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Effect of herbicides on weed, growth, yield and economics of summer greengram (*Vigna radiata* L.) in Balasore district of Odisha

P Giri, NK Jena, K Behera and AR Patra

Abstract
An on farm trial was conducted to assess the effect of herbicides on weed dynamics, crop growth, yield and economics of summer Greengram at Bishnupur and Basulidiga village of Baliapal and Basta block during summer 2020 and 2021 in Balasore district of Odisha, respectively. The experiment was laid out in RBD design consisting of four treatment *viz*. T_1: Farmer practice, hand weeding at 25 DAS; T_2: Pre-emergence application of Pendimethalin @1 kg ha^{-1} at 2 DAS; T_3: Post-emergence application of Imazethapyr @75 g ha^{-1} at 20 DAS and T_4: $T_2 + T_3$, replicated seven times. Pre emergence application of Pendimethalin @1 kg ha^{-1} followed by post emergence application of Imazethapyr @75 g ha^{-1} recorded the maximum number of branches plant^{-1} (6.3), number of pods plant^{-1} (34.8), test weight (3.67), seed yield (7.48 qha^{-1}) and stover yield (36.90 qha^{-1}) with higher weed control efficiency (76.2%). However, lone application of Imazethapyr @75 g ha^{-1} (PoE) recorded higher benefit cost ratio (2.43) which was statistically at par with sequential application Pendimathalin (PE) followed by Imazethapyr (PoE).

Keywords: Greengram, herbicide, pendimethalin, imazethapyr, weed control efficiency, economics

Introduction
Greengram (*Vigna radiata* L.) is the third most important pulse crop in India with an excellent source of protein (24.5%) with high quality lysine (460 mg/g N) and tryptophan (60 mg/g N). It is the major pulse crop of the state, Odisha with a total coverage of 894230 hectare which is about 44 per cent of the total pulse cultivating area of the state. Area under green gram crop in Balasore district is 16000 hectare with a productivity of 4.90 q ha^{-1} against 4.87 q ha^{-1} in Odisha (Anonymous, 2018) [3].
Weed infestation is a major constraints among the various factors responsible for poor yield in Greengram accounting 50 to 90% yield loss (Kumar *et al.*, 2006) [13]. Competition with the weeds leads to 30 to 80% reduction in grain yield of Greengram during summer (Algotar *et al.*, 2015) [1]. Weeds pose a serious threat to Greengram cultivation during early phase of crop growth. Weeds in Greengram fields reduce production efficiency by competing with crop plants for space, water, nutrients and light interception. Many perennial grasses and broad leaved weeds interfere in Greengram cultivation because this crop is very sensitive to weed competition in the first 4-5 weeks after emergence (Kumar *et al.*, 2005) [12]. Weed control is one of the essential agronomic measures to exploit the maximum yield potential of the newly developed high yielding varieties. Singh and Sheoran, 2008 [19] reported that the weed infestation if not checked within 20 DAS there would be a severe yield reduction to an extent of 38 per cent in contrast to 20 per cent yield reduction with unchecked weed infestation till 20 DAS in Greengram. Traditional practice of hand weeding requires dependence on increased number of labour during peak period of sowing and harvesting and becoming expensive (Vivek *et al*., 2008) [22]. So for effective and timely weed control in Greengram, use of herbicide with appropriate dose is necessary.

Materials and methods
An on farm trial was conducted to assess the effect of herbicide on growth, weed dynamics and yield parameters of summer Greengram at Bishnupur and Basulidiga village of Baliapal and Basta block during summer 2020 and 2021 in Balasore district of Odisha, respectively. Bishnupur experimental site has 21^0 40´ N latitude and 87^0 14´ E longitude with an altitude of 22.6 m above mean sea level. Similarly, Basulidiga has an latitude, longitude and altitude of 21^0 65´ N, 87^0 20´ E and 20.9 m, respectively.

Climate of the region is hot and high humid monsoon with mild winter. The total rainfall received during the crop season (January to April) for the year 2020 and 2021 was 428.2 mm and 256.6 mm, respectively. The minimum and the maximum temperature ranged from 17.8 °C to 33.5 °C during 2020 and 19.7 °C to 37.3 °C during 2021. The soil of the experimental site was slightly acidic in reaction having pH of 5.6 and 5.4, clay loam and sandy clay loam in texture with medium organic carbon content 0.59 and 0.54%, medium in nitrogen 286.4 and 274.3 kg ha^{-1}, phosphorus 18.6 and 16.2 kg ha^{-1} and potassium 183.0 and 178.5 kg ha^{-1}) content in Bishnupur and Baliapal, respectively.

The experiment was laid out in RBD design consisting of four treatment (T_1 Farmer practice: hand weeding at 25 DAS; T_2: Pre-emergence application of Pendimethalin @1 kg ha^{-1} at 2 DAS; T_3: Post-emergence application of Imazethapyr @75 g ha^{-1} at 20 DAS and T_4: T_2 + T_3) replicated seven times. Greengram variety IPM-02-14 was grown by the farmers. The crop was sown during 3rd week of January and harvested during 1st week of April. The recommended fertilizer dose of 20-40-40 kg N-P_2O_5-K_2O/ha was applied with a foliar application of DAP@2% at flowering stage. Pre and post emergence herbicide spray was done using 500 liters of water per hectare as per treatments. Standard recommended package of practices were followed for raising the crop. Observations on different growth, weed and yield parameters were taken and economic analysis was done.

Weed species were recorded in each plot by using a quadrate of 50 cm x 50 cm (0.25 cm^2) from the area marked for observation at 45 DAS. Weeds falling within the quadrate were cut close to the ground surface and dried in a hot air oven maintained at 70±2 °C till constant dry weight. Dry matter of weeds was recorded and expressed in g m^{-2}. Weed control efficiency of different treatments was calculated on the basis of reduction in weight in treated plots in comparison to weedy check and expressed as percentage. It was calculated by using the following formula:

$$WCE\ (\%) = \frac{\text{Weed dry matter in farmers practice plot} - \text{Weed dry matter in herbicide treated plot}}{\text{Weed dry matter in farmers practice plot}} \times 100$$

Three numbers of picking was done and the final crop yield was recorded and the gross return was calculated on the basis of prevailing market price of the produce. Benefit cost ratio was calculated by dividing cost of cultivation from the gross return of their respective treatment. The data on different characters were analyzed by using analysis of variance technique for Randomized Block Design (RBD) as suggested by Gomez and Gomez (1984) [7]. The data on weed density and weed dry matter were analyzed after doing log transformation. The results are presented at 5% level of significance (p = 0.05).

Results and discussion

Weed parameters

Major weed species associated with Summer Greengram in the experimental field were identified as *Cyperus rotundus, Cynodon dactylon, Digera arvensis, Digitaria sanguinalis, Eclipta alba, Commelina bengalensis, Dactyloctenium aegyptium, Physalis minima, Amaranthus viridis, Trianthema portulacastrum, Echinochloa crusgalli, Sorghum halepense, Vernonia cinerea, Euphorbia hirta.* This result confirmed the findings of Chhodavadia *et al*., 2014; Tamang *et al.,* 2015; Chaudhari *et al.,* 2016 [5, 21, 4].

Pre emergence application of Pendimethalin @1 kg ha^{-1} followed by post emergence application of Imazethapyr @75 g ha^{-1} significantly recorded the minimum numbers of weed population than the farmer's practice during both the years (Table 1). But, individual application of these herbicide were at par with each other. The remarkable reduction in weed population might be due to effective weed control in respective treatments of herbicidal control. These finding are confirmed with those reported by Raj *et al.,* 2010 [18]; Chaudhari *et al.,* 2016 [4]. Dry matter accumulated by weed was significantly higher under farmer's practices. Twice application of herbicide at their respective time accumulated the minimum dry matter by weed than the single application of herbicide. Pre emergence application of Pendimethalin @1 kg ha^{-1} followed by post emergence application of Imazethapyr @75g ha^{-1} significantly reduced the weed dry matter accumulation by 76.0, 47.3 and 39.2% over farmer's practice, pre emergence application of Pendimethalin @1 kg ha^{-1} and post emergence application of Imazethapyr @75 g ha^{-1}, respectively. These results are in agreement with the findings of Komal *et al.* 2015; Leva *et al*., 2018 [11, 17]. The maximum weed control efficiency was observed under the treatment with both pre and post emergence application of herbicides. Averaged over years, pre emergence application of Pendimethalin, post emergence application of Imazethapyr and pre followed by post emergence application accounted 54.6, 60.5 and 76.2% of weed control efficiency compared to farmer's practice with hand weeding at 25 DAS, respectively. This might be due to periodical removal of weeds by herbicidal control resulted in remarkable reduction in weed population and ultimately less dry weight of weeds. Similar results were obtained by Kushwah and Vyas, 2005; Yadav *et al*., 2019 [16, 23].

Table 1: Effect of weed management treatments on weed density, dry matter accumulation and control efficiency

Treatments	Weed density (No. m^{-2})		Weed dry matter accumulation (gm^{-2})		Weed control efficiency (%)	
	2020	2021	2020	2021	2020	2021
T_1: Farmer practice	13.65 (187.6)	12.91 (169.0)	9.42 (89.4)	8.50 (72.5)	-	-
T_2: Pendimethalin@ 1 kg ha^{-1}	9.56 (92.1)	8.95 (81.3)	6.53 (42.2)	5.67 (31.6)	52.87	56.42
T_3: Imazethapyr@ 75 g ha^{-1}	9.14 (84.3)	8.55 (73.6)	6.07 (36.2)	5.34 (28.0)	59.69	61.37
T_4: T_2 + T_3	7.23 (53.0)	6.79 (45.7)	4.81 (22.5)	4.15 (16.3)	74.89	77.48
S.Em±	0.55	0.55	0.34	0.34		
C.D. at 5%	1.64	1.65	1.02	1.02		

Original values are given in parentheses

Growth parameters

Weed management treatments influenced the number of branches per plant significantly (Table 2). Pre emergence application of Pendimethalin @1 kg ha^{-1} followed by post emergence application of Imazethapyr @75 g ha^{-1} recorded the maximum number of branches per plant which is statistically at par with sole application of Imazethapyr @75 g ha^{-1} as compared to farmer's practice during both the years. The treatments also exerted similar influence on number of pods per plant. Twice application of herbicide resulted an increased number of pods per plant of 39.4, 22.5 and 15.3% over existing farmer's practice, sole application of pre emergence and post emergence application, respectively. Sequential application of Pendimethalin @1 kg ha^{-1} (PE) and Imazethapyr @75 g ha^{-1} (PoE) significantly recorded the maximum test weight (100 seed weight) of 3.61 and 3.72 g followed by sole application of Imazethapyr and the existing farmer's practice recorded the minimum test weight of 2.96 and 3.21 g during 2020 and 2021, respectively. The lower value of these parameters under farmer's practice was due to high weed competition for light, water and nutrients during the initial crop growth stages before the hand weeding done at 25 DAS. These results confirmed the findings of Kaur *et al*., 2010; Khot *et al.*, 2012; Das *et al*., 2014; Singh *et al*., 2014a; Komal *et al.*, 2015; Kumar *et al.*, 2016 [8, 10, 6, 11, 14].

Seed and stover yield

Seed yield was significantly influenced by the treatment during both the years (Table 2). Pre emergence application of Pendimethalin @1 kg ha^{-1} followed by post emergence application of Imazethapyr @75 g ha^{-1} recorded the maximum (7.34 qha^{-1}) seed yield accounting 29.6% increase over the existing farmer's practice, which is at par with the treatments applied with the herbicide either as pre emergence or post emergence during 2020. However, during 2021 pre emergence application of Pendimethalin @1 kg ha 3^{-1} followed by post emergence application of Imazethapyr @75 g ha^{-1} significantly recorded higher (7.61 qha^{-1}) seed yield than the pre emergence application of Pendimethalin @1 kg ha$^{-1,}$ but, at par with the post emergence application of Imazethapyr @75 g ha^{-1}. Weed management treatments exerted significant difference on stover yield during both the years. Averaged over the years, pre emergence application of Pendimethalin @1 kg ha^{-1}, post emergence application of Imazethapyr @75 g ha^{-1} and application of Pendimethalin @1 kg ha^{-1} followed by Imazethapyr @75 g ha^{-1} accounted 18.5, 22.7 and 31.8% increase in stover yield than the farmer's practice. The increase in seed and stover yield was mainly due to maintenance of weed free environment, especially during critical growth stages of crop, reduce crop weed competition which helped in better growth and development of Greengram crop and ultimately resulting in higher seed and stover yield. These findings are accordance with the findings those of Chhodavadia *et al*., 2014; Chaudhari *et al.*, 2016 [5, 4].

Table 2: Effect of weed management treatments on yield and yield attributes

Treatment	No. of branches plant^{-1}		No. of pods plant^{-1}		100 seed weight (g)		Seed yield (q ha^{-1})		Stover yield (q ha^{-1})	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1: Farmer practice	4.6	4.3	19.7	22.5	2.96	3.21	5.17	5.69	23.54	26.20
T_2:Pendimethalin@ 1 kg ha^{-1}	5.0	5.4	26.4	27.6	3.29	3.49	6.84	6.83	29.07	32.53
T_3: Imazethapyr@ 75 g ha^{-1}	5.5	5.8	28.5	30.5	3.44	3.62	6.93	7.13	31.89	33.21
T_4: $T_2 + T_3$	6.2	6.4	34.1	35.5	3.61	3.72	7.34	7.61	35.16	38.64
S.Em±	0.3	0.3	2.4	2.2	0.04	0.04	0.26	0.22	2.74	2.53
C.D. at 5%	1.0	0.8	7.1	6.5	0.13	0.11	0.79	0.67	8.19	7.59

Economics

The weed management treatments didn't influence the cost of cultivation significantly (Table 3). However, the existing farmer's practice required higher cost of cultivation with an average value of 18060 ₹ ha^{-1} due to higher price involved in manual weeding during both the years of investigation. Pre emergence application of Pendimethalin @1 kg ha^{-1} followed by post emergence application of Imazethapyr @75 g ha^{-1} recorded the maximum gross and net return of 40,386 and 23,270 ₹ ha^{-1} during the year 2020. Similar finding was also observed in the year 2021 and the corresponding values for gross and net return were 41,879 and 24,159 ₹ ha^{-1}. Sole application of Imazethapyr as post emergence application recorded the maximum benefit cost ratio of 2.42 and 2.44 although the maximum productivity was found under the treatment with pre emergence application of Pendimethalin @1 kg ha^{-1}, followed by post emergence application of Imazethapyr @75 g ha^{-1} due to lower cost of cultivation along with equivalent productivity. Similar results were reported by Kundu *et al.*, 2009; Ali *et al.*, 2011 [15, 2].

Table 3: Effect of weed management treatments on economics

Treatments	Cost of cultivation (x 10^3₹ ha^{-1})		Gross return (x 10^3₹ ha^{-1})		Net return (x 10^3₹ ha^{-1})		B:C ratio	
	2020	2021	2020	2021	2020	2021	2020	2021
T_1:Farmer practice	17,684	18,435	28,443	31,271	10,759	12,837	1.62	1.73
T_2: Pendimethalin@ 1 kg ha^{-1}	16,377	16,616	37,636	37,557	21,259	20,941	2.31	2.30
T_3: Imazethapyr@ 75 g ha^{-1}	15,907	16,386	38,107	39,207	22,200	22,821	2.42	2.44
T_4: $T_2 + T_3$	17,116	17,720	40,386	41,879	23,270	24,159	2.39	2.42
S.Em±	776	1,055	1,446	1,223	1,447	1,815	0.11	0.16
C.D. at 5%	NS	NS	4,329	3,662	4,332	5,433	0.34	0.49

Conclusion

Unavailability of labours at the time of weeding resulting in sever weed infestation, which make manual weeding ineffective, tedious and costly. Under such circumstances, chemical control of weeds will be the viable and cost effective alternative for Greengram. Effective herbicide at appropriate rate may prove as an effective weed management method and replace the conventional methods of weed management.

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