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Evaluation of pre and post emergence herbicides for weed control in rice bean (*Vigna umbellata*) crop under rain-fed condition

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ABSTRACT

The experiment was conducted for three years during Kharif season 2015-2017 using pre- and post-emergent weedicides along with manual weed control methods at Main Agricultural Research Station, Hebbal, Bangalore, Karnataka. The pooled data of three years indicated that, weed free check and hand weeding twice at 3rd and 5th Weeks After Sowing (WAS) were found superior by recording significantly lower weed count, weed dry weight and weed control efficiency. Among the herbicides, application of pendimethalin 38.7% CS 1.0 kg a.i. ha-1 as Pre-emergence + one hand weeding at 5th WAS recorded lower weed count, weed dry weight and weed control efficiency followed by application of oxyfluorfen 23.5 EC 50 g a.i. ha-1 as Pre-emergence + one hand weeding at 5 WAS. However, plant height, numbers of branches plant-1, number of pods plant-1 were significantly higher with weed free check which was on par with integrated weed management of application of pendimethalin 38.7% CS 1.0 kg a.i. ha-1 as Pre-emergence + hand weeding at 5th WAS and hand weeding twice at 3rd and 5th WAS. With respect to economics, higher net returns and B:C ratio were found in application of pendimethalin 38.7% CS 1.0 kg a.i. ha-1as pre-emergence + hand weeding at 5th WAS followed by application of oxyfluorfen 23.5 EC 50 g a.i./ha as Pre-emergence + hand weeding at 5 WAS (2.61). None of the herbicides alone treatments were found effective in controlling all the types of weeds. Whereas, pre-emergence application followed by one hand weeding at 3rd week after sowing proved better for controlling weeds. The post emergent herbicides viz., fenoxaprop-p-ethyl (9% EC) 50g a.i. ha-1post- emergence (3 WAS) and quizalofop-p-ethyl (5% EC) 50g a.i. ha-1 post- emergence (3WAS) did not give significant result when compared to pre emergence weedicides alone.

Keywords: Bio-efficacy, economics, growth rice bean, seed yield and *weedicides*

Pulses are the major source of dietary protein in the vegetarian diet in India. In addition to major pulses like Chickpea, Pigeon pea, Green gram, Black gram, Lentil there are some underutilized minor pulse crops which are nutritionally rich and also has multiple uses. Among these, Rice bean is one such species which can be used as food legume, fodder and green manure crop. It is known by many names such as climbing bean, mountain bean, mambi bean, oriental bean, haricot bean, red bean and Jerusalem pea. Rice bean is being grown in India, Myanmar, Malaysia, China, Korea, Indonesia and Philippines. It is also cultivated to a limited extent in West Indies, USA and Australia. The seeds contain a high amount of protein (20.9%) and limiting amino acids, tryptophan (0.79-1.10%) and methionine (0.45-1.18%), which rank it as one of the best among pulses (NAS, 1979). Though it is suited for the lowland humid tropics, some of the cultivars are also adapted to subtropical conditions in the plains. It does well in sandy loam to heavy soils. It is also reported to be moderately drought tolerant (Duke, 1981). Analysis of the biochemical constituents of rice bean seeds (15–16) revealed variation for crude protein (17.8-25.2%), ash (3.8-4.1%), calcium (315–450 mg 100^{-1} g), phosphorus (197–393 mg 100^{-1} g), iron (1–5 mg 100^{-1} g).

In India, its distribution is mainly confined to the tribal regions of North Eastern hills and hilly tracts of Western and Eastern Ghats in North Eastern states of Arunchal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It is grown only on a limited scale in Eastern peninsular tracts (parts of Orissa and Chotanagapur) and Western peninsular tracts of Southern hills. Though, no information is available about the exact area under this crop in India, roughly it is estimated to be grown in around 15,000 ha. Rice bean is one of the potential neglected underutilized crop species. Its cultivation is gradually extending in many parts of India. The extent of crop–weed competition for these pulses and reduction in crop yields are dependent on type and intensity of weed flora present in the field. Ali and Lal (1989) reported 23.6% reduction in yield in pigeonpea, 52.4% in Urdbean and 38.3% in Mungbean. Weed management through herbicides is gaining popularity due to scarcity of labour for weeding on time. Further, manual weeding is also expensive, less efficient and cannot be performed under adverse soil and weather condition. Therefore, herbicides can be used as an alternative of manual or mechanical weeding. Previously, weed control through herbicides was considered a costly proposition. However, in recent times

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availability of low-dose, high potency, non-residual, broad spectrum herbicides has provided great opportunity to accomplish effective weed control at much lower cost than mechanical methods. Hence, application of *weedicides* for weed management is gaining more importance in recent days. In this context, the experiment on weed management study in rice bean have been planned to find out an effective pre and post emergence *weedicides* which can be used in rice bean cultivation.

MATERIALS AND METHODS

The experiment was carried out at Main Research Station, University of Agricultural Sciences, Hebbal, Bengaluru, India for three consecutive seasons of *Kharif* 2015, 2016 and 2017. The experiment was laid out in a Randomized Block Design with 10 treatments which was replicated thrice. The experimental plot is situated at an altitude of $12^0$58' North, longitude of 77^0 35' East and altitude of 899 meters above mean sea level. The normal annual rainfall is 892 mm. The soil type is red sandy loam with a pH of 6.55 and Electrical conductivity of 0.26 dS m^{-1}. The treatments include both pre-emergent and post emergent herbicides combinations along with manual hand weedings. Among the treatments, the pre-emergence herbicides tried were Oxyfluorfen 23.5 % EC 50 g *a.i.* ha^{-1}, Oxyfluorfen 23.5% EC 50 g *a.i.* ha^{-1}Pre-emergence + one hand weeding at 5WAS, pendimethalin 38.7% CS 1 kg *a.i.* ha^{-1} and pendimethalin 38.7% CS 1 kg *a.i.* ha^{-1} pre-emergence + one weeding at 5 WAS, post-emergence fenoxaprop-p-ethyl 9% EC 50g *a.i.* ha^{-1}, quizalofop-p-ethyl 5% EC 50g *a.i.* $ha^{-1}$and oxadiargyl (80% WP) 50 g *a.i.* ha^{-1}. In addition, weedy check (control) and weed free control. The Rice bean variety used in the experiment was 'KBR-1, a newly developed early maturing and high yielding variety. The spacing followed was 30 x 10 cm. The pre-emergence herbicides were applied one day after sowing using 750 litre ha^{-1} spray solution and the post-emergence herbicides were applied three WAS using 500 liters ha^{-1} spray solution. The weed free check involved three hand weeding at 20, 40 and 60 DAS. The weed count (no. m^{-2}) and dry weight of the weeds (g m^{-2}) were recorded by putting a quadrat of 0.5 m^2 at two random spots in each plot and worked out the mean values. Weed control efficiency (WCE) was calculated by using the formula as shown below.

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

Where, DMC is weed dry weight in control plot and DMT is weed dry weight in treated plot. B:C ratio was worked out by considering prevailing market price for rice bean seeds and the price for different inputs and farm operations were considered for cost of cultivation. Constant results were obtained during three years of the study for all the parameters and therefore, pooled analysis for three years was carried out and results are presented.

RESULTS AND DISCUSSION

The predominant weeds species observed in the experimental plots were *Digitaria margineta, Cyperus rotundus, Amaranthus virdis, Commelina benghalensis, Spillanthus acmella, Parthenium hysteroporus, Ageratum conyzoides, Eleusine indica, Euphorbia* spp. etc. There was a mixed weed flora in equal proportions of all three types of weeds viz., Grasses, BLW and sedges.

The bio-efficacy of different herbicides were presented in table 1 which is indicated that among the herbicides treatments, application of pre-emergence herbicides *viz*., pendimethaline 38.7% EC 1.0 kg *a.i.* ha^{-1} + hand weeding at 5^{th} WAS has recorded lower weed count (4.74) followed by oxyfluorfen 23.5 EC 50 g *a.i.* ha^{-1}+ hand weeding at 5 WAS (4.78) at 20 DAS as compared to weedy check (8.11). Similarly, at harvest, weed count, weed dry weight and higher weed control efficiency were recorded with application of pendimethaline 38.7% EC 1.0 kg *a.i.* ha^{-1}+ hand weeding at 5^{th} WAS (4.87, 5.97g and 83.86%, respectively) followed by Oxyfluorfen 23.5 EC 50 g *a.i.* ha^{-1}+ Hand weeding at 5 WAS (5.01, 7.39g and 74.68%, respectively) as compared to other treatments. However, bio-efficacy of post emergence herbicides *viz*., fenoxaprop-p-ethyl (9% EC) 50g *a.i.* ha^{-1} (5.73 and 10.40g, respectively) and quizalofop-p- ethyl (5% EC) 50g *a.i.* ha^{-1} (5.73 and 10.40, respectively) indicated that though recorded lower weed count and weed dry weight (5.56 and 9.67g, respectively) when compared to un weeded control at harvest. Both the chemicals were not shown higher weed control efficiency. This indicates that only grassy weed killers are not enough to control weeds in Rice bean crop. Hence, pre- emergence followed by one hand weeding proved better by recording lower weed count, weed dry weight and higher weed control efficiency as compared to other treatments. This could be attributed to the fact that pre-emergence herbicides kill all type of weed seeds and lead to less weed infestation during early stage of crop growth. Similar results were also obtained by Singh (2011) who reported that application of pendimethalin 30% EC @1.0 kg *a.i.* ha^{-1}+ one hand weeding at 25 DAS has given higher Black gram seed yield. The earlier studies were conducted by many workers proved that pendimethaline has been used as effective pre-emergence herbicides in pulses. However, Mishra and Bhan (1997) obtained higher grain yield due to better weed control with application of Fluchloraline (PPI) and pre-emergence

Table 1: Weed count, weed dry weight and weed control efficiency of rice bean as influenced weed control treatments (pooled)

Treatments	Weed count (no. m^{-2}) at 20 DAS	Weed count (no. m^{-2}) at harvest	Weed dry weight (g) at harvest	Weed control efficiency
T_1: Fenoxaprop-p-ethyl (9% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS)	58.44 (7.62)	32.78 (5.73)	110.44 (10.40)	49.51
T_2: Quizalofop-p- ethyl (5% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS)	59.00 (7.63)	31.89 (5.56)	100.72 (9.67)	55.73
T_3: Oxyfluorfen (23.5 %EC) 50 g a.i./ha pre-emergence	28.78 (5.31)	31.44 (5.55)	113.83 (10.550	49.77
T_4: Oxyfluorfen 23.5% EC) 50 g a.i./ha pre-emergence + one hand weeding at 5WAS	22.79 (4.78)	25.22 (5.01)	55.83 (7.39)	74.68
T_5: Oxadiargyl (80% WP) 50g *a.i.* ha^{-1} post-emergence (3 WAS)	55.78 (7.46)	42.22 (6.49)	166.83 (12.89)	24.55
T_6: Pendimethaline (38.7% CS) 1 kg *a.i.* ha^{-1} pre- emergence	29.89 (5.37)	30.22 (5.43)	88.28 (9.26)	60.61
T_7: Pendimethaline (38.7% CS) 1 kg *a.i.* ha^{-1} pre- emergence + one weeding at 5 WAS	23.56 (4.74)	23.00 (4.87)	36.11 (5.97)	83.86
T_8: Weed free control	8.44 (2.65)	11.11 (2.99)	10.66 (2.93)	95.31
T_9: Weedy check	65.67 (8.11)	58.00 (7.60)	221.44 (14.85)	-
SEm (±)	**0.28**	**0.185**	**0.329**	**3.16**
LSD (0.05)	**0.80**	**0.524**	**1.101**	**12.54**

Table 2: Growth and yield of rice bean as influenced by different weed control treatments (pooled)

Treatments	Plant height (cm)	Number of branches $plant^{-1}$	No. of pods $plant^{-1}$	Seed yield (kg ha^{-1})
T_1: Fenoxaprop-p-ethyl (9% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS)	17.30	5.21	19.52	790
T_2: Quizalofop-p- ethyl (5% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS)	19.56	6.25	21.13	1042
T_3: Oxyfluorfen (23.5 %EC) 50 g a.i./ha pre-emergence	15.45	5.42	16.21	898
T_4: Oxyfluorfen 23.5% EC) 50 g a.i./ha pre-emergence + one hand weeding at 5WAS	20.58	7.85	21.28	1335
T_5: Oxadiargyl (80% WP) 50g *a.i.* ha^{-1} post-emergence (3 WAS)	14.25	4.23	15.45	671
T_6: Pendimethaline (38.7% CS) 1 kg *a.i.* ha^{-1} pre- emergence	20.13	6.45	18.56	985
T_7: Pendimethaline (38.7% CS) 1 kg *a.i.* ha^{-1} pre- emergence + one weeding at 5 WAS	21.23	7.26	20.35	1467
T_8: Weed free control	22.50	8.50	23.45	1625
T_9: Weedy check	13.62	3.65	12.36	585
SEm (±)	**1.80**	**0.98**	**1.95**	**73**
LSD (0.05)	**5.24**	**3.21**	**5.68**	**215**

Table 3: Growth and yield of rice bean as influenced by different weed control treatments (pooled)

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
T_1: Fenoxaprop-p-ethyl (9% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS)	25680	89000	63320	3.47
T_2: Quizalofop-p- ethyl (5% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS)	25720	104200	78480	4.05
T_3: Oxyfluorfen (23.5 %EC) 50 g a.i./ha pre-emergence	24720	79800	55080	3.23
T_4: Oxyfluorfen 23.5% EC) 50 g a.i./ha pre-emergence + one hand weeding at 5WAS	26850	133500	106650	4.97
T_5: Oxadiargyl (80% WP) 50g *a.i.* ha^{-1} post-emergence (3 WAS)	24250	57100	32850	2.35
T_6: Pendimethaline (38.7% CS) 1 kg *a.i.* ha^{-1} pre- emergence	25245	98500	73255	3.90
T_7: Pendimethaline (38.7% CS) 1 kg *a.i.* ha^{-1} pre- emergence + one weeding at 5 WAS	27450	140700	113250	5.13
T_8: Weed free control	31950	162500	130550	5.09
T_9: Weedy check	22590	48500	25910	2.15
SEm (±)	**-**	**5250**	**4256**	**0.15**
LSD (0.05)	**-**	**15844**	**12852**	**0.45**

application of pendimethalin 30% EC @1.0 kg *a.i.* ha^{-1}+ one hand weeding at 30 DAS in Pigeon pea at Jabalpur, Madhya Pradesh.

As growth of crop plants are influenced by many factors, weed infestation during early stage of any crop plants affects growth by competing for land, water and nutrients. Noteworthy to state that, weed free control was recorded significantly higher plant height, number of branches per plant, number of pods per plant and seed yield (22.50cm, 8.50, 23.45 and 1625 kg ha^{-1}, respectively) which was on par with pre emergence application of pendimethaline 38.7% EC 1.0 kg *a.i.* ha^{-1} + hand weeding at 5th WAS (21.23cm, 7.26, 20.35 and 1467 kg ha^{-1}, respectively) as compared to other treatments and weedy check (Table 2). This could be attributed to the less weed infestation during early period of crop growth and removal of remaining weeds by hand at critical period of weed competition in this crop. The similar results were also be reported by Rahmat Ullah Khan *et al*. (2011) who revealed that the use of pendimethalin @ 2 l ha^{-1} in mung bean increased the plant height, pods per plant, grains per pod, 1000-seed weight and seed yield over the control and which was on par with hand weeding treatment in main contributing parameters of seed yield. Choudhary (2013) obtained higher seed yield with the pre-emergence application of pendimethalin 1.0 kg *a.i.* ha^{-1} in Black gram, pigeon pea, kidney bean, cowpea, chickpea and lentil in Himachal Pradesh. Significantly lower plant height, number of branches per plant, number pods per plant and seed yield kg ha^{-1} was recorded in unweeded control. This could be due to more completion of weeds with crop lead to less growth and yield. The yield reduction in weedy check as against weed free check is 64 %. The yield reduction in pre emergence application alone as compared to one hand weeding is 29.26% (Fig 1). The per cent yield increase in application of pendimethaline 38.7% EC 1.0 kg *a.i.* ha^{-1}+ hand weeding at 5th WAS is 60.12% over control followed by oxyfluorfen 23.5 EC 50 g *a.i.* ha^{-1}+ hand weeding at 5 WAS (56.17%).

Critical period of crop weed competition varies among different pulses. Integrated weed management (IWM) is basically integration of effective, dependable and workable weed management practices such as cultural, mechanical, chemical and biological that can be used economically by the farmers. Considering the scarcity of labour and economics of weedicides applied, it is concluded that the application of weedicides used in rice bean cultivation may reduce cost of production. Significantly higher gross returns, net returns and B:C ratio (Table 3) were recorded in application pendimethaline 38.7% CS 1.0 kg *a.i.* ha^{-1}+ hand weeding at 5th WAS (Rs.140700 ha^{-1}, Rs. 112250 ha^{-1} and 5.13, respectively) followed by oxyfluorfen 23.5 EC 50g a.i./ha + hand weeding at 5 WAS (Rs. 133500 ha^{-1}, Rs. 106650 ha^{-1} and 4.97, respectively) as compared the other treatments. This might be due to increased cost of cultivation of rice bean in weed free check treatment

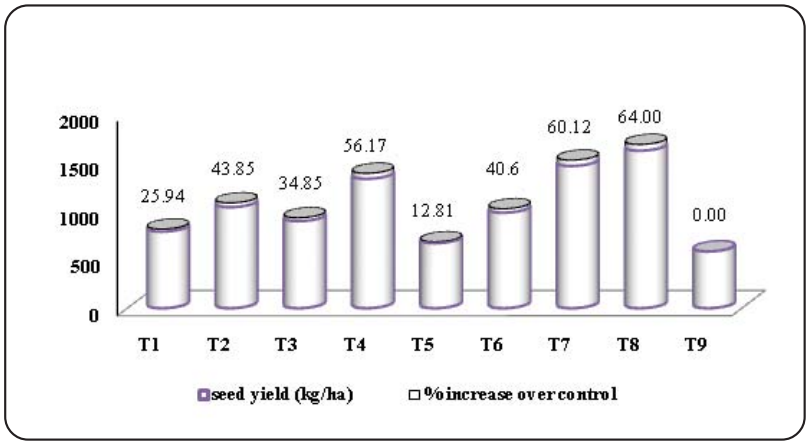

Fig. 1 : Percent increase in seed yield over control due to weedicides

due to higher labour wages. This cost was reduced in the herbicides treatments pendimethaline 38.7% EC 1.0 kg *a.i.* ha^{-1} + hand weeding at 5th WAS followed by oxyfluorfen 23.5 EC 50 g *a.i.* ha^{-1} + hand weeding at 5 WAS by using herbicides for effective control of weeds with reduced labour. The above results are in agreement with the findings of Kalhapure *et al*. (2011) who observed higher B:C ratio of 2.13 with the application of pendimethaline @ 1.0 kg a.i. ha^{-1} as pre-emergence with one hand weeding at 40 days after sowing in Soybean crop. Similarly, net returns of chickpea were significantly higher with pendimethaline 30 EC 0.5 kg *a.i.* ha^{-1} + one hand weeding at 30 DAS as compared to other treatments like pendimethaline1.0 kg *a.i.* ha^{-1} alone and control (Rathi *et al*., 2004). Tamang *et al.* (2015), obtained maximum cost benefit ratio from the treatment Vellore 32 (pendimethaline 30 EC + imazethapyr 2 EC) 1.0 kg *a.i.* ha^{-1}. Hand weeding treatments, though significantly reduced weed biomass and improved the grain yield, gave less benefit: cost ratio owing to higher cost of farm labour.

In the present study, it was observed that use of pendimethaline 38.7% CS 1.0 kg ha^{-1} as post-emergence + hand weeding at 5th WAS and oxyfluorfen 23.5 EC 50 g *a.i.* ha^{-1} as post-emergence + hand weeding at 5 WAS are found economically profitable for management of weeds in rice bean and to increase the productivity. None of the weedicides alone treatments were found effective in controlling all the types of weeds. Whereas, pre-emergence application followed by one hand weeding at 3rd week after sowing proved better for controlling weeds. The post emergent weedicides *viz*., fenoxaprop-p-ethyl (9% EC) 50g *a.i.* ha^{-1} post- emergence (3 WAS) and quizalofop-p-ethyl (5% EC) 50 g ai/ha post-emergence (3 WAS) did not give significant yield when compared to pre emergence weedicides alone.

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