International Journal of Advanced Life Sciences (IJALS)
ISSN 2277 – 758X
Daisy et al., IJALS, Volume (6) Issue (4) August - 2013. RESEARCH ARTICLE

Effect of System of Crop Intensification (SCI) practices on growth, yield attributes and yield of castor hy brid YRCH 1

M. Daisy, N. Thavaprakaash*, K. Velayudham and V. Divya**
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore- 3,
***Department of Agronomy, KVK, Pechiparai, Kanyakumari Dt. **Directorate of Crop Management, AC & RI, TNAU, Coimbaatore-3.**
Email : mdaisy.nkl@gmail.com

Abstract

Field experiment was conducted during late *Kharif* 2012-2013 at Tamil Nadu Agricultural University, Coimbatore under irrigated conditions on sandy clay loam and experiment was laid out in randomized complete block design, comprised of eight treatments were replicated thrice *viz.*, T_1 - 120 x 90 cm spacing + 100% NK (60 and 30 kg of N and K_2O ha^{-1}) + Hand weeding (HW) twice (30 and 60 DAS) – Control, T_2 - 120 x 120 cm spacing + 100% NK + HW, T_3 - 150 x 150 cm spacing + 100% NK + HW, T_4 - 150 x 150 cm spacing + 125% NK + HW, T_5 - 120 x 120 cm spacing + 100% NK + Mechanical weeding (MW) twice (30 and 60 DAS), T_6 - 150 x 150 cm spacing + 100% NK + MW, T_7 - 150 x 150 cm spacing + 125% NK + MW and T_8 - 90 x 90 cm spacing + 100% NK + HW. Growth characters such as plant height, number of branches $plant^{-1}$; yield attributes *viz.*, number of spikes $plant^{-1}$ and number of capsules $spike^{-1}$ were more under wider spacing of 150 x 150 cm along with 100% NK and hand weeding at 30 and 60 DAS. Closer spacing of 90 x 90 cm with 100% NK and hand weeding resulted significantly higher DMP and LAI. Wider spacing of 120 x 120 cm with 100% NK and mechanical weeding at 30 and 60 DAS produced higher castor bean yield, hundred been weight and benefit-cost ratio. However, higher stalk yield was observed at closer spacing of 90 x 90 cm with 100%NK and mechanical weeding. The information of the field experiment with respect to the above at various stages is discussed in detail.

Keywords : Castor, Growth characters, Yield attributes, Spikes, capsules and Benefit-cost ratio

Corresponding Author
M. Daisy
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore- 3, Tamilnadu, India
Email : mdaisy.nkl@gmail.com

Article History
Received on 29 June, 2013; Received in revised form 16 July, 2013; Accepted 21 July, 2013

Introduction

India is largest producer of castor and contributes to around 65 per cent of total production and dominating the global trade with a share of more than eight per cent. In the country, Gujarat ranks first with regards to area (57%), production (82.9%), and productivity (2010 kg ha^{-1}). Castor crop is raised on light textures soils under dry land by small farmers with low inputs and poor management resulting in reduced yield and net returns in rainfed farming system. Due to that, castor cultivation is beset with lots of problems of varying rainfall pattern, biotic and abiotic stress etc., Castor farmers in the arid and semi arid tracts of Tamil Nadu decides it was no longer remunerative crop which leads to decline in castor growing area. Having this issue, high yielding, drought resistant cultivar suited to rainfed as well as irrigated conditions have been developed. The productivity of castor can be increased with the use of latest castor hybrids and altering the planting pattern and implementing mechanization methods. Therefore, there is a need to change the planting pattern and needs to be worked with the cost of cultivation and benefit-cost ratio.

Crop geometry is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil and with above soil by harvesting the maximum possible solar radiation and in turn better photosynthate formation (Thavaprakaash *et al.*, 2005). Square arrangements of plants will be more efficient in the utilization of light, water, and nutrients available to the individual plants than in a rectangular arrangement. Square planting with wider spacing facilitates mechanical weeding in two way directions (Krishna *et al.*, 2008). Castor being an indeterminate type of growth and adoption of SCI practices may enhance the productivity and reduce the cost of cultivation. Though the spacing requirement of castor has been standardised, the information on the influence of square planting with wider spacing, enhanced fertilizer level and mechanical weeding on yield is lacking. It is felt necessary to develop an improved technology package, in the name of system of crop intensification (SCI) to improve the yield of castor. With this background, the present study was carried out with the following objectives.

Materials and methods

A field experiment was conducted at field No. 36 F, Eastern block farm, Tamil Nadu Agricultural University, Coimbatore, during the late *Kharif* season of 2012-13. The soil of the experimental site was well drained, sandy clay loam in texture (*Typic Haplustalf*), with a pH of 7.9 ,EC 0.57dSm^{-1},organic carbon 0.59% and available nitrogen (N), phosphorus (P) and potassium (K) were 191.1, 23.9 and 510.8 kg ha^{-1}, respectively. The experiment was laid out in randomized complete block design, comprised of eight treatments were replicated thrice with gross plot size of 108 m^2 *viz.*, T_1 - 120 x 90 cm spacing + 100% NK (60 and 30 kg of N and K_2O ha^{-1}) + Hand weeding (HW) twice (30 and 60 DAS) – Control, T_2 - 120 x 120 cm spacing + 100% NK + HW, T_3 - 150 x 150 cm spacing + 100% NK + HW, T_4 - 150 x 150 cm spacing + 125% NK + HW, T_5 - 120 x 120 cm spacing + 100% NK + Mechanical weeding (MW) twice (30 and 60 DAS), T_6 - 150 x 150 cm spacing + 100% NK + MW, T_7 - 150 x 150 cm spacing + 125% NK + MW and T_8 - 90 x 90 cm spacing + 100% NK + HW. The castor hybrid YRCH 1 was used as a test cultivar sown on 06.08.1012 at proposed square planting and wider spacing levels. Full dose of phosphorus and 50% NK was applied as basal at the time of sowing and remaining N and K was applied in two equal splits at 30 and 60 days after sowing of castor. Nitrogen was applied in the form of urea while phosphorous and potash was applied as single super phosphate and muriate of potash, respectively. Two hand weedings and mechanical weedings was carried out at 30 and 60 days after sowing. Mechanical weeding was carried out by VST power tiller. The cultural and agronomic practices with adequate irrigation were followed as per the recommendations of crop production guide (CPG, 2012). Crop was raised purely under irrigated condition, and the crop experienced a precipitation of 228.4 mm in 14 rainy days which was considered to be a drought year. Five plants were randomly selected from net plot area and tagged. Biometric observations were recorded at different growth stages *viz.*, 30, 60, 90 and 120 DAS and at harvest stages. Observations on growth characters, yield attributes and yield were noted during this study.

Results and discussion

Effect on growth characters

Plants grew taller (160.0 cm) with T_3 (150 x 150 cm spacing + 100% NK + hand weeding) at 90, 120 DAS and at harvest stages whereas, it was on par with T_6, T_7, T_4 and T_2. The treatment T_8 (90 x 90 cm spacing + 100% NK + hand weeding) produced the shortest plants (141.2 cm) at 90 DAS. The same trend was followed in 120 DAS and at harvest stages also. The probable reason for such a positive response due to wider geometry might have provided sufficient rooting and moisture extraction pattern which helped better absorption of water and nutrients, resulting in taller plants. This is in accordance with findings of Soratto *et al*. (2012) in castor.

Higher number of branches plant^{-1} (4.13) were recorded under wider spacing of 150 x 150 cm along with 100% NK and hand weeding at 60 DAS in castor than other treatments and it was statistically on par with all treatments except T_1 and T_8. The lowest number of branches plant^{-1} (1.90) were recorded under square planting with closer spacing of 90 x 90 cm with 100% NK and hand weeding and was remained on par with T_1. Similar results were replicated in the later stages (90 and 120 DAS and at harvest) of castor. Closer planted castor might have experienced competition for sunlight, water, nutrients, and space and in turn produced lower number of branches plant^{-1} and unit area^{-1}. Though more number of branches plant^{-1} was noted under widely planted castor, due to lack of population, the number of branches unit area^{-1} was lower. Hence, at moderate level of spacing (120 x 120 cm), the optimum level of competition between rows and plants would have prevailed which in turn increased the number of branches unit area^{-1}. These results are in conformity with Porwal *et al*. (2005) and Bhunia *et al*. (2012) in castor.

The SCI had significant influence on drymatter production at different stages of castor. The crop grown at closer square planting of 90 x 90 cm with 100% NK and hand weeding attained statistical supremacy by registering higher DMP at all stages than all other SCI practices tested and control. The minimum amount of DMP was registered in wider square planting of 150 x 150 cm with 125% NK and mechanical weeding. Drymatter production increased steadily with advancing growth stages and reached the maximum at harvest which could be attributed to higher population and accumulation of nutrients unit area^{-1} and higher leaf area index compared to wider spacing. Better nutrient uptake as evidenced in the present study might have provided better growth and in turn more DMP under closer spacing.

The closer crop geometry of 90 x 90 cm with 100% NK and hand weeding noted perceptibly higher LAI (5.57 and 3.91) 120 DAS and at harvest stages, respectively, compared to all other treatments imposed. The treatment with wider square planting of 150 x 150 cm with 125% NK application and mechanical weeding registered persistently lower LAI at all the crop growth stages of crop growth. The increase in leaf area index under closer spacing throughout the growth period was due to increased number of plants unit area^{-1} and in turn more number of leaves unit area^{-1}. These results are in accordance with the findings of Rao (1988) in rice; Ghose and Patra (1994); Cheghakhor *et al*. (2009) and Sivagamy and Rammohan (2012) in sesame.

The SCI practices obviously altered the CGR of castor at various stages of castor. Castor crop grown at square planting with closer spacing of 90 x 90 cm with 100% NK and hand weeding recorded significantly higher CGR at all growth stages as compared to all other SCI practices tested and control. The lowest CGR was recorded with wider square planting of 150 x 150 cm spacing along with 100% NK and mechanical weeding at 120 DAS - at harvest stages of castor. Higher crop growth rate (CGR) during vegetative phase was reported as the key parameter for higher photosynthetic efficiency throughout the crop growth period resulting in higher biomass accumulation (Laza *et al*., 2001 and Yang *et al*., 2007) in rice. The higher CGR with closer crop geometry may be attributed to the small ground area subtended by the individual plant which might have ensured early canopy ground cover, thus capturing more solar radiation and effective utilization soil moisture and nutrients. This is in line with the findings of Caliskan *et al.* (2004) and Umar *et al.* (2012) in sesame.

Yield attributes

Square planting with wider spacing of 150 x 150 cm with 100% NK and hand weeding produced lucidly more number of spikes plant^{-1} at 120 DAS and harvest stages over other SCI practices and control. Castor planted at the closest spacing (90 x 90 cm) with 100% NK and hand weeding obviously registered the least spikes plant^{-1}. This may be due to more radiation interception above the canopy and higher availability of nutrients and water below canopy to the individual plant under wider crop canopy during the growth cycle of the crop. The variability of micro climate condition of a crop alters the number of spikes plant^{-1} and variability in the yield. This is in agreement with the earlier findings of Kittock and Williams (1970) in castor. Reduced number of spikes was observed under closer spacing might be due to higher competition for nutrients, space and air between the plants.

Similar to spikes plant^{-1}, 150 x 150 cm spacing with 100% NK and HW produced higher number capsule spike^{-1} (36.50) at 120 DAS over others. Whereas, square planting with wider spacing of 120 x 120 cm along with 100% NK and mechanical weeding recorded the maximum number of capsules spike^{-1} (34.67) at harvest stage. The least capsules were observed under closer spacing of 90 x 90 cm with 100% NK and hand weeding treatment at all the stages of growth. This might be due to efficient utilization of both above and below ground resources due to wide area available to the individual plant might be the reason. Too closer or too wider planted plants might have experienced more and lesser competition, respectively, ultimately that would have attributed to below normal yield attributes like number of spikes m^{-2}. Similar results were reported by Soratto *et al.* (2012) in castor.

Square planting with wider spacing of 150 x 150 cm with 100% NK and hand weeding produced longer spikes (27.19 cm) at 60 DAS. The shortest spikes (22.69 cm) were noted with closer square planting of 90 x 90 cm with 100% NK and hand weeding at 60 DAS. The same trend was noticed at 90 and 120 DAS also. The enhanced length of spike at wider crop geometry was due to better crop growth, more space available for plants, lesser competition for moisture and nutrients between plants. This is in conformity with the findings of Subramani *et al.* (2002); Bhairappanavar *et al.* (2005) in blackgram, Goyal *et al.* (2010); and Siddaraju *et al.* (2010) in cluster bean.

SCI practices did not have striking influence on test weight of castor beans. However, the highest test weight (30.80 g) was recorded at wider spacing of 120 x 120 cm and 100% NK with mechanical weeding. The lowest test weight (28.67 g) was recorded in control (T_1).

Yield

Effect on bean yield

Significantly higher castor bean yield (2201 kg ha^{-1}) was recorded at 120 x 120 cm spacing with 100% NK and mechanical weeding than all other SCI practices. However, it was very much comparable with 120 x 90 cm spacing with 100% NK and hand weeding (2108 kg ha^{-1}) and 120 x 120 cm spacing with 100% NK and hand weeding (2085 kg ha^{-1}). The planting geometries which contributed for higher bean yield of castor under wider plant geometry over closer plant geometry was due to better availability of resources induced for better yield attributing characters, and effective weed control were helped the plants to exhibit their full potential and produced higher yield. Similar results were reported by Kantwa *et al.* (2006) in pigeonpea. Further, significant increase in yield of

Table 1. Effect of SCI practices on growth characters and yield attributes of Castor hybrid YRCH 1

Treatments		Plant Height		Number of branches $plant^{-1}$		Drymatter production kg ha-1		Leaf area Index		crop growth rate (gm^{-2} day^{-1})		spikes plant-1 (No)		Capsules spike-1 (Nos)		length of spike (Cm)		Test weight (g)
		120 Days	At harvest	120 Days	At harvest	120 Days	At harvest	120 Days	At harvest	90 – 120 Days	120 Days harvest	120 Days	At harvest	120 Days	At harvest	120 Days	At harvest	
T_1	120 x 90 cm spacing + 100% NK + HW (Control)	164	156.8	10.87	11.73	3578	6895	4.72	3.60	5.79	10.24	17.53	30.67	23.13	21.40	22.96	25.85	28.67
T_2	120 x 120 cm spacing + 100% NK + HW	178.2	170.9	14.53	15.57	2581	4299	3.94	3.13	3.16	3.98	22.40	32.33	31.30	30.51	26.61	24.59	29.35
T_3	150 x 150 cm spacing + 100% NK + HW	186.7	5.79	14.73	15.13	1911	3188	3.00	2.77	1.58	1.74	25.93	35.33	36.50	31.78	30.77	26.37	29.92
T_4	150 x 150 cm spacing + 125% NK + HW	186.5	179.8	14.27	15.67	1908	2896	3.11	2.58	1.34	1.63	25.47	35.00	36.43	32.88	30.61	27.16	30.64
T_5	120 x 120 cm spacing + 100% NK + MW	177.0	170.3	14.33	15.47	2522	5510	3.83	3.10	3.74	6.69	22.27	32.67	30.93	34.67	26.69	25.31	30.80
T_6	150 x 150 cm spacing + 100% NK + MW	185.5	174.9	14.40	14.90	1907	2890	2.99	2.60	1.19	1.47	25.60	35.00	36.43	27.86	30.69	25.36	30.40
T_7	150 x 150 cm spacing + 125% NK + MW	185.9	178.6	14.40	15.38	1899	2882	2.91	2.45	1.33	1.77	25.47	34.67	36.47	29.05	30.59	26.86	30.47
T_8	90 x 90 cm spacing + 100% NK + HW	159.3	152.7	6.77	8.03	5241	10093	5.57	3.91	14.42	19.97	16.43	29.00	15.13	12.51	21.6	27.45	29.27
SED		4.7	4.5	0.34	0.37	87	688	0.19	0.25	1.21	2.04	0.51	1.22	1.04	2.09	1.1	1.44	0.83
Cd (p=0.05)		10	9.7	0.71	0.79	187	1475	0.42	0.53	2.59	4.37	1.09	2.61	2.22	4.48	2.36	NS	NS

NK - Nitrogen and Potassium HW - Hand weeding MW - Mechanical weeding

Table - 2. Effect of SCI practices on yields, harvest index and economics of castor production

Treatments			Bean yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index	Cost of cultivation (`ha^{-1})	Gross return (`ha^{-1})	Net return (`ha^{-1})	B: C
T_1	-	120 x 90 cm spacing + 100% NK + HW (Control)	2108	6296	0.20	35569	84324	48755	2.37
T_2	-	120 x 120 cm spacing + 100% NK + HW	2085	6215	0.20	35569	83408	47839	2.34
T_3	-	150 x 150 cm spacing + 100% NK + HW	1902	4686	0.23	35569	76068	40499	2.14
T_4	-	150 x 150 cm spacing + 125% NK + HW	1947	4687	0.24	35859	77884	42025	2.17
T_5	-	120 x 120 cm spacing + 100% NK + MW	2201	6111	0.21	30469	88044	57575	2.89
T_6	-	150 x 150 cm spacing + 100% NK + MW	1595	4939	0.20	30469	63808	33339	2.09
T_7	-	150 x 150 cm spacing + 125% NK + MW	1667	4634	0.21	30759	67064	36305	2.18
T_8	-	90 x 90 cm spacing + 100% NK + HW	1260	10041	0.09	35569	50400	14831	1.42
		SEd	**103**	**365**	**0.01**	-	-	-	-
		CD (P=0.05)	**222**	**784**	**0.03**	-	-	-	-

- Nitrogen and Potassium HW - Hand weeding MW - Mechanical weeding

castor under wider row spacing was due to least competition for solar energy, water and nutrients. These results are conformity with Porwal *et al.* (2005); and Chauhan and Singh (1994) in castor.

The lowest castor bean yield (1260 kg ha^{-1}) was recorded under closer spacing of 90 x 90 cm and 100% NK along with hand weeding. 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 and blackgram.

Effect on stalk yield

Superior stalk yield (10041 kg ha^{-1}) at harvest was recorded with closer plant geometry of 90 x 90 cm and 100% NK along with hand weeding over other treatments. The lowest stalk yield of 4634 kg ha^{-1} was recorded with 150 x 150 cm spacing along with 125% NK and mechanical weeding. This was due to, higher leaf area index and drymatter production recorded due to closer spacing levels ultimately resulted in higher stalk yield. This might be due to more population unit area^{-1} under closer spacing which enhanced the stalk yield of castor. These results are in conformity with the findings of Patel *et al.* (2009) in castor.

Effect on harvest index

Higher harvest index (0.24) was observed under wider spacing of 150 x 150 cm along with 125% NK and hand weeding. The harvest index was lower

(0.09) under closer square planting of 90 x 90 cm spacing with 100% NK and hand weeding compared to all other SCI practices and control. This is because of increase in bean yield ultimately led to higher harvest index. Similar findings were also reported by and Siddaraju *et al*. (2010) in cluster bean. The lowest harvest index was recorded under closer crop geometry. Similar findings are in line with Rana *et al.* (2006) in castor and reported lower harvest index in castor under reduced spacing levels was mainly due to competition for nutrients, space and light and caused for reduction in harvest index.

Economics

The cost of cultivation was the highest (`35859 $ha^{-1}$) under 150 x 150 cm with 125% NK and hand weeding. Whereas, square planting with wider spacing of 120 x 120 cm with 100% NK and hand weeding resulted the lowest cost of cultivation (` 30469 ha^{-1}) and highest gross income (`88044 $ha^{-1}$). The lowest gross income was noted with (`50400 ha^{-1}) closer spacing of 90 x 90 cm spacing along with 100% NK and hand weeding.

Perusal of data showed that maximum net income of `57575 $ha^{-1}$ was realized in 120 x 120 cm spacing with 100% NK and mechanical weeding. The lowest net return of ` 14831 ha^{-1} was obtained under closer spacing level of 90 x 90 cm. The benefit cost ratio was the highest (2.89) in wider spacing of 120 x 120 cm and 100% NK along with mechanical weeding. The next best benefit cost ratio (2.37) was obtained under control (T_1) followed by T_2 (2.34). The output and input ratio was the minimum (1.42) in 90 x 90 cm spacing with 100% NK and hand weeding. This may be due to the operation costs in treatments with power tiller were lower than that of the other hand weeding methods which resulted better net return and B:C ratio. This is agreed with the findings of Rana *et al.* (2006) in castor and Firouzi and Alizadeh (2012) in groundnut.

Conclusions

The experimental results enlightened that there was marked variations on the productivity of castor due to adoption of system of crop intensification (SCI) practices. Castor hybrid YRCH 1 grown under 120 x 120 cm spacing with 100% NK and mechanical weeding twice at 30 and 60 DAS produced better yield besides being economically competitive and productive than other treatments. Locations where the mechanical weeders are not available, castor can be raised either 120 x 120 cm or 120 x 90 cm with 100% NK and hand weeding twice at 30 and 60 DAS for obtaining higher yield, oil yield and net return and per rupee invested.

References

Bhairappanavar, S.T., H.M. Jayadeva, T.H. Gowda and S. Shivanna. 2005. Effect of nutrients and spacing on the yield of urdbean under late sown condition. *Legume Res.*, 28(1) : 46-48.

Bhunia, S.R., R.P.S. Chauhan and B.S. Yadav. 2012. Effect of plant geometry and irrigation levels on productivity, yield components, water use and water use efficiency of castor (*Ricinus communis*) in canal command areas of north-western Rajasthan. *J. Rural Agric. Res.*, 12(2): 37-39.

Caliskan, S., M. Arstan, H. Atiogle and N. Isler. 2004. Effect of planting method and plant population on growth and yield of sesame (*Sesamum indicum* L.) in a Mediterranean type of environment. *Asian J. Plant Sci.*, 3(5): 610-613.

Chauhan, G.S. and I. Singh. 1994. Studies on stand geometry and intercropping of castor under irrigated and rainfed conditions of Rajasthan. *Crop Res.*, 7: 201-206.

Cheghakhor, A.Y., M. Meskararbashee, R. Mamaghan and M. Nabipour. 2009. Effect of row spacing and plant density on radiation use efficiency and extinction light coefficient on canopy of chickpea cultivars. *Res. Crops.*, 10(3): 545-554.

Firouzi, S. and M. Alizadeh. 2012. Evaluation of different weeding methods for groundnut in northern Iran. *African J. Agric. Res.*, 7(8): 1307-1311.

Ghose, D.C. and A.K. Patra. 1994. Effect of plant density and fertility levels on productivity and economics on summer sesame (*Sesamum indicum* L.). *Indian J. Agron.*, 39: 71-75.

Goyal, S., H.D. Verma and D.D. Nawange. 2010. Studies on growth and yield of *Kabuli* chickpea (*Cicer arietinum* L.) genotypes under different plant density and fertility levels. *Legume Res.*, 33(3): 221-223.

Crop Production Guide (CPG). 2012. Published by Department of Agriculture, Govt. of Tamil Nadu, Chennai and Tamil Nadu Agric. Univ., Coimbatore, Taminadu, India. pp. 180-185.

Kittock, D.L. and J.H. Williams. 1970. Effect of plant population on castor bean yield. *Agron. J.*, 62: 527 - 529.

Krishna, A., N.K. Biradarpatil, K. Manjappa and B.B. Channappagoundar. 2008. Evaluation of system of rice intensification cultivation, seedling age and spacing on seed yield and quality in samba masubri (BPT-5204) rice. *Karanataka J. Agri. Sci.*, 21(1): 20-25.

Laza, R.C., S. Peng, A.L. Sanico, R.M. Visperas and S. Akita. 2001. Higher leaf area, growth rate contributes to greater vegetative growth of F1 rice hybrids in the tropics. *Plant Prod. Sci.*, 4 (3): 184-188.

Patel, R.M., M.M. Patel and G.N. Patel. 2009. Effect of spacing and nitrogen levels on *Rabi* castor (*Ricinus communis* Linn.) grown under different cropping sequences in North Gujarat agro climatic conditions. *J. Oilseeds Res.*, 26(2): 123 - 125.

Porwal, M.K., S.K. Agarwal and A.K. Khokar. 2005. Effect of planting methods and intercrops on productivity and economics of castor (*Ricinus communis*) based intercropping systems. *Indian J. Agron.*, 51(4): 274-277.

Rana, D.S., Giri, G. and Pachauri, D.K. 2006. Evaluation of castor (*Ricinus communis*) genotypes for productivity, economics, litter fall and changes in soil properties under different levels of inter-row spacing and nitrogen. *Indian J. Agron.*, 51(4): 318 - 322.

Rao, P. 1988. Production trends of high density grain as influenced by nitrogen, season, crop canopy and duration of low land irrigated paddy. *Oryza.*, 25: 47-51.

Sathyamoorthi, K., M. M. Amanullah, K. Vaiyapuri and E. Somasundaram. 2008. Physiological parameters and yield of greengram (*Vigna radiata* (L.) Wilczek) as influenced by increased plant density and fertilizer levels. *Indian J. Crop. Sci.*, 3 (1): 115 - 122.

Siddaraju, R., S. Narayanaswamy, R. Gowda and S.R. Prasad. 2010. Studies on growth, seed yield and yield attributes as influenced by varieties and row spacing in cluster bean (*Cyamopsis tetragonoloba* L.). *Mysore J. Agric. Sci.*, 44(1): 16-21.

Sivagamy, K. and J. Rammohan. 2012. Influence of time of sowing and spacing on growth and yield attributes of sesame (KS 95010). *Madras Agric. J.*, 99(4-6): 329-331.

Soratto, P., G.D. Souza Schlick, A.M. Fernandes, M.D. Zanotto and C.A.C. Crusciol. 2012. Narrow row spacing and high plant population to short height castor genotypes in two cropping seasons. Industrial Crop Prod., 35: 244-249.

Subramani, M., A. Solaimalai and A.Velayutham. 2002. Effect of plant population and methods of fertilizer application on yield attributes of irrigated blackgram. *Madras Agric. J.,* 89 (4-6): 305-306.

Thavaprakaash, N., K. Velayudham and V.B. Muthukumar. 2005b. Effect of crop geometry, intercropping systems and integrated nutrient management practices on productivity of baby corn (*Zea mays* L.) based inter cropping system. *Res. J. Agri. Bio. Sci.,* 1(4): 295-302.

Tomer, S.S. and A.S. Tiwari. 1991. Effect of plant density on genotype of greengram and blackgram. *Indian J. Agric. Sci.,* 61: 126-127.

Umar U.A., M. Mahmud, I.U. Abubakar, B.A. Babaji and U.D. Idris. 2012. Effect of nitrogen fertilizer level and intra row spacing on growth and yield of sesame (*Sesamum indicum* L.) varieties. *Tech. J. Eng. Appl. Sci.*, 2(1): 22-27.

Yang, W., S. Peng, R.C. Laza, R.M. Visperas and M.L. Dionisio-Sese. 2007. Grain yield and yield attributes of new plant type and hybrid rice. *Crop Sci.*, 47: 1393-1400.

Corresponding Author : M.Daisy, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore- 3, Tamilnadu, India. *Email : mdaisy.nkl@gmail.com*