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Combined effect of herbicides and cultural methods of weed control on growth and yield of summer green gram (*Vigna radiata* L. Wilczek) under south Gujarat condition

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Abstract
A field experiment entitled "Combined effect of herbicides and cultural methods of weed control on growth and yield of summer green gram (*Vigna radiata* L. Wilczek) under south Gujarat condition." was carried out with twelve weed control treatments under Randomized Block Design with three replications at Navsari on clayey soil during summer season 2013. The results of present investigation revealed that different herbicides either applied as pre or post-emergence in the experiment was not found phytotoxic to the green gram crop as reflected in initial and final plant stand of the crop and higher grain and stover yield of green gram and net return can be accrued by keeping crop weed free throughout crop season. The next alternatives either adopting two hand weeding and interculturing at 20 and 40 DAS or application of pendimethalin @ 1.00 kg/ha as pre emergence + IC at 40 DAS can be adopted where farm labours are scarce, costly and timely not available.

Keywords: Green gram, weed control, interculturing, weedicides

Introduction
Pulses are the cheapest source of quality protein for the human being. The protein hunger is common problem in India, where majority populations have vegetative diet. It is well known that paucity of protein diet results in malnutrition. In general, pulses have two to three times more protein than the cereals or any other group of plants besides supply of micronutrients, low fat, high dietary fibre and complex carbohydrates. Pulses thus, occupy a unique position of the dietary of Indian people supplying the major portion of more balanced protein requirement and also serve as an excellent forage and grain concentration in feed of the large cattle population in the country.

Green gram (*Vigna radiata* L. Wilczek) is also known as *mung, moong, mungo,* golden gram, chickasaw pea and oregon pea. It contains about 25 per cent protein, 1.3 per cent fat, 3.5 per cent minerals, 4.1 per cent fibre and 56.7 per cent carbohydrate and appreciable amount of riboflavin and thiamine.

In India, green gram occupies an area of about 3.70 million hectares producing 1.58 million tonnes with an average productivity of 511 kg/ha (Anonymous, 2015-16) [3], whereas in Gujarat, it is grown over 1.37 lakh hectares with an annual production of 71 lakh tonnes leading to average productivity of 521 kg/ha (DOA, 2015-16) [6].

Green gram often suffers from severe weed competition in initial stage because their initial growth rate is relatively slow. Prevalence of higher temperature and availability of adequate moisture due to irrigation and inadequate preparatory tillage provides most congenial conditions for quick growth of weeds in summer season. Among the various factors, weed management is the most important factor for reduction of yield. Because weeds are silent, malignant, more competitive and on one side and on other hand, several herbicides have been found effective in controlling weeds. Decrease in mungbean productivity due to weed competition to the extent of 45.6% (Pandey and Mishra, 2003) [13]. Algotar *et al* (2015) [2] also stated that competition with the weeds leads to 30 to 80% reduction in grain yield of green gram during summer. Therefore, versatility of modern weed control through integration of effective herbicides and conventional method is an asset that must be exploited fully and consequently suitable yield of green gram.

Hand and mechanical control methods are used on a large scale but, cost is very high, unfavorable weather and soil condition and also the labors are not available at proper time. The chemical control of weeds is found to be effective and economical in initial stages of growth. However, herbicides alone are unable to give full control of weeds because of their selectivity. Not only have these, but also the continuous use of herbicides alone at higher doses aggravated the problems of residual toxicity. In addition to this, the exorbitant cost and non-availability of herbicides locally, prevent the farmers to harness good results from the use of these herbicides. Many researchers found the reduction of green gram yield because of weed (Singh *et al.*, 1996; Parasuraman, 2000; Yadav and Singh, 2005; Ali *et al.*, 2013) [20, 16, 22, 11]. Keeping all these points in view, the present research work entitled, "Combined effect of herbicides and cultural methods of weed control on growth and yield of summer green gram (*Vigna radiata* L. Wilczek) under south Gujarat condition." was undertaken at College Farm, N.M.C.A., Navsari Agricultural University, Navsari, Gujarat with the following objectives.

- To find out different weed flora of summer green gram.
- To evaluate the efficacy of different herbicides and their rate for control of weeds in summer green gram.
- To study the effect of different weed control practices on growth and yield of summer green gram.
- To work out economics for different weed control treatments.

Materials and Methods

A field experiment was conducted on plot E - 23 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during summer season of 2013. Geographically, Navsari is located at 20^0 – 57' N latitude, 72^0 – 54' E longitude and 10 meters above the mean sea level. The climate of this region is characterized by fairly hot summer, moderately cold winter and humid and warm monsoon with heavy rainfall. Usually the summer season commences during the middle of February and the temperature reaches to the maximum in April, hence it is hottest month of the season. The maximum and minimum temperature ranged from 38.4ºC to 13.3ºC. Relative humidity was ranging from 52.4 to 87.8 per cent at 7.30 am and 20.1 to 72.1 per cent at 2.30 pm. Bright sunshine hours were available in the range of 7.3 to 10.8 during the crop period. There was no rainfall during the crop season. Thus, the weather condition was normal and congenial for satisfactory growth of green gram crop. The soil of the experimental field was clayey in texture with low in available nitrogen (155.23 kg/ha), medium in available phosphorus (39.5 kg/ha), fairly rich in available potassium (467.81 kg/ha) and slightly alkaline in reaction (8.34 pH) with normal electric conductivity (0.36 EC). Total twelve treatments *viz.* T_1= Unweeded control, T_2= Weed free, T_3= Two Hand Weeding and Interculturing at 20 and 40 DAS, T_4= Pendimethalin 1.0 kg/ha as PE, T_5= T_4 + IC at 40 DAS, T_6= Imazethapyr 100 g/ha at 20 DAS, T_7= T_6 + IC at 40 DAS, T_8= Imazethapyr 150 g/ha at 20 DAS, T_9= Oxyfluorfen 240 g/ha at 20 DAS, T_{10}= T_9 + IC at 40 DAS, T_{11}= Quizalofop-p-ethyl 50 g/ha at 20 DAS, T_{12}= T_{11} + IC at 40 DAS was laid out with three replication in Randomized Block Design. The experimental plots were fertilized with recommended dose of nitrogen (20 kg/ha) and phosphorus (40 kg/ha) as basal just prior to sowing in the form of SSP and Urea. The seeds of green gram variety Meha (IPM 99-125) received from Mega seed, Pulses and Castor Research Unit, Navsari was used for this experiment. The seeds were sown in line at 45 cm spacing by weighing exact quantity for each plot @ 20 kg/ha on 5th March 2013. After one week of sowing, thinning was carried out to maintain optimum plant population in the experimental plot. The first irrigation was given immediately after sowing of seed for proper germination, whereas other four irrigations were applied to green gram crop during its life span as per crop need. The required quantity of herbicides *viz.* pendimethalin, imazethapyr, oxyfluorfen and quizalofop-p-ethyl were measured by measuring cylinder at the time of preparation of solution according to the treatments. The spraying was done by using Knapsack sprayer with flat fan nozzle using 500 liters of water per hectare. Weeding and interculturing were done with hoe as per treatment and plant protection measures were under taken as per the need of the crop. The statistical analysis of data of various characters studied in the investigation was done using analysis of variance techniques as suggested by Panse and Sukhatme (1985) [14]. The critical differences for comparing treatment means were worked out at 5 per cent level of significance.

Results and Discussion

Effect on growth and yield

Various weed management practices showed remarkable effect on crop growth. Plant height was increased consistently from 30 DAS until harvest (Table 1). Due to the elimination of early crop weed competition, plant height at 30 DAS, 60 DAS and at harvest were significantly higher with weed free (T_2) treatment, but it was at par with two hand weeding and interculturing at 20 and 40 DAS (T_3), pendimethalin @ 1.00kg/ha as pre emergence + IC at 40 DAS (T_5), imazethapyr 100 g/ha (T_7) and quizalofop-p-ethyl 50 g/ha + IC at 40 DAS (T_{12})**.** Weeds were effectively controlled under these treatments and hence there was no severe competition by weeds for moisture and nutrients resulted into higher plant height. Similar results also reported by Kushwah and Vyas (2005) [10], Ali *et al.* (2013) [1] and Chhodavadia *et al.* (2013) [5] in green gram.

Statistical analysis of data revealed that significant effect on yield attributes were observed due to the different weed control treatments tried in the experiment (Table 1). Significantly maximum number of pods per plant (18.40) was obtained under weed free treatment (T_2), but it was at par with two hand weeding and interculturing at 20 and 40 DAS (T_3), pendimethalin @ 1.00kg/ha as pre emergence + IC at 40 DAS (T_5), imazethapyr 100 g/ha (T_7) and quizalofop-p-ethyl 50 g/ha + IC at 40 DAS (T_{12}). Unweeded control (T_1) recorded significantly lowest number of pods per plant among all the weed control treatments. It might be due to effective control of weeds resulting in lesser competition of weeds for crop growth in these treatments. This facilitates the green gram crop to utilize more moisture, nutrients and solar radiation. Higher growth and resource utilization turned into more number of branches which results into more number of pods per plant under these treatments. Similar conclusion was drawn by Ali *et al.* (2013) [1], Chhodavadia *et al.* (2013) [5] in green gram and Jadhav (2013) [8] in soybean. Similar result was observed in the case of length of pod.

Significantly the highest grain yield of green gram (1266 kg/ha) was recorded under treatment T_2 (weed free). Among other weed management treatments two hand weeding and interculturing at 20 and 40 DAS (T_3), pendimethalin @ 1.00 kg/ha as pre emergence + IC at 40 DAS (T_5), imazethapyr 100 g/ha (T_7) and quizalofop-p-ethyl 50 g/ha + IC at 40 DAS (T_{12}) were at par with treatment T_2 (weed free). Higher seed

yield obtained under these treatments might be due to reduced weeds and competition free environment, especially during critical stages of crop growth favoured the crop to utilized the factors for crop growth and production and enhanced the well balanced source sink capacities which attributes to the more number of branches, pod and dry matter as compare to all other treatments and responsible for higher yield. In addition to this the least weed population and dry weight of weeds were recorded under these treatments are also responsible for better seed yield. Severe weed competition for resources under unweeded control affected the growth and yield attributes leading to poor seed yield of green gram. These findings are in accordance with those reported by Parasuraman (2000) [16], Kumar *et al.* (2004) [9], Nandan *et al.* (2011) [12], Yadav *et al.* (2011) [21], Raj *et al.* (2012) [17], Chhodavadia *et al.* (2013) [5], Panchal *et al.* (2015) [15], Muthuran *et al.* (2017) [11] and Gelot *et al.* (2018) [7]. Significantly the highest value of straw yield (1284 kg/ha) (Table 2) was observed under treatment T_2 (weed free), which was at par with treatments T_3, T_5, T_7, T_{12} and T_{10}. Favourable effect on growth characters by avoiding crop weed competition is responsible for higher straw yield under these treatments. A perusal of data presented in Table 2 revealed that harvest index was not influenced significantly due to different weed control treatments.

Table 1: Effect of different treatments on growth and yield attributes of green gram and dry weight of weeds

Treatments	Plant population per m row length		Plant height (cm) At			Number of pods/plant	Length of pod (cm)	Dry weight of weeds at harvest (g/plot)	Weed control efficiency (%)	Weed index (%)
	Initial	Final	30 DAS	60 DAS	harvest					
T_1= Unweeded control	4.34	3.68	15.41	24.91	30.00	10.76	4.79	494.33	0.00	63.52
T_2= Weed free	6.68	6.34	27.58	39.17	48.34	18.40	8.59	0.00	100.00	0.00
T_3= Two H.W. and I.C. at 20 and 40 DAS	6.34	6.01	25.85	36.28	46.17	17.90	8.09	58.33	88.19	4.49
T_4= Pendimethalin 1.0 kg/ha as PE	5.34	5.01	21.45	34.08	41.02	14.84	6.74	99.67	79.84	13.83
T_5= T_4 + I.C. at 40 DAS	6.34	6.01	25.14	36.05	45.76	17.60	7.94	66.33	86.57	6.73
T_6= Imazethapyr 100 g/ha at 20 DAS	5.01	4.68	20.63	33.55	40.55	14.54	6.34	111.33	77.47	30.60
T_7= T_6 + I.C. at 40 DAS	6.01	5.68	24.91	35.87	45.43	15.52	7.54	70.67	85.69	8.47
T_8= Imazethapyr 150 g/ha at 20 DAS	5.68	5.34	20.97	33.75	41.00	14.68	6.49	105.33	78.70	25.24
T_9= Oxyfluorfen 240 g/ha at 20 DAS	5.34	4.68	19.54	33.01	39.80	13.68	5.64	170.00	65.64	34.01
T_{10}= T9 + I.C. at 40 DAS	5.34	5.01	21.71	34.18	41.11	15.10	7.09	93.33	81.11	18.17
T_{11}= Quizalofop-p-ethyl 50 g/ha at 20 DAS	5.68	5.34	20.05	33.35	40.27	14.40	6.09	150.33	69.57	31.94
T_{12}= T11 + I.C. at 40 DAS	6.01	5.68	24.86	35.68	44.96	15.42	7.39	85.67	82.67	11.03
S.Em ±	0.50	0.49	0.93	1.20	1.57	1.08	0.41	6.88	1.36	2.55
C.D. at 5%	NS	NS	2.73	3.53	4.60	3.18	1.21	20.19	4.00	7.49
C.V.%	15.37	16.12	7.21	6.12	6.46	12.34	10.35	9.51	3.16	21.40

Effect on Weeds

Dry weight of weeds in each plot of the experiment recorded at harvest and differed significantly under different treatments (Table 1). The treatment weed free (T_2) recorded significantly lower dry weight of weeds, followed by treatments two hand weeding and interculturing at 20 and 40 DAS (T_3), pendimethalin @ 1.00 kg/ha as pre emergence + IC at 40 DAS (T_5) and imazethapyr 100 g/ha + IC at 40 DAS (T_7). This might be attributed to the effective control of weeds under these treatments, which reflected on less number of weeds and ultimately lower weed biomass. In addition to this, dense crop canopy might have suppressed weed growth and ultimately less biomass accumulation. The unweeded control (T_1) recorded significantly the highest dry weight of weeds (494.33 g ha^{-1}) this might be due to uncontrolled condition favoured luxurious weed growth leading to increased dry matter accumulation. These findings are in close conformity with those of Rathi *et al.* (2004) [18], Kumar *et al.* (2004) [9], Yadav *et al.* (2011) [21] and Ali *et al.* (2013) [1]. In case of weed control efficiency and weed index, examination of data presented in Table 1 indicated that besides weed free (T2), treatments two hand weeding and interculturing at 20 and 40 DAS (T3), pendimethalin 1.00 kg/ha as pre emergence + IC at 40 DAS (T5) and imazethapyr 100 g/ha at 20 DAS + IC at 40 DAS (T7) recorded lower weed index of 4.49, 6.73 and 8.47 % respectively and higher weed control efficiency 88.19, 86.57 and 85.69 % respectively. This might be due to elimination of weeds by manual weeding and interculturing or by integration with herbicides. The combined effect on dry weight of weeds and grain yield under these treatments might have been responsible for excellent weed indices. These findings are corroborating with those of Bhandari *et al.* (2004) [4], Raj *et al.* (2012) [17], Ali *et al.* (2013) [1], Panchal *et al.* (2015) [15], Muthuran *et al.* (2017) [11] and Gelot *et al.* (2018) [7].

Economics

Economic is the major consideration for the farmers while taking a decision regarding the adoption of a new technology. A perusal data presented in (Table 2) revealed that the maximum gross return of 58896 Rs/ha and net return of 41221 Rs/ha was accrued under weed free treatment (T_2) it was closely followed by two hand weeding and interculturing at 20 and 40 DAS (T_3) and pendimethalin @ 1.00 kg/ha as pre emergence + IC at 40 DAS (T_5), which recorded net return of 40849 and 40670 Rs/ha, respectively. The higher grain and straw yields recorded under these treatments might be responsible for higher gross and net return. The maximum B:C ratio of 2:76 was accrued under pendimethalin @ 1.00 kg/ha as pre emergence + IC at 40 DAS (T_5) followed by two

hand weeding and two interculturing at 20 and 40 DAS (T_3). These findings are in close vicinity with those reported by Sardana *et al.* (2006) [19] and Chhodavadia *et al*. (2013) [5].

Table 2: Effect of different treatments on yield and economics of green gram

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Gross return (Rs/ha)	Total cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C Ratio
T_1= Unweeded control	469	879	34.00	22439	13715	8724	0.64
T_2= Weed free	1266	1284	49.66	58896	17675	41221	2.33
T_3= Two H.W. and I.C. at 20 and 40 DAS	1219	1246	49.48	56724	15875	40849	2.57
T_4= Pendimethalin 1.0 kg/ha as PE	979	1055	48.26	45653	14375	31278	2.18
T_5= T_4 + I.C. at 40 DAS	1190	1227	49.30	55405	14735	40670	2.76
T_6= Imazethapyr 100 g/ha at 20 DAS	889	980	47.63	41461	15635	25826	1.65
T_7= T_6 + I.C. at 40 DAS	1169	1212	49.14	54424	15995	38429	2.40
T_8= Imazethapyr 150 g/ha at 20 DAS	956	1050	48.12	44610	15635	28975	1.85
T_9= Oxyfluorfen 240 g/ha at 20 DAS	845	947	47.15	39431	15335	24096	1.57
T_{10}= T9 + I.C. at 40 DAS	1045	1098	48.76	48672	15695	32977	2.10
T_{11}= Quizalofop-p-ethyl 50 g/ha at 20 DAS	871	968	47.42	40632	15235	25397	1.67
T_{12}= T11 + I.C. at 40 DAS	1137	1188	48.99	52962	15595	37367	2.40
S.Em ±	53.16	74.24	2.91				
C.D. at 5%	155.93	217.76	NS				
C.V.%	9.18	11.75	10.66				

Conclusion

It seems quite logical to conclude that potential production, profit and efficient and economic weed management in summer green gram under clayey soil of South Gujarat Agro-climatic condition can be achieved by following conventional method of hand weeding and interculturing to keep weed free condition or two hand weeding and interculturing at 20 and 40 DAS where labours are easily available. Alternatively integrated weed control method including pendimethalin 1.0 kg/ha as PE + IC at 40 DAS can be adopted where farm labours are scarce, costly and timely unavailable.

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