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RESEARCH NOTE

Integrated weed management minimizing crop yield reduction in vegetable peas

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ABSTRACT

Research experiment was carried out at the ICAR-Indian Agricultural Research Institute (IARI), New Delhi, during the winter season of 2021-22 (28°382 N latitude, 77°102 E longitude; altitude 229 m above mean sea level) to study the effect of integrated weed management practices in vegetable pea. Randomized complete block design with three replications was used to set up eight treatments as detailed in methodology. Compared to conventional weed management practices, integrated weed management is a viable option for effective weed management in vegetable peas. Sequential application of pre- and post-emergence herbicides, in conjunction with other practices such as mulching and mechanical weeding, effectively reduces crop-weed competition at critical growth stages, giving the crop a competitive advantage to grow to its full potential, positively influencing biomass production and crop productivity and lesser reduction in crop yield. As a result, sequential application of pendimethalin as PE 750 g/ha *fb* mulch *fb* ready mix of (metribuzin + clodinafop) as PoE 270 g/ha may be recommended for effective weed control, profitability, and long-term sustainability of vegetable peas. Next option could be mechanical weeding, which suppresses weeds, reduces herbicide use, and improves soil aeration, better nutrient mineralization, better soil tilth, temperature regulation, and also improves the water holding capacity of the soil.

Keywords: Integrated weed management, Metribuzin + clodinafop, Vegetable peas, Weed control efficiency, Weed control index

Vegetable pea (*Pisum sativum* var. *hortense* L.) is an important Leguminosae family winter crop. It is consumed worldwide in both fresh and processed forms. It is thought to have originated in the Near East and the Mediterranean, and it has been cultivated since the early Neolithic period (Ambika *et al.* 2022). India outperforms all other countries in terms of vegetable pea production. Vegetable pea is commercially grown in Northern India's plains during the *Rabi* (winter) season, whereas it is successfully grown in hilly areas during the summer months because it requires a cool climate for optimal growth in the early stages, it is grown as a *Rabi* crop from the beginning of October till end of November. Its growth is more likely in areas with a smooth transition from cold to warm weather. Cultivation in India is limited to 5.49 lakh ha with a production of 56.8 lakh MT and a productivity of 10.34 MT/ha (1st Advance Estimate, 2021-22). In the Delhi foothills, vegetable pea is grown as a second crop after rainy season crops such as maize and paddy. Currently, there is a significant mismatch between potential and realized yield in the state's vegetable pea production. During 2020-2021, approximately 0.3 lakh hectares of vegetable pea was cultivated in Delhi, yielding 0.7 lakh tonnes and a productivity of 2333 kg/ha. Talking about its constituents, peas are high in protein, sugars, carbohydrates, minerals, vitamins A, B, and C, and essential amino acids. In addition, a large portion of peas are processed (canned, frozen, or dehydrated) for year-round consumption (Anonymus 2019-20). Because of its slow growth and wide spacing, it provides ample opportunity for weeds to grow during the early stages of its life cycle, resulting in acute crop-weed competition for water, nutrients, space, and sunlight, resulting in a 40-70% reduction in crop yield (Harker *et al.* 2009).

Herbicide weed control is becoming more important and effective due to its ease of use, timely and precise weed control, and more economical (Kulshrestha *et al.* 2000, Sen *et al.* 2021). In peas only one broad spectrum herbicide namely pendimethalin has been recommended and used as pre-emergence (after 2-3 days of sowing) since long and it is quite effective for controlling weeds upto 15-20 days but, what about the weeds coming after 20-25 days after sowing? Using only pre-emergence herbicides are insufficient to control a wide range of weeds present under field conditions. Therefore, integration of herbicides with some other cultural options like use of crop residues, mechanical/manual weeding may provide effective weed control (Kaur *et al.* 2020a and 2020b). The outlook for weed

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management improves when chemical weed control methods are integrated into systems that link cultural, mechanical, rotational, and biological methods. By integrating weed management options, we can reduce chemical load (residue) issues in soil, plants, and water. Keeping these facts in view, this experiment entitled "Comparing the effectiveness of integrated weed management techniques in controlling weeds and minimizing crop yield reduction in vegetable pea (*Pisum sativum* var. *hortense* L.)" was planned and executed with an objective to study the effect of integrated weed management strategies on crop growth, productivity and yield loss. In this paper, the effect of integrated weed management practices on weed control efficiency, weed control index and reduction in crop yield due to weed infestation has been discussed.

The field experiment was carried out at the ICAR-Indian Agricultural Research Institute (IARI), New Delhi, during the winter season of 2021-22 (28°382 N latitude, 77°102 E longitude; altitude 229 m above mean sea level). The climate at the site is semi-arid and subtropical, with hot and dry summers and cold winters. The soil at the study site was sandy loam, with a pH of 7.8, EC of 0.47 dSm^{-1} and OC of 0.41%. A randomized complete block design with three replications was used to set up eight treatments *viz a viz.* mulch followed by (*fb*) metribuzin 70% WP (100g/ha) as early post-emergence at 2-3 leaf stage, mulch *fb* quizalofop 5% EC (50 g/ha) as post-emergence at 30 DAS, mulch *fb* metribuzin + clodinafop (270 g/ha) as post-emergence at 30 DAS, pendimethalin 30% EC (750 g/ha) as pre-emergence at 2 DAS *fb* mulch *fb* quizalofop-p-ethyl 5% EC (37.5g/ha) as post-emergence at 30 DAS, pendimethalin 30% EC (750 g/ha) as pre-emergence at 2 DAS *fb* Mulch *fb* metribuzin + clodinafop (270 g/ ha) at 30 DAS, two mechanical weeding (Pusa Mini Electrical Prime Mower) at 25 and 50 DAS, weed-free check (WFC), where weeds were manually removed to keep the crop weed-free throughout the crop growth and unweeded control (UWC), where weeds were allowed to grow with crops throughout the crop growth. Air-dried maize residue (3 t/ha as applicable to treatments) was immediately retained on the soil surface as mulch. All herbicides were applied with a knapsack sprayer fitted with a flat fan nozzle using 500 L/ha water. Vegetable pea (cv. *Pusa Pragati*) was sown on 11^{th}, November 2021, using 80 kg seed/ha. The observations on weeds were taken with a 1 m^2 quadrat at 40, 70 days after sowing and at harvest. The data on weed density and dry matter production was analyzed using square root transformation as ($\sqrt{x+0.5}$) for uniformity in their distribution. The data on weed control efficiency (WCE), weed control index (WCI) and weed index (WI) was calculated using the following equations:

$$WCE\ (\%) = (WP_c - WP_t)/WP_c * 100 \qquad (1)$$

where, WP_c and WP_t are weed density ($no.m^{-2}$) in UWC and treatment plots, respectively.

Weed control index (WCI), which reflects per cent reduction in weed dry weight by a treatment compared to UWC was determined using eq. 2.

$$WCI\ (\%) = (WD_c - WD_t)/WD_c * 100 \qquad (2)$$

where, WD_c and WD_t are weed dry weights (g/m^2) in the UWC and treatment plots, respectively.

Weed index (WI) is a measure of the efficiency of particular treatment in terms of yield output compared with that in WFC. It reflects percent yield loss due to weeds in a treatment compared to WFC and was calculated using eq. 3.

$$WI\ (\%) = (Y_{wf} - Y_t)/Y_{wf} * 100 \qquad (3)$$

where, Y_{wf} and Y_t are green pea yields in the WFC and treatment plots, respectively.

Weed interference and control efficiency

The major weed flora of the experimental site consists of a mixture of grassy, broad-leaved weeds and sedges (*Anagrallis arvensis*, *Chenopodium album*, *Chenopodium murale*, *Coronopus didymus*, *Fumaria parviflora*, *Medicago denticulata*, *Melilotus indica*, *Spergula arvensis*, *Avena ludoviciana*, *Cynodon dactylon*, *Phalaris minor*, *Asphodelus tenuifolius*, *Lolium temulentum* and *Cyperus rotundus*). The highest weed control efficiency (WCE) and weed control index (WCI) was obtained in weed free treatment, as this treatment was kept deliberately free from weeds throughout the crop growth period (**Table 1**). The highest WCE and WCI in this treatment was obtained because of zero competition between the crop and weeds. Among herbicidal treatments, application of pendimethalin fb mulch fb (metribuzin + clodinafop) recorded (60.58%) of WCE followed by mechanical weeding (58.39%) at harvest. Similarly, these two treatments were statistically at par in obtaining the WCI at harvest which was 62.2% with mechanical weeding and 60.4% with application of pendimethalin fb mulch *fb* (metribuzin + clodinafop) (**Table 1**). This could be attributed to the herbicide mixture's broad-spectrum activity and persistence, which reduced weed competition due to lower weed density and dry matter accumulation and was sustained throughout the crop growth period. Reduced crop-weed competition at critical growth stages increased the crop growth and made more space, nutrients, moisture, and light available. The findings of this study are consistent with the findings of another experiment, which discovered that an increase in seed yield could be attributed to effective weed control during the critical period of crop weed competition, which in turn reduced biotic stress (due to weed competition) and thus provided a weed-free environment. (moisture, nutrients, sunlight, *etc.*) for better growth and yield. (Kaur *et al.*). Remaining treatments recorded comparatively less WCE and WCI at all observational stages of the crop. The lowest WCE (33.20%) and WCI (32.09%) was reported in treatment where, mulch was applied followed by metribuzin at 100 g/ha as early post-emergence at 2-3 crop leaf stage.

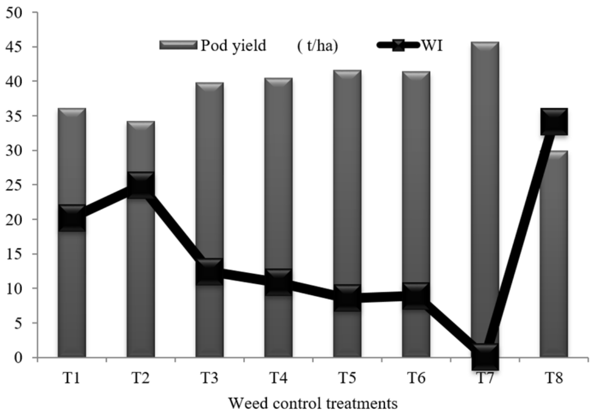
The plots treated with pendimethalin *fb* mulch *fb* quizalofop-p-ethyl, were able to provide good to excellent weed control. While pendimethalin is primarily a broad-leaf killer, quizalofop-p-ethyl herbicide is predominantly grass killer. It inhibits ACCase, a multifunctional, biotinylated protein found in plastid stroma that catalyses the ATP-dependent condensation of acetyl CoA and bicarbonate (HCO3-) to malonate in the fatty acid biosynthesis pathway (Liang Tong 2012). As a result, their integration has been shown to be more effective than most other treatments. In addition to this, inclusion of crop residues in the treatment further improved the WCE as well as WCI as weed seeds didn't get sufficient light and space to grow and compete with the crop.

Weed index

The weed index measures reduction in crop yield under different treatments due to presence of weeds in comparison to weed free plot. The reduction in yield ranged from 8.60 to as high as 34.12% because of the weed infestation observed under different weed control treatments (**Figure 1**). The reported yield loss was higher where application of only pre or post emergence herbicides was done. In the treatments where sequential application of herbicides along with retention of crop residue as mulch was done, reported less yield reduction. Pre-emergence application of pendimethalin *fb* mulch fb application of metribuzin + clodinafop had the lowest weed index (8.60%) or in other words we can say that reduction in yield in this treatment was less followed by mechanical weeding (8.94%). These two treatments were statistically at par with each other and significantly superior to rest of the treatments. Mechanical weeding (Pusa Mini Electrical Prime Mower at 25 and 50 DAS), showed promising results with lesser yield reduction and these results obtained may be because of better soil proliferation, uprooting of newly emerging weeds, better soil aeration and better root growth with mower at 25 and 50 DAS. Weeds compete with the crops for various growth factors like water, nutrients, space, light etc. and ultimately reduced the crop yield depending on the density and dry matter of weeds. In the treatments, where pre-emergence application of the herbicide was done, it controls the weeds which germinate along with the crop and post-emergence application of herbicide controls the second and afterward coming flushes of the weeds. So sequential application of herbicides reported less competition in these treatments compared to other treatments, resulting in lower yield reduction. In the weed free treatment (WFC, T_7), no reduction in yield was reported as no competition was there and this treatment was significantly superior to the rest of treatments studied. Contrary to this, unweeded control (T_8), where weeds were allowed to grow along with the crop and not a single weed control

Table 1. Weed control index (WCI) and Weed control efficiency (WCE) at 40, 70 days after sowing (DAS) and at harvest

Treatment	WCI (%)			WCE (%)		
	40 DAS	70 DAS	At harvest	40 DAS	70 DAS	At harvest
Mulch *fb* metribuzin 100g/ha EPoE at 2-3 leaf stage	31.41	33.70	33.20	36.66	38.63	32.09
Mulch *fb* quizalofop 50 g/ha PoE at 30 DAS	32.22	36.01	33.55	38.14	49.94	27.98
Mulch *fb* metribuzin + clodinafop 270 g/ha PoE at 30 DAS	47.47	51.68	45.46	47.04	59.38	44.65
Pendimethalin 750 g/ha PE at 2 DAS *fb* mulch *fb* quizalofop-p-ethyl 37.5g/ha PoE at 30 DAS	47.55	51.35	46.45	49.21	53.93	42.12
Pendimethalin 750 g/ha PE at 2 DAS *fb* Mulch *fb* metribuzin + clodinafop (270 g/ha) at 30 DAS	69.35	66.77	60.40	69.07	76.34	60.58
Two mechanical weedings (Pusa Mini Electrical Prime Mower) at 25 and 50 DAS	77.75	69.28	62.24	72.73	76.78	58.39
Weed-free check (WFC)	100.00	100.00	100.00	100.00	100.00	100.00
Unweeded control	0.00	0.00	0.00	0.00	0.00	0.00
LSD(p=0.05)	6.72	3.77	2.34	4.54	7.42	5.62



T_1- mulch *fb* metribuzin 100g/ha EPoE at 2-3 leaf stage, T_2- mulch *fb* quizalofop 50 g/ha PoE at 30 DAS, T_3- mulch *fb* metribuzin + clodinafop 270 g/ha PoE at 30 DAS, T_4- pendimethalin 750 g/ha PE at 2 DAS *fb* mulch *fb* quizalofop-p-ethyl 37.5g/ha PoE at 30 DAS, T_5- pendimethalin 750 g/ha PE at 2 DAS *fb* Mulch *fb* metribuzin + clodinafop (270 g/ha) at 30 DAS, T_6- two mechanical weedings (Pusa Mini Electrical Prime Mower) at 25 and 50 DAS, T_7- weed-free check (WFC) and T_8- unweeded control

Figure 1. Weed index (WI) showing vegetable pea yield losses across the various treatments

method was imposed for controlling weeds, recorded the maximum reduction in crop yield ranging to the tune of 34.12 % as seen in **Figure 1**. Weeds are more aggressive and competitive in nature; therefore, a significant reduction was noticed in this treatment and this treatment was significantly inferior to rest of the treatments.

Application of pre-emergence herbicide followed by (*fb*) post-emergence herbicides can improve broad-spectrum weed control, prevent weed shift, and delay resistance (Das *et al*. 2014, Kaur *et al*. 2020a). The plots treated with a combination of pre- and post-emergence application of herbicides as pendimethalin *fb* mulch *fb* quizalofop-p-ethyl was reported to provide good to excellent weed control. As a result, their integration has been shown promising results compared to other treatments. Our findings supported previous research results which found that integration of herbicides with some agro-practices, such as mechanical/manual weeding and crop residues, can selectively stimulate crop growth/ vigour and increase their competitiveness against weeds (Johnson and Holm 2010, Shalini and Singh 2014, Sen *et al.* 2020, Kaur *et al.* 2020a).

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