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Weed Management Efficacy of Mulches, Planting Methods and NAA Application in *Capsicum annuum* L. under Mid Hills of Himachal Pradesh

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ABSTRACT

Background: Sweet pepper is one of the most popular vegetables cultivated worldwide, which yield and quality is highly affected by weeds. Synthetic mulches and raised beds are a part of a wide strategy of integrated weed management in vegetable production systems.

Methods: A field experiment was carried out in Dr YSP UHF, Nauni, Solan (HP) for two years to evaluate the effect of polythene mulches, planting on raised beds (RB) and Naphthalene acetic acid (NAA) application on weed management and yield of sweet pepper (*Capsicum annuum* L.) crop.

Result: The interaction effect of raised bed (RB) + black polythene mulch (BPM) + NAA has recorded less weed density, greater weed control efficiency (64.12%) and lower dry weed biomass (117.83 g/m^2). However, highest yield (38.47 t/ha) of sweet pepper was recorded with raised bed (RB) + silver polythene mulch (SPM) + Naphthaleneacetic acid (NAA).

Key words: *Capsicum annuum* L., Mulching, Naphthalene acetic acid (NAA), Sweet pepper crop, Weed management.

INTRODUCTION

The sweet pepper (Capsicum *annuum* L.), also known as bell pepper, pepper, or capsicum, is one of the most delicious vegetables which consumed throughout the world as fresh in salad and culinary purpose also due to its great taste and appearance (Akinfasoye *et al*. 2006). It belongs to the nightshade *i.e*., Solanaceae family. Sweet pepper is assuming importance in human diet since it is rich in vitamins like A, C, E, B_1, B_2, D and minerals (Muhamman and Auwalu, 2008). However, there are several biotic and abiotic stresses which diminish its quality and yield. Weeds are major biotic factors that cause great yield loss of sweet pepper (Chaudhari *et al*. 2019). Estimates have shown that the yield of vegetables can be reduced by 45% to 95% due to crop-weed competition (Mennan *et al*. 2020). The emergence of weeds is very fast and they grow rapidly competing with the crop for growth resources *viz*., moisture, nutrients, sunlight and space during the entire vegetative and early stages of *C. annuum* (Hajebi *et al*. 2015). Weeds not only reduce the yield of vegetables but also decrease their quality and market value (Brown *et al*. 2019).

Weed control using herbicides has been an economical option in conventional vegetable production systems because it provides effective and sustainable weed control (Chauhan, 2020). However, overuse of herbicides causes environmental concerns owing to their possible negative effects on beneficial organisms (Wallia *et al*. 2006) and residual toxicity (Kropff and Walter, 2000). There has been a greater interest in non-chemical weed control after people became more aware of the damage caused by the misuse of herbicides (Jabran and Chauhan 2018). Besides chemical methods of weed management, weeds can be controlled using mechanical or other methods such as mulching and using different planting techniques (Bahadur *et al*. 2013).

Mulching is a simple and valuable technique that can be used to control weeds, save time and reduce labor. Mulching suppresses weed development by obscuration and suffocation. The probable reason could be that it might create partially anaerobic conditions for the survival of weed species and thus finally resulting in very low weed population (Bhullar *et al*. 2015). Mulching is viewed as fundamental in rainfed smallholder cultivation because of the several benefits they provide to the rhizosphere (Sangakkara *et al*. 2004). Black and infrared transmissible (IRT) plastic mulch provided almost 100% control of weed grasses. Mulching favors the

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reduction of evaporation leading to higher soil moisture content and reduction in weed growth which overall increase crop yield (Samtani *et al.* 2017).

Raised bed planting system has many benefits like water savings (up to 30%) combined with enhanced water use efficiency, improvement in soil physical property, nitrogen use efficiency, better utilization of sunlight, low crop-weed completion and ultimately enhancement in crop yield (Kumar *et al*. 2010). Raised bed planting had a maximum reduction in weed biomass than a flat-bed because in this method water was applied in furrows only and the rest of the area was always dry which did not permit much weed growth, so less interference of weeds in crop growth increases the yield (Bahadur *et al*. 2013).

Flower and fruit drop are considered as major constraints in the production of sweet pepper which is caused by physiological and hormonal imbalance particularly under unfavorable environments (Erickson and Makhart, 2001). Naphthalene acetic acid was found effective in increasing fruit set and is also used in reducing pre-harvest fruit drop and resulting in a higher number of fruits and yield (Akhter *et al*. 2018). The application of Naphthalene acetic acid (NAA) resulted in vigorous growth of the crop (increase size and number of leaves). Better growth and development of crop might have provided stiff competition between crops and weeds resulting into poor growth of weeds. Such situations might have resulted in minimum or reduced growth of weeds. Further, better canopy spread of the crop might have restricted the light required for proper photosynthesis by the weeds resulting in shortage of carbohydrates which could be another reason for reduced growth and development of weeds (Bijalwan, 2020). Hence the present study was undertaken with an objective to compare the performance of two planting methods *i.e.*, raised bed and flat-bed planting, three sources of mulch i.e., black polythene mulch, silver polythene mulch and no mulch and NAA 15 ppm at 30 and 45 days after transplanting and no NAA application in managing weeds and increase in sweet pepper yield.

MATERIALS AND METHODS

A field trial was conducted during *kharif* (rainy season) of 2017-18 and 2018-19 at Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh), Vegetable Experimental Farm [35°5′N latitude and 77°11′E longitude at an elevation of 1270 m (above MSL)]. Sweet pepper cultivar *Solan Bharpur* was used. Treatments included: two planting techniques: raised bed (RB) and flat-bed (FB); three mulching treatments: black polythene mulching (BPM), silver polythene mulching (SPM) and no mulch (NM) and two NAA treatments: NAA 15 ppm spray at 30 and 45 days after transplanting (DAT) and no NAA treatment. There were 12 treatments [RB + BPM + NAA @ 15 ppm spray at 30 and 45 DAT; RB + BPM + No NAA application; RB + SPM + NAA 15 ppm spray at 30 and 45 DAT; RB + SPM + No NAA application; RB + NM + NAA 15ppm spray at 30 and 45 DAT; RB + NM + No NAA application; Flat-bed (FB) BPM + NAA 15 ppm spray at 30 and 45 DAT; FB + BPM + No NAA application; FB + SPM + NAA 15ppm spray at 30 and 45 DAT; FB + SPM + No NAA application; FB + No mulch + NAA 15 ppm spray at 30 and 45 DAT and FB+ NM + no NAA application (control)] laid out in randomized block design with 3 replications. Raised beds of 15 cm height were taken maintaining a distance of 45 cm between the beds. Mulches of 50 μ (200 gauge thickness) were used for mulching according to the treatment combinations.

Weed density

The data was collected from each plot with the help of a quadrat of 1 m × 1 m placed randomly in each plot and the total number of weeds within the quadrat was counted.

Weed control efficiency (WCE) (%)

It was calculated at harvest as per the formula (Kondap and Upadhyay 1985) given below:

$$WCE = \frac{DMC\text{-}DMT}{DMC} \times 100$$

Where,

WCE= Weed control efficiency (per cent).

DMC= Weed biomass in control (weedy check) plot .

DMT= Weed biomass in treated plot.

Relative weed density (WD) (%)

It was calculated as a specific number of weeds (*Oxalis latifolia*, *Amaranthus* spp., *Cyperus rotundus* L., *Echinochloa crus-galli*, *Setaria* spp. and *Commelina benghalensis*) to the total number of weeds present in the 1 m^2 area of each plot. It was calculated as per the formula suggested by Gill and Kumar (1969):

Relative weed density (%) =

$$\frac{\text{Number of specific weed}}{\text{Total number of weeds}} \times 100$$

Dry biomass of weeds (g /m^2)

Observations on the weed dry weight (weed biomass) was recorded from an area of 1 m × 1 m in each plot. Fresh weight was recorded just after the collection of weeds from the field while dry weight was recorded after drying of weeds in an oven at 70°C and expressed as biomass (g/m^2).

The two-year data were averaged and analyzed. Analysis of variance (ANOVA) for the experiment was done as per the model suggested by Panse and Sukhatme (2000).

RESULTS AND DISCUSSION

Effect on weeds

The dominant weeds of experimental field were: *Setaria* spp., *Commelina benghalensis*, *Echinochloa crus-galli*, *Oxalis latifolia*, *Amarantus* spp. and *Cyperus rotundus* L.

Interaction effect of planting technique + mulching + NAA had significant effect on all weeds and crop yield characters (Table 1). Less weed density (270.33/m^2) was recorded with RB + BPM + NAA 15 ppm spray at 30 and 45 DAT and it was at par with RB + BPM + no NAA application (285.17/m^2); FB + BPM + NAA 15ppm spray at 30 and 45 DAT (332.17/m^2) and FB+ BPM + no NAA application (334.33/m^2). Greater weed density (1217.83/m^2) was in FB + NM + NAA 15ppm spray at 30 and 45 DAT. Higher weed control efficiency (64.12%) was recorded with above effective treatment combinations which was statistically at par with RB + BPM + no NAA application (63.36%) followed by FB + BPM + No NAA application (61.78%) and FB + BPM + NAA 15 ppm spray at 30 and 45 DAT (60.53%). Lower weed control efficiency (8.62%) was recorded in FB + NM + NAA 15ppm spray at 30 and 45 DAT. Similarly, low fresh and dry weed biomass was observed in RB + BPM + NAA 15 ppm spray at 30 and 45 DAT, *i.e*, 340.17 g/m^2 and 117.83 g/m^2, respectively. Control treatment had recorded high dry weed biomass (330.67 g/m^2). In the present study, mulching with black polythene recorded a minimum number of weeds with more weed control efficiency which could be because the mulch prevented the weed seeds to germinate (Ashrafuzzaman *et al.* 2011). The mulch could create partially anaerobic unfavorable conditions for the survival of weed species resulting in a very low weed density, although moisture and nutrients were available (Rimani *et al*., 2021).

A Combination of planting techniques, mulch and NAA spray showed significant results for weed intensity (Table 2). RB + BPM + NAA @ 15ppm application at 30 and 45 DAT has lower intensity of *Oxalis latifolia* (13.95%), *Amaranthus* spp. (5.21%), *Cyperus rotundus* (11.45%), *Echinochloa crus-galli* (4.56%), *Setaria* spp. (25.16%) and *Commelina benghalensis* (14.88%) as compared to control which recorded higher intensity of these weeds. Sharma and Sharma (2019) opined that the weed intensity is directly related to crop vigor and yield. The preventive effect of mulch on light penetration acted as a physical barrier affecting the growth of most of the annual and perennial weeds (Negi, 2015).

Effect on sweet pepper yield

The yield was the highest with RB + SPM + NAA 15 ppm application at 30 and 45 DAT (38.47 t/ha) and lowest (24.15 t/ha) in weedy control (Table 1). The soil moisture and temperature under mulch improves the plant microclimate leading to early growth and development, which advances the flowering with no or less nutrient competition between weed species and crop resulting in improved crop yield (Sampat *et al.* 2014 and Edgar *et al*. 2016). An exogenous application of growth regulators like naphthalene acetic acid affects the endogenous hormonal pattern of the plant either by supplementation of sub-optimal levels or by interaction with their synthesis, translocation, or inactivation of existing hormone levels which enhances crop yield (Basuchaudhari 2016 and Singh *et al*. 2017). NAA increases crop yield by reducing flower and fruit drop, increases the number of fruits, fruit length, fruit weight and many more yield contributing traits, all these traits directly related to enhanced yield (Gare *et al*. 2017 and Saini *et al*. 2019).

Table 1: Effect of planting method × mulching × NAA application on weed indices and yield of sweet pepper.

Treatments	Weed density (no. /m^2)	Weed control efficiency (%)	Weeds dry biomass (g/m^2)	Sweet pepper yield (t/ha)
RB + BPM + NAA application @ 15 ppm at 30 and 45 DAT	270.33±39.34^a	64.12 (53.20) ±1.63^a	117.83±6.53^a	36.74±0.97^b
RB + BPM + No NAA application	285.17±46.96^{ab}	63.36 (52.78) ±5.20^a	120.11±15.13^a	33.38±0.52^{cd}
RB + SPM + NAA application @ 15 ppm at 30 and 45 DAT	387.00±57.42^c	53.21 (46.84) ±3.24^a	153.67±12.34^a	38.47±0.61^a
RB + SPM + No NAA application	400.00±74.05^c	52.33 (46.33) ±2.26^a	156.67±9.22^a	33.83±0.09^c
RB + NM + NAA application @ 15 ppm at 30 and 45 DAT	1063.33±52.62^d	18.16 (24.57) ±9.71^{bc}	268.67±29.48^{bc}	28.30±1.12^f
RB + NM + No NAA application	1154.17±45.83^{de}	23.67 (25.76) ±20.01^b	250.50±63.33^b	25.92±0.39^h
FB + BPM + NAA application @ 15 ppm at 30 and 45 DAT	332.17±9.70^{abc}	60.53 (51.08) ±0.48^a	129.50±3.00^a	35.56±0.15^b
FB + BPM + No NAA application	334.33±10.97^{abc}	61.78 (51.82) ±3.03^a	125.50±10.83^a	31.51±0.70^e
FB SPM+ NAA application @ 15 ppm at 30 and 45 DAT	381.67±27.89^{bc}	53.29 (46.89) ±2.24^a	153.33±8.61^a	36.44±0.54^b
FB + SPM + No NAA application	409.50±43.31^c	51.89 (46.08) ±0.78^a	157.50±4.44^a	32.15±1.71^{de}
FB + NM + NAA application @ 15 ppm at 30 and 45 DAT	1217.83±107.30^e	8.62 (16.78) ±4.20^{cd}	301.17±6.60^{cd}	26.96±0.39^{fg}
FB+NM+ No NAA application (Control)	1189.67±58.50^e	0.00 (0.00) ±0.00^d	330.67±9.81^d	24.15±0.83^i
LSD (p = 0.05)	80.10	9.83	36.12	1.30

*Figures in parenthesis represent angular transformation.

Table 2: Effect of planting method × mulching × NAA application on relative weed density (%).

Treatments	*Oxalis latifolia*	*Amaranthus* spp.	*Cyperus rotundus*	*Echinochloa crus-galli*	*Setaria* spp.	*Commelina benghalensis*
RB + BPM + NAA application @ 15 ppm at 30 and 45 DAT	13.95 (21.92) ±0.79^{a}	5.21 (13.18) ±0.69^{a}	11.45 (19.78) ±0.50^{a}	4.56 (12.32) ±0.48^{a}	25.16 (31.10) ±0.91^{a}	14.88 (22.69) ±0.26^{a}
RB + BPM + No NAA application	19.20 (25.79) ±6.73^{b}	5.45 (13.50) ±0.27^{a}	11.65 (19.96) ±0.41^{a}	4.78 (12.63) ±0.12^{ab}	25.40 (30.27) ±0.46^{a}	15.11 (22.88) ±0.37^{a}
RB + SPM + NAA application @ 15 ppm at 30 and 45 DAT	24.71 (29.80) ±0.96^{cd}	7.55 (15.94) ±0.50^{ab}	17.55 (24.77) ±0.54^{c}	6.53 (14.80) ±0.39^{c}	28.59 (32.32) ±1.03^{b}	17.09 (24.41) ±0.69^{b}
RB + SPM + No NAA application	23.78 (29.18) ±0.24^{c}	7.64 (16.04) ±0.47^{ab}	17.58 (24.79) ±0.12^{c}	6.60 (14.89) ±0.29^{c}	29.22 (32.72) ±1.14^{bc}	17.51 (24.74) ±0.52^{b}
RB + NM + NAA application @ 15 ppm at 30 and 45 DAT	53.09 (46.77) ±0.67^{e}	18.64 (25.58) ±0.21^{e}	55.31 (48.05) ±0.76^{e}	11.53 (19.85) ±0.25^{e}	47.92 (43.81) ±0.94^{d}	26.37 (30.90) ±0.60^{d}
RB + NM + No NAA application	53.58 (47.05) ±0.28^{e}	18.51 (25.48) ±0.23^{e}	55.16 (47.96) ±1.66^{e}	11.39 (19.72) ±0.21^{e}	48.20 (43.97) ±1.88^{d}	26.66 (31.09) ±0.39^{d}
FB + BPM + NAA application @ 15 ppm at 30 and 45 DAT	14.71 (22.55) ±0.19^{a}	6.28 (14.50) ±0.35^{a}	14.34 (22.25) ±0.40^{b}	5.35 (13.37) ±0.19^{b}	26.29 (30.85) ±0.32^{a}	16.85 (24.24) ±0.28^{b}
FB + BPM + No NAA application	14.74 (22.57) ±0.62^{a}	6.54 (14.82) ±0.21^{a}	14.46 (22.35) ±0.20^{b}	5.10 (13.05) ±0.35^{ab}	26.11 (30.73) ±0.16^{a}	16.89 (24.27) ±0.04^{b}
FB SPM+ NAA application @ 15 ppm at 30 and 45 DAT	28.06 (31.99) ±0.61^{d}	9.50 (17.94) ±0.46^{b}	21.76 (27.80) ±1.06^{d}	8.10 (16.53) ±0.77^{d}	30.08 (33.26) ±0.84^{bc}	19.94 (26.52) ±0.53^{c}
FB + SPM + No NAA application	28.15 (32.04) ±0.57^{d}	9.78 (18.22) ±0.26^{b}	21.64 (27.72) ±0.87^{d}	8.37 (16.81) ±0.74^{d}	30.75 (33.68) ±0.58^{c}	20.09 (26.63) ±0.55^{c}
FB + NM + NAA application @ 15 ppm at 30 and 45 DAT	62.49 (52.24) ±1.51^{f}	20.91 (27.21) ±0.76^{e}	62.72 (52.37) ±0.93^{f}	12.94 (21.08) ±0.14^{f}	54.70 (47.69) ±0.92^{e}	31.36 (34.05) ±0.94^{e}
FB+NM+ No NAA application (Control)	62.76 (52.39) ±0.58^{f}	18.07 (24.98) ±5.35^{e}	62.90 (52.47) ±0.81^{f}	12.94 (21.08) ±0.14^{f}	54.97 (47.85) ±0.83^{e}	31.44 (34.10) ±0.82^{e}
LSD (p = 0.05)	2.55	2.06	0.62	0.76	0.72	0.59

*Figures in parenthesis represent angular transformation.

CONCLUSION

It is concluded from this study that the treatments, RB+BPM+NAA application @ 15 ppm at 30 and 45 DAT can provide significant weed control when compared to the FB+NM+ no NAA application and may be utilized to enhance weed management in sweet pepper fields. While, RB+SPM+NAA application @ at 30 7 and 45 DAT showed maximum sweet pepper fruit yield.

Conflict of interest: None.

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