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Influence of Seasons, Spacings, growth Hormones and Fertilizer Levels on Seed Yield of Sunnhemp (*Crotalaria juncea* L.)

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ABSTRACT: *Field experiment was conducted during* kharif, rabi *2009 and summer 2010 to study the effect of spacings, growth hormones and fertilizer levels in sunnhemp viz., Spacings: 1) 30 x 15 cm and 2) 45 x 15 cm: Growth regulators: 1) NAA (Naphthalene Acetic Acid) @ 20 mg / l of water and2) Water spraying: Fertilizers: 1) RDF (Control) -25 N: 50 P_2O_5:25 K_2O kg + 5 t FYM / ha, 2) RDF + 50 % additional P_2O_5, 3)PSB (PhosphorusSolubilizing Bacteria) @ 10 kg / ha + 5 t FYM / ha and 4) RDF + Nutrients (Sodiummolybdate - seedtreatment @ 4 g / kg of seed, soilapplication of $ZnSo_4$ @ 15 kg /ha and Boron @ 2.5 kg /ha) on seed yield and quality. Among the spacings, the spacing of 45x15 cm was recorded maximum seed yield per plant (18.79, 16.19 and 13.09g) and seed yield per hectare (18.01,13.81 and 11.45q) during* kharif, rabi *2009 and summer 2010, respectively. The NAA @ 20 mg /l of water recorded highest seed yield per plant (18.02, 15.04 and 11.85 g) and seed yield per hectare (17.56, 13.25 and 10.86 q) during* kharif, rabi *2009 and summer 2010, respectively. Among the fertilizer levels, maximum was recorded by RDF+Nutrients (Sodium molybdate as seed treatment @4g/kg of seed, soil application of ZnSo4@15kg/ ha and Boron @2.5kg/ha)with respect to seed yield per plant (18.72, 15.04 and 12.18g), and seed yield per hectare (18.41, 13.78 and 11.21q) during* kharif, rabi *2009 and summer 2010, respectively.*

Key words: *Fertilizer levels, Growth hormones, Sunnhemp*

INTRODUCTION

Sunnhemp (*Crotalaria juncea* L.) also known as Indian hemp, Bombay hemp or Banaras hemp belongs to the genus Crotalaria, consisting of over 600 species out of which *Crotalaria juncea* is the most important. It is one of the oldest known fibre crop in the Indo-Pakistan and grown throughout the tropics as green manure (Whyte and Trumple 1953). It plays an important role in the national economy by providing raw material for indigenous paper and textile industry. It is also in demand for a particular grade of fibre required for manufacturing tissue paper and paper for currency as it contains high percentage of cellulose and less amount of lignin. However, its importance as a green manuring crop needs special mention.

The season of seed production is one of the important factors, which influences the seed yield and quality, since the weather conditions such as temperature, relative humidity, photoperiod, and wind velocity vary from season to season resulting in differential seed yield and quality (Heydecker, 1972). Therefore, selection of best season for producing better quality seed becomes an integral part of a successful seed production programme. The sunnhemp crop is known to vary in its vegetative and reproductive growth periods with the climatic conditions. Hence, fixing the date of sowing also assumes paramount importance. Despite being a multi-purpose crop, sunnhemp has not gained due importance in our cropping system. Besides, little research work has been done on agronomic aspect of sunnhemp like row spacing and nutrient requirement *etc.*. Optimum spacing provides conditions for maximum light interception right from early period of crop growth. Further, it is important to realize that spacing should be defined not only in terms of number of plants per unit area but also in terms of arrangement of these plants on the ground (spatial/ geometry of planting). By changing the spacing, it is possible to achieve optimum vegetative and reproductive growth which can boost up the seed crop

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productivity. Therefore, there is a need to standardize the seed production technologies in sunnhemp *viz*., optimum sowing time in different seasons, spacing and growth hormone / micro nutrients / microbial (PSB) applications for seed yield.

MATERIAL AND METHODS

The field experiment was conducted to study the influence of seasons, spacings, growth hormones and fertilizer levels on seed yield of Sunnhemp (*Crotalaria juncea* L.) Local variety at College of Agriculture, Department of Seed Science and Technology Experimental block, UAS, Raichur under irrigated condition during *kharif*, *rabi* 2009 and summer 2010.The treatment details viz., Spacings: 1) 30 x 15 cm and 2) 45 x 15 cm: Growth regulators: 1) NAA (Naphthalene Acetic Acid) @ 20 mg / l of water and 2) Water spraying: Fertilizers: 1) RDF (Control) -25 N: 50 P_2O_5:25 K_2O kg + 5 t FYM / ha, 2) RDF + 50% additional $P_2O_{5,}$ 3) PSB (Phosphorus Solubilizing Bacteria) @ 10 kg / ha + 5 t FYM / ha and 4) RDF + Nutrients (Sodium molybdate - seed treatment @ 4 g / kg of seed, soil application of $ZnSo_4$ @ 15 kg /ha and Boron @ 2.5 kg /ha) on seed yield.

Number of Pods Per Plant

The numbers of pods present in each plant of five randomly tagged plants were counted. The average was calculated and expressed as number of pods per plant.

Number of Seeds Per Pod

Ten pods selected were used for recording the number of seeds per pod. Total numbers of seeds were counted and their average was expressed as number of seeds per pod.

Seed Recovery (%)

Seed yield obtained from corresponding plots were processed using recommended grading bottom screen size 2.00 (R) mm and the seed retained on the screen and the rejected seeds were weighed. The seed recovery percentage was calculated as follows:

$$Seed\ recovery\ (\%) = \frac{Weight\ of\ processed\ seed}{Total\ weight\ of\ unprocessed\ seed} \times 100$$

Seed Yield Per Hectare (q)

Seed yield obtained from each net plot was computed for hectare and expressed in quintals per hectare.

RESULTS AND DISCUSSION

The non-availability of good quality seed is one of the major constraints in popularizing the practice of green manuring with sunnhemp. Hence, the production and making available sufficient high quality seed of this crop at reasonable price is very much necessary. For seed production, suitable techniques have to be developed for each agro-climatic situation. The information available on seed production aspects of this crop is very meager. In the seed production programme, sowing time, spacing and nutrient management as most important aspects for increasing the productivity of seed.

Seed Yield Parameters as Influenced by Spacings

Marked variations due to spacings have been noticed with respect to characters like number of pods per plant, number of seeds per pod, seed recovery and seed yield. Spacings at 45 x 15 cm recorded more number of pods per plant (75.2, 51.5 and 40.6), number of seeds per pod (11.63, 8.58 and 7.46), seed yield per plant (18.79, 16.19 and 13.09 g), seed yield per plot (1.95, 1.49 and 1.24 kg), seed recovery (86.66, 84.32 and 79.20%) and seed yield per hectare (18.01, 13.81 and 11.45) in *kharif*, *rabi* 2009 and summer 2010, respectively (Table 1, 2, 3 and 4). Number of pods per plant, number of seeds per pod and seed yield was higher in the wider spacings which might be due to adequate availability of nutrients, light and space with lower population that resulted in improvement of yield attributing characters and yield. These results are in conformity with the earlier findings of Abid *et.al.*(1988) in cluster bean, Selvam (1994) in *Sesbania rostrata*.

Effect of Growth Regulators on Seed Yield

Naphthalene acetic acid (NAA) belongs to the auxin group of growth regulators. It is a synthetic auxin. Auxins are essential for enlargement and development of ovary into fruit (Salibury and Ross, 1969). Actually auxins are synthesized in the stem and root apices and transported through the plant axis.

The significant variations due to growth hormones with respect to yield characters like number of pods per plant (67.6, 44.4 and 35.7), number of seeds per pod (10.58, 8.25 and 7.00), seed yield per plant (18.02, 15.04 and 11.85 g), seed yield per plot (1.90, 1.43 and 1.17 kg), seed recovery (82.77, 81.40 and 77.58%) and seed yield per hectare (17.56, 13.25 and 10.86 q) during *kharif*, *rabi* 2009 and summer 2010, respectively. These results are conformity with the findings of Maske *et.al.* (1998) in soybean.

Table 1
Influence of Spacings, Growth Hormones, Fertilizer Levels and their Interaction on Number of Pods Per Plant in Sunnhemp *Kharif*, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	56.3	55.0	73.0	71.0	**63.8**	56.2	72.0	64.7	63.0
F_2	60.3	58.7	79.3	77.0	**68.8**	59.5	78.2	69.8	67.8
F_3	57.0	55.3	71.7	70.7	**63.7**	55.7	71.2	64.3	63.0
F_4	61.7	59.0	81.6	77.3	**69.9**	60.3	79.5	71.7	68.2
Mean	58.8	57.0	76.4	74.0	66.6	57.9	75.2	67.6	65.5
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.401	0.401	0.567	0.567	0.801	0.801	1.133		
CD (P=0.05)	1.372	1.372	1.940	1.940	2.741	2.741	3.878		

Rabi, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	34.6	32.0	51.3	47.6	**41.4**	33.3	49.5	43.0	39.8
F_2	35.3	32.6	56.0	48.6	**43.1**	34.0	52.3	45.6	40.6
F_3	33.0	31.0	51.0	47.0	**40.5**	32.0	49.0	42.0	39.0
F_4	36.0	33.0	58.3	52.3	**44.9**	34.5	55.3	47.1	42.6
Mean	34.7	32.1	54.1	48.9	42.5	33.4	51.5	44.4	40.5
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.298	0.298	0.422	0.422	0.596	0.596	0.843		
CD (P=0.05)	1.019	1.019	1.444	1.444	2.039	2.039	2.884		

Summer, 2010

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	27.8	23.3	40.3	37.0	**32.0**	25.3	38.6	33.8	30.1
F_2	30.0	26.0	45.0	39.6	**35.1**	28.0	42.3	37.5	32.8
F_3	26.6	23.0	39.6	36.3	**31.4**	24.8	38.0	33.1	29.6
F_4	30.3	26.6	46.3	41.0	**36.0**	28.5	43.6	38.3	33.8
Mean	28.5	24.7	42.8	38.5	33.6	26.6	40.6	35.7	31.6
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.187	0.187	0.264	0.264	0.374	0.374	0.528		
CD (P=0.05)	0.639	0.639	0.903	0.903	1.270	1.270	1.806		

Table 2
Influence of Spacings, Growth Hormones, Fertilizer Levels and their Interaction on Number of Seeds Per pod in Sunnhemp *Kharif*, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	8.00	8.00	11.00	10.67	**9.41**	8.00	10.83	9.50	9.33
F_2	9.67	9.67	13.00	11.00	**10.83**	9.67	12.00	11.33	10.33
F_3	7.67	7.66	10.67	10.66	**9.17**	7.66	10.67	9.17	9.17
F_4	11.00	10.67	13.66	12.33	**11.92**	10.83	13.00	12.33	11.50
Mean	9.08	9.00	12.08	11.17	10.33	9.04	11.63	10.58	10.08
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.162	0.162	0.229	0.229	0.324	0.324	0.458		
CD (P=0.05)	0.554	0.554	0.783	0.783	1.109	1.109	1.567		

Rabi, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	7.00	6.00	9.00	7.66	**7.42**	6.50	8.33	8.00	6.83
F_2	7.66	6.67	9.67	8.33	**8.08**	7.17	9.00	8.66	7.50
F_3	6.33	5.66	8.33	7.33	**6.92**	6.00	7.83	7.33	6.50
F_4	8.33	7.33	9.67	8.67	**8.50**	7.83	9.17	9.00	8.00
Mean	7.33	6.42	9.17	8.00	7.73	6.88	8.58	8.25	7.21
	S	G	F	S x G		G x F	S x F	S x G x F	
SEm±	0.164	0.164	0.232	0.232		0.328	0.328	0.464	
CD (P=0.05)	0.560	0.560	0.793	0.793		1.122	1.122	1.587	

Summer, 2010

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	5.33	6.00	7.33	6.33	**6.25**	5.67	6.83	6.67	5.83
F_2	5.66	6.33	8.33	7.67	**7.00**	6.00	8.00	7.33	6.66
F_3	5.00	5.66	7.00	6.00	**5.92**	5.33	6.50	6.33	5.50
F_4	6.00	6.67	8.67	8.33	**7.42**	6.33	8.50	7.67	7.17
Mean	5.50	5.17	7.83	7.08	6.65	5.83	7.46	7.00	6.29
	S	G	F	S x G		G x F	S x F	S x G x F	
SEm±	0.155	0.155	0.219	0.219		0.310	0.310	0.438	
CD (P=0.05)	0.530	0.530	0.749	0.749		1.060	1.060	1.498	

Table 3
Influence of Spacings, Growth Hormones, Fertilizer Levels and their Interaction on Seed Recovery (%) in Sunnhemp *Kharif*, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	77.24	75.31	85.95	83.92	**80.61**	76.28	84.94	81.60	79.62
F_2	79.13	78.53	88.84	88.00	**83.63**	78.83	88.42	83.99	83.27
F_3	75.84	73.38	85.07	82.81	**79.27**	74.61	83.94	80.45	78.10
F_4	80.15	79.63	89.97	88.70	**84.61**	79.89	89.34	85.06	84.17
Mean	78.09	76.72	87.46	85.86	82.03	77.40	86.66	82.77	81.29
	S	G	F	S x G		G x F	S x F	S x G x F	
SEm±	0.237	0.237	0.336	0.336		0.475	0.475	0.671	
CD (P=0.05)	0.811	0.811	1.150	1.150		1.626	1.626	2.296	

Rabi, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	77.22	76.10	82.74	82.61	**79.67**	76.66	82.68	79.98	79.35
F_2	79.25	77.88	85.98	84.50	**81.90**	78.57	85.24	82.62	81.19
F_3	75.22	75.73	82.42	82.14	**78.88**	75.48	82.28	78.82	78.93
F_4	80.33	78.93	87.99	86.18	**83.36**	79.63	87.09	84.16	82.56
Mean	78.01	77.16	84.78	83.86	80.95	77.58	84.32	81.40	80.56
	S	G	F	S x G		G x F	S x F	S x G x F	
SEm±	0.194	0.194	0.276	0.276		0.388	0.388	0.549	
CD (P=0.05)	0.660	0.660	0.944	0.944		1.327	1.327	1.878	

Summer, 2010

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	74.72	73.76	78.26	77.63	**76.08**	74.24	77.92	76.46	75.69
F_2	75.93	74.54	80.81	79.22	**77.63**	75.23	80.02	78.37	76.88
F_3	74.31	73.90	78.18	77.28	**75.92**	74.10	77.73	76.24	75.59
F_4	76.14	75.41	82.37	79.89	**78.65**	75.78	81.13	79.26	77.65
Mean	75.28	74.40	79.89	78.51	77.02	74.84	79.20	77.58	76.46
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.123	0.123	0.171	0.171	0.242	0.242	0.342		
CD (P=0.05)	0.420	0.420	0.585	0.585	0.828	0.828	1.170		

Table 4
Influence of Spacings, Growth Hormones, Fertilizer Levels and their Interaction on Seed Yield (q/ha) in Sunnhemp *Kharif*, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	16.08	14.84	17.99	17.44	**16.59**	15.46	17.71	17.03	16.14
F_2	17.06	15.46	19.00	17.77	**17.33**	16.28	18.39	18.02	16.63
F_3	15.61	14.99	17.22	16.75	**16.15**	15.31	16.99	16.42	15.88
F_4	18.05	17.68	19.47	18.42	**18.41**	17.87	18.95	18.76	18.05
Mean	16.70	15.75	18.42	17.60	17.12	16.23	18.01	17.56	16.68
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.113	0.113	0.159	0.159	0.225	0.225	0.318		
CD (P=0.05)	0.387	0.387	0.544	0.544	0.770	0.770	1.088		

Rabi, 2009

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	12.16	11.29	13.58	13.02	**12.51**	11.73	13.00	12.87	12.16
F_2	12.78	12.16	14.41	13.86	**13.30**	12.47	14.13	13.60	13.01
F_3	11.60	11.06	13.36	12.90	**12.23**	11.32	13.13	12.48	11.97
F_4	13.14	12.64	15.00	14.32	**13.78**	12.89	14.66	14.07	13.48
Mean	12.42	11.79	14.09	13.52	12.95	12.10	13.81	13.25	12.65
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.069	0.069	0.097	0.097	0.134	0.134	0.195		
CD (P=0.05)	0.230	0.230	0.330	0.330	0.450	0.450	0.450		

Summer, 2010

Treatments	S_1		S_2		*Mean*	*S x F*		*G x F*	
	G_1	G_2	G_1	G_2		S_1	S_2	G_1	G_2
F_1	9.10	8.27	11.51	10.71	**9.90**	8.68	11.10	10.31	9.48
F_2	10.40	9.47	12.04	11.32	**10.81**	9.94	11.68	11.22	10.40
F_3	9.10	7.87	11.38	10.46	**9.70**	8.48	10.92	10.24	9.16
F_4	10.83	9.78	12.53	11.70	**11.21**	10.30	12.11	11.68	10.74
Mean	9.86	8.85	11.86	11.05	10.40	9.35	11.45	10.86	9.95
	S	G	F	S x G	G x F	S x F	S x G x F		
SEm±	0.088	0.088	0.124	0.124	0.176	0.176	0.249		
CD (P=0.05)	0.301	0.301	0.424	0.424	0.602	0.602	0.852		

Seed Yield Parameters as Influenced by Fertilizer Levels

The fertilizer levels, F_2 (25 N: 50 P_2O_5:25 K_2O kg + 5 t FYM + 50 % additional P_2O_5 ha^{-1}) and F_4 (25 : 50 : 25 kg NPK per hectare and micro nutrients like Sodiummolybdate - seedtreatment @ 4 g / kg of seed, soilapplication of $ZnSo_4$ @ 15 kg /ha and Boron @ 2.5 kg /ha) exhibited marked variations for number of pods per plant, number of seeds per pod, seed yield per plant, seed yield per plot, seed recovery and seed yield per hectare in all the three seasons. Significantly higher number of pods per plant (69.9, 44.9 and 36.0), number of seeds per pod (11.92, 8.50 and 7.42), seed yield per plant (18.72, 15.40 and 12.18 g), seed yield per plot (1.99, 1.52 and 1.21 kg) and seed yield per hectare (18.42, 14.32 and 11.70 q) in *kharif*, *rabi* 2009 and summer 2010, respectively were recorded with fertilizer level of F_4 compared to F_1 and F_3. Significant increase in seed yield and its components was noticed in F_4 fertilizer level which may be attributed to the enhanced photosynthetic activity, greater accumulation and translocation of photosynthates from source to sink resulting in heavier and bolder seeds. These results are in agreement with the findings of Verma *et al.* (2004) in pigeon pea, Datta *et.al.* (2008) in coriander, Kipling *et.al.* (2011) in sunnhemp and Lakshmi Prasanna *et. al.* (2012) in cluster bean.

Use of micro nutrients plays a decisive role for getting higher seed yield as well as better quality. Though micro nutrients are required in small quantity to plants, their toxicity or deficiency may lead to poor seed yield and quality. Generally micronutrients are applied to crop through soil, seed and foliage. Among the several micronutrients useful for sustained crop productivity, zinc and molybdenum are more essential for obtaining increased seed yield and quality. Deficiency of minor elements may produce characteristic damage to seeds. Seeds deficient in molybdenum and zinc generally produce poorer plants than normal seeds (Hewitt *et.al.*, 1954).

Seed Yield Parameters as Influenced by Interaction Effects of Spacings and Growth Hormones

The interactions between spacings and growth hormones differed significantly for seed yield and its attributes in all the three seasons. Significantly higher number of pods per plant (76.4, 54.1 and 42.8), number of seeds per pod (12.08, 9.17 and 7.83), seed yield per plant (19.26, 16.86 and 13.46 g), seed yield per plot (1.99, 1.52 and 1.28 kg), seed recovery (87.46, 84.78 and 79.89%) and seed yield per hectare (18.42, 14.09 and 11.86 q) during *kharif*, *rabi* 2009 and summer 2010, respectively. This is because of the application of NAA had the potentiality to produce higher values for all the yield contributing characters. Besides, higher plant population per hectare has resulted less number of branches and pods. These results are in accordance with the findings of Biradar *et al.* (1991), Deshpande *et.al.* (2000) and Ekshing *et al.* (1995) in sunnhemp.

CONCUSION

The studies could be concluded that, *kharif* season is found suitable compared to *rabi* and summer with respect to wider spacings at 45 x 15 cm obtain maximum seed yield (18.01, 13.81 and 11.45 q) per hectare during *kharif*, *rabi* 2009 and summer 2010, respectively. Application of fertilizers and micro nutrients (25 N : 50 P_2O_5 : 25 K_2O kg + 5 t FYM /ha + Nutrients - Sodium molybdate as seed treatment @ 4 g/kg of seed, soil application of $ZnSo_4$ @ 15 kg / ha and Boron @ 2.5 kg/ha) was found optimum to obtain maximum seed yield (18.41, 13.78 and 11.21 q) in *kharif*, *rabi* 2009 and summer 2010, respectively.

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