, organic carbon, available N,P,K post-harvest of chilli. Efficiency of the weed management methods was assessed in terms of the weed control efficiency and weed index.

Broad leaf weeds dominated in the field and the major weeds were *Borreria hispida*, *Cleome burmanii*, *Cleome monophylla*, *Lindernia crustacea* and *Scoparia dulcis*. Other minor weeds were *Alternanthera bettzickiana, Ludwigia perennis, Ageratum conyzoides, Phyllanthus amara, Sida acuta, Mollugo disticha* and *Catharanthus pusillus.* Grass weed species observed were *Eleusine indica*, *Panicum maximum, Echinochloa colona, Eragrostis tenella, Digitaria ciliaris* and *Pennisetum pedicellatum*, whereas *Cyperus rotundus* and *Kyllinga monocephala* were the sedges observed in the experimental field.

At all stages of observation, the black polythene mulch recorded the highest weed control efficiency (96 %, 99 % and 99 % at 30, 60 and 90 DAT respectively) and the lowest weed dry matter production and weed index (Table 1) when compared to the other non-chemical weed management practices. Lament (1993) claimed that the soil temperatures under black plastic mulch during the daytime were generally 2.8°C higher at a depth of 5 cm and 1.7°C higher at 10 cm depth compared to that of bare soil. This property of black plastic mulch could reduce weed emergence. According to Narayan et al. (2017), black polythene mulch of 30 micron thickness (double coated) recorded lower weed density compared to paddy straw mulch. Similar results were documented by Chandran and Nelson (2018) in organically grown chilli with plastic mulch. Straw mulch, both when applied alone and when followed by a hand weeding at 60 DAT, controlled weeds effectively but not to the extent of polythene mulch. The weed suppression effect noted in straw mulch was in accordance with the reports of Sekhon et al. (2008). In the present study, stale seed bed was significantly inferior in reducing weed infestation and therefore recorded higher weed dry matter production as well as weed indices.

The plants were the tallest in polythene mulched plots at all stages of observation (Table 2) and also recorded maximum number of branches per plant. Vibhute and Singh (2019) had reported maximum

Table 1. Weed dry matter production, weed control efficiency and weed index as influenced by non-chemical weed management practices

Treatments	Weed dry matter production (g/m^2)			Weed Control Efficiency (%)			Weed index (%)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	
T1: Stale seed bed followed by two hand weedings at 30 DAT and 60 DAT	*5.24^{d} (27.50)	15.67^{b} (245.66)	13.82^{c} (191.00)	57.05	74.88	78.44	45.07
T2: Stale seed bed followed by one hand weeding at 45 DAT	5.65^{c} (31.97)	6.00^{d} (36.03)	14.71^{b} (216.53)	50.07	96.31	75.56	57.51
T3: Black polythene mulch	1.62^{g} (2.63)	2.80^{e} (7.86)	3.07^{g} (9.46)	95.89	99.19	98.93	0.00
T4: Straw mulch	2.88^{f} (8.33)	12.03^{c} (144.66)	12.08^{e} (146.00)	86.99	85.20	83.52	15.81
T5: Straw mulchfollowed by one hand weedingat 60 DAT	3.15^{e} (9.96)	12.08^{c} (146.00)	10.01^{f} (100.33)	84.44	85.07	88.67	18.08
T6: Hand weeding at 30 and 60 DAT	7.28^{b} (53.13)	12.59^{c} (158.66)	13.28^{d} (176.33)	17.02	83.77	80.10	40.43
T7: Unweeded control	8.00^{a} (64.03)	31.24^{a} (978.00)	29.77^{a} (886.30)	0.00	0.00	0.00	93.55
CD (0.05)	0.18 (2.23)	1.23 (73.72)	0.33 (9.20)				
S E(m)	0.06 (0.72)	0.39 (23.92)	0.10 (2.99)				

* $\sqrt{x+0.5}$ transformed values, original values in parantheses. In a column, means followed by common letters donot differ significantly at 5 % level in DMRT. DAT-Days after transplanting

Table 2. Yield, growth and B:C ratio of chilli as influenced by non-chemical weed management practices

Treatments	No. of fruits/plant	Plant height(cm) 30 DAT	60 DAT	90 DAT	Number of branches per plant 30 DAT	60 DAT	90 DAT	Fruit yield (t/ha)	B:C ratio
T1: Stale seed bed followed by two hand weedings at 30 DAT and 60 DAT	*117[c]	*15.67[c]	41.83[c]	12.33[c]	*2[b]	5a	5a	12.33[c]	1.01
T2: Stale seed bed followed by one hand weeding at 45 DAT	92[d]	15.33[c]	36.30[d]	9.53[d]	2b	3b	3b	9.53[d]	0.80
T3: Black polythene mulch	218[a]	20.33[a]	57.80[a]	22.44[a]	4a	5a	5a	22.44[a]	1.84
T4: Straw mulch	182[b]	17.53[b]	50.93[b]	18.89[b]	3ab	4ab	4ab	18.89[b]	1.42
T5:Straw mulch followed by one hand weeding at 60 DAT	177[b]	17.57[b]	51.20[b]	18.38[b]	3ab	4ab	4ab	18.38[b]	1.34
T6: Hand weeding at 30 and 60 DAT	120[c]	15.90[bc]	44.06[c]	13.37[c]	2b	5a	5a	13.37[c]	1.09
T7: Unweeded control	14[e]	12.26[d]	33.70[d]	1.44[e]	—	1c	1c	1.44[e]	0.12
CD (0.05)	9.68	1.73	4.79	1.25	1.14	1.27	1.19	1.25	
SE (m)	3.14	0.56	1.55	0.41	0.36	0.41	0.38	0.41	

* In a column, means followed by common letters donot differ significantly at 5% level in DMRT. DAT-Days after transplanting

plant height and number of primary branches in chilli when grown with black polythene mulch (25-micron) and drip fertigation at 125 per cent RDF. Ashrafuzzaman et al. (2011) also reported similar findings and stated that plastic mulches had positive effect on the growth and development of chilli. They also added that the highest number of branches per plant in chilli was observed in black plastic mulch, followed by blue and transparent plastic mulch. With respect to plant height, polythene mulching was followed by straw mulching both when done alone and when followed by a hand weeding, both of which were on par. All other treatments recorded lower values of plant height than polythene and straw mulching.

It was noticed that chilli plants in polythene mulching recorded significantly higher number of fruits per plant (218) and fruit yield (22.44 t/ha) (Table 2) which was followed by straw mulching when done alone (number of fruits/plant-182, fruit yield-18.89 t/ha) and when followed by one hand weeding (number of fruits/plant-177, fruit yield-18.38 t/ha). The yields of the two treatments with straw mulching were on par and significantly lower than polythene mulching. The yield in the treatment hand weeding at 30 and 60 DAT was 13.37 t/ha with 120 fruits per plant and in stale seed bed followed by two hand weedings was 12.33 t/ha with 117 fruits per plant, both of which were on par. The treatment stale seed bed followed by a hand weeding (fruit yield-9.53 t/ha, number of fruits/plant-92) had a lower yield than stale seed bed followed by two hand weedings. The lowest yield of chilli among all the treatments was recorded for the unweeded control (fruit yield-1.44 t/ha, number of fruits per plant-14).

The highest yield in polythene mulch could be linked to the weed-free situation prevailing in polythene mulching along with the improved soil physico-chemical properties. According to Ashrafuzzaman et al. (2011), plants on black plastic mulch had the highest number of fruits and highest yield. Black polythene mulch of 30-micron thickness (double coated) recorded highest number of fruits per plant (140/plant) and total fruit yield (463.08 q/ha) when compared with paddy straw mulch (Narayan et al., 2017). Moisture conservation, high yield, maximum water and fertilizer use efficiency and higher weed control were the benefits of black plastic mulch with drip fertigation (Vibhute and Singh, 2019). Fan et al. (2017) stated that besides controlling weeds, application of plastic mulches also accelerated plant growth, resulted in earlier crop maturity, improved crop biomass, yield and water use efficiency. Filipovic et al. (2016) also reported that black plastic mulches could enhance the number of fruits and flowers of bell pepper. Bhardwaj et al. (2018)

Table 3. Soil characteristics/properties as influenced by non-chemical weed management practices

Treatments	pH		Organic carbon (%)		Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	At 60 DAT	After final harvest	At 60 DAT	After final harvest	At 60 DAT	After final harvest	At 60 DAT	After final harvest	At 60 DAT	After final harvest
T1: Stale seed bed followed by two hand weedings at 30 DAT and 60DAT	*5.70^{a}	5.73^{a}	1.23^{d}	1.16^{de}		202.26^{d}	65.11^{de}	62.07^{e}	266.93^{d}	259.10^{e}
T2: Stale seed bed followed by one hand weeding at 45 DAT	5.26^{c}	5.26^{b}	1.34^{b}	1.14^{e}	239.16^{b}	238.86^{a}	63.87^{e}	63.57^{d}	365.33^{c}	364.00^{c}
T3: Blackp olythene mulch	5.53^{b}	5.63^{a}	1.45^{a}	1.49^{a}	247.40^{a}	238.23^{a}	73.14^{b}	72.96^{b}	396.83^{b}	394.60^{b}
T4: Straw mulch	5.26^{c}	5.23^{b}	1.25^{c}	1.33^{b}	226.13^{d}	219.26^{c}	76.51^{a}	79.17^{a}	413.70^{a}	408.13^{a}
T5:Straw mulch followed by one hand weeding at 60 DAT	5.23^{c}	4.96^{c}	1.15^{f}	1.24^{c}	246.16^{a}	232.26^{b}	68.87^{c}	68.58^{c}	365.63^{c}	357.03^{d}
T6: Hand weeding at 30 and 60 DAT	5.26^{c}	5.26^{b}	1.18^{e}	1.18^{d}	229.36^{c}	219.33^{c}	65.90^{d}	64.56^{d}	249.30^{e}	244.13^{f}
T7: Unweeded control	5.43^{b}	5.26^{b}	1.01^{g}	0.98^{f}	195.63^{f}	198.30^{e}	50.11^{f}	50.04^{f}	227.83^{f}	224.53^{g}
CD(0.05)	0.12	0.13	0.01	0.02	1.74	0.91	1.91	1.19	2.84	1.92
SE(m)	0.04	0.04	_	_	0.56	0.29	0.62	0.39	0.92	0.29
Pre-experimental condition	5.20		1.36		189.00		51.23		438.50	

* In a column, means followed by common letters donot differ significantly at 5% level in DMRT. DAT- Days after transplanting

claimed that chilli grown on raised beds with 100 microns Linear Low Density Poly Ethylene plastic mulch and drip irrigation recorded highest fruit set (38.47 per cent), length of fresh fruit (12.56 cm), diameter of fruit (3.52 cm) and fresh weight of fruit (8.42 g).

Polythene mulching was followed by straw mulching both when done alone and when followed by one hand weeding in terms of yield of chilli. Sekhon et al. (2008) observed that when chilli was grown in straw mulch, the yield increased and it might have been due to the decreased day time soil temperature and increased moisture retention capacity of soil. Hand weeding and stale seed bed treatments recorded significantly lower yield than polythene and straw mulched plots. The lowest chilli yield was obtained from the unweeded control.

Soil chemical characteristics were assessed and it was found that while there was an increase in pH of soil at 60 DAT and after the final harvest, decreases were also seen in some treatments (Table 3). The content of organic carbon in the soil was higher in polythene mulching at 60 DAT (1.45 %) and after the final harvest (1.49 %). Available N was found higher in black polythene mulch at 60 DAT. Plastic mulch improved soil fertility by reducing exhaustion risk of nitrogen and organic carbon present in the soil (Liu et al., 2015). Available P and K contents were higher in straw mulched plots, followed by polythene mulched plots. According to Grassbaugh et al. (2004), mulching with organic materials such as paddy straw could improve physical, chemical and biological properties of soil. The higher values of nitrogen and organic carbon in the polythene mulched plots, together with lower competition from weeds could be linked to the higher yield in polythene mulching.

Black polythene mulching recorded highest B:C ratio (1. 84) which was followed by straw mulching (1.42) and straw mulching followed by one hand weeding (1.34) (Table 2) which can be ascribed to the higher fruit yields realized in these treatments. All the treatments except stale seed bed followed by one hand weeding and unweeded control recorded B:C ratios greater than one. Unweeded control recorded the lowest B:C ratio (0.12).

It could be concluded that black polythene mulching and straw mulching were the best non-chemical methods for reducing weed dry matter production and increasing fruit yield and B:C ratio in chilli.

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