Short Communication

Integrated weed management in green gram [*Vigna radiata* (L.) Wilczek]

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Abstract

A field experiment was conducted from December 2020 to March 2021 at the Department of Agronomy, College of Horticulture, Vellanikkara, to develop an integrated weed management strategy for green gram. Hand weeding at 20 DAS and 40 DAS recorded the lowest weed dry matter production and the highest weed control efficiency. All the treatments where pre-emergence herbicide application was integrated with hand weeding were highly effective in reducing the weed dry matter production. Weed control efficiency was the highest (97 per cent) in imazethapyr + imazamox followed by (*fb*) hand weeding, and diclosulam *fb* hand weeding. Plant height, number of branches/plant, number of pods/plant and number of seeds/pod in green gram were significantly improved with weed management practices as compared with unweeded control. Weed control efficiency, biometric parameters and grain and haulm yields of green gram were significantly lower with the stale seed bed technique. Grain and haulm yields were the highest in hand weeding, which was statistically at par with all the weed management practices where herbicides were integrated with hand weeding. The highest B: C ratio was observed in imazethapyr + imazamox *fb* hand weeding (1.28), followed by diclosulam *fb* hand weeding (1.27).

Keywords: Diclosulam, Hand weeding, Imazethapyr + imazamox, Stale seed bed, Weed control efficiency.

India is the world's leading producer of green gram with a production of 2.50 Mt and productivity of 548 kg/ha (India Agri Stat, 2019). However, the production of green gram has remained almost static in recent years, which is a direct result of various biotic and abiotic stresses in nature. Weeds are the major biotic constraints that result in yield losses upto 70-72 per cent in green gram (Singh et al., 1991; Veeraputhiran, 2009). Hand weeding has been proved successful in achieving season-long weed control, but the high labour cost involved has created practical difficulties in adopting manual weeding on a large scale. This necessitated a shift to chemical weed control using herbicides. Though the use of herbicides is highly preferred due to the ease of application, quick action and reduced costs, long-term dependence on chemicals for weed control has created environmental problems. Thus, there is a need to integrate different methods of weed control to develop efficient and economically viable weed management strategies.

Mechanical methods like hand weeding, hand hoeing and mulching, cultural methods like crop rotation and stale seedbed, and chemical methods using pre-emergence herbicides like pendimethalin and oxyfluorfen, or post-emergence herbicides like quizalofop-ethyl and fenoxoprop-ethyl have been proved effective for weed control in green gram. First 30 DAS is found to be the critical period of crop-weed competition in green gram (Singh et al., 1991). Pre-emergence herbicides are highly successful in controlling all kinds of weeds in green gram in the initial periods of crop growth up to about

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30 days after sowing; however, no post-emergence herbicides are available which provide seasonlong control of broad leaved weeds in pulses (Kumar et al.,2016). In this study, integration of pre-emergence herbicides with hand weeding has been attempted to achieve broad-spectrum weed control in green gram.

A field experiment was conducted from December 2020 to March 2021 in a rice fallow under the Department of Agronomy, College of Agriculture Vellanikkara. The experimental site is located at a latitude of 10°31¹N and longitude of 76°13¹ E, at a height of 40.3m above Mean Sea Level. The soil of the experimental field is sandy loam in texture and acidic in reaction, with a pH of 4.7 and having available N, P and K contents of 75.6 kg/ha, 37.5 kg/ha and 93.5 kg/ha, respectively. The experiment consisted of eight treatments, replicated thrice in a randomized block design, and included stale seed bed for 14 days followed by (*fb*) shallow digging (T_1), stale seedbed for 14 days fb shallow digging *fb* oxyfluorfen, 150 g/ha at 0-3 DAS (T2), oxyfluorfen, 150 g/ha at 0-3 DAS *fb* hand weeding at 25 DAS (T3), imazethapyr, 50 g/ha at 0-3 DAS *fb* hand weeding at 25 DAS (T_4), imazethapyr + imazamox, 80 g/ha at 0-3 DAS *fb* hand weeding at 25 DAS (T_5), diclosulam, 15 g/ha at 0-3 DAS *fb* hand weeding at 25 DAS, hand weeding at 20 DAS and 40 DAS (T_7) and unweeded control (T_8). The field was ploughed with a tractor, cleared of weeds and levelled. Individual plots of size 20 m^2 (5m × 4m) were measured out for the experiment, and seed bed preparation was carried out in those plots receiving stale seed bed treatment. Irrigation was then given to the stale seed beds to stimulate weed seed germination. After 14 days, the new flushes of weeds emerged in the stale seedbeds were destroyed by gentle raking without disturbing the seed bed further. Seed bed preparation was carried out in the remaining plots and pre-emergence herbicidal treatments were applied on the same day. Sowing of the short duration green gram variety CO8 was done one day later at a spacing of 25 cm x 15 cm. Urea, factamphos and muriate of potash were used as sources of nitrogen, phosphorus and potassium respectively, so as to supply 20:30:30 kg N, P and K per hectare. Organic manure was not applied.

Observations on weed dry matter production was recorded at 30 DAS, 45 DAS and 60 DAS, and weed control efficiencies were calculated. Plant height and number of branches/plant were recorded at 30 DAS and 45 DAS. Yield attributes, *viz.,* number of pods/ plant, seeds/pod and 100 seed weight, and grain yield and straw yield were also recorded.

The experimental field was dominated by broad leaved weeds which accounted for 85.5 per cent of the total weed population, among which *Melochiac orchorifolia* (75%) was the most abundant. Other broad leaved weeds observed were *Aeschynomene indica, Grangea maderaspatana*, *Phyllanthus amara, Heliotropium indicum, Mimosa invisa* and *Mimosa pudica*. Among grasses, the major species identified were *Brachiaria mutica, Digitaria ciliaris, Echinochloa colona* and *Cynodon dactylon.* A few volunteer plants of *Oryza sativa* were also present in the field.

At 30 DAS, all the herbicidal treated and hand weeded plots showed high weed control efficiencies of more than 99 per cent, owing to the low weed dry matter production in these plots as compared to the unweeded control. The lowest weed control efficiency (85%) was observed in stale seed bed. At 45 DAS, hand weeding recorded the lowest weed dry matter production with a weed control efficiency of 98.9 per cent. It could be due to the two hand weedings done during the critical stages of crop-weed competition which ensured maximum control of both broad leaved weeds and grasses. Verma et al. (2017) also reported that hand weeding twice recorded lower weed dry matter production than herbicidal treatments in green gram. Weed dry matter production was also significantly lower in all the treatments where herbicide application was integrated with hand weeding, and recorded weed control efficiencies of 95 to 97 per cent. This might be attributed to the high efficiency of pre-emergence herbicides in suppressing the initial flushes of weed growth, augmented by the control of weeds which emerged later by hand weeding. Similar inferences were made by Natarajan et al. (2003) and Thirumalaivasan et al. (2016), who opined that the integration of pre-emergence herbicides with hand weeding could result in a significant reduction in weed dry matter production. However, weed dry matter was significantly higher in stale seed bed, where weed control efficiency was drastically reduced to 11 per cent, probably due to the inefficiency of the stale seedbed technique in controlling the later flushes of weeds germinated. This was in close conformity with the findings of Tehria et al. (2015) who observed that stale seed bed resulted in a higher weed dry matter production in pea as compared to herbicidal treatments. Hand weeding registered the lowest weed dry matter production and highest weed control efficiency at 60 DAS as well. Among the integrated weed management practices, highest weed control efficiency of 97 per cent was recorded in imazethapyr + imazamox *fb* hand weeding, and diclosulam *fb* hand weeding. The highest weed dry matter production was recorded in unweeded control at all stages of observations.

Significantly taller plants were observed in all the weed management practices as compared to unweeded control, which was most likely due to the reduced competitive interaction of the crop with the weeds for the resources available, which eventually led to an increase in the rate of photosynthesis and metabolic activities, thereby enhancing the overall growth. Hand weeding recorded greater plant height of 27.6 cm at 45 DAS, which was statistically at par to stale seedbed *fb* hand weeding. Though the effect of integrated weed management practices on number of branches/plant was insignificant at 30 DAS, significantly higher number of branches/plant was observed in hand weeding (7.6), which was on par with diclosulam *fb* hand weeding (7.3) at 45 DAS. Both plant height (22 cm) and number of branches/plant (6.2) were significantly lower in unweeded control at this stage. Similar findings were reported by Ali et al. (2013) and Verma and Choudhary (2020).

All the integrated weed management practices recorded significantly higher number of pods/plant

Table 1. Effect of integrated weed management practices on weed dry matter production and weed control efficiency

Treatments		Weed dry matter production (kg/ha)			Weed control efficiency (%)		
		30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1	SSBfor 14 days	10.78^b (117.52)*	51.05^a (2606.67)	55.78^b (3111.75)	85.30	11.69	11.80
T_2	SSB for 14 days, *fb* oxyfluorfen, 150g/ha at 0-3 DAS	2.34^c (5.52)	22.35^b (504.73)	28.37^c (807.00)	99.30	82.90	77.13
T_3	Oxyfluorfen,150 g/ha at 0-3 DAS, *fb* HW at 25 DAS	1.50^c (2.49)	10.44^c (109.41)	11.75^e (138.63)	99.69	96.29	96.07
T_4	Imazethapyr,50g/ha at 0-3DAS, *fb* HW at 25 DAS	1.69^c (3.08)	11.39^c (131.31)	13.78^d (190.39)	99.61	95.55	94.60
T_5	Imazethapyr + imazamox (RM), 80g/ha at 0-3 DAS, *fb* HW at 25 DAS	1.43^c (2.11)	8.92^c (81.01)	10.49^e (110.41)	99.74	97.25	96.87
T_6	Diclosulam,15g/ha at 0-3 DAS, *fb* HW at 25 DAS	1.54^c (2.37)	8.76^c (77.39)	10.58^e (112.03)	99.70	97.38	96.82
T_7	HW at 20 DAS and 40 DAS	1.25^c (1.62)	5.29^d (31.22)	7.98^f (64.91)	99.80	98.94	98.16
T_8	Unweeded control	28.25^a (799.86)	54.28^a (2951.67)	59.39^a (3528.08)	-	-	-
CD (0.05)		1.54	3.36	1.81	-		
SE(m)		0.51	1.11	0.60			

*$\sqrt{(x+0.5)}$ transformed values with original values in parantheses. In a column, mean followed by common letters do not differ significantly at 5 % level in DMRT

Table 2. Effect of integrated weed management practices on biometrics, yield attributes and yield of green gram

Treatments		Plant height (cm)		No. of branches /plant		No. of pods/ plant	No. of seeds/ pod	100 seed weight (g)	Grain yield (kg/ha)	Haulm yield (kg/ha)
		30DAS	45DAS	30DAS	45DAS					
T_1	SSBfor 14 days	13.07[a]	25.63[bc]	4.47	6.67[bc]	18.40[b]	10.30[a]	4.08	418.94[c]	995.80[c]
T_2	SSB for 14 days, *fb* oxyfluorfen, 150g/ha at 0-3 DAS	13.13[a]	27.17[ab]	4.40	6.67[bc]	20.33[a]	9.85[a]	4.24	478.73[bc]	1142.17[bc]
T_3	Oxyfluorfen,150 g/ha at 0-3 DAS, *fb* HW at 25 DAS	13.33[a]	24.57[c]	4.60	6.47[c]	20.53[a]	10.67[a]	4.19	505.73[abc]	1240.83[abc]
T_4	Imazethapyr,50g/ha at 0-3 DAS, *fb* HW at 25 DAS	13.47[a]	24.07[c]	4.13	6.60[bc]	20.27[a]	10.17[a]	4.15	503.65[abc]	1238.17[abc]
T_5	Imazethapyr + imazamox (RM), 80g/ha at 0-3DAS,*f b* HW at 25 DAS	13.33[a]	24.97[c]	4.40	6.60[bc]	20.67[a]	9.93[a]	4.28	548.72[ab]	1296.33[ab]
T_6	Diclosulam,15 g/ha at 0-3 DAS, *fb* HW at 25 DAS	13.40[a]	24.53[c]	3.93	7.33[ab]	20.60[a]	10.93[a]	4.27	534.75[ab]	1270.83[ab]
T_7	HW at 20 DAS and 40 DAS	13.50[a]	27.67[a]	4.67	7.60[a]	20.73[a]	10.87[a]	4.21	582.65[a]	1420.00[a]
T_8	Unweeded control	10.87[b]	22.00[d]	4.53	6.27[c]	15.00[c]	7.83[b]	4.08	174.63[d]	474.17[d]
CD (0.05)		1.55	1.96	NS	0.81	0.97	1.78	NS	91.74	256.46
SE(m)		0.51	0.64	-	0.26	0.31	0.58	-	30.24	84.54

In a column, mean followed by common letters do not differ significantly at 5% level in DMRT.

as compared with unweeded control. The number of pods was the highest (21) in hand weeding, which was followed by imazethapyr + imazamox *fb* hand weeding, and diclosulam *fb* hand weeding. However, the number of pods was significantly lower in stale seed bed (18). The number of seeds/ pod was statistically at par in all the weed management practices, with an average of 10 seeds/ pod, whereas the lowest number of seeds (8 nos./ pod) was observed in unweeded control. The higher number of pods/plant and seeds/pod observed under efficient weed management practices might have been due to the congenial environment provided for the growth of green gram, which eventually resulted in enhanced development of the reproductive structures and greater translocation of photosynthetic products from source to sink. However, 100 seed weight remained unaffected with integrated weed management practices, which was probably because it is primarily a varietal character. This was in close conformity with the results of Singh et al. (2019) who concluded that significantly higher number of pods/plant and seeds/pod in green gram were noticed under herbicide treated or manually weeded plots over unweeded control, whereas 100 seed weight was not influenced.

Hand weeding registered the highest grain yield and haulm yield of 583 kg/ha and 1420 kg/ha respectively, which was on par with all the weed management practices where herbicide application was integrated with hand weeding. Among the integrated weed management practices, the highest grain yield was obtained in imazethapyr +

Table 3. Effect of integrated weed management practices on economics of cultivation of green gram

Treatments		Cost of cultivation (Rs./ha.)	Gross returns (Rs./ha.)	Net returns (Rs./ha.)	B:C ratio
T_1	SSB for 14 days	28,038	31,421	3,383	1.12
T_2	SSB for 14 days, *fb* oxyfluorfen, 150 g/ha at 0-3 DAS	30,745	35,905	5,160	1.16
T_3	Oxyfluorfen, 150 g/ha at 0-3 DAS, *fb* HW at 25 DAS	31,945	37,930	5,985	1.18
T_4	Imazethapyr, 50g/ha at 0-3 DAS, *fb* HW at 25 DAS	31,188	37,774	6,586	1.21
T_5	Imazethapyr + imazamox (RM), 80g/ha at 0-3 DAS, *fb* HW at 25 DAS	32,028	41,154	9,126	1.28
T_6	Diclosulam, 15g/ha at 0-3 DAS, *fb* HW at 25 DAS	31,374	40,107	8,733	1.27
T_7	HW at 20 DAS and 40 DAS	37,638	43,699	6,061	1.16
T_8	Unweeded control	25,638	13,098	-12,540	0.51

imazamox *fb* hand weeding 93.5 kg/ha, Similar findings were reported by Tiwari et al. (2018) in black gram. It was again observed that diclosulam *fb* hand weeding also produced comparable grain yields (535 kg/ha), indicating that the broad spectrum action of the herbicide coupled with timely hand weeding ensured satisfactory weed control at critical stages of crop-weed competition, because of which green gram recorded higher yield attributes and yield. Similar results were reported in soybean by Nainwal et al. (2010). Grain and haulm yields were significantly lower in the stale seed bed treatment. Grain yield (175 kg/ha) and haulm yield (474 kg/ha) were invariably the lowest in unweeded control. It was observed that uncontrolled weed growth resulted in yield losses up to 70 per cent in green gram, which indicated that significant quantities of nutrients and other resources taken up by the weeds created a condition of stress for the crop plant that directly affected the growth and yield of green gram.

Although the higher yield in hand weeding resulted in the highest gross returns, net returns and B:C ratio were considerably reduced due to the high cost of cultivation involved. Higher monetary benefits were recorded in imazethapyr + imazamox *fb* hand weeding, and diclosulam *fb* hand weeding with net returns of Rs. 9,126/ha and Rs. 8,733/ha respectively. This was because the application of these pre-emergence herbicides *fb* hand weeding had reduced labour requirements as compared with two manual weedings, thereby reducing the total cost. Accordingly, B:C ratio was also the highest in imazethapyr *fb* hand weeding (1.28) and diclosulam *fb* hand weeding (1.27). Rao et al. (2017) also opined that the cost of cultivation was higher in the plots where manual weeding was done at 20 DAS and 40 DAS as compared with those which received either sole application of chemical herbicide, or integration of chemical with manual weeding, because of which a reduction in net returns and B:C ratio was observed.

It could be concluded that pre-emergence (0-3 DAS) application of either imazethapyr + imazamox @ 50 g/ha or diclosulam @ 15 g/ha, followed by one hand weeding at 25 DAS provided a suitable alternative to hand weeding in summer rice fallow green gram when the labour charges were too high or manual labour was scarce.

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