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Growth Parameters, Yield and Economics in Green Gram {*Vigna radiate* (L.) R. Wilczek} Crop under Different Methods of Planting and Weed Management Practices

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ABSTRACT

In bed planting method more crop growth rate and relative growth rate was observed at all stages of observations as compared to conventional and zero till planting method during both years except between 46 DAS- maturity during 2015 where crop growth rate and relative growth rate in bed planting method was statistically at par with crop growth rate and relative growth rate in zero till planting method. Except at 15 DAS, bed planting method resulted in significantly more leaf area index as compared to conventional and zero till planting method during both years. Bed planting method resulted in significantly more number of pods plant^{-1}. Seed yield being a function of yield attributes was also significantly more in bed planting method. Biological yield was also significantly more in bed planting method as compared to conventional and zero till planting method during both years. Maximum net returns were also found in bed planting method during both years. Crop growth rate, relative growth rate & leaf area index in green gram varied significantly among different weed management practices. At 15 DAS, weed management practices did not affect LAI but at remaining stages CGR, RGR (15-30 DAS, 31-45 DAS, 46 DAS-Maturity) and LAI (30 & 45 DAS) were improved in all weed management treatments compared to weedy check due to better control of weeds. Pods plant^{-1} varied among different weed management practices. Weed free treatment provided maximum seed yield, biological yield. All the weed management treatments showed higher gross returns, net returns as compared to weedy check.

Key words: *Economics, Green gram, Growth parameters, Weed management practices.*

INTRODUCTION

Being cultivated in arid and semi arid regions, green gram {*Vigna radiata* (L.) R. Wilczek} is one of the major *kharif* pulse crops in India. It is an important and the third most widely cultivated pulse crop in India next to chickpea and pigeonpea. It is a major edible legume seed in Asia (India, South East –Asia and East Asia) and is also eaten in Southern Europe and in the Southern USA. It is a major source of protein for vegetarians[1] and contains about 25% protein.

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The green gram is a fast growing, warm season legume. It reaches maturity very quickly under tropical and subtropical conditions where optimal temperatures are about 28-30^{0}C and always above 15^{0}C. Planting methods also influence the emergence pattern of weeds in a crop. Tillage influences weed infestation and thus interaction between tillage and weed control practices are commonly observed in crop production. Green gram plant is indeterminate in growth habit and in good rainfall season sometimes it leads to excessive growth and results in poor yield. Moreover, in flat planting method it is not easy to drain out the excessive water, so planting method such as raised beds may be helpful in removing the excess water and can avoid not only waterlogging but also helpful indirectly in controlling the excessive growth of plants. Zero tillage saves planting time, fuel and water, improves efficiency of applied fertilizer nutrients and weakens the weed population[4]. Farmers prefer this technology due to farm labour shortage and rising fuel prices. Zero tillage practices set in processes which initiate changes in soil physical, chemical and biological properties, which in turn, affect root growth and crop yield. In *kharif* season, weeds are serious problem due to favourable conditions for their growth. Weed management is also important key factor for enhancing 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, harbour insect-pest and plant diseases and reduce quality of farm produce and land value. Critical period for crop –weed competition in green gram is from 15-30 days after sowing[8].

MATERIALS AND METHODS

Field experiment was carried out at the Research farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana during ***kharif*** season of 2014 and 2015. The soil of the experimental field was sandy-loam in texture with pH 7.8. The soil was medium in organic carbon (0.28 %), available nitrogen (160 kg ha^{-1}), phosphorus (16 kg ha^{-1}) and potassium (342 kg ha^{-1}). Experiment was carried out using Split plot design in which three planting methods (Raised bed, Conventional and Zero till) were taken as main plot treatments and nine weed management practices[Weed free, Pendimethalin PRE @ 1000 g ha^{-1}, Imazethapyr PRE @ 70 g ha^{-1}, Imazethapyr PRE @ 100 g ha^{-1}, Imazethapyr 3-4 leaf stage @ 70 g ha^{-1}, Imazethapyr 3-4 leaf stage @ 100 g ha^{-1}, Imazethapyr + Imazamox(RM) 3-4 leaf stage @ 70 g ha^{-1}, Hand weeding (15 & 30 DAS), Weedy check] were used as sub plot treatment. During first year of study, field was ploughed in last week of June by cross harrowing followed by cultivator in plots where conventional tillage and raised bed method of planting was to be practiced and raised beds were prepared by bed planter machine, then planking was done to bring fine tilth and no soil disturbance was done in plots where zero till method of planting was practiced. With the application of glyphosate, previously growing weeds in plots where zero tillage was practiced were controlled. During second year of experimentation, plots of conventional till planting method were prepared with same operations as done in previous year in the last week of June while raised beds were kept as such and only their reshaping was done and no disturbance was done in plots where zero till planting method was practiced. Sowing was done on 30 june and 2 july during 2014 and 2015, respectively using seed rate 20 kg ha^{-1} (Variety MH-421) with recommended dose of fertilizer by seed cum fertilizer drill and by bed planter on raised beds with two rows of green gram on the bed (75 cm wide). Pre emergence application of Pendimethalin and imazethapyr was done on the soil surface as per treatment on the day of sowing and imazethapyr and imazethapyr + imazamox (RM) were applied at 3-4 leaf stage during both years of experimentation as per treatment. Application of herbicides was done using knapsack sprayer and sufficient moisture was maintained in the soil at the time of application. In weed free treatment plots, hand

weeding was done manually with the help of *kasola* and two hand weeding were done at 15 and 30 DAS in the plots where it was required as per treatment.

Crop growth rate

It is the rate of growth of plant calculated from the dry matter accumulation of the plant per day by the following formula:

$$\text{Crop growth rate} = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,

W_2 and W_1 are dry weight of plants at time t_2 and t_1, respectively.

Relative growth rate

Relative growth rate is the exponential increase in size of the plant relative to size of plant present at beginning of a given time interval and calculated by given formula:

$$\text{Relative growth rate} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

W_2 and W_1 are dry weight of plants at time t_2 and t_1, respectively.

Leaf area index

The leaf area index (LAI) is the ratio between leaf area to ground area. It was computed by using following formula:

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Ground area}}$$

The developed pods were picked from all the three tagged plants from each plot. After counting the pods of each plant, their average was recorded. From the recorded data of seed yield kg per plot, seed yield were computed kg per hectare on multiplying the yield per plot by conversion factor. From the recorded data of biological yield kg per plot, it was converted to kg per hectare on multiplying the yield per plot by conversion factor. The economics of different treatments was worked out by taking into consideration the prevailing rates of different cultural operations and using the minimum support price of the crop of the respective year. The cost of cultivation for each treatment was subtracted from the gross returns worked out for the respective treatment to calculate net returns for each treatment.

RESULTS AND DISCUSSION

Effect of planting methods on:

Growth parameters

At all stages of observation raised bed method showed significantly higher crop growth rate as compared to conventional and zero till planting method during both years of study except at 46 DAS- maturity stage of 2015 where crop growth rate in raised bed method was statistically at par with crop growth rate in zero till planting method (Table 1). Similar were the findings of Ram *et al*.[6] in soybean crop where crop growth rate at 45-60 DAS was found highest in all plots where raised bed planting was done.

With advancement of crop age relative growth rate (Table 2) in green gram decreased during both years of study. Raised bed method resulted in significantly maximum relative growth rate at all stages of observation as compared to conventional and zero till planting method except at 45 DAS-maturity stage of 2015, where relative growth rate in raised bed planting method was statistically at par with relative growth rate in zero till method.

Planting methods were not able to influence leaf area index significantly at 15 DAS during both years of study (Table 3). At

30 and 45 DAS, raised bed method resulted in significantly higher leaf area index during 2014 and 2015 as compared to conventional and zero till planting method while conventional and zero till planting method were statistically at par with each other. Similar were the findings of Dodwadiya and Sharma[3], Yadav and Singh[9] in green gram crop.

Yield

Among different planting methods, raised bed method resulted in significantly more number of pods plant^{-1} (Table 4) as compared to conventional and zero till planting method during 2014 and 2015. Seed yield being a function of yield attributes was also significantly more in bed planting method. Similar results were reported by Shivakumar *et al*.[7], Dhindwal *et al*.[2], Yadav and Singh[9] in green gram and Kang *et al*.[5] in soybean. The seed yield of green gram in raised bed planting was 16.6 and 6.0 percent higher than zero till method during 2014 and 2015, respectively. Biological yield (Table 4) was also significantly more in bed planting method as compared to conventional and zero till planting method during both years.

Economics

Maximum gross returns (₹ 40809/-, ₹ 42429/), net returns (₹ 18149/-, ₹ 17148/-) were recorded in raised bed planting method during 2014 and 2015, respectively (Table 4).

Effect of weed management practices on:

Growth parameters

Among weed management practices at all stages of observation, weedy check recorded lowest crop growth rate during both years of study (Table 1). At 15-30 DAS stage, weed free recorded maximum crop growth rate followed by post emergence application of Imazethapyr @ 100 g ha^{-1} during both years. At 31-45 DAS, maximum crop growth rate was found in weed free which was statistically at par with HW (15 & 30 DAS) during both years of study. At this stage, among treatments having herbicide application, maximum crop growth rate was recorded in post emergence application of Imazethapyr @ 100 g ha^{-1} followed by Imazethapyr @ 70 g ha^{-1} during both years. During 2014, at 46 DAS-maturity, maximum crop growth rate was found in weed free treatment which was statistically at par with post emergence application of Imazethapyr @ 100 g ha^{-1} and Imazethapyr @ 70 g ha^{-1}. However, during 2015, maximum crop growth rate was found in weed free treatment which was statistically at par with post emergence application of Imazethapyr @ 100 g ha^{-1} and HW (15 & 30 DAS).

During 15-30 DAS interval, weedy check treatment resulted in significantly minimum relative growth rate (Table 2) as compared to remaining weed management treatments whereas significantly maximum relative growth rate was found in weed free treatment at all stages of observation except at 46 DAS-maturity where treatment having post emergence application of Imazethapyr @ 100 g ha^{-1} resulted in maximum relative growth rate which was statistically at par with all treatments except weedy check and pre emergence application of Pendimethalin @ 1000 g ha^{-1} during 2014 .Weed free treatment resulted in maximum relative growth rate which were statistically at par with all treatments except weedy check during 2015.

Among different weed management practices, all treatments showed significantly higher leaf area index (Table 3) as compared to weedy check at 30 and 45 DAS. At 30 DAS leaf area index in all weed management treatments was statistically at par with each other except weedy check during 2014 and 2015. At 45 DAS, weed free resulted in significantly maximum leaf area index (3.05) as compared to other treatments during 2014 while during 2015 maximum leaf area index (3.17) was found in weed free which was statistically at par with HW (15 & 30 DAS). Leaf area index in all post emergence applied herbicides and pre emergence application of Imazethapyr @ 100 g ha^{-1} was statistically at par with each other.

Yield

During 2014, weed free treatment resulted in significantly maximum number of pods plant^{-1} (Table 4) as compared to other weed management treatments, while in 2015 weed free and HW (15 & 30 DAS) treatment

produced maximum number of pods plant^{-1} which were statistically at par with each other. Pendimethalin @ 1000 g ha^{-1} being at par with pre emergence application of Imazethapyr @ 70 g ha^{-1} produced significantly less number of pods as compared to rest of the herbicide treatments and although it was 18.7 and 21.9 percent higher than weedy check during 2014 and 2015, respectively. Post emergence application of Imazethapyr @ 100 g ha^{-1} resulted in significantly maximum number of pods plant^{-1} among treatments having herbicide application followed by post emergence application of Imazethapyr @ 70 g ha^{-1} and Imazethapyr + Imazamox @ 70 g ha^{-1} during both years of study. Weed free treatment produced significantly higher seed yield (Table 4) as compared to weedy check treatment during both years of study. The highest seed yield was found in weed free treatment closely followed by HW at 15 & 30 DAS during both years of study. Pendimethalin @ 1000 g ha^{-1} produced significantly lower seed yield among different herbicide treatments but it produced 72 and 58.3 percent higher seed yield than weedy check treatment during 2014 and 2015, respectively. Ready mix application of Imazethapyr + Imazamox (70 g ha^{-1}) produced significantly higher seed yield as compared to alone application of Imazethapyr @ 70 g ha^{-1} as pre emergence but it produced significantly lower yield than alone application of Imazethapyr as post emergence at the same rate of application. Maximum biological yield (Table 4) was observed in weed free treatment (3809, 3914 kg ha^{-1}) among different weed management treatments which was statistically at par with HW (15 & 30 DAS) during both years of study. Among pre emergence herbicides, Imazethapyr @ 100 g ha^{-1} resulted in significantly higher biological yield which was 43 and 41.6 percent higher than Pendimethalin @ 1000 g ha^{-1} during 2014 & 2015, respectively. Ready mix application of Imazethapyr + Imazamox (70 g ha^{-1}) as post emergence produced significantly higher biomass of green gram as compared to alone application of Imazethapyr as pre emergence. Imazethapyr applied as post emergence at either of the rate (70 g ha^{-1}, 100 g ha^{-1}) produced significantly higher green gram biomass as compared to pre emergence application during both years of study.

Economics

Among different weed management treatments, weedy check treatment resulted in minimum gross returns (₹ 13290/-, ₹ 15130/-) during both years (Table 4). Maximum gross returns (₹ 53022/-, ₹ 55343/-) were found in weed free treatment during 2014 and 2015, respectively followed by HW (15 & 30 DAS). In terms of net returns (Table 4), weedy check treatment resulted in loss of ₹ 3710/- and ₹ 3831/- during 2014 and 2015, respectively. Net returns were found maximum with post emergence application of Imazethapyr @ 100 g ha^{-1} (₹ 25545/-, ₹ 28887/-) during both years.

Table 1: Effect of planting methods and weed management on crop growth rate (mg plant $^{-1}$day^{-1})

Treatments	15-30 DAS		31-45 DAS		46 DAS-Maturity	
	2014	2015	2014	2015	2014	2015
A. Planting methods						
Raised bed	258.0	262.4	476.0	604.0	965.0	792.0
Conventional	242.0	244.2	416.0	444.0	885.0	743.0
Zero till	232.2	249.3	364.0	458.0	880.0	771.0
SEm±	1.14	0.99	4.5	4.9	9.8	8.2
CD at 5%	4.6	3.0	13.3	14.6	29.5	25.0
B. Weed management						
Weed free	313.2	325.7	577.0	672.0	1070.0	877.0
Pendimethalin PRE (1000 g ha^{-1})	212.1	235.1	357.0	438.0	747.0	680.0
Imazethapyr PRE (70 g ha^{-1})	254.0	255.8	338.0	437.0	843.0	726.0
Imazethapyr PRE (100 g ha^{-1})	258.1	262.2	345.0	440.0	868.0	752.0
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	269.0	275.5	444.0	528.0	1051.0	846.0
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	277.0	283.1	453.0	544.0	1057.0	854.0
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	265.3	266.5	427.0	507.0	1012.0	841.0
Hand weeding (15 & 30 DAS)	201.7	208.7	569.0	656.0	1039.0	853.0
Weedy check	147.1	155.1	258.0	296.0	502.0	490.0
SEm±	1.43	1.0	6.1	7.0	7.7	9.6
CD at 5%	4.0	3.0	17.4	20.1	22.2	28.9

Table 2: Effect of planting methods and weed management on relative growth rate (g $g^{-1}$$day^{-1}$)

Treatments	15-30 DAS		31-45 DAS		46 DAS-Maturity	
	2014	2015	2014	2015	2014	2015
A. Planting methods						
Raised bed	0.191	0.185	0.067	0.076	0.055	0.042
Conventional	0.187	0.178	0.064	0.067	0.052	0.038
Zero till	0.185	0.181	0.060	0.066	0.051	0.042
SEm±	0.001	0.001	0.001	0.001	0.001	0.001
CD at 5%	0.002	0.002	0.002	0.003	0.002	0.002
B. Weed management						
Weed free	0.204	0.198	0.086	0.092	0.054	0.042
Pendimethalin PRE (1000 g ha^{-1})	0.180	0.178	0.063	0.067	0.051	0.040
Imazethapyr PRE (70 g ha^{-1})	0.192	0.183	0.054	0.064	0.052	0.040
Imazethapyr PRE (100 g ha^{-1})	0.192	0.185	0.054	0.063	0.052	0.041
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	0.195	0.186	0.063	0.068	0.053	0.041
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	0.197	0.188	0.062	0.068	0.055	0.042
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	0.194	0.190	0.062	0.068	0.053	0.041
Hand weeding (15 & 30 DAS)	0.177	0.171	0.067	0.071	0.053	0.041
Weedy check	0.157	0.152	0.062	0.066	0.049	0.037
SEm±	0.001	0.001	0.001	0.002	0.001	0.001
CD at 5%	0.002	0.002	0.002	0.004	0.003	0.002

Table 3: Effect of planting methods and weed management on leaf area index of green gram

Treatments	15 DAS		30 DAS		45 DAS	
	2014	2015	2014	2015	2014	2015
A. Planting methods						
Raised bed	0.19	0.21	1.18	1.21	2.91	3.01
Conventional	0.19	0.19	1.14	1.16	2.78	2.85
Zero till	0.19	0.20	1.13	1.17	2.75	2.88
SEm±	0.001	0.003	0.004	0.006	0.02	0.03
CD at 5%	NS	NS	0.014	0.019	0.07	0.08
B. Weed management						
Weed free	0.19	0.21	1.17	1.20	3.05	3.17
Pendimethalin PRE (1000 g ha^{-1})	0.19	0.20	1.15	1.18	2.72	2.80
Imazethapyr PRE (70 g ha^{-1})	0.19	0.20	1.15	1.19	2.71	2.80
Imazethapyr PRE (100 g ha^{-1})	0.19	0.20	1.16	1.20	2.79	2.88
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	0.19	0.20	1.16	1.20	2.86	2.94
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	0.18	0.19	1.17	1.20	2.86	2.95
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	0.18	0.19	1.17	1.20	2.83	2.93
Hand weeding (15 & 30 DAS)	0.18	0.20	1.14	1.18	2.90	3.06
Weedy check	0.19	0.21	1.08	1.12	2.61	2.68
SEm±	0.005	0.004	0.013	0.010	0.03	0.04
CD at 5%	NS	NS	0.03	0.02	0.09	0.11

Table 4: Effect of planting methods and weed management on yield attributes, yield and economics of green gram

Treatments	Pods $plant^{-1}$ (no.)		Seed yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A. Planting methods										
Raised bed	29.2	30.4	835	857	3235	3333	40809	42429	18149	17148
Conventional	26.5	27.5	734	796	3000	3176	36015	39373	14155	14892
Zero till	25.6	28.4	716	810	2970	3200	35174	40057	14714	16976
SEm±	0.43	0.52	7.6	7.9	9.9	8.8				
CD at 5%	1.3	1.6	22	23	30	27				
B. Weed management										
Weed free	36.2	37.5	1094	1130	3809	3914	53022	55343	18022	15202
Pendimethalin PRE (1000 g ha^{-1})	20.3	21.7	457	475	2183	2344	22762	23971	3908	3050
Imazethapyr PRE (70 g ha^{-1})	22.4	24.7	659	713	2967	3211	32621	35682	13831	14825
Imazethapyr PRE (100 g ha^{-1})	25.0	27.3	712	746	3122	3321	35177	37279	15877	15912
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	29.4	31.0	873	978	3443	3627	42713	48110	23923	27253
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	31.7	33.5	917	1022	3551	3769	44845	50254	25545	28887
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	28.5	29.8	842	952	3391	3591	41280	47240	22367	26260
Hand weeding (15 & 30 DAS)	33.8	35.7	1033	1070	3798	3870	50283	52569	21283	19488
Weedy check	17.1	17.8	265	300	1351	1480	13290	15130	-3710	-3831
SEm±	0.78	0.79	10.4	8.1	23.4	25.0				
CD at 5%	2.2	2.3	29	23	68	72				

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