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Yield attributes and weed management practices on field pea (*Pisum sativum* L) in Indo-Gangetic plain of Varanasi

Rakesh Kumar, Vimal Kumar, SK Prasad, SK Verma and Shishu Pal Singh

Abstract
Yield and weed management practices on Indo-Gangetic Plain in irrigated field pea (*Pisum sativum* L) crop was conducted at the Agricultural Research Farm of B. H. U. Varanasi, during *rabi* season of 2010-11. The experiment was conducted in randomized block design (RBD) with 10 weed management treatments. The soil of experimental field was sandy clay loam in texture, with slightly alkaline in reaction (pH 7.8). The yield attributes *viz*., pods plant^{-1}, grains pod^{-1}, seed index (100-grain weight), grain yield, harvest index were recorded after harvest of crop. Experimental field was dominated by narrow leaved weeds which constituted 37.6 per cent and species wise were *Cyperus rotundus* L. (14.1%) and *Parthenium hysterophorus* L. (23.5%). Whereas, broad leaved weed species *Melilotus alba* (7.0%), *Solanum nigrum* L. (11.8%), *Chenopodium album* L. (35.3%), *Anagallis arvensis* L. (5.9%) and *Vicia sativa* L. (2.4%) accounted for 72.4 per cent of weed of total weed species. Among herbicidal treatments, sequential application of pendimethalin 1kg ha^{-1} (PE) + imazethapyr 50 g ha^{-1} (PoE) was proved to be the most effective in reducing the weed density and dry weight. It also recorded maximum weed control efficiency. The crop yield and yield attribute were maximum in pendimethalin 1kg ha-1 (PE) + imazethapyr 50 g ha-1 (PoE) treated plot followed by pendimethalin 1kg ha^{-1} (PE) + imazethapyr 75 g ha^{-1} (PoE) and quizalofop- ethyl 60 g ha^{-1} (PoE).

Keywords: Yield attributes, weed management practices, and field pea

Introduction
Globally, pulses are cultivated over an area of 62 m ha with the production of 47 million tones and average productivity of 7.60 q ha^{-1}. In India it is cultivated in 0.78 m ha with the annual production of 0.71 million tones and share 3.1 per cent of area and production in total pulse production. The pea growing states U. P. ranks first in area (0.413 m ha) and production (0.483 m tones) followed by Haryana and Madhya Pradesh (Anonymous, 2011) [3]. Pulses are the cheapest and important source of dietary protein for human. It also plays a vital role in improving soil health, by adding huge amounts of organic matter and fixing of biological nitrogen. It leaves about 30 kg N ha^{-1} into the soil which is useful for succeeding crop (Anonymous, 2006) [2]. The per capita availability of pulses has been decreased from 69.0 g day^{-1} in 1961 to 39.4 g day^{-1} 2012, which create an alarming situation calling for concerted and expeditious efforts in improving their vertical production (Anonymous,2012) [4]. The projected requirement of pulses for human consumption for the year 2021 AD is 26.9 million tonne for the moderate population growth of 1.6 per cent (Ali, M., 1994) [1].

Recently some of the post-emergence herbicides such as quizalofop, imazethapyr have been found effective in controlling weeds in soybean and field pea. Post- emergence application of quizalofop (50 and 60 g ha^{-1}) proved to reduce density and dry weight of both broad and narrow leaved weeds in pulses. Weeds are the major threats in field pea which limits the productivity (Tripathi, A. K. and Meena, H. N. 2011) [22]. The predominance species of weeds like *Chenopodium album*, *Cyperus rotundus*, *Parthenium hysterophorus* and *Anagallis arvensis* present in the field pea weeds due to its initial slow growth and short stature resulting in huge yield loss. Weed competition resulted in the reduction in the yield up to 65.8% (Mishra *et al*., 2006) [12]. For the control of weeds generally farmers adopted manual weeding (Singh and Wright, 2006) [23]. But due to increases labour cost and scarcity of labour, manual weeding become a difficult task in field pea, which force them for opting alternative, cheaper and easier method of chemical weed control.

Pre-emergence application of pendimethalin 1.0 kg ha^{-1} proved effective in reducing density and dry matter production of weeds resulted higher yield attributes and seed yield of field pea (Govardhan *et al*., 2007) [9].
The effect various herbicides suitable for weed control in field peas was obtained maximum seed yield of 2174 and 1436 kg ha^{-1} was obtained (Pandey *et al*., 2000) [15], *rabi* season increased green pod yields by 55.9-75.9% over the weedy control.The effects of integrated weed management in pea cultivars were increased pods $plant^{-1}$, seeds $pods^{-1}$ and yield significantly with equal magnitude (Rana, S. S., 2002) [17]. Garden pea (Singh and Angiras, N. N. 2004) [18] the highest number of pods per plant (13.2) and pod yield (10.8 t ha^{-1}). Weeds tend to offer severe competition and cause drastic yield reduction (up to the extent of 40 to 85%) depending upon the density and weed species present in field pea (Banga *et al*.,1998) [5], reduction in grain yield of field pea, 30 to 35% also reported by (Johnson, E. N. and Holm, F.A. 2010) [10], Yield loss due to weeds (about 70-80%) at a lower crop density (10 plants m^{-2}) than (30 plants m^{-2}) (Lemerle *et al*.,2006) [11] reported that the season long weed competition causing 32.4% reduction in grain yield of field pea.Grain yield of field pea (Veres, T. and Tyr, S., 2012) [23] under weedy check, which was mainly due to 57% reduction in number of pods and 23% reduction in grains.

Material and Methods

The geographical situation of this ancient and 'holy city' Varanasi lies in the North-Eastern plain zone of the Eastern part of the Uttar Pradesh at 25^0 18' North latitude, 83^0 3' East longitude and at altitude of 128.93 meter above the mean sea level (MSL) in the Northern Gangatic Alluvial Plain. In *rabi* seasons of 2010-2011 at the Agricultural Research Farm Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. Varanasi is situated in the eastern part of U.P. and have sub-tropical climate, characterized by hot summer and cool winter. Usually, May and June are hottest months with mean maximum temperature ranging from 39° to 43 °C. However, the coldest month is January with mean minimum temperature varying from 9° to 10 °C. In this region monsoon is usually starts from third week of June and lasts up to the end of September or sometimes up to the first week of October. The mean relative humidity remains 68%, which rises up to 89% during July-September and falls down during April to June.

Field preparation and Sowing

The field was ploughed (20 cm deep) once at a uniform depth followed by two to three cross harrowing was done. After harrowing the field should be leveled by given a gentle slope to ease irrigation. There should be of proper moisture in soil at the time of sowing for proper germination of seeds. The trial was laid out in a randomized block design and 3 replication. Variety HUDP-15 (Hindu University Dwarf pea-15) was developed at the Banaras Hindu University Varanasi in the year 1999. The crops were sown by hand using "Kudal" keeping 30 cm row to row spacing with seed rate of 80 kg ha^{-1}. As per treatment, full dose of nitrogen, phosphorus, potassium, sulphur, and zinc were applied as basal (just before sowing the crop). Likewise, nitrogen, phosphorus and potash contribution was met through Urea, SSP and MOP, respectively as per treatments.

Weed management practices

The use 4 herbicides mainly pendimethalin (1 kg ha^{-1}), quizalofop (60 g ha^{-1}), imazethapyr (75 g ha^{-1}) and chlorimuron ethyl (4 g ha^{-1}PPI) were used. The first doses of these herbicides were applied as pre-emergence (PE) and second dose of herbicides was applied at 45 DAS using Knapsack Sprayer. The spray volume was calculated on test-run basis and the measured amount of herbicide was mixed with water for each treatment, respectively.
Two manual weeding in research plot were done at 30 and 60 DAS by using spud.

Irrigation

To maintain uniform two irrigations were given at critical stages of crop growth to maintain the optimum moisture condition. No disease or pest protection measure were needed up to harvest of the crop during experimentation.

Yield Attributes and yield

The yield attributes and yield observations were taken at maturity harvesting time. Five plants from each plot excluding sample and from border rows were selected randomly and tagged to be used.

Number of pods $plant^{-1}$ -Total number of pod $plant^{-1}$ was recorded from five tagged plants.

Number of grains pod^{-1}- Five pods were taken at random from the tagged plants and total number of grains was counted and average number of grains pod^{-1} was calculated.

Grain yield (q ha^{-1}) - The produce of each net plot was threshed separately and weighed plot wise to work out seed yield. Then obtained values were converted into q ha^{-1}.

Harvest index- The recovery of grains in total produce was considered as 'Harvest index' (HI) which is expressed in percentage.
Harvest index was calculated by equation

$$\text{H.I.} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

The economic yield refers to the weight of grains only and both grain + straw constitute the biological yield.

Weed density (number m^{-2})

The weed density was determined by using quadrate. A quadrate of 0.5×0.5 m^2 size was placed at random and population of individual and total weed species were recorded at 30, 60, 90 DAS and at harvest. The weed population was expressed in number m^{-2}.

Weed control efficiency (%)

Weed control efficiency (WCE) was calculated by using the following formula.

$$\text{WCE} = \frac{\text{DMC} - \text{DMT}}{\text{DMC}} \times 100$$

Where, DMC = Dry matter production of weeds m^{-2} in control plot.
DMT = Dry matter production of weed m^{-2} in treated plot.

Weed control efficiency expressed in percentage.

Result and Discussion

Yield attributes

The yield attributing (Table: 1) characters *viz*, pods plant^{-1}, grains pod^{-1} and seed index (100-grain weight), were significantly influenced by the different weed management practices treatments. All the weed control treatments significantly influenced the yield attributes as compared to weedy check. Among, herbicidal treatments, sequential application of pendimethalin 1kg ha^{-1} (PE) + imazethapyr 50 g ha^{-1} (PoE) resulted into significantly the highest number of pods (19.31) plant^{-1}, number of grains (6.08) pod^{-1} and seed index (100-grain weight) (17.95) over imazethapyr 50 g ha^{-1}, chlorimuron- ethyl 4 g ha^{-1} and pendimethalin 1 kg ha^{-1} and it were at par with the application of pendimethalin 1 kg ha^{-1} + imazethapyr 75 g ha^{-1}, quizalofop- ethyl 50 g ha^{-1}, quizalofop-ethyl 60 g ha^{-1} and imazethapyr 75 g ha^{-1}. Higher yield attributes under these treatments may be due to lesser crop-weed competition, which gave better environment for crop growth and development of crop. These treatments weed population and their growth was abstracted during initial as well as latter stage of crop growth by sequential application of herbicides. It confirms the conclusion drawn by (Chaudhary *et al*., 2009) [7] from the results of their experiments on weed control in pulses. PoEergence application of imazethapyr at 30-35 DAS were also found equally effective in increasing yield attributes of field pea (Sikkema *et al*., 2015) [19]. Yield attributes *viz*., branches plant^{-1}, Pods plant^{-1}, seeds pod^{-1} and seed weight plant^{-1} was significantly increased under weed free environment (Munakamwe *et al*., 2008) [14].

Table 1: The yield attributes of Number of pods (plant^{-1}), Number of grains (pod^{-1}), Number of grains (pod^{-1}), 100- Seed weight (g), Grain yield (q ha^{-1}) and Harvest index (%) of weed management practices in irrigated field pea

Treatment	Number of pods	Number of grains	100- Seed weight	Grain yield	Harvest index
T_1 – Weed free (H W at 30 and 60 DAS)	21.01	6.41	22.04	21.67	25.0
T_2 – Pendimethalin 1.0 kg ha^{-1} (PE)	12.00	5.05	14.77	16.59	24.4
T_3 – Pendimethalin 1.0 kg (PE) + imazethapyr 75 g ha^{-1} (PoE)	18.93	5.88	17.50	19.46	24.3
T_4 – Quizalofop- ethyl 60 g ha^{-1} (PoE)	17.98	5.75	15.99	18.50	23.9
T_5 –Quizalofop- ethyl 50 g ha^{-1} (PoE)	16.98	5.66	16.06	17.54	23.4
T_6 –Imazethapyr 75 g ha^{-1} (PoE)	17.79	5.72	15.58	17.40	23.9
T_7 –Imazethapyr 50 g ha^{-1} (PoE)	15.43	5.24	15.60	15.85	23.1
T_8 – Chlorimuron- ethyl 4 g ha^{-1} (PPI)	12.00	6.08	15.46	15.67	23.2
T_9 – Pendimethalin 1kg ha^{-1} (PE) + imazethapyr 50 g ha^{-1} (PoE)	19.31	5.50	17.95	19.84	24.7
T_{10} –Weedy check	10.84	3.77	13.06	13.63	22.9
SEm ±	0.82	0.80	0.74	8.30	0.75
CD (P=0.05%)	2.44	0.25	2.29	24.50	N.S

Yield

The effect of weed management practices on grain yield of field pea was significant. The significantly (Table: 1) highest grain yield (19.84 q ha^{-1}) was achieve under sequential application of pendimethalin 1kg ha^{-1} (PE) + imazethapyr 50 g ha^{-1} (PoE) followed by pendimethalin 1kg ha^{-1} (PE) + imazethapyr 75 g ha^{-1} (PoE), quizalofop- ethyl 50 and 60 g ha^{-1} (PoE) and imazethapyr 75 g ha^{-1} (PoE) as compared to imazethapyr 50 g ha^{-1}, chlorimuron- ethyl 4 g ha^{-1}, pendimethalin 1 kg ha^{-1} and weedy check. These results can be attributed due to marked improvement in yield attributes under pendimethalin 1kg ha^{-1} (PE) + imazethapyr 50 g ha^{-1} (PoE) compared with other herbicides. These results are corroborated with the research results of (Rajeev *et al*., 2006) [16]. The minimum grain yield was recorded in weedy check because of more weed growth and poor performance of yield attributing characters. Similar results were in conformity with findings of (Buttar, *et al*., 2008) [6]. Relative weed free situation under herbicide treatment reduced the crop weed competition and thus lead to higher vegetative growth as affected in straw yield (Singh, G. and Wright, D., 2006) [20].

Maximum harvest index was recorded under sequential application of pendimethalin 1kg ha^{-1} (PE) + imazethapyr 50 g ha^{-1} (PoE) followed by pendimethalin 1kg ha^{-1} (PE) + imazethapyr 75 g ha^{-1} (PoE), quizalofop- ethyl 50 and 60 g ha^{-1} (PoE) and imazethapyr 75 g ha^{-1} (PoE) as compared to imazethapyr 50 g ha^{-1}, chlorimuron- ethyl 4 g ha^{-1}, pendimethalin 1 kg ha^{-1} and weedy check (Singh *et al*., 2008) [21].

Relative composition of weed flora

The important weed flora and their relative composition was recorded at 60 DAS in weedy check plot which revealed that weed flora of experimental field consists of narrow and broad leaved weeds in order of dominance. The important weed species (Table: 2) in control plots were *Cyperus rotundus* L. (14.1), *Chenopodium album* L. (35.3%), *Parthenium hysterophorus* L. (23.5%), *Solanum nigrum* L. (11.8%), *Melilotus alba* L. (7.0%), *Anagallis arvensis* L. (5.9%) and *Vicia sativa* L. (2.4%). Results are corroborated with research findings of (Dawson *et al*., 2006) [8], (Mishra *et al*., 2008) [13].

Table 2: The composition of number of weeds (m^{-2}) and Relative frequency of weeds (%) of narrow and broad leaved in weedy check at 60 DAS

Weed species	No. of weeds	Relative frequency of weeds
Cyperus rotundus L.	12.0	14.1
Chenopodium album L.	30.0	35.3
Parthenium hysterophorus L.	20.0	23.5
Solanum nigrum L.	10.0	11.8
Melilotus alba L.	6.0	7.0
Anagallis arvensis L.	5.0	5.9
Vicia sativa L.	2.0	2.4
Total	85.0	100.0

The experimental field properties of soil were sandy clay loam in texture, with slightly alkaline in reaction (pH 7.8) and moderately fertile being low in available organic carbon, nitrogen and sulphur and medium in available phosphorus and potassium.

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