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Research Paper

Effect of spacing and fertilizer management on seed production of sunnhemp (*Crotalaria juncea*)

S.R. MORE[1], D.P. PACHARNE[2] AND A.R. GAIKWAD[3]

Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra 413 722

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2013 to 2015 on medium black soils of Rahuri, Maharashtra, to find out suitable spacing and fertilizer level for growth and seed yield of sunnhemp (*Crotalaria juncea* L). Treatments consisted of 2 spacings, viz. S_1, 30 cm × 10 cm and S_2, 45 cm × 10 cm, in main plots and 5 fertilizer doses, viz. T_1, control; T_2, N : P_2O_5 : K_2O, 20 : 40 : 20 kg/ha + FYM 5 t/ha; T_3, N : P_2O_5 : K_2O, 20 : 40 : 40 kg/ha + FYM-5 t/ha; T_4, N : P_2O_5 : K_2O, 20 : 60 : 40 kg/ha + FYM 5 t/ha; and T_5, N : P_2O_5 : K_2O 20 : 60 : 60 kg/ha + FYM 5 t/ha in sub-plot treatments in split-plot design, replicated thrice. The gross and net plot sizes were 5.0 m × 4.0 m and 4.40 m × 3.60 m respectively. The results indicated that, the crop sown at spacing of 30 cm × 10 cm recorded significantly higher seed yield (1.76, 2.16, 1.79 and 1.90 t/ha) than 45 cm × 10 cm (1.30, 2.06, 1.58 and 1.65 t/ha) in the *kharif* 2013, 2014, 2015 and pooled mean. Similarly, it also registered more net returns (₹38.2 × 10^3/ha) and benefit: cost ratio (2.01) than spacing at 45 cm × 10 cm during pooled mean of 3 years. Sunnhemp crop recorded significantly higher seed yield (1.67, 2.28, 1.78 and 1.91 t/ha) with the application of fertilizer dose of 20: 60: 40 kg/ha, N : P_2O_5 : K_2O + FYM 5 t/ha than the control treatment, but it was at par with rest of all treatments during 3 years and pooled mean. Similar results were recorded for growth and yield attributes. This treatment also recorded significantly maximum net monetary returns (₹37.9 × 10^3/ha) and benefit: cost ratio (1.98) than rest of all treatments in pooled mean.

Key words **:** Economics, Fertilizer levels, Spacing, Seed yield, Yield attributes

India is the largest producer of sunnhemp (*Crotalaria juncea* L.) fibre followed by Bangladesh and Brazil, accounting for about 27 and 23% worlds area and production (Chaudhary, 2016). Seed plays an important role in agricultural sector since it is the key factor for improving the productivity, quality, diversification, value-addition and sustainability component of our agriculture. Quality seed of improved variety gives the highest return relative to its cost. Sunnhemp is cultivated almost in all the states of country but leading sunnhemp-growing states are Uttar Pradesh, Madhya Pradesh, Odisha, Bihar, Maharashtra, Rajasthan, Jharkhand, Punjab, Haryana and West Bengal. The area under this fibre crop is around 0.045 million ha and the annual production of fibre is 0.102 million bales, with an average productivity of 401 kg/ha (Tripathi *et al.*, 2013b). Since sunnhemp is a leguminous green manure crop, it has a tremendous potential in harvesting atmospheric nitrogen through biological nitrogen fixation and can supplement fertilizer nitrogen in rice–wheat cropping system. The 60-day-old crop accumulates about 170 kg N, 20 kg P and 130 kg K/ha (Patro, 2002).

Spacing is also one of the major factors affecting seed yield of different crops. It influences growth rate and crop yield as a result of inter-plant competition for different inputs needed for growth and development (Tripathi *et al*., 2013a). Among the various factors affecting its production, phosphorus plays an important role in enhancing the production and productivity of the crop. The unavailability of quality seeds and lack of improved agro-techniques like plant spacing and nutrient management are the major constraints for seed production of sunnhemp (Chaudhary, 2016). Keeping these points in view, the present investigation was undertaken to study the effect of different spacing and fertilizer levels on growth and seed yield of sunnhemp.

MATERIALS AND METHODS

The experiment was conducted during 2013–2015 under All India Network Project on Jute & Allied Fibres,

[2]Corresponding author's Email: pacharne.dattatray@rediffmail.com
[1]Groundnut Breeder, [2]Junior Jute Agronomist, [3]Jute Breeder, Jute AINP & Cotton Improvement Project, MPKV, Rahuri, Maharashtra 413 722

MPKV, Rahuri, (19° 48' N and 19° 57' N and 74° 32' E and 74° 19' E, 495 to 569 m above mean sea-level), Maharashtra. The soil of the experimental site is clay loam (clay 49.45%, silt 33.20% and sand 16.42%), having *p*H 8.4 and electrical conductivity 0.29 dS/m and organic carbon 0.58% in top of 15 cm soil. The soil-available nitrogen was low (178.11 kg/ha), medium in available phosphorus (17.02 kg/ha) and high in available potassium (423.0 kg/ha) and moderate in Fe, Mn, Zn and Cu i.e. 6.59, 9.51, 0.62 and 3.41 µg/g of soil. The field capacity, bulk density and permanent wilting point of the surface (0–15 cm) soil were 33.2% on volume basis, 1.36 g/cc and 16.71% respectively. The average annual rainfall at Rahuri is 520 mm. The rainfall received from south-west monsoon from May to November was 618.4, 493.6 and 380.8 mm and rainy days 38, 28 and 33 during 2013, 2014 and 2015, which was beneficial for crop growth and seed development. The average mean annual maximum and minimum temperature ranged from 33° to 43°C and 6° to 18°C respectively. The average relative humidity during morning and evening hours are 59 and 35% respectively. The experiment was laid out in split-plot design during the *kharif* season in 3 replications. The main plot treatments comprises 2 spacings, viz. S_1, 30 cm × 10 cm and S_2, 45 cm × 10 cm and sub-plot treatments comprises 5 fertilizer doses, viz. T_1, control; T_2, N : P_2O_5 : K_2O, 20 : 40 : 20 kg/ha + FYM 5 t/ha; T_3, N : P_2O_5 : K_2O, 20 : 40 : 40 kg/ha + FYM 5 t/ha; T_4, N : P_2O_5 : K_2O, 20 : 60 : 40 kg/ha + FYM 5 t/ha; and T_5, N : P_2O_5 : K_2O, 20 : 60 : 60 kg/ha + FYM 5 t/ha with sunnhemp variety 'SH 4'. The gross and net plot sizes were 5.0 m × 4.0 m and 4.40 m × 3.60 m respectively. Doses of N, P_2O_5 and K_2O were applied as per treatments fully at the time of sowing during the first week of July and the crop was harvested in the third week of November during 2013 to 2015. The intercultural operations, seed rate, protective irrigation as per critical growth stages, topping were done at 30 days after sowing and plant-protection measures were carried out as per the recommendations of sunnhemp crop.

In experimental plot, 5 plants were selected randomly from the second row of each plot for measurement of growth and yield attributes. The crop was harvested and threshed treatment-wise and seed yield were recorded from net plot and converted into t/ha. While calculating monetary returns, for sale of sunnhemp seed was taken as 40/kg. Net returns were calculated by deducting cost of cultivation from gross returns.

RESULTS AND DISCUSSION

Effect of spacing

Growth and seed yield: Crop sown at spacing of 30 cm × 10 cm and 45 cm × 10 cm did not differ significantly in growth and yield attributes, but the number of branches, basal diameter (cm) and number of pods/plant were maximum in 45 cm × 15 cm (Table 1). The crop sown at closer spacing recorded the higher plant population at 30 cm × 10 cm (3.33 lakh/ha) and it was reflected in significantly higher seed yield (1.76, 2.16, 1.79 and 1.90 t/ha) than 45 cm × 10 cm (1.30, 2.06, 1.58 and 1.65 t/ha) during 3 years and on pooled mean. The seed yield was 15.15% higher under plant spacing of 30 cm × 10 cm than spacing of 45 cm × 10 cm in the pooled mean (Table 2). This is because closer spacing of 30 cm × 10 cm harvested the maximum solar radiation and resulted in higher photosynthates, which translocated towards reproductive parts (capsule). Ulemale *et al.,* (2001) and Tripathi *et al.,* (2013a, b) also observed significant increase in seed yield of sunnhemp due to closer spacing.

Table 1. Effect of spacings and fertilizer levels on growth and yield attributes of sunnhemp (pooled mean of 3 years)

Treatment	Plant height (cm)	Branches/ plant	Capsules/ plant	Basal diameter/ plant	Seeds/ capsule	1,000-seed weight
Spacing						
30 cm × 10 cm	205.30	19.21	60.12	0.98	7.03	37.69
45 cm × 10 cm	202.70	19.12	67.33	1.04	8.11	37.95
SEm±	3.3	0.48	1.65	0.03	0.17	0.28
CD (P=0.05)	NS	NS	5.70	NS	0.51	NS
Fertilizer level (N: P_2O_5: K_2O, kg/ha)						
Control (0)	195.10	16.40	51.80	0.95	6.02	36.15
20 : 40 : 20	204.90	19.44	63.75	1.02	7.18	37.01
20 : 40 : 40	203.70	19.80	66.94	1.04	7.84	37.69
20 : 60 : 40	207.80	21.20	68.02	1.02	8.36	37.67
20 : 60 : 60	205.60	18.98	67.13	1.05	8.07	37.44
SEm±	3.30	1.06	3.43	0.03	0.24	0.16
CD (P=0.05)	NS	3.00	9.74	NS	0.71	0.51

Table 2. Seed yield and eeconomics of sunnhemp as influenced by spacing and fertilizer management

Treatment	Seed yield (t/ha)			Pooled mean	Cost of cultivation (× 10^3₹/ha)	Net returns (× 10^3₹/ha)	Benefit: cost ratio
	2013	2014	2015				
Spacing							
30 cm × 10 cm	1.76	2.16	1.79	1.90	37.8	38.2	2.01
45 cm × 10 cm	1.30	2.06	1.58	1.65	37.4	30.9	1.76
SEm±	0.07	0.04	0.06	0.06	–	1.84	–
CD (P=0.05)	0.43	NS	NS	0.21	–	6.37	–
Fertilizer level (N: P_2O_5: K_2O, kg/ha)							
Control (0)	1.31	1.89	1.33	1.51	35.0	25.4	1.73
20 : 40 : 20	1.46	2.10	1.74	1.77	37.4	33.8	1.90
20 : 40 : 40	1.66	2.18	1.77	1.87	38.0	36.8	1.97
20 : 60 : 40	1.67	2.28	1.78	1.91	38.5	37.9	1.98
20 : 60 : 60	1.56	2.20	1.73	1.83	39.1	34.1	1.90
SEm±	0.08	0.08	0.11	0.09	–	3.72	–
CD (P=0.05)	0.24	0.24	0.32	0.25	–	NS	–

Selling rate of sunnhemp 40,000/t

Economics: The economic analysis of different crop spacings showed that, the sowing of sunnhemp crop at 30 cm × 10 cm recorded the maximum seed yield and which is ultimately resulted in highest economic returns. At 30 cm × 10 cm spacing, significantly higher net returns (38.2 × 10^3₹/ha) and benefit: cost ratio (2.01) were recorded than spacing at 45 cm × 10 cm in pooled mean of 3 years (Table 2). This might be because this treatment resulted in the maximum seed yield as compared to 45 cm × 10 cm and that gave the maximum monetary benefit during pooled mean of 3 years. Our results confirm the findings of Ulemale *et al.* (2001), Yaragoppa *et al.* (2003) and Chaudhary (2016).

Effect of fertilizer

Growth and yield: The balanced nutrition through application of FYM with chemical fertilizer proved its superiority by recording significantly maximum growth and yield attributes. When sunnhemp crop fertilized with 20 : 60 : 40 kg/ha N: P_2O_5 : K_2O + FYM 5 t/ha recorded the maximum plant height (207.80 cm), branches/plant (21.20) and number of capsules/plant (68.02), number of seeds/capsule (8.36). Similarly, it was also resulted in higher seed yield (1.67, 2.28, 1.78 and 1.91 t/ha) during 3 years and pooled mean (Table 2). This indicated that the maximum seed yield of sunnhemp was achieved with application of fertilizer dose of 20 : 60 : 40 kg/ha of N : P_2O_5 : K_2O + FYM 5 t/ha during the period of experimentation. This might be because of balanced nutrition through application of FYM with phosphorus fertilizer may help in reducing the fixation of applied phosphorus, causing an increased uptake of essential nutrients that resulted in increased growth attributes. Sunnhemp, being a legume crop, shows more nitrate reductase activities in roots which is beneficial for pod/seed development stage. These results are in conformity with the results obtained by Kumar *et al.* (2005), Tripathi *et al.*, (2009).

Economics: The application of fertilizer doses as per treatments to the sunnhemp crop recorded different levels of seed yield and economic returns during the period of 3 years and pooled mean (Table 2). Among the fertilizer levels, the application of fertilizer dose 20 : 60 : 40 kg/ha of N : P_2O_5 : K_2O kg/ha + FYM 5 t/ha registered the maximum seed yield, which ultimately resulted in higher net monetary returns (37.9 × 10^3/ha) and benefit: cost ratio (1.98) than remaining fertilizer levels during the period of experimentation (Table 2). The results confirms findings of Ulemale *et al.* (2001), Patro *et al.* (2002), Yaragoppa *et al.*, (2003) and Tripathi *et al.* (2012).

Interaction

Interaction effects between the different spacings and fertilizer levels were found non-significant for growth, yield attributes and seed yield of sunnhemp.

On the basis of experiment, it could be concluded that the sowing of sunnhemp at spacing 30 cm × 10 cm with application of 20 : 60 : 40 kg/ha of N : P_2O_5 : K_2O along with FYM 5 t/ha is beneficial for higher seed production and economic returns of sunnhemp.

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