International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 10(5): 609-613, October 2017
DOI: 10.5958/2230-732X.2017.00075.4

AGRONOMY

Effect of System of Crop Intensification Practices on Productivity in Greengram (*Vigna radiata* (L.) Wilczek)

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Paper No. 620 Received: 14-5-2017 Accepted: 12-9-2017

ABSTRACT

Field experiment was conducted during three consecutive seasons (*Kharif* 2010, 2011 and 2012) at Wetland farms of Tamil Nadu Agricultural University, Coimbatore, to evaluate the System of Crop Intensification (SCI) practices on the growth and yield of Greengram. The experiment consisted of six treatments in the combination of maintaining two seedlings (one and two) and three spacing levels (20 × 20 cm, 25 × 25 cm, and 30 × 10 cm) which were tested in the Randomized Complete Block Design with four replications. Three seasons' pooled data revealed that the maximum growth characters such as plant height, LAI and DMP at 20 DAS, 40 DAS and at harvest stages were recorded in control (30 × 10 cm with two seedlings). The yield attributes such as number of clusters hill^{-1}, number of pods hill^{-1} and number of seeds pod^{-1} were higher in the single or the double seedlings maintained at 25 × 25 cm spacing level. Significantly higher grain yield (1091and 1060 kg ha^{-1}) was recorded in 25 × 25 cm spacing level with both the single and the double seedling maintained plots respectively, when compared to the other combinations. The same trend was noted with Harvest index too. Haulm yield also varied significantly and a maximum of 1486 kg ha^{-1} was observed in the control (Double seedlings sown at 30 × 10 cm spacing level).

Highlights

- SCI practices with single or double seeds sown at 25 x 25 cm produced higher growth and yield in Greengram

Keywords: Greengram, SCI practices, spacing, number of seedlings, grain yield

Pulses are the major source of dietary protein in the vegetarian diet of India. Pulses occupy a pivotal position in Indian agriculture by virtue of the fact that they constitute a major and the only high protein component for the average Indian diet. Pulses have a unique property of maintaining and restoring soil fertility through biological nitrogen fixation as well as in improving the physical properties of the soil by virtue of their deep root system (Neelam *et al.* 2014; Rakshit *et al.* 2014).

Greengram (*Vigna radiata* (L.) Wilczek) is an important pulse crop grown widely in both the tropical and the sub-tropical areas of the world. It is the third most important pulse crop after chickpea and redgram in India. It also has easy digestibility behaviour (Das and Barua 2015). The crop is well suited to a large number of cropping systems in the cereal-based diets of many people in Asia (Kaur and Sharma 2013). It has better nutritional quality; it is regarded as the 'Queen of pulses'. The crop is recognized as an excellent source of protein. In India, it is grown in 2.76 m ha with an average productivity of only 317 kg ha^{-1} (Duary *et al.* 2014).

System of Rice Intensification (SRI) is a novel methodology and by adopting these principles the production of rice has been reported to increase from 50 to 100 per cent (Uphoff 2011). Recently, the success of SRI practices are being extrapolated to other crops such as wheat, teff grass, maize, sorghum, finger millet, soybean, blackgram, kidney bean, lentil, mustard, sugarcane, tomato, brinjal, chilli, potato, carrot and onion in the name of the System of Crop Intensification (SCI) (ISD 2009). Similar to SRI, the SCI practices have also proved to increase twice the yield levels of the crops (Uphoff *et al*. 2011). In pursuit of extending the beneficial effect of SRI to SCI in greengram, the present study was programmed.

MATERIALS AND METHODS

Experimental location

Field experiment was conducted during the *Kharif* season (July–September) of 2010, 2011 and 2012 at Wetland farms, Tamil Nadu Agricultural University, Coimbatore, to evaluate the System of Crop Intensification practices on the growth and yield of Greengram. The farm is situated in Western Agro-Climatic Zone of Tamil Nadu at 11°N latitude and 77°E longitude with an altitude of 426.7 m above MSL. The experimental soil was clay loam in texture having 0.50-0.57% of organic carbon, 189-223 kg ha^{-1} of available nitrogen, 32.6-45.6 kg ha^{-1} of available phosphorus and 416-536 kg ha^{-1} of available potassium.

Treatment details

The experiment was laid out in a Randomized complete block design which comprised of six treatments. The treatments are as follows:

- T_1 - Single seed sown at 20 × 20 cm spacing
- T_2 - Single seed sown at 25 × 25 cm spacing
- T_3 - Single seed sown at 30 × 10 cm spacing
- T_4 - Double seeds sown at 20 × 20 cm spacing
- T_5 - Double seeds sown at 25 × 25 cm spacing
- T_6 - Double seeds sown at 30 × 10 cm spacing (Control).

The treatments were replicated four times. Greengram variety CO 6 was used for the study.

The seeds were first treated with *Trichoderma viride* @ 4 g kg^{-1} of seed and then with *Rhizobium* strain, shade dried and dibbled at different spacing levels as per the treatment schedule. Gap filling was carried out with the viable seeds in a place where germination had failed. Thinning was done at 10 DAS leaving healthy seedling(s) as per the treatment schedule. All other management practices were followed as per CPG (2012).

Data observation

The height of the plants was measured from the ground level to the tip of the last opened leaf from the randomly tagged five plants. To obtain drymatter production (DMP), five plants were pulled-off randomly, air dried and then oven dried at 80°C till a constant weight was obtained. The weight was recorded using an electronic top pan balance and expressed in kg ha^{-1}. The total number of green leaves, length and breadth of the third leaf from the top of the tagged plants were measured in each plot. The leaf area index was then worked out as suggested by Palanisamy and Gomez (1974), using the formula given below:

$$LAI = \frac{L \times B \times K \times \text{No. of green leaves hill}^{-1}}{\text{Spacing (cm}^2\text{)}}$$

Where,

L - Length of the third leaf from the top (cm)

B - Maximum breadth of the same leaf (cm)

K - Constant factor (0.662)

The number of clusters hill^{-1} was counted from five tagged plants and the mean number of cluster hill^{-1} was recorded. The number of pods hill^{-1} was counted from the same plants and the mean number of pods hill^{-1} was recorded. Number of seeds was counted from twenty randomly selected pods from the five tagged plants in each net plot and the mean number of seeds pod^{-1} was worked out. The length of the pods from the observation plants was measured and expressed in cm. The weight of 100 seeds drawn at random from the five randomly selected plants was recorded and expressed in gram.

For determining the grain yield, all the pods were harvested separately and threshed manually by beating with sticks, cleaned and dried to 12 per cent moisture level and the grain yield from the net plot was calculated and expressed in kg ha^{-1}. The haulm yield after threshing the pod from the plants from net plot was recorded and expressed in kg ha^{-1}. The harvest index was calculated with the help of the following formula given by Yoshida *et al.* (1972).

$$\text{Harvest index (HI)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})}$$

The observed pooled data on crop were statistically analyzed (Gomez and Gomez, 2010).

RESULTS AND DISCUSSION

Growth characters

Three seasons' pooled data of greengram indicated that the plant height differed significantly due to SCI practices at different stages barring at 20 DAS (Table 1). At 40 DAS, taller plants were recorded with double seedlings maintained at 30 × 10 cm, whereas, it was on par with double seeds sown either at 20 × 20 cm or 25 × 25 cm spacing level and also the single seedling maintained at 30 × 10 cm spacing level. The same trend was noticed at the harvest stage too. This was mainly due to the competition between the inter and the intra plants for sun light, water, nutrients and space at the closer spacing levels and the double seedlings which encouraged self-thinning of lateral branches and enhanced vertical growth rather than horizontal growth. Similar findings were also reported by Siddharaju *et al*. (2010) in cluster bean and Sathiyavani (2011) in greengram.

The treatments imposed had significant influence on drymatter production (DMP) at different stages of greengram. Pooled data of three years indicated that double seedlings maintained at 30 × 10 cm spacing level had registered higher DMP (159.9 kg ha^{-1}) at 20 DAS over the other evaluated treatments. However, at later stages (40 DAS and at harvest), it was on par with single seed sown at 30 × 10 cm spacing level. The least DMP (86.6 kg ha^{-1}) was observed when greengram was sown with single seed at 25 × 25 cm spacing level. It could be attributed to the fact of higher population and more accumulation of nutrients unit area^{-1} at closer spacing level compared to the wider spacing levels. This is in accordance with the earlier findings (Sathyamoorthi *et al*. 2008; and Sathiyavani *et al.* 2012).

The treatments imposed had significant influence on the leaf area index (LAI) of greengram at different stages. Based on the pooled data, double seedlings maintained at 30 × 10 cm spacing level recorded significantly higher LAI (0.091, 2.56 and 6.00) at 20 DAS, 40 DAS and at the harvest stages respectively, when compared to all other treatments. The lowest LAI at all the stages was recorded with single seedling maintained at 25 × 25 cm spacing level. Higher LAI at closer spacing level with double seedlings was mainly due to more population per unit area which produced more branches unit area^{-1} in turn with more leaves leading to higher LAI value. This is in conformity with the findings of Sathyamoorthi *et al*. (2008).

Yield attributes

Number of clusters hill^{-1} of greengram was significantly influenced by SCI practices (Table 2).

Three years pooled data indicated that double seedlings maintained at 25 × 25 cm spacing level recorded significantly higher number of clusters hill^{-1} (10.13) over others; however, it was statistically on par with single seedling maintained at 25 × 25 cm spacing (9.82) level. Single seedling maintained at 30 × 10 cm spacing registered the lowest number of

Table 1: Influence of SCI practices on growth characters of greengram (Pooled over three seasons)

Treatments	Plant height (cm)			DMP (kg ha^{-1})			LAI		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1 - Single seedling + 20 × 20 cm	17.3	47.1	66.0	91.5	1817	2642	0.047	1.49	4.65
T_2- Single seedling + 25 × 25 cm	17.2	48.4	66.2	86.8	1376	1888	0.022	1.27	3.37
T_3 - Single seedling + 30 × 10 cm	18.2	53.8	71.2	147.6	2244	3233	0.062	2.29	5.44
T_4 - Double seedlings + 20 × 20 cm	18.0	53.5	71.6	113.2	1908	2808	0.062	2.01	5.10
T_5 - Double seedlings + 25 × 25 cm	17.6	52.9	70.5	94.3	1397	1841	0.040	1.68	4.42
T_6- Double seedlings + 30 × 10 cm (Control)	18.3	55.1	71.4	159.9	2378	3400	0.091	2.56	6.00
SEd	0.6	1.2	1.4	4.2	85	121	0.02	0.17	0.23
CD (P=0.05)	NS	2.6	3.0	9.1	184	263	0.04	0.38	0.50

Table 2: Influence of SCI practices on yield attributes and yield of greengram

Treatments	No. of clusters hill^{-1}	No. of pods hill^{-1}	No. of seeds pod^{-1}	Pod length (cm)	100 seed weight (g)	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index
T_1 - Single seedling + 20 × 20 cm	7.20	38.30	12.62	8.24	8.24	996	1346	0.43
T_2- Single seedling + 25 × 25 cm	9.82	65.20	12.78	8.42	8.38	1060	1237	0.47
T_3 - Single seedling + 30 × 10 cm	5.00	26.40	12.62	8.23	8.23	914	1477	0.38
T_4 - Double seedlings + 20 × 20 cm	8.72	39.64	12.36	8.34	8.34	1022	1323	0.44
T_5 - Double seedlings + 25 × 25 cm	10.13	68.20	12.70	8.37	8.37	1091	1226	0.46
T_6- Double seedlings + 30 × 10 cm (Control)	6.45	28.40	12.64	8.15	8.25	925	1486	0.38
Sed	0.21	3.20	0.26	0.18	0.15	26	48	0.01
CD (P=0.05)	0.43	6.94	NS	NS	NS	56	104	0.02

clusters hill^{-1} (5.00). The same trend was also noticed with the number of pods hill^{-1}. More number of clusters and pods hill^{-1} were recorded under wider spacing with single or double seeds sown crop which was mainly due to abundant availability of resources such as light, water, nutrient and space which might have provided a chance for the conversion of the increased source to sink. Decrease in the number of clusters hill^{-1} under closer spacing was due to the mortality caused by mutual shading during pre-flowering stage of the crop. Similar findings were also reported by Subramani *et al.* (2002) in blackgram and Sathiyavani *et al.* (2012) in greengram.

In the present study, based on the pooled data, practically no striking influence of SCI practices (spacing levels and number of seedlings) was noticed on the length of pod, number of seeds pod^{-1} and 100 grain weight as documented in the early studies by Shamsi (2009) in chickpea. These parameters though have little influence on agronomic interventions, are mainly influenced by the genetic nature of the plant and hence, not influenced significantly.

Grain yield

SCI practices had significant influence on the grain yield of greengram. Based on the pooled data, double seedling maintained at 25 × 25 cm spacing level (T_5) registered significantly higher grain yield of greengram (1091 kg ha^{-1}) than all other SCI practices and control, however, it was comparable with the single seedling of 25 × 25 cm spacing (T_2) level (1060 kg ha^{-1}). The percentage yield increase due to T_5 and T_2 over control was 18.0 and 14.6. Optimum spacing would have effectively utilized the growth resources, particularly solar radiation compared to narrow spacing, where plants might have suffered due to mutual shading in case of adjoining rows and more plants. It is corroborating with the findings of Sathiyavani (2010). Single or double seedlings planted at 30 × 10 cm recorded comparatively lower grain yield. Higher plant density might have reduced the grain yield. This was due to more of vegetative growth and lesser yield attributes because of severe competition between plants. This is in agreement with the findings of Tomer and Tiwari (1991) in greengram.

Haulm yield

Haulm yield of greengram was significantly influenced by various spacing levels and the number of seedlings. Pooled data indicated that double seedlings maintained at 30 × 10 cm recorded significantly higher haulm yield (3379 kg ha^{-1}) compared to other treatments. The lowest haulm yield (1638 kg ha^{-1}) was recorded with single seedling spaced at 25 × 25 cm. Haulm yield was higher under double seedlings at 30 × 10 cm when compared to wider spacing, which was due to more population unit area^{-1}, in turn it contributed to more biomass and hence higher haulm yield. This was also documented earlier by Sathyamoorthi *et al.* (2008) and Sathyavani (2010).

Harvest index

Harvest index was significantly influenced by SCI practices in greengram. Based on the pooled data, the maximum harvest index (0.47) was observed under single seedling maintained at 25 × 25 cm spacing level and it was on par with double seedling maintained at 25 × 25 cm spacing (0.46). The increase in grain yield ultimately led to higher harvest index. Similar findings were also reported by Shukla and Dixit (1996). The lowest harvest index was recorded under closer spacing (30 × 10 cm) with either single or double seedlings (T_3 and T_6) due to more haulm yield. This indicated that not much of the photosynthate was partitioned to the main economic parts to make significant contribution to seed yield. This is in agreement with the findings of Agugo *et al*. (2010) in greengram.

CONCLUSION

From the experimental results obtained from field investigation over three years, it can be enlightened that greengram with either single or double seedlings maintained at 25 × 25 cm spacing level produced better growth characters, yield attributes and grain yield. Hence, it is concluded that under SCI greengram (variety CO 6) raised at 25 × 25 cm spacing with single or double seedlings and proved to be a better option for getting higher productivity under irrigated condition.

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