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Comparative evaluation of herbicides for weed management in *Lathyrus* under new alluvial zone of West Bengal

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Abstract
A field experiment was carried out at the District Seed Farm, A-B Block, Kalyani, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during winter season of 2017-18 with *Lathyrus* variety Bidhan Khesari 1 (BK-14-2) to analyze the effect of different herbicide combinations and weed management options in controlling the weeds as well as ensuring the growth and yield of grasspea. The experiment was laid out in randomized block design with 11 treatment combinations which were as follows: T_1 = Pendimethalin 30 EC (1 kg ha^{-1}) Pre-emergence + One hand weeding at 30 DAS, T_2 = Pendimethalin 38.7 CS (1 kg ha^{-1}) Pre-emergence, T_3 = Pendimethalin 38.7 CS (1 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS, T_4 = Sulfentrazone 39.6 EC (50 g lit^{-1}) Pre-emergence + One hoeing at 30 DAS, T_5 = Fenoxyprop-ethyl 9.3% W/W (60 g ha^{-1}) Post-emergence at 30 DAS, T_6 = Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence, T_7 = Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS, T_8 = Pendimethalin 38.7 CS + Imazethapyr 2% (Tank mix 1 kg ha^{-1}) Pre-emergence, T_9 = One hoeing at 30 DAS, T_{10} = Weed free (Two hoeing at 30 & 45 DAS) and T_{11} = Weedy check. All the treatment combinations in the experiment were replicated thrice. The result of the experiment revealed that highest plant biomass (51.18, 193.63 and 253.95 g) and LAI (0.95, 1.96 and 1.64) at 30, 60 and 90 DAS was observed in T_7 treatment among all others. The T_7 treatment gave the maximum number of seeds pod^{-1} (5) and highest seed yield (903.71 kg ha^{-1}) in grasspea in the investigation. The lowest value of total weed population (38.01, 51.33 and 72.66) and lowest weed dry mass (17.19, 46.41 and 74.25) at 30, 60 and 90 DAS was also recorded in T_7 treatment. Thus, application of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS were found more effective in reducing weed population and dry mass of weeds and producing better seed yield of *Lathyrus* in this zone.

Keywords: Herbicide, *Lathyrus*, weed management, yield

Introduction
Pulse constitute an important group of crops and have been the main stay in Indian Agriculture, as they restore soil fertility, improve physical condition of soil and provide nutritious food and fodder. Among the winter growing annual pulse crops, *Lathyrus sativus* (*Lathyrus* or khesari) is a high yielding, drought tolerant legume which can easily be grown as a relay crop under rice fallow situation (Bhowmick *et al.*, 2014) [1]. The dried seeds of *Lathyrus* contain 22.7-29.6% unrefined protein, 56.6-61.0% carbohydrates, 0.6-1 g fat, 1.5-2.3 g fibre, 90110 mg calcium, 629 mg potassium and 317- 500 mg phosphorus, essential amino acids like arginine (7.8 g), lysine (7.4 g), isoleucine (6.7 g), leucine (6.6 g), valine (4.7 g) per 100 g of protein (Parihar and Gupta, 2016) [4]. *Lathyrus* improves soil physical properties and fixes atmospheric nitrogen in their roots through symbiotic relationship with *Rhizobium leguminosaram.* The major *Lathyrus* growing states in India are Bihar, Madhya Pradesh, Maharashtra, West Bengal, Chhattisgarh, Uttar Pradesh, Rajasthan, and Gujrat etc. People from lower economic section consumed this legume crop as a staple food during famines and floods.

Some multi seasonal and perennial weeds that infest the individual crops have a great impact on the cropping system as a whole, thus, if weeds are not controlled prior to the flowering they bear seeds and build up weed seed population in soil that come up whenever they experience

favourable environment for emergence and growth. The critical crop weed competition period is an important factor in weed management as well as in crop production. Weeds are major problem for successful cultivation in *lathyrus* as their initial growth is relatively slow. *Lathyrus* when grown as winter crops mostly broad leaf weeds infest the crops but grasses and sedges do also appear. Early emerging weeds are thus more competitive. The weeds can be managed by adopting several methods including eco-physical, biological, and chemical and recently through combining direct and indirect approach *i.e.* integrated weed management. Several herbicides have been reported to control weeds in *Lathyrus*, but none of these can manage all categories of weed efficiency at all. In *Lathyrus*, Trifluralin 0.75 kg ha^{-1} followed by hand-weeding or trifluralin 0.75 kg ha^{-1} followed by Sethoxydim 0.3 kg ha^{-1} or Metribuzin 250 g ha^{-1} is one of the recommended application of herbicides (Wall and Friesen, 1991) [5]. The weed scientists, therefore, have been in search of herbicides, if applied, could allow the crop to grow weed free from the very day of the germination of the crop. Integrated weed management approach involving pre-emergence herbicide application followed by mechanical weeding after about a month of sowing is the widely adopted practice for managing weeds in most pulse crops (Kumar *et al.*, 2016) [3]. Pendimethalin and other herbicides, have the potentiality to control weeds both as pre and post-emergence application. These herbicides need to be investigated in *Lathyrus* field to control weeds in different agro-ecological situations.

Materials and Methods

A field experiment was carried out during *rabi* season of 2017-18 at the District Seed Farm, A-B Block, Kalyani, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India. As per analysis of soil samples, the experimental field was a medium land with well-drained gangetic alluvial soil (order: Inceptisol), that belonged to the class of sandy loam with medium fertility, almost neutral in reaction, organic carbon 0.75%, available nitrogen 225.25 kg ha^{-1}, phosphorus 28.24 kg $ha^{-1}$and potassium 157.14 kg ha^{-1} respectively.

The experiment was conducted in randomized block design (RBD) involving 11 treatments of herbicide and hand weeding combinations which were as follows: T_1 = Pendimethalin 30 EC (1 kg ha^{-1}) Pre-emergence + One hand weeding at 30 DAS, T_2 = Pendimethalin 38.7 CS (1 kg ha^{-1}) Pre-emergence, T_3 = Pendimethalin 38.7 CS (1 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS, T_4 = Sulfentrazone 39.6 EC (50 g lit^{-1}) Pre-emergence + One hoeing at 30 DAS, T_5 = Fenoxyprop-ethyl 9.3% W/W (60 g ha^{-1}) Post-emergence at 30 DAS, T_6 = Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence, T_7 = Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS, T_8 = Pendimethalin 38.7 CS + Imazethapyr 2% (Tank mix 1 kg ha^{-1}) Pre-emergence, T_9 = One hoeing at 30 DAS, T_{10} = Weed free (Two hoeing at 30 & 45 DAS) and T_{11} = Weedy check. All the treatment combinations in the experiment were replicated thrice. The *Lathyrus* variety used in the present investigation was Bidhan Khesari 1 (BK-14-2).

The grasspea seeds were sown in plot size of 4 m × 3 m area with a spacing of 30 cm × 10 cm and the seed rate of 60 kg ha^{-1} was followed. The crop was fertilized with a common dose of N: P_2O_5: K_2O at 20:40:40 kg ha^{-1} respectively. The data on growth attributes at 30, 60 and 90 DAS and yield attributes were recorded from 5 plants, selected randomly from each plot at maturity of the crop. Weed population counts were taken by placing a quadrate 0.5m × 0.5m area at two locations of each plot for studying the total weed population under different treatments at 30, 60 and 90 DAS respectively. After counting the different categories of weeds, these were washed thoroughly, kept in brown paper packet and dried in oven at 60 ^{0}C temperature. After drying, dry weight of weeds were recorded and then converted into weight (g) per square metre. The data obtained in the study were analyzed using 'Analysis of Variance' technique (ANOVA) following standard statistical procedures (Gomez and Gomez, 1984) [2].

Results and Discussion

Dry matter

Dry matter depicts the overall growth and vigour of any crop. Higher dry matter of crop signifies the healthy and free growth of standing crop. Weeds are competitor of crops in terms of nutrient absorption. Lesser dry matter may be due to high crop-weed competition. Dry matter accumulation of *Lathyrus* crop have been presented in Table 1. Dry mass of aerial parts m^{-2} was determined in this experiment at 30, 60 and 90 DAS. Dry biomass of the crop increased gradually with the age of the crop. At 30, 60 and 90 DAS, highest plant biomass was recorded in T_7 treatment (51.18 g, 193.63g and 253.95g) and it was significantly higher than others in the experiment. The lowest dry matter was observed in unweeded treatment at 30, 60 and 90 DAS (43.15 g, 152.77g and 212.05g). This is due to high crop-weed competition, meanwhile in T_7 treatment the most successful weed check was done. Pre emergence weedicide (Imazethapyr 2%) application along with regular weedicide (Pendimethalin 30 EC) and one hoeing at early vegetative phase gives a perfect result in combating weeds in *Lathyrus*.

LAI

Leaf area Index reflects the areal expression of any crop. In the experiment LAI of the *Lathyrus* were determined at 30, 60 and 90 DAS and are presented in Table 1. 60 DAS grass pea showed the maximum vegetative proliferation under T_7 treatment which clearly reflects the crop health and vigour. Throughout the crop period, i.e. 30 DAS, 60 DAS and 90 DAS, T_7 (0.95, 1.96 and 1.64) showed the maximum LAI while the lowest was observed under unchecked treatment (0.85, 1.83 and 1.53). One Hoeing at 30 DAS showed the benefit at 60 DAS in terms of LAI (Table 1). It actually delayed the crop-weed competition peak period which in return assured crop foliage growth.

Number of seeds pod^{-1}

Number of seeds pod^{-1} is one of the important yield attributing character depicting the crop physiology during a stress or competition period. The crop-weed competition create a stress situation for water and other resources. Under such situation accumulation of essential elements are profusely hindered and storage process that occur within the pod slows down. As a result small pods developed with lesser seeds in it. Number of seeds pod^{-1} of *Lathyrus* crop have been presented in Table 1. The T_7 treatment (5) gave the maximum number of seeds pod^{-1}while the unchecked treatment (1.33) resulted lowest number of seeds pod^{-1} in the investigation (Table 1).

Seed yield

Seed yield of the crop was distinctly influenced by the weed management treatments. As per the results of the investigation, the maximum seed yield (903.71 kg ha^{-1}) was obtained in T_7 treatment (Pendimethalin 30 EC + Imazethapyr 2% Ready mix @ 1 kg a.i. ha^{-1} Pre-emergence + one hoeing at 30 DAS) followed by 893.43 kg ha^{-1}in T_8 treatment (Pendimethalin 38.7 CS + Imazethapyr 2% Tank mix @ 1 kg a.i. ha^{-1} Pre-emergence). The minimum seed yield (657.25 kg ha^{-1}) was obtained in T_{11} treatment (weedy check). The reduction in yield under the control treatment (i.e. in T_1 treatment) may be attributed to reduced growth and number of plants and number of pods per unit area (Table 1). The average seed yield obtained was significantly more with weed management options. Crop performance was not good in the control treatment, thus, the yield ha^{-1} was significantly lower than that obtained in other treatments.

Table 1: Grass Pea growth and yield components under different weed control treatments during *rabi* season in New Alluvial Zone of West Bengal

Treatment	Dry mass of aerial plant parts in (g.)			Leaf Area Index			No of seeds pod^{-1}	Seed yield (kg/ha)
	30 DAS	60DAS	90DAS	30 DAS	60DAS	90DAS		
T_1	48.68	181.83	247.16	0.94	1.95	1.62	4.00	798.66
T_2	45.33	161.28	231.13	0.87	1.87	1.54	3.67	698.51
T_3	47.34	166.32	243.25	0.91	1.93	1.63	3.33	741.91
T_4	49.19	173.25	234.02	0.89	1.92	1.59	2.67	724.91
T_5	45.69	162.05	229.25	0.86	1.85	1.60	3.00	704.39
T_6	46.70	155.51	230.99	0.90	1.91	1.55	4.33	800.43
T_7	51.18	193.63	253.95	0.95	1.96	1.64	5.00	903.71
T_8	46.29	160.97	232.84	0.88	1.89	1.58	4.67	795.46
T_9	44.87	164.91	221.13	0.93	1.84	1.61	2.33	696.87
T_{10}	46.36	163.51	237.44	0.92	1.90	1.57	2.00	776.27
T_{11}	43.15	152.77	212.05	0.85	1.83	1.53	1.33	657.25
SEm (±)	1.64	2.04	2.28	0.004	0.006	0.01	2.04	3.16
CD at 5%	4.87	6.06	6.78	0.18	0.55	1.05	6.06	9.38

T_1 = Pendimethalin 30 EC (1 kg ha^{-1}) Pre-emergence + One hand weeding at 30 DAS, T_2 = Pendimethalin 38.7 CS (1 kg ha^{-1}) Pre-emergence, T_3 = Pendimethalin 38.7 CS (1 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS, T_4 = Sulfentrazone 39.6 EC (50 g lit^{-1}) Pre-emergence + One hoeing at 30 DAS, T_5 = Fenoxyprop-ethyl 9.3% W/W (60 g ha^{-1}) Post-emergence at 30 DAS, T_6 = Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence, T_7 = Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS, T_8 = Pendimethalin 38.7 CS + Imazethapyr 2% (Tank mix 1 kg ha^{-1}) Pre-emergence, T_9 = One hoeing at 30 DAS, T_{10} = Weed free (Two hoeing at 30 & 45 DAS) and T_{11} = Weedy check.

Total weed population m^{-2}

Total weed population of *Lathyrus* crop have been presented in Table 2. As the T_{11} treatment is the unchecked one, the weed population is very high, i.e. 153 weeds m^{-2} at 90 DAS. On the other treatments weed population at 30, 60 and 90 DAS was respectively ranging from 38 to 60 weeds m^{-2}, 51 to70 weeds m^{-2} and 73 to120 weeds m^{-2}. The lowest value of total weed population (38.01, 51.33 and 72.66 at 30, 60 and 90 DAS) was in T_7 treatment *i.e.* Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS throughout the growth phase. The application of regular herbicide in combination with pre-emergence herbicide application and hoeing resulted the perfect control for weeds in grass pea in the New Alluvial zone of West Bengal.

Dry matter of total weed m^{-2}

Dry matter of the grass pea crop of different treatments were previously discussed. Now in correspondence with this total dry mass of weeds m^{-2} were taken into account. The dry matter of weeds showed the similar pattern as the total weed population m^{-2}. Total weed dry mass of *Lathyrus* crop have been presented in Table 2. At 30 DAS, the highest dry mass of total weeds (69.74) was obtained in weedy check treatment (T_{11}). The lowest weed dry mass (17.19) was observed in T_7 at 30 DAS (Table 2). At 60 DAS, the highest dry mass of total weeds (209.22) was obtained in T_{11}. The lowest weed dry mass (46.41) was obtained observed in T_7 treatment. At 90 DAS, the highest dry mass of total weeds (334.75) was obtained in weedy check treatment (T_{11}). The lowest weed dry mass (74.25) was observed in T_7 treatment. The dry matter increased more during 60 DAS to 90DAS than 30 DAS to 60 DAS in all the treatment as the weed growth were at peak during this period (Table 2).

Table 2: Total weed population m^{-2} and dry matter of total weed m^{-2} at 30, 60 & 90 DAS in different weed control treatments during *rabi* season in New Alluvial Zone of West Bengal

Treatment	Total weed population/m^2			Dry matter of total weed/m^2		
	30 DAS	60DAS	90DAS	30 DAS	60DAS	90DAS
T_1	39.33	52.32	76.68	21.17	63.51	114.31
T_2	43.68	59.34	81.00	23.88	71.64	136.11
T_3	42.66	58.68	80.67	22.20	66.06	133.60
T_4	50.34	65.34	93.99	41.00	118.90	249.69
T_5	48.69	59.34	84.00	39.09	117.27	246.26
T_6	40.68	59.01	75.33	18.43	57.13	81.83
T_7	38.01	51.33	72.66	17.19	46.41	74.25
T_8	39.66	54.33	77.01	18.24	51.07	83.57
T_9	57.99	69.99	119.67	45.28	122.25	207.82

T_{10}	42.00	58.68	109.68	25.05	75.15	127.75
T_{11}	109.68	122.67	153.33	69.74	209.22	334.75
SEm (±)	9.30	7.36	6.60	1.06	5.52	3.04
CD at 5%	27.63	22.08	19.59	3.16	16.38	9.42

Correlation coefficients of growth attributes between Grass pea and its weed

The Table 3 clearly depicts a negative correlation between the grass pea and its weed in terms of growth attribute. With the advancement of vegetative phase the weed gradually face a tough competition with standing crop. The treatments of weed control have a positive role in the successful reduction in weed population. According to 90 DAS dry matter calculation of pea and its weed signifies that the crop weed nutrient competition was peak in this time. While the crop-weed competition for natural resources (*i.e.* sunlight) was at peak during 60 DAS accessed through the negative correlation between the LAI of grass pea and total weed population m^{-2}.

Table 3: Correlation coefficients of growth attributes between *Lathyrus* and its weed during *rabi* season in New Alluvial Zone of West Bengal

Parameters	30 DAS	60DAS	90DAS
Dry Matter of Crop Vs Weed	-0.59906	-0.43453	-0.72181
LAI Vs Total weed population	-0.52133	-0.6262	-0.43776

Conclusion

From the present investigation it may be found that, among the different herbicide combinations, application of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix 1.0 kg ha^{-1}) Pre-emergence + One hoeing at 30 DAS were found more effective in reducing weed population and dry mass of weeds and producing better seed yield of *Lathyrus* in New Alluvial Zone of West Bengal. Thus, it may be concluded that, application of pre emergence herbicides along with mechanical weeding can be more responsive and profitable for *Lathyrus* in this particular zone and farming community can be benefitted also.

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