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EFFICACY OF WEED CONTROL PRACTICES ON WEED DENSITY AND YIELD OF IRRIGATED GREENGRAM (*Vigna radiata* L.)

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Abstract

The effect of different weed control practices on density of grass weeds, sedges and broadleaved weeds and yield of green gram was studied at Agricultural College and Research Institute, Killikulam, Tamil Nadu Agricultural University using pre-emergence (PE) application of pendimethalin followed either by hand weeding or rotary weeding or application of early post-emergence herbicide (EPOE) *viz.*, imazethapyr, quizalofop-ethyl. In addition, application of early post-emergence herbicide was followed by mechanical weeding, hand weeding or rotary weeding twice and weed free condition were also tested with unweeded check. The results showed that the chemical methods of weed control (both PE and EPOE) were found to have maximum weed control effect and increased grain yield of about 30 % as compared to others.

Key words: Greengram, weed density of grasses, sedges and broadleaved weeds, PE, EPOE and Yield.

1. Introduction

Pulse crops have remained as a mainstay of Indian agriculture for centuries, since they are the main source of protein to vegetarian people of the country. India is the largest producer and consumer of pulses in the world about 34 % of world's area and 24 % of production (Pramanik, 2009). However, weeds offer sever competition to these crops during early stage of growth and reduce yield up to 95 % in wet season and 77 % in dry season (Rao 2003). Weeds have become the serious negative factor in green gram production too, as they reduce the yield to a great extent (Mohamed *et al*, 1987). For control of weeds several methods had been tried with varying degree of success, which include hand weeding, rotary weeding and use of herbicides. Among them, an integrated approach involving cultural method in combination with chemical methods is found to be more effective. Use of herbicides in conjunction with manual practices would make the herbicidal control more acceptable to farmers and allow complete control of weeds. Evolution of an economically viable and ecologically safe combination of physical, chemical, cultural and mechanical weed control technique would help to achieve control weeds and increase the yield. Hence, the present study was under taken to study the effectiveness of such an integrated weed control measure on growth and yield of green gram.

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2. Materials and Methods

A field experiment was conducted in D Block of the Central Farm, Agricultural College and Research Institute, Killikulam of Tamil Nadu Agricultural University during the year 2013 - 2014 to evolve an efficient and economic weed control practice for irrigated green gram. The experimental farm is located in the South Tamil Nadu at 8°46' N latitude, 77° 42' E longitude and at an altitude of 40 m MSL. The climate of the farm is semi-arid tropical**.** The mean annual rainfall is 786 mm. The mean maximum and minimum temperature of the location during cropping period were 33.4˚ and 23.6 ˚C respectively. The relative humidity ranged from 60 to 80 %. The soil of the experimental field is sandy clay loam and slightly alkaline with low in available nitrogen (268.0 kg ha^{-1}), medium in available phosphorus (17.0 kg ha^{-1}) and high in available potassium (242 kg ha^{-1}). Green gram cultivar Co 6 was sown during third week of November 2013. Recommended seed rate (25 kg ha^{-1}) and fertilizer dose of 25 kg N, 50 kg P_2O_5 and 25 kg K_2O ha $^{-1}$ was imposed. The experiment was conducted in a randomized block design with 15 treatments (at three different spacing to impose different weed control measures is given in Table 1) and replicated thrice. The treatments included application of pre-emergence herbicide pendimethalin followed by hand weeding or rotary weeding or early post-emergence herbicides *viz.*, imazethapyr, quizalofop-ethyl. In addition, application of early post-emergence herbicide was followed by mechanical weeding, or hand weeding or rotary weeding twice. A weed free condition was also tested with the treatment unweeded check. Weed density of different types of weeds was recorded at 15 days after sowing (DAS), 30 DAS and 45 DAS and grain yield of green gram were also recorded at harvest.

3. Results

Weed characters

Weed flora of the experimental field

Common weed flora of the experimental field (under unweeded check plot) at flowering stage during the cropping season consisted of grasses, sedges and broad-leaved weeds. They were identified at their flowering stage and among them, sedge constitutes the major type. The important grass weeds were *Dactyloctenium aegyptium*, *Chloris barbata*, *Cynodon dactylon* and sedge was *Cyperus rotundus*. Among the broad - leaf weeds *Phyllanthus niruri*, *Boerhavia diffusa*, *Cleome viscosa*, *Trianthema portulacastrum*, *Digera muricata* and *Tridax procumbens* were the prominent species. Such a wide spectrum of weeds in green gram and other pulse based cropping systems was reported by many workers *viz.*, Natarajan *et al.* (2003); Punia *et al.* (2004); Velmurugan (2012); Thirumalaivasan (2013).

Grass weeds density

Different weed control practices significantly reduced density of grass weeds at all the stages. The observations on grass weed density at 15, 30 and 45 DAS are presented in Table - 1. At 15 DAS, the grass weed density was significantly reduced in treatment (T_9) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* rotary weeding (15 - 20 DAS) which recorded the lower grass weed density of 10.00 m^{-2}. This treatment was followed by (T_8) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) which recorded a grass weed density of 10.33 m^{-2} and these two treatments were found to be on par with each other. The highest grass weed density (24.00 m^{-2}) was noticed in weedy check (T_{15}). At 30 DAS, significantly lower grass weed density (11.00 m^{-2}) was recorded with (T_2) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1}. The weedy check (T_{15}) recorded the highest grass weed density (28.80 m^{-2}).

At 45 DAS, among various weed control practices, (T_8) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) caused considerable reduction in grass weed population and registered significantly lower weed density of 7.25 m^{-2}. Again the highest grass weed density of

42.20 m^{-2} was recorded with unweeded control (T_{15}).

Sedge weeds density

Different weed control practices significantly reduced the sedge weed density. The observations recorded on sedge weed density at 15, 30 and 45 DAS are presented in Table - 2. At 15 DAS, the treatment (T_2) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} had recorded the lowest density of 13.10 m^{-2} which was on par with (T_8), pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} with a density of 14.00 m^{-2}. The highest sedge population was recorded under weedy check with a density of 29.82 m^{-2}.

In the case of 30 DAS, the treatment (T_8) was found to reduce sedge weeds as compared to 15 DAS, while there was an increase with treatment (T_2) at 18.00 m^{-2}. Different weed control treatments adopted significantly altered the sedge weed density at 45 DAS also. Here again, the lowest sedge count (9.25 m^{-2}) was recorded with (T_8) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1}. This was followed by the treatment T_2 with a density of 11.20 m^{-2} which was significantly higher than T_8. The highest sedge density of 59.17 m^{-2} was recorded in T_{15} weedy check.

Broad-leaved weeds density

The broadleaved weed density levels of different weed control treatments at 15, 30 and 45 DAS are presented in Table - 3. At 15 DAS, the chemical weed control with (T_8) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} recorded the lowest density (8.00 m^{-2}). The highest broad-leaved weed density (19.00 m^{-2}) was noticed with weedy check (T_{15}). Whereas at 30 DAS, the treatment (T_2) pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} was significantly superior in controlling broad - leaved weeds which accounted a lower broadleaved weed density of 10.06 m^{-2}. The same treatment (T_8) had a broad - leaved weed density of 11.03 m^{-2} which was next in order and was on par with T_2 but superior over rest of the treatments. Unweeded check (T_{15}) accounted the highest density of broad-leaved weeds (30.00 m^{-2}).

At later stage (45 DAS), pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} were on par and recorded a lower density of 8.05 (T_2) and 8.18 m^{-2} (T_8). The treatment wherein pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* one hand weeding (25 DAS) (T_7) recorded a broadleaved weed density of 9.11 m^{-2}. All the three treatments (T_2, T_8 and T_7) were statistically on par and superior over other treatments. Uunweeded check (T_{15}) recorded the highest broad-leaved weed density of 48.30 m^{-2}.

Effect of different weed management practices on grain yield

Grain yield recorded with various treatments clearly denoted the significant effect of various weed control treatments on crop yield (Table - 3). The weed free plot (T_{14}) recorded the highest grain yield of 1048 kg ha^{-1}. This was followed by the treatments T_8 and T_2, which recorded 1006 and 992 kg ha^{-1} respectively and were statistically on par with T_{14}. The treatments, which have pre-emergence application of herbicide followed by hand weeding (T_7 & T_1) and rotary weeding (T_3 and T_9) recorded grain yields ranging from 817 to 842 kg ha^{-1} and were on par among themselves. The treatments with manual or mechanical method alone (T_{12}, T_5, T_6 and T_{11}) where in pre-emergence chemicals were not used had recorded a low yield (680,674,689 and 658 kg ha^{-1}) than farmers' practices (790 kg ha^{-1}) (T_{13}). Mere use of early post-emergence herbicide (T_{10} and T_4) recorded only 590 and 578 kg ha^{-1}. The weedy check (T_{15}) recorded the lowest grain yield of 410 kg ha^{-1}.

Table – 1: Effect of weed management practices on grass weed density (no.m^{-2}) at 15, 30 and 45 DAS in irrigated Greengram

T. No	Spacing	Treatments	15 DAS	30 DAS	45 DAS
T_1	25 × 25 cm	PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	13.16 (3.63)	14.15 (3.76)	12.00 (3.46)
T_2		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* EPOE Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS)	12.00 (3.46)	11.00 (3.32)	10.10 (3.18)
T_3		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* Rotary Weeding (15-20 DAS)	14.00 (3.74)	14.00 (3.74)	13.00 (3.61)
T_4		EPOE- Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) *fb* Rotary Weeding (30 DAS)	18.20 (4.40)	22.02 (4.69)	18.40 (4.29)
T_5		Hand Weeding twice at 15 and 30 DAS	16.00 (4.00)	17.02 (4.13)	15.20 (3.90)
T_6		Rotary Weeding twice at 15 and 30 DAS	17.20 (4.15)	18.30 (4.28)	13.25 (3.64)
T_7	30 × 30 cm	PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	12.40 (3.52)	15.71 (3.96)	11.00 (3.32)
T_8		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* EPOE Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS)	10.33 (3.21)	12.03 (3.47)	7.25 (2.69)
T_9		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* Rotary Weeding (15-20 DAS)	10.00 (3.16)	15.30 (3.91)	11.40 (3.38)
T_{10}		EPOE - Quizalofop- ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) *fb* Rotary Weeding (30 DAS)	18.00 (4.24)	23.06 (4.88)	20.00 (4.47)
T_{11}		Hand Weeding twice at 15 and 30 DAS	17.00 (4.12)	22.00 (4.69)	14.00 (3.74)
T_{12}		Rotary Weeding twice at 15 and 30 DAS	15.13 (3.89)	19.00 (4.36)	12.93 (3.60)
T_{13}	30 × 10 cm	Farmers practice: PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	15.00 (3.87)	18.30 (4.28)	14.20 (3.77)
T_{14}		Weed free plot	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{15}		Weedy check	24.00 (4.90)	28.80 (5.30)	42.20 (6.50)
SEd			0.47	0.60	0.47
CD (P=0.05)			1.02	1.29	1.02

(Figures in parentheses are square root transformation values).

Table – 2: Effect of weed management practices on sedge weed density (no.m^{-2}) at 15, 30 and 45 DAS in irrigated Greengram

T. No	Spacing	Treatments	15 DAS	30 DAS	45 DAS
T_1	25 × 25 cm	PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	16.15 (4.02)	20.50 (4.53)	13.06 (3.61)
T_2		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* EPOE Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS)	13.10 (3.62)	18.00 (4.24)	11.20 (3.35)
T_3		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* Rotary Weeding (15-20 DAS)	18.09 (4.25)	22.51 (4.74)	14.54 (3.81)
T_4		EPOE- Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) *fb* Rotary Weeding (30 DAS)	23.60 (4.73)	31.00 (5.57)	22.00 (4.69)
T_5		Hand Weeding twice at 15 and 30 DAS	20.70 (4.55)	22.00 (4.69)	19.11 (4.37)
T_6		Rotary Weeding twice at 15 and 30 DAS	19.00 (4.36)	24.00 (4.90)	21.13 (4.60)
T_7	30 × 30 cm	PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	16.30 (4.04)	17.00 (4.12)	14.07 (3.75)
T_8		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* EPOE Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS)	14.00 (3.74)	13.27 (3.64)	9.25 (3.04)
T_9		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* Rotary Weeding (15-20 DAS)	18.00 (4.24)	19.19 (4.38)	13.40 (3.66)
T_{10}		EPOE - Quizalofop- ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) *fb* Rotary Weeding (30 DAS)	23.10 (4.81)	24.00 (4.90)	21.01 (4.58)
T_{11}		Hand Weeding twice at 15 and 30 DAS	22.09 (4.70)	23.00 (4.80)	21.31 (4.62)
T_{12}		Rotary Weeding twice at 15 and 30 DAS	21.00 (4.58)	22.86 (4.78)	20.00 (4.47)
T_{13}	30 × 10 cm	Farmers practice: PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	19.00 (4.36)	21.20 (4.60)	17.00 (4.12)
T_{14}		Weed free plot	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{15}		Weedy check	29.82 (5.46)	33.00 (5.74)	59.17 (7.69)
SEd			0.56	0.65	0.67
CD (P=0.05)			1.24	1.41	1.45

(Figures in parentheses are square root transformation values).

Table – 3: Effect of weed management practices on broadleaved weed density (no.m^2) at 15, 30 and 45 DAS and yield of irrigated Greengram

T. No	Spacing	Treatments	15 DAS	30 DAS	45 DAS	Grain yield
T_1	25 × 25 cm	PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	12.00 (3.46)	12.00 (3.46)	10.00 (3.16)	825
T_2		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* EPOE Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS)	11.00 (3.32)	10.06 (3.17)	8.05 (2.84)	992
T_3		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* Rotary Weeding (15-20 DAS)	10.20 (3.19)	12.00 (3.46)	11.00 (3.32)	817
T_4		EPOE- Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) *fb* Rotary Weeding (30 DAS)	17.09 (4.13)	20.00 (4.47)	19.41 (4.41)	578
T_5		Hand Weeding twice at 15 and 30 DAS	14.00 (3.74)	21.00 (4.58)	14.20 (3.77)	674
T_6		Rotary Weeding twice at 15 and 30 DAS	15.20 (3.90)	19.00 (4.36)	15.25 (3.91)	689
T_7	30 × 30 cm	PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	11.19 (3.35)	13.00 (3.61)	9.11 (3.02)	842
T_8		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* EPOE Quizalofop-ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS)	8.00 (2.83)	11.03 (3.32)	8.18 (2.86)	1006
T_9		PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* Rotary Weeding (15-20 DAS)	12.00 (3.46)	12.20 (3.49)	10.13 (3.18)	839
T_{10}		EPOE - Quizalofop- ethyl and Imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) *fb* Rotary Weeding (30 DAS)	16.50 (4.06)	21.00 (4.58)	15.00 (3.87)	590
T_{11}		Hand Weeding twice at 15 and 30 DAS	15.10 (3.89)	18.12 (4.26)	16.00 (4.00)	658
T_{12}		Rotary Weeding twice at 15 and 30 DAS	14.00 (3.74)	17.00 (4.12)	15.00 (3.87)	680
T_{13}	30 × 10 cm	Farmers practice: PE- Pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) *fb* One Hand Weeding (25 DAS)	12.13 (3.48)	15.25 (3.91)	12.05 (3.47)	790
T_{14}		Weed free plot	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1048
T_{15}		Weedy check	19.00 (4.36)	30.00 (5.48)	48.30 (6.95)	410
SEd			0.35	0.55	0.61	28
CD (P=0.05)			0.77	1.20	1.33	62.4

(Figures in parentheses are square root transformation values)

4. Discussion

Among various weed control practices, the treatment (T_8) of pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) with a spacing of 30 × 30 cm recorded estimably lower weed density. This might be due to the destructive effect of pre-emergence application of herbicides applied. The next order of lesser weed density was recorded by the treatment (T_2) of pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) with spacing 25 × 25 cm. Sequential use of pre-emergence and early post emergence herbicides effectively controlled broad spectrum of weeds like grasses, sedges and broadleaved weeds present in irrigated green gram. The results were in agreement with earlier findings of Raskar and Bhoi (2002) in soybean. They observed that pre plant incorporation of herbicide imazethapyr 2 % plus pendimethalin 30 % had effectively controlled grassy and broadleaved weeds.

The results were in accordance with the findings of Singh *et al.* (2006) and Kumar *et al.* (2008) who reported the killing effect of pre-emergence herbicides in germination phase of weeds leading to lesser density at early stage and it was followed by usage of early post-emergence herbicides in causing significant reduction of later established weeds.

The death of susceptible species of grass and broadleaf weeds by imazethapyr application was due to inhibition of acctolactate synthase (ALS) enzyme which is essential for leucine, valine and isoleucine synthesis in weeds (Stidham and Singh, 1991). Post emergence application of quizalofop-ethyl @ 37.5, 50, 75 and 100g ha^{-1} proved to be highly effective in controlling the grass and recorded more yield of soybean (Sharma, 2000) with high percentage reduction of total weed density. The current investigation is found in accordance with the above findings.

Invariably, the treatment of weedy check (T_{15}) registered the highest total weed density at all stages of observation *viz*., at 15, 30 and 45 DAS respectively. Similar finding was reported by Buttar *et al*. (2006), Ali *et al*. (2011) and Chhodavadia *et al*, (2014) in green gram.

The grain yield increased from 410 kg ha^{-1} in weedy check (T_{15}) to 1048 kg ha^{-1} in weed free condition (T_{14}). The treatments of T_8 and T_2 registered grain yields of 1006 and 992 kg ha^{-1} respectively and they were found comparable with weed free condition. This might be due to the reduced effect of weeds, competition free environment at the critical stages of crop, favourable conditions for the crop to utilize the resources and enhanced source sink capacities. Among the weed control treatments, pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (3 DAS) followed by early post-emergence herbicide quizalofop-ethyl and imazethapyr @ 50 g a.i. ha^{-1} (15 DAS) was found to result in higher grain yield as compared to all other treatments. These were in accordance with the earlier findings of Tewari *et al.* (2004); Singh *et al.* (2006); Dhaker *et al*. (2009); Dhaker *et al*. (2010); Patel *et al.* (2011).

The reason for better yield under use of herbicides and also its integration with other methods might be due to better control of all types of weeds as compared to manual or mechanical method alone. In addition to that, a uniform and good stand of the crop was observed which might have been due to application of pre and post emergence herbicides leading to lower nutrient depletion and dry matter production by weeds and thereby increasing the nutrient uptake of crop with more growth, favourable yield attributes and higher grain yield of irrigated green gram.

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