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Growth Analysis of Pigeonpea in Pigeonpea Based Cropping Systems as Influenced by Planting Methods, Geometry and Intercrops

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ABSTRACT

A field experiment was conducted to study the "growth and development of transplanted and direct sown pigeonpea at different cropping geometry and intercropping systems'' at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka on medium deep black soil under rainfed condition during 2016. The experiment was laid out using randomized complete block design with twelve treatment combinations replicated thrice. The treatments consisted of transplanted pigeonpea at 120 cm x 60 cm planting geometry, direct sown pigeonpea at 120 cm x 60 cm and 90 cm x 30 cm planting geometries, intercropped with soybean, greengram and blackgram at 1:2 row proportion and compared with sole treatments of transplanted and direct sown pigeonpea for their physiological growth parameters. Significantly higher leaf area (88.20 dm^2), total dry matter production (163.61 g $plant^{-1}$), absolute growth rate (14.87 g $plant^{-1}day^{-1}$), crop growth rate (20.65 g $m^{-2}day^{-1}$), biomass duration (11599 g days) at all the growth stages and grain yield (2,662 kg ha^{-1}) of pigeonpea were recorded with sole transplanted pigeonpea at a planting geometry (120 cm × 60 cm) as compared to leaf area, total dry matter production, absolute growth rate, crop growth rate, biomass duration and grain yield of pigeonpea in direct sown pigeonpea intercropping systems and sole direct sown pigeonpea treatments except transplanted pigeonpea at 120 cm × 60 cm geometry with greengram and soybean intercropping systems which were on par with each other.

Key words: *Pigeonpea, Transplanting, Direct sowing, Crop growth rate, Biomass duration*

INTRODUCTION

Pulses have remained an integral component of sustainable crop production system since time immemorial, especially in the rainfed areas. India ranks first in both area and production of all important pulses grown during *kharif*, *viz.* pigeonpea, greengram, blackgram, cowpea, horsegram and mothbean. Pigeonpea (*Cajanus cajana* L.) is one of the most important pulse crop cultivated in India which occupies an area of about 5.40 m ha with a total production of 4.78 m t, with an average productivity of 885 kg/ha. It is grown mostly as a rainfed crop in dryland areas.

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Among the states, Maharashtra leads in both area (1.53 m ha) and production (1.46 m t) followed by Karnataka with an area and production of 1.21 m ha and 0.91 m t, respectively[1]. The highest productivity is observed in Bihar (1702 kg/ha) followed by Gujarat (1156 kg/ha).

Among the different agronomic options, timely sowing/planting, choice of a suitable planting geometry (row spacing) and plant population for a particular genotype are the most important factors responsible for enhancing the grain yield. In dry farming areas of northern Karnataka, the rainfall is not only scanty but also erratic. Thus, soil moisture becomes the most limiting factor in pigeonpea production. In order to ensure timely sowing under delayed onset of monsoon, the transplanting of pigeonpea seedlings will be one of the better agronomic measures to overcome delayed sowing. This technique involves raising of seedlings in the polythene bags in the nursery for a period of 25 days and then transplanting those seedlings in the main field, immediately after soil wetting rains. The research studies showed that performance of transplanted pigeonpea was found superior with respect to productivity and profitability as compared to direct sown crop[2,3]. Intercropping of short duration legumes and pulses enhance the productivity and returns over sole pigeonpea. The initial slow growth rate and deep root system of pigeonpea offers good scope for intercropping with fast growing early maturing and shallow rooted crops[4], therefore it is grown as intercrop, which helps in efficient utilization of available resources for enhancing the productivity and profit.

Recently growing of transplanted pigeonpea is gaining importance as it is more productive and found handy during climatic aberrations mainly under delayed onset of monsoon. Intercropping in transplanted pigeonpea also offers greater scope for crop intensification as direct sown crop, however the studies on intercropping in transplanted pigeonpea are meager. With this background field investigation was carried out on intercropping of short duration pulses and legume oilseed in transplanted pigeonpea *vis-a-vis* direct sown pigeonpea to study the effect of planting method, geometry and intercropping on physiological growth analysis of pigeonpea.

MATERIAL AND METHODS

Soil and climate

The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka at 15^0 26' N latitude and 75^0 7' E longitude with an altitude of 678 m above mean sea level under rainfed condition during *Kharif* and *Rabi* (June to January) seasons of 2016-17. The soil of the experimental site is *Typic Hapstaurt* with pH of 7.1 and electrical conductivity of 0.32 dS m^{-1}. The soil is medium in organic carbon (0.52%) and low in available nitrogen (243 kg ha^{-1}) and medium in available P (27 kg ha^{-1}) and available K (283 kg ha^{-1}).

During the crop growth period, a total rainfall of 563.1 mm was received, which was optimum for good growth and higher yield. It helped for better growth and development of both the transplanted and direct sown pigeonpea. The mean maximum temperature during vegetative period of pigeonpea ranged from 26.3°C (July) to 27.1°C (September) and during reproductive stage ranged from 29.7°C (October) to 30.8°C (November) while the minimum temperature throughout the cropping period ranged from 14.4°C (November) to 21°C (June). The average mean monthly relative humidity during the vegetative growth period was ranged from 90.83 per cent (June) to 92.71 per cent (August) was slightly higher than average mean monthly relative humidity

Experimental design

The experiment was laid out in a randomized complete block design involving 12 treatments in 3 replications. The details of the treatments included transplanted pigeonpea at 120 cm x 60 cm planting geometry, direct sown pigeonpea at 120 cm x 60 cm and 90 cm x 30 cm planting geometries with intercropping of soybean, greengram and blackgram at 1:2 row proportion and sole treatment of transplanted

pieonpea at 120 cm x 60 cm planting geometry, direct sown pigeonpea at 120 cm x 60 cm and 90 cm x 30 cm planting geometries.

Planting material, planting and cultural practices

Pigeonpea variety 'TS 3R', soybean variety 'JS 335', greengram variety 'DGGV 2' and blackgram variety 'DBGV 5' were used. Pigeonpea and intercrops seeds were dry seed dressed with Trichoderma at the rate of 4g kg^{-1} seeds and later treated with Rhizobium and *Pseudomonas fluroscence* a P solubilizing culture at the rate of 500g ha^{-1} seed.

In order to raise seedlings of pigeonpea healthy bold treated seeds were sown in black polythene bags (size 15cm x 6cm) filled with soil and vermicompost in the last week of May. Regular watering was then done to raise the seedlings for a period of 4 weeks in the nursery. Transplanting of pigeonpea seedlings, direct sowing of pigeonpea and intercrops seeds were done at the onset of the rains during the last week of June. Marking with the help of marker was done as per the row and intra row spacing of respective treatments and at each hills small pits were opened with the help of pickaxe to a depth of 15-20 cm and then pigeonpea seedlings were transplanted after removing the polythene cover without disturbing the soil at the root zone of the pigeonpea seedling. The row spacing adopted for intercrops in transplanted pigeonpea and direct sown pigeonpea (120 cm x 60 cm) was 40 cm x 7.5 cm and in intercrops with direct sown pigeonpea (90 cm x 30 cm) was 30 cm x 10 cm. The recommended quantity of FYM (6 t ha^{-1}) was applied two weeks before sowing and transplanting of the crop. The entire quantity of recommended dose of fertilizer for pigeonpea (25:50:0 kg $N:P_2O_5:K_2O$ ha^{-1}) and $2/3^{rd}$ of recommended dose of fertilizer for soybean (26.6:53.3:16.6 kg $N:P_2O_5:K_2O$ ha^{-1}), greengram (16.6:33.3:0 kg $N:P_2O_5:K_2O$ ha^{-1}) and blackgram (16.6:33.3:0 kg $N:P_2O_5:K_2O$ ha^{-1}) in the form of urea, diammonium phosphate and muriate of potash were applied at the time of sowing and transplanting as basal dose at 5 cm deep and 5 cm away from the seeds and seedlings, then covered with soil.

Parameters measured

Observations on growth parameters such as leaf area, total dry matter production and per plant grain yield were recorded on five tagged plants selected from the net plot area.

Absolute growth rate (AGR): AGR is the dry matter production per unit time (g day^{-1}) and was calculated by using the following formula.

$$AGR\ (g\ day^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W_1 and W_2 are total dry matter weights (g) at time t_1 and t_2, respectively.

Crop growth rate (CGR): CGR is the rate of dry matter produced per unit ground area per unit time[5]. It was calculated by using the following formula and expressed as g dm^{-2} day^{-1}.

$$CGR\ (g\ m^{-2}\ day^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

Where, W_1 and W_2 are total dry matter weights (g) of the plant at times t_1 and t_2, respectively. A represents land area or spacing (m^2).

Relative growth rate (RGR): RGR is the rate of increase in the dry weight per unit dry weight already present and expressed as g/g/day[6]. RGR was calculated by using the following formula.

$$RGR\ (g\ g^{-1}\ day^{-1}) = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)}$$

Where, W_1 and W_2 are total dry matter weights (g) of the plant at times t_1 and t_2, respectively.

Biomass duration (BMD): BMD was calculated as given by Sestak *et al.*[7], and expressed in g days.

$$\text{BMD (g days)} = \frac{TDM_1 + TDM_2}{2} \times (t_1 - t_2)$$

Where, TDM_1 and TDM_2 represent total dry matter (g) at times t_1 and t_2, respectively.

Net assimilation rate (NAR): NAR was worked out by using established formula[6] shown below.

$$NAR\ (g\ m^{-2} day^{-1}) = \frac{(W_2 - W_1) \times (\ln L_2 - \ln L_1)}{(t_2 - t_1) \times (L_2 - L_1)}$$

Where, W_1 and W_2 are total dry matter weights (g) of the plant at times t_1 and t_2, respectively. L_1 and L_2 are leaf areas of the plant at times t_1 and t_2, respectively.

Statistical analysis and interpretation of data: Fisher's method of analysis of variance was used for analysis and interpretation of the data as outlined by Panse and Sukhatme[8]. The level of significance used in F and t tests was P=0.05. Critical differences were calculated wherever F tests were significant.

RESULTS AND DISCUSSION

Total dry matter production and leaf area of pigeopea

The functional leaves, dry matter production and leaf area are the main growth factors which may directly reflect to grain yield. At 60 days after transplanting (DAT) / days after sowing (DAS), significantly higher leaf area plant^{-1} (88.20 dm^2) and TDM production (163.61 g plant^{-1}) were recorded with sole transplanted pigeonpea at a planting geometry of 120 cm × 60 cm as compared to leaf area and TDM of pigeonpea in intercropping systems and sole direct sown and other transplanted pigeonpea treatments except transplanted pigeonpea at 120 cm × 60 cm geometry with greengram which was on par (Table 1). Sole transplanted pigeonpea (120 cm × 60 cm) and transplanted pigeonpea (120 cm × 60 cm) with intercropping of greengram, soybean and blackgram were significantly superior with respect to leaf area and TDM production over direct sown pigeonpea both as sole as well as intercropping at 120 cm × 60 cm and 90 cm × 30 cm planting geometries. Similar trend was observed with respect to leaf area and TDM production at all the stages of the crop growth (Table 1).

Higher growth attributes in transplanted pigeonpea might be due to early planting of 3 weeks grown up pigeonpea seedlings and relatively longer days available with higher photoperiod. In transplanted pigeonpea, the seedlings were raised earlier in the polythene bags for a certain period (3 weeks), after planting it develops vigorous root system and improves the utilization of natural resources mainly solar radiation, soil moisture, space and nutrients more efficiently as compared to direct sown pigeonpea. In transplanted pigeonpea, the crop was already established as it was 25-30 days advantage over direct sown pigeonpea and the component intercrops have least competition on pigeonpea hence it performed better and yield of pigeonpea with intercropping with greengram and soybean were on par with transplanted sole counterparts at 120 cm x 60 cm. These results are in accordance with the findings of Malik *et al.*[9], and Praharaj *et al.*[2], in pigeonpea. Pavan *et al.*[3], reported that transplanted pigeonpea at the spacing of 150 cm x 30 cm recorded significantly higher plant height (197.00 cm) and higher leaf area per plant was recorded in wider row spacing of transplanted pigeonpea at 120 cm x 60 cm which was found to be significantly superior over dibbled pigeonpea.

Net assimilation rate

Another parameter that is determined by the LAI of two consecutive growth stages is Net assimilation rate (NAR). It is the rate of increase in dry matter per unit leaf area which indicates the assimilatory capacity of plant. In this experiment NAR is significantly affected

by planting methods, geometry and intercropping systems (Table 1).

Maximum NAR was observed during 60 to 90 DAT/DAS and significantly higher NAR (21.23 g/day/m^2) was recorded with sole direct sown pigeonpea at 90 cm × 30 cm spacing. Sole direct sown pigeonpea at 90 cm × 30 cm spacing and direct sown pigeonpea (90 cm × 30 cm) with intercropping greengram (19.72 g/day/m^2), soybean (19.78 g/day/m^2) and blackgram (19.72 g/day/m^2) were significantly superior over both transplanted and direct sown sole pigeonpea as well as intercropping at 120 cm × 60 cm planting geometry (Table 1). During 90 to 120 DAT/DAS, NAR was significantly higher (4.65 g/day/m^2) in direct sown pigeonpea (90 cm × 30 cm) intercropping with blackgram and transplanted pigeonpea (90 cm × 30 cm) intercropped with greengram (3.85 g/day/m^2), soybean (3.69 g/day/m^2) and blackgram (3.61 g/day/m^2) were found on par. Lowest NAR (1.18 g/day/m^2) was recorded with sole direct sown pigeonpea at 120 cm x 60 cm spacing and was on par with direct sown pigeonpea (120 cm × 60 cm) intercropped with blackgram (1.19 g/day/m^2), greengram (1.32 g/day/m^2) and soybean (1.42 g/day/m^2).

Significant reduction of NAR in direct sown pigeonpea at 120 cm x 60 cm planting geometry both in sole as well as intercropping is mainly due to lower dry matter accumulation per unit time and unit leaf area because of lesser population per unit land area. Lower NAR in transplanted pigeonpea both in sole as well as intercropping over direct sown pigeonpea (90 cm x 30 cm) is mainly due increased LA and LAI which might have increased the mutual shading of leaves and led to decreased photosynthesis per unit leaf area. These results are in harmony with the results of Sheldrake and Narayanan[10] in pigeonpea and Addo-Quaye *et al.*[11], in maize-soybean intercropping system. NAR declined as the growth progressed and rise in shading due to increase in LAI accounted for the decline. Buttery[12] noted a decline in NAR as the season progressed and attributed this primarily to increasing LAI.

Absolute growth rate and crop growth rate

AGR indicates growth of plants while CGR indicates the dry matter production capacity per unit area and also indicates net primary productivity. As the results indicate planting methods, geometry and intercropping have significant effect on both AGR and CGR and it is clear that both parameters declined with an increase in the crop growth and were maximum at 60 - 90 DAT/DAS (Fig.1 & Table 2).

Sole transplanted pigeonpea at a planting geometry of 120 cm × 60 cm recorded significantly higher AGR (14.87 g $plant^{-1}day^{-1}$) and CGR (20.65 g $m^{-2}day^{-1}$) as compared to AGR and CGR of pigeonpea in intercropping systems and sole direct sown and other transplanted pigeonpea treatments except transplanted pigeonpea at 120 cm × 60 cm geometry with greengram, blackgram and soybean which were on par and significantly superior over direct sown sole pigeonpea as well as intercropping at 120 cm × 60 cm and 90 cm × 30 cm planting geometries at 60 - 90 DAT/DAS. Similar trend was observed during reproductive/flowering stage (90 to 120 DAT/DAS) and 120 DAT/DAS to harvest. The significant increase in AGR and CGR could be mainly due to the production of more dry matter which intern indicates higher leaf area production in transplanted piegonpea due early establishment and higher photosynthetic activity over direct sown pigeonpea and also indicates transplanted pigeonpea can overcome against competing intercrops. These results are in conformity with Mohanadas[13] who observed significantly higher total dry matter production $plant^{-1}$ (329.16 g $plant^{-1}$) in pigeonpea transplanting at 120 cm x 30 cm as compared to pigeonpea drill sown at 90 cm x 20 cm.

Biomass duration

The data pertaining to biomass duration (BMD) indicated significant differences among all the treatment at all the stages (Table 2). In general BMD increased continuously from 60 DAT/DAS to harvest in all the treatments at all the stages. Biomass duration (BMD) indicates the maintenance of dry

matter over a period of time and is essential for prolonged supply of photosynthates to the developing sink.

Significantly higher (11599 g days) BMD was recorded with sole transplanted pigeonpea at a planting geometry of 120 cm × 60 cm as compared to BMD of pigeonpea in intercropping systems and sole direct sown pigeonpea treatments except transplanted pigeonpea (120 cm × 60 cm) intercropped with greengram (10809 g days) and soybean (10722 g days) which were on par and also found significantly superior over direct sown pigeonpea intercropping systems both at 120 cm x 60 cm and 90 cm x 30 cm planting geometries. Similar trend was observed at all the crop growth stages. This is mainly due to better acquisition of growth resources by well established transplanted seedlings and also undergone lesser suppression by intercrops might have resulted in higher leaf area and total dry matter production which ultimately resulted in higher BMD of transplanted pigeonpea as compared to direct sown pigeonpea plots which were more suppressed by intercrops due to more competition offered by intercrops for the growth resources. These findings are in conformity with the findings of Goud and Andhalkar[14] in transplanted pigeonpea + soybean system, Poornima *et al*.[15], and Murali *et al.*[16], in transplanted pigeonpea with ragi intercropping system.

Relative growth rate

RGR is the rate of increase in the dry weight per unit dry weight already present; it indicates the proportionate growth of plant independent of their size. The data indicated that, RGR exhibited significant differences among the treatments at different stages. In general it is clear from the data that RGR declined with an increase in the crop growth (Fig. 2).

Significantly higher RGR was recorded in direct sown pigenopea (90 cm x 30 cm) intercropped with greengram (1:2) as compared to transplanted pigeonpea and direct sown pigeonpea at 120 cm x 60 cm planting geometry both in sole and intercropping systems except direct sown pigenopea (90 cm x 30 cm) as sole and intercropped with blackgram and soybean which were on par. The decline in RGR with the advancement in crop growth and the decreased RGR with transplanted pigeonpea (120 cm x 60 cm) treatments could be due increased leaf area and leaf area index which might have increased the mutual shading of leaves and led to decreased photosynthesis and dry matter accumulation per unit dry matter and per unit time. These results are in harmony with the results of Rajput *et al.*[17], in rice where higher RGR values were recorded with closure spacing than wider spacing.

Grain yield

Sole transplanted pigeonpea (120 cm × 60 cm) has recorded significantly higher grain yield (2,662 kg ha^{-1}) as compared to transplanted pigeonpea (120 cm x 60 cm) with blackgram intercropping and direct sown pigeonpea sole as well as intercropping both at 90 cm × 30 cm and 120 cm × 60 cm planting geometries. However, it was on par with transplanted pigeonpea (120 cm × 60 cm) with greengram (2,550 kg ha^{-1}) and soybean (2,537 kg ha^{-1}) intercropping systems. Significantly lower grain yield (1,121 kg ha^{-1}) was recorded with direct sown pigeonpea at 120 cm × 60 cm with blackgram intercropping system (Table 2). Pigeonpea grain yield obtained in sole transplanted pigeonpea (120 cm × 60 cm) was significantly higher by 34 per cent over sole direct sown pigeonpea at planting geometry of 90 cm × 30 cm spacing and by 56 per cent over sole direct sown pigeonpea at planting geometry of 120 cm × 60 cm spacing.

Significantly higher pigeonpea grain in transplanted pigeonpea was attributed to the better performance and higher yield parameters and growth parameters. The growth of the crops was better as it has advantage of early planting and better utilization of solar radiation. The transplanted pigeonpea has better establishment with well developed root system which might be resulted in higher uptake of soil moisture and nutrients from the soil. Several research studies under various soil and climatic conditions, reported higher grain yield of pigeonpea with transplanted method over dibbling was due to

improved growth and yield contributing parameters. These results are in harmony with the results of Anilkumar *et al.*[18], and Mallikarjun *et al.*[19]. Mohanadas[13] reported the superiority of transplanting of pigeonpea with respect to grain (2.39 t ha^{-1}) of pigeonpea as compared to dibbling (2.13 t ha^{-1}) and drill sown pigeonpea (1.69 t ha^{-1}).

There was no significant difference was observed with harvest index of pigeonpea as influenced by planting methods, geometry and intercrops.

Table 1: Leaf area, total dry matter production and NAR of pigeonpea as influenced by planting method, geometry and intercrops

Tr. No	Treatments	Leaf area (dm^2 $plant^{-1}$)			Total dry matter production (g $plant^{-1}$)				NAR (g day^{-1} m^{-2})	
		60 DAT/ DAS	90 DAT/ DAS	120 DAT/ DAS	60 DAT/ DAS	90 DAT/ DAS	120 DAT/ DAS	At harvest	60 - 90 DAT/ DAS	90-120 DAT/ DAS
T_1	Transplanted pigeonpea (120cm × 60cm) + soybean (1:2)	80.9	181.3	282.7	150.1	564.7	816.3	963.9	11.09	3.69
T_2	Transplanted pigeonpea (120cm × 60cm) + greengram (1:2)	82.4	182.3	289.9	152.9	567.6	837.1	976.1	10.98	3.85
T_3	Transplanted pigeonpea (120cm × 60cm) + blackgram (1:2)	79.5	174.5	269.8	147.4	543.4	779.1	933.7	10.91	3.61
T_4	Direct sown pigeonpea (120cm × 60cm) + soybean (1:2)	34.6	102.3	182.5	58.1	210.6	269.5	326.7	8.13	1.42
T_5	Direct sown pigeonpea (120cm × 60cm) + greengram (1:2)	35.2	99.6	175.3	55.9	204.8	258.9	311.2	8.02	1.32
T_6	Direct sown pigeonpea (120cm × 60cm) + blackgram (1:2)	31.7	95.5	165.4	53.3	196.6	242.3	290.2	8.30	1.19
T_7	Direct sown pigeonpea (90cm × 30cm) + soybean (1:2)	11.2	30.7	54.8	32.4	147.8	182.1	222.0	19.78	2.78
T_8	Direct sown pigeonpea (90cm × 30cm) + greengram (1:2)	11.5	31.3	58.9	33.0	150.4	195.9	232.0	19.84	3.46
T_9	Direct sown pigeonpea (90cm × 30cm) + blackgram (1:2)	11.7	31.5	60.9	33.6	151.8	213.7	246.7	19.72	4.65
T_{10}	Sole transplanted pigeonpea (120cm × 60cm)	88.2	198.3	318.9	163.6	609.7	860.7	1033.0	10.95	3.30
T_{11}	Sole direct sown pigeonpea (120cm × 60cm)	38.0	117.7	201.1	63.9	242.1	297.0	358.0	8.45	1.18
T_{12}	Sole direct sown pigeonpea (90cm × 30cm)	12.8	42.93	66.8	48.0	206.5	250.6	281.2	21.23	2.75
	S.Em.+	2.1	6.0	10.1	4.3	18.0	24.2	17.1	0.26	0.36
	LSD (0.05)	6.3	17.5	29.7	12.7	52.8	70.9	50.2	0.76	1.07

Table 2: CGR, BMD, grain yield and harvest index of pigeonpea as influenced by planting method, geometry and intercrops

Tr. No.	Treatments	CGR (g m^{-2} day^{-1})			BMD (g days)			Grain yield (kg ha^{-1})	Harvest index
		60 - 90 DAT/ DAS	90 - 120 DAT/ DAS	120 DAT/ DAS - Harvest	60 - 90 DAT/ DAS	90 - 120 DAT/ DAS	120 DAT/ DAS - Harvest		
T_1	Transplanted pigeonpea (120 cm × 60 cm) + soybean (1:2)	19.19	11.65	6.83	10722	20715	26703	2,537	21.4
T_2	Transplanted pigeonpea (120 cm × 60 cm) + greengram (1:2)	19.20	12.48	6.44	10809	21071	27199	2,550	21.0
T_3	Transplanted pigeonpea (120 cm × 60 cm) + blackgram (1:2)	18.34	10.91	7.16	10362	19838	25691	2,334	20.1
T_4	Direct sown pigeonpea (120 cm × 60 cm) + soybean (1:2)	7.06	2.73	2.65	4031	7201	8944	1,254	21.9
T_5	Direct sown pigeonpea (120 cm × 60 cm) + greengram (1:2)	6.89	2.50	2.42	3911	6957	8552	1,213	22.4
T_6	Direct sown pigeonpea (120 cm × 60 cm) + blackgram (1:2)	6.64	2.12	2.22	3748	6583	7988	1,121	21.4
T_7	Direct sown pigeonpea (90 cm × 30 cm) + soybean (1:2)	14.25	4.23	4.93	2703	4948	6062	1,684	20.5
T_8	Direct sown pigeonpea (90 cm × 30 cm) + greengram (1:2)	14.49	5.61	4.47	2752	5194	6419	1,789	20.8
T_9	Direct sown pigeonpea (90 cm × 30 cm) + blackgram (1:2)	14.59	7.65	4.07	2780	5482	6905	1,877	21.0
T_{10}	Sole transplanted pigeonpea (120 cm × 60 cm)	20.65	11.62	7.98	11599	22056	28407	2,662	21.3
T_{11}	Sole direct sown pigeonpea (120 cm × 60 cm)	8.25	2.54	2.82	4590	8087	9826	1,705	20.6
T_{12}	Sole direct sown pigeonpea (90 cm × 30 cm)	19.56	5.45	3.78	3818	6857	7978	1,988	20.4
	S.Em. ±	0.94	0.74	0.80	321	614	586	70	0.6
	L.S.D. (0.05)	2.76	2.17	2.33	943	1801	1720	205	NS

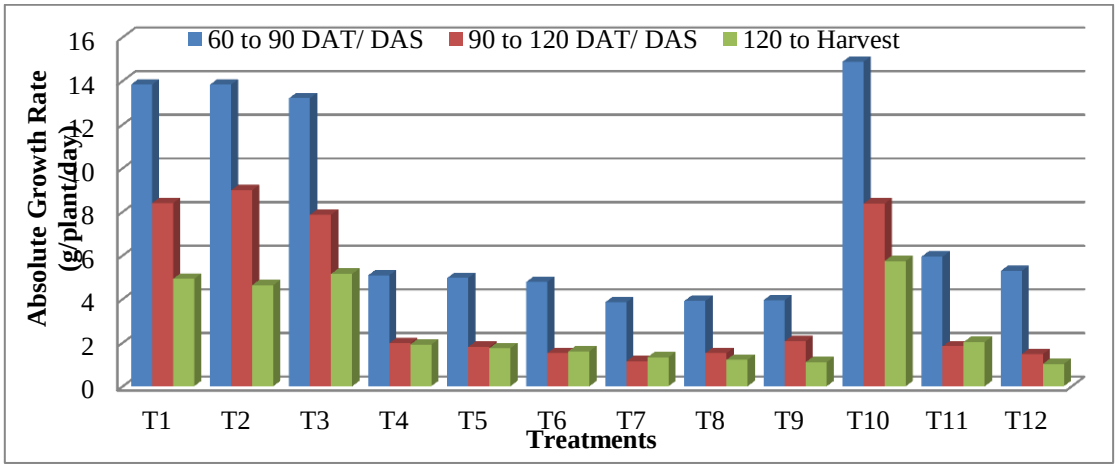

Fig. 1: Absolute growth rate of pigeonpea as influenced by planting methods, geometry and intercrops

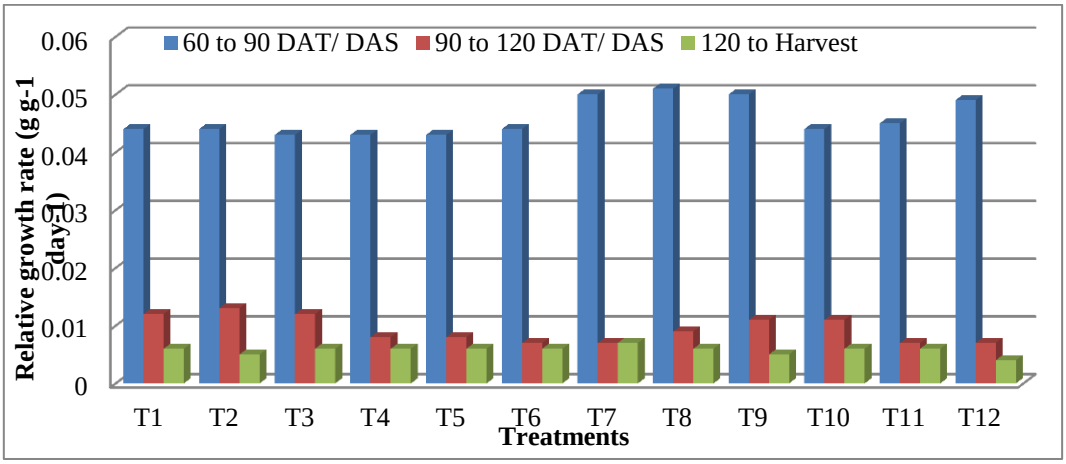

Fig. 2: Relative growth rate of pigeonpea as influenced by planting methods, geometry and intercrops

CONCLUSION

It can be concluded that, sole transplanted pigeonpea (120 cm x 60 cm) found superior than direct sown pigeonpea at 120 cm × 60 cm and 90 cm × 30 cm planting geometry and intercropping of transplanted pigeonpea (120 cm × 60 cm) with short duration pulses (greengram, blackgram and soybean) at 1:2 row proportion found superior than intercropping direct sown pigeonpea both at 120 cm × 60 cm and 90 cm × 30 cm planting geometries and sole pigeonpea treatments for leaf area, total dry matter production, absolute growth rate, crop growth rate, biomass duration and grain yield of pigeonpea, hence it can be recommended for adaptation in pigeonpea growing areas of northern Karnataka.

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