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Effect of integrated weed management on weed control and yield of summer greengram (*Vigna radiata* L. wilczek)

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Abstract
A field experiment was carried out during summer 2016 at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Gujarat to study effect of integrated weed management on weed control and yield of summer greengram (*Vigna radiata* L. Wilczek). Twelve treatments of integrated weed management were evaluated in randomized block design and replicated three times. Beside weed free treatment, an application of pendimethalin @ 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS treatment recorded higher plant height, seed yield, stover yield, net return, BCR and weed control efficiency as well as lower weed index and dry weight of weeds.

Keywords: dry weight of weed, greengram, pendimethalin, imazethapyr, quizalofop-p-ethyl, HW, IC, Seed yield, WCE, WI

Introduction
Pulses are considered as lifeblood of agriculture as they occupy a unique position in every known system of farming as main, catch, cover, green manure, intercrop and mix crop. Green gram (*Vigna radiata* L. Wilczek) is one of the most ancient and extensively grown pulse crop in India. Among the pulses, green gram is one of the most important and extensively cultivated pulse crop. In India, green gram occupies an area of about 3.70 million ha producing 1.58 million tones and productivity is 511 kg/ha (Anonymous, 2015-16) [1]. In Gujarat, it is cultivated in 1.37 lakh ha with an annual production of 71 thousand metric tonnes leading to average productivity of 521 kg/ha (DOA, 2015-16) [4]. It is obvious from these figures that the productivity of green gram both at state as well as national level is low. The average productivity of green gram is very less as compared to its genetic potential (1000-1500 kg/ha).
Weed management is an important key factor for enhancing the productivity of green gram, as weeds compete for nutrients, water, light and space with crop plants during early growth period. Moreover, besides low yield of crop, they increase production cost, harbor insect-pest and plant diseases, decreasing quality of farm produce and reduce land value. Of the different factors known for reduction in crop production, weeds are a major biotic constraint to crop production all over the world and India is no exception. Potential yield losses in green gram due to weeds have been estimated to range between 10-45% (Rao and Chauhan, 2014) [13]. Weed competition observed maximum during the active growth stage of crop like vegetative and flowering. Weed control in green gram during the early period of crop growth is most important. If weed growth is minimized during critical period of crop weed competition, the yield can be obtained equivalent to that of maintaining weed free condition. The critical period of crop-weed competition in case of summer green gram is 15-30 days after sowing (Mandal *et al.*, 2006) [9]. Therefore, it is an essential to control weeds during critical period of competition to obtain full yield potential. Integrated weed management approach involving the physical and chemical weed control techniques are found more effective to achieve complete, long and effective control of weeds during crop season, minimize harmful effect on soil health and reduced load of chemical residues in produce. Keeping this in view, the present investigation for weed control was undertaken in greengram.

Material and Methods

A field experiment was carried out during summer 2016 at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Gujarat to find out the effect of integrated weed management on weed control and yield of summer greengram. The soil was loamy sand in texture, low in organic carbon (0.17 %) and available N (160.7 kg/ha), medium in available P (38.9 kg/ha) and K (189.0 kg/ha) with pH 7.5. Twelve integrated weed management treatments along with unweeded control, as mentioned in Table 1, were evaluated in randomized block design and replicated three times. Greengram variety Gujarat Mung 4 was sown by keeping 30 cm distance between two row in all the treatments. A uniform basal dose of N and P_2O_5 (20 & 40 kg/ha) was applied at the time of sowing. Pre-emergence herbicide *viz.* pendimethalin was applied after sowing, while post emergence herbicides *viz.* quizalofop-p-ethyl and imazethapyr were sprayed at 16 DAS. Interculturing and hand weeding were carried out at 20, 30 and 40 DAS as per treatments. All the recommended package of practices was followed for the crop. Dry weight of weeds was recorded at harvest. Weed control efficiency and weed index were calculated from the related observations. The growth parameters were recorded at appropriate time during experiment. Yield parameters were also recorded at harvest. Economics was worked out according to prevailing market price.

Results and Discussion

Effect on weeds

The weed flora *viz*., grassy weeds: *Cynodon dactylon* (L.) Pers., *Digitaria sanguinalis* L. *Scop* and *Dactylocteniuma egyptium* (L.) Richt.; broad leaved weeds: *Boerhavia diffusa* L.,*Commelina benghalensis*., *Digeria arvensis*, *Portulaca oleracea* L., *Tribulus terrestris* L., *Chenopodium album* L., *Amaranthus spinosus* L., *Euphorbia hirta* L., *Phyllanthus niruri*. and *Vernonia boldwini* Torr.; sedge weed: *Cyperus rotundus* L. were observed in the experiment. The effect of different integrated weed management treatments was found significant with respect to weed parameters (Table 1). Percent mortality of weed was higher with an application of pendimethalin 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS. These findings are akin to report of Bhadauria *et al*. (2012) [3], Kalhapure *et al*. (2013) [6], Singh *et al*. (2014) [15] and Kavad *et al.* (2016) [7]. The lowest weed index was observed with application of pendimethalin 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS during experimental year. The lower values of weed index with these treatments were due to lower dry weed biomass and higher weed control efficiency. The findings are in agreement with the results reported by Kushwah and Vyas (2005), Singh and Kumar (2008) [14] and Prachand *et al*. (2015) [12]. Dry weight of weeds was significantly lower with weed free treatment, which was at par with application of pendimethalin 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS. Significantly máximum weed control efficiency was observed in application of pendimethalin 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS (T_8) followed by application of pendimethalin 1.0 kg/ha as PE + I.C. followed by H.W. at 30 DAS (T_2). Higher weed control efficiency was observed due to effective control of grasses and broad leaved weeds during initial crop growth stages with pre-emergence herbicide and late emerging weeds with post-emergence herbicide as well as by interculturing and hand weeding. The combined effect of herbicide, interculturing and hand weeding at 30 DAS resulted in remarkably lower weed population (Table 1) and ultimately less dry weight of weeds (Table 1) in case of treatments T_8 and T_2 responsible for higher weed control efficiency. Removal of weeds by means of interculturing and hand weeding at 20 and 40 DAS reduced weed population (Table 1) and dry weight of weeds (Table 1) may improve weed control efficiency in case of treatment T_{10}. These findings are akin to report of Singh and Kumar (2008) [14], Jha and Soni (2013) [5], Singh *et al.* (2014) [15] and Kavad *et al*. (2016) [7].

Table 1: Effect of different herbicides on grassy, broad leaves and sedge weed population, mortality of weed, dry weight of weeds, WCE and weed index

Treatments		Grassy weed population (m^2)	Broad leaf weed population (m^2)	Sedge weed population (m^2)	Mortality of weeds (%)	Dry weight of weeds at harvest (g/m^2)	Weed control efficiency (%)	Weed index
T_1	Pendimethalin 1.0 kg/ha PE	3.83 ^{c} (14.20)	3.28 ^{d} (10.27)	2.80 ^{c} (7.33)	-	29.1^{c}	44.36 ^{f} (41.98)	44.0 ^{ab} (41.74)
T_2	Pendimethalin 1.0 kg/ha PE + I.C. followed by H.W. at 30 DAS	2.52 ^{f} (5.87)	2.33 ^{I} (5.00)	1.88^{ef} (3.07)	-	15.2^{fg}	71.01 ^{bc} (57.75)	18.7 ^{ef} (24.34)
T_3	Quizalofop-p-ethyl 50 g/ha at 15-20 DAS + I.C. followed by H.W. at 30 DAS	4.62 ^{b} (20.87)	3.78 ^{c} (13.87)	3.33 ^{b} (10.60)	28.5^{d}	40.1^{b}	23.54 ^{g} (28.91)	45.0 ^{ab} (42.38)
T_4	Quizalofop-p-ethyl 75 g/ha at 15-20 DAS	4.62 ^{b} (20.87)	4.16 ^{b} (16.87)	3.33 ^{b} (10.60)	23.5^{e}	42.1^{b}	19.68 ^{g} (26.66)	49.3 ^{ab} (44.87)
T_5	Pendimethalin 1.0 kg/ha PE + Quizalofop-p-ethyl 75 g/ha at 15-20 DAS	3.33 ^{de} (10.60)	2.75^{fg} (7.07)	2.45 ^{d} (5.53)	35.5^{c}	21.0^{de}	59.83 ^{de} (50.97)	36.4 ^{bcd} (37.37)
T_6	Quizalofop-p-ethyl 100 g/ha at 15-20 DAS	3.63 ^{c} (12.73)	3.10 ^{de} (9.13)	2.65 ^{cd} (6.53)	30.6^{d}	25.8^{cd}	50.74 ^{ef} (45.69)	42.9 ^{ab} (41.19)
T_7	Imazethapyr 75 g/ha PE + I.C. followed by H.W. at 30 DAS	3.53 ^{cd} (12.00)	2.92^{ef} (8.07)	2.59 ^{d} (6.23)	-	23.8^{cd}	54.47^{e} (47.85)	40.6 ^{abc} (38.81)
T_8	Pendimethalin 1.0 kg/ha PE + Imazethapyr 75 g/ha PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS	2.26 ^{f} (4.60)	2.07 ^{j} (3.87)	1.74 ^{f} (2.53)	79.5^{a}	12.4^{g}	76.36^{b} (61.27)	9.5 ^{fg} (18.16)
T_9	Imazethapyr 100 g/ha PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS	2.68 ^{e} (6.73)	2.57^{gh} (6.13)	2.02 ^{e} (3.60)	44.4^{b}	17.9^{ef}	65.81 ^{cd} (54.50)	26.4 ^{cde} (31.02)

T_{10}	I.C. and H.W. at 20 and 40 DAS	2.63 ^{e} (6.47)	2.47 ^{hi} (5.67)	2.00 ^{e} (3.50)	-	16.5^{efg}	68.57^{bcd} (56.52)	23.3 ^{def} (28.65)
T_{11}	Weed free	0.71 ^{g} (0.00)	0.71 ^{k} (0.00)	0.71 ^{g} (0.00)	-	0.00^{h}	100 ^{a} (88.15)	0.00^{g} (4.05)
T_{12}	Unweeded control	7.27 ^{a} (52.40)	6.73 ^{a} (44.87)	5.20 ^{a} (26.53)	-	53.0^{a}	0.00^{h} (4.05)	56 ^{a} (48.63)
	S. Em. ±	0.61	0.44	0.30	0.84	1.60	3.02	4.63
	C. V. (%)	7.58	7.04	7.25	7.18	11.21	9.88	24.55

Note: Data given in parentheses are subjected to square root and arcsine transformation value

Effect on greengram

Different integrated weed management treatments showed significant effect on growth and yield attributes (Table 2). Maximum value of growth attributes *viz.*, plant height (56.7 cm) and dry matter accumulation per plant (26.03 g) and yield attributes *viz.*, number of pods per plant (24.13), length of pod (9.47 cm) and test weight (41.65 g) were recorded under weed free treatment which was at par with application of pendimethalin 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS (T_8), Pendimethalin 1.0 kg/ha as PE + I.C. followed by H.W. at 30 DAS (T_2) and interculturing and hand weeding at 20 & 40 DAS (T_{10}). These findings are in close proximity with findings of Pedde *et al.* (2013) [11] and Prachand *et al*. (2015) [12].

Different integrated weed management treatments tried in this experiment exerted significant effect on seed and stover yield of green gram. Weed free treatment recorded significantly higher seed and stover yield of 1181 and 3296 kg/ha, respectively (Table 3). However, it remained statistically at par with treatment T_8 (Pendimethalin 1.0 kg/ha as PE + imazethapyr 75 g/ha as PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS) but significantly superior than rest of the treatments. This might be due to reduced competition of weeds with greengram for space, light, nutrients and moisture with application of effective weed control methods. Weed free environment facilitated better growth and development at the critical growth stages of greengram resulted in increase in seed and stover yield. It might be due to lethal effect of pre emergence herbicide (Pendimethalin) at early stage of crop growth controlled weeds and at later, the weeds escaped from herbicidal effects were controlled by post emergence herbicide (Imazethapyr) as well as by interculturing and hand weeding at 30 DAS resulted in significant reduction of weeds which was responsible for higher yield. These findings are in close proximity with findings of Pedde *et al.* (2013) [11] and Prachand *et al*. (2015) [12].

Different integrated weed management treatments did not differ significantly to harvest index of greengram in present study (Table 3).

Table 2: Effect of different treatments on growth and yield attributes of summer greengram

Treatments		Plant height (cm)	Dry matter accumulation per plant (g)	Number of pods per plant	Length of pods (cm)	Test weight (g)
T_1	Pendimethalin 1.0 kg/ha PE	49.27 ^{bcd}	20.45 ^{bcde}	19.88 ^{bc}	7.85 ^{bcd}	37.28 ^{ab}
T_2	Pendimethalin 1.0 kg/ha PE + I.C. followed by H.W. at 30 DAS	53.20 ^{ab}	23.78 ^{abc}	22.45 ^{ab}	8.71 ^{abc}	37.17 ^{ab}
T_3	Quizalofop-p-ethyl 50 g/ha at 15-20 DAS + I.C. followed by H.W. at 30 DAS	48.33 ^{bcd}	19.92^{cde}	18.88 ^{c}	7.51 ^{bcd}	37.20 ^{ab}
T_4	Quizalofop-p-ethyl 75 g/ha at 15-20 DAS	46.20 ^{cd}	19.13 ^{de}	18.12 ^{cd}	7.39 ^{cd}	34.73 ^{bc}
T_5	Pendimethalin 1.0 kg/ha PE + Quizalofop-p-ethyl 75 g/ha at 15-20 DAS	51.47 ^{abc}	21.53 ^{bcd}	20.35 ^{bc}	8.20 ^{abcd}	36.53 ^{abc}
T_6	Quizalofop-p-ethyl 100 g/ha at 15-20 DAS	50.47 ^{abcd}	20.53 ^{bcde}	20.02 ^{bc}	7.94 ^{bcd}	36.00 ^{abc}
T_7	Imazethapyr 75 g/ha PE + I.C. followed by H.W. at 30 DAS	50.53 ^{abcd}	21.32 ^{bcd}	19.63 ^{bc}	8.09 ^{abcd}	36.40 ^{abc}
T_8	Pendimethalin 1.0 kg/ha PE + Imazethapyr 75 g/ha PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS	53.67 ^{ab}	24.82 ^{ab}	22.68 ^{ab}	8.90 ^{ab}	39.26 ^{ab}
T_9	Imazethapyr 100 g/ha PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS	52.67 ^{abc}	23.10 ^{abcd}	20.60 ^{bc}	8.44 ^{abcd}	36.91 ^{ab}
T_{10}	I.C. and H.W. at 20 and 40 DAS	53.13 ^{abc}	23.35 ^{abcd}	20.70 ^{bc}	8.48 ^{abcd}	37.05 ^{ab}
T_{11}	Weed free	56.67 ^{a}	26.03 ^{a}	24.13 ^{a}	9.47 ^{a}	41.65 ^{a}
T_{12}	Unweeded control	43.80 ^{d}	16.30 ^{e}	15.57 ^{d}	6.98 ^{d}	30.41 ^{c}
	S.Em. ±	2.06	1.31	0.96	0.44	1.72
	C. V. (%)	7.02	10.46	8.23	9.31	8.14

Table 3: Effect of different treatments on seed yield, stover yield, harvest index, net realization and BCR of summer greengram

Treatments		Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Net realization (Rs/ha)	BCR
T_1	Pendimethalin 1.0 kg/ha PE	657 ^{fg}	1970 ^{cde}	24.95	25290	1.19
T_2	Pendimethalin 1.0 kg/ha PE + I.C. followed by H.W. at 30 DAS	953 ^{bc}	2986 ^{ab}	24.20	28039	1.57
T_3	Quizalofop-p-ethyl 50 g/ha at 15-20 DAS + I.C. followed by H.W. at 30 DAS	654 ^{fg}	1818 ^{cde}	26.34	28457	1.05
T_4	Quizalofop-p-ethyl 75 g/ha at 15-20 DAS	600 ^{fg}	1767 ^{de}	25.31	26583	1.04
T_5	Pendimethalin 1.0 kg/ha PE + Quizalofop-p-ethyl 75 g/ha at 15-20 DAS	755 ^{def}	2227 ^{c}	25.18	28211	1.23
T_6	Quizalofop-p-ethyl 100 g/ha at 15-20 DAS	674 ^{fg}	2155 ^{cd}	23.84	27458	1.14
T_7	Imazethapyr 75 g/ha PE + I.C. followed by H.W. at 30 DAS	706 ^{ef}	2164 ^{cd}	24.60	27757	1.17

T_8	Pendimethalin 1.0 kg/ha PE + Imazethapyr 75 g/ha PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS	1070 ^{ab}	3048 ^{ab}	26.22	29385	1.66
T_9	Imazethapyr 100 g/ha PoE at 15-20 DAS + I.C. followed by H.W. at 30 DAS	873 ^{cde}	2745 ^{b}	24.05	28107	1.44
T_{10}	I.C. and H.W. at 20 and 40 DAS	905 ^{bcd}	2875 ^{ab}	24.03	29160	1.44
T_{11}	Weed free	1181 ^{a}	3296 ^{a}	26.37	35400	1.52
T_{12}	Unweeded control	523 ^{g}	1670 ^{e}	23.80	23662	1.03
	S. Em. ±	53.61	130.35	1.54		
	C. V. (%)	11.67	9.43	10.69		

Economics

The economics of different treatments as presented in Table 3 indicated that maximum gross realization, net realization and BCR were obtained with application of pendimethalin + imazethapyr + I.C. followed by H.W. at 30 DAS followed by weed free treatment. Similar trend was observed by Bagum and Rao (2006), Mathukia *et al*. (2015) [10] and Prachand *et al*. (2015) [12].

Summary and conclusion

Based on one year study, it is concluded that maximum seed yield and effective weed control in greengram can be achieved by maintaining weed free condition throughout crop growth period where labours are easily available. Under constraint of labour availability, maximum seed yield, better weed control and net profit can be achieved with application of pendimethalin @ 1.0 kg/ha as pre emergence + imazethapyr @ 75 g/ha as post-emergence at 15-20 DAS + interculturing followed by hand weeding at 30 DAS.

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