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Hariom
Research Scholar, Department of Agronomy, Sunrise University, Ramgarh, Alwar, Rajasthan, India

Shudhir Singh
Associate Professor, Department of Agronomy, Sunrise University, Ramgarh, Alwar, Rajasthan, India

Sriom
Assistant Professor, Department of Horticulture, Sanskriti University Mathura, Uttar Pradesh, India

Corresponding Author:
Hariom
Research Scholar, Department of Agronomy, Sunrise University, Ramgarh, Alwar, Rajasthan, India

Study the bio-efficacy of herbicides in chickpea and associated weeds chickpea (*Cicer arietinum* L.)

Hariom, Shudhir Singh and Sriom

Abstract

The present investigation entitled "Study the bio-efficacy of herbicides in chickpea and associated weeds Chickpea (*Cicer arietinum* L.)" was undertaken at the Agronomy Research Farm, Sunrise University, Ramgarh, Alwar Rajasthan. during Rabi season of 2021-22 and 2022-23 Experiment was carried out with 12 treatments *viz*: T_1- Imazethapyr + imazamox (PRE), T_2- Imazethapyr+ imazamox (POE) at 3-4 leaf stage, T_3- Imazethapyr (POE) at 3-4 leaf stage, T_4- Quizalofop ethyl (POE) at 3-4 leaf stage, T_5- Clodinofop (POE) at 3-4 leaf stage, T_6- Pendamethalin (PE), T_7- Pendamethalin (PE)+ Imazethapyr (POE), T_8- Oxyfluorfen (PE), T_9- Oxyfluorfen (PE)+ Quizalofop (POE), T_{10}- 1 Hand Weeding at 35-40 DAS, T_{11}- Weed Free and T_{12}- Weedy Check respectively laid out in Randomized Block Design with three replication.

Keywords: Bio-efficacy, weeds chickpea, *Cicer arietinum* L

Introduction

Pulses are an important commodity group of crops that provide high quality protein complementing cereal proteins for pre-dominantly substantial vegetarian population of the country. Although, being the largest pulse crop cultivating country in the world, the cultivation of pulses builds-up a mechanism to fix atmospheric nitrogen in their root nodules and thus meet their nitrogen requirements to a great extent.

In India, pulses can be produced with a minimum use of resources and hence, pulses become less costly even than animal protein. As compared to vegetables, pulses are rich in protein which are less expensive and can be cultivated as sole crop, inter-crop and as mixed crop, as well. Pulses are mostly cultivated under rainfed conditions and do not require intensive irrigation facility and this is the reason that pulses are grown in areas left after satisfying the demand for cereals/cash crops. Even in such conditions, pulses give better returns. Apart from this, pulses possess several other qualities such as they are rich in protein, improve soil fertility and physical structure, fit in mixed/inter-cropping system, crop rotations, dry farming and provide green pods for vegetable and nutritious fodder for cattle as well.

The per capita per day availability of pulses in 1951 was 60 g that dwindled down to a provisional level of 47.2 g in the year 2014. This amply proves that increase in population growth affects the pulses availability on per capita basis.

Introduction of herbicides has made it possible to control a wide spectrum of weeds in pulses effectively at a remunerative cost. Application of pendimethalin as pre-emergence at 1.0 kg ha^{-1} (Tewari *et al*., 2003 and Vaishya *et al*., 2005) [20, 21], imazethapyr as post-emergence at 0.1 kg ha^{-1}, clodinafop-propargyl 15 WP as post-emergence at 0.03 kg ha^{-1} and oxyfluorfen (600 g ha^{-1}) as weed control treatment provided effective control of annual broad leaved and grassy weeds in chickpea field as reported by many research workers from the various parts of the country. Weeds adversely affect the growth, yield and quality of crops by competing with them for space available soil moisture, nutrients and sunlight. Weeds indirectly reduce the yield potential by serving as alternate host to a number of crop pests. Weed species particularly, Vicia sativa in gram, provides shelter to *Helicoverpa armigera*, a major pest of chickpea.

Material and Methods

The field experiment was conducted during *rabi* season of the year 2021-22 and 2022-23 at Agronomy Research Farm of Sunrise University, Ramgarh, Alwar Rajasthan with twelve treatment and replicate thrice. India. The experimental site is situated in main campus of the university. The soil samples were collected at random from five places of the field with the help of a soil auger to a depth of 0-15 cm prior to the application of fertilizer. These samples were mixed together and a composite sample representing the whole field was taken and analysed to study the physico-chemical characteristics of soil of the experimental field and its fertility status. The physical analysis of the soil was done by using the "Bouyoucos & Hydrometer method" as described by Bouyoucos (1936). The observation were recorded Weed flora of the experimental field, Weed density (m-^{2}), Weed dry weight (g m^{-2}), Nitrogen uptake by weeds, Weed control efficiency (WCE) and Weed index (W I).

Result and Discussion

The present investigation entitled "Study the bio-efficacy of herbicides in chickpea and associated weeds in chickpea (*Cicer arietinum* L.)" was conducted during rabi season of 2021-22 and 2022-23 at the Agronomy Research Farm of Sunrise University, Ramgarh, Alwar Rajasthan.

The major weed flora recorded in experimental field in weedy check was *Chenopodium album* and *Anagallis arvensis* BLWs; *Phalaris minor*, *Avena fatua*, *Melilotus alba*, *Convovulus arvensis* and *Cynodon dactylon* among grassy weed and *Cyperus rotundus* as sedges.

The weed density recorded at 30, 60, 90 days and harvesting stage were subjected to statistically analysis. The highest weed density was significantly recorded with weedy check treatment (161.00 and 145.7 m-^{2}) at 30th days, 193.20 and 174.84 m^{-2} at 60th days, 213.00 and 209.81 m-^{2} at 90 days stage and 181.20 and 171.90 m-^{2} at harvesting stage in respective years. In general, the weed density was progressively increased with age of the crop i.e. 30th, 60th, to 90th days, however declined at harvesting stage in all weed control treatments during both years.

Among the herbicides treatments, application of pendamethiline (PE) followed by Imazethapyr (POE) (T) recorded the lowest number of weeds, 2.74 and 2.57 m-^{2} at 60th days, 3.61 and 3.49 m^{-2} at 90th days and 3.44 and 3.22 m^{-2} at harvesting stage in respective years which was followed by Oxyfluorfen (PE) fb Quizalofop ethyl (POE) (T), Imazethapyr + imazamox (POE), however, Imazethapyr+ imazamox (POE) at 3-4 leaf stage (T) was found to be the less effective at all stage of crop growth during both the years.

Table 1: Effect of weed control treatments on density of different weed species at 30 DAS of chickpea 2021-22

Treatments	*C. album*	*P. minor*	*A. arvensis*	*C. dactylon*	Others weeds	Total
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	3.93 (15.00)	2.41 (5.30)	2.05 (3.70)	1.12 (0.75)	2.05 (3.70)	5.37 (28.45)
Imazethapyr+ imazamox (POE) at 3-4 leaf stage @70g a.i ha^{-1}	7.10 (50.00)	4.24 (17.50)	3.53 (12.00)	1.67 (2.30)	3.57 (12.30)	9.71 (94.10)
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	7.51 (56.00)	4.52 (20.00)	3.78 (13.80)	1.76 (2.60)	3.78 (13.80)	10.32 (106.20)
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	8.15 (66.00)	4.86 (23.20)	4.10 (16.30)	1.97 (3.40)	4.09 (16.30)	11.20 (125.20)
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	8.51 (72.00)	5.04 (25.00)	4.27 (17.80)	1.97 (3.40)	4.26 (17.70)	11.66 (135.90)
Pendamethalin (PE) @ 1000g a.i ha^{-1}	4.06 (16.00)	2.47 (5.60)	2.12 (4.00)	1.22 (1.00)	2.12 (4.00)	5.57 (30.60)
Pendamethalin (PE) @ 1000 g a.i. ha^{-1} + Imazothapyr (POE) @ 75 g a.i ha^{-1}	3.08 (9.00)	1.90 (3.10)	1.64 (2.20)	1.00 (0.50)	1.64 (2.20)	4.18 (17.00)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	6.81 (46.00)	4.08 (16.20)	3.45 (11.40)	1.61 (2.10)	3.45 (11.40)	9.35 (87.10)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1} + Quizalofop (POE) @ 60 g a.i ha^{-1}	3.53 (12.00)	2.17 (4.20)	1.87 (3.00)	1.05 (0.60)	1.87 (3.00)	4.82 (22.80)
1 Hand Weeding at 35-40 DAS	4.63 (21.00)	2.81 (7.40)	2.36 (5.10)	1.22 (1.00)	2.38 (5.20)	6.33 (39.70)
Weed Free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy Check	9.23 (85.00)	5.52 (30.00)	4.63 (21.00)	2.12 (4.00)	4.63 (21.00)	12.69 (161.00)
SEm±	0.20	0.12	0.10	0.04	0.11	0.30
CD at 5%	0.59	0.36	0.31	0.13	0.32	0.89

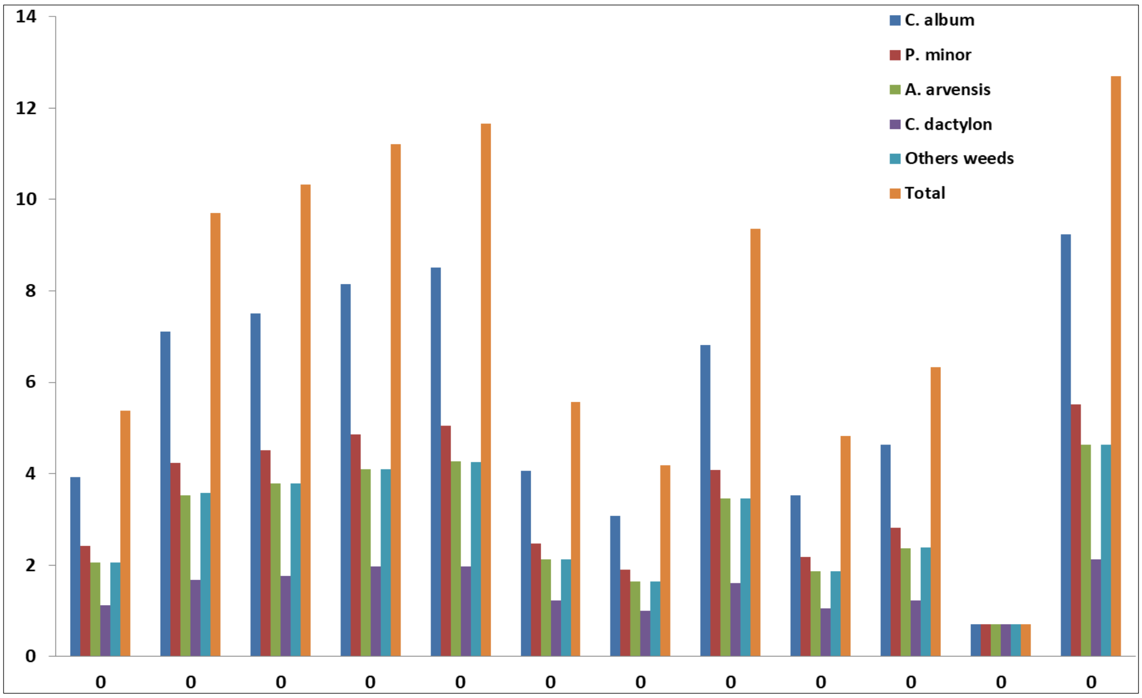

Fig 1: Effect of weed control treatments on density of different weed species at 30 DAS of chickpea 2021-22

Table 2: Effect of weed control treatments on density of different weed species at 30 DAS of chickpea 2022-23

Treatments	*C. album*	*P. minor*	*A. arvensis*	*C. dactylon*	Others weeds	Total
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	3.74 (13.50)	2.30 (4.80)	1.95 (3.30)	1.09 (0.70)	1.97 (3.40)	5.11 (25.70)
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	6.74 (45.00)	4.02 (15.70)	3.36 (10.80)	1.61 (2.10)	3.39 (11.00)	9.21 (84.60)
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	7.10 (50.00)	4.30 (18.00)	3.59 (12.40)	1.70 (2.40)	3.59 (12.40)	9.77 (95.20)
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	7.70 (59.00)	4.61 (20.80)	3.91 (14.80)	1.90 (3.10)	3.88 (14.60)	10.61 (112.30)
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	8.08 (65.00)	4.74 (22.00)	4.06 (16.00)	1.87 (3.00)	4.04 (15.90)	11.05 (121.90)
Pendamethalin (PE) @ 1000g a.i ha^{-1}	3.86 (14.40)	2.34 (5.00)	2.02 (3.60)	1.22 (1.00)	2.02 (3.60)	5.29 (27.60)
Pendamethalin (PE) @ 1000 g a.i. ha^{-1}+ Imazothapyr (POE) @ 75 g a.i ha^{-1}	2.93 (8.10)	1.81 (2.80)	1.58 (2.00)	1.00 (0.50)	1.58 (2.00)	3.99 (15.40)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	6.43 (41.00)	3.91 (14.80)	3.28 (10.30)	1.58 (2.00)	3.24 (10.00)	8.86 (78.10)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1} + Quizalofop (POE) @ 60 g a.i ha^{-1}	3.39 (11.00)	2.12 (4.00)	1.79 (2.70)	1.05 (0.60)	1.79 (2.70)	4.63 (21.00)
1 Hand Weeding at 35-40 DAS	4.41 (19.00)	2.68 (6.70)	2.26 (4.60)	1.22 (1.00)	2.28 (4.70)	6.04 (36.00)
Weed Free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy Check	8.79 (77.00)	5.24 (27.00)	4.41 (19.00)	2.05 (3.70)	4.41 (19.00)	12.07 (145.70)
SEm±	0.20	0.11	0.10	0.04	0.09	0.28
CD at 5%	0.60	0.33	0.30	0.12	0.28	0.81

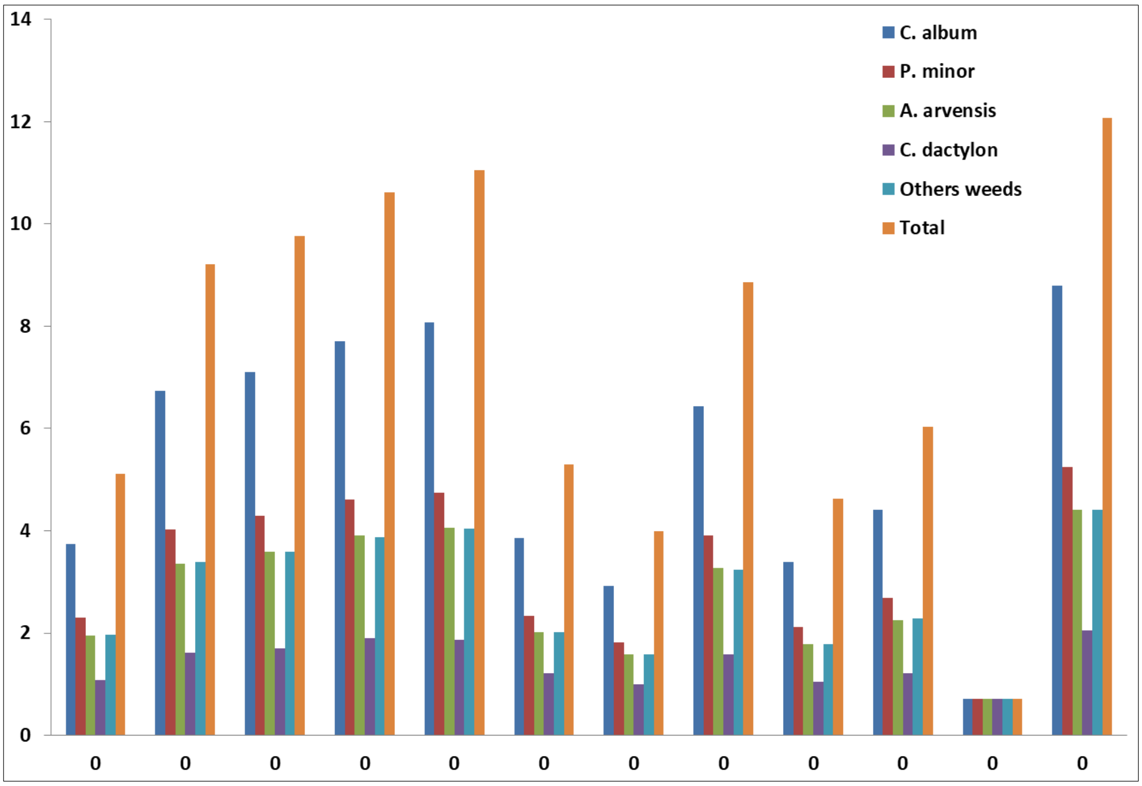

Fig 2: Effect of weed control treatments on density of different weed species at 30 DAS of chickpea 2022-23

Table 3: Effect of weed control treatments on density of different weed species at 60 DAS of chickpea 2021-22

Treatments	*C. album*	*P. minor*	*A. arvensis*	*C. dactylon*	Others weeds	Total
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	2.55 (6.00)	1.90 (3.10)	1.41 (1.50)	0.89 (0.30)	1.41 (1.50)	3.59 (12.40)
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	4.52 (20.00)	2.74 (7.00)	2.30 (4.80)	1.22 (1.00)	2.32 (4.90)	6.17 (37.70)
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	4.79 (22.50)	2.91 (10.00)	2.45 (5.50)	1.26 (1.10)	2.45 (5.50)	6.56 (42.60)
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.18 (26.40)	3.11 (9.20)	2.64 (6.50)	1.38 (1.40)	2.64 (6.50)	7.10 (50.00)
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.43 (29.00)	3.24 (9.20)	2.75 (7.10)	1.38 (1.40)	2.74 (7.00)	7.41 (54.50)
Pendamethalin (PE) @ 1000g a.i ha^{-1}	2.62 (6.40)	1.64 (2.00)	1.45 (1.60)	0.95 (0.40)	1.45 (1.60)	3.56 (12.20)
Pendamethalin (PE) @ 1000 g a.i. ha^{-1}+ Imazothapyr (POE) @ 75 g a.i ha^{-1}	2.02 (3.60)	1.30 (1.20)	1.22 (1.00)	0.84 (0.20)	1.22 (1.00)	2.74 (7.00)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	4.34 (18.40)	2.64 (6.50)	2.24 (4.50)	1.18 (0.90)	2.23 (4.50)	5.93 (34.80)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1} + Quizalofop (POE) @ 60 g a.i ha^{-1}	2.30 (4.80)	1.48 (1.70)	1.30 (1.20)	0.89 (0.30)	1.30 (1.20)	3.11 (9.20)
1 Hand Weeding at 35-40 DAS	2.98 (8.40)	1.87 (3.00)	1.58 (2.00)	0.95 (0.40)	1.61 (2.10)	4.05 (15.90)
Weed Free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy Check	10.12(102.00)	6.03 (36.00)	5.06 (25.20)	2.30 (4.80)	5.06 (25.20)	13.90 (193.20)
SEm±	0.13	0.09	0.08	0.03	0.08	0.22
CD at 5%	0.40	0.28	0.23	0.09	0.24	0.66

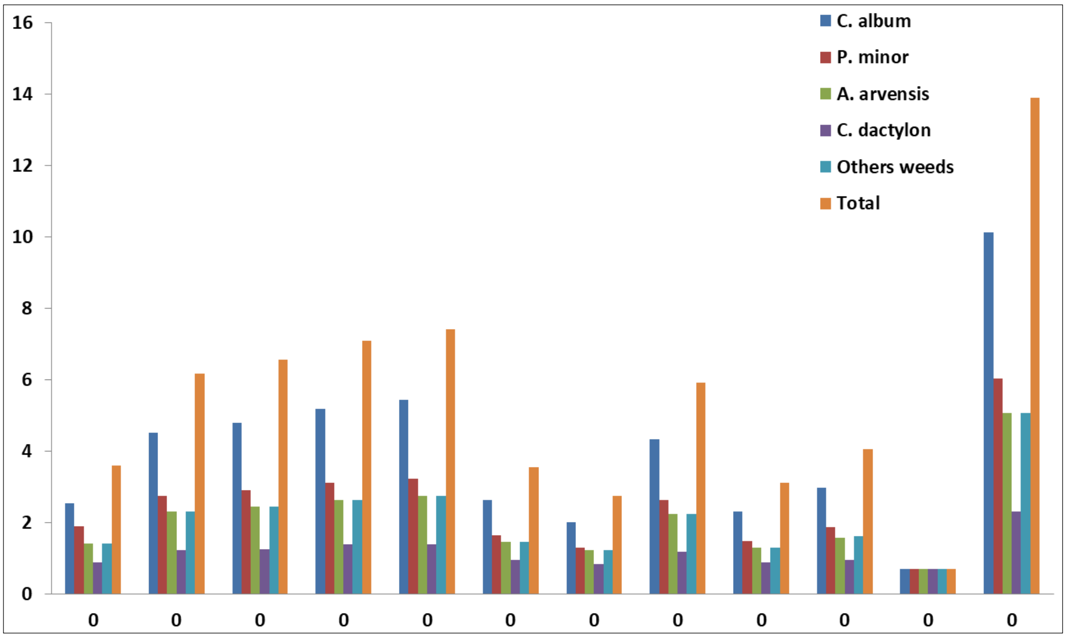

Fig 3: Effect of weed control treatments on density of different weed species at 60 DAS of chickpea 2021-22

Table 4: Effect of weed control treatments on density of different weed species at 60 DAS of chickpea 2022-23

Treatments	*C. album*	*P. minor*	*A. arvensis*	*C. dactylon*	Others weeds	Total
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	2.43 (5.40)	1.55 (1.90)	1.34 (1.30)	0.89 (0.30)	1.38 (1.40)	3.28 (10.30)
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	4.30 (18.00)	2.60 (6.30)	2.19 (4.30)	1.18 (0.90)	2.21 (4.40)	5.86 (33.90)
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	4.53 (20.00)	2.77 (7.20)	2.34 (5.00)	1.22 (1.00)	2.34 (5.00)	6.21 (38.20)
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	4.90 (23.60)	2.96 (8.30)	2.53 (5.90)	1.32 (1.25)	2.51 (5.80)	6.73 (44.85)
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.15 (26.00)	3.05 (8.80)	2.63 (6.40)	1.30 (1.20)	2.62 (6.40)	7.01 (48.80)
Pendamethalin (PE) @ 1000g a.i ha^{-1}	2.51 (5.80)	1.58 (2.00)	1.40 (1.45)	0.95 (0.40)	1.41 (1.50)	3.41 (11.15)
Pendamethalin (PE) @ 1000 g a.i. ha^{-1} + Imazothapyr (POE) @ 75 g a.i ha^{-1}	1.92 (3.20)	1.26 (1.10)	1.14 (0.80)	0.84 (0.20)	1.14 (0.80)	2.57 (6.10)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	4.12 (16.50)	2.53 (5.90)	2.14 (4.10)	1.14 (0.80)	2.12 (4.40)	5.64 (31.30)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}+ Quizalofop (POE) @ 60 g a.i ha^{-1}	2.21 (4.40)	1.45 (1.60)	1.26 (1.10)	0.87 (0.25)	1.26 (1.10)	2.99 (8.45)
1 Hand Weeding at 35-40 DAS	2.84 (7.60)	1.79 (2.70)	1.52 (1.80)	0.95 (0.40)	1.55 (1.90)	3.85 (14.40)
Weed Free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy Check	9.63 (92.40)	5.73 (32.40)	4.82 (22.80)	2.22 (4.44)	4.82 (22.80)	13.23 (174.84)
SEm±	0.13	0.09	0.07	0.02	0.07	0.18
CD at 5%	0.39	0.27	0.22	0.07	0.21	0.53

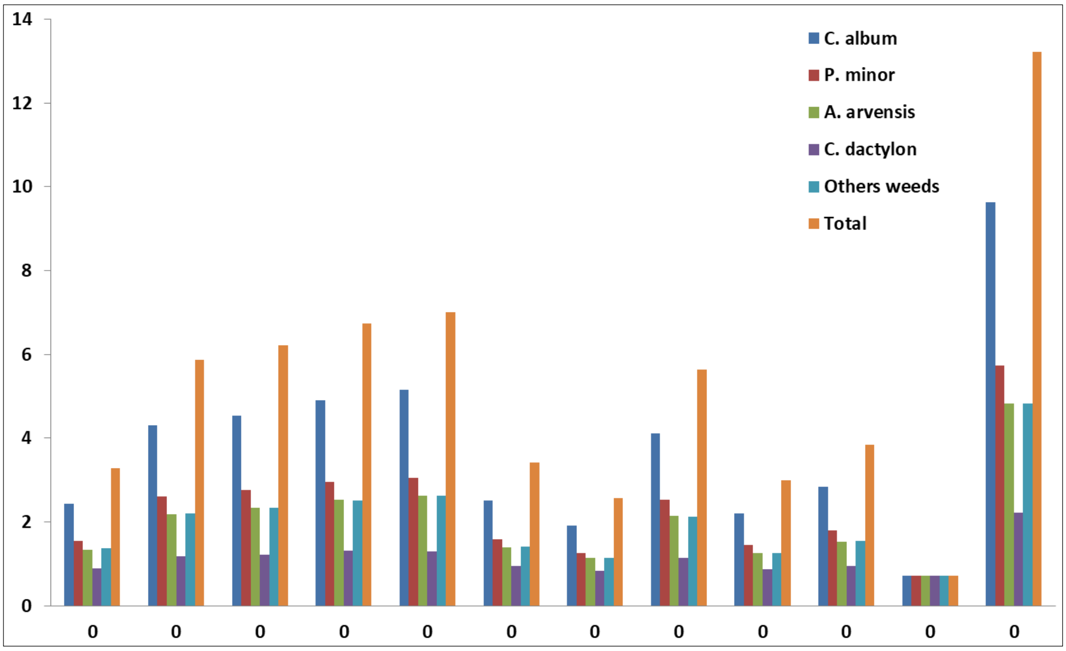

Fig 4: Effect of weed control treatments on density of different weed species at 60 DAS of chickpea 2022-23

Table 5: Effect of weed control treatments on density of different weed species at 90 DAS of chickpea 2021-22

Treatments	*C. album*	*P. minor*	*A. arvensis*	*C. dactylon*	Others weeds	Total
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	2.91 (8.00)	2.14 (4.10)	1.67 (2.30)	1.22 (1.00)	1.76 (2.60)	4.30 (18.00)
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	4.74 (22.00)	2.91 (8.00)	2.47 (5.60)	1.48 (1.70)	2.55 (6.00)	6.61 (43.30)
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	4.99 (24.50)	3.08 (9.00)	2.61 (6.30)	1.52 (1.80)	2.66 (6.60)	6.98 (48.20)
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.37 (28.40)	3.27 (10.20)	2.79 (7.30)	1.61 (2.10)	2.84 (7.60)	7.48 (55.60)
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.60 (31.00)	3.39 (11.00)	2.89 (7.90)	1.61 (2.10)	2.93 (8.10)	7.77 (60.10)
Pendamethalin (PE) @ 1000g a.i ha^{-1}	2.98 (8.40)	1.92 (3.20)	1.70 (2.40)	1.26 (1.10)	1.79 (2.70)	4.27 (17.80)
Pendamethalin (PE) @ 1000 g a.i. ha^{-1} + Imazothapyr (POE) @ 75 g a.i ha^{-1}	2.47 (5.60)	1.64 (2.20)	1.52 (2.00)	1.18 (0.90)	1.61 (2.10)	3.61 (12.60)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	4.57 (20.40)	2.83 (7.50)	2.41 (5.30)	1.45 (1.60)	2.47 (5.60)	6.39 (40.40)
Oxyfluorfen (PE) @200 g a.i ha^{-1}+ Quizalofop (POE) @60 g a.i ha^{-1}	2.70 (6.80)	1.79 (2.70)	1.58 (2.00)	1.22 (1.00)	1.67 (2.30)	3.91 (14.80)
1 Hand Weeding at 35-40 DAS	3.30 (10.40)	2.12 (4.00)	1.81 (1.80)	1.26 (1.10)	1.92 (3.20)	4.69 (21.50)
Weed Free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy Check	10.31 (106.00)	6.35 (40.00)	5.42 (29.00)	3.08 (9.00)	5.43 (29.00)	14.59 (213.00)
SEm±	0.17	0.10	0.08	0.05	0.09	0.25
CD at 5%	0.50	0.30	0.24	0.14	0.25	0.73

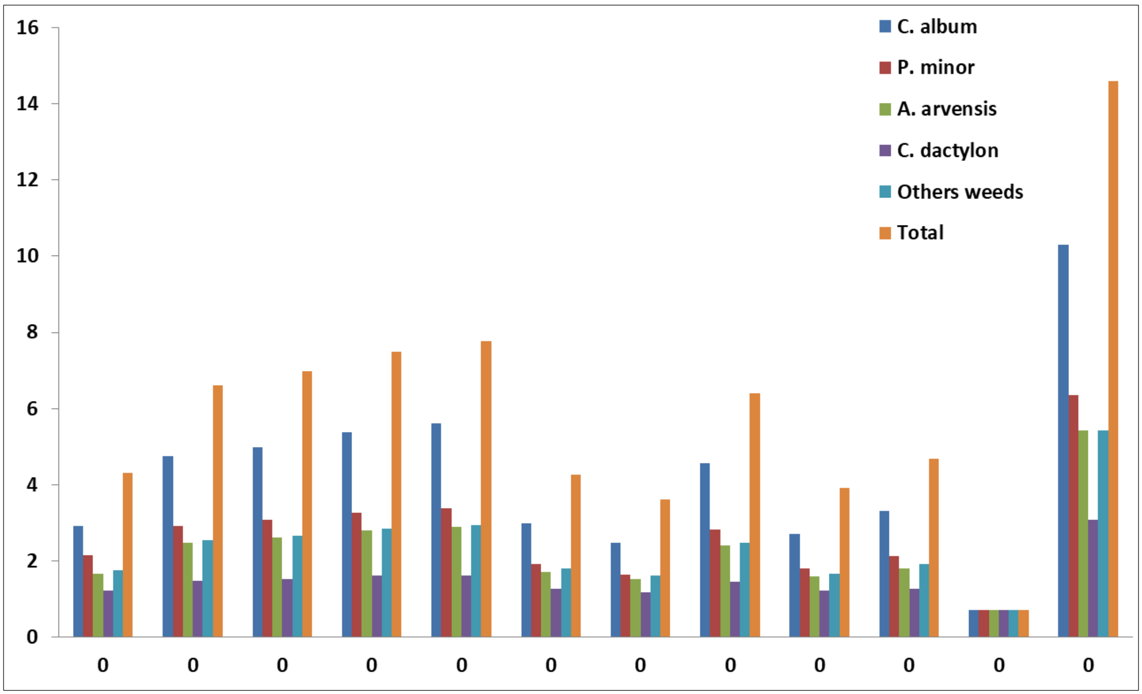

Fig 5: Effect of weed control treatments on density of different weed species at 90 DAS of chickpea 2021-22

Table 6: Effect of weed control treatments on density of different weed species at 90 DAS of chickpea 2022-23

Treatments	*C. album*	*P. minor*	*A. arvensis*	*C. dactylon*	Others weeds	Total
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	2.81 (7.40)	1.84 (2.90)	1.61 (2.10)	1.22 (1.00)	1.73 (3.00)	4.04 (15.90)
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	4.52 (20.00)	2.79 (7.30)	2.36 (5.10)	1.45 (1.60)	2.45 (5.50)	6.32 (39.50)
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	4.74 (22.00)	2.95 (8.20)	2.51 (5.80)	1.48 (1.70)	2.57 (6.10)	6.65 (43.80)
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.33 (28.00)	3.21 (9.80)	2.77 (7.20)	1.55 (1.90)	2.83 (7.50)	7.40 (54.40)
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	5.10 (25.60)	3.13 (9.30)	2.68 (6.70)	1.56 (1.95)	2.72 (7.50)	7.13 (50.45)
Pendamethalin (PE) @ 1000g a.i ha^{-1}	2.88 (7.80)	1.87 (3.00)	1.66 (2.55)	1.26 (1.10)	1.76 (2.50)	4.15 (16.75)
Pendamethalin (PE) @ 1000 g a.i. ha^{-1} + Imazothapyr (POE) @ 75 g a.i ha^{-1}	2.39 (5.20)	1.61 (2.10)	1.45 (1.60)	1.18 (0.90)	1.55 (2.20)	3.49 (11.70)
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	4.35 (18.50)	2.72 (6.90)	2.32 (4.90)	1.41 (1.50)	2.36 (5.10)	6.11 (36.90)
Oxyfluorfen (PE) @200 g a.i ha^{-1}+ Quizalofop (POE)@ 60 g a.i ha^{-1}	2.62 (6.40)	1.76 (2.60)	1.55 (1.90)	1.20 (1.95)	1.64 (6.90)	3.81 (14.05)
1 Hand Weeding at 35-40 DAS	3.18 (9.60)	2.05 (3.70)	1.76 (2.60)	1.26 (1.10)	1.87 (1.90)	4.53 (20.00)
Weed Free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy Check	10.54 (110.88)	6.27 (38.88)	5.27 (27.36)	2.41 (5.33)	5.28 (27.36)	14.49 (209.81)
SEm±	0.17	0.09	0.08	0.04	0.07	0.20
CD at 5%	0.49	0.25	0.25	0.12	0.21	0.58

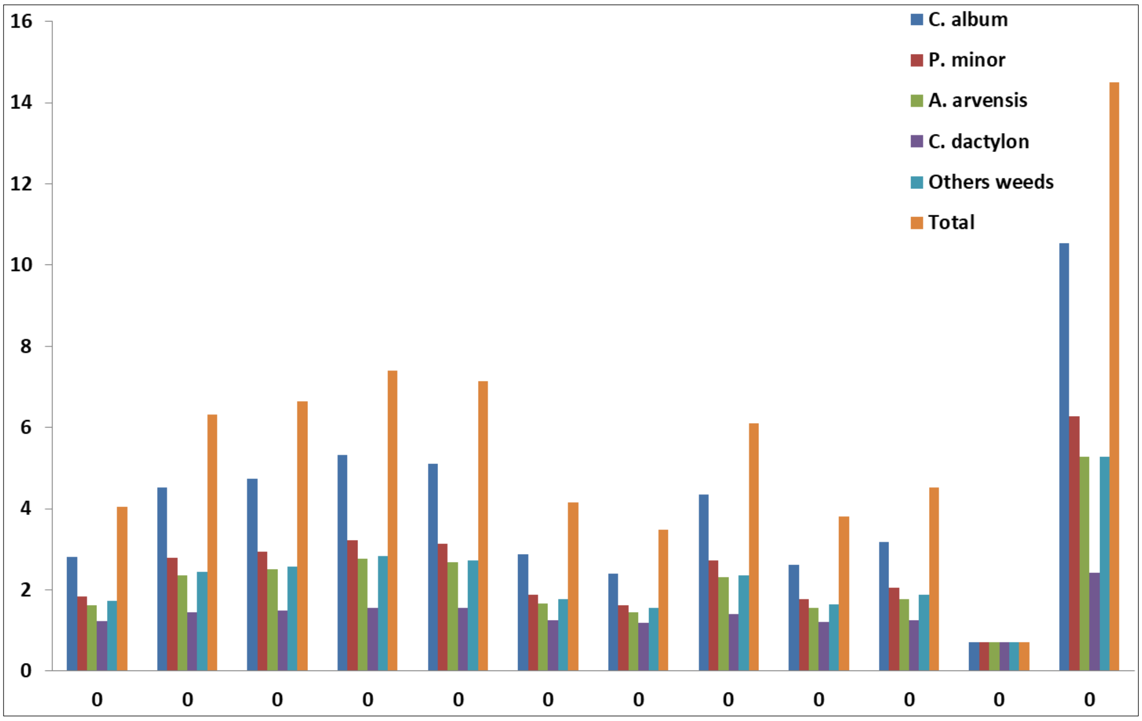

Fig 6: Effect of weed control treatments on density of different weed species at 90 DAS of chickpea 2022-23

Among the pre-emergence herbicides tested application of pendimethalin as pre emergence @ 1000g a.i ha-1 alone maintained its statistical superiority over Oxyfluorfen (PE) as pre mergence @ 200 g a.i ha-1 alone with regards to weed density at all stage of crop growth during both the years. Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha-1, Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha-1 and Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha-1 applied as alone either as pre or post emergence was found it statistical effective superiority over rest of the herbicides..

It is further noted that hand weeding twice maintained its statistical superiority over all treatment of herbicide applied as alone either pre-emergence or pot-emergence except pendimethalin @ 1.0 a.i./ha (PE) in at stage of crop growth during both year of experimentation.

Thus, it is inferred that sequential sprays of pendimethalin (PE) followed by Imazethapyr (PE)- T_7 was found statisticaly effective in reducing weed density during both the years which was followed by T_9, T_1, T_6 and T_{10} at all stage of crop growth, except 60 days stage where T_{10} was found statistical superior as compared to T_6 treatment. However, Pendamethalin (PE) @ 1000g a.i ha^{-1} applied as alone either as pre or post emergence was found it statistical effective statistically superiority over rest of the herbicides**.**

Weed dry weight recorded at 30, 60, 90 days and at harvesting stage yearwise amd total were affected statistically due to different weed management treatments during both the years.

The weed dry weight was recorded significantly the lowest (2.26 g m-2 and 2.16 g m-2) at 30 days (2.77 and 2.59 g m-2) at 60 days (4.98 and 4.82 g m-2) at 90 days stage and (5.63 and 5.46 g m-2) with sequential spray of pendimethalin @ 1.0 L a.i./ha (PE) followed by Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1} which was followed by sequential sprays of Oxyfluorfen (PE)+ Quizalofop (POE) @ 200 g a.i ha^{-1} + @ 60 g a.i ha^{-1} (T_9), Imazethapyr + imazamox (PRE) @ 70g a.i ha-1 (T_1) at all stage of crop growth in both year of experimentation. However, among the herbicide applied single either per emergence or post emergence, application of pendimethaline maintained its superiority over rest of the herbicides treatments at all stage of crop growth during both year of experimentation. Hand weeding twice recorded significantly the lowest dry weight of weed as compared to pendimethaline only at 60th day stage during both the years.

Weedy check treatment recorded significantly the highest weed dry weight (6.63 and 6.30 g m-2) at 30 days (14.04 and 13.37 g m-2) at 60 day stage (20.93 and 20.17 g m-2) at 90 days stage and (18.79 and 18.31 g m-2) in respective years as compared to all weed control treatments. The data revealed that sequential spray of herbicides was found to be the effective as compared to applied alone either pre or post emergence. Sequential spray of pendimethalin pre emergence @ 1000g a.i ha-1 fb Imazathapyr @ 75g a.i ha-1 was found to be the most effective weed control treatment which resulted in highest weed control efficiency i.e. 93.74% and 93.87% in respective years. However, pendimethaline herbicide applied as alone @ 1000g a.i ha^{-1} (Pre emergence) gave the highest weed control efficiency (91.15% and 91.23%) in respective years which was followed Oxyfluorfen (PE) @ 200 g a.i ha^{-1} + Quizalofop (POE) @ 60 g a.i ha^{-1} (92.72% and 92.64%), Imazethapyr @ 75g a.i ha^{-1} (76.05% and 77.05%) in respective years. Hand weeding twice was found to be most effective over of herbicide applied alone either pre or post emergence, except pendimethalin @ 1000g a.i ha^{-1} as pre emergence in both year of experimentation. Among the herbicide application, clodinofop @ 60g a.i ha-1 showed poor performance with weed control efficiency of 70.15% and 71.52% in respective years.

Sequential spray of pendimethalin (POE) @ 1000g a.i ha^{-1} recorded the lowest value of weed index (2.87 and 3.25%) in respective years followed by Oxyfluorfen (PE) @ 200 g a.i ha^{-1} fb Quizalofop (POE) @ 60g a.i ha^{-1} (14.08 and 14.53%), imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha-1 and Imazethapyr + imazamox (PRE) @ 70g a.i ha-1 (8.04 and 7.69%) in respective year. Among the herbicide applied alone either pre or post emergence,, pendimethalin @ 1.0 l a.i. (PE) recorded the lowest values of weed index (12.35% and 12.36%) which was followed by Oxyfluorfen (PE) 200 g a.i ha^{-1} (17.16 and 17.66%). The highest values of weed index (46.26 and 16.32% was under weed check treatment. Two hand weeding resulted in lower value of weed index (14.08 and 14.52%) as compared to herbicides applied alone treatments either post emergence except pendimethalin @ 1000g a.i ha^{-1} applied as pre – emergence which resulted in the lowest weed index (12.35 and 12.36%) in respective years.

Hence, weedy check treatment reduce the grain yield of chickpea to the tune of (46.26% and 46.32%) in respectively years. However, sequential spray of pendimethalin @ 1000g a.i ha^{-1} fb imazethapyr @ 75g a.i ha^{-1} gave the lowest reduction in grain yield (8.04 and 7.69%) in respective years.

Among the different weed control treatments, application of quizalofop (PRE) and Imazethapyr @ 60 g a.i. ha^{-1} (post emergence) was foundto be effective as compared to pre-emergence applied herbicide treatments e.g. pendimethalin @ 1000 g a.i. ha^{-1} and oxyfluorfen @ 200 g a.i. ha^{-1} (PE) which controlled the different weed species very effectively at all the stages of crop growth (60th, 90th & at harvest). The response of these all the treatments (T_2, T_3 and T_7, T_9) was almost same and superior over pre-emergence applied of either Pendamethalin (PE) + Imazethapyr (POE) (T_7) or Oxyfluorfen (PE) + Quizalofop (POE) (T_9) during both the years. However, combined application of pendimethalin showed comparatively better response over combined application with oxyfluorfen treatments. It might be due to the fact that in these combinations; BLWs were controlled by pendimethalin and oxyfluorfen and grassy weeds (Phalaris minor and Avena fatua) by quizalofop and imazamox. Sharma *et al*. 2009 and Punia *et al*. 2009 reported similar results. However, the response of Pendamethalin (PE)+ Imazothapyr (POE) @ 1000 g a.i. ha- 1+ @ 75 g a.i ha-1 (T_7) also declined the density of different weed species appreciably and proved superior over imazethapyr @ 75 g a.i. ha-1 as PoE alone. It might be due to better control of weeds by T_7 over T_9 especially BLWs, as Chenopodium album was one of the major dominating weed species in the experiment. In these treatments, though weed density declined fairley but some sort of phytotixicity on the crop was observed, which reduces the yields adversely. The similar type of results was reported by Mishra *et al*. (2005); Patel *et al*. (2006) [18] and Singh (2007).

In case of tank mixed herbicide treatments i.e. Pendamethalin (PE)+ Imazothapyr (POE) @ 1000 g a.i. ha^{-1}+ @ 75 g a.i ha^{-1} (T_7) and Oxyfluorfen (PE) @ 200 g a.i ha^{-1} (T_8), alone as well as applied in combination over pendimethalin @ 750 g a.i. ha-1 (PE) alone followed by Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1} (T_1) controlled the density and dry matter of weeds very effectively at 60th, 90th day and at harvest stage during both years of experimentation this decline was mainly due to phytotoxic effect of oxyfluorfen + quizalofop or pendamethalin + imazethapyr. Population of all the weed species and crop plants was burnt due to phytotoxicity. However, in case of pendimethalin @ 1000 g a.i. ha^{-1} with combination pendamethalin + imazethapyr (T_7) showed comparatively less phytotoxicity over treatments T_4, T_8 and T_9. Consequently in the later stages, chickpea crop rejuvenate to some extent, although, yield level were still poor over weed free and other good treatments. The reports are in the conformity of Ratnam *et al*. (2011) [19].

Table 7: Effect of weed control treatments on weed control efficiency (%) at harvest stage of chickpea

Treatments	Weed control efficiency	
	2017-18	2018-2019
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	91.05	91.66
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	78.50	79.32
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	76.05	77.05
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	72.38	73.58
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	70.15	91.52
Pendamethalin (PE) @ 1000g a.i ha^{-1}	91.18	91.23
Pendamethalin (PE) @ 1000 g a.i. ha^{-1} + Imazothapyr (POE) @ 75 g a.i ha^{-1}	93.74	93.87
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	79.96	80.68
Oxyfluorfen (PE) @ 200 g a.i ha^{-1} + Quizalofop (POE) @ 60 g a.i ha^{-1}	92.77	92.64
1 Hand Weeding at 35-40 DAS	89.33	89.52
Weed Free	-	-
Weedy Check	-	-

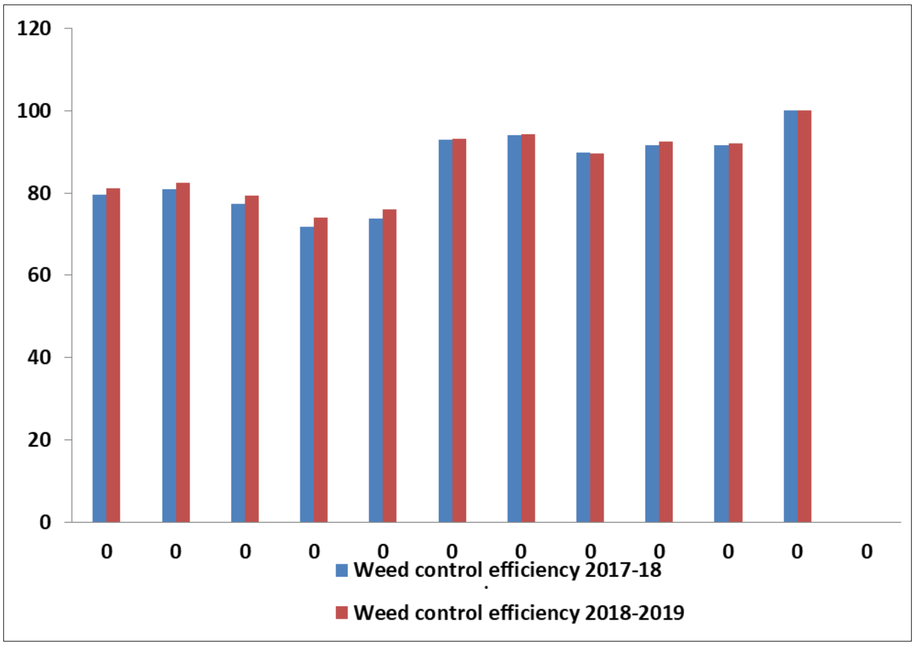

Fig 7: Effect of weed control treatments on weed control efficiency (%) at harvest stage of chickpea

Table 8: Effect of weed control treatments on weed index (%) at harvest stage of chickpea

Treatments	Weed index	
	2017-18	2018-2019
Imazethapyr + imazamox (PRE) @ 70g a.i ha^{-1}	18.97	19.32
Imazethapyr + imazamox (POE) at 3-4 leaf stage @ 70g a.i ha^{-1}	17.82	17.66
Imazethapyr (POE) at 3-4 leaf stage @ 75g a.i ha^{-1}	20.40	20.46
Quizalofop ethyl (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	24.71	24.22
Clodinofop (POE) at 3-4 leaf stage @ 60g a.i ha^{-1}	21.26	21.37
Pendamethalin (PE) @ 1000g a.i ha^{-1}	8.05	7.69
Pendamethalin (PE) @ 1000 g a.i. ha^{-1} + Imazothapyr (POE) @ 75 g a.i ha^{-1}	2.87	3.25
Oxyfluorfen (PE) @ 200 g a.i ha^{-1}	14.08	14.53
Oxyfluorfen (PE) @ 200 g a.i ha^{-1} + Quizalofop (POE) @ 60 g a.i ha^{-1}	12.07	11.97
1 Hand Weeding at 35-40 DAS	12.36	12.36
Weed Free	0.00	0.00
Weedy Check	46.26	46.32
SEm±	-	-
C.D. at 5%	-	-

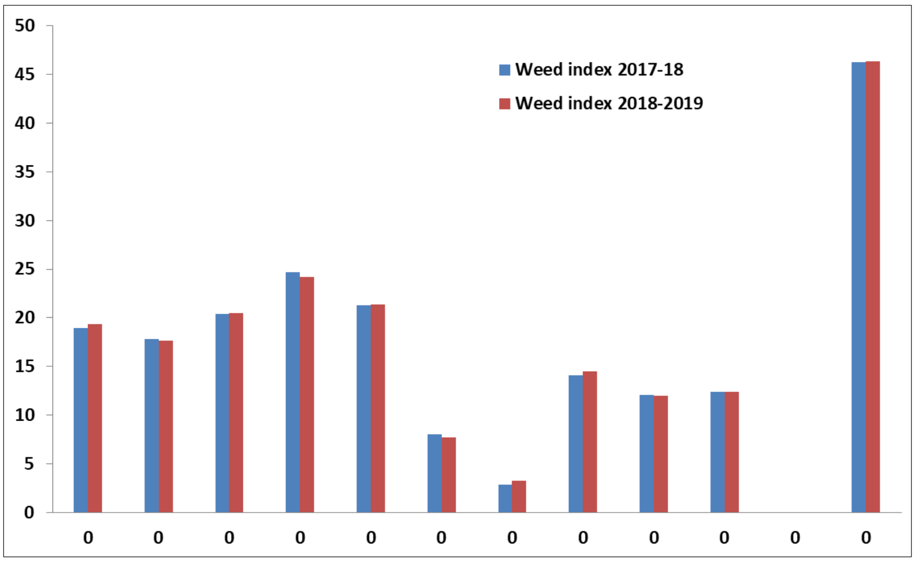

Fig 8: Effect of weed control treatments on weed index (%) at harvest stage of chickpea

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