

Original Research Article

Impact of yield attributes and yields of pigeonpea (*Cajanus cajan* (L.)) varieties under different sowing windows

Abstract: An agro-meteorological investigation was undertaken to determine “the impact of crop yield attributes and yield of pigeonpea (*Cajanus cajan*) varieties under different sowing windows” during *kharif*, 2017-18 and 2018-19 at Department of Agricultural Meteorology, College of Agriculture, Pune. In this context, an experiment was laid out in split plot design with three replications. The treatment comprised of four varieties viz., Vipula, Rajeshwari (Phule T 0012), BDN 711 and ICPH 2740 as main plot and four sowing windows viz., 24th, 26th MW, 28th and 30th MW as sub plot treatments. Yield contributing characters viz., number of pods plant⁻¹ (149.5 and 143.0), weight of pods plant⁻¹ (113.8 and 107.6 g) and 100 seed weight (10.79 and 10.75 g) were found significantly higher in var. ICPH 2740 over var. Vipula, Rajeshwari and BDN 711. Grain yield (26.59 and 28.14 q ha⁻¹) and stalk yield (39.61 and 36.7 q ha⁻¹) were significantly higher in var. ICPH 2740 followed by var. Rajeshwari, Vipula and BDN 711. On the other hand, Grain yield (24.31 and 22.86 q ha⁻¹) and stalk yield (63.6 and 61.8 q ha⁻¹) was higher in 24th MW sowing window during the year 2017-18 and 2018-19, respectively.

Key words: Yield attributes, pigeonpea, sowing window, ICPH 2740, grain yield and stalk yield

1. Introduction

Pigeonpea (*Cajanus cajan* (L.) Millspaugh) is one of the major ~~pulsepulses~~ ~~cropcrops~~ of the tropics and subtropics. It is the second most important pulse crop of India, after chickpea [1]. It is commonly known as arhar or red gram. It is an important source of high quality dietary protein and is mostly consumed in the form of split pulse; green seeds are used as a vegetable. On the other hand, crushed dry seeds are used as animal feed, green and dry leaves as fodder, stems as fuel wood and to make huts and baskets in tribal areas. It is an agricultural crop of rainfed-drylands which can be grown on mountain slopes to reduce soil erosion.

The area, productivity and production of pigeonpea in Maharashtra were 12.29 lakh hectares, 937 kg ha⁻¹ and 10.59 lakh ~~tonnes~~ ~~tons~~ respectively [2]. All of these cultivated types of

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pigeonpea fall into two group's viz., *Cajanus cajan* (L.) var. Bicolour and *C. indicus* (L.) var. flavus.

Pigeonpea is predominantly a crop of tropical areas mainly cultivated in semi-arid regions of India. Pigeonpea can be grown with a temperature ranging from 26 °C to 30 °C in the rainy season (June to October) and 17 °C to 22 °C in the post rainy (November to March) season. Pigeonpea is very sensitive to low radiation at pod development, therefore flowering during the monsoon and cloudy weather, leads to poor pod formation [3]. However, the nature of the response to temperature between the cardinal points is important for calculating the phenology, adaptation and yield of a crop [4].

Sowing dates has a profound impact on the crop performance as it determines the kind of weather conditions to which difficult phenological stages of the crop exposed. Delay in sowing time shortens the growing period, hastens maturity and ultimately reduces the yield [5]. Early sowing may prolong the vegetative growth period while delayed sowing may shrink the vegetative phase period, thereby resulting in poor dry matter accumulation leading to poor partitioning to reproductive parts and ultimately poor realization of the potential yield [6]. Therefore, a detailed study on different pigeonpea varieties under different sowing window would provide a base for understanding impact of crop yield attributes and yield under prevailed weather conditions.

2. Materials and methods

2.1 Location of the experimental site

The field experiment was conducted for two consecutive years at Department of Agricultural Meteorology farm, College of Agriculture, Pune during *kharif*, 2017 and 2018. The geographical location of the site (Pune) was 18° 32'N, latitude; 73°51'E, longitude and 559 m above mean sea level (MSL). The soil is medium black having depth of about 1m. The average annual rainfall of Pune is 675mm.

2.2 Weather conditions during experimental period

The weekly maximum temperature experienced during 2017-18 was 33.4 °C and lowest maximum temperature was 27.1 °C. The highest minimum temperature experienced was 23.9 °C

and the lowest was 10.3 °C. The maximum morning relative humidity was 97.0 per cent and the minimum was 81.1 per cent. The maximum evening relative humidity was 82.1 per cent and the minimum was 31.1 per cent. The total rainfall was 909.1 mm and maximum amount of rainfall 135.1 mm in a week.

The weekly maximum temperature experienced during 2018-19 was 33.8 °C and lowest maximum temperature was 26.2 °C. The highest minimum temperature experienced was 24.6 °C and the lowest was 8.7 °C. The maximum morning relative humidity was 94.3 per cent and the minimum was 77.9 per cent. The maximum evening relative humidity was 85.4 per cent and the minimum was 22.6 per cent. The total rainfall was 420.3 mm and maximum amount of rainfall 90.8 mm in a week.

2.3 Experimental details:

The experiment was conducted in a split plot design with three replications and sixteen treatment combinations of different varieties and sowing windows. The treatment comprised of four varieties viz., Vipula, Rajeshwari (Phule T 0012), BDN 711 and ICPH 2740 (*Mannem Konda Kandi*) as main plot and four sowing windows viz., 24th, 26th MW, 28th and 30th MW as sub plot treatments. Inter row spacing was 45 cm and plant to plant spacing was 20 cm. Gross plot size was 4.0 × 4.5 square metres and net plot size was 3.6 × 4.0 square metres. Seeds were treated with Thiram @ 4 g per kg of seed followed by Rhizobium and PSB @ 10 g per kg of seed. The seed rate @ 18 kg ha⁻¹ for all varieties. Urea and DAP were used as source of N and P, and applied as per recommended dose i.e., 25 kg N and 50 kg per hectare.

2.4 Yield attributes studies

The following yield contributing characters were recorded periodically on five observational plants from each net plot.

2.4.1 Number of pods plant⁻¹

The Number of pod plant⁻¹ was recorded from the selected five plants in each net plot at harvest.

2.4.2 Length of pod (cm) plant⁻¹

The length of pod plant⁻¹ was recorded from the selected five plants in each net plot at harvest.

2.4.3 Weight of pods plant⁻¹ (g)

The weights of pods plant^{-1} were recorded from the selected five plants in each net plot at harvest.

2.4.4 Number of grains pod^{-1} (g)

In this study number of grain per healthy pods were collected from the randomly selected five plants.

2.4.5 Test weight (g)

A random sample of 100 grains from each net plot was drawn and their weights were recorded.

2.5 Yield studies

2.5.1 Grain yield q ha^{-1}

The plants from each net plot (including observational plants) were harvested and threshed seeds were cleaned by winnowing and yield of grain kg plot^{-1} was converted in q ha^{-1} .

2.5.2 Stalk yield q ha^{-1}

The straw yield per net plot was obtained by difference in weight of total produce and seed weight was converted into q ha^{-1} .

3. Results and Discussion

3.1 Yield contributing characters

The mean periodical yield contributing characters of pigeonpea varieties viz., number of pods plant^{-1} (g), pod weight plant^{-1} (g), length of pods (cm), number of seeds pod^{-1} and 100 grain weight as influenced by different treatments were recorded at harvest and reported.

3.1.1 Number of pods per plant and pod weight plant^{-1} (g)

Data with respect to mean number of pods plant^{-1} and pod weight plant^{-1} as influenced by various treatments are presented in Table 1. The mean number of pods plant^{-1} was (138.8 and 131.4) and pod weight plant^{-1} was (105.8 and 98.6 g) during 2017-18 and 2018-19, respectively.

3.1.1.1 Effect of varieties

The pigeonpea varieties differ in their number of pods plant^{-1} . The number of pods plant^{-1} was found significantly higher in var. ICPH 2740 (149.5 and 143.0), followed by Rajeshwari (141.4 and 132.2), Vipula (135.3 and 128.3) and BDN 711 (128.9 and 122.1) during 2017-18 and 2018-19, respectively.

The pigeonpea varieties were also differ in their weight of pods plant⁻¹(g). The weight of pods plant⁻¹ was found significantly higher in var. ICPH 2740 (113.8 and 107.6 g), followed by Rajeshwari (108.6 and 102.4 g), Vipula (106.4 and 100.2 g) and BDN 711 (94.5 and 79.5 g) during 2017-18 and 2018-19, respectively.

The varietal effect on pods plant⁻¹ was significant. A var. ICPH 2740 was found significantly superior over other varieties. This can be attributed due to high leaf area index, better assimilation of photosynthates and efficiency to tolerate temperatures. These results are in confirmation with the findings of Mishra *et al.* [7].

3.1.1.2 Effect of sowing windows

The number of pods plant⁻¹ was recorded the highest at 24th MW (157.9 and 150.7) which was significantly superior over rest of the sowing windows, followed by 26th MW (146.8 and 136.8), 28th MW (134.5 and 126.0) and 30th MW sowing window (115.7 and 112.1) during 2017-18 and 2018-19, respectively.

The weight of pods plant⁻¹ was recorded the highest at 24th MW (117.7 and 112.7 g) which was significantly superior over rest of the sowing window followed by 26th MW (109.5 and 103.5 g), 28th MW (100.4 and 93.7 g) and 30th MW sowing window (95.7 and 79.8 g) during 2017-18 and 2018-19, respectively.

Phenological development from sowing to physiological maturity is dependent on the accumulation of thermal units above threshold or base temperature. A slow process of developmental events provides longer growing period and gives opportunity for the plant parts to survive with more number of pods and grains pod⁻¹. These results are concurrence with the findings of Hakim *et al.* [8] and Kumar *et al.*, [9].

Table 1. Number of pods plant⁻¹ and pod weight plant⁻¹ (g) of pigeonpea as affected by different treatments during 2017-18 and 2018-19

Treatment	No. of pods per plant			Pod weight per plant (g)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
A) Main plot treatments: Varieties						
V₁: Vipula	135.3 ^b	128.3 ^b	131.8 ^b	106.4 ^b	100.2 ^a	103.3 ^b
V₂: Rajeshwari	141.4 ^b	132.2 ^a	136.8 ^b	108.6 ^a	102.4 ^a	105.5 ^b
V₃: BDN 711	128.9 ^c	122.1 ^b	125.5 ^c	94.5 ^c	79.5 ^b	87.0 ^c
V₄: ICPH 2740	149.5 ^a	143.0 ^a	146.3 ^a	113.8 ^a	107.6 ^a	110.7 ^a
S. Em±	1.88	3.55	2.03	1.85	2.45	1.89
C. D. at 5%	6.51	12.29	6.26	6.40	8.48	5.83
B) Sub plot treatments: Sowing windows						
D₁: 24 MW	157.9 ^a	150.7 ^a	154.3 ^a	117.7 ^a	112.7 ^a	115.2 ^a

D₂: 26 MW	146.8 ^b	136.8 ^b	141.8 ^b	109.5 ^b	103.5 ^b	106.5 ^b
D₃: 28 MW	134.5 ^c	126.0 ^c	130.3 ^c	100.4 ^c	93.7 ^c	97.1 ^c
D₄: 30 MW	115.7 ^d	112.1 ^d	113.9 ^d	95.7 ^d	79.8 ^d	87.8 ^d
S. Em±	1.39	2.08	1.20	1.08	2.98	1.34
C. D. at 5%	4.06	6.08	3.40	3.14	8.69	3.81
C) Interaction (A×B)						
D₁V₁	156.7 ^b	138.0 ^{bc}	147.4 ^d	115.6 ^b	109.5 ^{ab}	112.5 ^b
D₂V₁	136.6 ^d	132.2 ^c	134.4 ^{ef}	109.1 ^c	102.0 ^b	105.6 ^c
D₃V₁	132.3 ^d	126.7 ^{cd}	129.5 ^f	101.3 ^d	95.5 ^{bc}	98.4 ^{cd}
D₄V₁	115.5 ^e	116.2 ^d	115.9 ^g	99.7 ^d	93.8 ^{bc}	96.8 ^d
D₁V₂	161.5 ^{ab}	161.0 ^{ab}	161.3 ^b	120.0 ^b	111.3 ^{ab}	115.7 ^b
D₂V₂	154.6 ^{bc}	136.7 ^c	145.6 ^d	115.3 ^{bc}	106.9 ^b	111.1 ^{bc}
D₃V₂	134.7 ^d	125.6 ^{cd}	130.1 ^f	101.6 ^d	97.5 ^{bc}	99.5 ^{cd}
D₄V₂	114.7 ^e	105.5 ^{de}	110.1 ^g	97.6 ^d	93.8 ^{bc}	95.7 ^d
D₁V₃	145.9 ^c	139.8 ^{bc}	142.8 ^{de}	103.8 ^{cd}	103.5 ^b	103.6 ^{cd}
D₂V₃	137.0 ^{cd}	128.2 ^{cd}	132.6 ^{ef}	99.5 ^d	94.3 ^{bc}	96.9 ^d
D₃V₃	129.1 ^d	119.5 ^d	124.3 ^f	89.9 ^e	83.3 ^c	86.6 ^e
D₄V₃	103.4 ^f	100.9 ^e	102.2 ^h	84.9 ^e	37.0 ^d	61.0 ^f
D₁V₄	167.6 ^a	164.1 ^a	165.9 ^a	131.4 ^a	126.5 ^a	129.0 ^a
D₂V₄	159.2 ^{ab}	150.0 ^b	154.6 ^c	114.1 ^{bc}	110.8 ^{ab}	112.4 ^{bc}
D₃V₄	142 ^{cd}	132.3 ^c	137.1 ^e	108.8 ^c	98.7 ^{bc}	103.8 ^{cd}
D₄V₄	129.4 ^d	125.5 ^{cd}	127.5 ^f	100.7 ^d	94.4 ^{bc}	97.6 ^d
S. Em±	2.78	4.17	2.39	2.15	5.96	2.68
C. D. at 5%	8.11	12.16	6.80	6.28	17.38	7.63
General Mean	138.8	131.4	135.1	105.8	98.6	101.6

Note: Observations with same superscript are on par and with different superscript are significantly different

3.1.1.3 Interaction effects

The interaction effect between pigeonpea varieties with different sowing windows were found significant for number of pods plant⁻¹. The sowing of var. ICPH 2740 during 24th MW i.e. D₁V₄ recorded higher number of pods plant⁻¹ (167.6 and 164.1). This was followed by var. Rajeshwari (161.5 and 161.0), Vipula (156.7 and 138.0) and BDN 711 (145.9 and 139.8) during 2017-18 and 2018-19, respectively.

The interaction effect between pigeonpea varieties with different sowing windows were also found significant for weight of pods plant⁻¹. The sowing of var. ICPH 2740 during 24th MW i.e. D₁V₄ recorded higher number of pods plant⁻¹ (131.4 and 126.5). This was followed by var.

Rajeshwari (120.0 and 111.3), Vipula (115.6 and 109.5) and BDN 711 (103.8 and 103.5) during 2017-18 and 2018-19, respectively. These results were confirmed with the results of Rani and Raji Reddy [10].

3.1.2 Length of pod (cm), number of grains pod⁻¹ and 100 grain weight

Data on mean length of pod (cm), number of grains per pod and 100 grain weight of pigeonpea as influenced significantly by the different treatment are presented Table 2 & 3. The mean length of pod was (4.926 and 4.909), number of grains per pod (4.220 and 4.160) and 100 grain weight (10.27 and 10.23) during 2017-18 and 2018-19.

3.1.2.1 Effect of varieties

The length of pod (cm) of pigeonpea was significantly higher (5.223 and 5.176 cm) in Rajeshwari which was superior over rest of all the genotypes, followed by ICPH 2740 (4.982 and 4.973), Vipula (4.966 and 4.958) and BDN 711 (4.533 and 4.528) during 2017-18 and 2018-19, respectively.

The number of grains per pod of pigeonpea was significantly higher (4.486 and 4.378) in Rajeshwari which was superior over rest of all genotypes, followed by Vipula (4.147 and 4.146), BDN 711 (4.136 and 4.115) and ICPH 2740 (4.131 and 4.104) during 2017-18 and 2018-19, respectively.

The 100 grains weight (g) of pigeonpea was significantly higher (10.79 and 10.75) in ICPH 2740 which was superior over rest of all the varieties, followed by Rajeshwari (10.34 and 10.32) and Vipula (10.13 and 10.11). The var. BDN 711 recorded significantly lower 100 grain weight (g) (9.81 and 9.74). Similar results were reported by Bedis *et al.* [11]. The difference in 100 grain weight (g) of pigeonpea variety might be due to inherent genetical potential varieties. Saxena *et al.*, [12] reported that seed size varies from 10.9 to 11.3 g/100 seeds with brown seed coat and 18.4% protein in ICPH 2740.

3.1.2.2 Effect of sowing windows

The length of pod plant⁻¹ of pigeonpea was recorded the non significantly highest at 24th MW (4.953 and 4.993) which was superior over rest of the sowing windows, followed by 26th MW (4.931 and 4.917), 28th MW (4.916 and 4.900) and 30th MW sowing window (4.904 and 4.885) during 2017-18 and 2018-19, respectively. The length of pod was not change with different sowing windows because genetic character of length of pod does not change with sowing windows.

Table 2. Length of pod and number of grains per pod of pigeonpea as affected by different treatments during 2017-18 and 2018-19

Treatment	Length of pod (cm)			No. of grains per pod		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
A) Main plot treatments: Varieties						
V ₁ : Vipula	4.966 ^b	4.958 ^b	4.962 ^b	4.147 ^b	4.046 ^b	4.096 ^b
V ₂ : Rajeshwari	5.223 ^a	5.176 ^a	5.199 ^a	4.486 ^a	4.378 ^a	4.432 ^a
V ₃ : BDN 711	4.533 ^c	4.528 ^c	4.531 ^c	4.136 ^b	4.105 ^c	4.120 ^b
V ₄ : ICPH 2740	4.982 ^b	4.973 ^b	4.977 ^b	4.131 ^b	4.111 ^b	4.121 ^b
S. Em±	0.024	0.015	0.015	0.007	0.009	0.013
C. D. at 5%	0.082	0.053	0.046	0.026	0.033	0.040
B) Sub plot treatments: Sowing windows						
D ₁ : 24 MW	4.953	4.933	4.943 ^a	4.244	4.185	4.215 ^a
D ₂ : 26 MW	4.931	4.917	4.924 ^a	4.228	4.171	4.200 ^a
D ₃ : 28 MW	4.916	4.900	4.908 ^b	4.227	4.147	4.187 ^b
D ₄ : 30 MW	4.904	4.885	4.895 ^b	4.200	4.138	4.169 ^c
S. Em±	0.016	0.014	0.010	0.011	0.013	0.006
C. D. at 5%	NS	NS	0.030	NS	NS	0.017
C) Interaction (A×B)						
S. Em±	0.032	0.029	0.021	0.022	0.026	0.012
C. D. at 5%	NS	NS	0.060	NS	NS	0.035
General Mean	4.926	4.909	4.917	4.220	4.160	4.190

Note: Observations with same superscript are on par and with different superscript are significantly different

Table 3. 100 seeds weight (g) per 100 seeds of pigeonpea as affected by different treatments during 2017-18 and 2018-19

Treatment	100 seeds weight (g)		
	2017-18	2018-19	Pooled
A) Main plot treatments: Varieties			
V ₁ : Vipula	10.13 ^c	10.11 ^c	10.12 ^c
V ₂ : Rajeshwari	10.34 ^b	10.32 ^b	10.33 ^b
V ₃ : BDN 711	9.81 ^d	9.74 ^d	9.77 ^d
V ₄ : ICPH 2740	10.79 ^a	10.75 ^a	10.77 ^a
S. Em±	0.03	0.03	0.02
C. D. at 5%	0.11	0.099	0.07
B) Sub plot treatments: Sowing windows			
D ₁ : 24 MW	10.41 ^a	10.37 ^a	10.39 ^a

D₂: 26 MW	10.31 ^b	10.30 ^b	10.31 ^b
D₃: 28 MW	10.20 ^c	10.18 ^c	10.19 ^c
D₄: 30 MW	10.15 ^d	10.06 ^d	10.10 ^d
S. Em±	0.028	0.026	0.018
C. D. at 5%	0.080	0.076	0.052
C) Interaction (A×B)			
S. Em±	0.06	0.05	0.04
C. D. at 5%	NS	NS	0.10
General Mean	10.27	10.23	10.25

Note: Observations with same superscript are on par and with different superscript are significantly different

The number of grains pod⁻¹ was non significantly maximum at 24th MW sowing window (4.244 and 4.185) which followed by 26th MW sowing window (4.228 and 4.171). This was followed by 28th MW sowing window (4.227 and 4.147). The least number of grains pod⁻¹ of pigeonpea was observed in 30th MW sowing window (4.200 and 4.138). Similar results were observed by Chauhan *et al.* [13], Salih [14] and Kumar *et al.* [9]. They reported that the number of seeds, seed weight and yield plant⁻¹ at harvest and 100 seed weight of all cultivars were greatly reduced by late sowing. The length of pod, number of grains weight and 100 grain weight were statistically non significant different sowing windows.

The 100 grains weight (g) of pigeonpea was recorded non significantly highest at 24th MW sowing window (10.41 and 10.37) which was followed by 26th MW sowing window (10.31 and 10.30). This was followed by 28th MW sowing window (10.20 and 10.18). The least 100 grains weight (g) of pigeonpea was observed in 30th MW sowing window (10.15 and 10.06 g). Similar results were reported by Rani and Raji Reddy [10] and revealed that delay in pigeonpea sowing from first fortnight of June to second fortnight of August during 2001-02 and 2002-03 resulted in significant reduction in the yield attributing characters.

3.1.2.3 Effects of interaction

The interaction effect between pigeonpea varieties with different sowing windows were found no significant for length of pod plant⁻¹, number of grains pod⁻¹ and 100 grains weight (g).

3.2 Yield studies

Data in respect of mean grain yield and stalk yield of pigeonpea as influenced by different treatments are presented in Table 4.

3.2.1 Grain yield (q ha⁻¹)

D₁: 24 MW	24.31 ^a	22.86 ^a	23.58 ^a	63.6 ^a	61.8 ^a	62.7 ^a
D₂: 26 MW	22.04 ^b	20.18 ^b	21.11 ^b	58.1 ^b	55.7 ^b	56.9 ^b
D₃: 28 MW	18.42 ^c	17.46 ^c	17.94 ^c	54.0 ^c	51.2 ^c	52.6 ^c
D₄: 30 MW	14.43 ^d	13.82 ^d	14.13 ^d	48.4 ^d	44.6 ^d	46.5 ^d
S. Em±	0.14	0.20	0.09	0.66	0.71	0.47
C. D. at 5%	0.42	0.59	0.27	1.93	2.06	1.32
C) Interaction (A×B)						
D₁V₁	23.78 ^c	22.39 ^{bc}	23.08 ^d	63.5 ^{ab}	62.3 ^a	62.9 ^b
D₂V₁	21.23 ^e	18.12 ^{ef}	19.67 ^g	56.9 ^c	54.8 ^{bc}	55.9 ^d
D₃V₁	17.03 ^g	15.76 ^{fg}	16.40 ⁱ	53.0 ^{cd}	50.9 ^{cd}	52.0 ^{ef}
D₄V₁	13.17 ⁱ	12.78 ⁱ	12.97 ⁱ	44.5 ^e	42.1 ^e	43.3 ^g
D₁V₂	24.80 ^b	22.93 ^b	23.86 ^b	64.1 ^{ab}	61.8 ^{ab}	62.9 ^b
D₂V₂	22.75 ^d	21.34 ^c	22.05 ^e	60.6 ^{bc}	58.1 ^b	59.3 ^c
D₃V₂	18.80 ^f	18.75 ^{ef}	18.78 ^h	53.2 ^{cd}	53.5 ^c	53.4 ^{de}
D₄V₂	15.62 ^h	14.77 ^h	15.20 ^k	50.8 ^d	43.5 ^e	47.2 ^f
D₁V₃	22.27 ^d	20.97 ^d	21.62 ^e	59.4 ^{bc}	57.2 ^{bc}	58.3 ^{cd}
D₂V₃	19.74 ^f	18.34 ^{ef}	19.04 ^h	53.6 ^{cd}	52.4 ^c	53.0 ^e
D₃V₃	16.46 ^{gh}	16.15 ^f	16.31 ^{ij}	51.6 ^d	47.8 ^d	49.7 ^f
D₄V₃	12.71 ⁱ	12.41 ^{ij}	12.56 ^m	48.9 ^d	46.4 ^{de}	47.6 ^f
D₁V₄	26.39 ^a	25.14 ^a	25.77 ^a	67.4 ^a	65.9 ^a	66.6 ^a
D₂V₄	24.45 ^{bc}	22.91 ^{bc}	23.68 ^c	61.3 ^b	57.4 ^{bc}	59.3 ^c
D₃V₄	21.36 ^e	19.17 ^e	20.27 ^f	58.2 ^{bc}	52.8 ^c	55.5 ^{de}
D₄V₄	16.22 ^{gh}	15.33 ^g	15.77 ^j	49.4 ^d	46.3 ^{de}	47.9 ^f
S. Em±	0.29	0.40	0.19	1.32	1.42	0.93
C. D. at 5%	0.84	1.18	0.54	3.86	4.14	2.65
General Mean	19.80	18.58	19.19	56.0	53.3	54.7

Note: Observations with same superscript are on par and with different superscript are significantly different

3.2.1.3 Effects of interaction

The grain yield (q ha^{-1}) was significantly influenced by interaction between varieties and sowing windows during the year 2017-18 and 2018-19. Sowing at 24th MW sowing window recorded maximum grain yield (26.39 and 25.14 q ha^{-1}) in var. ICPH 2740. This was followed by var. Rajeshwari (24.80 and 22.93), Vipula (23.78 and 22.39 q ha^{-1}), and BDN 711 (22.27 and 20.97 q ha^{-1}) during the year 2017-18 and 2018-19, respectively. These results showed that delay in sowing of pigeonpea varieties could not able to assimilate the more biomass resulted in reduced pod yield of pigeonpea. Similar results were found by Reddy *et al.* [16] and reported that a reduction of 23% means seed yield was observed with late sowing by 15-30 days, such as normal (June) sowing seed yield was high as compared to late sowing.

3.2.2 Stalk yield

Data with respect to mean stalk yield of pigeonpea as influenced by different treatments are presented in Table 4. The mean stalk yield of pigeonpea was 56.0 and 53.3 q ha⁻¹ during the year 2017-18 and 2018-19, respectively.

3.2.2.1 Effect of varieties

The stalk yield of pigeonpea was influenced significantly due to pigeonpea varieties. The stalk yield was significantly higher in ICPH 2740 (59.1 and 55.6 q ha⁻¹) and significantly superior rest of the pigeonpea varieties. This was followed by Rajeshwari (57.2 and 54.2 q ha⁻¹), Vipula (54.5 and 52.5 q ha⁻¹). The var. BDN 711 recorded significantly lower stalk yield (53.4 and 50.9 q ha⁻¹) during the year 2017-18 and 2018-19, respectively. The differences in stalk yield of pigeonpea varieties might be due to inherent genetical potential of pigeonpea variety. Plants of ICPH 2740 are non-determinate, photo-sensitive, and respond positively to wider spacing. It takes about 115-122 days to flower and its maturity is achieved in 180-190 days. Seed size varies from 10.9 to 11.3 g/100 seeds. Multi-locations evaluation of ICPH 2740 over five years produced on average 2792 kg ha⁻¹ yield with a range of 2207 - 3652 kg ha⁻¹ [12].

3.2.2.2 Effect of sowing windows

The stalk yield of pigeonpea was influenced significantly due to extended sowing windows. The stalk yield was the maximum at 24th MW sowing window (63.6 and 61.8 q ha⁻¹), this was followed by 26th MW (58.1 and 55.7 q ha⁻¹), 28th MW sowing window (54.0 and 51.2) and 30th MW sowing window (48.4 and 44.6 q ha⁻¹) during the year 2017-18 and 2018-19, respectively. A sowing window of 26th MW was favorable to high stalk production because of favorable weather condition. The results are similar as reported by Bedis *et al.* [11] and Sharanappa *et al.* [17]. Prasad *et al.* [18] observed that biological yield significantly affected by different sowing dates, the maximum biological yield (556.4 g plant⁻¹) on early sowing and with lowest biological yield (41.3 g plant⁻¹) recorded for late sowing.

3.2.2.3 Effects of interaction

The stalk yield (q ha⁻¹) was significantly influenced by interaction between varieties and sowing windows during the year 2017-18 and 2018-19. Sowing at 24th MW sowing window recorded maximum stalk yield (67.4 and 65.4 q ha⁻¹) in var. ICPH 2740. This was followed by var. Rajeshwari (64.1 and 61.8 q ha⁻¹), Vipula (63.5 and 62.3 q ha⁻¹) and BDN 711 (59.4 and 57.2 q ha⁻¹) during the year 2017-18 and 2018-19, respectively. These results showed that delay

in sowing of pigeonpea varieties could not able to assimilate the more biomass resulted in reduced haulm yield of pigeonpea [18], [11] and [14].

The manuscript has a poor scientific quality related to the discussion of the results; therefore, I suggest that the authors increase the scientific quality by discussing the results with scientific research already published. I suggest adding a couple of paragraphs like this:

Our results establish that climatological factors such as temperature and rainfall are key in the development of this crop, as established by the results of [19, 20] in arid tropical zones comparable with our study area. Historically, Pune is tropical wet and dry climate area, however, the mean monthly precipitation has varied through the years, with a decrease in precipitation in the summer, this can be evidenced in the results of [21, 22]. Our results coincide with the study carried out by [23, 24], who emphasize that sowing dates are the factor that most influences both in terms of yield and certain management characteristics in tropical, arid and semi-arid territories of Latin America.

It is important to note that the poor soil moisture condition causes delays in the growth of pigeonpea and other types of pulse crop and even in tropical territories, delays planting work, as established by studies by [25, 26, 27]. The water potentials that occur in soils in periods of drought prevent water absorption [28,29,30,31], affecting the sequence of events involved in the seed germination process [32, 33, 34].

In summary, the water stress associated with the sowing dates is, in terms of the amount of plant matter affected, the most important thing that this type of crop such as pigeonpea can suffer. In this sense, research carried out in tropical territories such as [35,36,37] have indicated that the stress caused by drought limits the productivity of these plants and that the intensity of their response depends on the severity and duration of the stress, and the state of development of the crop. That is why the search for sowing dates and varieties tolerant to drought stress constitutes one of the ways considered by researchers and producers for the exploitation of areas, where droughts are frequent or there is no necessary water supply [38, 39]. Given the intense drought and the scarcity of water resources that has been occurring in the study site that have forced to limit the areas dedicated to cultivation, our study emphasized the need and relevance of studies on the effects of the sowing date and impact of yield attributes.

4. Conclusions

Amongst all the pigeon pea cultivars, var. ICPH 2740 found significantly superior under extended sowing windows followed by var. Rajeshwari (Phule T 0012), Vipula and BDN 711.

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Sowing during 24th MW sowing window was observed to be the most suitable and optimum for pigeonpea considering the yield attributes and yield of the crop.

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