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RESEARCH PAPER

Performance of pigeonpea genotypes under transplanting technique

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Abstract : A field experiment was conducted for the yield maximization in pigeonpea through transplanting technique under dryland conditions in medium black soils at Regional Agricultural Research Station, Vijayapura (Karnataka) during *kharif* 2021-22. The experiment was laid out in split plot design with three replications. There were ten treatment combinations, consisting two varieties *viz*., TS-3R and GRG-152 in main plots and five dates of transplanting *viz*., direct sowing, II Fortnight (FN) of June, I FN of July, II FN of July and I FN of August in sub plots. The results revealed that thevariety TS-3R transplanted during II FN of June recorded significantly higher total dry matter production (230.90 g plant^{-1}), leaf area (82.88 dm^2 plant^{-1}), pods per plant (184.17), grain yield (1873 kg ha^{-1}), stalk yield (5001 kg ha^{-1}) and gross returns (₹ 118004 ha^{-1}) over other combinations. However, direct sown TS-3R recorded significantly higher net returns (₹ 78231 ha^{-1}) and B:C (3.38) as compared to other combinations. While, lower total dry matter production (121.72 g plant^{-1}), leaf area per plant (38.22 dm^2), lower number of pods per plant (92.25), grain yield (876 kg ha^{-1}), stalk yield (2665 kg ha^{-1}), net returns(₹ 9654 ha^{-1}) and B:C ratio (1.21) were recorded in GRG-152 transplanted during I FN of August compared to other interactions. Pigeonpea variety TS-3R transplanted during II FN of June produced superior growth, yield parameters and seed yield. However, the yield improvement was not substantial to overcome the additional costs involved in nursery raising and transplanting.

Key words: Fortnight, Pigeonpea, Transplanting, Varieties

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is second most important pulse crop in India after chickpea, which is primarily cultivated under rainfed condition. India has 90 per cent of the world's pigeonpea growing area and produces 85 per cent of the world's pigeonpea. It is grown on 4.53 million hectares with a production of 3.89 million tones and a productivity of 859 kg per hectare. Pigeonpea is grown in almost all the states and larger portion of the area is in the states like Karnataka, Maharashtra, Uttar Pradesh and Madhya Pradesh. It covered 15.45 lakh hectares area in Karnataka, with a production of 11.26 lakh tones and a productivity of 729 kg ha^{-1} (Anon., 2020). Among the different pulses grown in Karnataka, pigeonpea holds first place both in area and production. It is largely grown in Northern parts of Karnataka, especially in Kalaburgi, Vijayapura, Bidar and Raichur districts. It is vital to increase pulse crop yield and productivity to fulfill the demands of an ever-increasing population. There is no other way to enhance production other than to boost productivity by maximizing the use of existing resources (Saritha *et al*., 2012).

Late onset of monsoon is one of the constraints in pigeonpea production, which causes planting to be delayed. The time of sowing has a significant impact on pigeonpea vegetative and reproductive growth phases, as it determines the amount of time available for vegetative growth before flowering, which is mostly determined by photo period. As a result, one of the most basic needs for attaining maximum yield and high return on any crop is to sow at the suitable and proper time. In order to exploit maximum natural resources such as nutrient, sunlight, soil moisture and to ensure satisfactory yield optimum plant population must be maintained (Sharifi *et al*., 2009). As a result, they are known to affect crop environment, which influences yield and yield components. When sowing is delayed, pigeonpea suffers more. So, it should be sown early in the month of May to ensure a higher yield (Malik and Yadav., 2014).

Rainfall in Northern dry farming areas of Karnataka is not only scanty, but also irregular. As a result, soil moisture becomes the primary limiting factor in pigeonpea yield. Pigeonpea productivity is significantly lowered by terminal moisture stress during the reproductive period. Hence, the transplanting of pigeonpea seedlings will be one of the better agronomic measures to overcome delayed sowing due to the delayed onset of monsoon (Rajesh *et al*., 2013). This procedure involves raising of seedlings in polythene bags at the nursery for one month and transplanting them into the main field shortly after receipt of good rainfall. When compared to dibbled pigeonpea in Karnataka, the transplanted hybrid pigeonpea produced considerably greater yield characteristics, grain yield and stalk yield (Mallikarjun *et al*., 2014). Established seedlings can grow more quickly in the field and can be more competitive. Moreover, growing seedlings ahead of time and transplanting them into the field later after receiving good rainfall would assist reap the benefits of early sowing with a better yield than direct seeded pigeonpea. Hence, the present investigation was intended to know the influence of varieties and date of transplanting on yield attributes, yield and economics of pigeonpea under dryland conditions.

Material and methods

A field experiment was conducted during *kharif* season of 2021 at Regional Agricultural Research Station, Vijayapura,

Karnataka on vertisol having pH 8.26 and EC of 0.39 dSm^{-1}.The soil was low in organic carbon content (0.41%), low in available Nitrogen (166.5 kg N ha^{-1}), medium in available Phosphorus (31.58 kg P_2O_5 ha^{-1}) and high in available Potassium (346.1 kg K_2O ha^{-1}). The experimental site was located at latitude of 16° 77' North, longitude of 75° 74' East and an altitude of 516.29 meters above mean sea level in Northern Dry Zone of Karnataka (Zone 3). During the cropping year 2021-22, a total rainfall of 623 mm was received in 51 rainy days from April 2021 to March 2022 as against the normal rain of 594.4 mm which was received in 38 rainy days. The highest rainfall of 161.7 mm was received in the month of September followed by July 146.4 mm.

The experiment was laid out in split plot design with three replications. There were ten treatment combinations, consisting two varieties *viz.,* TS-3R and GRG-152 in main plots and five dates of transplanting *viz.,* direct sowing, II FN of June, I FN of July, II FN of July and I Fortnight of August in sub plots. Polythene bags of size 4"x6" inches were used to raise the pigeonpea seedlings. They were filled with soil and vermicompost (15 g). One to two bold healthy seeds of TS-3R and GRG-152 dibbled per polythene bag during II FN of May to I FN of July 2021(fortnight intervals). Watering was done once in two days regularly up to 25-30 days and one seedling per bag was retained by thinning. 25-30 day old seedlings were transplanted to the main field after receipt of good rainfall (or) by providing supplemental irrigation. At the time of sowing in field, the land was prepared to a fine seedbed and the plots were laid out. The varieties TS-3R and GRG-152 were used and fertilizer application was followed on the basis of the plant population occupied by crop. The full amount of fertilizer in the form of urea and di ammonium sulphate as per recommended package of practice 25:50:00 kg N, P_2O_5 and K_2O per ha was applied. Small pits were opened with the help of pick axe to a depth of 15-20 cm and then pigeonpea varieties TS-3R and GRG-152 seedlings were transplanted after removing the polythene cover without disturbing the soil near root zone of the pigeonpea seedlings with the planting geometry of 120 cm x 30 cm in respective treatments and replications during II FN of June to I FN of August 2021(fortnight intervals). Five plants in each treatment was selected at random and were cut at ground level at 60, 90,120 DAT/S and at harvest. The plant samples were partitioned into leaves, stem and reproductive parts (pod) and samples was dried first in the air for 2-3 days and then in the hot air oven at 65 ± 5 °C until a constant dry weight is obtained. Completely dried samples were weighed and the dry weights of different plant parts were expressed in grams per plant. Leaf area was measured by using leaf area meter (Biovis PSM). All the leaves of the five randomly selected plants were separated and were passed through leaf area meter. Later on mean leaf area was recorded and expressed in decimeter square per plant. Due to the incidence of pod borer (*Helicoverpa armigera*) the spray of emamectin benzoate 5% SG @ 0.5 g per liter of water was taken up to control the pest. Harvesting was done at physiological maturity of the crop. The net plot area as per the treatments was harvested by cutting the plants to the ground level. After harvesting, the plants were bundled and allowed for sun drying. After complete sun drying, the crop was threshed by beating with wooden sticks. The separated seeds were winnowed, cleaned and grain and haulm yield were expressed in kilogram per hectare.

The yield attributes and yield observations were recorded from the net plots and grain yield was converted to hectare basis in kilograms. The economics of each treatment was computed with prevailing market prices of the corresponding year. The yield was further computed for gross and net returns as well B:C ratio to assess the profitability. The benefit-cost ratio was worked out by dividing the gross returns by the total cost of cultivation of respective treatments. The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used for 'F' and 't' tests was P=0.05. Critical Difference (CD) values were calculated at 5 per cent probability level if the F test will found to be significant.

Results and discussion

Effect of date of transplanting on growth of pigeonpea

The plant height varied with varieties and date of transplanting. Significantly taller plants were recorded with the variety GRG-152 (151.26 cm) as compared to variety TS-3R at harvest (169.75 cm) which is depicted in Table 1. Pigeonpea transplanted during II fortnight (FN) of June recorded significantly taller plants (187.68 cm) at harvest as compared to later dates of transplanting. But, it was on par with direct sowing (180.05 cm).

Significantly taller plants were recorded with the variety GRG-152 transplanted during II FN of June (193.80 cm) at harvest over other interactions, however, it was on par with GRG-152 direct sowing (187.98 cm) at harvest. The taller plants were observed in the long and medium duration types than the short duration genotypes in this study results are agreed with the findings of Egbe (2005) observed that late-maturing long-duration varieties are generally tall, because of their prolonged vegetative phase, while the short-duration or early-maturing varieties are comparatively short in stature due to their short vegetative growth phase.

Significantly superior total dry matter production was recorded with the variety TS-3R (108.34, 166.76 and 199.01 g $plant^{-1}$, respectively at 90 DAT/S, 120 DAT/S and at harvest) as compared to the variety GRG-152 which is depicted in Table 1 and Fig1. The total dry matter production significantly influenced due to the date of transplanting at all the growth stages. Pigeonpea transplanted during II FN of June recorded significantly higher total dry matter production (33.63, 133.58, 194.12 and 221.36 g $plant^{-1}$, respectively at 60 DAT, 90 DAT, 120 DAT and at harvest) as compared to later dates of transplanting. But, it was on par with direct sowing (31.82, 128.28 and 209.68 g $plant^{-1}$, respectively at 60 DAS, 90 DAS and at harvest).

Significantly higher total dry matter production was recorded with variety TS-3R transplanted during II FN of June (136.13, 202.63 and 230.90 g $plant^{-1}$, respectively at 90 DAT, 120 DAT

Table 1. Growth attributes of pigeonpea as influenced by varieties, date of transplanting and their interactions

Treatments	Plant height (cm)	Total dry matter production (g plant^{-1})	Leaf area (dm^2 plant^{-1})
Varieties (V)			
V_1: TS-3R	153.72	199.01	67.68
V_2: GRG-152	169.75	176.91	60.95
S. Em±	2.62	2.67	1.09
C.D. at 5%	15.97	16.23	6.65
Date of transplanting (D)			
D_1: Direct sowing	180.05	209.68	74.62
D_2: II FN of June	187.68	221.36	77.87
D_3: I FN of July	164.17	188.91	70.15
D_4: II FN of July	152.37	173.30	55.50
D_5: I FN of August	124.39	146.53	43.43
S. Em±	2.71	4.17	1.16
C.D. at 5%	8.14	12.50	3.48
Interactions (V x D)			
V_1D_1	172.12	216.42	79.23
V_1D_2	181.57	230.90	82.88
V_1D_3	158.60	195.78	71.67
V_1D_4	148.23	180.60	55.99
V_1D_5	108.09	171.33	48.64
V_2D_1	187.98	202.94	70.01
V_2D_2	193.80	211.83	72.86
V_2D_3	169.74	182.04	68.63
V_2D_4	156.52	166.00	55.01
V_2D_5	140.69	121.72	38.22
S.Em±	4.32	5.91	1.83
C.D. at 5%	17.87	21.43	7.50

and at harvest) over other interactions. However, it was on par with TS-3R direct sowing (130.37, 194.71 and 216.42 g plant^{-1}, respectively at 90 DAS, 120 DAS and at harvest), GRG-152 transplanted during II FN of June (131.03, 185.60 and 211.83 g plant^{-1}, respectively at 90 DAT, 120 DAT and at harvest).

Pigeonpea sown on earliest date produced more number of branches, number of leaves and highest leaf area index which, absorbed the largest amount of photosyntheticaly active radiations (PAR) and produced highest total dry matter and grain yield and similar results were reported by Patel *et al.* (2000).

The variety TS-3R recorded significantly higher leaf area per plant (25.91, 85.23 and 67.68 dm^2, respectively at 60 DAT/S, 90 DAT/S and 120 DAT/S) as compared to variety GRG-152. The date of transplanting significantly influenced the leaf area per plant. Pigeonpea transplanted during II FN of June recorded significantly superior leaf area per plant (27.99, 93.25 and 77.87 dm^2, respectively at 60 DAT, 90 DAT and 120 DAT) as compared to later dates of transplanting. But, it was on par with direct sowing (26.34, 89.17 and 74.62 dm^2, respectively at 60 DAS, 90 DAS and 120 DAS).

The varieties and dates of transplanting significantly influenced leaf area. The variety TS-3R transplanted during II FN of June recorded significantly superior leaf area per plant (29.24, 97.14 and 82.88 dm^2, respectively at 60 DAT, 90 DAT and 120 DAT) over other interactions. However, it was on par with TS-3R direct sowing (27.04, 92.14 and 79.23 dm^2, respectively at 60 DAS, 90 DAS and 120 DAS), GRG-152 transplanted during II FN of June (26.74 and 89.36 dm^2, respectively at 60 DAT and 90 DAT).

This could be due to greater number of branches and leaves per plant in early transplanted pigeonpea. The higher leaf area and leaf area index in early planted pigeonpea resulted in increased production of photosynthates contributes to superior dry matter production as well as its partitioning to reproductive parts due to increased growing degree days. The results are in agreement with findings of Pavan *et al*. (2011).

Effect of date of transplanting on yield and yield attributing characters

The yield and yield attributes of pigeonpea were greatly influenced by varieties and date of transplanting. The number of pods per plant of pigeonpea was significantly differed due to varieties and date of transplanting. Significantly highest numbers of pods per plant (163.52) and numerically higher hundred grain weight (11.24 g) was recorded with the variety TS-3R as compared to variety GRG-152 (147.07) which is depicted in Table 2.

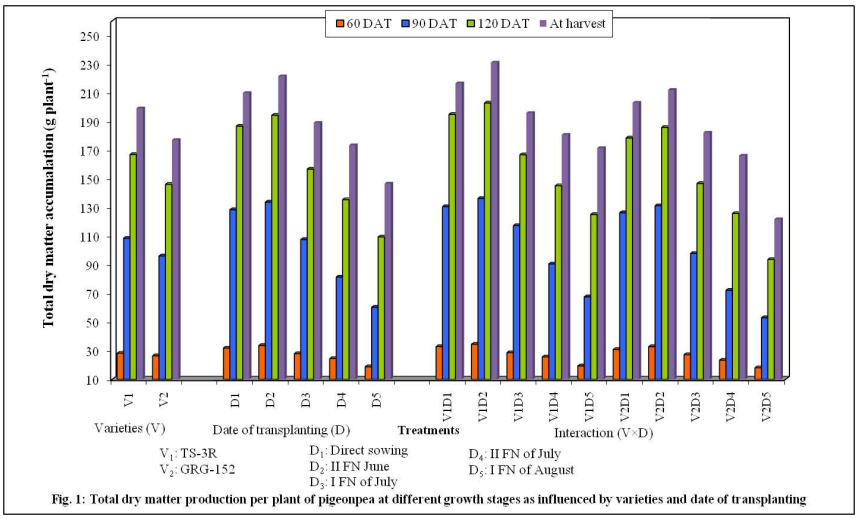

Fig. 1: Total dry matter production per plant of pigeonpea at different growth stages as influenced by varieties and date of transplanting

Among the dates of transplanting, pigeonpea transplanted during II FN of June recorded significantly more number of pods per plant (176.32) and numerically higher 100-grain weight (11.34 g) as compared to later dates of transplanting. But, it was on par with direct sowing (167.40 and 11.26 g). The interaction effects of varieties and date of transplanting differed significantly with each other with respect to number of pods per plant and significantly higher number of pods per plant (184.17) and numerically higher 100-grain weight (11.46 g) was recorded with the variety TS-3R transplanted during II FN of June over other interactions.

Table 2. Yield attributes and yield of pigeonpea as influenced by varieties, date of transplanting and their interactions

Treatments	Number of pods plant^{-1}	Hundred grain weight (g)	Grain yield(kg ha^{-1})	Stalk yield(kg ha^{-1})
Varieties (V)				
V_1: TS-3R	163.52	11.24	1657	4604
V_2: GRG-152	147.07	11.06	1435	3981
S.Em±	2.58	0.34	28	84
C.D. at 5%	15.71	NS	173	512
Date of transplanting (D)				
D_1: Direct sowing	167.40	11.26	1673	4530
D_2: II FN of June	176.32	11.34	1784	4763
D_3: I FN of July	165.03	11.19	1602	4362
D_4: II FN of July	156.81	11.06	1559	4390
D_5: I FN of August	110.92	10.91	1111	3417
S.Em±	3.60	0.53	40	108
C.D. at 5%	10.80	NS	119	325
Interactions (V x D)				
V_1D_1	168.97	11.32	1764	4789
V_1D_2	184.17	11.46	1873	5001
V_1D_3	171.93	11.24	1676	4529
V_1D_4	162.93	11.18	1626	4533
V_1D_5	129.59	10.98	1345	4168
V_2D_1	165.83	11.20	1581	4270
V_2D_2	168.47	11.21	1695	4525
V_2D_3	158.13	11.14	1529	4196
V_2D_4	150.69	10.93	1492	4248
V_2D_5	92.25	10.84	876	2665
S.Em±	5.24	0.75	58	161
C D at 5%	19.63	NS	216	618

NS - Non Significant

Table 3. Cost of cultivation, gross returns, net returns and B:C ratio of pigeonpea as influenced by varieties, date of transplanting and their interactions

Treatments	Cost of cultivation(₹ ha^{-1})	Gross returns(₹ ha^{-1})	Net returns(₹ ha^{-1})	B:C ratio
Varieties (V)				
V_1: TS-3R	43030	104367	61336	2.48
V_2: GRG-152	43030	90385	47354	2.15
S.Em±	-	1795	1534	0.04
C.D. at 5%	-	10925	9332	0.24
Date of transplanting (D)				
D_1: Direct sowing	32904	105381	72477	3.20
D_2: II FN of June	45562	112384	66822	2.47
D_3: I FN of July	45562	100947	55385	2.22
D_4: II FN of July	45562	98204	52642	2.16
D_5: I FN of August	45562	69963	24401	1.54
S.Em±	-	2491	2402	0.05
C.D. at 5%	-	7468	7202	0.16
Interactions (V x D)				
V_1D_1	32904	111135	78231	3.38
V_1D_2	45562	118004	72442	2.59
V_1D_3	45562	105567	60005	2.32
V_1D_4	45562	102417	56855	2.25
V_1D_5	45562	84709	39147	1.86
V_2D_1	32904	99626	66722	3.03
V_2D_2	45562	106763	61201	2.34
V_2D_3	45562	96327	50765	2.11
V_2D_4	45562	93992	48430	2.06
V_2D_5	45562	55216	9654	1.21
S.Em±	-	3627	3404	0.08
C.D. at 5%	-	13616	12337	0.30

The variety TS-3R coupled with early sowing get sufficient time and favorable environmental condition for proper growth and development which resulted in more number of pods plant^{-1}, higher leaf area development and high biomass accumulation which ultimately lead to significant improvement in seed yield. These results are in agreement with Dahariya *et al*. (2017) and Sharanappa *et al*. (2018).

Grain yield per hectare differed significantly due to varieties. Significantly higher grain yield per hectare was recorded with variety TS-3R (1657 kg ha^{-1}) as compared to variety GRG-152 (1435 kg ha^{-1}) (Table 2). Among the date of transplanting, grain yields per hectare varied significantly. Pigeonpea transplanted during II FN of June produced significantly superior grain yield (1784 kg ha^{-1}) as compared to later dates of transplanting. But, it was on par with direct sowing (1673 kg ha^{-1}). The interaction effects of varieties and date of transplanting differed significantly with each other with respect to grain yield per hectare and significantly higher grain yield (1873 kg ha^{-1}) was recorded with variety TS-3R transplanted during II FN of June over other interactions. However, it was on par with TS-3R direct sowing (1764 kg ha^{-1}), GRG-152 transplanted during II FN of June (1695 kg ha^{-1}) and TS-3R transplanted during I FN of July (1676 kg ha^{-1}).

It might be due more number of branches per plant, number of pods per and grain weight per plant produced by the variety TS-3R under early sown conditions. The increased grain yield due to early sowing is ascribed to the high leaf area index and its persistence, photosyntheticaly active radiation interception and absorption leading to higher dry matter accumulation before the crop reached the reproductive stage reported by Patel *et al*. (2000) and Rani and Reddy (2010).

The stalk yield of pigeonpea was significantly influenced by varieties, date of transplanting and their interactions. The variety TS-3R recorded significantly higher stalk yield (4604 kg ha^{-1}) as compared to variety GRG-152 (3981 kg ha^{-1}). Among varied date of transplanting, significantly highest stalk yield (4763 kg ha^{-1}) was recorded with pigeonpea transplanted during II FN of June as compared to later dates of transplanting. But, it was on par with direct sowing (4530 kg ha^{-1}). The interaction effect of varieties and date of transplanting had shown significant influence on stalk yield per hectare. The variety TS-3R transplanted during II FN of June recorded significantly greater stalk yield (5001 kg ha^{-1}) over other interactions. But, it was on par with TS-3R direct sowing (4789 kg ha^{-1}), TS-3R transplanted during I FN of July (4529 kg ha^{-1}) and GRG-152 transplanted during II FN of June (4525 kg ha^{-1}).

The higher stalk yield of early transplanting was attributed to excessive vegetative growth and dry matter accumulation in vegetative parts as compared to reproductive parts.The increase in the growth parameters like plant height, number of branches per plant and dry matter accumulation and distribution increases the stalk yield per hectare. These results were in line with Mallikarjun *et al*. (2014) and Nagamani *et al*. (2015) in pigeonpea.

Effect of date of transplanting on economics

The variety TS-3R recorded highest gross returns (₹ 104367 ha^{-1}), net returns (₹ 61336 ha^{-1}) and benefit cost ratio (2.48) over the variety GRG-152 (Table 3). This was attributed to higher grain yield and stalk yield of pigeonpea variety TS-3R. Guggari and Patil (2013) also found that significantly higher grain yield and yield attributes in TS-3R (medium duration variety) as compared to Gulyal local (short duration variety) and Asha (long duration variety).

Among dates of transplanting, pigeonpea transplanted during II FN of June recorded significantly higher gross returns (₹ 112384 ha^{-1}). But, direct sowing recorded significantly higher net returns (₹ 72477 ha^{-1}) and B:C (3.20) as compared to dates of transplanting.

Among the interaction of varieties and date of transplanting, variety TS-3R transplanted during II FN of June recorded significantly higher gross returns (₹ 118004 ha^{-1}). However, TS-3R direct sowing recorded significantly higher net returns (₹ 78231 ha^{-1}) and B:C (3.38) as compared to dates of transplanting. Goud and Andhalkar (2012) reported that sole transplanting of varying age pigeonpea seedling had significantly higher pigeonpea equivalent yield over direct sown sole crop. However, higher net returns and B:C ratio was recorded with direct sown sole pigeonpea over sole transplanting of varying age of pigeonpea seedling. Kalaghatagi *et al*. (2021) revealed that though transplanted pigeonpea varieties recorded more number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1} and grain weight per plant but the raising of seedlings in poly bags and transplanted to the main field required higher cost of cultivation compared to direct sowing.

Conclusion

Pigeonpea variety TS-3R transplanted during II FN of June produced superior growth, yield parameters and seed yield. But, net returns and B:C was higher in direct sown TS-3R. However, the yield improvement is not substantial to overcome the additional costs involved in nursery raising and transplanting. Variety TS-3R transplanting is more suitable for dryland conditions as compared to GRG-152.

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