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Effect of varieties and spacing on growth and yield of Soya bean [*Glycine max* (L.) Merrill] in Bishnupur district of Manipur

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Abstract
A field experiment was conducted at the Agricultural Research Farm of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Bishnupur, Utlou, Manipur to study the effect of varieties and spacing on growth, yield and yield attributes of Soya bean [*Glycine max* (L.) Merrill]. The results revealed that the growth attributes increased with higher planting space *i.e.* (45 cm x 15 cm) for all the growth stages. The variety JS-335 was found most effective compare to other varieties. The treatment V_1S_3 with variety JS - 335 and spacing 45 cm x 15 cm recorded maximum plant height, number of branches, for all the growth stages *i.e.* at 30, 45, 60 DAS and at maturity. The different planting spaces and varieties significantly enhanced the yield and yield attributes of soya bean. The treatment V_1S_3 with variety JS-335 and spacing of 45 cm x 15 cm gave the maximum grain yield (1822.66 kg/ha), stover yield (2528.33 kg/ha) and followed by treatment V_1S_2 (JS - 335 + 45 cm x10 cm). The highest gross return (₹ 91133), net return (₹ 55489) and benefit-cost ratio (2.55) were obtained from the treatment V_1S_3.

Keywords: Soya bean, varieties, spacing, growth, yield

Introduction
Soya bean [*Glycine max* (L.) Merrill] is one of the important legume crops and also known as the "Golden bean" of the 21st century. It accounts for more than 50 % of oilseed produced and 30 % of the total supply of all vegetable oils. It is cultivated for its fine taste and high nutritional value as source of protein, vitamins, minerals, energy (582 K. cal/100g) and fibre (1.9 %). As it contains about 20 % oils and 40 to 42 % protein and essential amino acid like lysine, *glycine*, and tryptophan. Soya bean has the capacity to fix soil atmospheric nitrogen by a symbiotic relationship with the bacterium *rhizobium* present in the root nodules and it has capable of transforming about 60-100 kg atmospheric nitrogen into 30-40 kg nitrogen in the soil. Apart from its high nutritive value, it has manifold uses in agriculture, *i.e.* soybean adds large amount of organic matter in soil and thereby improving physicochemical and biological properties of soil and resulting in significant improvement in productivity. Soya bean plays a vital role in agricultural economy of India. It accounts for more than 6.50 million ha cultivated area, with a production of more than 7 million tones with an average productivity 1,070 kg/ha^{-1} (Patil *et al*., 2010) [13].

Manipur is a unique state regarding agriculture and its allied activities as the major agricultural areas falls within the oblong land strip starting from north with a gradual tilt towards south. Manipur is one of the important soybean growing states in North-Eastern Hill region, the area, production and productivity of soybean are very negligible and remain almost static during last five years. The production of soybean in Manipur was 1.94 Mt in 2010-2011 (Department of Agriculture, Government of Manipur). The consumption of soybean in the state is still very low. Soybean is also major oilseed crop of Manipur that boosted the economy of the state (Raj *et al.*, 2014) [15]. Traditionally, it is consumed as fermented alkaline food "Hawaijar". Small-seeded local variety soybean grown in the hilly terraces of Manipur is used to prepare Hawaijar (Tamang, 2015) [17].

Varietal adaptation and sub-optimum plants stands are the important factors, which are generally associated with the low productivity. The newly released varieties due to their high yield potential and other advantages like early maturity, free from shattering habits, tolerances for disease and insect pest are main reason for good productivity of new varieties.

Optimum number of plants is required per unit area to utilize efficiently the available production factor such as water, nutrients, light and CO_2, maximum exploitation of this factor is achieved when the plant population puts forth maximum pressure on all the factors of production. As a result, individual plants are put under severe stress because of inter and intra plant competition. Normally maximum yield are obtained from plant population, which do not allow plants to achieve their individual maximum potential.

Spacing is also one of the important parameter, which ultimately affected nutrients uptake, growth and yield of plant. Increase in spacing, the total population decrease, but with more nutrition the individual plant grow better and get more yield and vice-versa. The increase or decrease of row spacing's and plant population has definite pattern in relation to the yield. In these simultaneous opposing effects of the two components there should be a point where maximum yield is expected and that should be at the optimum spacing. Among various agronomic yield limiting factors, planting pattern is considered of great importance. Lone *et al*. (2009) [7] stated that the optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro - climatic conditions. Keeping the above facts in view, an investigation was carried out to find out the effect of varieties and spacing on growth, yield and yield attributes of Soya bean [*Glycine max* (L.) Merrill].

Materials and Methods

A field experiment entitled "Effect of varieties and spacing on growth and yield of soyabean [*Glycine max* (L) Merrill]" was undertaken during the *kharif* season of 2018 at Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur, India. The experimental site is located at 24º43'54"N latitude and 93º51'31"S longitude with an altitude of 790 m above mean sea level. The physicochemical properties of the initial soil taken with the help of standard procedure were presented in Table 1. Soil texture was determined following (Bouyoucos, 1951**)** [4], pH and EC was estimated by Jackson (1973) [6], OC was estimated by Walkley and Black (1934) [20] available N, P and K was determined by Alkaline Potassium Permanganate method (Subbiah & Asija, 1956) [16], Bray and Kurtz No. 1 Method (Bray and Kurtz, 1945) and 1 N NH_4OAc (Jackson, 1973) [6] and the treatment detail of the experimental field was presented in Table 2.

Table 1: Mechanical and chemical analysis of soil

Soil characteristics	Interpretation
Textural class	Clay Soil
Sand (%)	23.8
Silt (%)	27.5
Clay (%)	48.7
pH	5.47
Electrical conductivity (EC 1:2.5) (dSm^{-1})	0.04
Organic Carbon (%)	1.00
Available N (kg N ha^{-1})	313.60
Available P (kg P_2O_5 ha^{-1})	47.17
Available K (kg K_2O ha^{-1})	268.80

Table 2: Treatment details of the experiment

Treatment	Treatment details (Variety + Spacing)	Symbols
T_1	JS-335 + 45 cm x5 cm	V_1S_1
T_2	JS-335 + 45 cm x10 cm	V_1S_2
T_3	JS-335 + 45 cm x 15 cm	V_1S_3
T_4	RKS-18 + 45 cm x5 cm	V_2S_1
T_5	RKS-18 + 45 cm x10 cm	V_2S_2
T_6	RKS-18 + 45 cm x 15 cm	V_2S_3
T_7	DS_b-19 + 45 cm x5 cm	V_3S_1
T_8	DS_b-19 + 45 cm x10 cm	V_3S_2
T_9	DS_b-19 + 45 cm x 15 cm	V_3S_3
T_{10}	MACS-1370 + 45 cm x5 cm	V_4S_1
T_{11}	MACS-1370 + 45 cm x10 cm	V_4S_2
T_{12}	MACS-1370 + 45 cm x 15 cm	V_4S_3

The experiment was laid out in FRBD with two factors *i.e.* Factor 1: Variety (V_1 - JS-335, V_2 - RKS-18, V_3 - DSb-19, V_4 - MACS-1370) and Factor 2: Spacing (S_1 – 45cm x 5 cm, S_2 – 45cm x 10 cm, S_3- 45cm x 15 cm) with 3 replications and 12 treatments. The seeds were sown in line with seed rate of 45 kg per ha. Biometric parameters namely plant height, number of branches per plant, root length, dry weight, root nodules per plant was recorded periodically at 30, 45, 60 days after sowing (DAS) and at maturity. Yield and yield attributing characters namely numbers of pods per plant, seeds per pods, 100 grain weight, grain yield (kg/ha), straw yield (kg/ha), biological yield (kg/ha), harvest index (%) were recorded at time of harvest. The economics of the different variety and spacing was also worked out. The data recorded for various characters were statistically analyzed by adopting the procedure of analysis of variance as per Gomez and Gomez (1984). Significance of the difference in the treatment effects were tested through "F" test and critical difference C.D. was calculated wherever the results were found significant.

Results and Discussion

Growth attributes

Perusal of data revealed that the growth attributes of different varieties and spacing of soya bean were significantly influenced (Table 3, Table 4, Table 5, Table 6 and Table 7). The growth attributes *i.e.* plant height, number of branches per plant, root length, dry weight per plant and number of root nodules per plant were highest for the variety (V_1) JS-335 followed by (V_2) RKS-18 and spacing (S_3) 45cm x 15 cm followed by (S_2) 45cm x 10 cm during 30, 45, 60 DAS and at maturity. The interaction of V_1S_3 (JS-335 + 45 cm x 15 cm) was found to highest for the growth attributes of soya bean followed by V_1S_2 (JS-335 + 45 cm x10 cm) during 30, 45, 60 DAS and at maturity. Significant enhancement in growth attributes under different varieties and spacing seems to be due to increase in cell division which results in rapid growth of plants. Variation in dry weight in varieties might be due to variation in overall growth and development of individual variety as it is also evident from various growth observations

like plant height and branches per plant discussed earlier in the chapter. The wider row spacing gave sufficient space, nutrients, moisture and sunlight for better overall development of individual plant results is good branching and more dry weight. Nodulation in variety is governed by certain genetic factors associated with micro climatic condition of soil in which plants grow, hence it varies from one variety to another. The less number of root nodules in respect of closer row spacing may be a resultant of competitive stress of various nutrients as well as for space congestion among plants at closer row spacing which restricted root development. Similar findings have been reported by Thakur and Vyas (2005) [18], Baghel and Singh (2009) [2], Malek *et al.* (2012) [8] and Patel and Mondal *et al.* (2014) [10] on soya bean.

Table 3: Effect of varieties and spacing on plant height (cm) of soya bean

Treatment	30DAS	45DAS	60DAS	Maturity
Varieties				
V_1	17.46	34.11	52.74	59.44
V_2	16.03	28.0..0	48.37	55.07
V_3	13.92	24.32	40.65	47.35
V_4	14.96	27.44	44.54	51.24
SE (m) ±	0.43	0.44	0.65	0.65
CD (0.05)	1.27	1.31	1.91	1.91
Spacing				
S_1	15.30	27.28	45.34	52.04
S_2	15.55	28.26	46.24	52.94
S_3	15.93	29.85	48.15	54.85
SE (m) ±	0.38	0.38	0.56	0.56
CD (0.05)	NS	1.13	1.66	1.65
Variety × Spacing				
V_1S_1	17.16	32.23	51.92	58.62
V_1S_2	17.40	34.06	52.29	58.99
V_1S_3	17.83	36.03	54.03	60.73
V_2S_1	15.83	27.63	47.03	53.73
V_2S_2	15.96	27.43	48.00	54.70
V_2S_3	16.30	28.93	50.10	56.80
V_3S_1	13.76	23.13	39.22	45.92
V_3S_2	13.80	24.56	40.46	47.16
V_3S_3	14.20	25.26	42.26	48.96
V_4S_1	14.43	26.13	43.20	49.90
V_4S_2	15.06	27.00	44.20	50.90
V_4S_3	15.40	29.00	46.23	2.93
SE (m) ±	0.748	0.765	1.123	1.123
CD (0.05)	NS	NS	NS	NS

Table 4: Effect of varieties and spacing on number of branches per plant of Soya bean

Treatment	30DAS	45DAS	60DAS	Maturity
Varieties				
V_1	2.16	3.74	5.01	5.17
V_2	1.09	2.74	4.22	4.38
V_3	1.05	2.02	3.01	3.26
V_4	1.79	2.43	3.06	3.76
SE (m) ±	0.039	0.05	0.055	0.055
CD (0.05)	0.115	0.147	0.162	0.162
Spacing				
S_1	1.73	2.66	3.79	3.95
S_2	1.80	2.78	3.97	4.13
S_3	1.88	2.09	4.19	4.35
SE (m) ±	0.034	0.043	0.047	0.047
CD (0.05)	0.100	0.127	0.140	0.140
Variety × Spacing				
V_1S_1	1.93	3.53	4.83	4.99
V_1S_2	2.03	3.73	5.06	5.22
V_1S_3	2.16	3.96	5.13	5.29
V_2S_1	1.86	2.60	3.93	4.09
V_2S_2	1.90	2.73	4.13	4.29
V_2S_3	1.93	2.90	4.60	4.76
V_3S_1	1.40	2.16	3.03	3.19
V_3S_2	1.50	2.20	3.10	3.26
V_3S_3	1.60	2.23	3.16	3.32
V_4S_1	1.73	2.33	3.36	3.52
V_4S_2	1.80	2.46	3.56	3.72
V_4S_3	1.83	2.50	3.86	4.02

SE (m) ±	0.067	0.086	0.095	0.095
CD (0.05)	NS	NS	NS	NS

Table 5: Effect of varieties and spacing on root length (cm) of soya bean

Treatment	30DAS	45DAS	60DAS	Maturity
Varieties				
V_1	10.49	15.36	16.48	16.83
V_2	10.03	14.12	14.78	15.31
V_3	9.32	13.03	13.69	14.36
V_4	9.69	13.69	14.00	14.69
SE (m) ±	0.037	0.055	0.072	0.077
CD (0.05)	0.11	0.162	0.211	0.226
S_1	9.75	13.82	14.34	14.95
S_2	9.89	14.07	14.07	15.27
S_3	10.008	14.46	15.16	15.67
SE (m) ±	0.032	0.048	0.062	0.066
CD (0.05)	0.095	0.141	0.183	0.196
Variety × Spacing				
V_1S_1	10.43	14.83	15.66	16.06
V_1S_2	10.47	15.00	16.56	16.83
V_1S_3	10.57	16.23	17.20	17.60
V_2S_1	9.80	13.83	14.33	14.96
V_2S_2	10.06	14.13	14.53	15.23
V_2S_3	10.23	14.40	15.46	15.73
V_3S_1	9.20	13.03	13.50	14.30
V_3S_2	9.30	13.40	13.76	14.36
V_3S_3	9.46	13.46	13.80	14.40
V_4S_1	9.56	13.56	13.86	14.46
V_4S_2	9.73	13.73	13.93	14.66
V_4S_3	9.76	13.760	14.2	14.93
SE (m) ±	0.064	0.095	0.124	0.133
CD (0.05)	NS	0.281	0.366	0.391

Table 6: Effect of varieties and spacing on dry weight (g) of soya bean

Treatment	30DAS	45DAS	60DAS	Maturity
Varieties				
V_1	8.05	12.18	19.81	22.77
V_2	6.69	10.87	18.84	21.28
V_3	4.49	8.46	16.34	19.01
V_4	4.99	9.88	17.82	19.59
SE (m) ±	0.102	0.138	0.185	0.05
CD (0.05)	0.302	0.408	0.472	0.147
S_1	5.74	9.97	17.86	20.34
S_2	6.05	10.41	18.18	20.61
S_3	6.38	10.66	18.58	21.03
SE (m) ±	0.089	0.12	0.16	0.043
CD (0.05)	0.261	0.353	0.472	0.127
Variety × Spacing				
V_1S_1	7.46	11.80	18.07	22.23
V_1S_2	8.17	12.22	18.50	22.76
V_1S_3	8.50	12.50	18.80	23.30
V_2S_1	6.37	10.40	16.96	20.96
V_2S_2	6.64	10.95	17.46	21.16
V_2S_3	7.05	11.25	17.66	21.70
V_3S_1	4.26	7.99	15.83	18.90
V_3S_2	4.43	8.64	15.96	19.03
V_3S_3	4.77	8.75	16.16	19.10
V_4S_1	4.85	9.70	16.20	19.26
V_4S_2	4.94	9.82	16.50	19.50
V_4S_3	5.17	10.12	16.60	20.00
SE (m) ±	0.177	0.239	0.32	0.086
CD (0.05)	NS	NS	NS	0.255

Table 7: Effect of varieties and spacing on number of nodules per plant of soya bean

Treatment	30DAS	45DAS	60DAS
Varieties			
V_1	11.12	20.32	30.27
V_2	10.69	19.66	27.5
V_3	9.98	18.07	20.42
V_4	10.38	18.56	24.19
SE (m) ±	0.048	0.123	0.129
CD (0.05)	0.14	0.362	0.381
Spacing			
S_1	10.36	18.85	24.61
S_2	10.56	19.23	25.63
S_3	10.71	19.37	26.53
SE (m) ±	0.04	0.106	0.112
CD (0.05)	0.121	0.314	0.33
Variety × Spacing			
V_1S_1	6.09	13.02	23.03
V_1S_2	7.13	13.3	24.23
V_1S_3	7.33	13.46	25.26
V_2S_1	6.05	12.06	20.43
V_2S_2	6.07	12.86	21.53
V_2S_3	6.08	13.03	22.53
V_3S_1	5.06	10.07	13.65
V_3S_2	6.00	11.02	14.03
V_3S_3	6.02	11.03	15.03
V_4S_1	6.03	11.43	17.06
V_4S_2	6.36	11.56	18.46
V_4S_3	6.43	11.06	19.03
SE (m) ±	0.082	0.213	0.224
CD (0.05)	NS	NS	NS

Yield attributes

Significantly higher number of pods per plant, seeds per pod and test weight was recorded from the variety (V_1) JS-335 followed by (V_2) RKS-18 and spacing (S_3) 45 cm x 15 cm

followed by (S_2) 45 cm x 10 cm (Table 8). The interaction of V_1S_3 (JS-335 + 45 cm x 15 cm) was found to highest for the yield attributes of soya bean followed by V_1S_2 (JS-335 + 45 cm x10 cm). Significant variation in pods per plant may be correlated with the number of branches. Wider row spacing given the sufficient space of individual plant for better reproductive growth and increase the pod bearing ability because easily provide essential plant nutrients in this row spacing. These findings are in good lines with those achieved by Thakur and Vyas (2005) [18], Malek *et al.* (2012) [8], Rahman *et al.* (2013) [14] and Mondal *et al.* (2014) [10]. The enhancement in number of seeds per pod under different varieties and spacing seems to be due to the variation in seeds per pod among varieties which accounted for varietals inheritance. Similar findings are also reported by Billore *et al.* (2000) [3], Parmar and Nema (2002) [12] and Masum *et al.* (2013) [9]. The test weight was found to be non-significant.

Table 8: Effect of varieties and spacing on number of pods per plant, number of seeds per pod and test weight (g) of soya bean

Treatment	Number of pods per plant	Number of seeds per pod	Test weight
Varieties			
V_1	70.43	2.95	12.31
V_2	65.46	2.81	12.09
V_3	38.52	2.29	11.76
V_4	57.93	2.56	11.98
SE (m) ±	0.398	0.020	0.188
CD (0.05)	1.175	0.058	NS
Spacing			
S_1	54.73	2.57	12.003
S_2	58.34	2.67	12.04
S_3	61.18	2.73	12.07
SE (m) ±	0.345	0.017	0.163
CD (0.05)	1.018	0.050	NS
Variety × Spacing			
V_1S_1	68.13	2.93	12.30
V_1S_2	70.30	2.94	12.30
V_1S_3	72.85	2.99	12.33
V_2S_1	63.83	2.75	12.01
V_2S_2	65.33	2.81	12.11
V_2S_3	67.20	2.86	12.14
V_3S_1	34.25	2.10	11.73
V_3S_2	37.87	2.36	11.76
V_3S_3	43.43	2.41	11.78
V_4S_1	52.70	2.48	11.97
V_4S_2	59.86	2.56	11.98
V_4S_3	61.23	2.63	11.99
SE (m) ±	0.69	0.034	0.325
CD (0.05)	2.035	0.100	NS

Yield

The analyzed data regarding the yield of soya bean were significantly influenced by different variety and spacing (Table 9). The grain yield, stover yield and biological yield were highest for the variety (V_1) JS-335 followed by (V_2) RKS-18 and spacing (S_3) 45cm x 15 cm followed by (S_2) 45cm xc10 cm. The interaction of V_1S_3 (JS-335 + 45 cm x 15 cm) was found to highest for the yield of soya bean followed by V_1S_2 (JS-335 + 45 cm x10 cm).

The variation in grain yield (kg/ha) in varieties may be due to maximum number of root nodules per plant, pods per plant, grain yield per plant and better seed index. This favorable phenomenon resulted in higher yield. Similar findings have been reported by Rahman *et al.* (2013) [14] and Vyas and Khandwe (2014) [19]. Straw yield is function of vegetative growth which is governed by plant parameters like plant height, number of branches and plant population per unit area influenced these characters to a great extent. This favorable morphological phenomenon in this variety resulted significantly higher straw yield. The results are in corroboration with the findings of Pandya *et al.* (2005) [11] and Rahman *et al.* (2013) [14].

Table 9: Effect of varieties and spacing on grain yield (kg/ha), stover yield (kg/ha), biological yield (kg/ha) and harvest index (%) of soya bean

Treatment	Stover yield	Grain yield	Biological Yield	Harvest Index
Varieties				
V_1	2451.78	1714.22	4166.00	41.12
V_2	2269.22	1493.00	3762.22	39.70
V_3	1752.22	1248.89	3001.11	41.57
V_4	2029.00	1408.11	3437.11	40.99
SE (m) ±	12.473	13.464	15.052	0.346
CD (0.05)	36.818	39.743	44.432	1.022
Spacing				
S_1	2032.33	1393.67	3426.00	40.72
S_2	2139.00	1479.08	3618.08	40.90
S_3	2205.33	1525.42	3730.75	40.91
SE (m) ±	10.802	11.66	13.036	0.3
CD (0.05)	31.886	34.419	38.479	NS
Variety × Spacing				
V_1S_1	2386.33	1605.00	3991.33	40.21
V_1S_2	2440.66	1715.00	4155.66	41.27
V_1S_3	2528.33	1822.66	4351.00	41.88
V_2S_1	2193.00	1461.67	3654.66	39.99
V_2S_2	2240.00	1502.33	3742.33	40.15
V_2S_3	2374.66	1515.00	3889.66	38.95
V_3S_1	1647.00	1144.67	2791.66	40.93
V_3S_2	1796.00	1286.33	3082.33	41.73
V_3S_3	1813.66	1315.66	3129.33	42.04
V_4S_1	1903.00	1363.33	3266.33	41.73
V_4S_2	2079.33	1412.66	3492.00	40.45
V_4S_3	2104.66	1448.33	3553.00	40.76
SE (m) ±	21.604	23.32	26.071	0.6
CD (0.05)	63.771	68.838	76.958	NS

Economics

The total cost of cultivation was found to be ₹35643.92 (Table 10). The highest gross return *i.e.* ₹91133.33 was obtained from the treatment V_1S_3 (JS-335 + 45 cm x 15 cm) followed by treatment V_1S_2 (JS-335 + 45 cm x10 cm). The highest net income was obtained from the treatment V_1S_3 (JS-335 + 45 cm x 15 cm) (₹55489.41). Similar findings were also reported by Singh *et al.* (2019).

The increase in net return was due to increase in yield attributing character and grain yield of soya bean. The benefit-cost ratio (BCR) or return per rupee investment was found to be highest (2.55) for the treatments V_1S_3 (JS-335 + 45 cm x 15 cm) followed by treatment V_1S_2 (JS-335 + 45 cm x10 cm) and the lowest BCR (1.60) is obtained from the treatment V_3S_1 (DS_b-19 + 45 cm x5 cm). The results corroborate the findings of Vyas and Khandwe (2014) [19].

Table 10: Effect of varieties and spacing on cost of cultivation (₹), gross return (₹), and net return (₹) and benefit cost ratio of soya bean

Treatment	Cost of cultivation (₹)	Gross return (₹)	Net return (₹)	B:C ratio
V_1S_1	35643.92	80250	44606	2.25
V_1S_2	35643.92	85750	50106	2.40
V_1S_3	35643.92	91133	55489	2.55
V_2S_1	35643.92	73083	37439	2.05
V_2S_2	35643.92	75116	39472	2.10
V_2S_3	35643.92	75750	40106	2.12
V_3S_1	35643.92	57233	21589	1.60
V_3S_2	35643.92	64316	28672	1.80
V_3S_3	35643.92	65783	30139	1.84
V_4S_1	35643.92	68166	32522	1.91
V_4S_2	35643.92	70633	34989	1.98
V_4S_3	35643.92	72416	36772	2.03

Conclusion

Based on the results from the experiment it can be concluded that the effect of varieties and spacing of Soya bean [*Glycine max* (L) Merrill] significantly increases the growth, yield attributes and yield of Soya bean. The treatment V_1S_3 (JS-335 + 45 cm x 15 cm) was found most effect from all the other treatment in terms of growth, yield and yield attributes and economics. From this research outputs we can conclude that the variety *i.e.* JS-335 and spacing 45 cm x 15 cm may be helpful for farmers in Manipur region and other area in the near future making soya bean cultivation economically and viable.

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