Indian Journal of Agronomy **66** (1): 112–117 (March 2021)

Research Communication

Productivity and profitability of seed *dhaincha (Sesbania cannabina)* + relay yard long bean (*Vigna unguiculata* subsp. sesquipedalis) under different date of planting and row spacing

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Received: December 2020; Revised accepted: March 2021

ABSTRACT

A field experiment was conducted at Bhubaneswar, Odisha, during the rainy (*kharif*) 2019 and winter (*rabi*) season 2019–20, to study the effect of date of planting and row spacing on the performance of seed *dhaincha* [*Sesbania cannabina* (Retz.) Pers.] and relay yard long bean [*Vigna unguiculata* subsp. *Sequipedalis (*L.) Verdc.]. The treatments comprising 5 dates of planting of *dhaincha,* viz. onset of monsoon (13 June), and one (20 June), two (27 June), three (4 July) and four (11 July) week(s) after onset of the monsoon, and 3 row spacing, viz. 80, 120 and 160 cm, giving rise to 15 treatment combinations, were tried in split-plot design with 3 replications. The dates of planting and row spacings were allocated to the main and the sub plots, respectively. Yard long bean (*bodi*) was planted as relay crop after the first picking and before final harvesting of *dhaincha.* Planting *dhaincha* on 13 June at row spacing of 80 cm resulted in the maximum seed yield of 1.27 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 yield. Planting of yard long bean on 5 October at row spacing of 80 cm gave the maximum fresh pod yield of 2.83 t/ha and planting on 5 October at row spacing of 120 cm and planting on 12 October at row spacing of 80 and 120 cm exhibited statistically similar fresh pod yield. Planting *dhaincha* on 13 June and relay yard long bean on 5 October at the closest row spacing of 80 cm resulted in the maximum system productivity (*dhaincha* seed-equivalent yield) of 3.06 t/ha, the maximum gross return of 192.68 × 10^3 ₹/ha and the maximum net return of 96.17 × 10^3₹/ha. All combinations of 2 earliest date of planting (13 and 20 June) and the closest and the moderate row spacing (80 cm and 120 cm) remained at par for these productivity and profitability indices.

Keywords : Phenology, System productivity, System profitability, Gross return, Net return

Among various *in-situ* green manuring crops, *dhaincha* is the most important one in rice ecosystem. The pre-rice fallow period of 45–60 days can very well be used for raising fast-growing *Sesbania cannabina*. Green-manuring with *dhaincha* in rice increases productivity of rice–wheat cropping system (Singh and Sharma, 2002). Of the various factors influencing seed production of *dhaincha*, optimum time of sowing is the most important aspect for obtaining higher seed yields. Early-sown seed *dhaincha* grown in the rainy (*kharif*) season is subjected to viviparous germination, if pod ripening coincides with rainfall. Sometimes, seed drying becomes a problem due to humid weather leading to loss in seed quality. In late-planted crop, seed filling is affected due to moisture stress. In this scenario, there is a need for deciding the optimum sowing window for *dhaincha* as *a* seed crop. Kumar *et al*. (2006) reported the maximum seed yield from *dhaincha* sown on 20 June.

Optimum spacing is also one of the major factors in exploiting the fullest potentiality of a plant. Optimum plant population facilitates utilization of available moisture and nutrients from the soil more effectively that leads to better dry-matter production and seed yield. Higher plant population causes overcrowding and mutual shading of plants while lower plant density results in suboptimal utilization of available resources, particularly sunlight. Consequently, in both the cases, seed yield per unit area decreases. Yaragoppa *et al.* (2003) reported increase in seed yield of *dhaincha* with the increase in plant density from 20,000 to

Based on a part of M.Sc. thesis of the first author, submitted to Odisha University of Agriculture and Technology, Bhubaneswar, in 2020 (unpublished)

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40,000 plants/ha at Raichur, Karnataka. Rajesh *et al*. (2017) at Killikulam, Tamil Nadu, reported higher yield attributes and seed yield at spacing of 120 cm × 30 cm compared to 120 cm × 20 cm, 90 cm × 30 cm and 90 cm × 20 cm.

After plucking of the matured pods of *dhaincha* for seed, sufficient plant biomass in the form of anchored plants (sticks) are left behind on the ground. Some trailing vegetables like yard long bean (*bodi jhudunga*) can be raised with the available soil moisture, off season rainfall or supplemental irrigation. Yard long bean provides vegetable during lean season. It can be planted as a relay crop before final harvest of *dhaincha*. *Dhaincha*, being a tall-stature crop, its anchored sticks act as effective staking material. Seed *dhaincha* and relay yard long bean will be a remunerative cropping system in uplands of Odisha. As information on agro-techniques like optimum time of planting and row spacing for the system are very meager, an experiment was conducted to assess the effects of these two factors on system productivity and economics.

The experiment was conducted at Agronomy Research Farm, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India. Bhubaneswar is situated at about 64 km away from the Bay of Bengal at 20^{O} 15'N and 85^{O} 52'E with an altitude of 25.9 m above the mean sea-level. The soil of the experimental site was sandy loam, acidic (*p*H 5.5) with low organic carbon (0.43%), low available nitrogen (193.75 kg/ha), high available P (28.84 kg/ha) and medium available K (124.59 kg/ha). The treatments comprised 5 dates of planting of *dhaincha* allocated to main plots, viz. D_1, onset of monsoon; D_2, 1 week after onset of monsoon; D_3, 2 weeks after onset of monsoon; D_4, 3 weeks after onset of monsoon; and D_5, 4 weeks after onset of monsoon, and 3 row spacings allotted to subplots, viz. S_1, 80 cm; S_2, 120 cm; and S_3, 160 cm, were tried in split-plot design with 3 replications. The plot size was 4.8 m × 3 m. The crop was fertilized with 20, 40 and 20 N, P_2O_5 and K_2O kg/ha. *Dhaincha* was sown first on 13 June 2019 after onset of monsoon and the subsequent sowings were made at 1 week intervals on 20 June, 27 June, 4 July and 11 July 2019 at row-to-row spacing as per treatment specifications. Thinning was done at 15 days after sowing by removing excess seedlings to maintain plant-to-plant spacing of 30 cm in the row. Plant-protection measures were adopted against cowbug or tree hopper (*Oxyrachis tarandus*) and aphid towards the end of August coinciding with flowering stage of the crop. Fully matured pods were harvested from net plot area in 2–3 phases to avoid shattering losses. After final plucking, the pods were threshed after sun drying.

Yard long bean cv. 'Savita' was planted as a relay crop after the first picking of matured pods and before the final harvesting of *dhaincha.* Planting was done by soil working and preparing furrows beside rows of *dhaincha*. The first planting was done on 5 October and the subsequent plantings were done at weekly intervals, i.e. on 12 October, 19 October, 26 October and 2 November 2019. Seeds of yard long bean were planted with plant-to-plant distance of 30 cm. The crop was raised with uniform fertilizer dose of 25, 50 and 25 N, P_2O_5 and K_2O kg/ha and farmyard manure @ 5 t/ha. The fertilizer was applied in 3 splits, viz. 20% N + 100% P_2O_5 + 50% K_2O as basal, 40% N at 15 DAP and 40% N + 50% K_2O at 30 DAP. Fresh pods were plucked plot-wise at marketable size in phases and were expressed as t/ha.

Phenological events were recorded from 10 tagged

Table 1. Effect of date of planting and row spacing on phenology, growth parameters and yield attributes of *dhaincha* at harvesting time

Treatment	Days to 50% flowering	Days to 1st picking	Plant height (cm)	Primary branches/ plant	Horizontal spread (cm)	Drymatter production (t/ha)	Pod/ plant	Seeds/ pod	Test weight (g)
Date of sowing									
13 June 2019	55.9	115.0	252.9	21.2	135.3	9.44	64.5	32.3	17.68
20 June 2019	55.2	113.8	249.8	20.7	125.2	9.22	63.7	31.2	17.49
27 June 2019	53.3	111.7	250.1	15.4	115.5	7.77	61.0	29.7	17.31
4 July 2019	51.6	107.3	247.8	15.2	113.0	5.38	52.9	29.2	15.34
11 July 2019	50.3	106.0	245.9	15.1	108.3	5.27	50.5	29.2	14.44
SEm±	0.5	0.5	4.1	0.4	5.6	0.28	1.0	0.4	0.09
CD (P=0.05)	1.6	1.6	NS	1.3	18.4	0.91	3.4	1.2	0.28
Row spacing									
80 cm	53.2	110.5	259.5	15.9	115.0	8.19	56.6	29.6	16.29
120 cm	53.4	110.9	249.2	17.6	120.2	7.36	58.4	29.5	16.38
160 cm	53.2	110.9	239.2	19.1	123.3	6.70	60.6	31.9	16.67
SEm±	0.3	0.5	1.9	0.3	1.9	0.21	0.5	0.6	0.15
CD P=0.05)	NS	NS	5.7	0.9	5.7	0.61	1.3	1.7	NS

plants/plot and days to attainment of phenophases were calculated. The system yield was expressed as *dhaincha* seed-equivalent yield (DSEY), where the DSEY (t/ha) of yard long bean was calculated as:

DSEY = (Yb. Pb/Pd)

Where Yb is the economic yield of relay yard long bean (t/ha), Pb is the price of relay yard long bean (₹/t) and Pd is the price of *dhaincha* seed (₹/t).

The price of *dhaincha* seed was ₹62,940/t, and of fresh pod of yard long bean ₹40,000/t. The system-equivalent yield was computed by adding DSEY of yard long bean with *dhaincha* seed yield for each plot.

Days to attainment of phenophases, viz. 50% flowering and first picking in *dhaincha,* decreased with the delay in planting (Table 1). Both date of planting and row spacing exerted significant influence on plant height. Plant height decreased with delay in planting, while early planting ensured better crop establishment and seedling vigour. Our results confirm the findings of Kumar *et al*. (2006). Early-sown crop tolerated excess rainfall at later stages. The emergence and growth of late-sown *dhaincha* was affected. Among the row spacings, the closest spacing of 80 cm resulted in the maximum plant height. This was due to keenest competition among plants for light at the closest row spacing. Furthermore, the competition for light becomes severe in the *kharif* season. Taller plants at closer spacings were also reported by Parlawar *et al.* (2001) and Yaragoppa *et al*. (2003) in *dhaincha,* and Lamani *et al*. (2004) in sunnhemp.

Branches/plant showed decreasing trend with delay in planting. More branches/plant with earlier planting in *dhaincha* was also reported by Kumar *et al*. (2006). The widest row spacing recorded the maximum branches/plant and the number decreased with decrease in row spacing. This corroborates the findings of Parlawar *et al*. (2001) and Sangeetha *et al*. (2011) in *dhaincha.* Higher horizontal spread was recorded with earlier planting and wider row spacing. The row spacings of 80, 120 and 160 cm resulted in 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 under-utilization of row spacing at 160-cm-row spacing. Both date of planting and row spacing influenced dry-matter production significantly. Higher dry-matter production was recorded with earlier planting and close spacing. Early planting provided congenial weather conditions for crop emergence, establishment and growth. Although the widest row spacing resulted in the maximum branches/plant and horizontal spread the closest row spacing recorded the maximum dry-matter production owing to the maximum plant density. Sangeetha *et al.* (2011) reported higher dry-matter production in *dhaincha* with closer spacing.

Planting time and row spacing influenced pods/plant in *dhaincha* significantly. The earliest date of planting (13 June) resulted in the maximum of 64.5 pods/plant, while the second date of planting recorded statistically similar pods/plant and further delay in planting decreased pods/plant significantly. Early planting promoted more branches/plant, better vertical growth and higher biomass production that resulted in production of more pods/plant. Higher pods/plant with early planting was reported earlier by Ulemale *et al*. (2002) in sunnhemp at Akola and Kumar *et al*. (2006) in *dhaincha.* Among the 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 nutri-

Table 2. Effect of date of planting and row spacing on phenology and yield attributes of yard long bean

Treatment	Days to 50% flowering	Days to 1st picking of fresh pods	Pod length (cm)	Pods/plant	Single pod weight (g)
Date of planting					
5 October	45.6	55.0	46.7	4.9	21.8
12 October	44.9	54.9	42.8	4.9	21.4
19 October	43.4	53.9	33.1	4.3	20.7
26 October	42.2	52.9	29.3	3.2	17.3
2 November	40.9	51.8	29.1	2.2	16.4
SEm±	0.3	0.5	0.7	0.1	0.4
CD (P=0.05)	1.1	1.5	2.2	0.2	1.4
Row spacing (cm)					
80 cm	43.6	53.5	35.1	3.5	18.6
120 cm	42.8	54.1	36.4	3.8	19.1
160 cm	43.8	53.5	37.1	4.4	20.9
SEm±	0.4	0.3	0.3	0.1	0.2
CD (P=0.05)	NS	NS	0.9	0.2	0.6

ent, light, moisture and space decreased performance of individual plants. Increase in pods/plant with decrease in plant population or increase in spacing was reported earlier by Yaragoppa *et al*. (2003) in *dhaincha* at Raichur, Karnataka; Lamani *et al*. (2004) in sunnhemp at Bailhongal, Karnataka and Shastri *et al*. (2007) in sunnhemp at Dharwad and Sangeetha *et al*. (2011) in *dhaincha.* Both factors influenced seeds/pod significantly. *Dhaincha* planted at the earliest showed 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 withdrawal of monsoon. The widest row spacing recorded the maximum seeds/pod. Parlawar *et al*. (2001) reported increase in seeds/pod with increase in spacing in *dhaincha* and Ulemale *et al.* (2002) in sunnhemp and Kumar *et al.* (2006) in *dhaincha.* Only date of planting influenced the test weight (1,000-seed weight) significantly. The earliest date of planting resulted in the heaviest seeds, while delay in planting decreased the test weight significantly. The early planting ensured supply of sufficient soil moisture

Table 3. Effect of date of planting and row spacing on system productivity

Treatments	Row spacing (cm)			Mean
	80	120	160	
Date of planting				
		Seed yield of dhaincha (t/ha)		
13 June	1.271	1.030	0.788	1.030
20 June	1.176	1.079	0.703	0.986
27 June	0.913	0.825	0.675	0.804
4 July	0.726	0.617	0.505	0.616
11 July	0.712	0.599	0.490	0.601
Mean	0.959	0.830	0.632	0.807
SEm±		D = 0.017, S = 0.012, D × S=0.084,		S × D = 0.028
CD (P=0.05)		D = 0.054, S = 0.037, D S = 0.258,		S × D = 0.082
		Fresh pod yield of yard long bean (t/ha)		
5 October	2.831	2.484	2.136	2.484
12 October	2.694	2.555	2.014	2.421
19 October	2.315	1.889	1.973	2.059
26 October	2.046	1.890	1.728	1.888
2 November	2.026	1.863	1.707	1.865
Mean	2.382	2.136	1.911	2.143
SEm±		D = 0.024, S = 0.018, D × S = 0.122, S × D = 0.040		
CD (P=0.05)		D = 0.078, S = 0.053, D × S = 0.372, S × D = 0.118		
		Dhaincha seed-equivalent yield of yard long bean (t/ha)		
5 October	1.791	1.580	1.358	1.576
12 October	1.714	1.625	1.281	1.540
19 October	1.473	1.201	1.255	1.310
26 October	1.301	1.202	1.099	1.201
2 November	1.288	1.185	1.085	1.186
Mean	1.513	1.359	1.216	1.363
SEm±		D = 0.016, S = 0.011, D × S = 0.080, S × D = 0.026		
CD (P=0.05)		D = 0.054, S = 0.034, D × S = 0.245, S × D = 0.076		
		System dhaincha seed-equivalent yield (t/ha)		
13 June (Dh)–5 October (YLB)	3.061	2.610	2.146	2.606
20 June (Dh)–12 October (YLB)	2.889	2.704	1.984	2.526
27 June (Dh)–19 October (YLB)	2.385	2.026	1.930	2.114
4 July (Dh)–26 October (YLB)	2.027	1.819	1.604	1.817
11 July (Dh)–2 November (YLB)	2.000	1.784	1.576	1.787
Mean	2.473	2.189	1.848	2.170
SEm±		D = 0.033, S = 0.024, D × S = 0.164, S × D = 0.053		
CD (P=0.05)		D = 0.108, S = 0.070, D × S = 0.502, S × D = 0.157		

D, date of planting; S, row spacing, D × S, date in same or different level of row spacing; S × D, row spacing in same level of date. Dh, *dhaincha*; YLB, yard long bean; price of *dhaincha* seed (₹/t), ₹62,940; price of fresh pod (₹/t), ₹40,000

during seed filling due to monsoonal rain. The findings are in agreement with Yadav (2003) on cowpea with early sowing. The widest row spacing of 160 cm recorded the maximum test weight of seeds and the values decreased with the decrease in row spacing. But the differences were not statistically significant. Similar findings were reported earlier by Parlawar *et al.* (2001) in cowpea, Kumar *et al*. (2006) in *dhaincha;* Devi and Rao (2007) in cowpea; Shoeran and Rana (2007) in forage cowpea and Chaudhary *et al*. (2013) in *dhaincha.* The mean test weight was 16.45 g. The present result confirmed the values reported by Chanda *et al*. (2019) in respect of seeds of *Sesbania cannabina*.

Yard long bean planted on 5 October came to flowering and 1st picking stage after 45.6 and 55 days after planting (DAP), being at par with 12 October planting (Table 2). Both date of planting and row spacing influenced pod length of yard long bean significantly. The earliest date of planting recorded the maximum pod length of 46.7 cm. Delay in planting decreased the pod length significantly. As yard long bean is a warm=season vegetable, delay in planting led to coincidence of growth and development with period of low temperature. Better growth under early planting resulted in longer pods. Among row spacings, the widest row spacing recorded the maximum pod length. Both factors influenced the pods/plant significantly. Yard long bean planted on 5 October produced the maximum pods/plant, while 12 October planting resulted in statistically similar pods/plant. These 2 planting dates provided required warm environment for growth and development of the crop. In subsequent dates, crop growth coincided with period of low temperature. The widest row spacing (160 cm) resulted in the maximum pods/plant owing to optimum growth of plants and trapping of adequate amount of resources. Both factors influenced single pod weight of yard long bean significantly. Planting the crop on 5 October produced the heaviest pod (21.8 g/pod). Subsequent 2 dates resulted in statistically similar pod weight, while further delay in planting reduced single pod weight due to unsuitable weather-condition for this warm-season crop. Among row spacings, the widest row spacing recorded the heaviest pods.

Interaction effects of both factors on seed yield of *dhaincha* were significant (Table 3). Planting *dhaincha* on 13 June at row spacing of 80 cm gave the maximum seed yield, while its planting on 13 June at row spacing of 120 cm and on 20 June at row spacing of 80 cm or 120 cm recorded statistically similar seed yield/ha. In all the 5 dates of planting, seed yield decreased with the increase in row spacing. Planting yard long bean on 5 October at row spacing of 80 cm recorded the maximum fresh pod yield of 2.831 t/ha and planting on 5 October at row spacing of 120 cm and on 12 October at row spacing of 80 cm or 120 cm recorded statistically similar fresh pod yield/ha. The interaction effects of both the factors on DSEY/ha exhibited exactly the similar trend as the yield of component crops.

Table 4. Effect of date of planting and row spacing on system production economics

Particulars	Row spacing (cm)			Mean
	80	120	160	
Date of planting				
		Gross return (×10³ ₹/ha)		
13 June (Dh)–5 October (YLB)	192.68	164.27	135.09	164.01
20 June (Dh)–12 October (YLB)	181.86	170.19	124.90	158.98
27 June (Dh)–19 October (YLB)	150.13	127.53	121.47	133.05
4 July (Dh)–26 October (YLB)	127.58	114.51	100.97	114.35
13 July (Dh)–2 November (YLB)	125.90	112.30	99.18	112.46
Mean	155.63	137.76	116.32	136.57
SEm±		D = 2.08, S = 1.50, D × S = 10.31, S × D = 3.35		
CD (P=0.05)		D = 6.78, S = 4.42, D × S = 31.59, S × D = 9.89		
		Net returns (×10³ /ha)		
13 June (Dh)–5 October (YLB)	96.17	74.76	79.74	83.55
20 June (Dh)–12 October (YLB)	95.21	72.48	62.01	76.56
27 June (Dh)–19 October (YLB)	67.78	50.46	56.12	58.12
4 July (Dh)–26 October (YLB)	54.47	45.19	45.78	48.48
11 July (Dh)–2 November (YLB)	56.94	46.75	32.75	45.48
Mean	74.11	57.93	55.28	62.44
SEm±		D = 1.65, S = 1.02, D × S = 7.45, S × D = 2.27		
CD (P=0.05)		D = 5.37, S = 3.00, D × S = 22.99, S × D = 6.71		

D, Date of planting; S, row spacing; D × S, date in same or different level of row spacing; S × D, row spacing in same level of date; *Dh, dhaincha*; YLB, yard long bean

Dhaincha and yard long bean planted on the earliest 2 dates at row spacing of 80 and 120 cm recorded statistically similar DSEY.

Interaction effects of both the factors on system gross and net returns were significant and the earliest date of planting of both the crops at row spacing of 80 cm recorded the maximum system gross and net returns of ₹192.68 × 10^3 and ₹96.17 × 10^3/ha, respectively (Table 4). Planting *dhaincha* on 13 and 20 June and yard long bean on 5 and 12 October at row spacing of 80 and 120 cm recorded statistically similar system gross return/ha. Planting *dhaincha* on 13 June and yard long bean on 5 October at all row spacings and *dhaincha* on 20 June and yard long bean on 12 October at row spacing of 80 cm recorded statistically similar system net return.

Thus, it can be concluded that planting of seed *dhaincha* on 13 or 20 June and yard long bean on 5 or 12 October at row spacing of 80 or 120 cm resulted in the maximum productivity and profitability from *dhaincha* + yard long bean relay cropping system under upland conditions of Odisha.

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