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System Productivity and Economics of Transplanted and Direct Sown Pigeonpea at Different Cropping Geometry and Intercropping Systems

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ABSTRACT

A field experiment was conducted to study the "System productivity and economics of transplanted and direct sown pigeonpea at different cropping geometry and intercropping systems'' at MARS, UAS, Dharwad, Karnataka on medium deep black soil under rainfed condition during 2016. The experiment was laidout using RCBD 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 system productivity and profitability. Significantly higher grain (2,662 kg ha^{-1}) and stalk + husk yield (9,836 kg ha^{-1}) of pigeonpea was recorded with sole transplanted pigeonpea at a planting geometry of 120 cm × 60 cm spacing as compared to yield of pigeonpea in intercropping systems and sole direct sown and transplanted pigeonpea treatments except transplanted pigeonpea at 120 cm × 60 cm geometry with greengram (2,550 kg ha^{-1} and 9,580 kg ha^{-1}, respectively) and soybean (2,537 kg ha^{-1} and 9,340 kg ha^{-1}, respectively) intercropping systems which were on par with each other. Transplanted pigeonpea at 120 cm × 60 cm geometry with blackgram intercropping system produced significantly higher pigeopea equivalent yield (3,987 kg ha^{-1}) and net returns (Rs. 1,38,476 ha^{-1}) as compared to sole transplanted pigeonpea (120 cm × 60 cm) and direct sown sole pigeonpea as well as intercropping systems at 120 cm × 60 cm and 90 cm × 30 cm geometry. The next best systems which recorded significantly higher system productivity and net returns were transplanted pigeonpea at 120 cm × 60 cm geometry with soybean (3,861 kg ha^{-1} and Rs. 1,31,105 ha^{-1}, respectively) and greengram (3,833 kg ha^{-1} and Rs. 1,29,650 ha^{-1}, respectively) intercropping.

Key words: *Pigeonpea, Transplanting, Direct sowing, Productivity, Net returns*

INTRODUCTION

Pigeonpea [*Cajanus cajana* L.] is one of the most important pulse crop cultivated in India and Karnataka. It is the most preferred soil restorative crop of rainfed areas as it extracts moisture and nutrients from deeper layer and makes this crop ideal for rainfed condition. To mitigate the protein malnutrition, it is the important pulse crop in India and Karnataka.

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It is grown as both sole and inter crop during *kharif* and *rabi* season. It performs well in poor soils and in dryland farming regions of the country[14]. In India, pigeonpea occupies an area of about 3.47 million ha with a total production of 2.55 million tonnes, with an average productivity of 711 kg ha^{-1}. It is grown mostly as a rainfed crop in dryland areas. Among the different pulses grown in Karnataka, pigeonpea holds first place both in area and production. Pigeonpea is largely grown in Northern parts of Karnataka, especially in Kalburgi, Vijayapur, Bidar and Raichur districts.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 best agronomic measures to overcome delayed sowing[13]. 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. Several short duration crops mainly greengram, blackgram, soybean, groundnut, maize, sorghum and pearlmillet could be grown as intercrop in long duration pigeonpea for increasing productivity and maintaining soil fertility. Intercropping of short duration legumes and pulses not only enhance the productivity but also the net returns over sole pigeonpea.

MATERIAL AND METHODS

The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka on medium black soil under rainfed condition during *kharif* 2016. During the crop growth period, a total rainfall of 563.1 mm was received which was optimum for good growth and higher yield. The soil of the experimental site was clay with pH of 7.1 and electrical conductivity of 0.32 dS m^{-1}. The soil was 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}). The experiment was laid out in a randomized complete block design (RCBD) 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 treatments of transplanted and direct sown pigeonpea.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 4 gm kg^{-1} seeds and later treated with Rhizobium and *Pseudomonas fluroscence* P solubilizing culture at the rate of 500 gm ha^{-1} seed. For raising of seedlings, pigeonpea healthy bold treated seeds were sown in black polythene covers (size 15 cm x 6 cm) in the month of last week of May to grow the seedlings by filling soil and well vermicompost and regular watering was done to raise seedlings for 4 weeks in the nursery. Transplanting of pigeonpea seedlings was done looking in to the onset of rains during last week of June along with direct sowing of pigeonpea and intercrops. 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 picax 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 followed 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 (DAP) 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.

RESULTS AND DISCUSSION

Performance of pigeonpea

Sole transplanted pigeonpea with planting geometry of 120 cm × 60 cm recorded significantly higher pigeonpea grain yield (2,662 kg ha^{-1}) and stalk + husk yield (9,836 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 systems both at 90 cm × 30 cm and 120 cm × 60 cm planting geometries. However, it was on par with transplanted pigeonpea at 120 cm × 60 cm spacing with greengram (2,550 kg ha^{-1} and 9,580 kg ha^{-1}, respectively) and soybean (2,537 kg ha^{-1} and 9,340 kg ha^{-1}, respectively) intercropping systems (Table 1). Pigeonpea grain and stalk + husk yields obtained in sole transplanted pigeonpea at planting geometry of 120 cm × 60 cm spacing were significantly higher by 34 and 26 per cent respectively over sole direct sown pigeonpea at planting geometry of 90 cm × 30 cm spacing and by 56 and 49 per cent respectively over sole direct sown pigeonpea at planting geometry of 120 cm × 60 cm spacing.The yielding ability of a crop is the reflection of growth and yield attributing characters. Significantly higher pigeonpea grain and stalk + husk yield ha^{-1} in transplanted pigeonpea could be due to significantly higher assimilation of photosynthates, total dry matter production per plant (1,033 g) and higher number of pods per plant (1,138) which recorded in sole transplanted pigeonpea at 120 cm × 60 cm spacing and it was significantly superior to direct sown sole pigeonpea as well as intercropping both at 120 cm × 60 cm spacing and at 90 cm × 30 cm spacing (Figure 1). This might be due to the advantage of early planting of 3 weeks grown up pigeonpea seedlings with well established root system and exposed to relatively longer days available, provide higher photoperiod required for growth of plant. 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 has already established as it was 25-30 days advantage over direct sown pigeonpea and the component fast covering soybean, greengram and blackgram intercrops have least competition on pigeonpea hence it performed better. As the competition was minimum, yield of pigeonpea with intercropping with greengram and soybean were on par with transplanted sole pigeonpea at 120 cm x 60 cm. Several research studies under various soil and climatic conditions, reported higher grain yield of pigeonpea with transplanted than direct sown was mainly due to improved growth and yield contributing parameters[1,4,7,11,12] . Mohanadas[8] reported the superiority of transplanting of pigeonpea with respect to grain and stalk yield (2.39 t ha^{-1} and 5.85 t ha^{-1}, respectively) of pigeonpea as compared to direct dibbling (2.13 t ha^{-1} and 5.22 t ha^{-1}, respectively) and drill sown pigeonpea (1.69 t ha^{-1} and 4.14 t ha^{-1}, respectively).

Effect of intercrops

Among all the intercropping treatments, transplanted pigeonpea at planting geometry of 120 cm × 60 cm spacing intercropped with greengram, soybean and blackgram recorded significantly higher pigeonpea grain yield (2,550 kg ha^{-1}, 2,537 kg ha^{-1} and 2,334 kg ha^{-1}, respectively) and stalk + husk yield (9,580 kg ha^{-1}, 9,340 kg ha^{-1} and 9,304 kg ha^{-1}, respectively) as compared to direct sown pigeonpea intercropping with soybean, greengram and blackgram at both 120 cm × 60 cm and 90 cm × 30 cm geometry. Increase in grain yield was 102 %, 110 % and 108 % in transplanted pigeonpea with intercropping soybean, greengram and blackgram respectively as compared to direct sown pigeonpea at 120 cm × 60 cm with soybean,

greengram and blackgram intercropping systems respectively and 51 %, 43 % and 24 % increase over direct sown pigeonpea at 90 cm × 30 cm with soybean, greengram and blackgram intercropping systems respectively. Better acquisition of growth resources by well established transplanted seedlings therefore undergone lesser suppression by intercrops might have resulted in higher growth and yield parameters which ultimately resulted in higher yield 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[3] in transplanted pigeonpea + soybean system, Poornima *et al*.[10] and Murali *et al.*[9] in transplanted pigeonpea with ragi intercropping system. Goud and Andhalkar[3] recorded higher pigeonpea grain yield in soybean + transplanted pigeonpea (6:1) intercropping with transplanting of 4 weeks old seedlings produced significantly higher pigeonpea grain yield (769 kg ha^{-1}) as compared to soybean + direct sown pigeonpea (301 kg ha^{-1}).Among the three intercrops grown both in transplanted and direct sown pigeonpea, intercropping with greengram recorded significantly higher growth and yield parameters of pigeonpea both in transplanting method at 120 cm × 60 cm spacing and direct sowing at 120 cm × 60 cm and 90 cm × 30 cm planting geometry. This could be due to higher number of pods, grain weight and lower competition, which is because of early maturity and senescence of greengram. Further, it was attributed to better plant development resulting in more uniform distribution of plants over cropped area which was coupled with greater light interception, efficient utilization of moisture, nutrients and solar energy under lower degree of inter and intra plant competitions. These favorable conditions for growth caused significantly higher values of yield components under pigeonpea and greengram intercropping system. This is in conformity with the results of Udhaya *et al.*[17] and Sharma *et al*.[15], Malik *et al*.[6] observed that, the intercropping of mungbean in pigeonpea did not affect grain yield of pigeonpea (1,194 and 1,443 kg ha^{-1}) and instead gave an additional grain yield of mungbean (237 and 256 kg ha^{-1}) in both the years, respectively.

Performance of intercrops

Higher seed/grain and haulm yield of intercrops soybean (1,770 kg ha^{-1} and 2,810 kg ha^{-1}, resepctively), greengram (1,556 kg ha^{-1} and 2,154 kg ha^{-1}, resepctively) and blackgram (1,617 kg ha^{-1} and 2,456 kg ha^{-1}, resepctively) was recorded in intercropping with direct sown pigeonpea at a planting geometry of 120 cm × 60 cm spacing as compared to intercropping with transplanted pigeonpea at a planting geometry of 120 cm × 60 cm and direct sown pigeonpea at 90 cm × 30 cm spacing. Higher yields in intercropping with direct sown pigeonpea at wider geometry (120 cm × 60 cm) could be attributed to growth and yield parameters and lower competition, which was because of wider space available and also it was attributed to better plant development resulting in more uniform distribution of plants over cropped area which was coupled with greater light interception, efficient utilization of moisture, nutrients and solar energy under lower degree of inter and intra plant competitions. These favorable conditions for growth caused higher values of yield components under spacing of 120 cm x 60 cm for pigeonpea and 40 cm x 7.5 cm for soybean. These findings are in accordance with the findings of Goud and Andhalkar[3], Kumawat *et al*.[5] and Udhaya *et al*[17].

System productivity and economics

Transplanted pigeonpea (120 cm x 60 cm) intercropping with blackgram at 1:2 row proportion recorded significantly higher pigeonpea equivalent yield (3,987 kg ha^{-1}), gross returns (Rs. 1,83,507 ha^{-1}), net returns (Rs. 1,38,476 ha^{-1}) and benefit cost ratio (4.08) as compared to other intercropping systems and sole crops except transplanted pigeonpea (120 cm x 60 cm) with intercropping of soybean and greengram which were on par. Significantly lower pigeonpea equivalent yield (1,705 kg ha^{-1}), gross returns (Rs. 77,709 ha^{-1}), net returns (Rs. 43,685 ha^{-1}) and benefit cost

ratio (2.28) were recorded with sole direct sown pigeonpea at 120 cm x 60 cm spacing which was on par with sole direct sown pigeonpea with 90 cm x 30 cm (Table 2). Higher pigeonpea equivalent yield with pigeonpea transplanted at 120 cm x 60 cm was 50, 45 and 43 per cent with intercropping of blackgram, soybean and greengram respectively over sole pigeonpea at 120 cm x 60 cm. This was attributed to additional yield of all the three component crops and their better performance in transplanted pigeonpea with higher market prices. Higher pigeonpea equivalent yield, gross returns, net returns and B:C ratio in transplanted treatments might be due to efficient utilization of natural resources which might have resulted in better plant growth ultimately produced higher crop yield, gross and net returns. These results confirmed the findings of Kumawat *et al*.[5] and Srichandan and Mangaraj[16].

Table 1: Grain and stover yield of pigeonpea and intercrops as influenced by planting methods, geometries and intercrops

Tr. No.	Treatments	Pigeonpea		Intercrops	
		Grain yield (kg ha^{-1})	Stalk+ husk yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	Transplanted pigeonpea (120 cm × 60 cm) + soybean (1:2)	2,537	9,340	1,702	2,568
T_2	Transplanted pigeonpea (120 cm × 60 cm) + greengram (1:2)	2,550	9,580	1,444	1,629
T_3	Transplanted pigeonpea (120 cm × 60 cm) + blackgram (1:2)	2,334	9,304	1,550	2,299
T_4	Direct sown pigeonpea (120 cm × 60 cm) + soybean (1:2)	1,254	4,467	1,770	2,810
T_5	Direct sown pigeonpea (120 cm × 60 cm) + greengram (1:2)	1,213	4,224	1,556	2,154
T_6	Direct sown pigeonpea (120 cm × 60 cm) + blackgram (1:2)	1,121	4,127	1,617	2,546
T_7	Direct sown pigeonpea (90 cm × 30 cm) + soybean (1:2)	1,684	6,527	1,642	2,309
T_8	Direct sown pigeonpea (90 cm × 30 cm) + greengram (1:2)	1,789	6,841	1,422	1,519
T_9	Direct sown pigeonpea (90 cm × 30 cm) + blackgram (1:2)	1,877	7,068	1,439	2,278
T_{10}	Sole transplanted pigeonpea (120 cm × 60 cm)	2,662	9,836	-	-
T_{11}	Sole direct sown pigeonpea (120 cm × 60 cm)	1,705	6,584	-	-
T_{12}	Sole direct sown pigeonpea (90 cm × 30 cm)	1,988	7,806	-	-
	S.Em. ±	70	248	-	-
	L.S.D. (0.05)	205	728	-	-

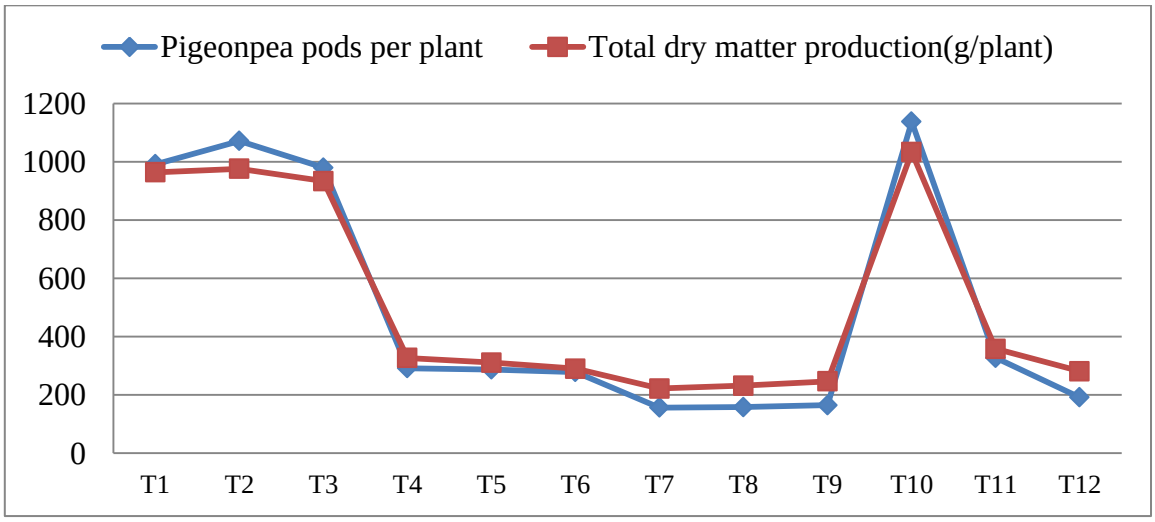

Fig. 1: Total dry matter production and number of pigeonpea pods as influenced by planting methods, geometries and intercrops

Table 2: System productivity and economics of pigeonpea based cropping systems as influenced by planting methods, geometries and intercrops

Tr. No.	Treatments	Pigeonpea equivalent yield (kg ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
T_1	Transplanted pigeonpea (120 cm × 60 cm) + soybean (1:2)	3,861	1,78,266	1,29,650	3.67
T_2	Transplanted pigeonpea (120 cm × 60 cm) + greengram (1:2)	3,833	1,75,900	1,31,105	3.93
T_3	Transplanted pigeonpea (120 cm × 60 cm) + blackgram (1:2)	3,987	1,83,507	1,38,476	4.08
T_4	Direct sown pigeonpea (120 cm × 60 cm) + soybean (1:2)	2,631	1,22,567	79,956	2.88
T_5	Direct sown pigeonpea (120 cm × 60 cm) + greengram (1:2)	2,596	1,20,194	81,404	3.10
T_6	Direct sown pigeonpea (120 cm × 60 cm) + blackgram (1:2)	2,846	1,31,814	92,788	3.38
T_7	Direct sown pigeonpea (90 cm × 30 cm) + soybean (1:2)	2,961	1,36,915	93,601	3.16
T_8	Direct sown pigeonpea (90 cm × 30 cm) + greengram (1:2)	3,053	1,40,219	1,00,726	3.55
T_9	Direct sown pigeonpea (90 cm × 30 cm) + blackgram (1:2)	3,412	1,57,413	1,17,684	3.96
T_{10}	Sole transplanted pigeonpea (120 cm × 60 cm)	2,662	1,21,136	80,907	3.01
T_{11}	Sole direct sown pigeonpea (120 cm × 60 cm)	1,705	77,709	43,685	2.28
T_{12}	Sole direct sown pigeonpea (90 cm × 30 cm)	1,988	90,474	55,346	2.58
	S.Em. ±	124	5,478	5,478	0.13
	L.S.D. (0.05)	363	16,068	16,068	0.37

CONCLUSION

The above results it can be concluded that, sole transplanted pigeonpea was found more productive and profitable as compared to direct sown pigeonpea at 120 cm × 60 cm and 90 cm × 30 cm planting geometry with respect to higher pigeonpea grain yield. Among the intercropping systems, transplanted pigeonpea at 120 cm × 60 cm planting geometry intercropped with blackgram and soybean at 1:2 row proportion were found to be more productive and profitable pigeonpea based intercropping systems as they recorded higher pigeonpea equivalent yield with higher net returns and benefit cost ratio as compared to other intercropping systems and sole direct sown and transplanted pigeonpea treatments.

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