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Effect of imezathyper and its combination with imezamox on nodulation and economic yield of blackgram

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Abstract
Among major legumes crops Blackgram [*Vigna mungo* (L.) Hepper] is the one of the important legume crops contributing 8-10% yield production, in India. Legumes crops have nitrogen requirements that typically are met through inoculation with effective nitrogen fixing Rhizobia. Besides managing weeds, the herbicides also affect plant growth by reducing microbial activity along with nitrogen fixation, immediately after application. The experiment was conducted in *Kharif* season 2014 at Research Farm, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India in randomized block design with three replication and twelve treatments on blackgram to find out the Effect of Imezathyper and its Combination with Imezamox on Nodulation and Economic Yield of Blackgram. Results revealed that he maximum number of nodules (56.80 /plant), dry weight of nodules (73.60 mg/plant) and seed yield of 990 kg/ha was registered with treatment T_{11} (two hand weeding at 20 & 40 DAS), which was statistically identical to T_8 (imezathyper + imezamox (pre-mix) 80 g/ha PoE) and T_{10} (imezathyper + pendimethalin (pre-mix) 1000 g/ha PE) and significantly higher compared to rest of treatments. The treatment T_{12} (weedy check) gave lowest number of nodules (31.23 /plant), minimum dry weight of nodules (29.37 mg/plant) and seed yield (378 kg/ha) over rest of treatments. It may therefore be concluded that weed management by ecosafe pre and post- emergence herbicides especially at critical crop weed competition period helps to increase the production as well as root nodulation of blackgram.

Keywords: Blackgram, imazethapyr, imezamox, pendimethalin, root nodules

Introduction
Blackgram is grown all over the world, mostly in tropical and sub-tropical countries for grains, green manuring, fodder and forage as sole crop, intercrop, mixed crop and in sequential cropping systems. The low levels of availability of legume grains in India could be mitigated not only by increasing the production but also by minimizing the quantitative and qualitative losses of grain by weeds through their control. Blackgram is usually accompanied by luxuriant weed growth during the rainy (*Kharif*) season owing to abundant rainfall received during monsoons leading to serious crop losses. The crop is not a very good competitor against weeds (Choudhary *et al*., 2012) [2] and therefore, weed-control initiatives are essential to ensure proper crop growth, particularly in the early growth period. Depending on the nature, density and period of occurrence, weeds can cause losses of grain yield of blackgram varying from 41.6 to 64.1% (Chand *et al*., 2004; Rathi *et al*., 2004; Singh, 2011) [1, 8, 10]. Presently, only pre-emergence herbicides are available which are recommended to manage weeds in *Kharif* blackgram. Sometimes early rains soon after the sowing make it almost impossible to spray pre-emergence herbicides on this crop. Further, many a times weeds emerge at a later stage which can be controlled by hand-weeding (Chand *et al*., 2004) [1]. Also, hand-weeding is labour-intensive, time-consuming, costly and tedious process. The critical period of crop–weed competition in blackgram usually falls between 15 and 45 days after sowing (DAS) (Vivek *et al*., 2008) [14] and many a times, labour is not available particularly when critical period of crop–weed competition sets in. Moreover, monsoon rains make it impossible to go for hand-weeding due to wet field conditions.

Under these situations, use of post-emergence herbicides offers an alternative for effective weed management in blackgram. Imazethapyr, a broad-spectrum herbicide, has soil and foliar activity that allows flexibility in its application timing and has low mammalian toxicity (Tan *et al*., 2005) [12]. Imazethapyr applied as post-emergence at 70 to 80 g/ha as PE and PoE respectively, alone and with combination as pre mix shows season-long control of many weeds without injuring blackgarm (Ram *et al*., 2013) [7]. In blackgram, Nandan *et al*. (2011) [4] reported that post-emergence application of imazethapyr at 50 g/ha had no adverse effects on rainfed blackgram growth characters and resulted in statistically similar grain yield to that of 2 hand-weeding (20 and 40 days after sowing). Crop injury due to herbicides, if any, may vary with the herbicide, application dose, application timing and varietal tolerance. Tolerance of blackgram cultivars to the imezamox class of herbicides would be a desirable agronomic trait and little information is available on this aspect particularly under irrigated conditions. Hence present study conducted was to determine the tolerance of blackgram crop to imazethapyr and to find out the efficacy of pre, post-emergence and pre mix application of imazethapyr at different doses and timings against weeds.

Materials and Methods

A field experiment was conducted at Rajmata Vijayaraje Scindhia Krishi Vishwa Vidayalaya Gwalior, Madhya Pradesh, India, (26º13' North latitude and 78º14' East longitude and 206 meters above mean sea level), during 2014 under rainfed conditions. The experiment comprised 12 weed-control treatments, *viz*. imazethapyr at 2 doses, i.e. 70 and 80 g/ha as PE and PoE, 2 hand-weeding (20 and 40 DAS), imezathyper + imezamox (pre-mix) @ 70 g a.i./ha imezathyper + imezamox (pre-mix) @ 80 g a.i./ha as PE, imezathyper + imezamox (pre-mix) @ 70 g a.i./ha PoE imezathyper + imezamox (pre-mix) @ 80 g a.i./ha PoE, sprayed at 2 and 25 days after sowing (DAS), pendimethalin @ 1000 g a.i./ha PE, pendimethalin + imezathyper (pre-mix) @ 1000 g a.i./ha PE and weedy check with blackgram cultivars (T-9). The experiment was conducted in randomized block design. The soil was Sandy clay loam. The top 0–15 cm layer of the soil profile was neutral in pH (7.5, 1: 2 soil: water ratio), with 0.40dS/m electrical conductivity, low in $KMnO_4$ – oxidizable 240.5 kg/ha N (177.50kg/ha) and Walkley and Black organic carbon (0.42%), medium in Olsen- P (14.2kg/ha) and 1 N NH4 OAc-extractable K (143.8 kg/ha). The meteorological data recorded at meteorological observatory of the University indicated that rainfall received during the crop season was 577.86 mm in 2014. The crop experienced mean weekly maximum temperatures ranging from 34.5 to 41.8 ºC, whereas, the mean weekly minimum temperature ranged from 19.4 to 26.4º during 2014, respectively. Seedbed was prepared by 2 cultivations followed by double planking. The sowing was done at a depth of 4–6 cm in moist soil in rows 40 cm apart with manually using seed rate of 18 kg/ha. Before seeding, the seeds were treated with Captan at 3 g/kg seed to prevent seed-borne diseases. The experiments were sown on 19 July 2014, respectively. The crop was fertilized with 20 kg N, 50 kg P_2O_5 and K_2O 20 kg /ha. Nitrogen and phosphorus were applied through urea (46% N) and single superphosphate (16% P_2O_5) and K_2O through murate of potash respectively. Total quantity of all the fertilizers was applied at sowing. The spray of herbicide was done with the help of knap-sack sprayer fitted with flat-fan nozzle using spray volume of 375 litres/ha. In hand-weeding treatment, weeding was done with a hand-hoe. No irrigations were applied as per the requirement of the crop seasons. Thiodan 35 EC (endosulfan) was sprayed @ 2.5 litres/ha during both the years to control pod-borer. The crop was harvested manually on 11 October 2014. The crop was sun-dried for 3 days and manual threshing was done separately from each experimental unit. Data on number of nodules with respect to native rhizobia and nodule dry weight were recorded at 30 i.e. at flower-initiation stage, 60 DAS and at Harvest stage. Five plants from each plot were uprooted carefully, their roots were washed and nodules were detached and counted. Dry weight of nodules, shoots and roots was determined after drying to constant weight at 65 ºC. The data on dry weight of weeds were recorded on whole-plot basis at harvesting. The weeds were cut at the stem base near the soil surface, put in the paper bags after sun drying, then dried in an oven at 60 ºC for 72 hours and biomass was recorded. At maturity, observations on plant height, branches/plant and pods/plant were taken from 5 random plants/plot. Pods were collected from 5 plants in each plot and threshed manually to record seeds/pod. A 100-seed sample was collected from each plot for recording 100-seed weight. Biological yield and grain yield were recorded on a plot basis and harvest index was calculated.

Weed-control efficiency (WCE) was calculated as

$$WCE = \frac{(\text{Dry weight of weeds in weedy check} - \text{Dry weight of weeds in treatment})}{\text{Dry weight of weeds in weedy check}} \times 100$$

Gross returns were calculated by taking the sale price of blackgram as 36 per kg. Net returns (RS. /ha) were calculated as: Net returns = Gross returns - cost of cultivation including the cost of individual treatments. Benefit: cost ratio was calculated after dividing net returns with the cost of cultivation. All the data were subjected to analysis of variance (ANOVA) as per the standard procedures. The comparison of treatment means was made by critical difference (CD) at $P \leq 0.05$.

Results and Discussion

Blackgram tolerance to herbicide No visual adverse effects in terms of yellowing, leaf injury or necrosis or change in morphology was observed on blackgram crop due to pre, post-emergence and pre mix application of imazethapyr at different doses and timings. The visual observations on growth showed that both the cultivars of blackgram revealed good degree of tolerance to imazethapyr. Nandan *et al*. (2011) [4]. Application of imazethapyr with different doses and timing with single and pre mix application along with imezamox had no adverse effect on number of nodules/plant and dry weight of nodules/plant when recorded at 30 60 DAS and harvest stage (Table 1). Imezathyper + imezamox (pre-mix) 80 g/ha PoE at 30,60 DAS and harvest stage recorded the number of nodules/plant and dry weight of nodules/plant which was statistically at par with 2 hand-weeding (20 and 40 DAS) and indicated that application of imazethapyr was safe to the crop even at the highest dose of 80 g/ha. Reduction in number of nodules/plant and dry weight of nodules/plant with weedy check, could be attributed to increasing dry matter of weeds, which led to more competition with the crop and thereby decreased its growth.

Number of nodules/plant and dry weight of nodules/plant (mg)

Nodulation was significantly influenced by different weed-control treatments and blackgram cultivars (Table 1). Number of nodules and dry weight of nodules was the highest in imezathyper + imezamox (pre-mix) 80 g/ha PoE at 30,60 DAS and harvest stage, being statistically at par with pendimethalin + imezathyper (pre-mix) 1000 g/ha PE and 2 hand-weeding (20 and 40 DAS) but was significantly better than all other weed-control treatments and weedy check. Better growth attributes caused more accumulation and translocation of photosynthates by the crop, which resulted in more number and dry weight of nodules (Choudhary *et al*., 2012) [2]. Goud *et al*. (2013) [3] also reported that imazethapyr @ 75 g/ha had no adverse effect on nodule number and biomass relative to weedy check and hand-weeding in chickpea. The absence of any adverse effect of imazethapyr on nodulation may also be attributed to the fact that imazethapyr has been reported to positively affect nodule initiation and nodule development (Royuela *et al*., 2000) [9].

Biological yield, grain yield and harvest index

Different weed-control treatments had a significant influence on biological yield and grain yield (Table 1). Highest biological yield was obtained with two hand weeding at 20 and 40 DAS which was statistically at par with imezathyper + imezamox (pre-mix) 80 g/ha PoE and pendimethalin + imezathyper (pre-mix) 1000 g/ha PE except with pendimethalin 1000 g/ha PE and weedy check. Application of two hands weeding at 20 and 40 DAS and imezathyper + imezamox (pre-mix) 80 g/ha PoE and pendimethalin + imezathyper (pre-mix) 1000 g/ha PE gave the highest grain yield of blackgram which was at par with imezathyper 80g/ha PoE but significantly higher than all other weed-control treatments, different times had no adverse effect on growth of blackgram. Different weed-control treatments had a significant influence on harvest index (Table 2). Highest harvest index (%) was obtained with two hand weeding at 20 and 40 DAS which was statistically at par with all other weed-control treatments except with weedy check.

Table 1: Effect of different weed control measures on number of nodules per plant, dry weight of nodules per plant (mg) biological yield (kg/ha), seed yield (kg/ha) and harvest index (%) at successive crop growth stages

Treatments	Symbol	Dry weight of nodules per plant at			Number of nodules per plant at			Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
		30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest			
Imezathyper 70 g/ha PE	T_1	21.20	53.50	53.20	25.07	44.07	41.80	2669	664	24.87
Imezathyper 80 g/ha PE	T_2	22.67	58.40	58.07	25.67	46.00	43.67	2930	742	25.38
Imezathyper 70 g/ha PoE	T_3	23.90	61.17	60.73	25.40	48.30	46.33	3138	807	25.73
Imezathyper 80g/ha PoE	T_4	25.87	67.83	67.17	27.00	52.73	51.67	3477	898	25.83
Imezathyper + Imezamox (pre-mix) 70 g/ha PE	T_5	20.07	47.93	47.60	24.40	39.50	36.83	2344	560	23.89
Imezathyper + Imezamox (pre-mix) 80 g/ha PE	T_6	20.93	50.57	50.07	24.60	41.67	38.67	2448	599	24.50
Imezathyper + Imezamox (pre-mix) 70 g/ha PoE	T_7	23.50	65.20	64.53	26.00	51.17	50.50	3268	846	25.90
Imezathyper + Imezamox (pre-mix) 80 g/ha PoE	T_8	27.33	73.60	72.00	28.40	55.87	54.70	3646	964	26.44
Pendimethalin 1000 g/ha PE	T_9	20.07	47.17	46.50	24.07	39.17	36.13	2266	534	23.48
Pendimethalin + Imezathyper (pre-mix) 1000 g/ha PE	T_{10}	28.67	71.80	70.93	29.20	54.20	53.67	3555	924	26.00
Two hand weeding at 20 and 40 DAS	T_{11}	30.00	73.60	72.27	30.67	56.80	55.47	3698	990	26.78
Weedy check	T_{12}	16.00	29.37	28.80	21.00	31.23	26.83	1862	378	20.21
S.E.(m)±		0.51	0.98	1.09	0.38	1.03	0.81	64	28	0.29
C.D. (at 5%)		1.49	2.90	3.23	1.13	3.05	2.40	190	82	0.85

PE: Pre-emergence, PoE: Post-emergence, DAS: Days after sowing

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