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Effect of integrated Weed Management Practices on Growth and Yield of Cauliflower (*Brassica oleracea* var. *botrytis*)

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ABSTRACT: The present investigation entitled "Effect of integrated weed management on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.)" was carried out at the Agriculture Research Farm of Abhilashi University, Mandi during 2021-2022 to evaluate the effect of integrated weed management practices on growth and yield of cauliflower. The experiment was laid out in a randomized block design (RBD) with three replications, and seven treatments. Soil of the experimental field was slightly acidic in nature with low in nitrogen and medium in phosphorus and potassium content and low in organic carbon. The result revealed that (T_2) Weed free recorded the highest plant heights (44.06 cm) at 60 DAT, number of leaves at (17.40) at 60 DAT, diameter of curd (16.43) at harvest, days to harvesting (90.14) at harvesting, fresh weight of leaves (230.57) at harvest, dry weight of leaves (27.67) at harvest and average weight of curd (644.53) at harvest, yield per plot (9.03kg) and yield per hectare (225.83 q) which was followed by (pendimethalin 1.5 Kg/ha + HW 30 DAT (T_7). While the maximum weed count (89.66), fresh weight of weeds (1733.96 g), and dry weight of weeds (312.11 g) were observed under (T_1) weedy check, and the minimum weed count (0.00), fresh weight of weeds (0.00 g) and dry weight of weeds (0.00g) were observed under weed free (T_2). The highest WCE (100%) and lowest weed index (0.00%) were observed in (T_2) weed-free and the lowest WCE (0.00 %) and highest weed index (72.07%) were in weedy check (T_1). *Stellaria media* L., *Vicia sativa* L., *Lysimachia arvensis* var. *caerulea* (L.), etc., were the major weeds observed in the experimental field. Gross income was recorded high in treatment T_2 (weed free) while net income and B:C was recorded maximum under treatment T_7 (Pendimethalin @ 1.5 kg a.i./ha + one HW at 30 DAT), making it an economically practical option for controlling weeds in cauliflower.

Keywords: IWM, Cauliflower, growth, treatments, yield.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most popular vegetable crops among the cole crops and has originated from the Mediterranean region. Brassicaceae family member cauliflower is farmed for its white, delicate curd used in soup, pickles, curries, and other vegetable dishes. It has a high quality of proteins and is peculiar in the stability of vitamin C after cooking. It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium, etc. It is a seed-reproducing annual plant. The white inflorescence meristem makes up the cauliflower curd. The edible section of broccoli differs from cauliflower curd in that it has flower buds. In addition to these "cole" crops—broccoli, Brussels sprouts, cabbage, collard greens, and kale—which are all members of various cultivar groups—*Brassica oleracea* also contains high-quality proteins and is peculiar in the stability of vitamin C after cooking. It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium, etc. According to Jood and Neelam (2011), cauliflower fresh curd is incredibly nutritious and contains 90.8 g of moisture, 2.6 g of protein, 0.4 g of fat, 1.2 g of fiber, 4.0 g of carbohydrates, 1.5 mg of iron, 1.5 mg of calcium, 1.5 mg of phosphorous, 1.5 mg of carotene, 1.0 mg of niacin, and 56 mg of vitamin C per 100 g of edible portion. Cauliflower may have cancer-fighting power and packs a noteworthy nutrition punch with 1 cup of fresh cauliflower being an excellent source of vitamins C and K and a good source of fiber, folate, and vitamin B6. India ranks second in the area and production of cauliflower in the world after China. In India, major

cauliflower-growing states are West Bengal, Bihar, Madhya Pradesh, Orissa, Gujarat, Haryana, etc. It is grown in an area of about 485.60 thousand hectares with a production of 9536.03 thousand metric tons in the country (Anonymous, 2022). Being an important off-season vegetable crop of mid and high hills of H.P., it is grown in an area of about 5.64 hectares with a production of 135.11 metric tons (Anonymous, 2022). It is a highly delicate crop that requires more attention to grow well than the majority of other vegetables. Weeds top the list of agricultural pressures in India, where the country experiences significant losses every year. Weeds account for 33% of the total loss. Weeds take away a significant amount of soil's available nutrients, between 30 and 40%. Weeds substantially inhibit crop plant growth, which lowers yield and quality (Mal *et al.,* 2005). Although extensive research on different areas of cauliflower farming has been done in India, the issue of weeds in this crop needs special attention because they reduce the yield and degrade the quality of the output when present in the field. Controlling weeds is essential for the profitable cultivation of cauliflower because weed competition with cauliflower over a longer period greatly reduces crop growth and curd yield. Weed competition early in the season can cause irreversible growth and yield losses of cauliflower and add significantly to the cost of farm operations. Shoot dry weight and curd output decreased on average by 81 and 89 percent, respectively (Qasem, 2009). It is well known that manual hand weeding can successfully reduce weed growth. However, labour is now highly expensive, and their unavailability at the right moment makes the already difficult task of weed management even more difficult. However, an environmentalist says that using pesticides alone may not be the best solution because they harm sustainable agriculture. Therefore, combining cultural and herbicidal control for increasing cauliflower output would be the best option for weed control in cauliflower.

MATERIAL AND METHODS

The present investigation was conducted during the Rabi season 2021-22 at the Agriculture Research Farm School of Agriculture, Abhilashi University, Mandi (H.P) to evaluate the effect of Integrated Weed Management practices on the growth and yield of cauliflower. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Seven treatments, including a control, were evaluated to assess their impact on the cauliflower crop. The cauliflower variety *Coral White* + was used in the experiment. Seeds were sown in well-prepared nursery beds measuring 3 m in length, 2 m in width, and 0.15 m in height. The soil was enriched with a mixture of well-rotted farmyard manure (FYM), urea, single super phosphate (SSP), and muriate of potash (MOP). Thiram @ 3g/kg of seeds was applied to treat the seeds before sowing. Regular watering was provided during the germination and growth period. At the time of transplanting the experimental field was harrowed twice and ploughed once with a tractor to attain a fine tilth. Soil pulverization was done using a power tiller, followed by planking. Raised beds of dimensions 2 m × 2 m × 0.1 m were prepared. Nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) were added to the soil using urea, single super phosphate and muriate of potash, respectively. Full doses of P_2O_5 (75 kg/ha) and K_2O (80 kg/ha) were given at the time of transplanting. Half doses of N (120 kg/ha) were applied at the time of field preparation and the remaining half dose was given after six weeks of transplanting in the form of urea as a top dressing. Herbicides, Pendimethalin, were used as pre-emergence and sprayed three days after transplanting. Hand weeding was performed 30, 45 and 60 days after transplantation. Mulching with paddy straw was done to suppress weed growth. Irrigation was also provided at regular intervals depending on weather conditions. Various growth and yield metrics were recorded from five randomly chosen plants in each plot. The observations included plant height, number of leaves per plant, size of curd, days to harvesting, fresh and dry weight of leaves, average weight of curd, yield per plot, and yield per hectare. For the dry weight parameter, the curd and the weeds were kept in the hot air oven for 3 days at 75°C to maintain a consistent weight. Weed control efficiency (WCE) was estimated by the formula given by Mani *et al.* (1973), and the result was reported in percentage form. Whereas the weed index (WI) was determined using the formula specified by Gill and Vijayakumar (1969), and the result was also reported in percentage form. The data obtained for various parameters were subjected to statistical analysis using the standard procedure of analysis of variance (ANOVA).

RESULTS AND DISCUSSION

In this study, the soil characteristics of the experimental field were determined to establish the initial status of the soil. To achieve this, Auger sampling was employed, randomly collecting samples from different sections of the field at a depth of 0-15 cm. An active soil sample was then made from the composite and subjected to chemical analysis. The results from the soil testing laboratory indicated several key findings. Firstly, the soil displayed a slightly acidic reaction. Secondly, the available nitrogen content was found to be low. Lastly, the soil exhibited a medium level of available phosphorus and potassium content.

Crop Studies

Plant height. The experiment conducted on different treatments revealed varying effects on plant height. The highest plant height (44.06) was observed under treatment T_2 (weed-free) followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). The minimum plant height (34.06 cm) was found under treatment T_1 (weedy check). The presence of weeds in treatment T_1 (weedy check) likely hurt plant growth for several reasons. Weeds compete with crops for essential resources such as nutrients, water, and sunlight. As a result, they

deprived the cultivated plants of these vital elements, leading to stunted growth and reduced overall height. Due to high competition with weeds, the shortest plant height was obtained in the weedy check. The same result was obtained by Manish *et al*. (2018) in cauliflower.

Number of leaves. The highest number of leaves per plant (17.40) were recorded under treatment T_2 (weed-free) which was followed by treatment T_7 (pendimethalin 1.5 kg a.i./ha. + HW after 30 DAT). The lowest number of leaves per plant (13.26) was noted in treatment T_1 (weedy check). The increased number of leaves per plant in both weed-free and herbicide-treated plots can be attributed to the plant's ability to efficiently utilize the available space, moisture, and light, promoting vigorous growth. Whereas the weedy check plots faced intense competition with weeds for essential resources like moisture, nutrients, space, and light. As a result, the crop's growth was severely impacted, and the number of leaves per plant was limited in comparison to the weed-free treatment. The same result was obtained by Sen *et al.* (2018) in cauliflower.

Size of curd. The maximum size of curd (16.43) was recorded under treatment T_2 (weed-free) which was followed by treatment T_7 (pendimethalin 1.5 kg a.i./ha. + one HW 30 DAT) and the minimum size of curd was noted in treatment T_1 (weedy check). The difference in the size of curd between weed-free and weedy check conditions is due to weed competition. In weed-free conditions, plants have better access to essential resources, leading to healthier growth and more curd. The same result was obtained by Bana *et al*. (2012) in cauliflower.

Days to harvesting. Results showed that treatment T_2 (weed-free) reported minimum days (90.01) for days to harvesting followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). Maximum days (99.04) were noticed for days to harvesting in T_1 (weedy check). In weed-free conditions, cauliflower plants experienced earlier harvests due to better access to essential resources like water, nutrients, and sunlight, leading to efficient growth and development. Conversely, weedy check conditions with competing weeds delay cauliflower plant maturity and subsequent harvests, as weeds deprive the plants of crucial resources and hinder their growth. The absence of weeds allows cauliflower plants to thrive and mature faster, resulting in earlier harvests, while the presence of weeds delays maturity and leads to delayed harvests. The same result was obtained by Bana *et al.* (2012) in cauliflower.

Fresh weight of leaves. Results showed that treatment T_2 (weed-free) reported a maximum fresh weight of curd (230.57 g), followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). The minimum fresh weight of curd (170.52 g) was noticed under treatment T_1 (weedy check). The plants in weed-free and herbicide-treated plots were able to make the most use of the available space, moisture, and light that aided the plants in growing rapidly may be the cause of the increased fresh weight in leaves in those plots as compared to the weedy control. This promoted healthier leaf growth and improved leaf weight.

Dry weight of leaves. Results showed that treatment T_2 (weed-free) reported a maximum dry weight of curd (24.67 g), followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). The minimum fresh weight of curd (24.67 g) was noticed under treatment T_1 (weedy check). The plants in weed-free and herbicide-treated plots were able to make the most use of the available space, moisture, and light that aided the plants in growing rapidly may be the cause of the increased fresh weight in leaves in those plots as compared to the weedy control. This promoted healthier leaf growth and improved leaf weight.

Average weight of curd. Results showed that treatment T_2 (weed-free) reported a maximum average weight of curd (644.53 g), followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). The minimum average weight of curd (254.25 g) was noticed under treatment T_1 (weedy check). In the weed-free treatment, curd achieves maximum weight due to no competition from weeds for essential resources like nutrients, water, and sunlight. The same result was obtained by Sen *et al*. (2018) in cauliflower.

Yield per plot. Results showed that treatment T_2 (weed-free) reported a maximum (9.03 kg) yield per plot, followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). The minimum yield per plot (2.69 kg) was found under treatment T_1 (weedy check).Due to an improvement in plant development and eventual output with less crop weed competition, treatment T_2 (weed-free) had the best curd yield per plot. Low crop weed competition allowed the plants to efficiently use the assimilates, which led to an increase in the crop's dry matter, which in turn increased yield and yield-attributing characteristics.

Yield per hectare (q). Results showed that treatment T_2 (weed-free) reported a maximum (225.87 q) yield per hectare, followed by T_7 (pendimethalin 1.0 kg/ha. + HW after 30 DAT). The minimum yield per plot (67.37 q) was found under treatment T_1 (weedy check). The reason for the increase in total yield in treatment T_2 (weed-free) may be related to the plants' improved use of moisture, light, water, and space as a result of the absence of weeds at the start of the crop growth phase. Weed competition in the crop was minimal during the critical growth period, which led to increased plant growth, fresh head weight, and eventually increased crop yield.

Weed studies

Weed Flora. The various weeds observed in the experimental field were: *Stellaria media, Vicia sativa, Lathyrus aphaca, Lysimachia arvensis var. caerulea, Poa annua* L., *Phalaris minor, Alopecurus aequlis, Avenafatua* L., *Melilotus indicus* L., *Bromus catharticus, Euphorbia helioscopis* L., *Lepidium didymium* L., *Lepidium, hirtum* L., *Chenopodium album* L., *Triflolium repens* L., *Ranuculus arvensis* L., *Ranuculus repens* L., *Elymus caninus* L.

Weed count per meter square. The results showed that the maximum weeds (89.66) were found in treatment T_1 (weedy check), followed by T_4 [organic

mulch (paddy straw)]. The lowest weed density was found under treatment T_2 (weed-free). There were no weeds under treatments under treatment T_2 (weed-free). The weed count was high in the weedy check condition because weeds were permitted to grow next to the cauliflower plants, increasing weed density. On the other hand, the weed count was lowest in the weed-free condition since all weeds had been entirely removed from the field.

Fresh and dry weight of weeds. The results showed that the highest fresh and dry weight of weeds (1733.96 g and 312.11 g) were found in treatment T_1 (weedy check), followed by T_4 [organic mulch (paddy straw)]. The lowest fresh and dry weed weight was found under treatment T_2 (weed-free). The fresh weight and dry weight of weeds were highest in the weedy check condition because the weeds were allowed to grow unchecked alongside the cauliflower plants, resulting in vigorous weed growth. In the absence of weed control measures, the weeds had access to ample resources like nutrients, water, and sunlight, enabling them to thrive and accumulate more biomass. On the other hand, in weed-free conditions, the fresh and dry weight of weeds was lowest because efforts were made to control or eliminate weeds. The absence of weed competition and management practices limited the growth and development of weeds, leading to reduced fresh weight and dry weight compared to the weedy check condition. The same result was obtained by Sen *et al*. (2018) in cauliflower.

Weed control efficiency. The results showed that the maximum weed control efficiency (100%) was found in treatment T_2 (weed-free) followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT). The minimum weed control efficiency was found under treatment T_1 (weedy check). Because there were no weeds in the weed-free situation, weed management was most effective because weed development was fully stopped. This promotes the best development and productivity by enabling cauliflower plants to acquire nutrients, thrive without competition, and grow. In contrast, weed control effectiveness is lowest in the weedy check condition when weeds were permitted to grow unchecked alongside plants. The same result was obtained by Kaur *et al*. (2020) in cauliflower.

Weed Index. The results showed that the maximum weed index (72.07) was found in treatment T_1 (weedy check), followed by T_4 [organic mulch (paddy straw)]. The lowest weed index (0.00) was observed under treatment T_2 (weed-free). The minimum WI in treatment T_2 (weed-free) might be because there were fewer weeds, which reduced competition between the cauliflower crop and weeds for nutrients, space, and light, resulting in reduced yield loss. Low weed Index in other treatments as compared to weedy check could be described as the less influence of weeds on yields.

Economics

Cost of cultivation (₹/ha). The treatment T_2 (weed-free) had the highest total cost of cultivation (₹ 139415.52)). The overall cost of cultivation was lowest (₹ 90665.52) in treatment T_1 (weedy check).

Gross return (₹/ha). The treatment T_2 (weed-free) had the highest gross return (₹ 361325.60) followed by T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT) (₹ 324590.00). The overall gross return was lowest in treatment T_1 (weedy check) (₹ 107801.33).

Net return (₹/ha). The treatment T_7 (pendimethalin 1.5 kg/ha. + HW after 30 DAT) had the highest net return (₹ 222674.88) followed by T_2 (weed-free) (₹ 221910.08). The overall net return was lowest in treatment T_1(weedy check) (₹ 17135.81).

Table 1: Growth parameters influenced by different treatments.

Treatments	Plant height at 30 DAT	Plant height at 45 DAT	Plant Height at 60 DAT	NO. of leaves at 30DAT	No. of leaves AT 45 DAT	No. of leaves at 60 DAT
T_1	11.96	20.44	34.06	6.43	9.56	13.26
T_2	18.80	27.01	44.06	9.10	13.36	17.40
T_3	17.74	25.57	37.44	8.33	11.16	15.30
T_4	15.57	23.57	34.40	7.00	10.00	14.46
T_5	17.36	26.03	35.84	8.06	10.90	15.20
T_6	16.39	24.39	34.74	7.73	10.63	15.00
T_7	18.20	26.35	39.77	8.60	11.33	16.10
S.E. (m) ±	0.78	0.90	1.42	0.33	0.68	0.50
CD at 5%	2.44	2.81	6.65	1.03	2.14	1.57

Treatments	Size of curd	Days to harvesting	Fresh weight of leaves	Dry weight of leaves
T_1	11.10	99.04	170.52	20.46
T_2	16.43	90.01	230.57	27.67
T_3	14.40	93.21	214.05	25.68
T_4	12.79	97.05	182.05	21.84
T_5	15.11	94.01	200.58	24.07
T_6	13.40	96.20	190.58	22.86
T_7	16.17	92.08	219.12	26.29
S.E. (m) ±	1.00	0.90	6.71	0.80
CD at 5%	3.12	2.82	20.91	2.50

Table 2: Yield parameters influenced by different treatments.

Treatments	Average weight of curd	Yield per plot(kg)	Yield per hectare (hac)
T_1	254.25	2.69	67.37
T_2	644.53	9.03	225.83
T_3	479.25	6.12	153.00
T_4	348.14	3.84	96.04
T_5	373.75	4.85	121.22
T_6	358.85	4.54	113.53
T_7	552.65	8.11	202.87
S.E. (m) ±	19.66	0.45	11.25
CD at 5%	61.24	1.40	35.05

Table 3: Weed parameters influenced by different treatments.

	Weed count (No./m^2)	Fresh weight of weeds (g/ m^2)	Dry weight of weeds (g/m^2)	Weed control efficiency (%)	Weed index (%)
Treatments	At harvest	At harvest	At harvest		
T_1	9.50 (89.66)	41.64 (1733.96)	17.69 (312.11)	0.00	72.07
T_2	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	100.00	0.00
T_3	5.46 (29.00)	23.56 (559.58)	10.31 (106.32)	65.68	36.90
T_4	7.38 (53.66)	32.37 (1049.09)	14.14 (199.33)	36.21	59.60
T_5	5.73 (32.00)	24.87 (622.97)	10.88 (118.36)	62.00	49.26
T_6	6.31 (39.00)	26.88 (722.62)	11.75 (137.30)	56.05	52.66
T_7	4.62 (20.66)	19.97 (407.55)	8.75 (77.43)	75.28	15.08
SE(m) ±	0.21	1.35	0.58	-	-
CD at 5%	0.66	4.23	1.83	-	-

CONCLUSIONS

From the experimental observations, it can be concluded that data for growth, yield, and weed parameters were examined by using the statistical package OPSTAT was determined to be significant. The growth, yield, and quality attributes were found to be highest under treatment T_2 (weed-free). It was also very helpful in controlling the weeds at all growth stages. The highest cost of cultivation ₹ 139415.5 was reported in T_2 (weed-free) because of the high labour cost. However, the highest net return and benefit-cost ratio were found highest in treatment T_7 (Pendimethalin 1.5 kg/ha. + HW after 30 DAT) due to the lesser cost of cultivation. Hence, the treatment T_7 (Pendimethalin 1.5 kg/ha. + HW after 30 DAT) has proved to be the best for attaining the maximum return under the climatic conditions of Chail Chowk, Mandi (HP).

FUTURE SCOPE

To reduce herbicide reliance and maintain crop productivity, integrated weed management (IWM) strategies aim to both disrupt weed population dynamics and reduce weed interference by coherently combining a diversity of chemical, physical, and cultural weed management practices at the cropping system scale.

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