ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

"Comparative study on effect of spacing on the growth and yield of different varieties of black gram (*Vigna radiata* L.) under Subabul (*Leucaena leucocephala*) based agrosilviculture system"

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Manuscript Info

Manuscript History:

Received: 14 April 2015
Final Accepted: 22 May 2015
Published Online: May 2015

Key words:

spacing, subabul, straw yield, pod, harvest index

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Abstract

Present investigation was carried out at experimentation centre and research field of School of Forestry & Environment, SHIATS, Allahabad, to study the effect of spacing on the growth and yield of different varieties of black gram (*Vigna radiata* L.) under Subabul (*Leucaena leucocephala*) based agrosilviculture system. The maximum plant height (36.73 cm), absolute growth rate (0.79 g day^{-1}), number of pods (15.63 pods $plant^{-1}$), number of grains (8.6 grains pod^{-1}) and straw yield (14.23 q ha^{-1}) was recorded in Treatment T_6 (30 X 15 cm with T 9 variety). Whereas, maximum number of branches (7.26 branches $plant^{-1}$), leaves (21.73 leaves $plant^{-1}$), nodules (16.75 nodules $plant^{-1}$), dry weight (23.96 g), pod length (8.11 cm) and test weight (4.53 g) was recorded in treatment T_9 (40 X 15 cm with T9 variety). Grain yield (8.13 q ha^{-1}) and harvest index (37.87 %) was recorded in treatment T_3 (20 X 15 cm with T9 variety) and treatment T_8 (40 X 15 cm with Shekhar 2 variety) respectively.

INTRODUCTION

Black gram (*Vigna mungo* L.) is important native pulse crop of India and is grown under mono, mixed and multiple cropping systems during rainy (kharif), spring and summer seasons under wide range of agro-climatic conditions. Black gram also known as mashkalai, urdbean or blackbean. Black gram (*Vigna mungo*) is the third important pulse crop in India. Population growth of an annual rate of 1.3%, with 83% of these increases occurring in developing countries **(Khush, 2001)**, has increased the demand for agricultural products and hence increased the pressure on arable lands. Efforts to increase crop production productivity in a sustainable way are needed. Hence pressure on forest lands could be relieved by incorporating trees in agricultural systems. Agroforestry is said to have among others the following advantages: protect soils from erosion and maintains soil fertility, without the use of inorganic fertilizer; provide natural pest control; diversify the risks of crop failure and also enhances resilience and to increase the agricultural output **(Pinho *et al.*, 2012; Marten, 2001)**; and hence also the ability to improve the food security, nutrition, income, health, shelter, social cohesion, energy resources and environmental sustainability.

Material and Methods

The experiment was carried out was carried out at experimentation center and research field of School of Forestry & Environment, Sam Higginbottom Institute of Agriculture Technology & Sciences, Deemed-to-be-University, Allahabad during Kharif season of 2014-15 in Randomize Block Design with three replication, treatments were allotted in each plot randomly. Treatments were consists of different varieties of Black gram i.e.

PUSA 1, SHEKHAR 2 and T 9, and spacing i.e. 20x15, 30x15 and 40x15 cm. Details of different treatments combinations are given in table 1.

Table 1 Details of treatment combinations

S. No.	Treatment	Variety(v)	Spacing(s)	combination
1	T_1	PUSA 1	20X15	$S_1 \times V_1$
2	T_2	SHEKHAR 2	20X15	$S_1 \times V_2$
3	T_3	T 9	20X15	$S_1 \times V_3$
4	T_4	PUSA 1	30X15	$S_2 \times V_1$
5	T_5	SHEKHAR 2	30X15	$S_2 \times V_2$
6	T_6	T 9	30X15	$S_2 \times V_3$
7	T_7	PUSA 1	40X15	$S_3 \times V_1$
8	T_8	SHEKHAR 2	40X15	$S_3 \times V_2$
9	T_9	T 9	40X15	$S_3 \times V_3$

Results and Discussion

The data appended in the table 2 for plant height, at 15 DAS the maximum plant height i.e. 10.7 cm was observed in treatment T_3 (20x15 cm, T9) and minimum i.e. 8.46 cm was observed in treatment T_2 (20x15cm, shekhar2). However, at 30 DAS it is observed that the maximum plant height was in treatment T_6 (30x15 cm, T9) i.e. 17.76 cm and minimum i.e. 13.2 cm was in treatment T_2 (20x15 cm, Shekhar2). At 45 DAS the maximum plant height i.e. 29.07 cm was recorded in treatment T_6 (30x15 cm, T9) and the minimum was observed from the treatment T_8 (40x15 cm, Shekhar2) i.e. 24.78 cm. At the time of maturity, the maximum plant height i.e. 36.73 cm in treatment T_6 (30x15 cm, T9) and the minimum i.e. 31.78 cm was observed in treatment T_2 (20x15 cm, Shekhar2). **A. K. K. *et al* (2007),** also conclude that moderate row spacing viz., 30 and 35 cm numerically produced the highest plant height i.e. 49.89 and 49.22 cm respectively. The data appended in table 3 for branches per plant, revealed that at 30 DAS, it is observed that the maximum number of branches i.e. 3.55 branches per plant was observed in treatment T_9 (40x15 cm, T9) and minimum number of branches per plant i.e. 1.73 was in treatment T_2 (20x15 cm, Shekhar2). However at 45 DAS it observed that maximum number of branches per plant i.e. 6.75 branches per plant was shown by T9 (40x15 cm, T9) and the minimum i.e. 4.1 branches per plant was recorded in treatment T_2 (20x15 cm, Shekhar2) and at maturity, the maximum number of branches i.e. 7.26 branches per plant was recorded in treatment T_9 (40x15 cm, T9) and the minimum number of branches i.e. 5.26 branches per plant was recorded in treatment T_2 (20x15 cm, Shekhar2). **A. K. K. *et al*. (2007)** also observe maximum number of braches per plant (3.12) on wider plant geometry (45cm). Data appended in table 4 revealed that, the maximum number of leaves for 30 DAS i.e. 8.84 leaves per plant have been observed in treatment T_6 (30x15 cm, T9) and minimum i.e. 6.4 leaves per plant was observed in treatment T_8 (40x15 cm, Shekhar2). However at 45 DAS, it is observed that the maximum number of leaves i.e. 22.56 leaves per plant was observed in treatment T_4 (30x15 cm, Pusa1) and minimum i.e. 19.5 leaves per plant was observed in treatment T_3 (20x15 cm, T9). However, at the maturity, the maximum number of leaves i.e. 21.73 leaves per plant in treatment T_9 (40x15 cm, T9) and minimum i.e. 16.06 leaves per plant in treatment T_1 (120x15cm, Pusa1). **A. K. K. *et al.* (2007)** also observe maximum number of trifoliate per plant (24.33) on wider plant geometry (45cm) in Mash bean. Data appended in table 5 for number of nodules reviled that, at 30 DAS, the maximum number of nodules i.e. 7.36 nodules per plant was observed in treatment T_3 (20x15 cm, T9) and minimum i.e. 5.23 nodules per plant was recorded in treatment T_8 (40x15 cm, T9). However at 45 DAS it was observed that maximum number of nodules i.e. 14.76 nodules per plant was in treatment T_5 (30x15 cm, Shekhar2) and minimum i.e. 12.3 nodules per plant was recorded in treatment T_3 (20x15 cm, T9). At the maturity of black gram the maximum number of nodules i.e. 16.76 nodules per plant was observed in treatment T_9 (40x15 cm, T9) and minimum i.e. 12.93 nodules per plant was recorded in treatment T_4 (30x15 cm, Pusa1).

Data appended in table 6 for dry weight (g) revealed that, at 15 DAS the maximum dry weight i.e. 1.09 g was observed in treatment T_6 (30x15 cm, T9) and minimum i.e. 0.74 g was recorded in treatment T_1(20x15 cm, Pusa1). However, at 30 DAS it was observed that the maximum dry weight i.e. 3.66 g was recorded in treatment T_9 (40x15 cm, T9). At 45 DAS the maximum dry weight i.e. 13.26 g was recorded in treatment T_9 (40x15 cm, T9) and minimum i.e. 9.8 g dry weight was observed in treatment T_1 (20x15 cm, Pusa1). At maturity, maximum dry weight i.e. 23.96 g was recorded in treatment T_9 (40x15 cm, T9) and minimum i.e. 18.4 g of the dry weight was observed in treatment T_1 (20x15 cm, Pusa1). Data appended in table 6 for absolute growth rate, at 0-15 DAS maximum AGR i.e. 0.073 g per day was observed in treatment T_6 (30x15cm, T9) and minimum was observed 0.05 g per day in

treatment T_1 (20x15 cm , pusa1). At 15-30 DAS, maximum AGR i.e. 0.18 g per day was observed in treatment T_9 (40x15 cm, T9) and minimum was observed 0.12 g per day in treatment T_1 (20x15 cm, pusa1). Whereas, at 30-45 DAS maximum AGR i.e. 0.73 g per day was observed in treatment T_6 (30x15cm, T9) and minimum was observed 0.57 g per day in treatment T_2 (20x15 cm, Shekhar 2).

Data appended in table 8 for pod length, number of pods and number of grains per pod, the maximum of the pod length i.e. 8.11 cm was observed in treatment T_9 (40x15 cm,T9) and minimum i.e. 5.63 cm was observed in treatment T_1 (20x15 cm , pusa1). The maximum number of pods per plant i.e. 15.63 pods per plant was observed in treatment T_6 (30x15cm, T9) and minimum i.e. 11.78 pods per plant was observed in T_2 (20x15 cm, Shekhar2). The maximum number of grains i.e. 8.6 grains per pods was observed in treatment T_6 (30x15 cm, T9) and minimum i.e. 5.46 grains per pods was observed in treatment T_7 (40x15 cm, Pusa1). **Mehmud *et al.* 1997; Kumar *et al.*** 1997 also suggest that pod length decrease by increasing the spacing in legume crops. Similar findings were also confirmed by **Ihsanullah *et al.* (2002).**

Data appended in table 9 for grain yield and straw yield revealed that, the maximum grain yield i.e. 8.13 q per ha was recorded from treatment T_3 (20x15 cm, T9) and minimum i.e. 6.23 q per ha was recorded in treatment T_7 (40x15 cm, Pusa1). Whereas, the maximum straw yield i.e. 14.23 q per ha was recorded in treatment T_6 (30x15cm, T9) and minimum i.e. 11.26 q per ha was recorded in treatment T_8 (40x15 cm, Shekhar2). **Borah, 1994 and Mishra & Mishra, 1995;** also conclude that there is a trend, as row spacing increases, grain yield also increases. Data appended in table 9 for harvest index, the maximum test weight i.e. 4.53 g was observed in treatment T_9 (40x15 cm, T9) and minimum i.e. 2.73 g was observed in treatment T_2 (20x15 cm, Shekhar2). **Ihsanullah *et al.* (2002)** also conclude that maximum test weight (63.94 gm) was recorded in 25 cm row spacing. The maximum harvest index i.e. 37.87 % was observed in treatment T_8 (40x15 cm, Shekhar2) minimum i.e. 33.51 % was observed in treatment T_7 (40x15 cm, Pusa1). **Shrivastav *et al.* (1996)** also concluded that increased level of row spacing generally increases the harvest index.

Table 2 Effect of different variety and spacing on plant height (cm) of black gram

	Plant height (cm) 15 DAS				Plant height (cm) 30 DAS				Plant height (cm) 45 DAS				Plant height (cm) 60 DAS			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	9.23	8.46	10.7	**9.46**	16.43	13.2	16.98	**15.53**	26.7	25	26.65	**26.11**	32.52	31.78	32.87	**32.39**
Spacing 30x15	10.04	9.01	9.35	**9.58**	17.01	16.53	17.76	**17.1**	29.06	26.61	29.07	**28.24**	35.12	33.95	36.73	**35.26**
Spacing 40x15	9.15	8.55	9.12	**8.94**	16.52	15.31	16.75	**16.19**	25.36	24.78	28.33	**26.15**	32.56	32.03	33.35	**32.64**
Mean	**9.69**	**8.67**	**9.50**		**16.65**	**15.01**	**17.16**		**27.04**	**25.46**	**28.01**		**33.4**	**32.58**	**34.31**	
	F test	S.EM(±)		C.D at 5%	F test	S.EM(±)		C.D at 5%	F test	S.EM(±)		C.D at 5%	F test	S.EM(±)		C.D at 5%
Variety	S	0.41		0.89	S	0.26		0.55	S	0.26		0.55	S	0.57		1.21
Spacing	S	0.41		0.89	S	0.26		0.55	S	0.26		0.55	S	0.57		1.21
Interaction	S	0.72		1.54	S	0.45		0.96	S	0.45		0.96	NS	0.98		2.09

Table 3 Effect of different variety and spacing on number of branches per plant of black gram

	Number of branches 30 DAS				Number of branches 45 DAS				Number of branches 60 DAS			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	2.06	1.73	2.06	**1.95**	4.8	4.1	4.56	**4.48**	6.33	5.26	6.33	**5.97**
Spacing 30x15	2.2	3.11	2.72	**2.67**	4.73	4.6	4.33	**4.55**	6.5	6.06	6.4	**6.32**
Spacing 40x15	2.55	3.01	3.55	**3.03**	4.23	4.4	6.75	**5.12**	6.66	6.33	7.26	**6.75**
mean	**2.27**	**2.61**	**2.77**		**4.35**	**4.6**	**5.21**		**6.49**	**5.88**	**6.66**	
	F test	S.EM(±)		C.D at 5%	F test	S.EM(±)		C.D at 5%	F test	S.EM(±)		C.D at 5%
Variety	S	0.15		0.32	NS	0.20		0.43	**S**	0.23		0.49
Spacing	S	0.15		0.32	NS	0.20		0.43	**S**	0.23		0.49
Interaction	S	0.26		0.56	NS	0.35		0.74	**NS**	0.40		0.85

Table 4 Effect of different variety and spacing on number of leaves per plant of black gram

	Number of leaves 30 DAS				Number of leaves 45 DAS				Number of leaves 60 DAS			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	7.6	6.66	7.33	**7.19**	21.86	20.26	19.5	**20.54**	16.06	18.2	17.06	**17.11**

Spacing 30x15	8	7.76	8.84	**8.2**	22.56	19.93	20.06	**20.85**	19.43	20	20.06	**19.83**
Spacing 40x15	6.53	6.4	7.26	**6.73**	20.4	21.6	21.53	**21.18**	18.2	17.33	21.73	**19.09**
mean	**7.37**	**6.94**	**7.81**		**21.61**	**20.59**	**20.36**		**17.9**	**18.51**	**19.61**	
	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%			
Variety	S	0.49	0.49	NS	0.61	1.30	S	0.36	0.77			
Spacing	**NS**	0.49	0.49	**NS**	0.61	1.30	**S**	0.36	0.77			
Interaction	**NS**	0.85	0.85	**NS**	1.06	2.26	**S**	0.63	1.34			

Table 5 Effect of different variety and spacing on number of nodules per plant of black gram

	Nodules per plant at 30 DAS				**Nodules per plant at 45 DAS**				**Nodules per plant at 60 DAS**			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	6.13	5.44	7.36	**6.31**	13.46	14.13	12.3	**13.3**	14.67	16.2	14.66	**15.18**
Spacing 30x15	6.76	5.76	6.5	**6.34**	13	14.76	14.53	**14.1**	12.93	14.13	13.36	**13.47**
Spacing 40x15	5.43	5.23	6.1	**5.58**	14.46	12.7	13.67	**13.61**	15.13	14.6	16.76	**15.5**
mean	**6.10**	**5.47**	**6.65**		**13.64**	**13.86**	**13.5**		**14.24**	**14.97**	**14.92**	
	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%			
Variety	S	0.338	0.717	NS	0.342	0.727	S	0.38	0.81			
Spacing	**S**	0.338	0.717	**NS**	0.342	0.727	**S**	0.38	0.81			
Interaction	**NS**	0.585	1.24	**S**	0.593	1.259	**S**	0.66	1.41			

Table 6 Effect of different variety and spacing on dry weight (g) of black gram

	Dry weight (g) 15 DAS				**Dry weight (g) 30 DAS**				**Dry weight (g) 45 DAS**				**Dry weight (g) 60 DAS**			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	0.74	0.86	0.92	**0.84**	2.56	2.83	2.88	**2.75**	9.1	10.66	11.66	**10.47**	18.4	19.23	19.66	**19.1**
Spacing 30x15	0.766	0.91	1.09	**0.922**	2.66	2.93	3.06	**2.88**	10.76	11	11.86	**11.21**	20.63	21.73	22.86	**21.74**
Spacing 40x15	0.92	0.97	1.01	**0.967**	2.9	3.06	3.66	**3.20**	11.66	12.3	13.26	**12.41**	21	22.8	23.96	**22.59**
mean	**0.81**	**0.91**	**1.00**		**2.70**	**2.94**	**3.2**		**10.51**	**11.32**	**12.26**		**20.01**	**21.253**	**22.16**	

	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%	F test	S.EM(±)	C.D at 5%
Variety		0.41	0.89		0.1317	0.279		0.4256	0.902	S	0.4517	0.958
Spacing		0.41	0.89		0.1317	0.279		0.4256	0.902	S	0.4517	0.958
Interaction		0.72	1.54		0.228	0.483		0.7371	1.562	NS	0.7823	1.659

Table 7 Effect of different variety and spacing on absolute growth rate (g per day)

	AGR (g per day) 0-15 DAS				**AGR (g per day) 15-30 DAS**				**AGR (g per day) 30-45 DAS**			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	0.05	0.06	0.062	**0.057**	0.12	0.13	0.13	**0.127**	0.62	0.57	0.53	**0.573**
Spacing 30x15	0.052	0.061	0.073	**0.062**	0.13	0.13	0.13	**0.13**	0.65	0.71	0.73	**0.697**
Spacing 40x15	0.062	0.065	0.068	**0.065**	0.13	0.14	0.18	**0.15**	0.62	0.7	0.71	**0.677**
mean	**0.05**	**0.062**	**0.0677**		**0.127**	**0.133**	**0.146**		**0.63**	**0.66**	**0.656**	
	F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%	
Variety		0.002	0.004			0.009	0.019			0.033	0.073	
Spacing		0.002	0.004			0.009	0.019			0.033	0.073	
Interaction		0.003	0.007			0.015	0.033			0.058	0.126	

Table 8 Effect of different variety and spacing on pod length (cm), number of pods and number of grains per pod

	Pod length (cm)				**Number of pods**				**Number of grains per Pod**			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	5.63	6.47	7.26	**6.45**	12.96	11.78	14.56	**13.1**	5.73	6.76	8.3	**6.93**
Spacing 30x15	6.7	6.97	7.86	**7.17**	13.63	12.53	15.63	**13.93**	6.06	6.73	8.6	**7.13**
Spacing 40x15	7.3	7.53	8.11	**7.64**	12.93	15.43	13.26	**13.87**	5.46	6.3	7.4	**6.38**
mean	**6.54**	**6.99**	**7.74**		**13.17**	**13.24**	**14.48**		**5.75**	**6.59**	**8.1**	
	F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%	
Variety	S	0.36	0.77		NS	0.43	0.92		S	0.22	0.46	
Spacing	**S**	0.36	0.77		**S**	0.43	0.92		**S**	0.22	0.46	
Interaction	**NS**	0.63	1.34		**S**	0.75	1.59		**NS**	0.38	0.80	

Table 9 Effect of different variety and spacing on grain yield (q per ha), straw yield (q per ha), Test weight and harvest index (%)

	Grain Yield (q per ha)				Straw yield (q per ha)				Test weight (g)				Harvest index (%)			
	V_1	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**	**V_1**	**V_2**	**V_3**	**mean**
Spacing 20x15	13.03	12.3	14.13	**13.15**	7.09	7	8.13	**7.40**	2.83	2.73	3.34	**2.96**	36.06	36.2	36.53	**36.26**
Spacing 30x15	12.86	11.86	14.23	**12.98**	6.53	6.86	8.08	**7.15**	3.09	3.2	3.7	**3.33**	33.65	36.64	36.21	**35.5**
Spacing 40x15	12.36	11.26	13.3	**12.31**	6.23	6.86	7.99	**7.02**	3.1	3.63	4.53	**3.75**	33.51	37.87	37.53	**36.3**
mean	**12.75**	**11.8**	**13.88**		**6.61**	**6.90**	**8.06**		**3.00**	**3.18**	**3.85**		**34.41**	**36.9**	**36.75**	
	F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%		F test	S.EM(±)	C.D at 5%	
Variety	S	0.18	0.40		NS	0.18	0.39		S	0.16	0.34		NS	0.6576	1.39	
Spacing	**S**	0.18	0.40		**S**	0.18	0.39		**S**	0.16	0.34		**S**	0.6576	1.394	
Interaction	**NS**	0.32	0.69		**NS**	0.31	0.67		**NS**	0.28	0.60		**NS**	1.139	2.415	

Conclusion

The effect of practicing farming under subabul, an overall reduction in yield was observed in comparison to monoculture, when production from agroforestry is being calculated, net return in monetary terms increased and huge return was obtained by the trees.

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