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Seed Yield and Economics of Prickly Sesban under Spatio-Temporal Variation in Sowing in Coastal Odisha

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Abstract: Field experiment was conducted at Bhubaneswar, Odisha during *kharif* 2019 to study the response of prickly sesban to spatio-temporal variation in planting. The treatments of the study comprised five dates of planting. First sowing was done with onset of monsoon on June 13 and rest four at weekly intervals. *on* 20 and 27 June, 4 and 11 July with three row spacings *viz*. 80, 120 and 160 cm. Planting on 13 June at row spacing of 80 cm recorded the maximum seed yield of 1.271 t/ha while planting on 13 June at row spacing of 120 cm and planting on 20 June at row spacing of 80 and 120 cm recorded statistically similar seed yields. All other combinations of date of planting and row spacing were inferior to the combination of 13 June planting with row spacing of 80 cm. The earliest date of planting at the closest row spacing recorded the maximum net return of Rs 96.17 x10^3/ha and return per rupee investment of Rs 2.27.

Keywords: *Dhaincha*, Phenology, Productivity, Profitability, Seed yield

Green manuring crops can meet a substantial portion of the nitrogen requirement of rice and provide organic matter to the soil to maintain soil fertility (Mondal and Goswami 2019).Among the green manuring crops, prickly sesban or *dhaincha* [*Sesbania cannabina* (Synonym: *S. aculeata*)] is the most important *in-situ* green manuring crop in rice ecosystem as it best fits into the pre-rice fallow period of 45-60 days (Sakthirama and Sivakumar 2017). Its vigorous root system utilizes a significant amount of sub-soil phosphorus and transfers it to the surface soil when incorporated. Despite this, farmers are averse to continue the practice of *dhaincha* green manuring owing to various constraints. Of the various factors influencing seed production of *dhaincha*, optimum time of sowing is the most important aspect for obtaining higher yields, as it provides optimum growing conditions for the crop. Early sown *dhaincha* during *kharif* is subjected to viviparous germination if pod ripening coincides with rainfall events. In contrary, seed filling is affected in late planted crops due to moisture stress. Sometimes seed drying becomes a problem due to humid weather leading to loss in seed viability. In this context, there is a need for deciding optimum sowing window for *dhaincha* as seed crop. Row spacing is one of the important factors in achieving optimum level of plant density. Optimum plant population utilizes available moisture and nutrients from the soil more effectively and leads to better dry matter production and accumulation which is manifested as good seed yield. Higher plant population leads to overcrowding and mutual shading of plants. Lower plant density results in sub optimal utilization of the available resources, particularly, sunlight. In both cases, seed yield per unit area decreases. Kumar et al (2006) reported the maximum seed yield of *dhaincha* with row spacing of 60 cm on sandy loam soils at Hissar, Haryana. Sangeetha et al (2011) have reported higher seed yield with plant density of 74,000 plants/ha in sandy clay loam soils at Rajendranagar. Better yield attributes and higher seed yield were reported by Rajesh et al (2017) at spacing of 120 cm x 30 cm compared to 120 cm x 30 cm and 90 cm x 30 cm at Killikulam, Tamil Nadu. Information on agro-techniques like optimum time of sowing and row spacing for seed *dhaincha* under sub humid condition are meager. It needs immediate attention of the researchers to self-sustain and strengthen the *dhaincha* seed production and supply chain in Odisha and adjoining states. With this backdrop, a field experiment was conducted during *kharif* season of 2019 to study the response of seed-*dhaincha to* spatio-temporal variation in sowing.

MATERIAL AND METHODS

The field experiment was conducted in the Agronomy Main Research Farm, Department of Agronomy, Odisha University of Agriculture and Technology, Bhubaneswar (20^0 15'N, 85^0 52'E and 25.9 m above the MSL), Odisha, India. The soil (0-15 cm) of the experimental site was characterized by sandy loam texture, acidic (pH: 5.5), normal electrical conductivity (0.032 dS/m), low organic carbon (0.427%), low available N (193.75 kg/ha), high available P (28.84 kg/ha) and medium available K (124.59 kg/ha).

The treatments comprised five dates of planting of *dhaincha* at weekly interval *viz.* D_1-onset of monsoon; D_2-one week after; D_3-two weeks after; D_4-three weeks after and D_5-four weeks after were allocated to main-plots; and three row spacings *viz*. S_1-80 cm, S_2-120 cm and S_3-160 cm were allocated to the sub-plots. These were in split-plot design with three replications having individual unit plot size of 4.8 m x 3 m. The crop was fertilized with 20-40-20 kg/ha of N-P_2O_5-K_2O. Sowing was done first on 13 June 2019 after onset of monsoon and the subsequent sowings were done at weekly intervals i.e. on 20 June, 27 June, 4 July and 11 July 2019 at row to row spacing as per the treatment specifications. Thinning of excess seedlings was carried out at 15 days after planting (DAP) to maintain intra-row spacing of 30 cm. Fully matured pods were harvested from net plot area in 2-3 phases to avoid shattering losses and the pods were threshed after sun drying.

RESULTS AND DISCUSSION

Phenology: On an average, *dhaincha* took 53.3 and 110.8 days for attainment of phenophases, 50% flowering and 1st picking of matured pods (Table 1). Between two factors under study, only date of planting influenced days to attainment of phenophases significantly. Among different stages, 13 June planting took the maximum number of days for attainment of these two developmental stages, being at par with 20 June planting. Further delay in planting reduced the number of days for attainment of these two phenophases. Better vegetative growth associated with earlier planting delayed the process of switch over from the vegetative to reproductive phase and hence, more number of days was required for attainment of the phenophases. The findings are in agreement with the findings of Triveni and Martinluther (2011) in *dhaincha*, and Sandya and Singh (2018) and Kumar et al (2019) in *kharif* pigeon pea.

Growth parameters: Both date of planting and row spacing exerted significant influence on plant height (Table 2). Plant height decreased with delay in planting while early planting facilitated better crop establishment at seedling stage that facilitated better tolerance to water logging at later stages. However, the emergence and growth of late sown *dhaincha* were affected. Taller plants with earlier sowing were also reported by Kumar et al (2006) in *dhaincha.* Among the row spacings, the closest spacing (80 cm) recorded the maximum plant height due to the keenest competition among plants for light. Competition for light became apparent, when canopy of adjacent plant came closer. Furthermore, competition for light is severe in *kharif* season. Taller plants at closer spacings were reported by Parlawar et al (2001) and Yaragoppa et al (2003) in *dhaincha* and Lamani et al (2004) in sun hemp. Both factors exerted significant influence on branch number (Table 2). Branches/plant decreased with

Table 1. Effect of date of planting and row spacing on days to attainment of phenophases (2019)

Particulars	Row spacing (cm)			Mean
	80	120	160	
Date of planting				
Days to 50% flowering				
D_1: 13 June	55.0	56.0	56.7	55.9
D_2: 20 June	55.7	55.0	55.0	55.2
D_3: 27 June	53.0	54.0	53.0	53.3
D_4: 04 July	51.7	51.0	52.0	51.6
D_5: 11 July	50.7	51.0	49.3	50.3
Mean	53.2	53.4	53.2	53.3
CD (p=0.05)	D = 1.6, S = NS, D x S = NS, S x D = NS			
Days to 1st picking of matured pods				
D_1: 13 June	115.3	115.0	114.7	115.0
D_2: 20 June	113.0	114.7	113.7	113.8
D_3: 27 June	111.0	112.0	112.0	111.7
D_4: 04 July	106.3	109.0	106.7	107.3
D_5: 11 July	106.7	104.0	107.3	106.0
Mean	110.5	110.9	110.9	110.8
CD (p=0.05)	D = 1.6, S = NS, D x S = NS, S x D = NS			

D = Date of planting, S = Row spacing, D x S= Date at same or different row spacing, S x D = Row spacing at date delay in planting. More number of branches/plant was reported with earlier planting of *dhaincha* (Kumar et al 2006). The widest row spacing recorded the maximum number of branches/plant and the values decreased with decrease in row spacing. This corroborated the findings of Parlawar et al (2001) and Sangeetha et al (2011) in *dhaincha.* Interaction effects of both factors on branches/plant were found significant. Early sowing and wider row spacing acted synergistically to increase branches/plant. Both factors exerted significant influence on horizontal spread (Table 2). More horizontal spread was recorded with earlier planting and wider row spacing. The mean horizontal spread was 119.5 cm. The row spacings of 80,120 and 160 cm recorded the horizontal spread of 115, 120.2 and 123.3 cm indicating overcrowding at 80 cm row spacing, optimum canopy growth at 120 cm row spacing and underutilization of row spacing at 160 cm row spacing. The mean dry matter production was 7.415 t/ha. These factors influenced dry matter production significantly. Higher dry matter production was associated with earlier planting and close spacing. Early planting provided congenial weather conditions for crop emergence, establishment and growth. Although, the widest row spacing

Table 2. Effect of date of planting and row spacing on growth parameters of seed *dhaincha* at harvest (2019)

Date of planting	Row spacing (cm)			Mean
	80	120	160	
Plant height (cm)				
D_1: 13 June	266.3	259.3	233.1	252.9
D_2: 20 June	261.6	246.1	241.6	249.8
D_3: 27 June	257.9	246.7	245.8	250.1
D_4: 04 July	256.0	248.1	239.4	247.8
D_5: 11 July	255.5	245.8	236.3	245.9
Mean	259.5	249.2	239.2	249.3
CD (p=0.05)	D = NS, S = 5.7, D x S = NS, S x D = NS			
Branches/plant				
D_1: 13 June	20.0	20.6	23.1	21.2
D_2: 20 June	19.8	20.7	21.8	20.7
D_3: 27 June	13.5	15.7	17.0	15.4
D_4: 04 July	12.7	16.2	16.8	15.2
D_5: 11 July	13.5	14.9	16.8	15.1
Mean	15.9	17.6	19.1	17.5
CD (p=0.05)	D = 1.3, S = 0.9, D x S = 6.1, S x D = 1.9			
Horizontal spread (cm)				
D_1: 13 June	132.8	135.8	137.5	135.3
D_2: 20 June	121.1	128.6	126.0	125.2
D_3: 27 June	108.4	108.6	129.5	115.5
D_4: 04 July	106.7	117.1	115.4	113.0
D_5: 11 July	105.9	110.8	108.3	108.3
Mean	115.0	120.2	123.3	119.5
CD (p=0.05)	D = 18.4, S = 5.7, D x S = NS, S x D = NS			
Dry matter production (t/ha)				
D_1: 13 June	10.014	9.514	8.784	9.437
D_2: 20 June	9.872	9.194	8.585	9.217
D_3: 27 June	8.343	7.084	7.895	7.774
D_4: 04 July	7.225	5.665	3.243	5.378
D_5: 11 July	5.500	5.339	4.967	5.269
Mean	8.191	7.359	6.695	7.415
CD (p=0.05)	D = 0.905, S = 0.605, D x S = 4.277, S x D = 1.352			

recorded the maximum branches/plant and horizontal spread, the closest row spacing recorded the maximum dry matter production due to the maximum plant density. Sangeetha et al (2011) have also reported higher dry matter production in *dhaincha* with closer spacing.

Yield attributes: Planting on 13 June recorded the maximum length of pod. Pod length decreased due to delay in planting. However, row spacing did not exert significant influence on pod length (Table 3). Both factors influenced pods/plant significantly. Planting on 13 June resulted in the maximum of 64.5 pods/plant (Table 3). The second date of planting recorded statistically similar pod count while further delay in planting decreased pods/plant significantly. More branches/plant, better vertical growth and higher biomass production under early planting resulted in production of more pods/plant. Higher pods/plant with early planting was reported earlier by Ulemale et al (2002) in sunnhemp, Yadav (2003) in cow pea and Kumar et al (2006) in *dhaincha.*

Table 3. Effect of date of planting and row spacing on yield attributes of seed *dhaincha*

Date of planting	Row spacing (cm)			Mean
	80	120	160	
Date of planting				
Pod length (cm)				
D_1: 13 June	18.6	18.7	18.8	18.7
D_2: 20 June	19.0	18.5	18.4	18.6
D_3: 27 June	17.7	16.5	17.7	17.3
D_4: 04 July	16.5	16.2	16.5	16.4
D_5: 11 July	17.1	15.2	16.6	16.3
Mean	17.8	17.0	17.6	17.5
CD (p=0.05)	D = 1.2, S = NS, D x S= NS, S x D = NS			
Pods/plant				
D_1: 13 June	63.2	63.5	66.7	64.5
D_2: 20 June	62.3	64.5	64.2	63.7
D_3: 27 June	60.1	58.3	64.7	61.0
D_4: 04 July	51.0	54.2	53.6	52.9
D_5: 11 July	46.4	51.6	53.5	50.5
Mean	56.6	58.4	60.6	58.5
CD (p=0.05)	D = 3.4, S = 1.3, D x S = 12.5, S x D = 3.0			
Seeds/pod				
D_1: 13 June	33.1	30.8	32.8	32.3
D_2: 20 June	31.1	29.3	33.3	31.2
D_3: 27 June	28.1	29.4	31.5	29.7
D_4: 04 July	27.4	29.6	30.7	29.2
D_5: 11 July	28.1	28.4	31.0	29.2
Mean	29.6	29.5	31.9	30.3
CD (p=0.05)	D = 1.2, S = 1.7, D x S = NS, S x D = NS			
1,000 seed weight (g)				
D_1: 13 June	17.54	17.78	17.72	17.68
D_2: 20 June	17.23	17.40	17.83	17.49
D_3: 27 June	17.50	17.61	16.81	17.31
D_4: 04 July	15.17	15.03	15.81	15.34
D_5: 11 July	14.02	14.10	15.18	14.44
Mean	16.29	16.38	16.67	16.45
CD (p=0.05)	D = 0.28, S = NS, D x S = NS, S x D = NS			

Among three row spacings, the widest row spacing recorded the maximum pods/plant and the values decreased with decrease in row spacing. More intense competition at closer spacing among plants for nutrient, light, moisture and space decreased the performance of individual plants. Increase in pods/plant with decrease in plant population or increase in spacing was also reported earlier by Yaragoppa et al (2003) and Sangeetha et al (2011) in *dhaincha and* Lamani et al (2004) and Shastri et al (2007) in sunnhemp. *Dhaincha* planted at the earliest with the widest row spacing recorded the maximum pods/plant due to synergistic effect between the two factors under study. The date of planting and row spacing significantly influence seeds/plant (Table 3). *Dhaincha* planted at the earliest recorded the maximum seeds/pod and the values decreased with delay in planting. Delayed planting decreased seeds/pod due to terminal moisture stress. Being an indeterminate plant, the pod and the seed setting spread over a longer period, even after

Table 4. Effect of date of planting and row spacing on yield and production economics of seed *dhaincha* (2019)

Date of planting	Row spacing (cm)			Mean
	80	120	160	
Date of planting				
Seed yield of *dhaincha* (t/ha)				
D_1: 13 June	1.271	1.030	0.788	1.030
D_2: 20 June	1.176	1.079	0.703	0.986
D_3: 27 June	0.913	0.825	0.675	0.804
D_4: 04 July	0.726	0.617	0.505	0.616
D_5: 11 July	0.712	0.599	0.490	0.601
Mean	0.959	0.830	0.632	0.807
CD p(=0.05)	D = 0.054, S = 0.037, D x S = 0.258, S x D = 0.082			
Stover yield of *dhaincha* (t/ha)				
D_1: 13 June	8.743	8.484	7.996	8.408
D_2: 20 June	8.696	8.115	7.882	8.231
D_3: 27 June	7.431	6.259	7.220	6.970
D_4: 04 July	6.499	5.047	4.738	5.428
D_5: 11 July	4.788	4.739	4.477	4.668
Mean	7.231	6.529	6.462	6.741
CD (p=0.05)	D = 0.909, S = 0.613, D x S = NS, S x D = NS			
Net return (x10^3 Rs/ha)				
D_1: 13 June	44.31	32.73	20.62	32.55
D_2: 20 June	37.43	36.38	15.23	29.68
D_3: 27 June	24.28	22.62	16.48	21.13
D_4: 04 July	15.86	12.79	8.80	12.48
D_5: 11 July	14.81	13.09	8.10	12.00
Mean	27.34	23.52	13.85	21.57
CD (p=0.05)	D = 3.67, S = 2.55, D x S =17.78, S x D = 5.71			
Return per rupee investment (Rs)				
D_1: 13 June	2.24	2.02	1.71	1.99
D_2: 20 June	2.02	2.16	1.53	1.90
D_3: 27 June	1.73	1.77	1.64	1.71
D_4: 04 July	1.53	1.49	1.38	1.47
D_5: 11 July	1.50	1.53	1.36	1.46
Mean	1.81	1.79	1.52	1.71
CD (p=0.05)	D = 0.13, S = 0.10, D x S = 0.67, S x D = 0.22			

Price of *dhaincha* seed Rs 62,940/t

withdrawal of monsoon. The widest row spacing recorded the maximum seeds/pod. Increase in seeds/pod with increase in spacing was reported by Parlawar et al (2001) and Kumar et al (2006) in *dhaincha and* Ulemale et al (2002) in sunnhemp. The date of planting influenced 1,000 seed weight significantly (Table 3). The earliest date of planting recorded the heaviest seeds and delay in planting decreased the test weight significantly. The early planting ensured supply of sufficient soil moisture during seed filling due to presence of monsoon-rain. This was in contrary to the findings of Ulemale et al (2002) who did not find any difference in 1,000 seed weight of sunnhemp among different sowing dates (15 June, 30 June and 15 July). However, the findings are in agreement with Yadav (2003) on cowpea under early sowing. The widest row spacing of 160 cm recorded the maximum test weight of seeds and the values decreased with closer row spacing but without significant differences. Similar findings were also reported earlier by Kumar et al (2006) and Chaudhary et al (2013) in *dhaincha.*

Yield: Planting time and row spacing influenced seed yield of *dhaincha* significantly (Table 4). Planting on 13 June gave the maximum seed yield of 1.031 t/ha and 20 June planting gave the statistically similar seed yield. Planting on 27 June, 3 July and 10 July decreased seed yield by 29, 40 and 42%, respectively compared to 13 June planting. The closest row spacing (80 cm) produced the maximum seed yield (0.96 t/ha), while 120 and 160 cm spacings recorded 18 and 34% less seed yields, respectively. Planting on 13 June at row spacing of 80 cm recorded the maximum seed yield of 1.271 t/ha while planting on 13 June at row spacing of 120 cm and planting on 20 June at row spacing of 80 and 120 cm recorded statistically similar seed yields. All other combinations of date of planting and row spacing recorded significantly lesser seed yield. In all the five dates of planting, seed yield decreased with increase in row spacing. Ulemale et al (2002) reported higher seed yield of sunnhemp with early sowing (15 June) at Akola, Maharashtra. The maximum seed yield at moderate spacing were also reported by Despande et al(2000), Lamani (2004) and Shastri et al(2007) in sunnhemp, and Parlawar et al(2001) and Sangeetha et al(2011) *in dhaincha*. These factors influenced stover yield of *dhaincha* significantly (Table 4). The earliest planting (13 June) recorded the maximum stover yield of 8.408 t/ha, while planting on 20 June recorded statistically similar stover yield with reduction in yield at subsequent planting dates. The closest row spacing recorded the maximum stover yield of 7.23 t/ha, but further increase in spacing decreased stover yield significantly. However, the interaction effects of both factors were non-significant for stover yield.

Economics: Planting *dhaincha* on 13 June 2019 resulted in maximum net return of Rs 32.55 × 10^3/ha while planting a week later generated statistically similar net return (Table 4). However, further delay in planting reduced net return significantly. The closest row spacing recorded the maximum mean net return of Rs 27.34x10^3/ha, whereas the other two row spacings recorded significantly lower values. The maximum mean net return of Rs 44.31 × 10^3/ha was obtained from *dhaincha* sown on 13 June at row spacing of 80 cm. Planting on 13 June at row spacing of 120 cm, and on 20 June at row spacing of 80 and 120 cm recorded statistically similar net return. The date of planting and row spacing influenced return/rupee investment significantly (Table 4). Planting on 13 June recorded the maximum mean return/rupee investment of Rs 1.99 while 20 June planting recorded statistically similar trend but delay in planting reduced profit planting *dhaincha* at the closest row spacing of 80 cm recorded further the maximum mean return/rupee investment of Rs 1.81 and 120 cm spacing was at par. Planting *dhaincha* on 13 June at row spacing of 80 cm recorded the maximum return/rupee investment of Rs 2.24 and planting on 13, 20 and 27 June at all the three row spacing recorded statistically similar results.

CONCLUSIONS

The optimum planting window for seed *dhaincha* was from 13 to 20 June (3rd week of June) in sub humid climate of coastal Odisha. Row spacings of 80 and 120 cm proved superior to 160 cm. Hence, it is advisable to plant seed *dhaincha* in the 3rd week of June in coastal Odisha at row spacing of 80 or 120 cm for maximizing productivity and profitability**.**

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