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Effect of sowing window, planting geometry and varieties on growth and yield of pigeonpea

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Abstract
A field experiment entitled "Effect of sowing window, planting geometry and varieties on growth and yield of pigeonpea" was conducted during *kharif* 2021-22 and 2022-23 at UAS, GKVK, Bengaluru. The experiment was laid out in split-split design with three replications. The combined effect of sowing window and planting geometry on pigeonpea growth parameters and grain yield was studied. The results revealed that sowing during first fortnight of May month resulted in higher plant height, number of branches, leaf area at all growth stages and pigeonpea grain yield (1945 kg ha^{-1}) compared to other treatments. For planting geometry, paired row geometry resulted in higher plant height and pigeonpea grain yield (1203 kg ha^{-1}) compared to normal row geometry. Among varieties BRG-3 recorded higher growth parameters at all stages and pigeonpea grain yield (1198 kg ha^{-1}) compared to BRG-4. The interaction effect for all the parameters were found to be non-significant in all the cases.

Keywords: Pigeonpea, planting geometry, sowing window, varieties

Introduction
In addition to food security, "nutritional security" has recently emerged as a global problem that the scientific community is haunted by. According to Reddy (2010) [6], pulse crops are sometimes referred to as "poor man's meat." It can be considered a good solution to combat nutritional insecurity because of its high protein content. The only practical way to increase pigeonpea yield is to manage different biotic and abiotic elements, as there isn't much room to expand the crop's territory within the nation. Pigeonpea productivity is limited by a number of factors, including inadequate drainage or stagnant water; flower drop in the winter due to low temperatures; a lack of high-yielding disease-resistant cultivars; smaller land holding and longer crop maturity; the effects of climate change; unpredictable rainfall; growing on marginal land; and weed infestation. Redgram is typically planted in intercropping arrangements with cereals on marginal areas that receive rainfed conditions. Growers of pigeonpeas have various obstacles that hinder their ability to increase its productivity. Water stress (drought and water logging), lack of suitable varieties, different sowing windows in existing varieties, late arrival of inputs, adoption of inappropriate planting geometry and plant population, and insufficient technology transfer are some of the constraints. The key to increasing yields in pigeonpea is choosing the right sowing date, variety, and spacing.

Since the majority of pigeonpea types are photoperiod-sensitive, the sowing date has a significant impact on the vegetative and reproductive processes. The non-monetary input of sowing time has a significant impact on the growth and output of this crop. Between the vegetative and reproductive stages on the one hand, and the climatic rhythm on the other, it assures perfect balance. Additionally, it is crucial for the crop's accumulation of dry matter. Late-sown crops may limit the accumulation of biomass and, as a result, the reduction in yield, whereas early-sown crops may collect excessive dry matter and reduce podding. Pigeonpea grain yields are low when sowings are delayed past the ideal time (Rao *et al*., 2004; Kumar *et al*., 2008) [5, 3].

It is well recognized that agronomic practices such as managing plant population have an impact on crop environment, which in turn affects yield and yield components. Maintaining optimal population levels is necessary to make the most of all available natural resources, including nutrients, sunlight, soil moisture, and yield (Swathi *et al*., 2017) [7]. By using suitable farm machinery to ensure that the pairs are planted widely enough apart, the paired row planting strategy enables prompt weed control.

In order to harvest higher yields, the system also enables improved light interception by the crop and resource sharing (Gill *et al*., 1995) [1]. Now is the moment to learn the ideal distance between pairs as well as within pairs in order to maximize the yields of red gram seeds. The study was conducted to determine the impact of various spacings while keeping the aforementioned concerns in mind. within a pair and between pairs on growth and productivity of pigeonpea in a paired row planting system.

Materials and Methods

A field study entitled "Studies on sowing window, planting geometry and varieties on growth and yield of pigeonpea" was conducted during *Kharif* 2021 and 2022 at University of Agricultural Sciences, GKVK, Bengaluru. The soil of the experimental unit was red sandy loam in texture having low organic carbon (0.43%). The soil was medium in available nitrogen (287.25 kg ha^{-1}), phosphorous (36.5 kg ha^{-1}) and potassium (255.5 kg ha^{-1}). Available zinc (2.1 mg kg^{-1}) and iron (10.6 mg kg^{-1}) was found to be in sufficiency range. The experiment was laid out on split-split design with twenty-four (24) treatments and were replicated thrice summing up to 72 plots. The main factor was sowing windows (D) (D_1: May first fortnight**,** D_2: May second fortnight**,** D_3: June first fortnight**,** D_4: June second fortnight**,** D_5: July first fortnight**,** D_6: July second fortnight). The sub factor was planting geometry (P) **[**P_1: Normal rows (120 cm × 30 cm), P_2: Paired rows (60/120 cm × 30 cm)] and the sub-sub factor was varieties (V) **(**V_1: BRG-3**,**V_2: BRG-4). The plant samples were dried to a constant weight in a hot air drier maintained at 65±5°C temperature. The growth attributes and seed yield were calculated as per the standard protocols. For comparison between the treatment means, an appropriate value of critical difference (C.D) was worked out wherever F-test was significant. All the data were analyzed and the results are presented and discussed at a probability level of 5 percent.

Results and Discussion

Effect of sowing windows, planting geometry and varieties on plant height, branches and leaf area of pigeonpea

The plant height (cm) of pigeonpea at different stages (30, 60, 90, 120 DAS and at harvest) was significantly influenced by sowing window, planting geometry and varieties. The two season data and pooled data is given in table 1.

Among sowing window significantly taller plants (pooled data) was observed with first fortnight of May sown pigeonpea (31.12 cm, 73.85 cm, 142 cm, 167 cm and 192 cm at 30, 60, 90, 120 DAS and at harvest, respectively) followed by second fortnight of May (28.64 cm, 69.79 cm, 129 cm, 160 cm and 179 cm at 30, 60, 90, 120 DAS and at harvest, respectively). Whereas, significantly lower plant height was recorded in second fortnight of July (21.49 cm, 53.40 cm, 70.13 cm, 81.63 cm and 86 cm at 30, 60, 90, 120 DAS and at harvest, respectively).

In planting geometry significantly taller plants at all growth stages (pooled data) was recorded by paired row geometry (67.86 cm, 115 cm, 131 cm and 155 cm at 60, 90, 120 DAS and at harvest, respectively) compared to normal row geometry (64.83 cm, 109 cm, 135 cm and 144 cm at 60, 90, 120 DAS and at harvest, respectively).

Among varieties BRG-3 being a erect growing variety recorded significantly taller plants(pooled data) (68.11 cm, 115 cm, 135 cm and 162 cm at 60, 90, 120 DAS and harvest, respectively) compared to the spreading variety BRG-4 (64.58 cm, 109 cm, 131 cm and 137 cm at 60, 90, 120 DAS and at harvest, respectively).

Number of branches of pigeonpea was significantly influenced by sowing window, planting geometry and varieties. The pooled data of primary branches and secondary branches are given in Fig.1 and 2, respectively.

For sowing window both primary and secondary branches were significantly more (pooled data) were recorded with first fortnight of May (3.37, 7.05, 10.43 and 15.04 primary branches at 60, 90, 120 DAS and at harvest respectively and 17.30, 27.79 and 38.88 secondary branches at 90, 120 DAS and at harvest respectively). It was followed by second fortnight of May (3.03, 5.87, 8.88 and 14.11 primary branches at 60, 90, 120 DAS and at harvest respectively and 16.16, 23.14 and 30.39 secondary branches at 90, 120 DAS and at harvest respectively). Whereas significantly lower number of branches were recorded during second fortnight of July (0.89, 1.24, 4.53 and 5.16 primary branches at 60, 90, 120 DAS and at harvest respectively and 3.50, 5.00 and 8.79 secondary branches at 90, 120 DAS and at harvest respectively).

Significantly more number of branches among planting geometry at all growth stages (pooled data) were recorded in case of normal row geometry (2.39, 4.53, 10.31 and 12.16 primary branches at 60, 90, 120 DAS and at harvest respectively and 12.24, 17.85 and 30.80 secondary branches at 90, 120 DAS and at harvest respectively) compared to paired row geometry (2.25, 3.91, 4.97 and 9.83 primary branches at 60, 90, 120 DAS and at harvest respectively and 10.23, 15.46 and 25.01 secondary branches at 90, 120 DAS and at harvest respectively).

Among varieties BRG-4 being a spreading type of plant displayed significantly more number of branches(pooled data), both primary and secondary (2.47, 4.46, 8.09 and 12.92 primary branches at 60, 90, 120 DAS and at harvest respectively and 11.78, 17.58 and 31.99 secondary branches at 90, 120 DAS and at harvest respectively) compared to BRG-3 (2.16, 3.99, 7.19 and 9.07 primary branches at 60, 90, 120 DAS and at harvest respectively and 10.69, 15.73 and 23.82 secondary branches at 90, 120 DAS and at harvest respectively).

Leaf area (cm^2) of pigeonpea was significantly influenced by sowing window, planting geometry and varieties. The pooled data is given in fig.3.

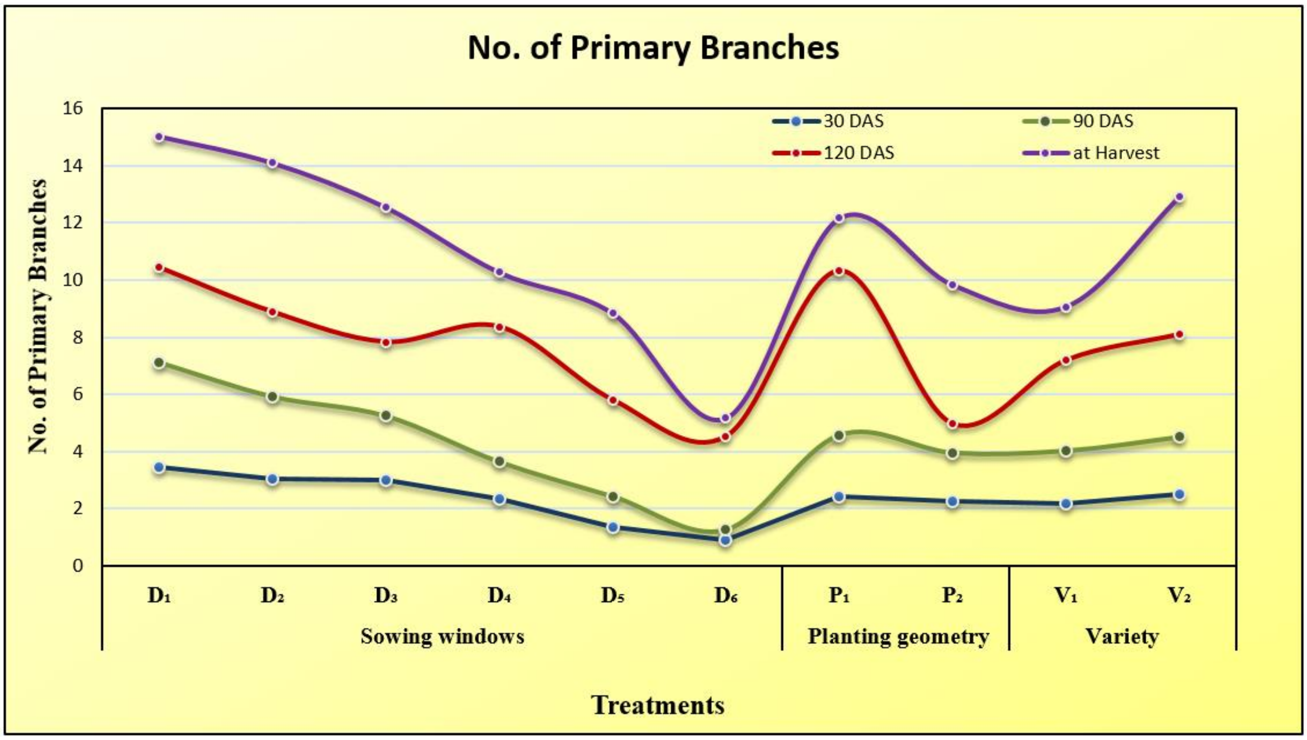
Significantly larger leaf area at all growth stages (pooled data) for different sowing window were recorded with May first fortnight sowing (66.23 cm^2, 656.5 cm^2, 1068 cm^2, 4542 cm^2 and 2980 cm^2 at 30, 60, 90, 120 DAS and at harvest), followed May second fortnight (61.85 cm^2, 583.3 cm^2,1046 cm^2,3882 cm^2 and 2344 cm^2 at 30, 60, 90, 120 DAS and at harvest). It was succeeded by June first fortnight (39.40 cm^2, 581.7 cm^2, 1039 cm^2, 3533 cm^2 and 2924 cm^2 at 30, 60, 90, 120 DAS and at harvest). Significantly lower leaf area was recorded during July second fortnight (12.46 cm^2, 183.4 cm^2, 257 cm^2, 1408 $cm^2$and 798 cm^2 at 30, 60, 90, 120 DAS and at harvest).

In case of planting geometry significantly higher leaf area (pooled data) was recorded with normal row geometry (40.44 cm^2, 531.70 cm^2, 846.30 cm^2, 3378 cm^2 and 2366 cm^2 at 30, 60, 90, 120 DAS and at harvest) compared to paired row system (34.96 cm^2, 411.90 cm^2, 724.50 cm^2, 2989 cm^2, and 2118 cm^2 at 30, 60, 90, 120 DAS and at harvest).

Significantly higher leaf area was recorded with BRG-3 (pooled data) (514.64 cm^2, 866.7 cm^2, 3769 cm^2 and 2605 cm^2 at 60, 90, 120 DAS and at harvest) compared to BRG-4 (429 cm^2, 704.10 cm^2, 2598 cm^2 and 1879 cm^2 at 60, 90, 120 DAS and at harvest).

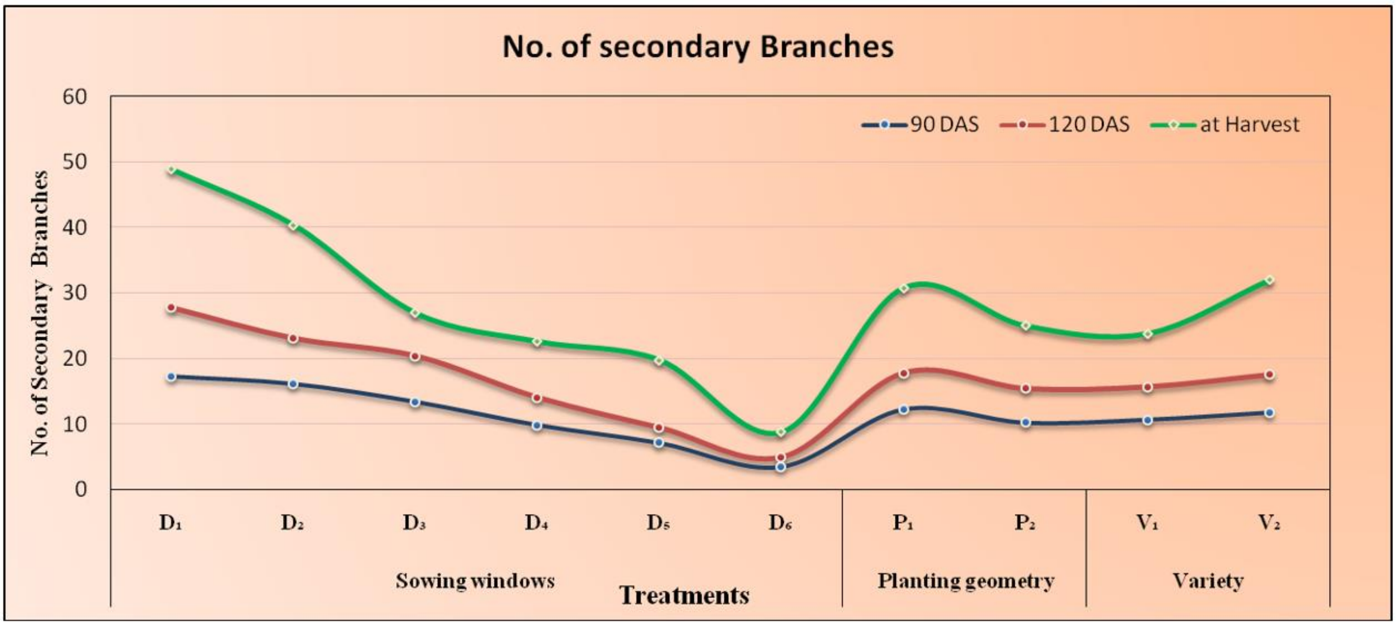
Table 1: Plant height (cm) of pigeonpea as influenced by sowing window, planting geometry and varieties

Treatments	30 DAS			60 DAS			90 DAS			120 DAS			Harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Sowing Windows (D)															
D_1: 1st FN May	32.94	29.29	31.12	76.53	71.17	73.85	150	134	142	168	162	167	193	190	192
D_2: 2nd FN May	30.40	26.88	28.64	71.85	67.72	69.79	137	122	129	162	154	160	179	179	179
D_3: 1st FN June	27.94	24.54	26.24	71.53	67.54	69.53	128	116	122	140	143	143	167	157	162
D_4: 2nd FN June	26.80	24.46	25.63	68.15	64.95	66.55	118	110	114	131	139	135	157	137	147
D_5: 1st FN July	22.94	20.79	21.87	66.53	63.40	64.97	109	102	106	119	128	123	143	122	132
D_6: 2nd FN July	22.56	20.43	21.49	54.68	52.11	53.40	71.67	68.59	70.13	82.35	74.92	81.63	85.14	86.53	86
S.Em.±	1.49	1.42	1.46	1.65	1.57	1.37	3.06	2.80	2.93	3.45	2.47	2.09	1.80	3.92	1.51
CD at 5%	4.70	4.47	4.59	5.20	4.93	4.32	9.64	8.81	9.22	10.88	7.77	6.57	5.66	12.36	4.75
Planting geometry(P)															
P_1: Normal rows (120cm × 30cm)	27.00	24.15	25.58	66.69	62.97	64.83	115	104	109	128	137	135	147	142	144
P_2: Paired Rows (60/120cm×30cm)	27.52	24.64	26.08	69.73	65.99	67.86	120	110	115	137	127	131	161	149	155
S.Em.±	1.05	1.00	1.02	0.95	0.90	0.87	1.83	1.55	1.69	2.01	0.99	1.07	1.01	1.86	1.01
CD at 5%	NS	NS	NS	2.93	2.77	2.69	5.64	4.78	5.21	6.18	3.04	3.28	3.12	5.73	3.09
Varieties(V)															
V_1: BRG – 3	27.70	24.82	26.26	70.02	66.19	68.11	120	110	115	145	151	135	171	152	162
V_2: BRG - 4	26.82	23.98	25.40	66.39	62.76	64.58	115	104	109	120	112	131	136	139	137
S.Em.±	0.69	0.66	0.67	1.21	1.14	1.12	1.72	1.47	1.60	1.87	2.25	1.58	1.83	2.10	2.24
CD at 5%	NS	NS	NS	3.51	3.33	3.26	5.03	4.29	4.66	5.44	6.56	4.60	5.34	6.12	6.54
Interactions															
D×P S.Em.±	2.57	2.44	2.51	2.33	2.21	2.14	4.49	3.80	4.15	4.92	2.42	2.61	2.48	4.56	2.46
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D×V S.Em.±	1.69	1.60	1.65	2.95	2.80	2.74	4.22	3.60	3.91	4.57	5.51	3.86	4.48	5.14	5.49
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P×V S.Em.±	0.98	0.93	0.95	1.70	1.62	1.58	2.44	2.08	2.26	2.64	3.18	2.23	2.59	2.97	3.17
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D×P×V S.Em.±	2.39	2.27	2.33	4.17	3.96	3.88	5.97	5.09	5.53	6.46	7.79	5.46	6.34	7.27	7.77
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS



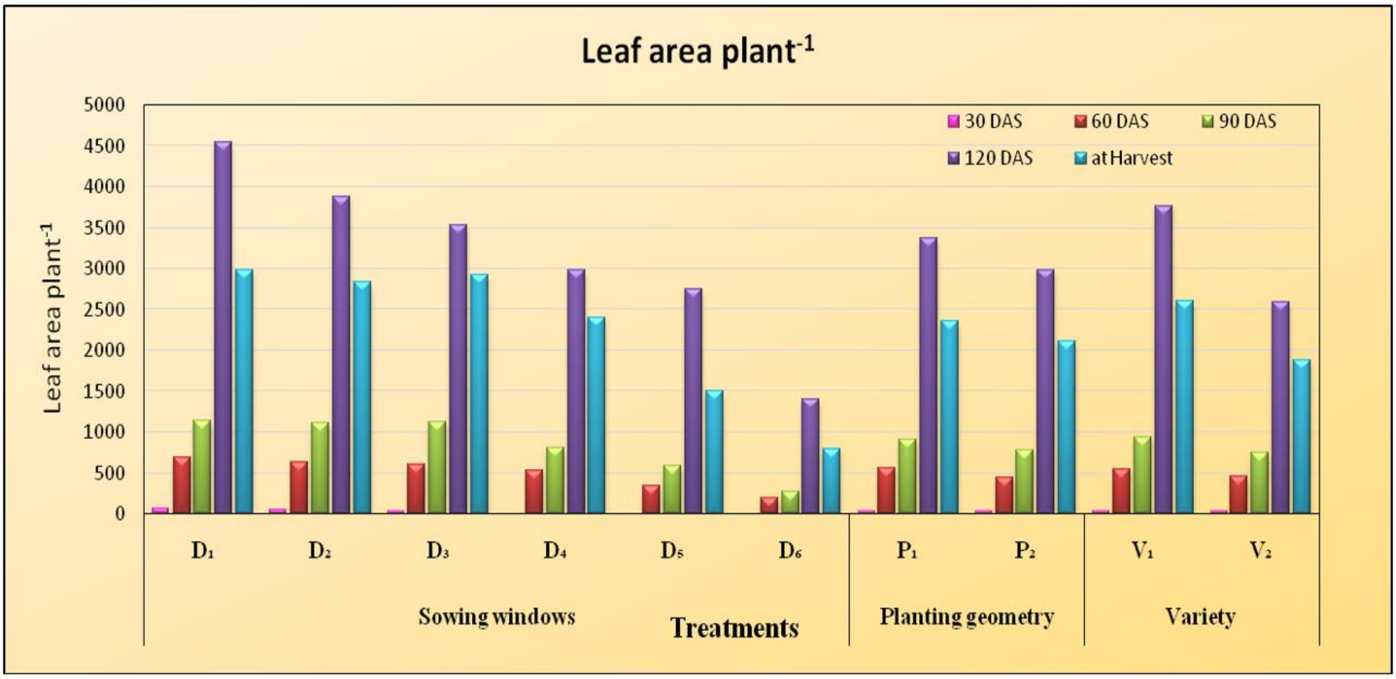
D_1: 1st FN May, D_2: 2nd FN May, D_3: 1st FN June, D_4: 2nd FN June, D_5: 1st FN July, D_6: 2nd FN July, P_1: Normal rows (120cm × 30cm), P_2: Paired Rows (60/120cm×30cm), V_1: BRG – 3, V_2: BRG – 4

Fig 1: Influence of sowing windows, planting geometry and varieties on primary branches of pigeonpea



D_1: 1st FN May, D_2: 2nd FN May, D_3: 1st FN June, D_4: 2nd FN June, D_5: 1st FN July, D_6: 2nd FN July, P_1: Normal rows (120cm × 30cm), P_2: Paired Rows (60/120cm×30cm), V_1: BRG – 3, V_2: BRG - 4

Fig 2: Influence of sowing windows, planting geometry and varieties on number of secondary branches of pigeonpea



D_1: 1st FN May, D_2: 2nd FN May, D_3: 1st FN June, D_4: 2nd FN June, D_5: 1st FN July, D_6: 2nd FN July, P_1: Normal rows (120cm × 30cm), P_2: Paired Rows (60/120cm×30cm), V_1: BRG – 3, V_2: BRG - 4

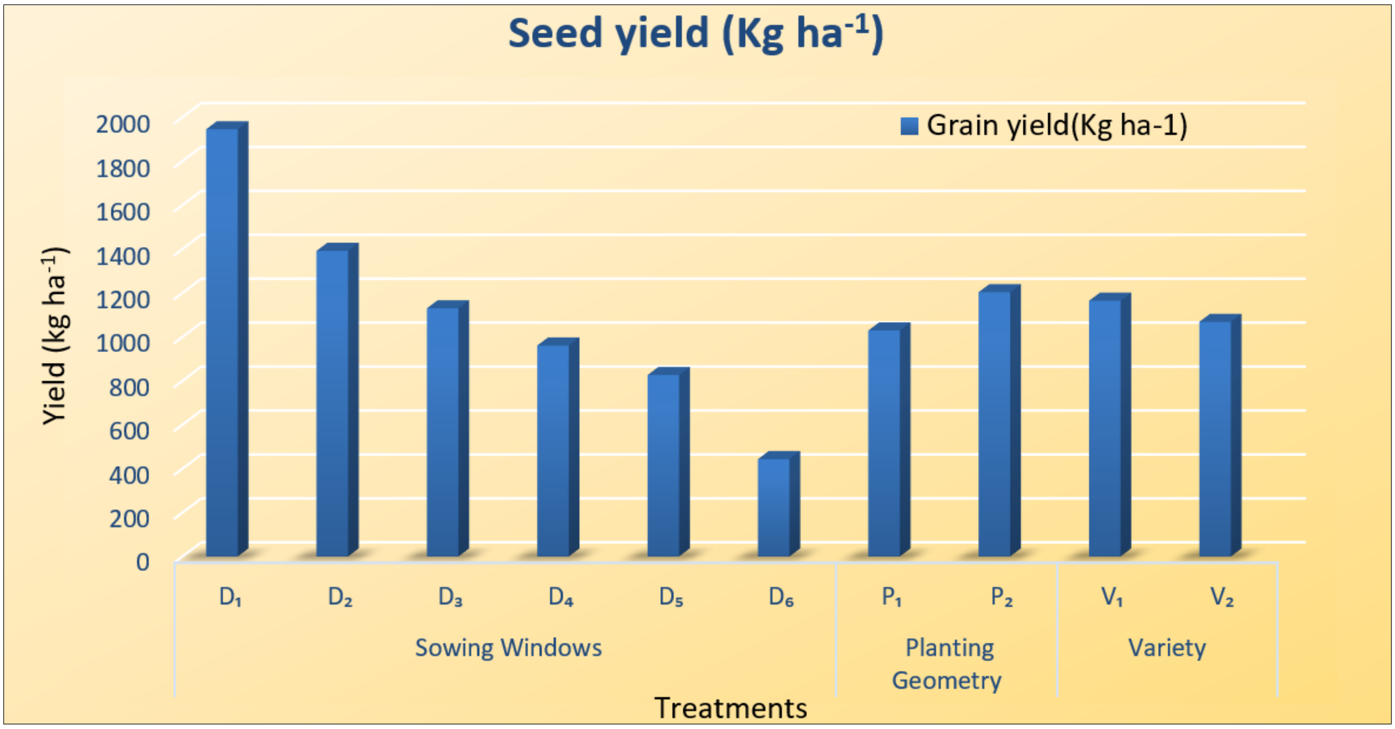
Fig 3: Influence of sowing windows, planting geometry and varieties on leaf area of pigeonpea

Effect of sowing windows, planting geometry and varieties on pigeonpea grain yield

The grain yield of pigeonpea were significantly influenced by sowing window, planting geometry and varieties. The pooled data is given in Fig. 4.

As per the pooled data the crop sown during first fortnight of May recorded significantly higher grain yield of 1945 kg ha^{-1}. It was followed by second fortnight of May with the grain yield of 1392 kg ha^{-1}, followed by 1130 kg ha^{-1} in the first fortnight of June. Significantly lower grain yield was recorded in second fortnight of July (443 kg ha^{-1}). Paired row system of planting recorded significantly higher grain yield (pooled data) of 1203 kg ha^{-1} compared to normal row planting 1029 kg ha^{-1}. Among the varieties BRG-3 recorded significantly higher grain yield (pooled data) compared to BRG-4. BRG-3 recorded 1198 kg ha^{-1} grain yield while BRG-4 produced 1034 kg ha^{-1} grain yield.

Pigeonpea is a warm season crop, it requires optimum moisture during initial state due to slow growth. During reproductive stage it needs higher temperature and humidity and lesser moisture. The rainfall received at early stages were adequate for better vegetative growth. From flowering onwards (Sept-Oct) till maturity there was excess moisture, low maximum and minimum temperature and lesser sunshine hours which negatively affected the crop growth and more so in case of July sowings. Sowing very late in the season could led to suboptimal conditions, which might have affected the seed index. Sowing window could also be affected the exposure of pigeonpea crops to pests and diseases. Sowing at right time might have helped to reduce the risk of pest and disease infestations, which impacted crop health and, consequently, test weight. These findings are in same line with that of Patil *et al*. (2015) [4] and Gupta *et al*. (2016) [2].



D_1: 1st FN May, D_2: 2nd FN May, D_3: 1st FN June, D_4: 2nd FN June, D_5: 1st FN July, D_6: 2nd FN July, P_1: Normal rows (120cm × 30cm), P_2: Paired Rows (60/120cm×30cm), V_1: BRG – 3, V_2: BRG - 4

Fig 4: Influence of sowing windows, planting geometry and varieties on grain and stalk yield of pigeonpea

Conclusion

In conclusion, the study demonstrated that sowing window, planting geometry, and variety selection significantly impact the growth and yield of pigeonpea. Early sowing during the first fortnight of May resulted in superior growth parameters and grain yield compared to later sowing dates. Planting geometry of 60/120 cm x 30 cm proved to be the most effective in maximizing grain yield, while the variety BRG-3 emerged as the highest yielding cultivar. These findings provide valuable insights for optimizing pigeonpea cultivation practices to enhance productivity and ensure sustainable production.

Future Scope

Future research could also focus on developing new tools and technologies to help farmers make informed decisions about sowing window, planting geometry, and variety selection. For example, decision support systems could be developed to help farmers identify the best sowing time and plant spacing for their fields, based on real-time weather data and soil moisture conditions. Overall, there is a great deal of scope for further research on the effect of sowing window, planting geometry, and varieties on growth and yield of pigeonpea. This research can help to develop more efficient and sustainable crop management systems for pigeonpea production, and improve the livelihoods of pigeonpea farmers.

Conflict of Interest

Authors have declared that no competing interests exist.

Author contributions

Swati Dash Conceptualization, investigation, original draft preparation, analysis K. Murali Conceptualization, framed research proposal, draft correction S. Kamala Bai Conceptualization and manuscript correction Atheekur Rehman H.M. Conceptualization and manuscript correction A. Sathish Conceptualization and manuscript correction.

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