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Effect of Dates of Sowing and Varieties on Growth and Yield of Cluster Bean [*Cyamopsis tetragonaloba* (L) Taub] under Rainfed Conditions

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Abstract

A study was conducted during the *kharif* season of 2023 at the School of Agricultural Sciences, Nagaland University (NU: SAS) to evaluate the performance and variability for growth and yield contributing characters of cluster bean against different dates of sowing and variety under the rainfed conditions. The experiment was conducted in Split Plot Design (SPD) with three replications. The treatment combination consisted of three dates of sowing (1st June, 1st July and 1st August) and five varieties (RGC-936, RGr-12-1, RGC-1017, RGC-1038 and RGC-1066). The results revealed that cluster bean growth and yield attributing characters were significantly affected by different dates of sowing and varieties, second date of sowing (1st July) recorded the highest growth and yield attributes at all the growth stages. Among the five varieties used, number of cluster plant^{-1} (17.59), number of pod cluster^{-1} (4.82) and pod length (7.78 cm) were higher in variety RGr-12-1. However, plant height (124.41 cm), number of green leaves plant^{-1} (42.05), number of pod plant^{1} (99.63) and test weight (25.51 gm) were maximum with the variety RGr-12-1. The variety (RGr-12-1) recorded the highest stalk yield (2820.72 kg ha^{1}) and grain yield (1044.22 kg ha^{1}) followed by variety RGC-1066 (2651.59 kg ha^{-1} and 982.27 kg ha^{-1}) respectively. After a comparative study of different sowing dates and varieties of cluster bean it was found that superior variety RGr-12-1 sown on 1st July was most suitable followed by 1st August date of sowing and variety RGC 1066 in rainfed condition of experimental site.

***Key words*:** Cluster bean, Date of sowing, Growth attributes, Varieties, Yield, Yield attributes

Cluster bean (*Cyamopsis tetragonoloba* L.) is predominantly cultivated in dry and semi-dry regions across India, Pakistan, South Africa, and the United States [1]. Cluster bean (*C. tetragonoloba*) belongs to tribe *Indigoferae* of family *Leguminosae*. Cluster bean commonly known as guar, is indeed an important crop, especially in dry regions. It plays a crucial role in agriculture due to its various applications and benefits, both as a cash crop and for its contributions to soil health. India is the world-leader for cluster bean production as it contributes 80% shares of its total production. Galactomannans is a polysaccharide that is derived from guar and known as guar gum [2]. Grain of cluster bean is made of germ (41-46%), endosperm (34-43%) and hull (13-18%) [3-4]. Cluster bean (guar) is a cash crop for its application in textile, paper, petroleum, mining, pharmaceuticals, explosives, and food industries [1]. Cluster bean is also a good source of fats, proteins, phosphorous, calcium, and mineral salts [5]. Cluster bean, being a leguminous crop, aids in the fixation of atmospheric nitrogen, thereby enhancing soil fertility [6].

India becomes the leading producer of gaur with 80 per cent of the world production followed by Pakistan with 35 per cent and remaining 5 per cent contributed by USA, Middle East and African countries. On the average at the National level guar is cultivated on about 2.96 million hectares of area and produces 1.22 million tonnes of guar seed in the country with average National productivity of 0.41 tons per hectare.

Sowing time affects the whole plant growth cycle including seed germination, seedling emergence, vegetative plant growth, flowering, pod formation, grain filling, and crop maturity. When crop is sown early, plants make its vegetative phase prolonged compared to reproductive phase depending upon atmospheric temperature and rainfall of area. But when the crop is sown late, flowering comes earlier and plants could not complete their normal vegetative phase [7]. The increase in temperature accelerates the phenological cycle of plants [8], leading to a decline in crop yield of crop [9]. Therefore, cluster bean production is directly related to the annual rainfall, temperature and humidity of area [10]. Different sowing times are practiced in different parts of the world.

The months of May and August are considered the best sowing time for yield purpose in Pakistan, while in the Mediterranean environment of Italy, mid-May is considered most beneficial to obtain a higher yield [11]. Late sowing of cluster bean after 15th July caused the reduction in seed, straw, and biological yields compared to before 15th July sowing. Guar yield in our country is extremely low and has been static over

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the past several decades. This may probably be due to the fact that low and erratic distribution of rainfall, extreme temperatures coupled with very few investigations made for agronomic practices. Appropriate sowing time helps to more efficient use of water, sunshine hours and higher photosynthetic rates.

MATERIALS AND METHODS

The research entitled "Effect of dates of sowing and varieties on growth and yield of cluster bean [*Cyamopsis tetragonaloba* (L) Taub] under rainfed condition" was carried out in the experimental farm of School of Agricultural Sciences (SAS), Medziphema Campus, Nagaland University, during the *kharif* season of 2023. The experiment was conducted in the Agronomy Farm of NU: SAS, Medziphema, situated at an altitude of 310 meters above sea level with the geographical location at 25°45′43″ North latitude and 95°5′43″ East longitude. The climatic condition of the experimental farm lies in the sub humid tropical climatic zone with high humidity, moderate temperature and medium to high relative humidity, moderate temperature and medium to high rainfall. The average rainfall varies between 2000-2500 mm annually. The mean temperature ranges from 21 °C – 32 °C during summer and rarely goes below 8 °C in winter due to high atmospheric pressure. The soil condition of the experiment farm was found to be well drained and sandy loam in texture.

RESULTS AND DISCUSSION

Growth attributes

Sowing 1st July showed the highest plant population at 20, 40 and 60 DAS (31.72, 28.35 and 25.69) followed by 1st August and lowest found in 1st June of date of sowing (30.51, 26.40 and 23.67) at 20, 40 and 60 DAS respectively. In case of varieties also found significant influenced by the different varieties at 20, 40 and 60 DAS. Maximum plant population was found in variety V_2 (RGr-12-1) at 20, 40 and 60 DAS (33.62, 29.46 and 26.80) respectively, followed by V_5 (RGC 1066) and lowest plant population was observed in variety V_4 (RGC 1038) at 20, 40 and 60 DAS (28.47, 24.97 and 22.31) respectively, and similar result were also found in the works of Priyadarshini *et al.* [12]. The interaction effect date of sowing and varieties could not show any significant differences in terms of plant population at 20, 40 and 60 DAS. Different date of sowing showed significant differences in plant height at all growth stages. The tallest plant height in date of sowing 1st July showed at 20, 40, 60 DAS and at harvest (10.36, 21.33, 45.96 and 120.36) followed by 1st August and the lowest was found in 1st June of date of sowing (9.27, 19.51, 41.85 and 108.40) at 20, 40, 60 DAS and at harvest respectively. In case of varieties also found significant influenced by different varieties at 20, 40, 60 DAS and at harvest. Maximum plant height was found in variety V2 (RGr-12-1) at 20, 40, 60 DAS and at harvest (10.91, 23.14, 48.03 and 124.41) respectively, followed by V5 (RGC 1066) and lowest plant height was observed in variety V4 (RGC 1038) at 20, 40, 60 DAS and at harvest (9.41, 19.39, 42.59 and 110.31) respectively. The variance in plant height observed may be related to the availability of favourable conditions such as temperature, relative humidity and average rainfall in month of July. Deka *et al.* [13] observed the high rainfall and soil moisture content favors longer vegetative growth in sowing date of cluster bean in 1st July. Similar information revealed by [14] in response to vegetative growth. No significant differences were observed due to the interaction effect between sowing dates and varieties on plant height at all the growth stages.

Table 1 Effect of varieties and weed control methods on growth attributes of cluster bean

Treatments	Plant height (cm)				Plant population (m^{-2}) and number of tillers m^{-2} at 60 and 90 DAS			Number of green leaves $hill^{-1}$		
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
Date of Sowing										
D_1-1st June	9.27	19.51	41.85	108.40	30.51	26.40	23.67	7.35	17.07	35.52
D_2-1st July	10.36	21.33	45.96	120.36	31.72	28.35	25.69	8.37	20.07	41.74
D_3-1st August	10.18	20.97	45.57	115.36	30.83	27.01	24.35	8.21	19.02	39.55
SEm±	0.08	0.27	0.47	1.17	0.23	0.29	0.32	0.14	0.14	0.35
CD(P=0.05)	0.33	1.06	1.85	4.58	0.91	1.13	1.24	0.54	0.55	1.36
Varieties										
V_1-RGC 936	9.41	19.39	42.59	110.31	30.75	26.36	23.59		17.91	37.25
V_2- RGr-12-1	10.91	23.14	48.03	124.41	33.62	29.46	26.80	8.32	20.21	42.05
V_3-RGC 1017	9.94	20.49	43.48	112.64	30.85	27.35	24.69	8.16	18.85	39.22
V_4-RGC1038	9.33	19.21	42.54	107.94	28.47	24.97	22.31	7.53	17.25	35.86
V_5-RGC 1066	10.09	20.78	45.65	118.23	31.41	28.13	25.47	8.24	19.37	40.29
SEm±	1.02	0.94	1.29	1.70	2.36	2.54	2.60	0.61	1.77	3.68
CD(P=0.05)	2.95	2.71	3.73	4.90	30.75	26.36	23.59	7.62	17.91	37.25

Leaves are responsible for photosynthesis, the process by which plants convert light energy into chemical energy, for their growth and development. The result showed that sowing dates significantly influenced number of green leaves at all growth stages of cluster bean. Date of sowing 1st July showed highest number of green leaves per plant at 20, 40 and 60 days after sowing (8.37, 20.07 and 41.74) followed by 1st August and lowest found in 1st June of date of sowing (7.35, 17.07 and 35.52) at 20, 40 and 60 DAS respectively. In case of varieties also found significant influenced by different varieties at 20, 40 and 60 DAS. Maximum number of green leaves per plant was found in variety V_2 (RGr-12-1) at 20, 40 and 60 DAS (8.32, 20.21 and 42.05) respectively, followed by V_5 (RGC 1066) and lowest number of green leaves per plant was observed in variety V_4 (RGC 1038) at 20, 40 and 60 DAS (7.53, 17.25 and 35.86) respectively. This was further supported by notably higher crop growth rates during the later stages of development. Similar information revealed by [15] in response to vegetative growth. The interaction effects between the sowing dates and varieties could not showed any significant effect on number of green leaves at 20, 40 and 60 DAS. Dates of sowing showed a significant variance in crop growth rate at 20-40 and 40-60 DAS. It was evident from the data that the highest crop growth rate at 20-40 DAS (2.42 g m^{-2} day^{-1}) and 40-60 DAS (4.43 g m^{-}

^{2} day^{-1}) was recorded with sowing date 1st July compared to the other dates of sowing and lowest was found in 1st June date of sowing at 20-40 DAS (1.91 g m^{-2} day^{-1}) and 40-60 DAS (4.19 g m^{-2} day^{-1}). Different varieties showed significant influence on crop growth rate at 20-40 DAS and 40-60 DAS. Among the different varieties used the highest crop growth rate at 20-40 DAS (2.30 g m^{-2} day^{-1}) and 40-60 DAS (4.38 g m^{-2} day^{-1}) was recorded with the variety (V_2-RGr-12-1) and the lowest crop growth rate at 20-40 DAS (2.12 g m^{-2} day^{-1}) and 40-60 DAS (4.11 g m^{-2} day^{-1}) was recorded with the variety (V_1 RGC 936) at 20-40 DAS and 40-60 days after sowing (DAS). A significant decrease in growth parameters were observed due to early sowings. This might be due to favourable climatic conditions prevailed during the crop growth period by late sown crop when compared to early sowings. Among the different dates of sowing and varieties, a steady increased in CGR during the later stage of plant growth compared to initial intervals of crop growth stage and the similar result reported by Maurya *et al.* [16] and Buttar and Kaur [17]. There was no significant effect observed due to the interaction of sowing dates and varieties on crop growth rate at 20-40 and 40-60 days after sowing (DAS). It is evident from the data that highest relative growth rate at 20-40 DAS (0.072 g g^{-1} day^{-1}) and 40-60 DAS (0.060 g g^{-1} day^{-1}) was recorded with sowing date 1st July compared to the other dates of sowing and lowest was found in 1st June date of sowing at 20-40 DAS (0.049 g g^{-1} day^{-1}) and 40-60 DAS (0.037 g g^{-1} day^{-1}). Different varieties showed significant influence on relative growth rate at 20-40 DAS and 40-60 DAS. Among the different varieties used the highest relative growth rate at 20-40 DAS (0.079 g g^{-1} day^{-1}) and 40-60 DAS (0.068 g g^{-1} day^{-1}) was recorded with the variety (V_2-RGr-12-1) and the lowest crop growth rate at 20-40 DAS (0.039 g g^{-1} day^{-1}) and 40-60 DAS (0.028 g g^{-1} day^{-1}) was recorded with the variety (V_1 RGC 936) at 20-40 DAS and 40-60 DAS and the similar result reported by Maurya *et al.* [16] and Butter and Kaur [17]. The interaction effects between the sowing dates and varieties could not show any significant effect on relative growth rate at 20-40 and 40-60 DAS respectively.

Table 2 Effect of varieties and weed control methods growth attributes of cluster bean

Treatments	CGR (g m^{-2}day^{-1})		RGR (g g^{-1} day^{-1})		Days to 50% flowering	Days to maturity
	20-40 DAS	40-60 DAS	20-40 DAS	40-60 DAS		
Date of Sowing						
D_1-1st June	1.91	4.19	0.049	0.037	36.19	105.57
D_2-1st July	2.42	4.43	0.072	0.060	42.40	112.61
D_3-1st August	2.21	4.31	0.053	0.041	40.22	108.05
SEm±	0.14	0.07	0.003	0.006	0.35	0.96
CD(P=0.05)	0.43	0.20	0.009	0.020	1.39	3.76
Varieties						
V_1-RGC 936	2.12	4.11	0.039	0.028	37.92	104.10
V_2- RGr-12-1	2.30	4.38	0.079	0.068	42.72	117.82
V_3-RGC 1017	2.19	4.24	0.043	0.032	39.90	109.37
V_4-RGC1038	1.97	4.16	0.031	0.020	36.52	99.91
V_5-RGC 1066	2.21	4.30	0.052	0.041	40.95	112.53
SEm±	0.83	0.42	0.040	0.029	3.74	10.43
CD(P=0.05)	2.12	4.11	0.039	0.028	37.92	104.10

Table 3 Effect of varieties and weed control methods on growth attributes of cluster bean

Treatments	No. of cluster plant^{-1}	No. of pods cluster^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pod length (cm)	Test weight (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)
Date of Sowing									
D_1-1st June	14.59	3.74	55.07	5.40	6.48	20.75	884.25	2514.00	26.02
D_2-1st July	17.59	4.82	87.22	6.48	7.78	23.90	1003.57	2639.74	27.55
D_3-1st August	16.54	4.64	78.34	6.25	7.51	23.24	953.55	2603.19	26.81
SEm±	**0.14**	**0.08**	**1.89**	**0.18**	**0.10**	**0.31**	**8.09**	**22.09**	**0.46**
CD(P=0.05)	**0.56**	**0.33**	**7.41**	**0.71**	**0.41**	**1.20**	**31.76**	**86.71**	**NS**
Varieties									
V_1-RGC 936	15.43	3.87	61.17	5.56	6.67	21.22	903.17	2435.65	27.05
V_2- RGr-12-1	17.73	5.37	99.63	7.03	8.44	25.51	1044.22	2820.72	27.02
V_3-RGC 1017	16.38	4.41	72.67	6.03	7.23	22.58	926.66	2509.78	26.97
V_4-RGC1038	14.76	3.78	56.71	5.51	6.60	21.04	879.29	2405.46	26.77
V_5-RGC 1066	16.89	4.55	77.52	6.11	7.32	22.80	982.27	2651.59	27.03
SEm±	**0.53**	**0.18**	**5.48**	**0.32**	**0.29**	**0.87**	**31.77**	**86.73**	**0.78**
CD(P=0.05)	**1.55**	**0.51**	**15.98**	**0.95**	**0.83**	**2.54**	**92.72**	**253.11**	**NS**

Yield attributes and yield

The number of clusters per plant plays a significant role in yield attributes in cluster beans. Cluster beans typically produce multiple clusters of pods per plant and the number of clusters per plant can impact various yield attributes such as overall yield, pod size, pod number and seed yield. The maximum number of cluster per plant recorded in date of sowing 1st July (17.59) followed by 1st August and lowest found in 1st June date of sowing (14.59). In case of varieties also found significant influenced by different varieties. Maximum number of cluster per plant recorded in variety V_2-RGr-12-1 (17.73) followed by V_5-RGC 1066 and lowest number of cluster per plant was observed in variety V_4-RGC 1038 (15.43) at the harvest time of cluster bean. These results are in concurrence with the findings of those reported by Vir and Singh [18] and Kumar and Ram [19]. The number of pods per cluster profoundly impacts cluster bean yield serving as a crucial determinant of overall productivity. The maximum number of

pods per cluster recorded in date of sowing 1st July (4.82) followed by 1st August (4.64) and lowest found in 1st June date of sowing (3.74). Different variety also showed significant differences in number of pods per cluster at the harvest time. Maximum number of pods per cluster recorded in variety V_2-RGr-12-1 (5.37) followed by V_5-RGC 1066 and lowest number of pods per cluster was observed in variety V_4-RGC 1038 (3.87) at the harvest time of cluster bean [6]. The number of pods per plant is vital for seed yield in cluster beans directly impacting overall productivity. Variations in this parameter can arise from genetic differences among varieties, where certain cultivars are bred to produce more pods per plant. The maximum number of pods per plant recorded in date of sowing 1st July (87.22) followed by 1st August (78.34) and lowest found in 1st June date of sowing (55.07). In case of varieties also found significant influenced by different varieties. Maximum number of pods per plant recorded in variety V_2-RGr-12-1 (99.63) followed by V_5-RGC 1066 (77.52) and lowest number of pods per plant was observed in variety V_4-RGC 1038 (56.71) at the harvest time of cluster bean. The data pertaining to this trait are in accordance with the studies conducted by Anandhi and Oommen [20] and Jitender *et al.* [21].

Table 4 Interaction effect of date of sowing and varieties on growth attributes of cluster bean

Treatments	Plant population (m^{-2})			Plant height (cm)				Number green leaves $plant^{-1}$			Crop growth rate (g m^{-2} day)		Days to 50% flowering	Days to maturity
D × V	20	40	60	20	40	60	At harvest	20	40	60	20-40 DAS	40-60 DAS		
D_1V_1	30.93	24.76	21.77	8.33	17.17	39.81	103.17	6.80	16.00	33.30	6.80	16.00	33.99	98.99
D_1V_2	31.73	26.23	23.57	9.35	21.27	43.11	111.70	7.21	16.95	35.28	7.21	16.95	35.96	104.87
D_1V_3	30.58	27.08	24.42	9.73	20.05	41.68	107.99	7.87	17.50	36.42	7.87	17.50	37.10	108.29
D_1V_4	30.26	26.76	24.10	9.45	19.47	42.08	108.97	7.37	17.32	36.02	7.37	17.32	36.68	107.04
D_1V_5	30.67	27.17	24.51	9.51	19.59	42.55	110.20	7.48	17.58	36.56	7.48	17.58	37.22	108.68
D_2V_1	29.81	26.31	23.66	9.69	19.95	44.97	116.42	7.67	18.01	37.45	7.67	18.01	38.10	101.30
D_2V_2	36.51	33.01	30.35	12.59	25.93	53.55	145.35	9.04	23.24	48.34	9.04	23.24	49.01	132.02
D_2V_3	29.80	26.30	23.64	9.77	20.13	43.41	112.47	8.05	18.93	39.38	8.05	18.93	40.06	105.17
D_2V_4	29.98	26.48	23.82	9.85	20.29	43.79	113.41	8.11	19.06	39.64	8.11	19.06	40.30	105.91
D_2V_5	32.50	29.66	27.01	9.88	20.35	44.08	114.16	8.98	21.10	43.89	8.98	21.10	44.55	118.66
D_3V_1	31.50	28.00	25.34	10.22	21.05	42.99	111.35	8.39	19.72	41.01	8.39	19.72	41.67	112.01
D_3V_2	32.64	29.14	26.48	10.78	22.21	47.44	116.19	8.70	20.44	42.52	8.70	20.44	43.19	116.56
D_3V_3	32.17	28.67	26.01	10.33	21.29	45.34	117.47	8.56	20.13	41.87	8.56	20.13	42.55	114.65
D_3V_4	25.18	21.68	19.02	8.68	17.87	41.76	101.45	7.11	15.36	31.94	7.11	15.36	32.59	86.77
D_3V_5	31.06	27.56	24.90	10.88	22.41	50.33	130.34	8.27	19.43	40.42	8.27	19.43	41.08	110.24
SEm ±	1.40	1.50	1.54	0.56	1.17`	2.40	5.58	0.36	1.05	2.18	2.50	3.63	2.22	6.19
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5 Interaction effect of date of sowing and varieties on yield attributes and economics of cluster bean

Treatments	No. of cluster $plant^{-1}$	No. of pods $cluster^{-1}$	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Pod length (cm)	Test weight $(g)^{-1}$	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
D_1V_1	13.53	2.79	38.20	4.46	5.35	18.01	832.23	2272.0	18.01	23590	37450.38	13860.38	1.59
D_1V_2	14.48	3.81	55.46	5.48	6.57	20.97	917.27	2504.1	20.97	23590	41276.95	17686.95	1.75
D_1V_3	15.03	4.19	63.63	5.86	7.03	22.09	880.14	2402.8	22.09	23590	39606.09	16016.09	1.68
D_1V_4	14.84	3.91	58.08	5.58	6.69	21.26	889.67	2428.8	21.26	23590	40035.03	16445.03	1.70
D_1V_5	15.10	3.97	59.96	5.64	6.76	21.43	901.94	2462.3	21.43	23590	40587.37	16997.37	1.72
D_2V_1	15.52	4.15	64.51	5.81	7.17	22.43	963.83	2631.3	22.43	23590	43372.47	19782.47	1.84
D_2V_2	20.76	7.05	149.13	8.72	10.46	30.42	1253.48	3422.0	30.42	23590	56406.48	32816.48	2.39
D_2V_3	16.45	4.23	69.81	5.90	7.08	22.21	924.91	2525.0	22.21	23590	41620.78	18030.78	1.76
D_2V_4	16.58	4.31	71.58	5.98	6.97	21.95	934.05	2550.0	21.95	23590	42032.44	18442.44	1.78
D_2V_5	18.62	4.34	81.07	6.01	7.21	22.51	941.56	2570.5	22.51	23590	42370.40	18780.40	1.80
D_3V_1	17.23	4.68	80.80	6.25	7.50	23.21	913.45	2493.7	23.21	23590	41105.06	17515.06	1.74
D_3V_2	17.96	5.24	94.30	6.91	8.29	25.14	961.92	2626.0	25.14	23590	43286.19	19696.19	1.83
D_3V_3	17.65	4.79	84.58	6.33	7.59	23.45	974.93	2661.6	23.45	23590	43871.99	20281.99	1.86
D_3V_4	12.88	3.14	40.47	5.12	6.14	19.93	814.14	2222.6	19.93	23590	36636.51	13046.51	1.55
D_3V_5	16.95	5.34	91.53	6.67	8.01	24.46	1103.30	3012.0	24.46	23590	49648.48	26058.48	2.10
SEm ±	0.92	0.30	9.49	0.56	0.50	1.51	55.03	150.22	2.34				
CD (p=0.05)	NS	NS	NS	NS	NS	NS	179.45	489.91	NS				

The number of seeds per pod significantly impacts cluster bean yield as more number of seeds per pod directly enhance seed production per plant. The maximum number seeds per pods recorded in date of sowing 1st July (6.48) followed by 1st August (6.25) and the lowest was found in 1st June date of sowing (5.40). Different variety also showed significant differences in number seeds per pods at the harvest time. Maximum number seeds per pods recorded in variety V_2-RGr-12-1 (7.03) followed by V_5-RGC 1066 (6.11) and lowest number seeds per pods was observed in variety V_4-RGC 1038 (5.51) at the harvest time of cluster bean. Favorable climatic conditions, particularly during the reproductive phase, significantly contributed to the development of yield attributes. This was due to a positive sink-to-source ratio, which facilitated the translocation of assimilates to reproductive components. These findings are consistent with Patel *et al.* [22] and Vishal *et al.* [23]. Pod length is important for cluster bean yield as longer pods typically contain more number of seeds which is

directly enhancing yield. The maximum pod length recorded in date of sowing 1st July (7.78) followed by 1st August (7.51) and lowest found in 1st June date of sowing (6.48). In case of varieties also found significant influenced by different varieties. Maximum pod length recorded in variety V_2-RGr-12-1 (8.44) followed by V_5-RGC 1066 (7.32) and lowest pod length was observed in variety V_4-RGC 1038 (6.60) at the harvest time of cluster bean. These results were in conformity with the findings of Rai *et al*. [6]. Maximum test weight recorded in variety V_2-RGr-12-1 (25.51) followed by V_5-RGC 1066 (22.80) and lowest test weight was observed in variety V_4-RGC 1038 (21.04) at the harvest time of cluster bean. The data pertaining to this trait are in accordance with the studies conducted by Anandhi and Oommen [20] and Jitender *et al*. [21]. The seed yield of cluster bean is influenced by sowing dates and varieties as both factors impact the plant growth environment and genetic performance. The maximum seed yield recorded in date of sowing 1st July (1003.57) followed by 1st August (953.55) and lowest found in 1st June date of sowing (884.25). In case of varieties also found significant influenced by different varieties. Maximum seed yield recorded in variety V_2-RGr-12-1 (1044.22) followed by V_5-RGC 1066 (982.27) and lowest seed yield was observed in variety V_4-RGC 1038 (879.29) at the harvest time of cluster bean. This is due to favorable weather conditions that likely enhanced photosynthetic activity and the translocation of assimilate. These factors contributed to better germination, increased plant height, and positively impacted the number of branches per plant, pod development and seed formation [24]. The interaction of sowing dates and varieties significantly affect the seed yield of cluster bean. Among the different interaction maximum seed yield (1253.48) was obtained with the interaction of sowing date 1st July and cluster bean variety (V_2-RGr-12-1) and lowest seed yield (832.23) was recorded in interaction of sowing dates 1st June and cluster bean variety (V_1- RGC-936). The findings were in conformity with the findings of Mevada *et al.* [25]. Maximum stalk yield recorded in variety V_2-RGr-12-1 (2820.72) followed by V_5-RGC 1066 (2651.59) and lowest stalk yield was observed in variety V_4-RGC 1038 (2405.46) at the harvest time of cluster bean. Crops sown in the first week of July absorbed more radiation and had better energy efficiency than those sown on other dates. This likely contributed to the higher yield and superior yield attributes observed in these crops. Delays in sowing led to a decline in both yield and yield attributes, with the highest values found in crops sown during the early July period [26-28]. The interaction of sowing dates and varieties significantly affect the stalk yield of cluster bean. Among the different interaction maximum stalk yield (3422.00) was obtained with the interaction of sowing date 1st July and cluster bean variety (V_2-RGr-12-1) and lowest seed yield (2272.0) was recorded in interaction of sowing dates 1st June and cluster bean variety (V_1- RGC-936). Different dates of sowing and varieties are found non-significant effect on harvest index of cluster bean. The days to 50% flowering in cluster bean are crucial for optimizing growth and yield as this milestone marks the transition from vegetative to reproductive stages [29-30]. Different date of sowing showed significant differences in days to 50% flowering in cluster bean. The maximum days to 50% flowering recorded in date of sowing 1st July (42.40) followed by 1st August (40.22) and lowest found in 1st June date of sowing (36.19). In case of varieties also found significant influenced by different varieties [31]. Maximum days to 50% flowering recorded in variety V_2-RGr-12-1 (42.72) followed by V_5-RGC 1066 (40.95) and lowest days to 50% flowering was observed in variety V_4-RGC 1038 (36.52). Similar results were also observed by Ali *et al.* [7]. No significant differences were observed due to the interaction effect between sowing dates and variety on days to 50% flowering. Different date of sowing showed significant differences in days to maturity in cluster bean. The maximum days to maturity recorded in date of sowing 1st July (112.61) followed by 1st August (108.05) and lowest found in 1st June date of sowing (105.57). In case of varieties also found significant influenced by different varieties [32-33]. Maximum days to maturity recorded in variety V_2-RGr-12-1 (117.82) followed by V_5-RGC 1066 (112.53) and lowest days to maturity was observed in variety V_4-RGC 1038 (99.91). The data pertaining to this trait are in accordance with the studies conducted by Deka *et al.*, [13]. The cost of cultivation in all different dates of sowing and variety are (23590 Rs ha^{-1}) in cluster bean. The maximum gross returns, net returns and B:C ration was found in 2nd date of sowing (1st June) and variety (V_2- Rgr-12-1) RS.56406.48 ha^{-1}, Rs. 32816.48 ha^{-1} and 2.39 respectively, results collaborate with the findings of Deka *et al.* [13].

CONCLUSION

After summarizing all the observation, the following conclusions are drawn from the findings of the research work. Second date of sowing (1st July) showed best performance in term of growth and yield attributes compared to later sowing date 1st August and early sowing dates (1st June). The most suitable date of sowing of cluster bean under rainfed condition of Nagaland was found to be 1st July. The cluster bean variety RGr-12-1 was found to be most adaptable followed by RGC-1066 according to the present investigation. The highest benefit cost ratio (2.39) was recorded in treatment combination of 2nd date of sowing (1st July) and variety (V_2- Rgr-12-1).

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