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RESEARCH PAPER

Performance of pigeonpea genotypes to planting methods and geometry under irrigation

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Abstract: A field experiment was conducted at Agricultural Research Station, Almel of University of Agricultural Sciences, Dharwad in northern dry zone of Karnataka to studythe performance of pigeonpea genotypes to planting methods and geometry under irrigation during *kharif* 2015. The experiment was laid out in split-plot design involving two genotypes (GRG-811 and TS-3R) and nine planting methods and geometry (transplanting as well as dibbling at 120 cm x 30 cm, 120 cm × 60 cm, 150 cm x 30 cm and 150 cm x 60 cm and drill sowing of seeds at 90 cm x 20 cm). higher yield was achieved in GRG-811 due to the better growth and yield parameters *viz.,* total dry matter production and plant height at harvest (282.39 g plant^{-1} and 147.76 cm, respectively), number of pods plant^{-1} (242.73), grain yield plant^{-1} (136.14 g) and 100 seed weight (10.16 g).Among the planting methods and geometry, significantly higher grain yield was recorded in pigeonpea transplanted at 120 cm x 30 cm (2,388 kg ha^{-1}) as compared to pigeonpea dibbled at 120 cm x 30 cm (2,131 kg ha^{-1}) and pigeonpea drill sown at 90 cm x 20 cm (1,690 kg ha^{-1}). Among the interaction effects of genotype, planting methods and planting geometry, significantly higher grain yield (2,462 kg ha^{-1}), gross returns (₹ 1,96,987 ha^{-1}), net returns (₹ 1,48,947 ha^{-1}) and BC ratio (4.10) was recorded with GRG-811 transplanted at 120 cm x 30 cm as compared to other interactions.

Key words: Dibbling, Drilling, Pigeon pea, Transplanting

Introduction

Pigeon pea is grown world over mostly in tropical and subtropical countries of Asia, Africa, and Caribbean island nations for grain, green manuring, fodder and forage as sole crop, intercrop, mixed crop and in sequential cropping system. India ranks first with about 75 per cent of world area and 67 per cent of production. It has occupied an area of 36.3 lakh hectares with the production of 27.6 lakh tonnes and average productivity of 760.3 kg per ha. Karnataka is one among the important states having an area of 7.74 lakh ha with a production of 4.63 lakh tonnes and productivity of 598 kg per ha. (Tiwari and Shivhare, 2016). It is the most preferred crop of rainfed areas as it extracts the moisture and nutrients from deeper layer and makes this crop ideal for rainfed condition. It performs well in poor soils and in less moisture available regions.

The factors largely responsible for its low productivity are mainly attributed to the abiotic stresses related to moisture content and soil fertility especially during early crop growth stages. Soil moisture related limitation is the major constraint to higher productivity of pigeonpea in Indian subtropics and complemented/supplemented with climatic aberrations experienced by the crop which is not conducive for its growth and development. Transplanting and hand dibbling methods of pigeonpea cultivation are the recently adopted techniques in the northern Karnataka and gaining importance in pigeonpea growing regions. This technology improves both production and productivity of pigeonpea.

There fore, keeping the above facts in view, a field experiment entitled "Performance of pigeonpea genotypes to planting methods and geometry under irrigation" was conducted at Agricultural Research Station (ARS), Almel (Tq: Sindagi, Dist: Vijayapura) during *kharif,* 2015 to standardize different planting methods and geometry for higher yield of pigeonpea under irrigation and to assess dry matter production, partitioning in different plant parts & to work out the economics of different systems.

Material and methods

A field experiment entitled Performance of pigeonpea genotypes to planting methods and geometry under irrigation was conducted at Agriculture Research Station, Almel, during *kharif*, 2015. The soil of the experimental site is medium black and the texture of the soil is clayey, which belongs to the order *Vertisols.* Fertility status of the soil includes available N 154 kg ha^{-1}, available P 24.50 kg ha^{-1}, available K 287 kg ha^{-1} and organic carbon 0.49%.

The treatment combinations were laid out in split-plot design with three replications.The experiment consists of 3 replications and 18 treatments with combinations of 2 main plots as genotypes *i.e.* GRG-811 & TS-3R. The experiment also included with 9 sub plots as planting methods and planting geometry, transplanting of pigeonpea seedlings at 120 cm x 30 cm., 120 cm x 60 cm., 150 cm x 30 cm.,150 cm x 60 cm and dibbling of pigeonpea seeds at 120 cm x 30 cm., 120 cm x 60 cm.,150 cm x 30 cm.,150 cm x 60 cm.& drill sowing seeds at 90 cm x 20 cm (RPP).

GRG-811 a medium duration (170-180 days) variety having indeterminate growth habit, bold seeds. It is wilt-resistant and tolerant to sterility mosaic disease. Similarly, TS-3R a medium duration variety (150-165 days), is red and bold seeded. It is resistant to wilt disease.

Recommended doses of farm yard manure@ 6.0 t $ha^{-1}$and fertilizer 25:50 kg N: $P_2O_5ha^{-1}$ were applied. The experimental area was tilled and brought to fine tilth. Polythene bags of size 5"x4" were used to raise the pigeonpea seedlings. They were filled with soil and vermicompost in 3:1 proportion. Two to three bold healthy seeds of GRG-811 and TS-3R were dibbled per polythene bag on 24^{th} May, 2015. Watering was done regularly and one seedling per bag was retained by thinning. The pigeonpea genotypes GRG-811 and TS-3R were sown as per the treatment spacing with the seed drill in the main field on 25^{th} June, 2015.Furrows were opened with the help of plough to a depth of 15-20 cm and then pigeonpea genotypes GRG-811 and TS-3R seedlings were transplanted after removing the polythene cover without disturbing the soil near root zone of the pigeonpea seedlings as per the planting geometry in respective treatments and replications.

Intercultivation was done thrice at 25, 40 and 60 days after planting. Hand weeding was done at 15 and 90 days after planting to keep the plots free from weeds during cropping period.Pigeonpea crop was protected against *Helicoverpa armigera (pod borer) with the sprays of* Profenofos @ *2.0 ml l^{-1} of water after 90 days, Emamectin benzoate*@ 0.2 g l^{-1} of water after 105 days and *Flubendamide* @ 0.25 ml l^{-1} of water after 120 days during flowering and pod filling stages, respectively.

The data recorded on various characters were subjected to Fisher's method of analysis of variance and interpretation of the data as outlined by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was P = 0.05. Least significant difference (LSD) values were calculated whenever the 'F' test was significant.

Results and discussion

Two genotypes differed significantly with respect to grain yield. Significantly higher grain yield was obtained with GRG-811 (2046 kg ha^{-1}) as compared to TS-3R (1977 kg ha^{-1}). Genotypes differed significantly with respect to yield parameters *viz.,* number of pods $plant^{-1}$ (242.73), grain yield $plant^{-1}$ (136.14 g), 100 seed weight (10.16 g), Stalk yield (5.01 t ha^{-1}) were significantly higher when compared to the genotype TS-3R (225.81, 132.23 g and 9.59 g, 4.84 t ha^{-1} respectively). The difference in grain yield of pigeon pea genotype was due to efficient utilization of growth resources by GRG-811which was also reported by Pramesh *et al.* (2006), Guggari and Patil (2013) and Bharathkumar *et al.* (2015).

Genotypes differed significantly with respect to dry matter production and its distribution in various plant parts. Genotype GRG-811 recorded significantly higher total dry matter production (282.39 g $plant^{-1}$) at harvest as compared to genotype TS-3R (266.50 g $plant^{-1}$). Similar trend was observed in dry matter accumulation in reproductive parts and growth parameters *viz.,* plant height at harvest (147.76 cm), number of primary branches $plant^{-1}$ at harvest (15.43) and days to 50 per cent flowering (99.67 days). These parameters were significantly lower in genotype TS-3R as compared to GRG-811.

Table 1. Effect of planting methods and geometry on yield and yield parameters of pigeonpea genotypes under irrigation

Treatment	At harvest		
	Plant height (cm)	Number of primary branches $plant^{-1}$	Dry matter production at harvest (g $plant^{-1}$)
Genotypes (G)			
G_1 (GRG-811)	147.76	15.43	282.3
G_2 (TS-3R)	130.23	13.28	266.5
S.Em±	0.50	0.09	0.54
C.D. at 5%	3.07	0.54	3.30
Crop geometry (S)			
S_1 (Transplanting at 120 cm x 30 cm)	158.13	18.70	329.1
S_2 (Transplanting at 120 cm x 60 cm)	143.23	16.40	313.9
S_3 (Transplanting at 150 cm x 30 cm)	135.33	14.57	291.0
S_4 (Transplanting at 150 cm x 60 cm)	132.73	13.47	276.1
S_5 (Dibbling at 120 cm x 30 cm)	143.83	15.80	294.4
S_6 (Dibbling at 120 cm x 60 cm)	139.00	13.93	267.0
S_7 (Dibbling at 150 cm x 30 cm)	134.77	13.27	258.2
S_8 (Dibbling at 150 cm x 60 cm)	133.67	12.57	239.8
S_9 (Drill sown at 90 cm x 20 cm)	130.27	10.50	200.0
S.Em±	1.15	0.20	0.74
C.D. at 5%	3.30	0.59	2.14
Interaction (G×S)			
G_1S_1	171.67	20.00	337.4
G_1S_2	150.47	17.33	320.5
G_1S_3	144.33	14.93	300.7
G_1S_4	137.93	14.40	284.2
G_1S_5	155.80	17.00	300.6
G_1S_6	149.67	14.73	273.8
G_1S_7	142.40	14.60	267.0
G_1S_8	140.53	14.07	248.9
G_1S_9	137.07	11.80	207.9
G_2S_1	144.60	17.40	320.8
G_2S_2	136.00	15.47	307.3
G_2S_3	126.33	14.20	281.3
G_2S_4	127.53	12.53	268.0
G_2S_5	131.87	14.60	288.2
G_2S_6	128.33	13.13	260.3
G_2S_7	127.13	11.93	249.4
G_2S_8	126.80	11.07	230.8
G_2S_9	123.47	9.20	192.1
S.Em±	1.62	0.29	1.05
C.D. at 5%	4.67	0.83	3.02

Grain yield of pigeonpea genotypes differed significantly due to planting methods and geometry. Within the planting methods and geometry significantly higher grain yield was recorded in transplanted pigeonpea at 120 cm x 30 cm (2388 kg ha^{-1}) as compared to dibbled pieonpea at 120 cm x 30 cm (2131 kg ha^{-1}) and drill sown pigeonpea at 90 cm x 20 cm

Table 2. Effect of planting methods and geometry on yield parameters of pigeonpea genotypes under irrigation

Treatment	Number of pods plant^{-1}	Grain yield plant^{-1} (g)	100 seed weight (g)	Grain yield ha^{-1} (kg)	Stalk yield ha^{-1} (t)
Genotypes (G)					
G_1 (GRG-811)	242.73	136.14	10.16	2046	5.01
G_2 (TS-3R)	225.81	132.23	9.59	1977	4.84
S.Em±	0.76	0.26	0.01	21.40	0.01
C.D. at 5%	4.61	1.61	0.07	63.80	0.03
Crop geometry (S)					
S_1 (Transplanting at 120 cm x 30 cm)	291.28	178.42	12.07	2388	5.85
S_2 (Transplanting at 120 cm x 60 cm)	268.86	159.55	11.20	2150	5.27
S_3 (Transplanting at 150 cm x 30 cm)	245.00	134.73	10.22	2041	5.00
S_4 (Transplanting at 150 cm x 60 cm)	234.77	131.15	10.00	2002	4.91
S_5 (Dibbling at 120 cm x 30 cm)	254.81	146.02	10.42	2131	5.22
S_6 (Dibbling at 120 cm x 60 cm)	236.33	127.48	9.52	1964	4.81
S_7 (Dibbling at 150 cm x 30 cm)	219.76	123.05	8.99	1898	4.65
S_8 (Dibbling at 150 cm x 60 cm)	196.33	115.79	8.50	1842	4.51
S_9 (Drill sown at 90 cm x 20 cm)	161.30	91.48	7.95	1690	4.14
S.Em±	1.91	0.53	0.03	55.64	0.01
C.D. at 5%	5.50	1.53	0.09	160.30	0.02
Interaction (G×S)					
G_1S_1	304.19	182.75	12.56	2462	6.03
G_1S_2	282.39	163.41	11.69	2209	5.41
G_1S_3	249.13	135.35	10.32	2074	5.08
G_1S_4	242.58	131.53	10.25	2013	4.93
G_1S_5	263.15	150.01	10.57	2204	5.40
G_1S_6	243.57	127.13	9.79	1985	4.86
G_1S_7	226.94	123.39	9.24	1906	4.67
G_1S_8	205.88	117.79	8.79	1856	4.55
G_1S_9	166.72	93.92	8.22	1707	4.18
G_2S_1	278.37	174.09	11.59	2314	5.67
G_2S_2	255.34	155.69	10.70	2092	5.12
G_2S_3	240.87	134.11	10.12	2007	4.92
G_2S_4	226.96	130.77	9.75	1992	4.88
G_2S_5	246.47	142.03	10.27	2059	5.04
G_2S_6	229.09	127.83	9.25	1942	4.76
G_2S_7	212.57	122.71	8.75	1890	4.63
G_2S_8	186.77	113.79	8.21	1828	4.48
G_2S_9	155.89	89.05	7.69	1674	4.10
S.Em±	2.70	0.75	0.04	78.53	0.01
C.D. at 5%	7.77	2.17	0.13	226.27	0.03

(1690 kg ha^{-1}). Significantly higher yield parameters like number of pods plant^{-1} (291.28), grain yield plant^{-1} (178.42 g) and 100 seed weight (12.07 g) in transplanted pigeonpea at 120 cm x 30 cm as compared to dibbled pigeonpea at 120 cm x 30 cm (254.81, 146.02 g and 10.42 g, respectively) and drill sown pigeonpea at 90 cm x 20 cm (161.30, 91.48 g and 7.95 g, respectively). Significantly higher stalk yield was observed in transplanted pigeonpea at 120 cm x 30 cm (5.85 t ha^{-1}) as compared to dibbled pigeonpea at 120 cm x 30 cm (5.22 t ha^{-1}) and drill sown pigeonpea at 90 cm x 20 cm (4.14 t ha^{-1}). Significantly higher growth parameters *viz.,* plant height at harvest (158.13 cm), number of primary branches plant^{-1} (18.70) were higher and days to 50 per cent flowering (97.50 days) were lesser in pigeonpea transplanted at 120 cm x 30 cm as compared to dibbled pigeonpea at 120 cm x 30 cm (143.83 cm, 15.80, 102.50 days, respectively) and drill sown pigeonpea at 90 cm x 20 cm (130.27 cm, 10.50, 119.00 days, respectively).Total dry matter production at harvest was significantly higher in pigeonpea transplanted at 120 cm x 30 cm (329.16 g plant^{-1}) as compared to dibbled pigeonpea at 120 cm x 30 cm (294.44 g plant^{-1}) and drill sown pigeonpea at 90 cm x 20 cm (200.08 g plant^{-1}) and similar trend observed at 60 DAS and 110 DAS. These results are in accordance with the findings of Potdar *et al.* (2010), and Salakinkoppa and Patil (2010) in pigeonpea. They reported that higher grain yield of pigeonpea with transplanting method over dibbling was due to improved growth and yield attributing parameters.

Among the interaction effects of genotypes, planting methods and geometry significantly higher grain yield was recorded with genotype GRG-811 transplanted at 120 cm x 30 cm (2462 kg ha^{-1}) as compared to genotype GRG-811 dibbled at 120 cm x 30 cm (2204 kg ha^{-1}); drill sown at 90 cm x 20 cm (1707 kg ha^{-1}), genotype TS-3R transplanted at 120 cm x 30 cm (2314 kg ha^{-1}); dibbled at 120 cm x 30 cm

Table 3. Effect of planting methods and geometry on the economics of pigeonpea cultivation under irrigation

Treatment	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns(₹ ha^{-1})	BC ratio
Genotypes (G)				
G_1 (GRG-811)	163695	45041	118439	3.61
G_2 (TS-3R)	158199	44968	113015	3.50
S.Em±	2003	-	2003	0.11
C.D. at 5%	8105	-	8105	0.35
Crop geometry (S)				
S_1 (Transplanting at 120 cm x 30 cm)	191067	48046	143058	3.98
S_2 (Transplanting at 120 cm x 60 cm)	172013	47741	124301	3.61
S_3 (Transplanting at 150 cm x 30 cm)	163240	47526	115739	3.44
S_4 (Transplanting at 150 cm x 60 cm)	160173	47341	112859	3.39
S_5 (Dibbling at 120 cm x 30 cm)	170507	42801	127260	3.94
S_6 (Dibbling at 120 cm x 60 cm)	157080	42681	113968	3.64
S_7 (Dibbling at 150 cm x 30 cm)	151853	42636	108777	3.53
S_8 (Dibbling at 150 cm x 60 cm)	147360	42591	104332	3.42
S_9 (Drill sown at 90 cm x 20 cm)	135227	43676	91251	3.07
S.Em±	2049	-	2049	0.13
C.D. at 5%	7019	-	7019	0.32
Interaction (G×S)				
G_1S_1	196987	48081	148947	4.10
G_1S_2	176693	47801	128925	3.70
G_1S_3	165893	47531	118387	3.49
G_1S_4	161013	47371	113669	3.40
G_1S_5	176320	42861	133011	4.07
G_1S_6	158773	42691	115650	3.68
G_1S_7	152507	42671	109396	3.54
G_1S_8	148507	42601	105470	3.45
G_1S_9	136560	43761	92499	3.10
G_2S_1	185147	48011	137169	3.86
G_2S_2	167333	47681	119676	3.51
G_2S_3	160587	47521	113091	3.38
G_2S_4	159333	47311	112048	3.37
G_2S_5	164693	42741	121508	3.81
G_2S_6	155387	42671	112285	3.61
G_2S_7	151200	42601	108159	3.51
G_2S_8	146213	42581	103194	3.40
G_2S_9	133893	43591	90002	3.05
S.Em±	3053	-	3053	0.18
C.D. at 5%	11018	-	11018	0.52

(2059 kg ha^{-1}) and genotype TS-3R drill sown at 90 cm x 20 cm (1674 kg ha^{-1}). All yield parameters *viz.*, number of pods plant^{-1} (304.19), grain yield plant^{-1} (182.75 g) and 100 seed weight (12.56 g) were significantly higher in GRG-811 transplanted at 120 cm x 30 cm as compared to other interaction effects of genotypes, planting methods and geometry.

Significantly higher stalk yield was observed in genotype GRG-811 transplanted at 120 cm x 30 cm (6.03 t ha^{-1}) as compared to genotype GRG-811 dibbled at 120 cm x 30 cm (5.40 t ha^{-1}); drill sown at 90 cm x 20 cm (4.18 t ha^{-1}), genotype TS-3R transplanted at 120 cm x 30 cm (5.67 t ha^{-1}); dibbled at 120 cm x 30 cm (5.04 t ha^{-1}), and genotype TS-3R drill sown at 90 cm x 20 cm (4.10 t ha^{-1}). Under transplanting at planting geometry of 120 cm x 30 cm better yield was due to better performance of pigeon pea genotypes as compared to rest of the planting method and geometry. These results are in accordance with the earlier findings of Mallikarjun *et al.* (2014) and Jamadar and Sajjan (2014).

Significantly higher growth parameters *viz.,* plant height at harvest (171.67 cm), number of primary branches plant^{-1} at harvest (20.00) were higher and days to 50 per cent flowering (95.00 days) were lesser in genotype TS-3R transplanted at 120 cm x 30 cm as compared to other interactions. Total dry matter production at harvest was significantly higher in genotype GRG-811 transplanted at 120 cm x 30 cm (337.44 g plant^{-1}) as compared to other interactions and similarly, it was observed at 60 DAS and 110 DAS.

Economic analysis revealed that the gross returns (₹ 163695 ha^{-1}), net returns (₹ 118439 ha^{-1}) and BC ratio (3.61) were significantly higher in genotype GRG-811 as compared to genotype TS-3R (₹ 158199 ha^{-1}, ₹ 113015 ha^{-1} and 3.50, respectively). Cost of cultivation was more in GRG-811

(₹ 45041 ha^{-1}) than TS-3R (₹ 44968 ha^{-1}).Among the planting methods and geometry significantly higher gross returns (₹ 191067 ha^{-1}), cost of cultivation (₹ 48046 ha^{-1}), net returns (₹ 143058 ha^{-1}) and BC ratio (3.98) were found in transplanted pigeonpea at 120 cm x 30 cm than dibbled pigeonpea at 120 cm x 30 cm (₹ 170507 ha^{-1}, ₹ 42801 ha^{-1}, ₹ 127260 ha^{-1} and 3.94, respectively) and drill sown pigeonpea at 90 cm x 20 cm (₹ 135227 ha^{-1}, ₹ 43676 ha^{-1}, ₹ 91251 ha^{-1} and 3.07, respectively). One of the major reasons for cost escalation was higher cost of laborers for the transplanting than direct sown pigeon pea (Pavan *et al.,* 2009)

Within the interaction effects of genotypes, planting methods and geometry significantly, higher gross returns (₹ 196987 ha^{-1}), cost of cultivation (₹ 48081 ha^{-1}), net returns (₹ 148947 ha^{-1}) and BC ratio (4.10) were found in genotype GRG-811 transplanted at 120 cm x 30 cm than other interactions.

Conclusion

From this research it could be concluded that, pigeonpea genotype GRG-811 is suitable for Northern Dry Zone of Karnataka (Zone 3) during *kharif* season under irrigation as it recorded higher grain yield with higher net returns and benefit cost ratio compared to TS-3R. Among the different planting methods and geometry, transplanting coupled with planting geometry at 120 cm x 30 cm is ideal than dibbled and drill sown methods of pigeonpea cultivation under irrigation, with regard to higher grain yield, net returns and benefit cost ratio.

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