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Performance of planting patterns and weed control treatments on growth of spring season green gram (*Vigna radiata* L.) and associated weeds

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Abstract
The field experiment entitled "Performance of planting patterns and weed control treatments on growth of spring season Green gram (*Vigna radiata L.*) and associated weeds*"* was conducted during the spring season on the research farm of the School of Agriculture, Lovely Professional University, Phagwara (Punjab).Fifteen treatments combination of three main plot treatments (planting pattern) *viz*., M1: Row sowing, M2: Cross sowing, and M3: Bed sowing and five weed control treatments in subplots *viz*., T1: Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em, T2: Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, T3: Parimaze 10 SC (imazethapyr 50 gm /ha), post em, T4: One hand weeding, T5: Unweeded (control) were kept. The experiment was laid out in Split-Plot Design with four replications. Among planting patterns total weed count and dry matter was observed to be at par among flat planting and bed planting and both these techniques produced significantly higher weed count and their dry matter than cross sowin. Significantly low weed count and dry matter accumulation by weeds was obtained under Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, one hand weeding, Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em and Parimaze 10 SC (imazethapyr 50 gm /ha), post em treatments.as compared to unweeded (control).The plant height was significantly more under bed sowing than cross sowing and row sowing. Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W recorded the significantly highest plant height among all weed control treatments. The dry matter accumulation by plant was found to be more in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W which was significantly better than one hand weeding, Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em, Parimaze 10 SC (imazethapyr 50 gm /ha), post em and unweeded (control) treatments. Significantly higher seed yield was recorded under the cross sowing (15.67 q/ha) method of planting pattern than bed (14.15q/ha) and row sowing method (13.88 q/ha). The yield under cross sowing was 10% and 11% percent higher than bed sowing and flat sowing techniques respectively. In different weed control treatments, the higher seed yield was recorded under Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W(16.85 q/ha) and lowest seed yield was observed under unweeded control(10.28 q/ha) which was significantly less than other weed control treatments. The percentage increase in Stomp 30 EC (pendimethalin 0.50 kg /ha), pre em, f.b. one HW, one hand weeding, Stomp 30 EC (pendimethalin 0.75 kg /ha), and pre em. Parimaze 10 SC (imazethapyr 50 gm /ha), post em, was 39%, 34.82%, 33.6%, 28.90%, more than unweeded control respectively.

Keywords: Planting patterns, weeds, weed control, green gram

Introduction
Pulses are the major source of protein for the vegetarian population of India and constitute as an important crop group in Indian Agriculture, as it provides food and fodder, improves fertility of soil and its physical conditions. Pulses are also known to cure some human diseases such as cardiovascular and colon cancer diseases etc. India is the largest consumer and producer of pulses, constituting 24% of production and 34% of the world's cultivated area (Muthuram *et al.*, 2018) [5]. Pulses can be cultivated on wide range of climatic and soil conditions and plays an important eco-friendly role because these crops help to release soil bound phosphorus, fixation of atmospheric nitrogen and thus maintaining the soil fertility and therefore, contributing towards the sustainability of different farming systems. It can be grown as seed, fodder as well as green manure crop. In India many pulses are grown such as black gram, chickpea, pigeon pea, green gram, lentil etc.
Green gram contains 1.3% minerals, 25% proteins, 4.1% fibre, 56.7% carbohydrate and 3.5% minerals. Green gram is primarily grown in rainy season but the release of early maturing varieties, green gram is also considered as an ideal pulse crop for spring season.

The productivity of green gram is very low in India despite the high importance of this crop in the diet. Spring season cultivation of green gram is more accepted by farming community. But, *kharif* season green gram is not widely accepted as it is highly prone to excessive rainfall and attack of insect pest and disease during this season. Spring season green gram is best for the cultivation because it is more sure crop due to less attack of insect pests and no risk due to rainfall as compared to rainy season crop.

Among pulses, green gram (*Vigna radiata* L.) ranks third in India in terms of production i.e 1.52 million tons and area i.e 3.77 million ha after chickpea and pigeon pea. It is one of the most prominently cultivated crops in India. Locally it is known by the name of moong. The main reason for the lower productivity of green gram is due to crop weed competition and other reasons such as timely sowing, maintaining optimum population, control of diseases and pests etc. are also responsible. About 50 to 90% yield loss in green gram cultivation is due to weed infestation which is a major constraint in green gram cultivated during spring season. It is reported that if an infestation of weeds is not checked before 20 days after sowing (DAS), then it causes severe yield loss which may extend up to 38% or more. In the wet season, losses due to uncontrolled growth of weed was 95% and in the dry season it was 77% (Dash *et al.*, 2018) [1].

There are various factors that cause the low yield of a green gram are improper planting patterns, lack of knowledge about herbicide use, non- adoption of proper date of sowing, imbalanced use of fertilizers, and insufficient plant protection measures. Among these factors, planting pattern and proper date of sowing are the basic factors that are of great importance.Planting pattern is the basic factor to increase the yield and growth of the crop. Different planting patterns help to increase the yield by maintaining a proper plant stand. The planting pattern affects the utilization of moisture from the soil and radiation interception. The major method of green gram sowing is still broadcasting, which is considered as the major yield and growth-limiting factor in this crop. For higher production line sowing in rows of green gram is documented as the best strategy. Raised bed planting method in green gram efficiently reduces *Cyperus rotundus and E. colona* population and maximizes weed control efficiency. Other than bed sowing, cross sowing is also followed in the green gram for optimum yield. (Fraz *et al.*, 2006) [2]. Growth attributes such as plant height, dry matter accumulation and number of branches per plant and yield attributes like pods/plant, seeds/ plant, stover and seed yield are significantly affected by different planting patterns.

Material and Methods

The experiment was conducted at research farm, Department of Agronomy, Lovely Professional University, Phagwara Punjab. The experimental farm is situated at 31º15.491ˈN latitude and 75º42.476ˈE longitude. The area falls under the subtropical region in the central plain of agro-climatic zones of Punjab and 252 m mean average above Arabian Sea level. The Punjab region comes under sub-tropics. In summers weather of Punjab is hot and cool in winters. The summer starts from the April month of the year up to mid-September, the highest temperature rises up to 45 degree Celsius in the month of June. The Punjab regions receives monsoon from the end of June up to September. The amount of rainfall received is optimum for the crop growth. The month of July receives the highest rainfall in the whole year and the highest temperature is experienced in May and June. Extreme cold weather is experienced during December and January it lowers down to even 0 ^{0}C. Soil samples from 0 to 15 cm depth of soil were collected from the experimental field before the crop sowing to examine the basic physical and chemical properties of the soil. Chemical properties of the soil of experimental field Electrical Conductivity (ds/m) (0.17), Soil pH(7.5), Organic carbon(0.355), Available Nitrogen (kg/ha) (379.9), Available Phosphorous (kg/ha) (24), Available Potassium (kg/ha) (227).

The experiment consisted of fifteen treatments in Split Plot Design having three main plots and 5 subplots with four replications. Main plot consists of three planting patterns M1- Row sowing (22.5cm), M2- Cross sowing(22.5cm x 22.5cm), M3- Bed sowing (Two/rows) and five Sub plots (Weed control treatments) T1- Stomp 30 EC (pendimethalin 0.75 kg a.i /ha), pre em, T2 - Stomp 30 EC (pendimethalin 0.5 kg a.i /ha), pre em. fb one H.W, T3- Parimaze 10 SC (imazethapyr 50 gm a.i /ha), post em, T4- One hand weeding, T5 - Unweeded (control). The size of the experimental plot was 7m x 3.25m**.** Green gram variety used in experiment was SML 1827. The recommended seed rate for sowing summer green gram variety was 30 kg/ha. The seeds of green gram variety were sown manually in the field on 30th March, 2021. The depth of sowing was 2 to 3 cm. After proper field preparation, lay out and sowing was done. A recommended dose of 15 kg N and 40 kg P2O5 was uniformly applied to all the plots as per the recommendation. Urea was used as nitrogen source and single super phosphate for phosphorous source. Entire dose of phosphorous and half dose of nitrogen was applied at the time of sowing after field preparation. The remaining dose of nitrogen was applied after 25 days of sowing as top dressing by using urea fertilizer. As per treatment pre- emergence application of pendimethalin 0.75 kg a.i /ha, pendimethalin 0.5 kg i/ha, was done within 24 hours after sowing, and post emergence application of imazethapyr 50 gm a.i /ha was done 25 DAS for controlling associated weeds of green gram. Hand weeding was performed 20 days after sowing in T4 and 28 DAS in T2 treatment. The weeding was done manually with the help of khurpi. No efforts were made to control the weeds of weedy check treatment and were allowed to grow along with crop up to harvest. Irrigations were applied as per the requirement of the crop. The quadrant of 30cm x 30cm was thrown twice randomly per plot and the number of weed plants and their dry matter was noted. The plant height was recorded for the 5 plants/plot in centimeters from the ground level to the tip of growing point of plants with the help of scale. The term weed control efficiency is expressed in% and calculated at harvest. It refers to reduction of weed growth due to weed control treatments.

$$\text{WCE (\%)} \frac{\text{X-Y}}{\text{X}} = \text{X } 100$$

X = Dried weight of weeds in weedy check plot.
Y= Dried weight of weeds in treatment for which WCE is to be calculate.

The growth and yield attributes were observed at the time of harvest. Net plot harvested was 2sqm.

Result and Discussion

i. Total weed count

The total weed count at harvest was found to be significant among planting patterns and the total weed count in cross sowing (16.87 m-2) was significantly low among all the planting patterns (Table 1). The total weed count in row sowing was highest (35.74 m-2) which was at par with bed sowing (35.52 m-2). Among sub plot treatments total weed count was found to be significant among weed control treatments, the total weed count in unweeded control was (69.37 m-2) which was significantly highest among all other treatments. In Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, total weed count was significantly lowest (5.55 m-2) as compared to other weed control treatments and it was at par with one hand weeding (17.98 m-2) which was significantly better than Parimaze 10 SC (imazethapyr 50 gm /ha), post em (30.52 m-2) and Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em (25.53m-2). Similar results were found by Komal *et al.* (2015) [4] at Rajasthan in which total weed count was found to be highest in un-weeded control and lowest among herbicide and integrated weed control treatments.

At harvest, the maximum dry weight of weeds was recorded under the row sowing method i.e. 8.88 q/ha. Which is at par with bed sowing (7.68 q/ha) (Table 1) and both these techniques records significantly higher weed dry matter accumulation than cross sowing (4.97 q/ha). The significantly highest dry matter accumulation by weeds was observed in unweeded (control) (22.13 q/ha) than all other weed control treatments. The lowest weed dry matter accumulation was recorded under Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W (0.36 q/ha) which was significantly less than above application of Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em (4.56 q/ha), and one-hand weeding (3.25 q/ha). Dry matter by weeds was significantly more in unweeded (control) than all other weed control treatments. Similarly Yadav *et al.* (2019) they observed that in unweeded (control) highest dry matter accumulation of weeds were reported whereas other herbicidal and integrated weed control treatments resulted into lesser weed dry matter accumulation.

The data revealed that among planting patterns the highest weed control efficiency was observed in cross sowing (77.54%) which were followed by bed sowing and row sowing being 65.29% and 59.87% respectively(Table 1). Among weed control treatments the highest weed control efficiency was achieved by integrated weed control method i.e. Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W (98.37%) which was followed by one hand weeding (85.31%) and Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em (79.39%). The lowest weed control efficiency recorded in Parimaze 10 SC (imazethapyr 50 gm /ha), post em. Similar results were recorded by Singh *et al.* (2015) [6].

Table 1: Influence of planting pattern and different weed control treatments on periodic weed count per square meter, dry weight of weeds (q/ha) and on weed control efficiency

Treatments	Periodic weed count/ square meter, At harvest	Dry matter accumulation by weeds (q/ha), At harvest	WCE (%), At harvest
Main plots (Planting pattern)			
M1- Row sowing (22.5cm)	35.74	8.88	59.87
M2- Cross sowing (22.5cm x 25cm)	16.87	4.97	77.54
M3- Bed sowing (Two/rows)	35.52	7.68	65.29
CD 5%	11.65	2.45	-
Sub plots (Weed control treatments)			
T1- Stomp 30 EC (pendimethalin 0.75 kg a.i /ha), pre em	23.53	4.56	79.39
T2 - Stomp 30 EC (pendimethalin 0.5 kg a.i/ha), pre em. fb one H.W	5.55	0.36	98.37
T3- Parimaze 10 SC (imazethapyr 50 gm a.i/ha), post em	30.52	5.58	74.78
T4- One hand weeding	17.98	3.25	85.31
T5 –Un-weeded (control	69.37	22.13	-
CD 5%	16.31	4.38	NA
C.D. Interactions	NS	NS	-

Growth parameter

Plant height (cm) at harvest was significantly influenced by different weed control treatments and planting patterns as shown in (Table 2). Under different planting patterns, the highest plant height was observed in bed sowing which was significantly more than row sowing and cross sowing method of planting. The lowest height was recorded in un-weeded (control) among different weed control treatments which was significantly less than Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em and Parimaze 10 SC (imazethapyr 50 gm /ha), post em. Integrated of Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. with one H.W gave significantly higher plant height than all other treatments due to better weed control in this treatment. The lowest plant height in unweeded treatment may be due to severe crop weed competition for the resources, which resulted in lower uptake of moisture and nutrient which adversely affected plant height. These findings are in agreement with those reported by Hasanain *et al.* (2020) [3] in Uttarakhand.

At harvest the dry matter accumulation by plants was non-significant due to planting patterns whereas in different weed control treatments were found to be significant. The data in the (Table 2) revealed that significantly higher plant dry matter (g) was recorded in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, than all other weed control treatments except one hand weeding treatment. The lowest plant dry matter was observed in unweeded (control) than all weed control treatments due to poor crop growth because of weed competition in this treatment as compared to all other weed control treatments. Similar findings were observed by Verma *et al.* (2020) [7].

The number of leaves at harvest were significantly influenced by planting pattern and weed control treatment.(Table 2) In the planting patterns, significantly higher number of leaves per plant were recorded under cross sowing than row sown crop. Also row sowing recorded the lowest number of leaves which is statistically at with bed sowing but significantly less than cross sowing technique. In the weed control treatments,

the higher number of leaves per plant were recorded in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W which being at par with one hand weeding. Whereas, the lowest number of leaves per plant were observed in unweeded (control0 which was statistically at par with Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em, and Parimaze 10 SC (imazethapyr 50 gm /ha), post em.

Table 2: Influence of planting pattern and different weed control treatments on plant height (cm), number of leaves/plant and plant dry matter (gm)

Treatments	Plant height (cm) At harvest	Periodic number of leaves/plant, At harvest	Periodic dry matter accumulation /plant (g), At harvest
Main plots (Planting pattern)			
M1- Row sowing (22.5cm)	49.50	26.87	50.35
M2- Cross sowing (22.5cm x 25cm)	53.94	35.45	62.16
M3- Bed sowing (Two/rows)	55.25	32.92	54.42
CD 5%	0.30	6.19	NS
Sub plots (Weed control treatments)			
T1- Stomp 30 EC (pendimethalin 0.75 kg a.i /ha), pre em	51.90	30.20	57.74
T2 - Stomp 30 EC (pendimethalin 0.5 kg a.i /ha), pre em. fb one H.W	58.27	38.33	71.21
T3- Parimaze 10 SC (imazethapyr 50 gm a.i /ha), post em	50.09	29.33	52.98
T4- One hand weeding	54.65	35.50	61.57
T5 –Un-weeded (control)	49.55	25.37	34.72
CD 5%	0.38	6.15	8.41
C.D. Interactions	0.69	NS	NS

Yield attributes

A perusal of data (Table 3) indicated that different weed management treatments significantly affected the number of pods per seed at harvest but in the planting pattern it was observed as non-significant. The higher number of pods per seed were observed in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, which was significantly more than one hand weeding, Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em, Parimaze 10 SC (imazethapyr 50 gm /ha), post em and unweeded control treatment. However, the number of pods per plant in unweeded control (10.16) were significantly less than all the treatments which might be due to severe crop weed competition for the resources.

In the planting patterns, it is depicted that significantly more number of seeds per pod were in the cross sowing method of planting than bed sowing (9.97) and row sowing planting of green gram and both latter treatments were found to be at par among themselves (Table 3). Whereas in weed control treatment, the highest number of seeds per pod were recorded in Stomp 30 EC (pendimethalin 0.5 kg /ha) pre em. fb one H.W which was significantly higher than one hand weeding, Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em and Parimaze 10 SC (imazethapyr 50 gm /ha), post em. Among all the weed control treatments unweeded control recorded significantly lowest seeds per pod than all other weed control treatments.

Under planting pattern, significantly highest test weight was recorded under cross sowing (38 g) as compared to bed sowing (36.94 g) and line sowing (36.53g) (Table 3). While, in different weed control treatments, the highest test weight was recorded under Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W (41g) which was significantly higher than other weed control treatments. The lowest test weight was obtained under unweeded (control) (33.42) which was significantly less than all other weed control treatments. Similar results were obtained by Verma *et al.,* (2020) [7].

Seed yield and straw yield (q/ha)

Among planting patterns, the highest seed yield was recorded under the cross sowing method of planting (15.67 q/ha) which was significantly more than bed and row sowing method (Table 4) The yield under bed sowing technique (14.15 q/ha) was at par with row sowing (13.88 q/ha) technique. Higher yield in cross sowing may be due to better weed control (Table 1) better growth parameters (Table 2) and better yield attributes (Table 3). The yield under cross sowing was 10% and 11% percent higher than bed sowing and flat sowing (16.85 q/ha).was observed in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W. which was significantly more than one hand weeding (15.77 q/ha), Stomp 30 EC (pendimethalin 0.75 kg /ha), pre em (15.48 q/ ha), Parimaze 10 SC (imazethapyr 50 gm/ha) (14.46 q/ha), post em and unweeded (control) treatment(10.28 q/ha) While lowest seed yield was obtained in unweeded (control) which was significantly less than all other weed control treatments. Higher seed yields in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, may be due to the maintenance of the weed-free environment, especially during the critical growth period of green gram, which resulted into more plant height (Table 2), more dry matter/plant(Table 2) and more yield attributes (Table 3)as compared to control. The percentage increase in Stomp 30 EC (pendimethalin 0.50 kg /ha), pre em, f.b. one HW, one hand weeding, Stomp 30 EC (pendimethalin 0.75 kg /ha), and pre em. Parimaze 10 SC (imazethapyr 50 gm /ha), post em, was 39%, 34.82%, 33.6%, 28.90%, and more than unweeded control respectively. Verma *et al.* (2020) reported similar findings.

The highest straw yield was recorded under the cross sowing method of planting which was significantly more than bed sowing and row sowing methods (Table 4). However, in weed control treatments significantly higher straw yield was depicted in Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W, than all other treatments. The lowest straw yield was recorded under unweeded control which was at par with Parimaze 10 SC (imazythapyr 50 gm /ha), post em. And both these treatments recorded significantly less straw yield than integrated weed control treatment. Due to timely management of weeds in integrated treatments maximum nitrogen was utilized by the crop, which resulted in more vegetative growth of the plant.

Table 3: Influence of planting pattern and different weed control treatments on no. of pods per plant, no. of seeds per pod and 1000 seed weight (g)

Treatments	No. of pods/plant	No. of seeds /pod	1000 seed weight(g)
Main plots (Planting pattern)			
M1- Row sowing (22.5cm)	15.60	9.84	36.53
M2- Cross sowing (22.5cm x 22.5cm)	20.62	10.24	38
M3- Bed sowing (Two/rows)	17.42	9.97	36.94
CD 5%	NS	0.14	0.55
Sub plots (Weed control treatments)			
T1- Stomp 30 EC (pendimethalin 0.75kg a.i /ha), pre em	18.87	10.20	36.85
T2 - Stomp 30 EC (pendimethalin 0.5kg a.i /ha), pre em. fb one H.W	24.62	11	41.00
T3- Parimaze 10 SC (imazethapyr 50gm a.i /ha), post em	15.45	9.91	35.82
T4- One hand weeding	20.29	10.46	38.66
T5 -Unweeded (control	10.16	8.51	33.42
CD 5%	3.43	0.61	1.31
C.D. Interactions	NS	NS	NS

Table 4: Influence of planting pattern and different weed control treatments on seed yield (q/ha) and straw yield (q/ha)

Treatments	Seed yield(q/ha)	Straw yield(q/ha)
Main plots (Planting pattern)		
M1- Row sowing (22.5cm)	13.88	16.5
M2- Cross sowing(22.5cm x 22.5cm)	15.67	16.95
M3- Bed sowing (Two/rows)	14.15	16.49
CD 5%	0.72	0.37
Sub plots (Weed control treatments)		
T1- Stomp 30 EC (pendimethalin 0.75 kg a.i /ha), pre em	15.48	15.84
T2 - Stomp 30 EC (pendimethalin 0.5 kg a.i /ha), pre em. fb one H.W	16.85	20.17
T3- Parimaze 10 SC (imazethapyr 50 gm a.i /ha), post em	14.46	13.94
T4- One hand weeding	15.77	19.17
T5 –Un-weeded (control	10.28	13.92
CD 5%	0.80	0.85
C.D. Interactions	NS	NS

Conclusion

From the experimental results it can be concluded that in spring green gram, among planting patterns, cross sowing technique significantly improved the growth, yield attributes, yield and productivity of green gram as compared to other methods. Pre- em application of pendimethalin at 0.5 kg/ha f.b H.W was found to be significantly superior to other herbicidal treatments with respect to seed yield. The combination of Stomp 30 EC (pendimethalin 0.5 kg /ha), pre em. fb one H.W with cross sowing planting pattern was also found to be most effective in controlling the weeds in green gram under irrigated conditions.

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