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Influence of Different Date of Sowing on Performance of Pigeonpea Genotypes during *Rabi*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To determine the optimum date of sowing to realize higher growth and seed yield in *rabi* Pigeonpea.
Study Design: Split plot.
Place and Duration of Study: Siddapur research farm of RARS, Warangal during *rabi,* 2023-24.

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Methodology: The experiment consisted of totally sixteen treatments which was laid out in split plot design with three replications. Treatments included were four dates of sowing in the main plot M_1-September 30th, M_2-October 15th, M_3-October 30thand M_4- Novenber15th, 2023 and four treatments of varieties in sub plots S_1-WRGE-93, S_2-WRGE-121, S_3-WRGE-97 and S_4-WRGE-182 randomly placed in subplots of the main plot.

Results: Maximum plant height (149.1 cm), dry matter production (602 gm^{-2}), number of fruiting branches plant^{-1} (13.9) number of pods plant^{-1} (162.7), number of seeds pod^{-1} (4.08), seed yield (42.3 g plant^{-1} and 1392 kg ha^{-1}) and stalk yield(4151 kg ha^{-1}) was noticed in crop Sownon September 30th, 2023. Significantly maximum plant height (137.7 cm), dry matter production (516 g m^{-2}), number of fruiting branches plant^{-1} (11.7),number of pods plant^{-1} (144), number of seeds pod^{-1} (3.85),seed yield (37.9 g plant^{-1} and 1181 kg ha^{-1}) and stalk yield (3801 kg ha^{-1}) was observed inS_4-WRGE-182, which was found on par with S_2-WRGE-121 having plant height (134.6cm), dry matter production (512 g m^{-2}),number of fruiting branches plant^{-1} (11.2),number of pods plant^{-1} (130.3),number of seeds pod^{-1} (3.74), seed yield (35.9 g plant^{-1} and 1166 kg ha^{-1}) and stalk yield (3744 kg ha^{-1}). Lowest growth and yieldparameters were recorded in the crop sown on 15th November and in variety S_3-WRGE-97.

Conclusion: Among varieties, WRGE-182 (S_4)and WRGE-121 (S_2) performed better in terms of growth and yield. Crop sownon September 30th, 2023 revealed better performance in terms of growth and yield under the present study during *rabi* conditions.

Keywords: Sowing dates; varieties; growth; yield.

1. INTRODUCTION

Pulses form an integral part of vegetarian diet in Indian subcontinent. Pulses are popularly known as “Poor man’s meat” and “rich man’s vegetable” as a result of being a major source of proteins, vitamins and minerals especially for vegetarian diets in India [1]. Besides being rich source of protein, they maintain soil fertility through biological nitrogen fixation and improve the soil organic matter by leaf defoliation at the time of maturity. Thus, pulses play a vital role in furthering the sustainable agriculture.

In India, pulses have been cultivated since the time immemorial under rainfed conditions, which are characterised by poor soil fertility and moisture stress. More than 78 per cent of the area under the pulse is still under rainfed, and therefore, productivity has not increased as it should have been after the release of dozens of improved varieties. India, being the largest producer of pulses in the world occupies 37 per cent of global pulse area and 29 per cent of global pulse production (dpd.gov.in).The level of productivity of pulses in India is far below the average productivity of the world As a result the per capita availability of pulses has declined from 64 g per day (1951-56) to 44.93g per day (2021-22) as against FAO/WHO's recommendation of 80 g per day (Annual report, 2022-23). This has lead to the crisis of shortage of pulses in India. Thus, there is an urgent need to increase the production of pulses to meet the requirement by manipulating the production technologies appropriately.

Pigeonpea (*CajanauscajanL.*) is the most important *kharif* season grain legume, grown predominantly under rainfed conditions in India as well as in Telangana. It is also known as redgram, arhar or tur. India ranks first in redgram production with 42.2 lakh tonnes, cultivated in 49 lakh ha area with a productivity of 931 kg ha^{-1}. In India, pigeonpea stands in second position next to chickpea in total pulse production. In Telangana, redgram is cultivated in 3.14 lakh ha area with a production of 2.41 lakh tonnes and a productivity of 860 kg ha^{-1}[2].

Pigeonpea is perennial in nature. But, with manipulation in the date of sowing, it could be made to look and behave like an annual herb and dry up at the end of its reproductive phase. Most varieties of pigeonpea are photosensitive and therefore, sowing date has an important influence on the vegetative and reproductive processes.

Time of sowing, a non-monetary input, has a considerable influence on length of growing season, growing degree days, growth, development and yield of pigeonpea. It ensures the complete harmony between vegetative and reproductive phases on one hand and climatic rhythm on the other hand. Further, sowing time also plays an important role in dry matter accumulation by the crop. Early sown crop may accumulate excessive dry matter and reduce podding, while delayed sowings beyond the optimum sowing window period result in reduced biomass accumulation and low grain yields of pigeonpea (Rao et al., 2004; Kumar et al.,2008).

The mid-early varieties Telangana kandi-1, Telangana kandi-2, Warangal kandi-1 and WRGE-182 are recently released from PJTSAU. Farmers are growing these varieties across the Telangana state especially during *kharif* season and also during *rabi* season (2021-22) in nearly 5,600 acres. Now, efforts are on to produce pigeonpea seed on a large scale by Telangana State Seed Development Corporation (TSSDC), Government of Telangana, Hyderabad in *rabi* for its utilization in ensuring *kharif* season. However, so far, varieties have been bred only for *kharif* season. Hence, there is a dire need to evaluate them and identify high yielding ones suitable for *rabi* season in Telangana.

Telangana kandi-1 (WRGE-93) is a mid-early (155-165 duration) pigeonpea variety recommended in medium to black soils under rainfed situations of Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Orissa in *kharif* and late *kharif* seasons which yields about 1500-1800 kg ha^{-1}. It is bold and red coloured seed with 100 seed weight of 9-11 g, containing 19.86% of protein and 2.46% of fiber. Its special characters are, it is high yielding variety, moderately resistant to *Fusarium* wilt, moderately tolerant to *Helicoverpa armigera*, indeterminate in growth with profuse branching.

Telangana kandi-2 (WRGE-121) is a mid early (155-165 duration) pigeonpea variety recommended in medium to black soils under rainfed situations of Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Orissa in *kharif* and late *kharif* seasons which yields about 1500-1800 kg ha^{-1}.It is bold and red coloured seed with 100 seed weight of 10 g, containing 23.09% of protein, 37.90 ppm of Fe, 25.04 ppm of Zn and 2.36% of fiber. Its special characters are, it is moderately resistant to Fusarium wilt, moderately tolerant to *Maruca vitrata* and podfly, indeterminate in growth with profuse and long fruiting branching.

Warangal kandi-1 (WRGE-97) is a mid early (150-160 duration) pigeonpea variety recommended in medium and heavy black cotton soils of Telangana state which is released in 2019. It is indeterminate, spreading type having green coloured stem, oblong shaped leaf, absent pubescence on lower surface of the leaf with plant height of 150 cm. The pods are green coloured with brown streaks. The pods are 4-5 cm lengthy with prominent constriction, consisting of 4 seeds per pod. The seeds are large sized, brown coloured, oval shaped with 100 seed weight of more than 9-11 g. This variety is moderately resistant to *Fusarium* wilt.

WRGE-182 is a mid early (150-160 duration) pigeonpea variety. It has completed minikit first year and now it is in second year of minikit.

2. METHODS AND MATERIALS

Field experiment was conducted at Siddapur research farm of RARS, Warangal during *rabi* (2023-24). The experimental site is geographically located in Central Telangana agro climatic zone of Telangana. The soil of experimental site had high pH in reaction(7.9), EC(0.61 dsm^{-1}), medium in organic carbon (0.64%), low in available N(184 kg ha^{-1})& high in Phosphorous (105.19 kg ha^{-1}) and available potassium (643 kg ha^{-1}).

The experiment consisted of totally sixteen treatments which was laid out in split plot design with three replications. Treatments included were four dates of sowing in the main plot M_1-30th September, M_2-15th October, M_3-30th October and M_4-15thNovenber and four treatments of varieties in sub plots S_1-WRGE-93, S_2-WRGE-121, S_3-WRGE-97 and S_4-WRGE-182 randomly placed in subplots of the main plot. The treatments are sown with a spacing of 90×20 cm. Recommended dose of fertilizers 20-50-00 NPK ha^{-1},urea and single super phosphate are the fertilisers used in this experiment. Adequate plant protection measures were taken as per requirement. Randomly five plants were selected and tagged from each plot for recording various growth and yield parameters periodically and at harvest through destructive and non-destructive sampling. The rainfall of 24mm was received during 2 rainy days during the entire period of crop growth. The mean maximum temperature and minimum temperature recorded was 32.7^{o}C and 20.4^{o}C respectively. The mean weekly bright sunshine hours varied from 3.2 to 9.4hr day^{-1} with an average of 6.9hrday^{-1}. All the data recorded in the study were conducted statistical analysis of variance technique for split plot design.

3. RESULTS AND DISCUSSION

3.1 Effect of Sowing Time

At harvest, the plant height was significantly higher recorded in cropsownon September 30th, 2023 (149.1 cm)than that of crop sown on October15th, 2023 (141.9 cm), October 30th,2023 (132.3 cm) and November15th, 2023 (106.0 cm). Delaying the sowing date may be the cause of the decreased plant height in the crop seeded on November 15th, 2023. Agronomic dwarfing, or a sharp decrease in plant height as a result of a delayed planting date, was noted. The results with Panda et al. [3] and Ram et al. [4] are comparable. According to their findings, pigeonpea plants grow more diminutive as the sowing dates are postponed. Drymatter production was highly influenced by the dates of sowing. Significantly higher dry matter production (602 g m^{-2}) was recorded in crop sown on September 30th, 2023 than that of crop sown on October 15th, 2023 (566 g m^{-2}), October 30th, 2023 (422 g m^{-2}) and November 15th, 2023 (401 g m^{-2}). Consistent with the findings of Parimal et al.[5], higher dry matter in the crop sown on September 30th, 2023, could be attributed to increased plant metabolic activity and solar energy harvesting efficiency in the optimal sowing time coupled with favorable climate conditions, especially temperature, rainfall and solar radiation.

The number of fruiting branches plant^{-1} were significantly higher in the crop sown on September 30th,2023(13.9) than that of crop sown on October15th, 2023 (11.9), October30th,2023 (8.1) and November 15th,2023 (6.6). The favorable environmental conditions for early-sown crops, especially during the vegetative growth period, could be the cause for this. Similar results were reported by Islam et al. [6] and Kumar et al.[7]. The number of pods plant^{-1} were significantly higher in the crop sown on September 30th,2023 (162.7) than that of crop sown on October15th, 2023 (133.8), October30th,2023 (85.8) and November 15th,2023 (68.9). The highest number of pods plant^{-1} in September 30th sown crop might be due to a better balance between vegetative and reproductive phases and sufficient time available for setting of pods. These findings are in agreement with those of Rani and Reddy [8], Singh et al. (2016) and Aruna and Kumar [9] reported for pigeonpea. The cropsownon September 30th,2023 recorded significantly higher number of seeds pod^{-1} (4.08) than that of crop sown on October15th, 2023(3.84), October30th,2023 (3.47) and November 15th,2023 (2.88). The highest number of pods plant^{-1} in the crop sown on September 30th directly contributed to obtain a larger number of seeds pod^{-1}. These results are in contrast with the results of Nagamani et al*.* (2020) and Laxminarayana [10].

Among the sowing dates, the seed yield plant^{-1} was recorded significantly higher in the crop sown on September 30th, 2023 (42.3 g) than that of cropsownon October15th, 2023(34.7 g), October30th,2023 (24.9 g) and November 15th,2023 (19.8 g). Similar findings were observed by Hardev [11]. The seed yieldha^{-1}wassignificantlyhigherinthecropsownonSeptember 30th,2023 (1392 kgha^{-1})thanthatofcropsownonOctober15th, 2023 (1228 kgha^{-1}), October30th,2023 (1035 kg ha^{-1}) and November 15th,2023 (704 kg ha^{-1}) and further, margin of decrease of seed yield from 11.8-49.4% with delayed sowing from September 30th,2023 sown crop to other tested sowing dates. The higher seed yield witnessed in pigeonpea crop sown earlier might be a result of favorable environmental conditions, leading to greater leaf area and higher biomass accumulation, ultimately improving seed yield. These results are consistent with the findings of Nagamani et al. [12], Dash et al. [13], Kumar et al. (2023) and Pawar et al. [14]. The stalk yield was significantly influenced by different dates of sowing.

Among the dates of sowing, the cropsownon September 30th,2023 recorded significantly higher stalk yield (4151 kg ha^{-1}) than that of crop sown onOctober15th, 2023 (3697 kg ha^{-1}), October30th,2023 (3245 kg ha^{-1}) and November 15th,2023 (2203 kg ha^{-1}). Sowing of pigeonpea on 30th September resulted maximum stalk yield due to optimum utilization of solar radiation, temperature, higher assimilates production and its conversion to starch resulting in higher stalk yield. These finding are similar to those reported by Egbe et al. [15] and Malik and Yadav [16].

3.2 Performance of Varieties

Among the varieties, plant height was significantly higher in WRGE-182 variety (137.7 cm)thanthatofWRGE-93 (130.6 cm) and WRGE-97 (126.3cm) but on par with WRGE-121 (134.6 cm) variety. The increased plant height in WRGE-182 and WRGE-121could be because of their prolonged vegetative phase due to indeterminate growth habit of varieties. This, inturn, results in a significant increase in plant height of varieties. Sujathammaet al. [17] and Gaikwad et al. [18] also expressed similar views regarding effect of varieties on plant height. Significantly higher drymatter production wasrecordedunderWRGE-182 variety (516 gm^{-2}) than that of WRGE-93 (501 gm^{-2}) and WRGE-97 (463 g m^{-2}) but was on par with WRGE-121 (512 g m^{-2}). This might be due to the variation in growth habits and enhancement of cell elongation by optimum utilization of temperature and rainfall water thereby resulting in higher dry matter production. The results were in line with the findings of Bansalet al. [19] and Sepat et al. [20]. The interaction effect between date of sowing and different varieties was found to be significant on drymatter production (g m-2). Similar findings were reported by Panda et al.[3].

Among the varieties, WRGE-182 (11.7) recorded significantly higher number of fruiting branches plant^{-1}than WRGE-93(9.6) and WRGE-97 (8.0) but was on par with WRGE-121 (11.2) variety. The increase in number of fruiting branches in varieties WRGE-182 and WRGE-121 might be due to genetic capability and better utilization of resources. Similar observations were reported by Kaur et al. [21] and Math et al.[22]. Significantly higher number of pods plant^{-1} were recorded by WRGE-182 (144.0) compared to WRGE-93 (97.0) and WRGE-97 (79.9) but was on par with WRGE-121 (130.3) variety. This can be attributed due to high leaf area, better assimilation of photosynthates and efficiency to tolerate temperatures. These results are in confirmation with the findings of Nagaraju et al. [23] and Mishra et al. [24].Similar findings were reported by WRGE-182 (3.85) recorded significantly higher numberofseedspod^{-1}than WRGE-93(3.53) andWRGE-97 (3.15) but was on par with WRGE-121 (3.74) variety. The increase in the numberofseedspod^{-1} of WRGE-182 may be attributed to an increase in the more production, efficient translocation of photosynthates to the sink [25].

WRGE-182 recorded significantly higher seed yield (37.9 g) plant^{-1}than WRGE-93 (27 g) and WRGE-97 (21 g) but was on par with WRGE-121 (35.9 g) variety**.** Similar results of seed yield plant-^{1}was observed by Dugesaret al. [26]. WRGE-182 (1181 kgha^{-1}) recorded significantly higher seed yield than WRGE-93 (1057 kg ha^{-1}) and WRGE-97 (955 kgha^{-1}) varieties but on par with the seed yieldofWRGE-121 (1166 kg ha^{-1}) pigeonpea variety. The greater seed yield in WRGE-182 may be attributed to its genetic potential and superior growth traits, such as a higher total number of branches plant^{-1}, number of pods plant^{-1} and number of seeds pod^{-1}. These findings align with those reported by Kishore et al. [27], Abishek et al.[28] and Math et al. [22]. Significantly higher stalk yield was reported byvariety WRGE-182 (3801 kg ha^{-1}) than that of WRGE-93 (3025 kg ha^{-1}) and WRGE-97 (2725 kg ha^{-1})varieties but on par with variety WRGE-121 (3744 kg ha^{-1}). The superiority of growth characters like plant height, branches, leaf area and dry matter accumulation may be the possible reason for the production of higher stalk yield in WRGE-182. These results align with those reported by Bansal et al.[19] and Pavani et al. [29]. The interaction between dates of sowing and the varieties showed significant effect on number of pods plant^{-1}, seed yield plant^{-1}, seed yield ha^{-1} and stalk yield ha^{-1}ofpigeonpea. Similar result were reported by Panda et al. [3], Chawhan et al. [30] and Egbe et al. [13]. The sowing dates and varieties did not significantly influence the harvest index of pigeonpea [31-33].

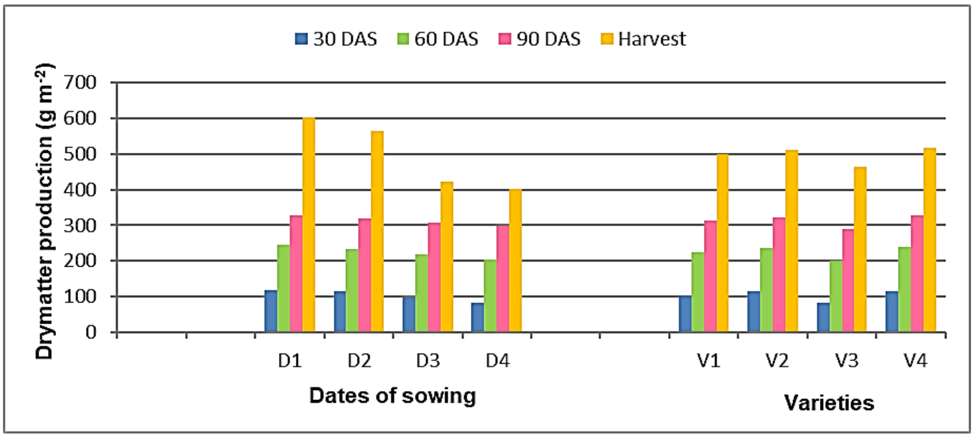

Fig. 1. Growth and yield parameters of pigeonpea as influenced by dates of sowing and varieties

Table 1. Growth and yield parameters of pigeonpea as influenced by dates of sowing and varieties

Treatments	Plant height (cm)	Dry matter production (g m^{-2})	No. of fruiting branches $plant^{-1}$	No. of pods $plant^{-1}$	No. of seeds pod^{-1}
Main factor: Dates of Sowing					
D1- September 30th,2023	149.1	602	13.9	162.7	4.08
D2- October15th, 2023	141.9	566	11.9	133.8	3.84
D3-October30th,2023	132.3	422	8.1	85.8	3.47
D4-November 15th,2023	106.0	401	6.6	68.9	2.88
SEm ±	1.7	4.3	0.3	4.9	0.05
CD(p=0.05)	5.8	15.0	1.1	16.8	0.18
Subfactor: Varieties					
V1- WRGE- 93	130.6	501	9.6	97.0	3.53
V2-WRGE-121	134.6	512	11.2	130.3	3.74
V3- WRGE-97	126.3	463	8.0	79.9	3.15
V4-WRGE-182	137.7	516	11.7	144.0	3.85
SEm ±	1.2	3.7	0.4	5.7	0.06
CD(p=0.05)	3.4	10.8	1.3	16.6	0.17
Interaction (Factor(D) at same level of V)					
SEm ±	2.6	7.7	0.8	11.0	0.11
CD(p=0.05)	NS	22.6	NS	32.0	NS
Interaction(Factor (V) at same level of D)					
SEm ±	2.3	7.4	0.9	11.3	0.11
CD(p=0.05)	NS	21.6	NS	33.1	NS

Table 2. Interaction effect between dates of sowing and varieties on dry matter production

Treatments	Dry matter production (g m^{-2}) at harvest				
	D_1- September 30th,2023	D_2 - October15th, 2023	D_3 - October30th, 2023	D_4 –November 15th, 2023	Mean
V_1 - WRGE-93	617	575	430	380	501
V_2 - WRGE- 121	578	578	462	430	512
V_3 - WRGE- 97	567	516	388	381	463
V_4 - WRGE- 182	648	596	407	412	516
Mean	602	566	422	401	
Factors	SEm ±	CD(p=0.05)			
D x V	7.7	22.6			
V x D	7.4	21.6			

Table 3. Interaction effect between dates of sowing and varieties on number of pods plant^{-1}

Treatment	Number of pods plant^{-1}				
	D_1- September 30th,2023	D_2 - October15th, 2023	D_3 - October30th, 2023	D_4 – November 15th, 2023	Mean
V_1 - WRGE-93	160.3	99.3	93.0	35.3	97.0
V_2 - WRGE- 121	145.7	146.3	129.7	99.3	130.3
V_3 - WRGE- 97	100.1	112.0	55.0	52.7	79.9
V_4 - WRGE- 182	244.7	177.5	65.5	88.3	144.0
Mean	162.7	133.8	85.8	68.9	
Factors	SEm ±	CD(p=0.05)			
D x V	11.0	32.0			
V x D	11.3	33.1			

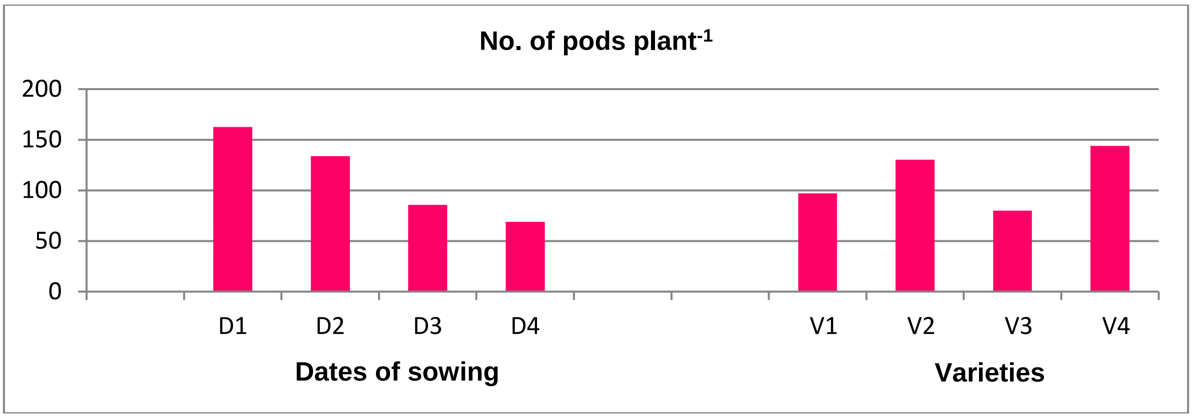

Fig. 2. Interaction effect between dates of sowing and varieties on number of pods plant^{-1}

Table 4. Yield of pigeonpea as influenced by dates of sowing and varieties

Treatments	Seed yield (g) plant^{-1}	Seed yield (Kg ha^{-1})	Stalk yield (Kg ha^{-1})	Harvesting index (%)
Main factor: Dates of Sowing				
D1- September 30th,2023	42.3	1392	4151	26.2
D2- October15th, 2023	34.7	1228	3697	26.4
D3-October30th,2023	24.9	1035	3245	26.4
D4-November 15th,2023	19.8	704	2203	26.0
SEm ±	1.4	10	121	0.7
CD(p=0.05)	4.9	35	419	NS
Subfactor: Varieties				
V1- WRGE- 93	27.0	1057	3025	26.1
V2-WRGE-121	35.9	1166	3744	26.6
V3- WRGE-97	21.0	955	2725	26.0
V4-WRGE-182	37.9	1181	3801	26.3
SEm ±	0.8	7	98	0.5
CD(p=0.05)	2.4	22	286	NS
Interaction(Factor(D) at same level of V)				
SEm ±	2.0	16	208	1.1
CD(p=0.05)	5.9	48	608	NS
Interaction(Factor(V) at same level of D)				
SEm ±	1.6	15	196	1.0
CD(p=0.05)	4.8	44	571	NS

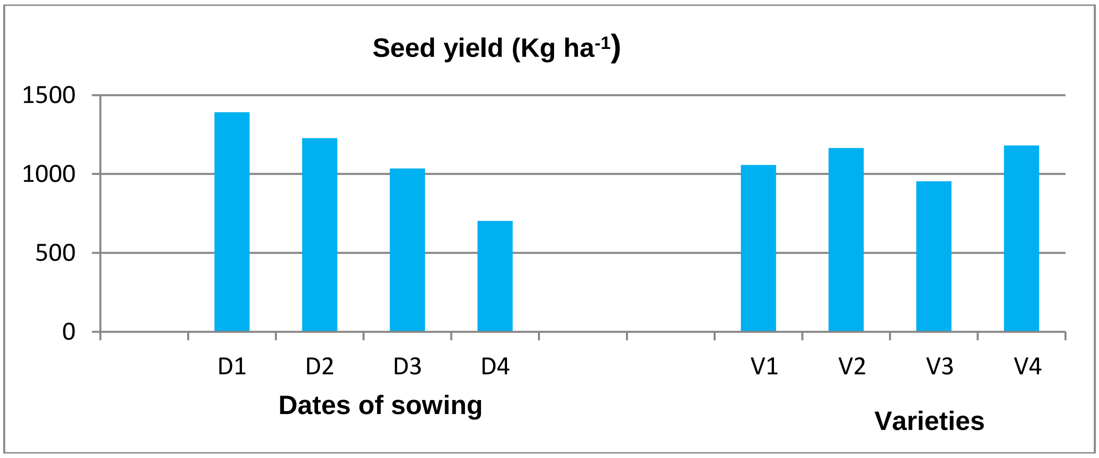

Fig. 3. Yield of pigeonpea as influenced by dates of sowing and varieties

Table 5.Interaction effect between dates of sowing and varieties on seed yield (g) plant^{-1}

Treatment	Seed yield (g) plant^{-1}				
	D_1- September 30th,2023	D_2 - October15th, 2023	D_3 - October30th, 2023	D_4 – November 15th, 2023	Mean
V_1 - WRGE-93	43.3	28.7	25.2	10.7	27.0
V_2 - WRGE- 121	39.7	30.7	43.3	30.0	35.9
V_3 - WRGE- 97	32.0	26.4	16.9	8.7	21.0
V_4 - WRGE- 182	54.3	53.0	14.4	30.0	37.9
Mean	42.3	34.7	24.9	19.8	
Factors	SEm ±	CD(p=0.05)			
D x V	2.0	5.9			
V x D	1.6	4.8			

Table 6.Interaction effect between dates of sowing and varieties on seed yield (Kg ha^{-1})

Treatment	Seed yield (Kg ha^{-1})				
	D_1- September 30th,2023	D_2 - October15th, 2023	D_3 - October30th, 2023	D_4 – November 15th, 2023	Mean
V_1 - WRGE-93	1389	1204	1056	579	1057
V_2 - WRGE- 121	1296	1274	1166	926	1166
V_3 - WRGE- 97	1215	1108	926	570	955
V_4 - WRGE- 182	1667	1325	992	741	1181
Mean	1392	1228	1035	704	
Factors	SEm ±	CD(p=0.05)			
D x V	16	48			
V x D	15	44			

Table 7.Interaction effect between dates of sowing and varieties on stalk yield (Kg ha^{-1})

Treatment	Stalk yield (Kg ha^{-1})				
	D_1- September 30th,2023	**D_2 - October15th, 2023**	**D_3 - October30th, 2023**	**D_4 – November 15th, 2023**	**Mean**
V_1 - WRGE-93	3863	3555	3008	1672	3025
V_2 - WRGE- 121	3560	3398	4567	3452	3744
V_3 - WRGE- 97	3529	3135	2599	1637	2725
V_4 - WRGE- 182	5651	4700	2804	2051	3801
Mean	4151	3697	3245	2203	
Factors	**SEm ±**	**CD(p=0.05)**			
D x V	208	608			
V x D	196	571			

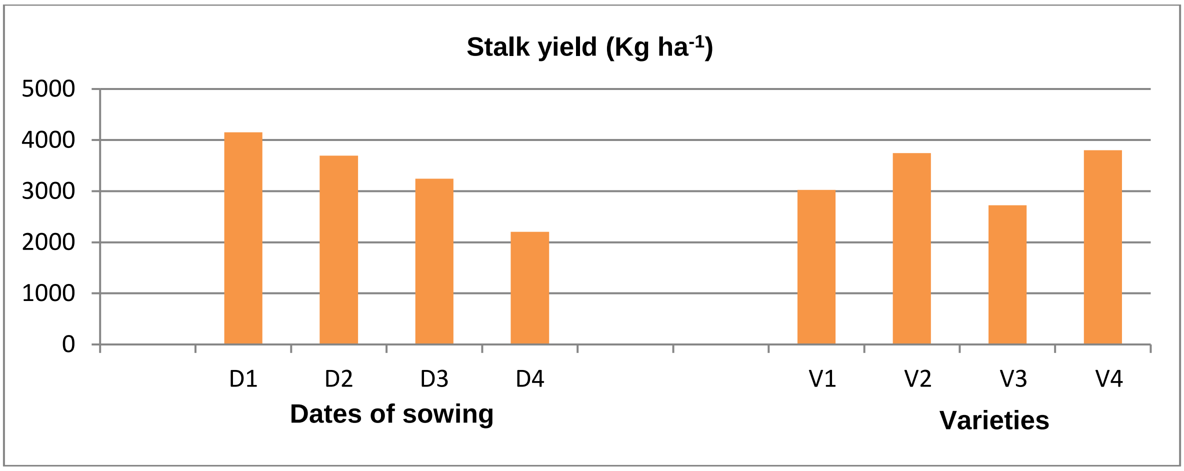

Fig. 4. Interaction effect between dates of sowing and varieties on stalk yield (Kg ha^{-1})

4. CONCLUSION

Based on the research work, it can be concluded that among different sowing dates, crop sownon September 30th, 2023 (M_1) performed better in terms of growth and seed yield and among the varieties, WRGE-182 (S_4) and WRGE-121 (S_2) performed better in dry matter production resulting in higher seed yield under *rabi* conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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