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Chemical weed management in pea (*Pisum sativum* L.)

S. K. DAS

Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani- 741235, Nadia, West Bengal, India

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ABSTRACT

Field experiments were conducted for three years at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal, India during rabi 2010, 2011 and 2012 to develop an efficient eco-friendly chemical weed management practice with newer herbicidal molecules in pea. The experiment was laid out in a randomized block design with three replications having twelve treatments viz. W_0 – Weedy check, W_1 – Hand weeding twice at 15 and 30 DAS, W_2 – Pendimethalin @ 1.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS, W_3– Quizalofop ethyl @ 37.5g ha^{-1} as PoE (Post-emergence) at 10-15 DAS, W_4 – Chlorimuron ethyl @ 4.0g ha^{-1} as PoE (10-15 DAS),W_5 – Fenoxaprop-p-ethyl @ 50g ha^{-1} as PoE (10-15 DAS), W_6 – Imazethapyr @ 25ml ha^{-1} as PoE (15-20 DAS), W_7 – Pendimethalin @ 2.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS, W_8 –Quizalofop ethyl @ 75 g ha^{-1} as PoE (Post-emergence)at 10-15 DAS, W_9 – Chlorimuron ethyl @ 8.0g ha^{-1} as PoE (10-15 DAS), W_{10} – Fenoxaprop-p-ethyl @ 100g ha^{-1} as PoE (10-15 DAS), W_{11} – Imazethapyr @ 50ml ha^{-1} as PoE (15-20 DAS). Experimental results revealed that highest seed yield (961.0 kg.ha^{-1}) was recorded under the treatment W_1 and lowest with W_0 (421.0 kg.ha^{-1}). Application of chemical herbicides significantly improved the seed yield over W_0. Application of Imazethapyr @ 25ml ha^{-1} as PoE (916.0 kg.ha^{-1}) was found at par with W_1. The lowest weed density and weed dry weight (8.3 gm^{-2})was recorded in hand weeding twice followed by application of Imazethapyr @ 50ml ha^{-1}as PoE (15-20 DAS) (12.1 gm^{-2}). Among the chemical herbicides, applied at recommended doses, Imazethapyr @ 25ml ha^{-1}as PoE at15-20 DAS recorded highest (71 %) weed control efficiency with significantly higher seed yield. Overdose of chemical herbicides though recorded higher weed control efficiency but reduced pea yield due to negative effect on plant growth and yield attributing characters. Chemical weed control measures increased the total microbial population by 23 to 76.7 per cent over weedy check and 10.6 to 58.9 per cent over twice hand weeding It was also revealed that nodulation in pea was not affected significantly due to the application of chemical herbicides.

Keywords: Chemical weed management, microbial population, nodulation, seed yield, weed control efficiency

With the growing population of the world in general and the developing countries in particular, demands are overwhelmed for enhanced food production. Besides emphasizing on main crops and vegetables, various pulses also play an important role to satisfy the growing human food demands. Among many others, pea is an important pulse crop and a source of food for the people. Pulses are mostly grown by the small and marginal farmers under resource constraints situation. Pea is mostly grown by the farmers during *rabi* season. Weeds are a major problem for pea production. Weeds cause 37.3 to 64.4 per cent reduction in pea yield (Tewari *et al*., 1997; Banga *et al*.; 1998 and Harker, 2001). Peas are poor competitors, particularly at the seedling stage, avoiding early season weed interference is critical. The critical period for crop weed competition in pea is up to 60 days after sowing (Kumar *et al*., 2009). Weeds can hamper pea production in many ways. First, weeds can reduce yield through competition for light, moisture, nutrients, and space. Second, weeds may harbour insect pests and pathogens that can affect crop production. Finally, late season weeds can be a nuisance that reduces harvest efficiency. Since hand weeding and other weed control methods are laborious, time consuming, costly and difficult, chemicals are the obvious and cost effective methods of weed control. For this many pre-emergence herbicides were released and used by the farmers but very few post-emergence herbicides are available. The chemical weed control method is becoming popular among the farmers as they continue to realize the usefulness of herbicides.

Therefore, this experiment was initiated with the objective to develop a suitable, effective and eco friendly chemical weed management practice for pea and at the same time to study the effect of over dose application of these herbicides on pea.

MATERIALS AND METHODS

Field experiments were conducted at Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal, India situated at 24^{0}60'N latitude, 88^{0}15' E longitude at an elevation of 19.0 meters above the mean sea level (MSL) during *rabi* 2010, 2011 and 2012. Initial soil samples were collected randomly from different locations of the experimental area with the help of auger from 0-15 cm. soil depth. Those were then thoroughly mixed, dried in shade and sieved and the volume of soil samples to be analyzed were there after reduced using partitioning method. Those soil samples were then kept in polythene bags for mechanical and chemical analysis. The soil of the experimental field

E-mail: sanjibag@gmail.com

was sandy loam in texture and slightly alkaline in reaction (pH 7.5) having total N content of 0.051 per cent, 74 kg available P_2O_5 ha^{-1} and 112 kg available K_2O ha^{-1} . The experiment was laid out in a randomized block design with three replications having twelve treatments *viz.* W_0 – Weedy check, W_1 – Hand weeding twice at 15 and 30 DAS, W_2 – Pendimethalin @ 1.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS, W_3– Quizalofop ethyl @ 37.5g ha^{-1} as PoE (Post-emergence) at 10-15 DAS, W_4 – Chlorimuron ethyl @ 4.0g ha^{-1} as PoE (10-15 DAS),W_5 – Fenoxaprop-p-ethyl @ 50g ha^{-1} as PoE (10-15 DAS), W_6 – Imazethapyr @ 25ml ha^{-1} as PoE (15-20 DAS), W_7 – Pendimethalin @ 2.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS, W_8 –Quizalofop ethyl @ 75 g ha^{-1} as PoE (Post-emergence) at 10-15 DAS, W_9 – Chlorimuron ethyl @ 8.0g ha^{-1} as PoE (10-15 DAS), W_{10} – Fenoxaprop-p-ethyl @ 100g ha^{-1} as PoE (10-15 DAS), W_{11} – Imazethapyr @ 50ml ha^{-1} as PoE (15-20 DAS) with a plot size of 4 x 3 m. Treatments W_2 to W_6 were the recommended doses for respective herbicides and treatments W_7 to W_{11} were the double the recommended doses of the respective herbicides. The short duration pea variety used was 'GF-68' and the seed rate was 60 kg ha^{-1}. sown with a spacing of 30 x 10 cm. The fertilizer applied was 20-40-40 kg N-P- K ha^{-1}. applied as basal in the form of urea, single super phosphate and muriate of potash. The herbicides were sprayed by using hand operated knapsack sprayer fitted with herbicide nozzle of ASPEE ULV 100. The spray volume used was 400L ha^{-1}. Density of weeds *viz.*, grasses, sedges and broad leaf weeds were recorded species wise in a fixed square meter area at pre treatment, 15, 30 and 45 DAS. Dry weight of weeds were recorded from 0.25 m^2 destructive sampling area.

Weed control efficiency was also calculated as suggested by Maity and Mukherjee (2011). For microbial population study, soil samples were collected from each treatment and from this representative soil sample of each treatment, 1g of field soil was measured by precision balance and then it was diluted up to 10^6 times by following serial dilution method as done by Elad *et al*. (1980), Baker (1968) and Naher (2013). Then this diluted soil was spreaded into the media plates to develop microbial colony. To enumerate total bacterial, fungal and actinomycetes population nutrient agar (NA), potato dextrose agar (PDA) amended with 30ppm rose bengal and actinomycetes media plates were used, respectively. The number of Colony Forming Units (CFU) were counted 1DA (Day after) 3DA and 6DA by keeping the plates in incubator at 25-30°C as done by Elad *et.al.*(1980), Baker (1968) and Naher (2013). The microbial population was expressed in terms of CFU g^{-1} of soil. Nodulation was studied at 15 days interval starting from 15 DAS up to 45 DAS. Only active nodules were considered. The nodules with the pink colour of leg haemoglobin were considered active nodules. Nodules were dried in a hot air oven at 75°C and their dry weights were recorded in a sensitive balance to get the dry weight of nodule per plant.

Data on seed yield (kg ha^{-1}) were recorded at harvest. Analysis of variance of the data in the experimental design and comparison of means at pd"0.05 were carried out, using MSTAT-C software.

RESULTS AND DISCUSSION

Yield attributing characters and seed yield

Experimental results revealed that weed management practices significantly influenced the yield attributing characters and seed yield of pea variety GF-68 (Table 1 and 2). Based on the pooled value of three years, it was observed that highest plant height (61 cm), number of primary branches $plant^{-1}$ (2.8), number of pods $plant^{-1}$ (13.8), number of seeds pod^{-1} (5.92), test weight (14.4 g) and seed yield (961 kg.ha^{-1}) was recorded under the treatment W_1 (Twice hand weeding), might be due to adequate weed control during the cropping period, which provided maximum moisture and nutrients for healthy plant growth (Sultana *et al*., 2009) and lowest plant height (40 cm), number of primary branches $plant^{-1}$ (2.0), number of pods $plant^{-1}$ (7.1), number of seeds pod^{-1} (5.25), test weight (13.5 g) and seed yield (421 kg.ha^{-1}) was recorded with weedy check (W_0) which was mainly due to heavy infestation of weeds. These results corroborated with the findings of Mathukia *et al*.(2015). Application of chemical herbicides significantly improved the seed yield over W_0. Among the chemical weed control measures, application of Imazethapyr @ 25ml ha^{-1}as PoE (15-20 DAS)(W_6) recorded highest plant height (58 cm), number of primary branches $plant^{-1}$ (2.7), number of pods $plant^{-1}$ (12.3), number of seeds pod^{-1} (5.85), test weight (14.1g) and seed yield (916 kg ha^{-1}) of pea which was found *at par* with W_1, mainly attributed to better weed control efficiency by reducing the weed density and weed dry weight with no harmful effect on plant. The result corroborated with the findings of Hanson and Thill (2001). These results corroborated with the findings of Das *et al*. (2014), Asaduzzaman *et al*. (2010) and Mundra and Maliwal (2012). But application of higher or double dose of Imazethapyr @ 50ml ha^{-1}as PoE (15-20 DAS) recorded significant yield reduction (829 kg ha^{-1}) compared to application of Imazethapyr @ 25ml ha^{-1}mainly attributed to shorter plant height (51 cm), reduced number of primary branches per plant (2.5), pods $plant^{-1}$ (10.9), seeds pod^{-1} (5.67) and test weight (13.8 g) with thickened leaves and shorter internodes length which might be due to a toxic effect of on plant growth by the use of overdose of the herbicide. These sorts of findings were also recorded for other chemicals also.

Table 1: Effect of different weed management practices on seed yield (kg.ha^{-1}) of pea (pooled)

Treatment	2010	2011	2012	Mean
W_0 – Weedy check	432	410	420	421
W_1 – Hand weeding twice at 15 and 30 DAS	987	925	971	961
W_2 – Pendimethalin @ 1.0 kg ha^{-1}as PE (pre-emergence) at 1 DAS	843	886	875	868
W_3– Quizalofop ethyl @ 37.5g ha^{-1}as PoE (Post-emergence) at 10-15 DAS	855	828	837	840
W_4 – Chlorimuron ethyl @ 4.0g ha^{-1} as PoE (10-15 DAS)	748	720	731	733
W_5 – Fenoxaprop-p-ethyl @ 50g ha^{-1} as PoE (10-15 DAS)	834	825	810	823
W_6 – Imazethapyr @ 25ml ha^{-1}as PoE (15-20 DAS)	934	900	914	916
W_7 – Pendimethalin @ 2.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS	837	819	774	810
W_8 – Quizalofop ethyl @ 75 g ha^{-1} as PoE (Post-emergence)at 10-15 DAS	737	715	741	731
W_9 – Chlorimuron ethyl @ 8.0g ha^{-1} as PoE (10-15 DAS)	584	683	665	644
W_{10} –Fenoxaprop-p-ethyl @ 100g ha^{-1} as PoE (10-15 DAS)	812	786	805	801
W_{11} –Imazethapyr @ 50ml ha^{-1}as PoE (15-20 DAS)	827	815	845	829
SEm (±)	**22.9**	**24.6**	**23.7**	**24.0**
LSD (0.05)	**68.3**	**73.3**	**70.5**	**71.2**

Weed flora

The experimental field was dominated by natural infestation of broad leaf weed (BLW) like *Anagalis arvensis , Chenopodiuln album, Convolvulus arvensis, Fumaria parviflora, Melilotus alba, Lathyrus aphaca, Euphorbia hirta, Parthenium hysterophorus, Gnaphalium leuteoalbum, Commelina banghalensis* and grasses like *Echinochloa colona, Cynodon dactylon, Digitaria sanguinalis* and sedges like *Cyperus rotundus*. The maximum weed density and weed dry weight(56.5 gm^{-2}) was recorded in weedy check followed by Chlorimuron ethyl @ 4.0g ha^{-1} as PoE at 10-15 DAS (26.8 gm^{-2}) are given in table 3. The lowest weed density and weed dry weight (8.3 gm^{-2})was recorded in hand weeding twice followed by application of Imazethapyr @ 50ml ha^{-1}as PoE (15-20 DAS) (12.1 gm^{-2}) (Table 3). Weed dry weight reflects the growth potential of the weeds and is a better indicator of its competitive ability with the crop plants. Un-weeded check recorded the highest weed growth and weed biomass. Highest weed control efficiency (85.3%) was recorded with hand weeding twice followed by application of Imazethapyr @ 50ml ha^{-1}as PoE at15-20 DAS (78.6%). Hand weeding at 15 DAS effectively prevent or control early emerged weeds followed by hand weeding at 30 DAS control the later emerged weeds (Yadav *et al*., 2004). Among the chemical herbicides, applied at recommended doses, Imazethapyr @ 25ml ha^{-1}as PoE at15-20 DAS recorded highest (71 %) weed control efficiency with significantly higher seed yield. Overdose of chemical herbicides though recorded higher weed control efficiency but reduced pea yield due to negative effect on plant growth and yield attributing characters.

Total microbial population

Total microbial population was significantly influenced by weed management practices. Highest microbial population (64.5×10^6 CFU g^{-1} of soil) at harvest was recorded with application of Fenoxaprop-p-ethyl @ 50g ha^{-1}as PoE (10-15 DAS) which was found *at par* with W_2, W_3, W_4, W_6, W_{10} and W_{11} and lowest with hand weeding twice (36.5×10^6 CFU g^{-1} of soil). The result was in conformity with the findings reported by Ali *et.al*. (2014). Twice hand weeding recorded significantly lower microbial population than chemical weed control measures. This was in conformity with Sapundjieva *et.al*. (2008). Chemical weed control measures increased the total microbial population by 23 to 76.7 per cent over twice hand weeding and 10.6 to 58.9 per cent over weedy check which might be due to the fact that initially total microbial population did not vary significantly in all the treatments but after herbicide application; they differ for a short period of

Table 2: Effect of different weed management practices on yield attributing characters of pea (pooled)

Treatment	Plant height (cm)	No. of primary branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000 seed weight (g)
W_0 – Weedy check	40	2.0	7.1	5.25	13.5
W_1 – Hand weeding twice at 15 and 30 DAS	61	2.8	13.8	5.92	14.4
W_2 – Pendimethalin @ 1.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS	57	2.6	11.7	5.76	14.0
W_3– Quizalofop ethyl @ 37.5g ha^{-1} as PoE (Post-emergence) at 10-15 DAS	56	2.6	11.2	5.70	13.9
W_4 – Chlorimuron ethyl @ 4.0g ha^{-1} as PoE (10-15 DAS)	46	2.3	9.8	5.58	13.7
W_5 – Fenoxaprop-p-ethyl @ 50g ha^{-1} as PoE (10-15 DAS)	56	2.5	10.8	5.65	13.9
W_6 – Imazethapyr @ 25ml ha^{-1}as PoE (15-20 DAS)	58	2.7	12.3	5.85	14.1
W_7 – Pendimethalin @ 2.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS	50	2.4	10.6	5.63	13.8
W_8 –Quizalofop ethyl @ 75 g ha^{-1} as PoE (Post-emergence)at 10-15 DAS	45	2.2	10.0	5.55	13.6
W_9 – Chlorimuron ethyl @ 8.0g ha^{-1} as PoE (10-15 DAS)	44	2.1	9.6	5.45	13.6
W_{10} – Fenoxaprop-p-ethyl @ 100g ha^{-1} as PoE (10-15 DAS)	49	2.4	10.4	5.60	13.7
W_{11} – Imazethapyr @ 50ml ha^{-1}as PoE (15-20 DAS)	51	2.5	10.9	5.67	13.8
SEm (±)	**1.10**	**0.20**	**0.30**	**0.07**	**0.20**
LSD (0.05)	**3.20**	**0.60**	**0.90**	**0.20**	**0.40**

time. Having the ability to degrade herbicides, microorganisms utilize them as a source of biogenic elements for their own physiological processes. As herbicides have toxic effects on microorganisms; they reduce their abundance, activity and consequently, the diversity of their communities before degradation. Immediately after application, the toxicity of herbicides is normally most severe as their concentration in soil is highest but with the advancement of time, microorganisms degraded the herbicides and their concentration gradually reduced up to half-life. After that, carbon released from degraded herbicide leads to an increase of the soil microflora population (Bera and Ghosh, 2013). Chemical herbicides generally stimulated and increased the soil fungi and actinomycetes population and reduced the bacterial population to some extent and increased the overall total microbial population as also reported by Ali *et.al*. (2014), Adil *et al*.(2012) and Anderson *et al*.(2004). Application of double the recommended doses of herbicides found to have a negative effect on the total microbial population particularly in case of Pendimethalin @ 2.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS, Quizalofop ethyl @ 75 g ha^{-1} as PoE (Post-emergence)at 10-15 DAS and Chlorimuron ethyl @ 8.0g ha^{-1} as PoE (10-15 DAS).

Nodulation

Experimental results revealed that nodulation in pea was not affected significantly due to the application of chemical herbicides . This was in conformity with the findings of Raman and Krishnamoorthy (2005). Highest nodule number (16.7 nos.plant^{-1}) and nodule dry weight

Table 3: Effect of different weed management practices on weed density, weed dry weight, weed control efficiency, total microbial population and nodulation of pea (pooled)

Treatment	Weed density (Nos. m^{-2}) 45 DAS	Weed dry weight (gm^{-2}) 45 DAS	Weed control efficiency (%)	Total microbial population ($CFU \times 10^6$ g^{-1} of soil) at harvest	No. Of nodules	Nodule dry weight (mg $plant^{-1}$ 45 DAS)
W_0 – Weedy check	360.8	56.5	0.0	40.6	14.0	80.1
W_1 – Hand weeding twice at 15 and 30 DAS	46.3	8.3	85.3	36.5	16.7	110.3
W_2 – Pendimethalin @ 1.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS	126.6	20.2	64.2	52.8	15.3	104.5
W_3– Quizalofop ethyl @ 37.5g ha^{-1}as PoE (Post-emergence) at 10-15 DAS	132.4	22.1	60.9	62.9	14.8	100.2
W_4 – Chlorimuron ethyl @ 4.0g ha^{-1}as PoE (10-15 DAS)	146.9	26.8	52.6	59.5	14.4	98.3
W_5 – Fenoxaprop-p-ethyl @ 50g ha^{-1} as PoE (10-15 DAS)	140.2	25.5	54.9	64.5	14.6	100.5
W_6 – Imazethapyr @ 25ml ha^{-1} as PoE (15-20 DAS)	110.1	16.4	71.0	63.8	15.6	105.3
W_7 – Pendimethalin @ 2.0 kg ha^{-1} as PE (pre-emergence) at 1 DAS	89.8	12.8	77.3	45.8	14.5	97.2
W_8 –Quizalofop ethyl @ 75 g ha^{-1} as PoE (Post-emergence)at 10-15 DAS	95.1	14.9	73.6	47.6	14.2	92.3
W_9 – Chlorimuron ethyl @ 8.0g ha^{-1}as PoE (10-15 DAS)	106.6	16.2	71.3	44.9	14.2	86.4
W_{10} – Fenoxaprop-p-ethyl @ 100g ha^{-1}as PoE (10-15 DAS)	100.2	15.8	72.0	50.1	14.4	95.7
W_{11} – Imazethapyr @ 50ml ha^{-1} as PoE (15-20 DAS)	82.3	12.1	78.6	49.5	14.7	99.3
SEm (±)	**2.60**	**0.50**	**-**	**5.50**	**0.90**	**9.70**
LSD (0.05)	**7.90**	**1.30**	**-**	**16.80**	**2.70**	**29.00**

(115.3 mg $plant^{-1}$) were recorded with the treatment twice hand weeding which was found statistically *at par* with the application of chemical herbicides. The lowest nodule number (14.0 $plant^{-1}$) and nodule dry weight (80.1 mg $plant^{-1}$) were recorded with the treatment weedy check which was significantly lower than all other treatments might be due to poor growth of the plant itself. Significant inhibitory effects of herbicides on nodulation were not found could be due to their rapid inactivation in soil or its rapid translocation along with photosynthate, to distant metabolic sink. Similar type of findings were also reported by Ali *et al*.(2014) and Fernandez *et al*. (1992). Applied herbicides at their respective recommended doses and in higher doses were found to have no significant negative impact on nodule density and biomass but affected plant growth at higher concentration. Similar type of findings were also reported by Gonzalez *et al*.(1996) .

Thus, based on 3 years' data it can be concluded that application of Imazethapyr @ 25ml ha^{-1}as PoE (15-20 DAS) may be a suitable, effective and eco-friendly chemical weed management practice for pea.

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