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Efficacy of Different Herbicides on Weed Control in Coriander

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Abstract

Field experiment was conducted to study the bio-efficacy of different herbicides on growth and yield of Coriander (*Coriandrum sativum* L.) at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru during *rabi* 2020-21. The experiment was laidout in RCBD design with 12 treatments replicated thrice. Major weed floras in the experimental plots were *Digitaria sanguinalis* L., *Echinochloa colonum* L., *Ageratum conyzoides* L. and *Mollugo verticillata* L. At harvest lower weed density (37.48 no. m^{-2}), weed dry weight (12.64 g m^{-2}) and higher weed control efficiency (81 %) were recorded from intercultivation and hand weeding at 20 DAS and 40 DAS and among herbicides pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE) recorded significantly lower weed density (60.45 no./m^2), weed dry weight (21.73 g/m^2) and higher weed control efficiency (67.51 %). Intercultivation and hand weeding at 20 DAS and 40 DAS recorded significantly higher seed yield (816 kg ha^{-1}), gross return (Rs.66027 ha^{-1}) and net return (Rs.27527 ha^{-1}). Among the herbicides pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE) recorded significantly higher seed yield (676 kg ha^{-1}), gross return (Rs.53106 ha^{-1}) and net return (Rs.25005 ha^{-1}), was on par with Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE). The cost-benefit ratio was recorded higher in pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) followed by pendimethalin 38.7 EC 1000 g a.i. ha^{-1} (PE) - imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE). Weedy check recorded lower seed yield, gross return, net return and cost-benefit ratio.

Keywords: Pendimethalin, Imazethapyr, Pre-emergence, Weed index

Coriander (*Coriandrum sativum* L.) is an aromatic herbaceous umbellifer commonly known as Chinese parsley or cilantro or dhania. All parts of coriander are edible and they are used in ayurvedic medicine, oil, perfumery and culinary purpose. Seed also provides significant amounts of dietary fibre and minerals *viz*., calcium, selenium, iron, magnesium and manganese. India is the world's largest producer of coriander, accounting for more than 70 per cent of global production (Anonymous, 2018). There is little room to expand the area under this crop due to non avalailability of cultivable land and to meet the demand for this spice crop management practices are the only way to increase productivity per unit area per unit time. Again, among various production factors which limit the productivity of coriander is weed management which reduces the yield to agreat extent. Coriander is a short-statured crop grows slowely in the bigning is severely smothered by weeds in its development resulting in severe competition and possibly crop failure. Coriander seed yields are reduced by 20-50 per cent when weed growth are not controlled timely (Nagar *et al*., 2009). During the early stages of growth, there is a lot of competition for the crop, weed management practices are very important not only to check the yield losses but also to increase the nutrient use efficiency.

Generally, weeds are managed manually but, hand weeding is laborious and timely weeding is not possible due to the non-availability of labor along with the very soft and succulent nature of plants make even it is difficult to go for hand weeding. Whereas, physical

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and cultural methods of weed control may not be feasible in the conditions like heavy rainfall and highly weed-infested fields. In such cases exploring the possibility of herbicide usage is most effective and economically feasible. A combination of pre and post-emergence herbicides should be evaluated to manage the complex and dynamic weed flora in coriander throughout the crop growth period. Herbicides applied before and after crop emergence may be a viable option for controlling weeds from seeding to harvesting. Herbicides applied prior to emergence are effective in controlling weeds from the initial crop stage, which may not be possible with manual weeding. Therefore, the study was carried out to find effective herbicides which are economically feasible for weed control and for realizing higher productivity and profitability of coriander crop.

Material and Methods

The experiment was conducted in Agronomy Field Unit, Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bangalore (13° 05' North latitude, 77° 34' East longitude and 924 m above mean sea level altitude) under Eastern Dry Zone (ACZ-V) of Karnataka. The soil of the experimental site was red sandy loam with acidic pH (5.84), electrical conductivity of 0.17 dS m^{-1} and organic carbon content was 0.44 per cent. The soil is low in available nitrogen and medium in available phosphorous and potassium. The experiment was laid out in RCBD with twelve treatments replicated thrice and treatments *viz*., pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE), oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE), oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE), alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE), imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (EPOE), imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE), pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE), oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)-imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE), oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)-imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE), alachlor 50 EC 1000 g a.i. ha^{-1} (PE)-imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE), intercultivation and hand weeding at 20 DAS and 40 DAS a weedy check. The crop was sown in the *rabi* season (15th October 2020 to 2nd February 2021) and received a total rainfall of 268.6 mm. The actual rainfall was more than normal in the months of November, December of 2020 and January of 2021. Variety Arka-Isha was sown in line with row spacing of 30 cm in rows and after two weeks of sowing plant to plnat spacing was maintained by 10 cm spacing between plants. At the time of sowing recommended dose of fertilizer (35:35:35 kg N:P_2O_5:K_2O ha^{-1}) was applied through urea, single super phosphate, muriate of potash, respectively.

Sedges, grasses and broad-leaved weeds were counted separately within a random quadrat of 0.5 x 0.5 m in each net plot at 30, 60, 90 DAS and at the harvest. The weight of oven-dried weeds at 65°C was recorded at each stage. The data on weed density for the normality of distribution, the data were transformed by using the square root (x+1) transformation and log (x+2) transformation. The weed control efficiency was worked out based on the data from weed dry weight in the field using the formula suggested by Mani *et al*. (1973). Plant height, number of branches per plant, dry matter accumulation and leaf area from five randomly selected tagged plants were measured and averaged at 30, 60, 90 DAS and at harvest. The number of umbel per plant, number of umbellets per umbel and number of seeds per umbel were recorded at harvest from five randomly selected tagged plants were counted and averaged. Seeds harvested from net plot were dried and weighed. On the basis of seed weight per net plot, the seed yield per hectare was calculated and expressed in kg ha^{-1}. Weed index was worked out by using the grain yield of coriander. The data obtained were subjected to statistical analysis by analysis of variance (ANOVA) for the randomized block design to test the significance of the over all differences among the treatments by the "F" test and a conclusion was drawn at 5 per cent probability level. The economic feasibility of the treatments was worked out keeping in view the cost of herbicides and current selling price of produce.

$$\text{Weed control efficiency} = \frac{\text{Dry weight of weeds in unweeded check plot-Dry weight of weeds in the treated plot}}{\text{Dry weight of weeds in unnweeded check plot}} \times 100$$

$$\text{Weed index} = \frac{\text{from weed free plot-Yield drom treated for which weed index is to be worked out}}{\text{Yield from weed free plot}} \times 100$$

Results and Discussion

Weed Flora

The most common weed flora found in the experimental fields were *Cyperus rotundus* (L.), *Cynodon dactylon* (L.), *Digitaria sanguinalis* (L.), *Echinochloa colonum* (L.), *Eleusine indica* (L.), while among broad leaf weeds, *Ammannia baccifera* (L.), *Ageratum conyzoides* (L.), *Alternanthera sessilis* (L.), *Borreria articularis* (L.) and *Mollugo verticillate* (L.). Other weeds that were found in lower densities include *Dactyloctenium aegyptium* (L.), *Emilia sanchifolia* (L.), *Euphorbia hirta* (L.) and *Phylanthus niruri* (L.) among broad leaf weeds. At all stages of coriander crop growth in the experimental field, grasses were dominant, followed by broad leaf weeds, and sedge was the lowest.

Effect on Weed

The effect of different herbicides on total weed density, weed dry weight and weed control efficiency in coriander were presented in Table 1 and 2. Significantly lower total weed density in all the stages of coriander and lower weed dry weight (12.64 g m^{-2}) at harvest were observed in treatment involving intercultivation and hand weeding at 20 DAS and 40 DAS, due to the physical uprooting of both above and below ground parts of weeds by the manual hand weeding, which inturn helped in reducing the weed density and weed dry weight. The same treatment also recorded higher weed control efficiency (81 %) as the efficiency of human labor in removing all the types of weeds is high and helps in recording lower weed dry weight. Similar findings were recorded from Dhakad *et al*., 2017 and Yadav *et al*., 2015. Among herbicidal treatments, pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) recorded significantly lower total weed density in all the stages of coriander, weed dry weight (21.73 g m^{-2}) and higher weed control efficiency (67.51 %) at harvest, has it controlled a broad spectrum of weeds by disrupting the nucleus, inhibiting cell division and reducing the total weed density. Even dinitroanilines gave good results because they have a high level of persistence in soil compared to other herbicides. Similar findings were reported from Nagar and Dinesh, 2017 and Kothari *et al*., 2008. However, it was on par with pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE), oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) and oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE).

Fig. 1 shows clearly showed the invers relationship between weed index and weed control efficiency. Lower weed index of 16.67 per cent and 17.05 per cent were recorded from treatment pendimethalin 38.7

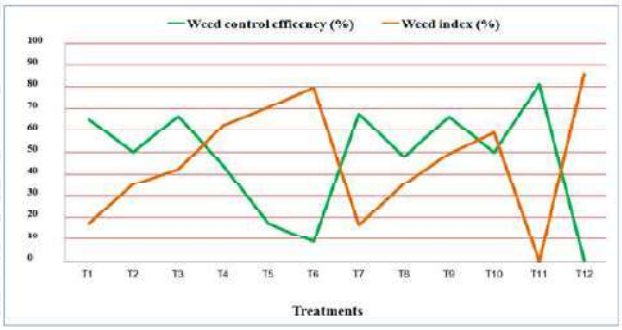

Fig. 1: Weed control efficiency and weed index as influenced by different herbicides in coriander

EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) and pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE), respectively due to efficient control of weeds and reduced crop weed competition helped to achieve good seed yield. Similar results were also reported by Gohil *et al.* (2012) and Nagar *et al.* (2009).

Effect on Crop

Intercultivation and hand weeding at 20 and 40 DAS recorded significantly higher plant height (52.80, 84.78 and 86.41 cm) and number of branches (7.24, 8.88 and 8.88 plant^{-1}) of coriander at 60 DAS, 90 DAS and at harvest, respectively are presented in theTable 3.

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TABLE 1A

Effect of different herbicides on weed density (no. m^{-2}) at 30 and 60 days after sowing of coriander

Treatments	30 DAS				60 DAS			
	Sedge+	Grasses#	Broad leafweeds #	Total#	Sedge+	Grasses#	Broad leafweeds #	Total#
T_1	1.66 (1.80)	0.90 (6.01)	0.95 (7.03)	1.23 (15.84)	1.87 (2.53)	1.17 (12.98)	1.17 (12.93)	1.48 (28.44)
T_2	1.71 (1.93)	1.25 (16.01)	1.09 (10.24)	1.48 (28.18)	1.94 (2.77)	1.32 (19.21)	1.27 (16.93)	1.61 (38.91)
T_3	1.67 (1.79)	0.89 (6.50)	0.95 (7.44)	1.25 (15.73)	1.87 (2.51)	1.11 (11.60)	1.21 (15.76)	1.50 (29.87)
T_4	1.67 (1.80)	1.34 (20.10)	1.24 (15.58)	1.59 (37.39)	1.89 (2.50)	1.41 (23.93)	1.40 (23.53)	1.71 (49.95)
T_5	1.68 (1.86)	1.36 (21.23)	1.38 (23.94)	1.68 (47.28)	1.95 (3.03)	1.43 (25.25)	1.45 (27.12)	1.75 (55.40)
T_6	1.67 (1.80)	1.41 (24.08)	1.37 (27.49)	1.71 (53.37)	1.98 (2.95)	1.48 (28.57)	1.47 (30.42)	1.80 (65.93)
T_7	1.65 (1.71)	0.82 (4.66)	0.94 (6.80)	1.14 (12.17)	1.90 (2.65)	1.11 (10.85)	1.14 (10.77)	1.40 (23.27)
T_8	1.67 (1.79)	1.27 (17.01)	1.25 (17.43)	1.56 (36.03)	1.87 (2.51)	1.36 (24.16)	1.34 (21.91)	1.66 (48.58)
T_9	1.70 (1.88)	0.84 (4.93)	0.98 (7.98)	1.18 (14.29)	1.92 (2.69)	1.14 (11.78)	1.14 (11.87)	1.41 (26.34)
T_{10}	1.67 (1.78)	1.37 (21.75)	1.33 (21.35)	1.66 (44.78)	1.88 (2.55)	1.43 (27.32)	1.41 (26.43)	1.73 (56.30)
T_{11}	1.37 (0.90)	0.73 (3.33)	0.75 (3.92)	1.00 (8.15)	1.58 (1.50)	0.98 (7.98)	0.98 (8.35)	1.28 (19.16)
T_{12}	1.76 (2.11)	1.51 (30.40)	1.46 (29.23)	1.79 (61.59)	2.01 (2.82)	1.56 (34.70)	1.48 (31.36)	1.84 (68.89)
F-test	*	*	*	*	*	*	*	*
SEm±	0.058	0.06	0.07	0.04	0.07	0.05	0.05	0.04
CD at 5 %	0.169	0.18	0.20	0.11	0.19	0.11	0.12	0.11

Data within parentheses are original values; # - data analyzed using log (x+2) transformation, + - square root (x+1) transformation

T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)
T_5 - Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (EPOE)
T_6 - Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS
T_{12} - Weedy check

TABLE 1B

Effect of different herbicides on weed density (no. m-2) at 90 days after sowing and at harvest of coriander

Treatments	90 DAS				Harvest			
	Sedge+	Grasses#	Broad leafweeds #	Total#	Sedge+	Grasses#	Broad leafweeds #	Total#
T_1	2.21 (3.91)	1.45 (26.62)	1.43 (25.15)	1.76 (55.68)	2.24 (4.05)	1.51 (31.58)	1.46 (27.21)	1.81 (62.84)
T_2	2.30 (4.34)	1.57 (35.73)	1.47 (27.73)	1.84 (67.80)	2.36 (4.58)	1.64 (42.30)	1.52 (31.24)	1.90 (78.12)
T_3	2.24 (4.18)	1.49 (28.76)	1.48 (29.00)	1.80 (61.94)	2.25 (4.30)	1.52 (31.23)	1.50 (30.07)	1.83 (65.47)
T_4	2.22 (3.95)	1.57 (39.07)	1.54 (33.14)	1.88 (76.16)	2.23 (4.00)	1.64 (42.10)	1.60 (37.89)	1.93 (83.99)
T_5	2.37 (4.62)	1.63 (40.93)	1.63 (43.00)	1.96 (88.56)	2.36 (4.58)	1.67 (45.37)	1.68 (46.49)	1.99 (97.11)
T_6	2.26 (4.17)	1.64 (41.54)	1.64 (47.32)	1.97 (93.03)	2.41 (4.91)	1.70 (47.66)	1.71 (50.57)	2.02 (103.15)
T_7	2.28 (4.12)	1.43 (25.83)	1.39 (23.12)	1.74 (53.07)	2.29 (4.45)	1.51 (30.71)	1.43 (25.03)	1.80 (60.45)
T_8	2.23 (3.99)	1.56 (34.74)	1.54 (34.48)	1.87 (73.21)	2.24 (4.01)	1.63 (40.92)	1.61 (38.84)	1.93 (83.77)
T_9	2.25 (4.10)	1.44 (26.12)	1.41 (24.16)	1.75 (54.37)	2.33 (4.19)	1.52 (31.13)	1.46 (26.92)	1.80 (62.08)
T_{10}	2.22 (3.97)	1.60 (38.29)	1.58 (40.73)	1.90 (82.99)	2.23 (4.00)	1.63 (40.69)	1.64 (43.71)	1.95 (88.40)
T_{11}	1.69 (1.86)	1.21 (14.56)	1.21 (14.91)	1.51 (31.33)	1.76 (2.10)	1.31 (18.65)	1.27 (16.72)	1.59 (37.48)
T_{12}	2.30 (4.33)	1.67 (45.00)	1.67 (49.75)	2.00 (99.09)	2.50 (5.25)	1.72 (50.61)	1.71 (51.06)	2.03 (106.26)
F-test	*	*	*	*	*	*	*	*
SEm±	0.10	0.07	0.06	0.04	0.11	0.04	0.04	0.03
CD at 5 %	0.29	0.19	0.18	0.12	0.33	0.13	0.11	0.08

Data within parentheses are original values; # - data analyzed using log (x+2) transformation, + - square root (x+1) transformation

T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)
T_5 - Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (EPOE)
T_6 - Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10 % SL @ 25 g a.i. ha^{-1} (PoE)
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS
T_{12} - Weedy check

TABLE 2

Effect of different herbicides on total weed dry weight and weed control efficiency at harvest of coriander

Treatments	Weed dry weight (g m^{-2})			Weed control efficiency (%)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)	2.37	18.40	22.93	83.16	70.50	65.26
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)	4.40	27.57	33.23	69.09	55.59	50.05
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)	2.10	19.55	22.34	85.11	68.86	66.31
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)	4.78	33.16	37.25	66.19	46.78	43.90
T_5 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (EPOE)	9.72	44.93	55.23	31.66	27.97	17.36
T_6 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	10.89	49.33	60.50	23.58	21.06	8.88
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	2.04	17.17	21.73	85.59	72.41	67.51
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	4.68	28.12	34.26	67.00	54.67	47.81
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	2.13	17.53	22.60	85.03	71.81	66.05
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	5.12	31.17	33.10	63.95	49.99	49.90
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS	0.25	5.37	12.64	98.26	91.33	81.00
T_{12} - Weedy check	14.20	62.63	66.50	-	-	-
F-test	*	*	*	*	*	*
SEm±	0.83	1.88	2.54	5.76	2.73	3.40
CD at 5 %	2.45	5.51	7.45	16.89	8.02	9.97

Complete removal of weeds at 20 and 40 DAS by hand weeding which ultimately results in least crop weed competition throughout the crop growth period. Among herbicidal treatments, pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) recorded a significantly higher plant height (42.08, 72.02 and 73.67 cm) and number of branches (5.76, 7.30 and 7.30 $plant^{-1}$) at 60 DAS, 90 DAS and at harvest, respectively as compared to other treatments. Among herbicides pendimethalin is found to be highly efficient in controlling weeds, reduced the crop weed competation and increased the resource availibilty and these findings are in agreement with the results of Hadavani (1995). However, it was on par with pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE), oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) and oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE). Whereas, significantly lower plant height and number of branches were recorded from the weedy check at 60 DAS, 90 DAS and at harvest.

Treatment with intercultivation and hand weeding at 20 and 40 DAS recorded significantly higher leaf area (284.44, 17.97 and 3.98 cm^2 $plant^{-1}$) and dry matter accumulation (6.79, 16.34 and 19.42 g $plant^{-1}$) at 60 DAS, 90 DAS and at harvest, respectively are presented in the Table 4. Among herbicidal treatments,

TABLE 3

Plant height and number of branches per plant at different growth stages in coriander as influenced by different herbicide

Treatments	Plant height (cm)			Number of branches per plant		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)	41.63	71.01	73.05	5.75	7.25	7.25
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)	34.96	57.85	60.72	4.16	5.45	5.45
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)	42.01	70.53	72.69	5.66	7.13	7.13
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)	34.19	56.49	61.10	3.93	4.86	4.86
T_5 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (EPOE)	33.79	54.11	58.70	3.44	5.09	5.09
T_6 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	32.12	51.75	56.62	2.89	3.57	3.57
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	42.08	72.02	73.67	5.76	7.30	7.30
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	35.79	58.31	61.47	4.04	5.53	5.53
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha-1 (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	41.14	70.36	73.13	5.78	7.23	7.23
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	36.20	57.69	61.11	4.00	5.36	5.36
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS	52.80	84.78	86.41	7.24	8.88	8.88
T_{12} - Weedy check	32.69	50.28	54.79	1.75	3.22	3.22
F-test	*	*	*	*	*	*
SEm±	3.00	4.07	3.55	0.42	0.50	0.50
CD at 5 %	8.80	11.92	10.41	1.23	1.48	1.48

pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) recorded a significantly higher leaf area at all the stages as compared to other treatments. The increased leaf area has facilitated to capture of more solar radiation for metabolic use, more CO_2 fixation and produced greater photosynthates which caused a positive effect on biomass production and increased the dry matter production per plant and results are in line with Singh *et al*. (2009). However, it was on par with pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE), oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) and oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE). Whereas, significantly lower leaf area per plant and dry matter accumulation were recorded from the weedy check at 60 DAS and at harvest as it recorded the lowest plant height and number of branches.

Yield attributes, as well as seed yield, were significantly influenced by the application of different herbicides. Results obtained revealed that significantly higher yield attributes like number of umbels per plant (32.28), number of umbellates per umbel (7.71), number of seeds per umbel (30.86) and seed yields (816 kg ha^{-1}) were recorded from intercultivation and hand weeding

TABLE 4

Coriander leaf area (cm^2 $plant^{-1}$) and dry matter accumulation per plant at different growth stages as influenced by different herbicides

Treatments	Leaf area (cm^2 $plant^{-1}$)			Dry matter accumulation (g $plant^{-1}$)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)	227.36	13.44	2.81	5.83	13.04	16.13
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)	177.77	10.12	1.97	4.29	10.29	12.06
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)	235.90	14.50	2.85	5.68	13.27	15.34
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)	151.29	10.12	1.96	3.34	10.11	12.28
T_5 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (EPOE)	142.68	9.92	1.86	3.06	8.11	10.01
T_6 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	139.77	9.67	1.76	2.27	7.17	8.98
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	236.43	14.69	2.99	5.94	13.29	16.35
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	178.79	10.10	2.08	4.84	10.25	12.43
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	231.02	13.84	2.81	5.92	13.24	15.52
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	154.28	9.26	1.91	4.33	9.85	12.59
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS	284.44	17.97	3.98	6.79	16.34	19.42
T_{12} - Weedy check	92.79	8.54	1.55	2.33	5.29	7.05
F-test	*	*	*	*	*	*
SEm±	15.21	1.10	0.25	0.27	0.93	0.93
CD at 5 %	44.61	3.21	0.72	0.79	2.72	2.72

at 20 and 40 DAS are presented in the Table 5 and Fig. 2. Among herbicidal treatments pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) recorded significantly higher yield attributes and which is on par with pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE), oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) and oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE). Among herbicides, pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) recorded higher seed yield (676 kg ha^{-1}) due to efficient control of the weed, reduces the crop weed competition leading to good growth and yield attributes resulted in an increased rate of photosynthesis and supply of photosynthates to various metabolic sinks increased the yield of the crop. These findings are in agreement with those of Yadav

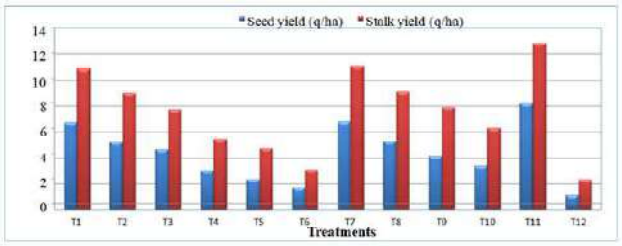

Fig. 2: Seed yield and stalk yield as influenced by different herbicides in coriander

TABLE 5

Number of umbels per plant, number of umbellets per umbel, number of seeds per umbel and thousand seed weight (g) in coriander as influenced by different herbicides

Treatments	No. of umbel per plant	No. of umbellets per umbel	No. of seeds per umbel	Seed yield (kg ha^{-1})	Weed index (%)
T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)	25.24	6.11	23.14	672	17.05
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)	17.38	4.79	14.28	518	35.40
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)	23.36	6.19	23.05	465	42.28
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)	16.92	4.73	15.29	303	62.19
T_5 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (EPOE)	9.87	4.74	14.58	231	70.76
T_6 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	8.49	4.39	10.74	164	79.64
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)-Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	25.45	6.20	23.61	676	16.67
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1}(PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	16.75	4.79	14.86	524	35.54
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	23.39	6.15	21.84	412	49.42
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	16.92	4.01	14.37	336	58.88
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS	32.28	7.71	30.86	816	0.00
T_{12} - Weedy check	6.88	3.97	11.43	110	86.43

TABLE 6

Cost of cultivation, gross retuns, net return and C-B ratio in coriander as influenced by different herbicides

Treatments	Cost of cultivation (Rs.ha-1)	Gross returns (Rs.ha-1)	Net returns (Rs.ha-1)	C : B
T_1 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE)	27101	52465	25364	1.94
T_2 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE)	25178	40564	15386	1.61
T_3 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1} (PE)	26154	37953	11799	1.45
T_4 - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE)	26119	29895	3776	1.14
T_5 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (EPOE)	25319	23954	-1364	0.95
T_6 - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	25319	21258	-4060	0.84
T_7 - Pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	28101	53106	25005	1.89
T_8 - Oxadiargyl 80 WP @ 70 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	26178	43339	17161	1.66
T_9 - Oxyfluorfen 23.5 EC @ 200 g a.i. ha^{-1}1 (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	27154	38319	11165	1.41
T_{10} - Alachlor 50 EC @ 1000 g a.i. ha^{-1} (PE) - Imazethapyr 10% SL @ 25 g a.i. ha^{-1} (PoE)	27119	29054	1935	1.07
T_{11} - Intercultivation and hand weeding at 20 DAS and 40 DAS	38500	66027	27527	1.71
T_{12} - Weedy check	24659	17547	-7111	0.71

TABLE 7

Correlation studies of weed parameters, weed control efficiency, weed index with coriander yield and growth parameters

Particulars	Weed dry weight	Weed density	Weed control efficiency	Weed index	Plant height	Number of branches per plant	Leaf area	Crop dry matter accumulation	Seed yield
Weed dry weight	1.000								
Weed density	0.939 **	1.000							
Weed control efficiency	-1.000 **	-0.941 **	1.000						
Weed index	0.885 **	0.909 **	-0.885 **	1.000					
Plant height	-0.871 **	-0.975 **	0.873 **	-0.847 **	1.000				
Number of branchesper plant	-0.935 **	-0.975 **	0.937 **	-0.890 **	0.965 **	1.000			
Leaf area	-0.842 **	-0.964 **	0.844 **	-0.849 **	0.996 **	0.951 **	1.000		
Crop dry matter accumulation	-0.964 **	-0.981 **	0.965 **	-0.904 **	0.961 **	0.980 **	0.944 **	1.000	
Seed yield	-0.886 **	-0.910 **	0.886 **	-1.000 **	0.850 **	0.891 **	0.852 **	0.906 **	1.00

** Significant at 1%; * Significant at 5%

et al. (2015), Nagar and Dinesh (2017) and Dhakad *et al*. (2017).

Economics

The economics of different herbicides used in coriander are presented in Table 6. Among different treatments, a higher cost of cultivation was recorded in intercultivation and hand weeding at 20 DAS and 40 DAS (Rs.38,500 ha^{-1}) with the highest gross returns (Rs.66,027 ha^{-1}) and net returns (Rs.27,527 ha^{-1}). A higher cost-benefit ratio of 1.94 was obtained in pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) due to higher weed control efficiency with no phytotoxic effect on the crop. Similar results were recorded from Dhakad *et al*., 2017. However, it was followed by pendimethalin 38.7 EC @ 1000 g a.i. ha^{-1} (PE) - imazethapyr 10 per cent SL @ 25 g a.i. ha^{-1} (PoE) recorded 1.89. Whereas, the lowest cost-benefit ratio of 0.71 was recorded from a weedy check.

Correlation Study

Correlation studies of weed parmeter, weed control efficiency, weed index with coriander growth and yield parameters in different herbicides effects on coriander reveled that (Table 7), a strong negative correlation exist between weed dry weight with coriander height, number of branches, leaf area, dry matter accumulation and seed yield. Even similar negative relation was observed with weed density. Highly positive correlation was observed between coriander seed yield and its dry matter(r=0.906**) inturn its dry matter as highly negative relation with that of weed dry matter (r=-0.964**) and density(r=-0.981**), hence weed density and its dry matter should be in lowest as much as possible in order increase the seed yield of coriander.

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