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RESEARCH ARTICLE

Integrated Weed Management in Cluster Bean (*Cyamopsis tetragonoloba* L. Taub.)

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ABSTRACT

A field experiment was conducted at the Research Farm, ITM University, Gwalior; Madhya Pradesh during the kharif seasons of 2017 under the edaphic and climatic conditions of Gwalior (M.P.). The experiment consisted 8 weed management treatments (Imazethapyr @ 70 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Quizalofop @ 50 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Fenoxaprop-p-ethyl @ 70 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Imazethapyr + Imazamox @ 50 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Pendimethalin @ 750 g a.i./ha (PE) + 1 HW at 20 DAS, Hand weeding at 20 DAS + Hoeing at 40 DAS, Weed free and Weedy check). It was laid out in randomized block design with 3 replications. Herbicides were applied by knap sack sprayer fitted with flat pan nozzle using 500 litre/ha water. In the plots involving hand weeding treatment, weeds were removed manually at 20, 40, 60 DAS and as necessity as per treatment. All other agronomic practices were adopted as per recommended package of practices. The studied for selected attributes by using 3 plants in randomized manner in the seeding depth. Weed free treatment recorded significantly effective values of weed parameters viz. total dry weight (g/m^2) & weed control efficiency (%) and crop parameters viz. growth parameters [plant height (cm), number of branches/plant & dry weight/plant (g)], yield attributes [number of pods/plant, number of seeds/pod & test weight (g], computed parameters [seed yield (kg/ha), stover yield (kg/ha) & harvest index (%)], quality parameters [protein content (%), protein yield (kg/ha), gum content (%) & gum yield (kg/ha)] & economics [gross monetary return (₹/ha), net monetary return (₹/ha) & B:C ratio (₹/ha)] over rest of the treatments. The next effective was Hand weeding at 20 DAS + Hoeing at 40 DAS; which was at par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS.

Key words: *Cluster bean; Weed control efficiency; Weed management practices.*

The word Guar (*Cyamopsis tetragonoloba* L. Taub) represents it's derivation from sanskrit word 'GAUAAHAR'; which means cow fodder or otherwise fodder of the livestock. Basically, Guar is one of the droughts tolerant, deep rooted and hardy annual *kharif* legume crop of India.

Cluster bean crop has a great role to play in nitrogen economy for the succeeding crop as it builds up soil fertility by fixing atmospheric nitrogen and by addition of organic matter. It is a good source of carbohydrates, protein, fiber and minerals like calcium, phosphorus and iron as well as contains appreciable amount of vitamin C and it has become an important industrial crop with a great potential for foreign exchange (*Kumar, 2005*).

The crop is being cultivated under rainfed condition in India since ancient time. The Agro-ecological conditions of India are ideal for guar cultivation. India is the largest grower and producer country of Guar in the world and the same is grown in the north-western states of India namely; Rajasthan, Gujarat, Haryana, Punjab and some parts of U.P. and M.P.

Cluster bean is grown for green fodder, vegetable, green manuring, gum and seed purpose. India is the largest grower and producer of Cluster bean in the world. It contributes 82% share in the world's total production. In the recent years, besides its conventional

uses, it has emerged as an industrial crop, due to presence of galactomannan (gum) in its endosperm, which is around 30-35% of seed weight. *Yaduraju (2006)* reported that in India, weeds contribute highest (37%) annual yield losses of agricultural produce as compared to that of insects (29%), diseases (22%) or other pests (12%). *Saxena et al. (2004)* reported that the competition between weeds and crop caused 53.7% reduction in seed yield and if keeping the crop weed-free for the initial 30 and 40 days reduced the weed dry weight by 63.4 and 75%, respectively. Hence, cluster bean required an initial 40 days weed-free period for better seed yield.

During rainy season weeds are not physically controlled timely mainly owing to unpredictable rains and unavailability of labourer at one time on larger areas at critical stage and devotion of more time and input for food grain crops. Hence it becomes inevitable to use herbicides. However, herbicides alone might fail to give satisfactory control of weeds because of reasons like short period persistence and reduced efficiency on late emerging weeds that ultimately cause severe reduction in crop yields. Hand weeding is a traditional and effective method of weed control; but it is very costly, so it was felt necessary to evaluate post-emergence herbicides which can be the best alternative to traditional practices (*Yadav et al., 2011*).

In the last four decades, considerable developments have been taken place in chemical weed control, thereby increasing the crop returns by reducing the cost of production. However, much needed information on the right kind of herbicides, the time, rate and method of application and residual effects on the succeeding crops are lacking in our country. Keeping these facts in view, the present investigation planned with the following objectives:

- To assess the effect of different herbicides on various species of weeds
- To find out the suitable weed management practice for effective weed control in Cluster bean.
- To assess the effect of weed management practices on growth, yield and quality parameters of Cluster bean
- To workout the economic viability of the treatments.

METHODOLOGY

A field experiment was conducted at the Research Farm, ITM University, Gwalior; Madhya Pradesh during the *kharif* seasons of 2017 under the edaphic and climatic conditions of Gwalior (M.P.). The topography of the field was uniform with proper drainage. The soil was sandy clay loam, light alkaline (pH 7.5), available nitrogen (222.5 kg/ha), available phosphorus (16.5 kg/ha) and available potassium (198 kg/ha). The experiment consisted 8 weed management treatments (Imazethapyr @ 70 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Quizalofop @ 50 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Fenoxaprop-p-ethyl @ 70 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Imazethapyr + Imazamox @ 50 g a.i./ha (PoE) at 20 DAS + 1 HW at 40 DAS, Pendimethalin @ 750 g a.i./ha (PE) + 1 HW at 20 DAS, Hand weeding at 20 DAS + Hoeing at 40 DAS, Weed free and Weedy check). It was laid out in randomized block design with 3 replications. A uniform dose of 20 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha was applied through urea, single super phosphate and muriate of potash; respectively in as a basal dose in crop rows at about 5 cm below Cluster bean. Total rainfall in the respective seasons during the crop period was 70.0 mm. Life-saving irrigations were applied to overcome water deficit. Herbicides were applied by knap sack sprayer fitted with flat pan nozzle using 500 litre/ha water. In the plots involving hand weeding treatment, weeds were removed manually at 20, 40, 60 DAS and as necessity as per treatment. All other agronomic practices were adopted as per recommended package of practices. The studied for selected attributes by using 3 plants in randomized manner in the seeding depth.

Important monocot weeds were *Cyperus rotundus* (L.) and *Cynodon dactylon* (L.) Pers.; while dicot weeds were *Commelina benghalensis* (L.), *Digera arvensis* (L.) Forsk. and *Celosia argentea* (L.). Out of these, *Cyperus rotundus* (L.) and *Celosia argentea* (L.) were the most dominant ones.

All the data were statistically analyzed using the F-test procedure given by *Gomez and Gomez (1984)*. The difference between treatment means were compared with the critical differences (CD) at 5% level of probability (P=0.05).

RESULTS AND DISCUSSION

The mean values of only such treatments having significant differences are discussed in order to provide a quick grasp of trends exhibited by the parameters (Table 1-3).

The complete control of *Digera arvensis*, *Celosia argentea*, *Commelina benghalensis*, *Cyperus rotundus* & *Cynodon dactylon* as well as total weed dry weight

Table 1. Effect of integrated weed management practices on species-wise weed population, total weed population, total weed dry weight and weed control efficiency in cluster bean

Treatment	Population of Digera arvensis/m^2	Population of Celosia argentia/ m^2	Population of Commelina benghalensis/m^2	Population of Cyperus rotundus/m^2	Population of Cynodon dactylon/m^2	Total weed dry weight (g/m^2)	WCE (%)
W_1	1.262 (1.11)	1.343 (1.34)	1.343 (1.34)	1.386 (1.44)	1.386 (1.44)	12.07	88.84
W_2	1.350 (1.33)	1.503 (1.78)	1.503 (1.78)	1.350 (1.33)	1.350 (1.33)	13.68	87.28
W_3	1.310 (1.22)	1.433 (1.56)	1.433 (1.56)	1.303 (1.22)	1.303 (1.22)	12.27	88.64
W_4	1.177 (0.89)	1.262 (1.11)	1.262 (1.11)	1.220 (1.00)	1.220 (1.00)	9.26	91.42
W_5	1.386 (1.44)	1.535 (1.89)	1.566 (2.00)	1.426 (1.56)	1.426 (1.56)	15.29	85.77
W_6	1.220 (1.00)	1.303 (1.22)	1.303 (1.22)	1.260 (1.11)	1.260 (1.11)	10.26	90.49
W_7	0.707 (0.00)	0.707 (0.00)	0.707 (0.00)	0.707 (0.00)	0.707 (0.00)	0.00	100.00
W_8	2.570 (6.11)	2.614 (6.33)	2.436 (5.44)	3.153 (9.44)	2.777 (7.22)	107.82	0.00
S.E.(m)±	0.073	0.097	0.105	0.092	0.094	1.86	1.71
C.D. (P=0.05)	0.222	0.295	0.318	0.279	0.284	5.64	5.20
Transformation	√x+0.5	√x+0.5	√x+0.5	√x+0.5	√x+0.5		

W_1, Imazethapyr @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_2, Quizalofop @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_3, Fenoxaprop-p-ethyl @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_4, Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_5, Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS; W_6, Hand weeding at 20 DAS + Hoeing at 40 DAS; W_7, weed free; W_8, Weedy check; NS, Not-significant; S, Significant; Figures in parentheses indicate original values

(g/m^2) were recorded under weed free treatment. The next effective treatment was Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS over rest of the treatments; while maximum population was registered under weedy check. The significantly higher weed control efficiency (100%) was recorded under weed free treatment. The next effective treatments was Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS +1 HW at 40 DAS (91.42%); while minimum was recorded under weedy check over rest of the treatments (Table 1).

The superiority of Imazethapyr + Imazamox @ 50 g a.i./ha over rest of the herbicidal treatments may be due to their broad-spectrum effects by combination of two molecules; which enhance weed controlling ability over rest of the herbicides. The broad-leaf weeds were unaffected by Quizalofop @ 50 g a.i./ha and Fenoxaprop-p-ethyl @ 70 g a.i./ha due to their molecular makeup is based on controlling only narrow-leaf weed flora. The other explanations of the lower weed dry weight in the former treatments were mainly due to effective weed control efficiency; which resulted in lower population of narrow-leaf and broad-leaf weeds. The results are in conformity with the findings of *Dhaker et al. (2009), Yadav et al. (2011), Singh and Punia (2012), Patel et al. (2014), Singh et al. (2014), Yadav et al. (2014)* and *Singh et al. (2016).*

All the integrated weed management practices increased plant height, number of branches/plant and dry weight/plant over weedy check. The significantly maximum values were registered under weed free treatment (111.22 cm, 7.78 & 20.56 g; respectively) over rest of the treatments. The next effective treatment was Hand weeding at 20 DAS + Hoeing at 40 DAS; which was at par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS. The significantly higher value of CGR was obtained with weed free treatment (9.14 g/m^2/day); while lowest was observed under weedy check over remaining treatments. The second-best treatment was

Table 2. Effect of integrated weed management practices on crop growth & physiological attributes of cluster bean

Treatment	Plant height (cm)	Number of branches/ plants	Dry weight/ plant (g)	Crop growth rate ($g/m^2/day$)
W_1	97.11	4.22	12.44	5.33
W_2	96.22	3.34	11.33	4.78
W_3	96.67	3.78	11.89	4.96
W_4	104.33	5.89	16.33	7.17
W_5	104.00	5.56	15.89	6.81
W_6	104.89	6.44	17.11	7.47
W_7	111.22	7.78	20.56	9.14
W_8	90.00	2.22	6.67	2.75
S.E.(m)±	1.98	0.36	1.06	0.47
C.D. (P=0.05)	6.00	1.10	3.22	1.42

W_1, Imazethapyr @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_2, Quizalofop @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_3, Fenoxaprop-p-ethyl @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_4 Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_5, Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS; W_6, Hand weeding at 20 DAS + Hoeing at 40 DAS; W_7, Weed free; W_8, Weedy check; NS, Not-significant

Table 3. Phytotoxicity symptoms under 10-point scale after application of different herbicides on cluster bean

Days of Treatment	Phytotoxicity parameters					
	Chlorosis	Necrosis	Wilting	Scorching	Hyponasty	Epinasty
1 DAA						
W_1	0	0	0	0	0	0
W_2	0	0	0	0	0	0
W_3	0	0	0	0	0	0
W_4	0	0	0	0	0	0
W_5	0	0	0	0	0	0
3 DAA						
W_1	2	0	0	0	0	0
W_2	0	0	0	0	0	0
W_3	0	0	0	0	0	0
W_4	2	0	0	0	0	0
W_5	0	0	0	0	0	0
5 DAA						
W_1	1					
W_2	0	0	0	0	0	0
W_3	0	0	0	0	0	0
W_4	1	0	0	0	0	0
W_5	0	0	0	0	0	0
7 DAA						
W_1	0	0	0	0	0	0
W_2	0	0	0	0	0	0
W_3	0	0	0	0	0	0
W_4	0	0	0	0	0	0
W_5	0	0	0	0	0	0
10 DAA						
W_1	0	0	0	0	0	0
W_2	0	0	0	0	0	0
W_3	0	0	0	0	0	0
W_4	0	0	0	0	0	0
W_5	0	0	0	0	0	0

W_1, Imazethapyr @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_2, Quizalofop @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_3, Fenoxaprop-p-ethyl @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_4, Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_5, Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS

Hand weeding at 20 DAS + Hoeing at 40 DAS; which was on par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS (Table 2).

On the basis of visual observations on 0-10 point scale; none of the herbicidal weed control treatments was found phytotoxic on crop in terms of different phytotoxic effects viz. chlorosis, necrosis, wilting, scorching, hyponasty and epinasty during the experimentation except Imazethapyr @ 70 g a.i./ha at 20 DAS and Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS; which cause chlorosis symptoms at 3 DAA and within 3 to 4 days plant recovered itself, hence their impact on plant growth was negligible and plants did not show any abnormalities (Table 3).

The integrated weed management practices showed significant impact upon number of pods/ plants, number of seeds/pods, test weight, seed yield, stover yield and harvest index (Table 4). Maximum values (59.87, 6.48, 25.75 g, 2973 kg/ha, 4488 kg/ha and 39.84%; respectively) were registered under weed free treatment, while minimum was recorded under weedy check treatment (44.99, 2.55, 16.91 g, 539 kg/ha, 922 kg/ha and 36.90%; respectively). The next effective treatment was Hand weeding at 20 DAS + Hoeing at 40 DAS (55.21, 5.57, 23.67 g, 2164 kg/ha, 3308 kg/ha and 39.54%; respectively); which was at par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS (54.81, 5.31, 23.16 g, 1964 kg/ha, 3065 kg/ha and 39.06%; respectively) and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS (54.25, 5.09, 22.55 g, 1797 kg/ha, 2857 kg/ha and 38.61%; respectively).

The integrated weed management practices showed significant impact upon protein content, protein yield, gum content and gum yield (Table 4). Higher values were registered under weed free treatment (36.03%, 1074 kg/ha, 30.98% and 923 kg/ha; respectively), while minimum was recorded under weedy check treatment (28.43%, 153 kg/ha, 24.45% and 132 kg/ha; respectively). The next effective treatment was Hand weeding at 20 DAS + Hoeing at 40 DAS (33.88%, 737 kg/ha, 29.14% and 634 kg/ha; respectively); which was at par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS (33.67%, 662 kg/ha, 28.96% and 569 kg/ha; respectively) and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS (33.48%, 602 kg/ha, 28.79% and 518 kg/ha; respectively).

Table 4. Effect of integrated weed management practices on yield attributes, quality parameters and yield of cluster bean

Treatment	Number of pods/plants	No. of seeds/ pod	Test weight (g)	Protein content (%)	Gum content (%)	Seed yield (kg/ha)	Stover yield (kg/ha)	Protein yield (kg/ ha)	Gum yield (kg/ha)	Harvest index (%)
W_1	49.80	3.99	20.39	31.37	26.97	1146	1857	359	3 09	38.17
W_2	49.01	3.58	19.03	30.62	26.33	934	1568	286	246	37.31
W_3	49.51	3.80	19.95	31.01	26.67	1058	1746	327	282	37.74
W_4	54.81	5.31	23.16	33.67	28.96	1964	3065	662	569	39.06
W_5	54.25	5.09	22.55	33.48	28.79	1797	2857	602	518	38.61
W_6	55.21	5.57	23.67	33.88	29.14	2164	3308	737	634	39.53
W_7	59.87	6.48	25.75	36.03	30.98	2973	4488	1074	923	39.84
W_8	44.99	2.55	16.91	28.43	24.45	539	922	153	132	36.90
S.E.(m)±	1.29	0.21	0.66	0.66	0.57	144	219	58	50	0.09
C.D. (P=0.05)	3.91	0.64	2.01	2.00	1.72	436	665	175	151	0.27

W_1, Imazethapyr @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_2, Quizalofop @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_3, Fenoxaprop-p-ethyl @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_4, Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_5, Pendimethalin @ 750 g a.i./ ha + 1 HW at 20 DAS; W_6, Hand weeding at 20 DAS + Hoeing at 40 DAS; W_7, Weed free; W_8, Weedy check

Cost of cultivation of ₹20201/ha was common for all the treatments. But the cost of integrated weed management practices varied from treatment to treatment. The highest gross cost of cultivation (₹31451/ha) was incurred under weed free treatment followed by Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS (₹25594/ha) over rest of the treatments (Table 5).

The integrated weed management practices showed significant impact upon gross monetary return, net monetary return and B:C ratio (Table 5). Higher values were registered under weed free treatment (₹180652/ha, ₹146201/ha and ₹5.74; respectively), while minimum was recorded under weedy check treatment (₹32794/ha, ₹12563/ha and ₹1.62; respectively). The next effective treatment was Hand weeding at 20 DAS + Hoeing at 40 DAS (₹131467/ ha, ₹106266/ha and ₹5.22; respectively); which was at par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS (₹119376/ha, ₹93782/ ha and ₹4.66; respectively) and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS (₹109235/ha, ₹83972/ha and ₹4.32; respectively).

This might be due to favourable conditions created by weed management practices; which resulted higher accumulation of crop dry matter and optimum translocation of food materials to the pod as well as effective uptake of nutrients and moisture. Several investigators have reported that the soil thermal regime under plant covered was different from that of bare soil. Soil temperature often being lower under dense plant covered surfaces than in light plant covered soil. This might be due to effective control of weeds and thus resulted in lower accumulation of dry matter in weeds and lower crop-weed competition associated with effective availability of moisture and nutrients to Cluster bean crop. These results are in line with the work of *Saxena et al. (2004), Punia et al. (2011), Jakhar et al. (2013), Rawat et al. (2013), Yadav et al. (2013), Sharma (2014), Singh et al. (2014), Singh et al. (2016), Gupta et al. (2017)* and *Sharma et al. (2018).*

CONCLUSION

Weed free treatment recorded significantly

Table 5. Effect of integrated weed management practices on economics of cluster bean

Treatment	Cost of cultivation (₹/ha)	Gross monetary return (₹/ha)	Net monetary return (₹/ha)	B:C Ratio (₹/ha)
W_1	24689	69684	44995	2.82
W_2	25350	56800	31450	2.24
W_3	24820	64357	39538	2.59
W_4	25594	119376	93782	4.66
W_5	25264	109235	83972	4.32
W_6	25201	131467	106266	5.22
W_7	31451	180652	149201	5.74
W_8	20201	32794	12563	1.62
S.E.(m)±	-	8739	8739	0.33
C.D. (P=0.05)	-	26508	26508	1.00

W_1, Imazethapyr @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_2, Quizalofop @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_3, Fenoxaprop-p-ethyl @ 70 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_4, Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS; W_5, Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS; W_6, Hand weeding at 20 DAS + Hoeing at 40 DAS; W_7, Weed free; W_8, Weedy check

effective values of weed parameters viz. total dry weight (g/m^2) & weed control efficiency (%) and crop parameters viz. growth parameters [plant height (cm), number of branches/plant & dry weight/plant (g)], yield attributes [number of pods/plant, number of seeds/pod & test weight (g], computed parameters [seed yield (kg/ha), stover yield (kg/ha) & harvest index (%)], quality parameters [protein content (%), protein yield (kg/ha), gum content (%) & gum yield (kg/ha)] & economics [gross monetary return (₹/ha), net monetary return (₹/ha) & B:C ratio (₹/ha)] over rest of the treatments. The next effective was Hand weeding at 20 DAS + Hoeing at 40 DAS; which was at par with Imazethapyr + Imazamox @ 50 g a.i./ha at 20 DAS + 1 HW at 40 DAS and Pendimethalin @ 750 g a.i./ha + 1 HW at 20 DAS.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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