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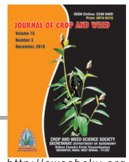

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Effect of integrated weed management on cauliflower (*Brassica oleracea* var. *botrytis* L.)

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ABSTRACT

The present investigation was conducted during 2018-19 at the Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India. The experiment was carried out in Randomized Block Design with 10 treatments and 3 replications. The treatments consisted of T_1 (Weedy check), T_2 (Weed free), T_3(One Hand weeding at 25 DAT), T_4 (Paddy straw mulch @ 5 t ha^{-1}), T_5 (Oxyfluorfen @ 0.8 kg ha^{-1} (PE)), T_6 (Pendimethalin @ 1 kg ha^{-1} (PE)), T_7 (Oxyfluorfen @ 0.8 kg ha^{-1}+ Paddy straw mulch @ 5 t ha^{-1}), T_8 (Oxyfluorfen @ 0.8 kg ha^{-1} + 2 Hand weedings at 25 DAT and 50 DAT), T_9 (Pendimethalin @ 1 kg ha^{-1} +Paddy straw mulch @ 5 t ha^{-1}),T_{10} (Pendimethalin @ 1 kg ha^{-1} + 2 Hand weedings at 25 DAT and 50 DAT).Observations were recorded on the basis of weed parameters and yield parameters. Minimum weed density (weeds mÉ^{2}), weed dry weight (g mÉ^{2}), weed index and maximum weed control efficiency (%) was recorded in T_2 (weed free). Maximum yield contributing attributes were listed in treatment T_2 (weed free) which was followed by T_7 (Oxyfluorfen @ 0.8 kg ha^{-1} + Paddy straw mulch @ 5 t ha^{-1}).

Keywords: Cauliflower, hand weeding, mulching, oxyfluorfen, pendimethalin

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is a cool season crop, botanically referred to as the genus *Brassica*. The chromosome number of cauliflower is 2n=18. The name cauliflower has been originated from the Latin words 'Caulis' meaning stem and 'Florish' meaning flower. Cauliflower was introduced in India from England by Britishers in 1822 and in such a short period of its introduction, it has gained a lot of importance among the researchers, farmers and consumers. In India it was introduced during the period of East India Company (Rai and Yadav, 2005). Cauliflower is one of the most popular vegetable crop among the cole crops. Cauliflower has high protein and peculiar in stability of vitamin C after cooking (Singh, 1997). It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium *etc*. It also contains vitamin A. Hundred gram edible portion of cauliflower has high quality protein (2.6g), moisture (90.8 g), fat (0.4 g), carbohydrates (4.0 g), calcium (33.0 mg), phosphorous (57.0 mg), iron (1.5 mg), thiamine (0.04 mg), riboflavin (0.10 mg), vitamin C (56.0 mg) and 30 Kcal energy (Singh, 1998). Integrated weed management (IWM) can be defined as a holistic approach to weed management that integrates various techniques of weed control to provide the crop with an advantage over weeds (Herker and Onovan, 2013). Chemical weed control is a better supplement to traditional methods and forms an integral part of the modern crop production. Thus, use of herbicides is one of the options left with the farmers to eliminate crop weed competition at early growth stage of crop. Mulching is an effective method in manipulating crop growing environment to increase yield and improve product quality by controlling weeds, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Opara-Nadi, 1993). Besides hand weeding and herbicidal control, mulching (particularly plastic mulch and rice straw mulch) has also been advocated by many researchers as an effective mean for reducing weed population (Bana *et al*., 2012). Therefore, keeping in view the above facts in mind, an attempt has been made in the present investigation to study the effect of integrated weed management on cauliflower (*Brassica oleracea* var. *botrytis* L.).

MATERIALS AND METHODS

The present investigation was conducted during 2018-19 at the Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India. Raised nursery beds of 3 x 1 m size were prepared by mixing well rotten FYM in the soil @ 20 kg per bed. The seeds of Cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Pusa Snowball K-1 were sown 5 cm apart in rows. The complete dose of phosphorus and potassium and 1/3 dose of nitrogen was applied at the time of field preparation as basal dose. However the rest of nitrogen were applied in two equal splits *viz.* one

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and two months after transplanting. FYM was applied @ 25 tonnes ha^{-1} before transplanting. One month seedlings were transplanted at 60 × 45 cm accommodating 25 plants in 7.20 square meter beds. Transplanting was done on 26 Oct, 2018 followed by light irrigation for 3-4 days. The experiment was deliberated in a Randomized Block Design with three replication and ten treatments. The treatments consisted of T_1(Weedy check), T_2 (Weed free), T_3(One Hand weeding at 25 DAT), T_4 (Paddy straw mulch @ 5 t ha^{-1}), T_5 (Oxyfluorfen @ 0.8 kg ha^{-1} (PE)), T_6 (Pendimethalin @ 1 kg ha^{-1} (PE)), T_7 (Oxyfluorfen @ 0.8 kg ha^{-1}+ Paddy straw mulch @ 5 t ha^{-1}), T_8 (Oxyfluorfen @ 0.8 kg ha^{-1} + 2 Hand weeding at 25 DAT and 50 DAT), T_9 (Pendimethalin @ 1 kg ha^{-1} +Paddy straw mulch @ 5 t ha^{-1}),T_{10} (Pendimethalin @ 1 kg ha^{-1} + 2 Hand weedings at 25 DAT and 50 DAT). Weed parameters were recorded at 30, 60 DATand at harvest.Observations were recorded on randomly selected plants with different characters *i.e.* weed density (weeds m^{-2}), weed dry weight (gm^{-2}), weed control efficiency (%), weed index (%), curd length (cm), curd diameter (cm), days taken to harvest, curd equatorial diameter (cm), curd polar diameter (cm), dry weight of curd (g), dry matter content (%), curd weight (g), curd yield per plot (kg), curd yield per hectare (t ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%).The weed density and dry weight were analyzed after subjecting the original data to the square root transformation (Panse and Sukhatme, 1985). The data pertaining to attributes were statistically analyzed as per design of experiment and treatments mean was tested at 5 % level of significance (Gomez and Gomez, 1983).

Weed control efficiency was calculated by standard formula.

$$\text{WCE }(\%) = \frac{\text{Weed dri weight in weedy check-Weed dri weight in treatment}}{\text{Weed dri weight of weedy check}} \times 100$$

Weed index was calculated by using the following formula.

$$\text{Weed index }(\%) = \frac{\text{X-Y}}{\text{X}} \times 100$$

Where, X= curd yield from the weed free check

Y = curd yield from the treatment for which weed index is calculated

RESULTS AND DISCUSSION

Effect on weeds

Weed density per meter square area of cauliflower recorded at 30, 60 DAT and at harvest was remarkably affected by different weed management practices. There was no weed under T_2 (weed free) at all the stages *i.e.* at 30, 60 DAT and at harvest. The lowest weed density under this treatment was due to continuously hand weeding and hoeing which did not allow growth of weeds at all stages of crop growth which leaded to no competition among weeds and crop plants. Minimum weed density was observed T_8 (Oxyfluorfen @ 0.8 kg ha^{-1} + 2 Hand weeding at 25 DAT and 50 DAT) at 30 DAT, at 60 and at harvest minimum weed density was observed in T_7 (Oxyfluorfen @ 0.8 kg ha^{-1} + Paddy Straw mulch @ 5 t ha^{-1}).Whereas, the maximum weed density at 30, 60 DAT and at harvest were recorded in T_1 (Weedy check) having value of (6.38, 9.11 and 11.75 weed m^{-2}). Pre emergence application of herbicide was accompanied by hand weeding resulted in effective control of broad leaved weeds, grasses and to some extent sedges due to its broad spectrum action and herbicidal effect over cell membrane causing disruption of the cells, ionic balance and ultimately death of weeds (Rao, 2000). Mulching improves the physical condition of soil like increase the moisture conservation, reduce the soil compaction, maintain the soil temperature so crop was well established and suppress the weed growth (Ram *et al.,* 2013).The lowest weed dry weight at 30, 60 DAT and at harvest were recorded in T_2 (weed free). Minimum weed density was observed in T_8 (Oxyfluorfen @ 0.8 kg ha^{-1} + 2 Hand weeding at 25 DAT and 50 DAT) at 30 DAT, at 60 and at harvest minimum weed density was observed in T_7 (Oxyfluorfen @ 0.8 kg ha^{-1}+ Paddy straw mulch @ 5 t ha^{-1}).This is due to use of oxyfluorfen being a very good effect on suppressing weeds, which is indicated by the decrease of weed dry weight (Qasem, 2007). Mulching the soil surface can prevent weed seed germination or physically suppress seedling emergence (Bhardwaj, 2013). On the other hand, highest weed dry weight was found in T_1 (Weedy check).Weed control efficiency (%) of cauliflower showed a larger effect of different weed management practices. The maximum weed control efficiency (100%) was found with the treatment T_2 (weed free). The herbicidal treatment showing best weed control efficiency was T_8 (Oxyfluorfen @ 0.8 kg ha^{-1} + 2 Hand weedings at 25 DAT and 50 DAT) at 30 DAT, at 60 and at harvest minimum weed control efficiency was observed in T_7 (Oxyfluorfen @ 0.8 kg ha^{-1} + Paddy Straw mulch @ 5 t ha^{-1}). The higher weed control efficiency under these treatments was reflected due to good effect of herbicides and through lower dry weight of weeds in cauliflower (Sen *et al*., 2018). Paddy straw mulch showed better performance over control because of better soil environment created by mulching (Thentu *et al*., 2016). Minimum weed control efficiency at 30, 60 DAT and at harvest was recorded under the treatment T_3 (1 hand weeding at 25 DAT). Weed index is indirectly related to the reduction in yield due to weed population and weed dry weight. The highest weed index data was recorded in the treatment T_1 (Weedy check). Excess weed growth and highest weed dry matter accumulation, suppression of crop plants by emerging weeds and more utilization of nutrients and moisture by weed canopy affect the yield of the cauliflower (Kumar *et al*., 2015 and Sen *et al*., 2018). The lowest weed index indicated that there was no reduction in yield in this treatment due to weed infestation (Thakare *et al*., 2018).

Effect on yield contributing attributes

Curd length and diameter were significantly affected by different levels of treatments. The mean performance of different treatments showed that maximum curd length (14.49 cm) and curd diameter (20.07 cm) were recorded in treatment T_2 (Weed free). Whereas minimum curd length (11.92 cm) and diameter (16.15 cm) was recorded in T_1 (Weedy check**).** This might be due to weed free environment as a result of efficient weed control and effective utilization of all available resources lower weed weight up to harvest and higher weed control index (Gandolkar *et al*., 2015). Minimum curd length and diameter was reported in T_1 (control) due to more weed competition. Minimum days taken to harvest (76.90 days) were taken under treatment T_2 (Weed free). It might be due to less weed crop competition for spacing, light, water and nutrients (Bana *et al.*,2012). Minimum curd diameter was observed in T_1 (control) due to more weed competition.Maximum curd equatorial diameter was recorded in treatment T_2 (Weed free) which had recorded (15.28 cm) and curd polar diameter was observed 13.30 cm in T_2. This may be attributed to proper aeration, reduced crop weed competition and better utilization of resources (Space, light, moisture and nutrients *etc.*) by the crop (Sankar *et al*., 2015). Minimum curd equatorial and polar diameter was observed in T_1 (Weedy check). Dry weight of curd was maximum in T_2 *i.e.* 94.13 g. However, minimum dry weight of curd (47.87 g) was under T_1. The increase in dry weight may be due to less crop weed competition for light, nutrients, moisture and space resulting in increasing availability of assimilates to plant vegetative phase which is directly responsible for better growth of curd and ultimately yield (Bhayan *et al*., 1985) and also might be due to the control of weed infestation at early stage and less crop weed competition during the critical growth stage of the crop (Sen *et al.,* 2018).The study revealed that all weed treatments caused significant percentage increase in dry matter content over control T_1(Weedy check). But the maximum dry matter content of curd (10.27 %) was obtained from T_2 (Weed free). This can be attributed to increase in plant growth and ultimately yield attributing character with reduced crop weed competition. The increased stalk length, number of leaves, leaf length and dry weight of plant are directly responsible for increasing dry matter production. Higher synthesis and accumulation of photosynthates in the plant resulted in increasing the dry matter (Sen *et al.,* 2018).The treatment T_2 (Weed free) resulted maximum (994.50 kg) curd weight. The relatively higher average curd weight was obtained in various weed control treatments. This can be attributed to increase in plant growth and ultimately yield attributing character with reduced crop weed competition (Sen *et al.,* 2018).Whereas the minimum curd weight (563.63 g) was recorded in T_1 (Weedy check).

Effect on crop yield and economics

Maximum curd yield per hectare was recorded in T_2 (Weed free) *i.e.* 30.79 t ha^{-1}. According to Islam *et al.* (2014) this might be due to better availability, solubility, mobility and utilization of plant nutrients resulting in plant growth and curd production. Organic mulches return organic matter and plant nutrients to the soil and improve the physical, chemical and biological properties of the soil after decomposition, which in turn increases crop yield (Bhardwaj, 2013). The minimum curd yield ha^{-1} 17.45 t ha^{-1} was recorded in treatment T_1 (Weedy check).The biological yield of cauliflower was significantly influenced by different weed management practices. The maximum biological yield (1.65 kg) was observed in the treatment of T_2 (Weed control). It might be due to less weed crop competition for spacing, light, water and nutrients. Organic mulch are efficient in reduction of nitrates leaching, improve soil physical properties, prevent erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle as well as increase the biological activity (Muhammad *et al*., 2009). The minimum (1.35 kg) biological yield was observed in control (T_1). It is evident from the weed management practices, treatment T_2 (weed free) recorded maximum harvest index (60.10 %). Minimum harvest index was recorded (41.42 %) in treatment T_1 (Weedy check). This might be due to lesser crop-weed competition for light, nutrients, moisture and space resulting into increasing availability of assimilates for growth and developments of plants (Mal *et al.,*

Table 1: Effect of integrated weed management on Weed density and Weed dry matter in cauliflower

Sr. No.	Weed density (weeds m^{-2})			Weed dry matter (g m^{-2})		
	30	60	At harvest	30	60	At harvest
T_1	6.38(40.16)	9.11(82.58)	11.75(138.57)	2.59(10.21)	9.70(93.66)	13.20(173.79)
T_2	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
T_3	3.07(8.96)	6.82(46.05)	9.58(91.57)	1.50(1.78)	8.02(63.86)	11.18(124.49)
T_4	4.01(15.65)	3.14(9.65)	4.43(19.24)	2.39(5.19)	3.90(14.86)	7.17(51.03)
T_5	3.20(9.73)	5.42(28.94)	8.51(72.03)	1.75(2.59)	7.88(61.68)	10.78(115.67)
T_6	3.67(13.01)	4.44(19.29)	7.43(54.69)	1.99(3.47)	6.19(37.91)	9.14(83.21)
T_7	2.60(6.28)	2.57(6.16)	4.29(17.96)	1.37(1.39)	3.39(11.10)	6.57(42.75)
T_8	2.26(4.66)	3.65(12.91)	5.53(30.07)	1.17(0.88)	4.40(19.11)	8.17(66.35)
T_9	3.32(10.56)	2.77(7.19)	4.38(18.71)	1.88(3.04)	3.56(12.28)	6.78(45.52)
T_{10}	2.49(5.74)	3.99(15.46)	6.16(37.46)	1.24(1.06)	5.12(25.83)	8.75(76.18)
S.Em (±)	**0.12**	**0.19**	**0.28**	**0.08**	**0.19**	**0.21**
CD $_{0.05}$	**0.35**	**0.57**	**0.83**	**0.22**	**0.56**	**0.64**

**Data in parentheses is original and transform by ($\sqrt{x + 0.5}$)*

Table 2: Effect of integrated weed management on weed control efficiency (%) and weed index in cauliflower

Sr. No.	Weed control efficiency (%)			Weed index (%)
	30	60	At harvest	
T_1	0.00	0.00	0.00	43.33
T_2	100.00	100.00	100.00	0.00
T_3	82.53	31.82	28.37	34.52
T_4	49.15	84.13	70.64	10.93
T_5	74.66	34.14	33.44	28.02
T_6	65.97	59.53	52.12	22.97
T_7	86.35	88.15	75.40	4.61
T_8	91.35	79.59	61.82	15.29
T_9	70.25	86.89	73.81	7.61
T_{10}	89.65	72.42	56.17	19.34

Table 3: Effect of integrated weed management on Yield attributes in Cauliflower

Sr.No.	Curd length (cm)	Curd diameter (cm)	Days taken to harvest	Curd equatorial diameter (cm)	Curd polar diameter (cm)	Dry weight of curd (gm)	Dry matter content (%)	Curd weight (g)	Curd yield (t ha^{-1})
T_1	11.92	16.15	96.60	9.95	8.56	47.87	6.10	563.63	17.45
T_2	14.49	20.07	76.90	15.28	13.30	94.13	10.27	994.50	30.79
T_3	12.13	16.94	94.32	11.02	9.78	64.65	6.53	651.17	20.16
T_4	13.70	18.43	85.33	13.95	11.69	86.37	8.55	885.81	27.42
T_5	12.55	17.22	93.94	11.54	10.12	69.76	6.90	715.83	22.16
T_6	12.89	17.68	92.00	12.05	10.63	74.93	7.47	766.10	23.72
T_7	14.18	19.10	82.83	14.99	12.75	92.14	9.57	948.68	29.37
T_8	13.38	18.07	87.09	13.23	11.50	82.89	8.02	842.43	26.08
T_9	13.97	18.57	83.00	14.48	12.02	90.78	9.03	918.80	28.45
T_{10}	13.16	17.94	89.49	12.62	11.13	79.39	7.83	802.17	24.84
S.Em (±)	**0.35**	**0.58**	**2.65**	**0.54**	**0.59**	**1.55**	**0.42**	**26.62**	**0.82**
CD $_{0.05}$	**1.04**	**1.71**	**7.88**	**1.61**	**1.76**	**4.61**	**1.25**	**79.09**	**2.45**

Table 4: Effect of integrated weed management on crop yield and economics of cauliflower

Sr. No.	Curd yield (t ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Gross return (₹ ha^{-1})	Net return (ha^{-1})	B:C
T_1	17.45	1.35	41.42	261748.2	185680.9	2.44
T_2	30.79	1.65	60.10	461845.8	357778.5	3.44
T_3	20.16	1.44	45.17	302401.8	223184.5	2.82
T_4	27.42	1.57	56.28	411368.6	334101.3	4.32
T_5	22.16	1.52	47.09	332433	252955.7	3.18
T_6	23.72	1.53	50.16	355776.8	278277.3	3.59
T_7	29.37	1.60	59.22	440565.4	359888.1	4.46
T_8	26.08	1.57	53.74	391226	306148.7	3.60
T_9	28.45	1.59	57.86	426690.7	347991.2	4.42
T_{10}	24.84	1.56	51.49	372526.2	295317.1	3.82
S.Em (±)	**0.82**	**0.03**	**1.16**			
CD $_{0.05}$	**2.45**	**0.08**	**3.45**			

2005).The maximum income (both gross and net) was obtained in treatment T_2 (Weed free) which was followed by T_7 **(**Oxyfluorfen (PE) @ 0.8 kg ha^{-1} + Paddy straw mulch @ 5 t ha^{-1}**)**. On the other hand, the lowest income was obtained in T_1 (Weedy check). The benefit cost ratio was found highest under treatment T_7 **(**Oxyfluorfen (PE) @ 0.8kg ha^{-1} + Paddy straw mulch @ 5 t ha^{-1}). These results are in close proximity with the findings of (Thakare *et al.* 2018).

CONCLUSION

From the findings of above investigation it is concluded that different weed management practices significantly reduced the weed population and increased cauliflower yield with mulching and application of different herbicides. Overall, herbicide applied in T_7 (Oxyfluorfen @ 0.8 kg ha^{-1} + Paddy straw mulch @ 5 t ha^{-1}) was proved to be the best weed control method.Results revealed that paddy straw mulch controlled all weeds, which resulted in the highest cauliflower yield, but it is the most laborious method to control weeds as compared to the application of herbicides. Therefore, the use of oxyfluorfen 23.5 % EC as pre emergence herbicide and paddy straw mulch is recommended for the farming community of the area to achieve maximum cauliflower yield.

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