RESEARCH ARTICLE Legume Research- An International Journal, Volume 45 Issue 2: 182-188 (February 2022)

Growth and Yield Performance of Black Gram (*Vigna mungo* L.) under Malabar Neem (*Melia dubia*) Plantations in Western Zone of Tamil Nadu

R. Ajaykumar, P. Prabakaran, K. Sivasabari[1]

10.18805/LR-4658

ABSTRACT

Background: Black gram (*Vigna mungo.* L) is one of the most cultivated legume pulse crop with high nutritive value and Malabar neem (*Melia dubia*) is an emerging industrial agroforestry tree in Southern India. To maximize the land utilization with a field experiment was conducted at Western zone of Tamil Nadu to investigate the performance of black gram varieties under different spatial arrangements of *Melia dubia* plantations.

Methods: An agroforestry trial was laid out in randomized block design (RBD) with eight treatments and three replications during *kharif* and *rabi* (2019-20) season. Black gram crop varieties (V_1 - CO6 and V_2 - VBN 6) were intercropped with *M. dubia* (1.5 year old plantation) with three different spacing of S_1 (3 × 1.5 m), S_2 (3 × 3 m) and S_3 (4 × 4 m) while S_0 as open field (Sole crop of black gram) for both the season.

Result: The results of pooled analysis of two season shown that, treatment S_0V_2 recorded plant height (49.96 cm), number of branches (3.76), number of leaves (259.75), number of flowers (53.44), number of pods (22.85), seed yield per plant (5.38 g) and seed yield per hectare (0.82 tonnes) in open condition. Similarly in intercropping the growth and yield attributes of black gram were minimum performance recorded in CO 6 at closer spacing (3 × 1.5 m). In tree growth maximum pooled height increment (1.57 m) was observed in closer spacing (3 × 1.5 m) and maximum diameter recorded in wider spacing of both varieties. Hence wider spacing of S_3 (4 × 4 m) can be suggested for intercropping under *M. dubia* plantations upto 4 years.

Key words: Agroforestry, Blackgram, Growth, *Melia dubia*, Yield.

INTRODUCTION

Agroforestry is a dynamic and ecological based natural resource management system, through which the combination of trees/woody perennials in farm and rangelands, diversifies and sustains production for increased social, economic and environmental benefits (Sureshbhai *et al.,* 2017). The intercropping of pulses with commercial tree species in initial stages of establishment is desirable for replenishment of soil fertility by legumes and additional income to the farmers. Spatial arrangement of trees in plantation plays an important role in growth and yield of agricultural intercrops as well as trees. In order to utilize the interspaces in early stages in closer spacing and wider spacing even in later stages of plantation development, the selection of the crops for intercropping is important. The intercropping of agricultural crops not only gives additional income to farmers but also improves the soil condition due to different intercultural practices and fertilizer application and weeding during crop period (Bhusara *et al*., 2018). The current supply of raw materials for industries like pulpwood, plywood and furniture and biomass energy in the country is far behind the demand. Not only is the forest wealth of the country is poor but its productivity in terms of Mean Annual Increment (MAI) is also one of the lowest. The average MAI of Indian Forest is 0.5-0.7 m^3 ha^{-1} compared to the global average of 2.1 m^3 ha^{-1} (Srivastava, 2005). It is estimated that the demand for timber is likely to grow from 58 million cubic meters in 2005 to 169 million cubic meters in 2025 (Goswami *et al*., 2020; Saravanan *et al*., 2014).

Black gram (*Vigna mungo* L.) also known as urd bean in India is one of the most important cultivated pulse crops of the 'Vigna' group and cultivation from ancient times (Pandey *et al.,* 2019). It is an important rainfed short duration legume crop of India and occupying an area of 44.93 lakh ha with 29.26 lakh tonnes production and 651 kg/ha productivity. It is grown in various agro-ecological conditions and cropping systems with diverse agricultural practices, both in rainy (*kharif*) and post rainy (*rabi*) seasons (Singh and Ahlawat, 2005). It is grown in summer and winter and accounts for 28 per cent of world grain legume production. In Tamil Nadu, black gram is

Department of Crop Management, Vanavarayar Institute of Agriculture, Pollachi-642 103, Tamil Nadu, India.
[1]Department of Soil Science and Agricultural Chemistry, Amrita School of Agricultural Sciences, Coimbatore-642 109, Tamil Nadu, India.

Corresponding Author: R. Ajaykumar, Department of Crop Management, Vanavarayar Institute of Agriculture, Pollachi-642 103, Tamil Nadu, India. Email: ajaykumar.tnau@gmail.com

How to cite this article: Ajaykumar, R., Prabakaran, P., Sivasabari, K. (2022). Growth and Yield Performance of Black Gram (*Vigna mungo* L.) under Malabar Neem (*Melia dubia*) Plantations in Western Zone of Tamil Nadu. Legume Research. 45(2): 182-188. DOI: 10.18805/LR-4658.

Submitted: 12-05-2021 **Accepted:** 05-10-2021 **Online:** 27-10-2021

considered as an important pulse crop and it is grown in an area of 3.72 lakh hectares with a production of 1,262 lakh metric tonnes and productivity of 645 kg/ha (Veeramani, 2019).

Melia dubia (Malabar neem) is a fast growing indigenous industrial wood species which belongs to the family Meliaceae. It is one of the most important multipurpose trees with a straight cylindrical trunk attaining a height of 20-25 m with a spreading crown and a straight bole of 9 m length and 1.2-1.5 m girth. *M. dubia* is predominantly growing in Southern India whose cultivation has now expanded to whole of the country (Parthiban *et al.,* 2009). It is a short rotation and multi utility tree, mainly used as a raw material for various woods based industries like plywood, pulp and paper production and in packing case, matches splints *etc.* (Sarvade *et al.,* 2014). The tree girth obtained more than 40 cm is saleable at the minimum rate of Rs 2000 to Rs. 7500 per ton for match, veneer and pulp industry. It is an ideal species for plywood and pulpwood industry apart from being extensively used in afforestation (Partiban *et al*., 2009; Priyanka *et al*., 2019). It is a promising tree highly suitable for agroforestry or farm forestry with a life cycle of 8 to 12 years is gaining economic importance both in domestic and global markets and its grows up to 40 feet within two years of planted tree yielding up to 40 tons of biomass on an average per acre per annum of 10 year old plantation. The minimum cultivation period is six years and it can be allowed up to 8 years for good economic value. About 400 trees can be planted in an acre which fetches Rs. 10-12 lakhs in 6-8 years (Goswami *et al*., 2020; Yadav *et al*., 2019). Considering its fast growing ability and multipurpose uses, it is also accepted as an ideal agroforestry species. Large scale plantations of *M. dubia* have been raised by various state forest departments and private entrepreneurs in Southern India (Chauhan and Kumar, 2014; Kumar *et al.,* 2017).

M. dubia is one of the emerging industrial agroforestry plantations in Southern India intercropped with various agricultural crops in large scale plantations for pulpwood and paper industry. To maximize the land utilization, an agroforestry trial was laid to investigate the performance of black gram varieties under different spatial arrangements of 1.5 year old *Melia dubia* plantation.

Table 1: Soil physico-chemical characteristics of the experimental fields.

Particulars	Values
I Mechanical analysis	
Clay (%)	44.2
Silt (%)	19.5
Course sand (%)	18.2
Fine sand (%)	18.1
Textural class	Clay loam
II Chemical analysis	
pH	7.85
Electrical conductivity (dSm^{-1})	0.42
Organic carbon (%)	0.58
Available nitrogen (kg ha^{-1})	264
Available phosphorus (kg ha^{-1})	16.7
Available potassium (kg ha^{-1})	426
III Irrigation water characteristics	
pH	7.6
Electrical conductivity (dSm^{-1})	1.18

MATERIALS AND METHODS

Details of the experimental site

A field experiment was conducted during the year of 2019-20 (*Kharif* and *Rabi* season) at Vanavarayar Institute of Agriculture, Pollachi, Tamil Nadu (10.66°N and 76.88°E with an altitude of 198 m above MSL). The maximum and minimum temperature ranged from 29.0 to 32.7°C and 19.2 to 23.7°C, respectively. With regard to relative humidity, there was a fluctuation from 77.5 to 94 per cent (07 22 hours) and from 49.6 to 77.3 per cent (14 22 hours). There was a total rainfall of 742 mm was received in 117 rainy days. The evaporation and bright sunshine hour's day^{-1} ranged from 2.8 to 6.2 mm and 3.1 to 7.2 hours, respectively.

The initial analysis of the soil of the experimental site revealed that the soil was slightly alkaline (pH= 7.85) with low in soluble salts (EC= 0.42 dSm^{-1}), medium in organic carbon content (0.58 per cent), medium in available N (264 kg ha^{-1}), medium in P_2O_5 (16.7 kg ha^{-1}) and high in K_2O (426 kg ha^{-1}). The irrigation water was found to be neutral in reaction (pH= 7.6) with medium level of the soluble salts (EC= 1.18 dSm^{-1}). Detailed soil physico-chemical characteristics of the soil are presented in Table 1.

Table 2: Characteristics of black gram CO 6 and TNAU (black gram) VBN 6.

Character	CO 6	TNAU (black gram) VBN 6
Special features	Moderately resistant to YMV disease. Field tolerance to aphids, pod borer and synchronized maturity.	Resistant to yellow mosaic, synchronized pod maturity.
100 grain weight	5.0 - 6.2 g	3.8-4.0 g
Parentage	DU 2 × VB 6	Vamban 3 × *Vigno mungo silvestris*
Hairiness of pods	Non hairy	Hairy
Suitable season	*Kharif* and *Rabi*	*Kharif* and *Rabi*
Duration	60-65 days	66-70 days
Source of release	Tamil Nadu Agricultural University, Coimbatore	National Pulses Research Centre, Tamil Nadu Agricultural University, Vamban, Pudukkottai.

Experimental details

The experiments designed for intercropping of two black gram high yielding varieties *viz*., CO 6 - V_1 and VBN 6 - V_2 sowing at two different seasons like *Kharif* and *Rabi* season with *Melia dubia* variety of MTP 1 which was planted in 2016 with three spacing of S_1 (3 × 1.5 m), S_2 (3 × 3 m) and S_3 (4 × 4 m) while S_0 as open field (Sole crop of black gram). Experiment is designed in randomized block design (RBD) with eight treatments and three replications.

The treatments for black gram crop includes-
T_1- S_0V_1 = Black gram variety CO 6 sole crop.
T_2- S_0V_2 = Black gram variety VBN 6 sole crop.
T_3- S_1V_1 = *M. dubia* (3 × 1.5 m) + black gram variety CO6.
T_4- S_1V_2 = *M. dubia* (3 × 1.5 m) + black gram variety VBN 6.
T_5- S_2V_1= *M. dubia* (3 × 3 m) + black gram variety CO 6.
T_6- S_2V_2 = *M. dubia* (3 × 3 m) + black gram variety VBN 6.
T_7- S_3V_1 = *M. dubia* (4 × 4 m) + black gram variety CO6.
T_8- S_3V_2= *M. dubia* (4 × 4 m) + black gram variety VBN 6.

The treatments of *Melia dubia* includes, T_1 (S_1), T_2 (S_2), T_3 (S_3), T_4 (S_1V_1), T_5 (S_1V_2), T_6 (S_2V_1), T_7 (S_2V_2), T_8 (S_3V_1) and T_9 (S_3V_2). Character of the black gram variety CO 6 and TNAU (black gram) VBN 6 was furnished in Table 2.

The recommended doses of N, P_2O_5, K_2O were 25, 50, 25 kg ha^{-1}, respectively. Full dose of nitrogen, phosphorus, potassium in the form of urea, DAP, MOP were applied basal as per treatments. In addition to gypsum 20 kg ha^{-1} and soil application of 25 kg $ZnSO_4$ ha^{-1} were applied. All other agronomic practices were adopted as per needs of the crop.

Growth and yield attributes as black gram height, number of branches, number of leaves and number of flowers was recorded before final harvest by randomly selecting 5 plants in each replication and treatment. The maximum plant height was measured from the base of the stem to the tip of the longest trifoliate leaf. Number of pods in individual selected plant was counted at every picking and finally these were added to obtain the mean number of pods per plant. Yield per plot (10 sq. m) was worked out for respective plots and expressed in kg. Yield per hectare was calculated by plot value × 1000 expressed in tonne. With respect of *Melia dubia,* growth attributes *viz.,* tree height (m) and diameter (cm) were documented at two months interval. Data were analyzed statistically using Fisher's analysis of variance techniques and least significant difference (LSD) test at 5 per cent probability level was employed to test the significance among treatment's means.

RESULTS AND DISCUSSION

The data of growth and yield parameters of black gram as sole crop and under different spatial arrangements of *M. dubia* for both the season of study (*Kharif* and *Rabi*) and pooled analysis are shown in Table 3, 4 and 5.

Growth attributes

Growth attributes of black gram in pooled analysis of both season like plant height (49.96 cm), number of branches (3.76), number of leaves (259.75), number of flowers (53.44) and number of pods (22.85) are recorded significantly high in T_2- S_0V_2 *i.e*. open condition as compared to with *M. dubia* based agroforestry model. Further, wider agroforestry tree spacing played an important role in *M. dubia* (4 × 4 m) on growth attributes compared to closer spacing 3 × 1.5 m in T_3 (S_1V_1). It might be due to less availability of light under different spacing of trees compared to open condition as sole crop. The similar reduction in growth attributes of intercrops in agroforestry was recorded by Rani *et al*. (2015), Rajalingam *et al*. (2016). Green gram and lentil are shade sensitive which results poor branching and pod settings in pulses (Nandal and Singh, 2001).

Yield parameters

In terms of yield parameters of black gram showed that the maximum yield for variety VBN 6 in the open condition as compared to the different spacing of *M. dubia* as maximum yield of seed per plant (g/plant) and seed yield (tonne/ha). black gram reported the highest seed yield in T_2 (sole

Table 3: Growth attributes of black gram under *Melia dubia* based agroforestry model.

Treatments	Height (cm)			No. of branches (no.)			No. of leaves/plant		
	Kharif	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled
T_1- S_0V_1	43.45	47.23	45.34	3.22	3.45	3.34	231.43	243.54	237.49
T_2- S_0V_2	48.54	51.38	49.96	3.65	3.86	3.76	254.54	264.95	259.75
T_3- S_1V_1	31.25	33.24	32.25	2.18	2.95	2.57	167.43	175.67	171.55
T_4- S_1V_2	28.74	31.34	30.04	2.54	2.79	2.67	158.86	171.38	165.12
T_5- S_2V_1	39.55	39.58	39.57	3.11	3.22	3.17	198.58	209.55	204.07
T_6- S_2V_2	38.48	40.43	39.46	2.98	3.25	3.12	208.45	217.43	212.94
T_7- S_3V_1	41.45	46.25	43.85	3.21	3.56	3.39	218.54	238.44	228.49
T_8- S_3V_2	42.30	48.33	45.32	3.05	3.23	3.14	224.65	245.65	235.15
S.Em ±	3.45	2.45	1.98	0.12	0.17	0.09	10.24	12.65	7.98
CD at 5%	10.65	7.56	6.11	0.33	0.47	0.25	31.14	38.47	24.27
S.Em ± (Y × T)			2.18			0.11			12.05
CD at 5% (Y × T)			NS			NS			NS
CV%	8.12	10.57	9.34	5.17	5.49	5.33	12.53	15.24	13.88

cropping with variety VBN 6) as 5.38 g/plant and 0.82 tonnes/ha while in intercropping maximum yield was recorded with T_7- (variety VBN 6 with *M. dubia* at 4 × 4 m spacing) as 5.24 g/plant and 0.80 tonnes/ha. The yield reduction in pulses in intercropping with trees also reported by Bhusara *et al.* (2018), Pandey *et al.* (2019) and Nandal and Hooda (2005). *Faidherbia albida* with pulses reported that grain yield is black gram in lower canopy density than the monocrops and higher canopy density, which support that if canopy is properly managed the yield reduction in intercropping with trees can be reduced (Korwar and Pratibha, 1999).

Growth attributes of *Melia dubia* with intercropping

The tree height of *Melia dubia* in black gram agroforestry model recorded an increasing trend before intercropping as well as after harvesting of the intercrops. The results revealed that the tree height varied from 3.88 m to 6.89 m and 4.23 m to 8.09 m before sowing and after harvesting of the intercrops respectively and also exhibited significant difference in height increment. Among the different spacing arrangements, maximum height increment in the tree component was recorded under *M. dubia* (3 × 1.5 m) + CO 6 (1.57 m) in *Kharif* season and the lowest was reported under *Melia* (4 × 4 m) + VBN 6 (0.34 m) when compared to controls (Table 6). Significant difference was observed in diameter at breast height among different spacing and black gram variety combinations under agroforestry model before sowing and after harvesting of the intercrops. The results revealed that diameter at breast height ranged between 10.54 cm and 20.73 cm before sowing and 10.85 cm to 23.04 cm after harvesting the intercrops in combination of two seasons. Similar results for higher productivity of crop combination with *Ailanthus excelsa* was reported by Rajalingam *et al.* (2016). Better growth performance of guava + wheat compared to sole crop of wheat (Dalal *et al.*, 2016). Growth attribute of Pungam based agroforestry system, seed source of *Pongamia pinnata* (MAP111) + Soybean

Table 4: Reproductive growth attributes of black gram under *Melia dubia* based agroforestry model.

Treatments	No. of flowers/plant			No. of pods/plant		
	Kharif	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled
T_1- S_0V_1	43.32	48.54	45.93	18.54	19.42	18.98
T_2- S_0V_2	51.44	55.43	53.44	21.85	23.84	22.85
T_3- S_1V_1	22.43	28.84	25.64	14.56	15.33	14.95
T_4- S_1V_2	26.74	30.44	28.59	15.05	16.40	15.73
T_5- S_2V_1	35.44	38.18	36.81	17.44	18.43	17.94
T_6- S_2V_2	39.65	42.53	41.09	15.32	16.93	16.13
T_7- S_3V_1	42.43	47.85	45.14	18.34	18.98	18.66
T_8- S_3V_2	50.33	52.54	51.44	20.53	21.87	21.20
S.Em ±	1.08	1.39	1.15	0.97	1.02	0.91
CD at 5%	2.37	3.053	2.52	2.98	3.13	2.79
S.Em ± (Y × T)			1.785			1.684
CD at 5% (Y × T)			NS			NS
CV%	10.54	12.07	11.31	7.45	8.14	7.795

Table 5: Yield parameters of black gram under *Melia dubia* based agroforestry model.

Treatments	Seed yield (g/plant)			Seed yield (g/plot)			Seed yield (t/ha)		
	Kharif	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled
T_1- S_0V_1	5.21	5.38	5.30	778.35	774.58	776.46	0.78	0.77	0.78
T_2- S_0V_2	5.32	5.43	5.38	813.58	821.18	817.38	0.81	0.82	0.82
T_3- S_1V_1	3.86	3.67	3.77	571.63	594.25	582.94	0.57	0.59	0.58
T_4- S_1V_2	3.92	4.01	3.97	636.35	657.90	647.13	0.64	0.66	0.65
T_5- S_2V_1	4.45	4.54	4.50	661.90	672.00	666.95	0.66	0.67	0.67
T_6- S_2V_2	4.78	4.85	4.82	684.68	716.65	700.66	0.68	0.72	0.70
T_7- S_3V_1	5.01	5.18	5.10	738.65	756.63	747.64	0.74	0.76	0.75
T_8- S_3V_2	5.22	5.26	5.24	789.38	804.10	796.74	0.79	0.80	0.80
S.Em ±	0.27	0.34	0.21	15.78	19.52	11.08	0.04	0.05	0.04
CD at 5%	0.84	1.06	0.66	47.13	58.31	33.10	0.12	0.15	0.12
S.Em ± (Y × T)			0.31			18.65			0.05
CD at 5% (Y × T)			NS			NS			NS
CV%	8.77	9.47	9.12	11.24	13.54	12.39	8.58	9.78	9.18

Table 6: Growth increment in *Melia dubia* with blackgram based agroforestry model at *Kharif* and *Rabi* season.

Treatment	Height (m)						Diameter (cm)					
	Kharif			*Rabi*			*Kharif*			*Rabi*		
	Before sowing	Harvesting	Increment	Before sowing	Harvesting	Increment	Before sowing	Harvesting	Increment	Before sowing	Harvesting	Increment
T_1	4.03	5.43	1.4	5.56	6.32	0.76	10.54	10.86	0.32	10.89	11.32	0.43
T_2	4.21	5.11	0.9	5.28	5.68	0.4	15.49	16.41	0.92	16.48	17.19	0.71
T_3	4.43	5.34	0.91	5.65	6.13	0.48	17.45	18.34	0.89	18.51	20.4	1.89
T_4	5.17	6.74	1.57	6.89	8.09	1.2	10.67	10.85	0.18	10.96	11.44	0.48
T_5	3.88	4.23	0.35	4.38	4.89	0.51	11.44	11.86	0.42	11.92	12.32	0.4
T_6	3.97	4.35	0.38	4.41	4.96	0.55	14.32	14.68	0.36	14.78	15.06	0.28
T_7	4.32	5.44	1.12	5.68	6.38	0.7	16.15	16.97	0.82	17.04	17.85	0.81
T_8	4.48	5.23	0.75	5.67	6.54	0.87	15.54	16.42	0.88	16.53	17.04	0.51
T_9	4.76	5.45	0.69	5.78	6.12	0.34	18.67	20.53	1.86	20.73	23.04	2.31
Mean	4.36	5.26	0.90	5.48	6.12	0.65	14.47	15.21	0.74	15.32	16.18	0.87
SEd	0.34	0.42	0.04	0.21	1.02	0.02	0.43	1.14	0.01	1.23	1.07	0.03
CD (0.05)	0.68	0.84	0.08	0.42	2.04	0.04	0.86	2.28	0.02	2.46	2.14	0.06

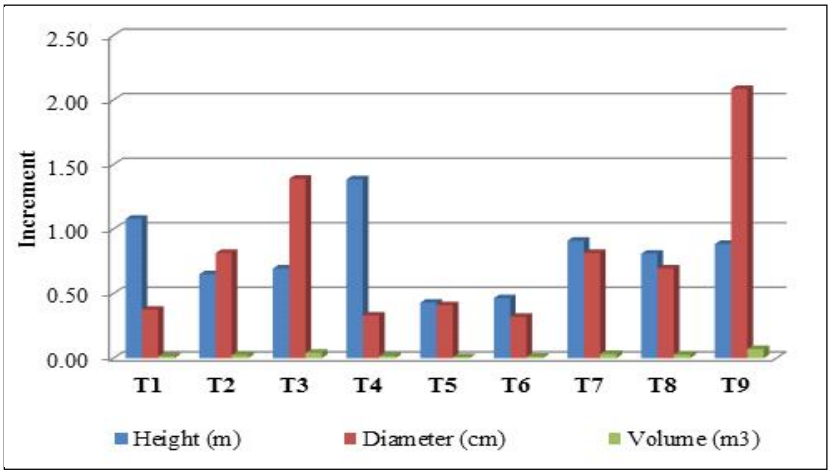

Fig 1: Variations in growth attributes of *Melia dubia* under agroforestry model.

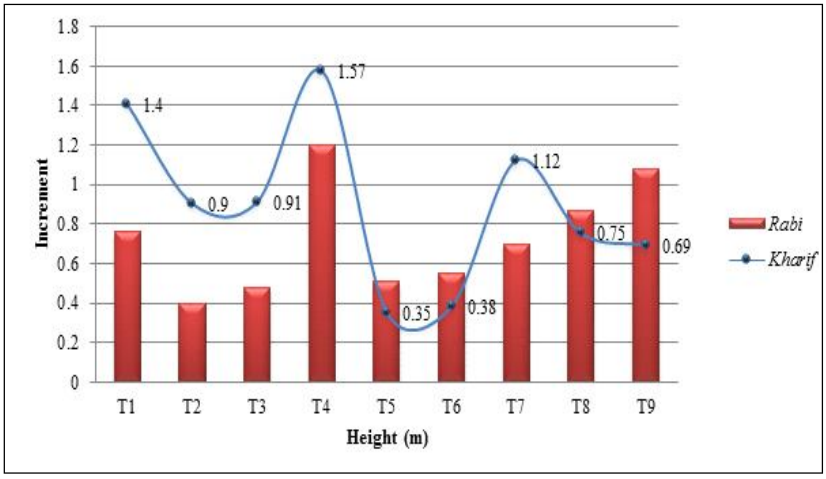

Fig 2: Growth attributes (height) of *M. dubia* in different spatial arrangement under agroforestry model at *kharif* and *rabi* season.

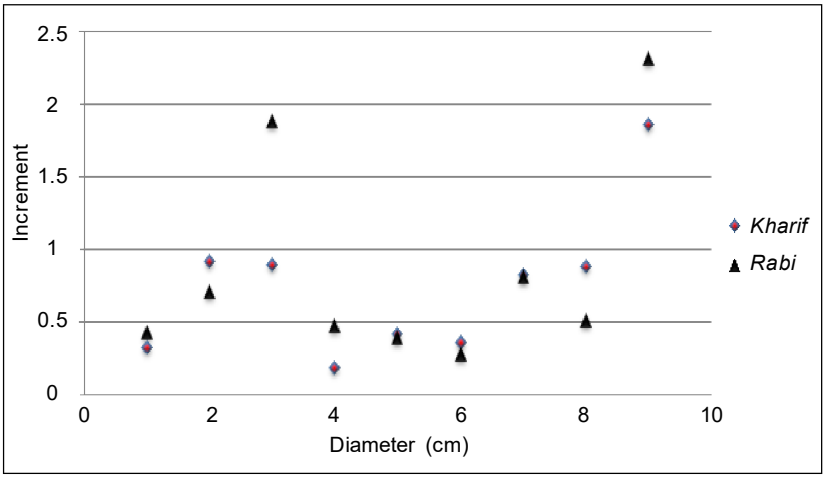

Fig 3: Growth attributes (Diameter) of *M. dubia* in different spatial arrangement under agroforestry model at different seasons.

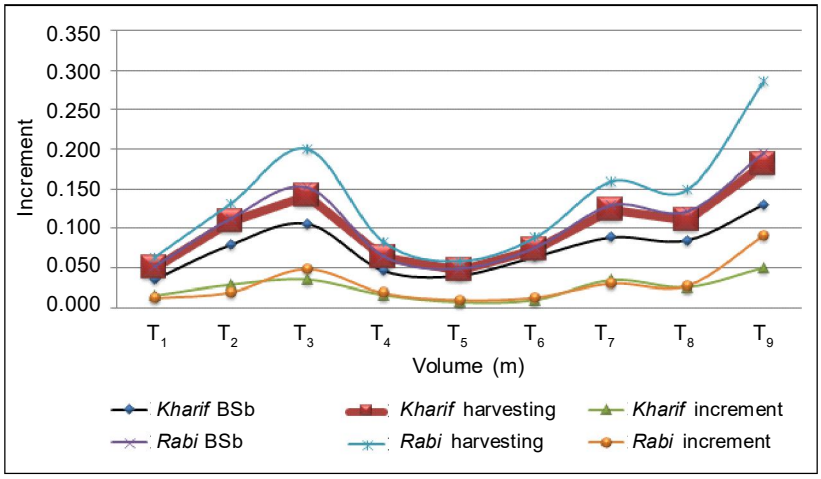

Fig 4: Growth attributes (Volume) of *M. dubia* in different spatial arrangement under agroforestry model at *kharif* and *rabi* season.

recorded higher productivity compared to sole crop (Parthiban and Fernandaz, 2017; Rao *et al.,* 2017). The growth and yield of annual crops were found to be less in intercrop compared to sole crop, while the volume of trees and growth rate improved when planted along with intercropping of pluses (Ashalatha *et al.,* 2015). Similarly, the competitive effect of trees on yield attributes and yield of black gram and mustard was observed tree spacing many influence the growth rate of both crops under agroforestry model. The light intercepted by under storey crops was more when the trees were pruned up to 70 per cent this has been directly influenced the crop height and gaining maximum seed yield and the trees were allowed to grow normally (Newaj *et al*., 2005). Patil and Channabasappa (2008), reported that when adaptation of closer spacing were reduce the seed yield of black gram and wider spacing may increase the light intensity to understory crops. Similarly, various agricultural crops growing under *Acacia auriculiformis* based agroforestry system *viz*., maize, sorghum, sunflower and groundnut adjoining to tree line were observed lesser yield compared with the wider tree spacing (Nagagouda, 1990; Solaimalai *et al.,* 2005).

The *M. dubia* trees performed better in intercropping than in sole plantations (Fig 1-4) in both the season of observations. The maximum average increment of height was in T_4- S_1V_1 as 1.39 m in both seasons while maximum DBH increment was in T_9- S_3V_2 as 2.09 cm. Hence, the maximum tree height was exposed in closer spacing and highest DBH shows at wider spacing with black gram based agroforestry system. Thus intercrops favouring the growth of *M. dubia* probably due to application nutrients and irrigation to crops are also utilized by the trees.

CONCLUSION

Intercropping of pulses with fast growing trees provide maximum returns to the farmers as compared to sole plantation or sole cropping. In the present study, the intercropping of black gram varieties with *Melia dubia* plantations in different spacing were the highest under sole cropping compared to intercropping. The growth and yield parameters of *M. dubia* were found maximum with intercrops than sole plantation irrespective of the spatial arrangement.

The average maximum seed yield of black gram with intercropping reported in T_8- (variety VBN 6 with *M. dubia* at 4 × 4 m spacing) as 0.80 tonnes/ha which shows marginal reduction of 0.02 tonnes/ ha in yield than sole cropping. Hence wider spacing of S_3 (4 × 4 m) can be suggested for intercropping under *M. dubia* plantations in initial 4 years. If we consider the economic return from the tree crop at the stage of harvesting, the financial benefits were more in the intercropping systems as compared to the sole cropping systems. It may also reduce the risk of crop failure and compensate the return from the trees. The interaction of trees and crops can be utilized for maximum gain by technological interventions and good agricultural practices.

REFERENCES

Ashalatha, A., Divya, M.P., Ajayghosh, V. (2015). Development of suitable *Melia dubia* based agroforestry models for higher productivity. Madras Agricultural Journal. 102(7-9): 264-267.

Bhusara, J.B., Dobriyal, M.J., Thakur, N.S., Sondarva, R.L., Prajapati, D.H. (2018). Growth and yield performance of green gram under *Melia composita* plantations. Journal of Pharmacognosy and Phytochemistry. 7: 1490-1494.

Chauhan, S. and Kumar, A.A. (2014). Assessment of variability in morphological and wood quality traits in *Melia dubia* Cav. for selection of superior trees. Journal of the Indian Academy of Wood Science. 11(1): 25-32.

Dalal, V., Bhardwaj, K.K., Khajuria, S., Singh, M.K., Singh, P. (2016). Effect of agri-silvi-horticultural system on growth and yield of wheat. Indian Journal of Agroforestry. 18(1): 34-38.

Goswami, M., Bhagta, S. and Sharma, D. (2020). *Melia dubia* and its Importance: A Review. International Journal of Economic Plants. 7(1): 029-033.

Korwar, G.R. and Pratibha, G. (1999). Performance of short duration pulses with African winter thorn (*Faidherbia albida*) in semi-arid regions. Indian Journal of Agricultural Sciences. 69: 560-562.

Kumar, M., Thakur, N.S., Bardhan, K., Bhusara, J.B. (2017). Effect of teak (*Tectona grandis* L.)-*Ocimum* spp-based silvi-medicinal systems on growth and physiological parameters of *Ocimum* spp. International Journal of Farm Sciences. 7: 8-14.

Nagagouda, V.B. (1990). Performance of tree species and their influence on seasonal crops in agroforestry system under irrigation. Ph. D. Thesis, Univ. Agric. Sci., Dharwad (India).

Nandal, D.P.S. and Hooda, M.S., (2005). Production potential of some agricultural crops under different spacings of poplar. Indian Journal of Agroforestry. 7(1): 16-20.

Nandal, D.P.S. and Singh, R.R., (2001). Productivity of different cropping sequences in *Dalbergia sissoo* Roxb. based agro-silviculture system. Indian Journal of Forestry. 24(4): 433-436.

Newaj, R., Bhargava, M.K., Shanker, A.K., Yadav Ajit, R.S. and Rai, P. (2005). Resource capture and tree-crop interaction in Albizia procera-based agroforestry system. Archives of Agronomy and Soil Science. 51(1): 51-68.

Pandey, A.K., Gupta, V.K., Solanki K.R. (2019). Productivity of neem-based agroforestry system in semi-arid region of India. Range Management and Agroforestry. 31: 144-149.

Parthiban, K.T. and Fernandaz, C.C. (2017). Industrial agroforestry: Status and development in Tamil Nadu. Indian Journal of Agroforestry. 19: 1-11.

Parthiban, K., Bharathi, A., Srenivasan, R., Kamala, K., Rao, M. (2009). Integrating *Melia dubia* in Agroforestry farms as an alternate pulpwood species. American Psychological Association News. 34: 3-4.

Patil, M.B. and Channabasappa, K.S. (2008). Effect of tree management practices in *Acacia auriculiforms* is based agroforestry system on growth and yield of associated black gram. Karnataka Journal Agriculture Science. 21(4): 538-540.

Priyanka, S., Ashok, K., Pande, P.K. and Gupta, P.K. (2019). Variations in certain wood quality parameters of *Melia dubia* Cav. Indian Forester. 145(11): 1098-1104.

Rajalingam, G.V., Divya, M.P., Prabaharan, C., Parthiban, K.T. (2016). Performance of vegetable crops under *Ailanthus excelsa* based agroforestry system. Indian Journal of Agroforestry. 18: 16-20.

Rani, S., Rajasekaran, A., Benbi, D.K., Chauhan, S.K. (2015). Cost benefits analysis and yield performance of agricultural crops under poplar and fruit crop in north western zone of Punjab, India. International Journal of Scientific Research. 4: 2277-8179.

Rao, O.P., Pradyuman, S., Gupta, R.J. and Verma, S.K., (2017). Growth and yield performance of wheat (*Triticum aestivum*) at different crop distance from tree base under *Populus deltoides* Bartr. ex. Marsh. based agri silviculture system. Indian Forester. 143(6): 577-580.

Saravanan, V., Partiban, K.T., Thiruneraiselvan,S., Kumar, P., Vennila, S., Kanna, S.U. (2014). Comparative study of wood physical and mechanical properties of *Melia dubia* with *Tectona grandis* at different age gradation. Research Journal of Research Sciences. 3: 256-263.

Sarvade, S., Mishra, H.S., Kaushal, R., Chaturvedi, S., Tewari, S. and Jadhav, T.A. (2014). Performance of wheat (*Triticum aestivum* L.) crop under different spacing of trees and fertility levels. African Journal of Agricultural Research. 9(9): 866-873.

Singh, D.P. and Ahlawat, I.P.S., (2005). Greengram (*Vigna radiata*) and blackgram (*V. mungo*) improvement in India: Past, present and future prospects. Indian Journal of Agricultural Science. 75(5): 243-250.

Solaimalai, A., Muralidaran, C. and Subburamu, K. (2005). Alley cropping in rainfed agroecosystem- A review. Agricultural Reviews. 26(3): 157-172.

Srivastava, M.B. (2005). Timber Industries and Non-timber Forest Products. CBS Publication, New Delhi, 518.

Sureshbhai, P.J., Thakur, N.S., Jha, S.K., Kumar, V. (2017). Productivity and carbon sequestration under prevalent agroforestry systems in Navsari district, Gujarat, India. International Journal of Current Microbiology and Applied Sciences. 6(9): 3405-3422.

Veeramani, P. (2019). Effect of plant spacing on the growth and yield of black gram (*Vigna mungo*). Journal of Krishi Vigyan. 8: 101-104.

Yadav, D., Sahoo, G. and Wani, A.M., (2019). Growth performance and variability studies in different half sib families of *Melia dubia* under greenhouse condition. Journal of Pharmacognosy and Phytochemistry. 8(2): 1008-1011.