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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 401-404

www.thepharmajournal.com
Received: 01-01-2023
Accepted: 04-02-2023

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Effect of pre and tank mix post emergence herbicides application on growth, yield and economics of chickpea (*Cicer arietinum* L.)

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Abstract
An experiment entitled "Weed management in chickpea (*Cicer arietinum* L.,)" was conducted during *rabi* 2021 at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule. Experiment consisted of ten treatments laid out in randomized block design with three replications. Among the different weed control treatments, grain yield and straw yield was observed better with application of oxyfluorfen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_{10}) and it was found at par with application of pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_7), pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_3) and oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_4). Higher gross returns, net monetary returns and B:C ratio was under the treatment with application of oxyfluorfen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_{10}) among the different weed management treatments when compared to the application of herbicides alone.

Keywords: Chickpea, pre emergence, tank mix post emergence, grain yield and economics

Introduction
Chickpea plays a major role in enhancing soil fertility through their nitrogen-fixing capacity. It can fix up to 140 kg N ha^{-1} in a growing period [6]. It adds plenty of organic matter for maintaining and improving soil health and fertility. It leaves a considerable amount of residual nitrogen for subsequent crops. It has been distinguished into two categories based on seed characteristics, the 'Desi' types, with relatively small, angular seeds with a rough texture and the 'Kabuli' types, which are larger, rounded and cream-colored seeds.
India contributes 70% of the total world chickpea production of 116.2 lakh tonnes cultivated fewer than 112 lakh hectares with a productivity of 1036 kg ha^{-1} in 2020-21 [1]. In chickpea weeds emerge and grow rapidly in many flushes. In the legumes principally in the case of chickpea pendimethalin @ 1000 g ha^{-1} applied as pre-emergence is a very typical herbicide that is used to control all types of weeds, but there are no herbicides available to apply as post-emergence to control the emerging BLWs effectively. Even if the pre-emergence application of herbicide is missed due to any reason, in that case, post-emergence herbicide application to control the grassy, as well as non-grassy weeds, is very much required. No matter how hand weeding has been found very effective but the shortage of labor when there is a need and at more rates has become a serious question. The chickpea, in spite of the fact that it is an important *rabi* pulse crop yet no required information on efficient weed management, is available, especially for the eastern part of Uttar Pradesh where the sowing of chickpea is further delayed due to many problems. So, the application of individual herbicides alone is not much more effective and economical weed control measures under such conditions. In the current time, some of the very effective high-potential herbicide molecules have evolved which may be useful to limit the wide spectrum of weed infestation in chickpea. Further, if their molecules are used in a mixture may be more effective to control the wide spectrum of weeds.
It will assist the farmers and also to scientific workers to conduct research on the weed management of chickpea. It makes better weed control practices that comprise chemical weed control with newer formulations and herbicide blends. The assumption is that weeds can be controlled effectively and yield is maintained at a lower rate of input practices by the improved management strategy.

Material and Methods

The field experiment was conducted in the *rabi* season of year 2021. Climatologically, this area falls in the sub-tropical region at the North. Generally monsoon commences by third week of June and retreats at the end of September with the average annual rainfall of 607 mm. Experiment consisted of ten treatments laid out in randomized block design with three replications. The treatments consist with weedy check (T_1), weed free (T_2), pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_3), oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_4), pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* imazethapyr 0.1 kg *a.i* ha^{-1} (PoE) (T_5), pendimethalin 1 kg *a.i.* ha^{-1}(PE) *fb* quizalofop ethyl 0.05 kg *a.i* ha^{-1} (PoE) (T_6), pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_7) oxyflurofen 0.1 kg *a.i.* ha^{-1}(PE) *fb* imazethapyr 0.1 kg *a.i* ha^{-1} (PoE) (T_8), oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* quizalofop ethyl 0.05 kg *a.i* ha^{-1} (PoE) (T_9) and oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE)(T_{10}). The seed of chickpea variety Phule Vikram was sown on 17th November 2021 at spacing of 30 x 10 cm^2 using seed rate 70 kg ha^{-1}. The fertilizer was applied as per the recommended dose to chickpea crop as 20:50:25 kg NPK ha^{-1}. The required quantity of herbicides *viz.*, pendimethalin, oxyfluorfen, quizalofop ethyl and imazethapyr was measured by weighing balance and measuring cylinder at the time of preparation of solution according to treatments. The spraying was done by using knapsack sprayer with flat fan nozzle using 500 liters of water ha^{-1}. The crop was grown with recommended package of practices and was harvested at maturity on 16th March 2021. A statistical method of analysis of variance and interpretation of data as suggested by [5], for split plot design. Standard error of mean (SEm) was worked out for each factor and interaction. Whenever the results were significant, the critical difference (C.D.) at 5 per cent level of significance was worked out.

Results and Discussion

Effect of weed management treatments on yield attributes and yield

The important yield contributing characters like number of pods plant^{-1}, number of seeds pod^{-1}, weight of grain plant^{-1}, test weight (g) were significantly more under weed free treatment. Among the different weed management treatments, application of oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_{10}) was significantly superior over other weed management treatments but it was at par with application of pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_7), pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_3) and oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_4). The grain and straw yield (qt ha^{-1}) of chickpea was recorded to be significantly higher (27.21 and 66.42 qt ha^{-1}, respectively) in weed free treatment (T_2). Among the different weed control practices, spraying of oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_{10}) which recorded significantly maximum grain and straw yield (25.47 qt ha^{-1} and 62.94 qt ha^{-1}) as compared to other treatments of weed control and it was found at par with application of pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_7), pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_3) and oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_4). Among the different weed control practices used in the experiment, application of pre-emergence herbicide followed by post emergence tank mix herbicide treatment was found significantly better than application of post-emergence herbicide only in respect of grain and straw yield of chickpea may probably be due to better weed management resulting in improvement in all growth and sink parameters which contributed higher yield owing to favourable condition in absorbing soil moisture, nutrient content and sunlight penetration during crop growing period. The grain and straw yield was significantly lowest under weedy check treatment. These results correlate with the findings of [2], [3] and [7]

Effect of different weed management practices on economics of chickpea

The gross and net monetary returns were found maximum (₹ 136060 and ₹ 89860 ha^{-1}, respectively) in weed free (T_2) treatment. Among the different weed control treatments, application of oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_{10}) recorded highest gross and net monetary returns (₹ 127345 and ₹ 89459 ha^{-1}, respectively) than other weed management treatments and was found to be at par with application of pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_7) (₹124856 and ₹ 86596 ha^{-1}, respectively), pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_3) (₹124228 and ₹ 84450 ha^{-1}, respectively) and oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_4) (₹122294 and ₹82890ha^{-1}, respectively). The benefit cost ratio was also maximum in application of oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_{10}) (3.36) followed by pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE) (T_7) (3.26), pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_3) (3.12) and oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding (T_4) (3.10). These treatments were observed to be better to other treatments. These results corroborate with the findings of [8], [4], [3] and [7]

Table 1: No. of pods plant $^{-1}$, weight of pods plant $^{-1}$(g), weight of grain plant $^{-1}$(g) and 100 grain weight (g) as influenced by different herbicidal treatments

Treatment Details		No. of pods plant $^{-1}$	Weight of pods plant $^{-1}$(g)	Weight of grain plant $^{-1}$(g)	100 grain weight (g)
T_1	Weedy check	55	17.96	13.39	18.43
T_2	Weed free	75	28.33	26.63	19.07
T_3	Pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding	69	24.32	22.28	18.83
T_4	Oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding	68	23.94	21.91	18.84
T_5	Pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* imazethapyr 0.1 kg *a.i* ha^{-1} (PoE)	64	20.59	18.96	20.56
T_6	Pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* quizalofop ethyl 0.05 kg *a.i* ha^{-1} (PoE)	63	19.40	18.05	17.60
T_7	Pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE)	70	24.71	22.53	15.91
T_8	Oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* imazethapyr 0.1 kg *a.i* ha^{-1} (PoE)	64	21.21	19.17	17.94
T_9	Oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* quizalofop ethyl 0.05 kg *a.i* ha^{-1} (PoE)	63	19.94	18.46	19.19
T_{10}	Oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE)	71	25.98	22.98	16.88
	SE(m)	1.46	0.56	0.95	0.99
	C. D. @ 5%	4.35	1.67	2.84	NS
	General mean	66.16	22.64	20.44	18.33

Table 2: Grain yield (qt ha^{-1}), straw yield (qt ha^{-1}), total cost of cultivation (₹ ha^{-1}), gross returns (₹ ha^{-1}), net returns (₹ ha^{-1}) and B:C ratio in chickpea crop as influenced by different treatments

Treatment Details		Grain yield (qt ha^{-1})	Straw yield (qt ha^{-1})	Gross returns (₹ ha-1)	Total cost of cultivation (₹ ha-1)	Net returns (₹ ha-1)	B:C ratio
T_1	Weedy check	5.69	23.37	028426	30000	-1574	0.94
T_2	Weed free	27.21	66.42	136060	46200	89860	2.94
T_3	Pendimethalin 1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding	24.97	61.94	124228	39778	84450	3.12
T_4	Oxyfluorfen 0.1 kg *a.i.* ha^{-1} at PE *fb* one hand weeding	24.46	60.92	122294	39404	82890	3.10
T_5	Pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* imazethapyr 0.1 kg *a.i* ha^{-1} (PoE)	20.80	53.61	104022	36544	67478	2.84
T_6	Pendimethalin 1 kg *a.i.* ha^{-1}(PE) *fb* quizalofop ethyl 0.05 kg *a.i* ha^{-1} (PoE)	19.90	51.80	099506	37204	62302	2.64
T_7	Pendimethalin 1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE)	24.85	61.69	124856	38260	86596	3.26
T_8	Oxyflurofen 0.1 kg *a.i.* ha^{-1}(PE) *fb* imazethapyr 0.1 kg *a.i* ha^{-1} (PoE)	20.90	53.79	104486	36170	68316	2.88
T_9	Oxyflurofen 0.1 kg *a.i.* ha^{-1}(PE) *fb* quizalofop ethyl 0.05 kg *a.i* ha^{-1} (PoE)	20.45	52.89	102232	36830	65402	2.77
T_{10}	Oxyflurofen 0.1 kg *a.i.* ha^{-1} (PE) *fb* tank mix imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) (PoE)	25.47	62.94	127345	37886	89459	3.36
	SE(m)	0.48	0.97	973.74	698.31	1187.91	-
	C. D. @ 5%	1.45	2.90	2893.23	2074.87	3529.60	-
	General mean	21.47	54.94	110346	37827	69517	-

Conclusion

Among the different weed control treatments application of pre-emergence herbicide *i.e.* oxyfluorfen 0.1 kg *a.i.* ha^{-1} followed by post-emergence application of tank mix herbicides *i.e.* imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) at 20 DAS (PRE followed by (*fb*) tank mix POST) will provide more consistent weed control than the other method of weed management. This kept the weeds in control and resulted in producing a maximum yield of chickpea crop. From the economic point of view application of pre-emergence herbicide *i.e.* oxyfluorfen 0.1 kg *a.i.* ha^{-1} followed by post-emergence application of tank mix herbicides *i.e.* imazethapyr (50% *a.i.*) + quizalofop ethyl (50% *a.i.*) at 20 DAS could be economical viable treatment based on B: C ratio amid various weed management treatments.

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