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Growth and yield of sunnhemp (*Crotalaria juncea* L.) as influenced by spacing and topping practices

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Field experiment were conducted during rainy (kharif) season of 2009 and 2010 to study the effects of various spacing and topping practices on growth and seed yield of sunnhemp. Spacing (30 × 10 cm, 30 × 20 cm, 45 × 10 cm and 45 × 20 cm) in main plots and topping (no topping, topping at 30 days after sowing and topping at 45 days after sowing) in sub plots were studied in split plot design with three replications. The individual plant performance with respect to plant height, basal diameter, dry matter accumulation, number of branches and yield attributes was found maximum under the spacing of 45 × 20 cm whereas total biomass and seed yield per unit area was obtained highest with the spacing of 30 × 10 cm. Topping at 30 days after sowing gave higher yield attributes and seed yield being at par with topping at 45 days after sowing. Thus sunnhemp grown at the spacing of 30 × 10 cm coupled with topping at 30 days after sowing realized higher yield.

Key words: Sunnhemp, spacing, topping, seed yield.

INTRODUCTION

Sunnhemp (*Crotalaria juncea* L., *Fabaceae*), a native of India, is a fast growing annual crop. It is an important source of natural fibre. Traditionally its fibre is used in preparation of ropes, twines, fishing nets, tat-patties, handmade paper etc. (Tripathi et al., 2012). It has been identified as the most promising indigenous raw material for manufacturing of high quality tissue paper, cigarette paper and paper for currency. It is one of the most outstanding green manure crops suited to almost all parts of the India (Ram and Singh, 2011). In Hawaii, sunnhemp (Tropic Sun) has added 150 to165 kg of nitrogen per hectare to the soil when grown for 60 days and then incorporated in test plots (Rotar and Joy, 1983). Sunnhemp possesses medicinal properties and is also used as forage to a limited extent. In present day context of climate change, it holds high promise on account of its ability to fix atmospheric nitrogen, adding organic matter into the soil, suppressing weeds, reducing soil erosion and controlling root knot nematode populations thereby reducing dependence of agriculture on chemical inputs.

Despite having many valuable uses, acreage under this crop has drastically reduced in past decades. The unavailability of good quality seeds is one of the important reasons for reduced popularity of sunnhemp (Chittapur and Kulkarni, 2003). Seed is the critical input in any agricultural system and high yield of quality seed can be obtained only with improved agro-techniques. Abundant research has been done aiming at standardization of different factors for seed production in many crops but most of the agronomic practices have still not been standardized for seed crop of sunnhemp.

Spacing is one of the 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. Thus investigation on spacing arrangements becomes mandatory for

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understanding the mechanism of yield enhancement. Apical topping breaks the apical dominance and induces development of lateral branches thereby increase the site for pod development. The practice of topping has proved to be effective in increasing the yield levels of different crops (Bhattacharjee and Mitra, 1999; Sajjan et al., 2002; Jagannatham et al., 2008; Singh et al., 2011). Very meager information on spacing along with topping is available in seed crop of sunnhemp. Keeping these points in view the present investigation was carried out to study the effect of spacing and topping management practices on growth and seed yield of sunnhemp.

MATERIALS AND METHODS

The field experiment was conducted at Sunnhemp Research Station (CRIJAF-ICAR), Pratapgarh, Uttar Pradesh (25° 34' N latitude and 81° 59' E longitude) during the rainy (Kharif) seasons of 2009 to 2010 and 2010 to 2011 on a sandy loam soil with pH 7.6, organic carbon 2.7 g/kg, bulk density 1.42 g/cc and available nitrogen, phosphorus and potassium 225, 12.2 and 189 kg/ha, respectively. The research station is located at a height of 137 m above sea level. The experiment was laid out in split plot design keeping spacing treatments in main plots and topping in sub plots with three replications. The experiment comprised of four levels of spacing (30 × 10 cm, 30 × 20 cm, 45 × 10 cm and 45 × 20 cm) and three levels of topping (no topping, topping at 30 days after sowing and topping at 45 days after sowing) constituting 12 treatment combinations. The crop was sown on 05.08.2009 and 06.08.2010 during 1st and 2nd years of study, respectively. The sunnhemp variety Shailesh (SH-4) was sown manually in plot size of 4.5 × 5.0 m during both the years. The station received total annual rainfall of 634 mm and 932 mm during the year 2009 to 2010 and 2010 to 2011, respectively. The nutrients NPK were applied at the rate of 20, 40 and 20 kg per ha. The full dose of nitrogen, phosphorus and potassium were applied through urea, single super phosphate and muriate of potash at the time of sowing as basal dose. The crop was thinned 10 days after sowing to maintain plant to plant spacing according to treatments. Remaining package of practices was adopted as per recommendation. The crop was harvested at maturity at the age of 140 days. Observations were recorded both on plant as well as on plot basis at the time of harvest. The plant based data comprised of plant height, basal diameter, number of primary and secondary branches per plant, dry matter accumulation per plant, number of pods per plant, pod weight per plant and seed yield per plant. Plot based data included biomass, seed and stalk yield. Individual plant data were recorded for five random plants and averaged. The statistical analysis of the experimental data was carried out using Indostat.

RESULTS AND DISCUSSION

Effect of spacing on growth characteristics

Spacing had significant impact on growth characteristics of seed crop of sunnhemp during both the years of experimentation (Table 1). Basal diameter, number of primary and secondary branches and dry matter accumulation per plant were observed highest under the influence of wider spacing (40 × 20 cm) whereas opposite trend was observed in case of plant height. The highest plant height was observed under the effect of closer spacing (30 × 10 cm) and vice versa although the treatment effect was non significant. The plant height decreased gradually with the increase in spacing. The closer spacing between plants caused comparatively lesser availability of space around the plants for lateral development therefore, forced them to grow vertically. Similar results on plant height were reported by Ram and Singh (2011). The basal diameter (9.12 mm) recorded under the spacing of 45 × 20 cm was superior over rest of the spacing. The spacing of 30 × 20 cm and 45 × 10 cm were at par with respect to their effect on basal diameter. The minimum basal diameter (7.66 mm) was recorded under the spacing of 30 × 10 cm. Rajendra et al. (2008) also reported the positive effect of wider spacing on basal diameter in mesta.

The highest number of primary branches per plant (7.14) was observed in spacing of 45 × 20 cm followed by spacing of 30 × 20 cm (6.45) whereas minimum was recorded in 30 × 10 cm spacing. Similarly in case of secondary branches also the maximum value (17.01) was obtained in 45 × 20 cm of spacing followed by 30 × 20 cm of spacing and being least under 30 × 10 cm spacing (12.69). The variation in dry matter accumulation per plant was also found significant due to different spacing treatments. The highest dry matter accumulation per plant (73.11 g) was noticed under the spacing of 45 × 20 cm which was significantly superior to other spacing treatments whereas lowest was found under the effect of 30 × 10 cm (45.94 g). The better growth characteristics of plant like basal diameter and branches under wider spacing may be attributed to presence of sufficient space that reduced inter plant competition, availability of sufficient moisture, nutrient and light for their development under reduced inter plant competition and high dry matter accumulation was probably due to profuse branching and better growth and development of the plants. The similar findings in sunnhemp crop were reported by Ulemale et al. (2003).

Effect of topping on growth characteristics

The data presented in Table 1 indicated that basal diameter, number of primary and secondary branches per plant and dry matter accumulation per plant increased significantly with the practice of topping compared to no topping whereas opposite trend was noted in plant height during both the years. The results revealed that plant height decreased significantly due to topping in comparison to no topping. The lowest plant height (196.14 cm) was noticed when the topping was done at 30 days after sowing followed by topping at 45 days after sowing. Although un-topped plants achieved maximum plant height (219.94 cm) maximum dry weight per plant was recorded when plants were topped at 30 days after sowing perhaps due to more number of branches associated with this treatment. Decrease in plant height

Table 1. Effect of spacing and topping on growth parameters of seed crop of sunnhemp.

Treatments	Plant height(cm)		Basal diameter(mm)		Primary branch/plant		Secondary branch/plant		Dry matter/plant (g)	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Spacing										
30 × 10 cm	206.31	218.92	7.60	7.72	5.40	5.51	12.67	12.72	45.22	46.67
30 × 20 cm	201.07	212.13	8.42	8.81	6.40	6.50	15.19	15.46	58.56	60.44
45 × 10cm	203.21	215.87	8.34	8.45	6.19	6.12	14.46	14.28	52.44	53.78
45 × 20 cm	200.04	208.04	8.97	9.28	7.16	7.12	16.97	17.06	72.00	74.22
S.Em. (±)	5.52	5.19	0.21	0.15	0.24	0.17	0.56	0.69	3.39	2.63
CD at 5%	NS	NS	0.73	0.51	0.83	0.59	1.94	2.39	11.73	9.11
Topping										
No topping	215.48	224.40	8.12	8.22	5.92	5.97	13.95	14.35	53.83	54.08
Topping at 30 DAS	191.35	200.93	8.66	8.95	6.62	6.62	15.73	15.46	60.50	63.33
Topping at 45 DAS	201.15	215.90	8.23	8.52	6.33	6.34	14.78	14.82	56.83	58.92
S.Em. (±)	5.12	2.84	0.14	0.15	0.18	0.14	0.41	0.27	1.48	2.29
CD at 5%	15.34	8.50	0.42	0.46	0.54	0.42	1.24	0.82	4.43	6.87

as a result of topping was reported by Obasi and Msaakpa (2005) in cotton. This shows that topping at earlier stages of crop growth inhibits vertical growth. This is in accordance to the report of Bhattacharjee and Mitra (1999) where they found maximum plant height in un-topped plants. They reported topping at 45 days after sowing in jute to be optimum for seed yield and component traits. Significantly maximum basal diameter (8.66 mm) was recorded by topping at 30 days after sowing followed by topping at 45 days after sowing (8.23 mm) compared to no topping. Lowest basal diameter (8.12 mm) was recorded in un-topped plants. Similarly topping at 30 days after sowing recorded maximum number of primary (6.62) and secondary branches (15.59) per plant being at par with topping at 45 days after sowing but significantly superior to no topping. This is in agreement to the reports of Marie et al. (2007) in okra. The topping at 45 days after sowing was at par with that of no topping. Toping practices exerted significant variations in dry matter accumulation by the plants. The highest dry matter accumulation per plant (61.91g) was observed by the practice of topping at 30 days after sowing followed by topping at 45 days after sowing. The lowest dry matter accumulation per plant (53.95 g) was noted in un-topped plants. Similar findings on growth characteristics was reported by Kathiresan and Duraisamy (2001) in sesbania, Lakshmi et al. (1995) in mesta and Marie et al. (2007) in okra.

Effect of spacing on yield attributes

Most of the yield attributing characters of seed crop of sunnhemp was significantly influenced due to different spacing treatments except test weight (1000 seed weight) during both the years (Table 2). The number of pods per plant, pod weight per plant, seed yield per plant and number of seeds per pod were noted maximum under wider spacing of 45 × 20 cm followed by 30 × 20 cm of spacing and being lowest in the spacing of 30 × 10 cm. Number of pods per plant is one of the most effective elements in producing seed yield. Spacing of 45 × 20 cm recorded significantly maximum number of pods per plant (74.04) being statistically on par with that at 30 × 20 cm of spacing during second year whereas lowest values (47.09) were noted in the spacing of 30 × 10 cm. The enhancement in number of pods per plant under the influence of wider spacing might be on account of maximum number of primary and secondary branches per plant at the same spacing which resulted into increase in pod weight

Table 2. Effect of spacing and topping on yield attributing characters of seed crop of sunnhemp.

Treatments	Pods/plant		Pod weight/plant (g)		Seed yield/plant (g)		Seeds/pod		Test weight (g)	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Spacing										
30 × 10 cm	44.33	49.86	14.89	16.56	9.42	10.36	7.34	7.29	37.58	37.78
30 × 20 cm	57.84	67.48	20.67	22.42	12.67	13.02	8.20	8.08	38.34	38.67
45 × 10cm	52.00	60.27	18.89	20.57	10.87	11.34	7.79	7.47	38.18	38.28
45 × 20 cm	69.64	78.44	24.22	26.02	14.82	15.18	8.68	8.36	38.79	39.08
S.Em. (±)	2.52	3.50	1.27	1.18	0.71	0.45	0.25	0.20	0.36	0.32
CD at 5%	8.73	12.13	4.4	4.07	2.45	1.56	0.86	0.70	NS	NS
Topping										
No topping	51.93	58.00	18.00	18.75	10.93	11.55	7.84	7.47	37.80	38.22
Topping at 30 DAS	59.70	70.80	21.67	23.63	12.92	13.50	8.11	8.12	38.59	38.71
Topping at 45DAS	56.23	63.23	19.33	21.80	11.98	12.37	8.06	7.79	38.27	38.43
S.Em. (±)	1.77	2.15	0.97	0.76	0.39	0.44	0.28	0.17	0.41	0.33
CD at 5%	5.32	6.44	2.9	2.29	1.17	1.32	NS	NS	NS	NS

per plant and ultimately seed yield per plant. Data on number of seeds per pod also followed the similar trend. Plants under the spacing of 45 × 20 cm being at par with 30 × 20 cm recorded significantly maximum number of seeds per pod. The increasing trend in test weight was also observed with increase in spacing but not up to the level of significance. The superiority of individual plant performance at wider spacing might be attributed to less plant competition for nutrients, moisture, space, solar radiation etc which finally led towards better growth and development of the plants. The results are in close conformity with the findings of Ulemale et al. (2003) and Shastri et al. (2007).

Effect of topping on yield attributes

The data recorded on effect of topping on different yield attributing characters are depicted in Table 2. It is evident from the result that due to topping practices significant variations were recorded in number of pods per plant, pod weight per plant and seed yield per plant however no significant difference was observed in number of seeds per pod and test weight. Significantly maximum number of pods per plant (65.25), pod weight per plant (22.65 g) and seed yield per plant (13.21 g) was noticed under the influence of topping at 30 days after sowing compared to no topping (54.96, 18.37 and 11.24 g, respectively). The difference between topping at 45 days after sowing and no topping was found non significant except for pod weight per plant during second year where it happened to be significant. The increment in yield attributes under the influence of topping might be attributed to better growth characteristics like dry matter accumulation per plant coupled with profuse branching. The significant difference due to different topping practices was not noticed on number of seeds per pod and test weight but still the increasing trend was observed. The results corroborate with the findings of Lakshmi et al. (1995), Bhattacharjee and Mitra (1999), Kathiresan and Duraisamy (2001) and Marie et al. (2007) who mentioned a significant increase in yield attributes by practice of apical bud topping in different crops.

Effect of spacing on yield

Different spacing treatments were found to have significant influence on total biomass, seed yield and finally on stalk yield during both the years of investigation (Table 3). In contrast to effect of spacing on growth and yield attributes of individual plant the maximum values of different yield was observed under the influence of closer

Table 3. Effect of spacing and topping on biomass, seed and stalk yield of seed crop of sunnhemp.

Treatments	Biomass yield (q/ha)		Seed yield (q/ha)		Stalk yield(q/ha)	
	2009-2010	2010-2011	2009-2010	2010-2011	2009-2010	2010-2011
Spacing						
30 × 10 cm	93.52	91.83	14.74	15.80	78.78	76.03
30 × 20 cm	74.97	75.76	12.74	13.42	62.23	62.34
45 × 10 cm	81.24	82.31	13.57	14.53	67.67	67.78
45 × 20 cm	67.57	67.34	11.80	12.34	55.77	55.00
S.Em. (±)	3.73	2.77	0.41	0.51	2.53	2.45
CD at 5%	12.89	9.60	1.42	1.75	8.75	8.47
Topping						
No topping	76.91	73.97	12.47	13.28	64.44	60.69
Topping at 30 DAS	81.47	85.10	13.96	14.89	67.51	70.21
Topping at 45 DAS	79.59	78.85	13.20	13.90	66.39	64.95
S.Em. (±)	1.17	1.98	0.31	0.36	0.81	1.67
CD at 5%	3.52	5.93	0.93	1.08	2.43	5.00

spacing. The spacing of 30 × 10 cm being statistically on par with that at 45 × 10 cm recorded significantly higher biomass (92.67 q/ha) and seed yield (15.27 q/ha) followed by spacing of 30 × 20 cm. The lowest biomass (67.45 q/ha) and seed yield (12.07 q/ha) was found under the influence of 45 × 20 cm of spacing. The seed yield realized under the spacing of 30 × 10 cm was 24.91 and 28.04% higher compared to spacing of 45 × 20 cm during both the years respectively. The similar trend of spacing was noticed on stalk yield also. This reveals that although at wider spacing seed yield per plant was higher than that at closer spacing but seed yield per hectare was low on account of lower plant density under this spacing. The improvement in yield attributes under wider spacing failed to compensate for lower number of plants per unit area under this spacing. Although at closer spacing plants became sub marginal and produced yield below their potentiality but the cumulative effect of large number of sub marginal plants increased the total yield per hectare. The similar findings were reported by Ulemale et al. (2002) and Shastri et al. (2007) in sunnhemp.

Effect of topping on yield

Topping practices significantly influenced the total biomass, seed and stalk yield during both the years (Table 3). Topping at 30 days after sowing resulted into significantly higher biomass (83.28 q/ha) and seed yield (14.42 q/ha) compared to no topping (75.44 and 12.87 q/ha, respectively). On an average increase in seed yield was noticed to the tune of 12.04%. The stalk yield also followed similar trend. The difference between no topping and topping at 45 days after sowing was found non significant with respect to biomass, seed and stalk yield. The higher yield under the effect of topping might be attributed to better growth characteristics which resulted in considerable improvement in yield attributing characters like number of pod, pod weight and seed yield per plant and finally reflected into yield. In addition significantly more number of primary and secondary branches carrying more number of pods per plant under topping treatment might have multiplicative effect on seed yield. The significant higher seed yield recorded in topped plants may also be attributed to diversion of photosynthates and metabolites produced by leaves to strong carbohydrate sinks that is, pods, when compared to apical meristem in un-topped plants. The results confirmed the findings of Bhattacharjee and Mitra (1999) and Jagannatham et al. (2008) in jute, Lakshmi et al. (1995) in mesta, Kathiresan and Duraisamy (2001) in sesbania.

Conclusion

Thus from the present study it may be concluded that sowing of seed crop of sunnhemp at the spacing of 30 × 10 cm coupled with topping at 30 days after sowing is effective in increasing the seed yield of sunnhemp.

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