

# Optimum Sowing Window and Suitable Varieties for Cultivation Soybean (*Glycine max* L.) during Off-Season in Northern Telangana Zone

International Journal Environment and Climate Change

Comment [A1]: What is the meaning of window?

## ABSTRACT

**Aims:** To identify the optimum sowing time and suitable varieties of soybean for profitable cultivation during the off-season in the Northern Telangana Agroclimatic zone of Telangana state in India.

**Study design:** Strip plot design with three replications.

**Place and Duration of Study:** The Regional Sugarcane and Rice Research Station, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rudrur, Nizamabad District, Telangana state, India, between October 2022 and June 2023.

**Methodology:** The field experiment was conducted in medium clay loam soil under irrigated condition. The experiment was laid out in strip plot design with three varieties viz., JS 335 ( $V_1$ ), ASB 22 ( $V_2$ ) and KDS 726 ( $V_3$ ) as horizontal strips and nine dates of sowings viz., 3 Oct ( $D_1$ ), 19 Oct ( $D_2$ ), 3 Nov ( $D_3$ ), 19 Nov ( $D_4$ ), 3 Dec ( $D_5$ ), 19 Dec ( $D_6$ ), 3 Jan ( $D_7$ ), 19 Jan ( $D_8$ ) and 3 Feb ( $D_9$ ) as vertical strips, replicated thrice. The seeds were sown by dibbling at 5 cm apart within the row and rows were spaced at 45 cm apart. Standard recommended package of practice of *kharif* season suggested by PJTSAU was followed. The data on growth, phenology, yield attributes was recorded on selected 5 plants, averaged/plant and grain yield was recorded from net plot, converted to one hectare and analyzed statistically using OP Stat.

**Results:** The results of the experiment revealed that, the cv. KDS 726 recorded the maximum plant height (35.2 cm) and biomass accumulation ( $8.93 \text{ g plant}^{-1}$ ) which was significantly more over the cv. JS 335 and cv. ASB 22 in 3 Nov and 19 Oct sowings, respectively. The cultivars the cv. JS 335 ( $V_1$ ) recorded more number of pods over cv. ASB 22 ( $V_2$ ) and cv. KDS 726 ( $V_3$ ) in 19 Oct ( $D_2$ ), 3 Nov ( $D_3$ ), 19 Nov ( $D_4$ ), 3 Dec ( $D_5$ ) and 3 Jan ( $D_7$ ) sowings. The cv. KDS 726 ( $V_3$ ) was found superior in terms of seeds  $\text{pod}^{-1}$  (3.0) which was comparable to cv. JS 335 ( $V_1$ ) and significantly more over cv. ASB 22 ( $V_2$ ) when it was sown on 19 Oct ( $D_2$ ). The cv. KDS 726 ( $V_3$ ) recorded significantly more test weight (g) over cv. JS 335 ( $V_1$ ) and cv. ASB 22 ( $V_2$ ) from 19 Oct ( $D_2$ ) to 3 Jan ( $D_7$ ) sowings. The cv. ASB 22 sown on 3 Oct produced significantly more grain yield ( $753 \text{ kg ha}^{-1}$ ) and haulm yield ( $1599 \text{ kg ha}^{-1}$ ) over cv. JS 335 and cv. (KDS 726).

**Conclusion:** The soybean cv. ASB 22 with sowing first week of Oct was found to be suitable for cultivation during the off season.

**Key words:** Soybean, off season, varieties, Dates of sowing, growth, phenology, yield & yield attributes, and economics

## 1. INTRODUCTION

Soybean is recognized as the "Golden bean" of the 21<sup>st</sup> century. The demand for soybean is raising globally due to its inimitable composition, outstanding dietetic value and health benefits (Khan *et al.*, 2020). It occupied a prominent position among the legumes that supplement nearly one-third of the world population. India is the 5<sup>th</sup> largest soybean producer after Brazil (34.45 %), U.S.A. (29.01 %), Argentina (16.56 %), and China (4.00 %). In India, soybean produced over an area of 121.5 lakh hectares with a

production of 129.9 lakh tones and productivity of 1069 kg ha<sup>-1</sup> (Indiastat, 2021). The major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana. In Telangana, soybean produced over an area of 1.55 lakh hectares with a production of 2.68 lakh tonnes and productivity of 1731 kg ha<sup>-1</sup> (Indiastat, 2021). Though the soybean crop has immense opportunity in global market, yields are extremely less than its potential yield in Telangana. In Telangana, the soybean crop is cultivated during *kharif* season. The main factors that reduce its yields are climate unevenness, inappropriate growing time, lower germination percentage, meager quality and scarcity of seed. Further the viability and longevity of soybean seeds very low. Therefore there is a less opportunity to store the seeds produced during *kharif* for the next *kharif* season. It is inevitable to import the seed from distance places like north India every season which is much expensive for the farmers of Telangana. If the crop produced during rabi or summer (off season), the seeds can be used for next *kharif* so that, the additional cost incurred on cold storage and transport can be minimized. No documented results are available on soybean cultivation during the off-season for either grain or seed purposes. The suitable planting date of soybean is probably the most conspicuous cultural practice for maximizing seed yield during the off-season. Different varieties of soybean are sensitive to changes in environmental conditions where the crop is being grown. Therefore, it is necessary to study the genotype x environment interactions to identify the varieties which are stable in different environments (Calvino *et al.*, 2003). Keeping in view of the poor germination, shortage of seed availability in soybean, arising opportunity for alternate crops to *rabi* rice, increase in irrigation potential, and variable climatic conditions in Telangana, the present investigation is prioritized to identify the optimum time of sowing and suitable cultivars for growth and yield of soybean during the off-season in Northern Telangana zone.

## 2. MATERIALS AND METHODS

A field experiment was conducted during off-season 2022-23 at Regional Sugarcane & Rice Research Station, Rudrur, Nizamabad. Which is geographically located at 18° 56' N latitude and 77° 87' E longitude, at an altitude of 404 m above the mean sea level situated in Northern climatic zone of Telangana. The soil of experimental field was clay loam in texture, low in available nitrogen (120 kg ha<sup>-1</sup>) and organic carbon content (0.38%), and high in available phosphorus (42.08 kg ha<sup>-1</sup>) and potassium (285.2 kg ha<sup>-1</sup>). The experiment was laid out in strip plot design with twenty seven treatments, comprising of three varieties *viz.*, JS 335 (V<sub>1</sub>), ASB 22 (V<sub>2</sub>) and KDS 726 (V<sub>3</sub>) as horizontal strips and nine dates of sowings *viz.*, 3 Oct (D<sub>1</sub>), 19 Oct (D<sub>2</sub>), 3 Nov (D<sub>3</sub>), 19 Nov (D<sub>4</sub>), 3 Dec (D<sub>5</sub>), 19 Dec (D<sub>6</sub>), 3 Jan (D<sub>7</sub>), 19 Jan (D<sub>8</sub>) and 3 Feb (D<sub>9</sub>) as vertical strips, replicated thrice. A seed rate of 75 kg ha<sup>-1</sup> was used for sowing. The spacing adopted was 45 cm x 5 cm sown at a depth of 3-4 cm. Seeds were treated with Carbendazim @ 1 g kg<sup>-1</sup> of seed to protect crop against seed borne diseases. Recommended dose of 60-60-40 (N - P<sub>2</sub>O<sub>5</sub> - K<sub>2</sub>O) kg ha<sup>-1</sup> was applied to soybean crop, in the form of urea, single super phosphate and muriate of potash, respectively to all the plots. Total quantity of phosphorus and potassium was applied as basal whereas nitrogen was applied in two equal splits, one at the time of sowing and another at 30 days after sowing. The crop was irrigated at an interval of 7 to 10 days depends up on visual moisture stress symptoms exhibited by the crop canopy. Standard recommended package of practice of *kharif* season suggested by PJTSAU was followed. The data on growth, phenology, yield attributes was recorded on selected 5 plant, averaged/ plant and grain yield was recorded from net plot, converted to one hectare and analyzed statistically using OP Stat.

## 3. RESULTS AND DISCUSSIONS

### 1. Plant height (cm)

The interaction effect of varieties and dates of sowing on plant height of soybean recorded at 75% pods dry stage was significant (Table 1). Among the cultivars, the cv. KDS 726 recorded the maximum plant height of 35.2 cm which was significantly more over the cv. JS 335 (27.0 cm) and cv. ASB 22 (25.6 cm) in 3 Nov (D<sub>3</sub>) sown crop. However, the plant height of these two cultivars was on par with each other. Similar trend was also observed in 19 Oct (D<sub>2</sub>) sowing. In 3 Oct (D<sub>1</sub>), 19 Nov (D<sub>4</sub>), 3 Dec (D<sub>5</sub>), and 3 Feb (D<sub>9</sub>)

sowings, the plant heights among the cultivars did not differ significantly. The individual varietal performance under different dates of sowing showed that, the cv. JS 335 (V<sub>1</sub>) recorded the tallest plants with 19 Dec (D<sub>6</sub>) date sown crop. However, it was comparable with D<sub>2</sub>, D<sub>3</sub>, D<sub>4</sub>, D<sub>5</sub>, D<sub>8</sub> and D<sub>9</sub> dates' sowings and significantly more over D<sub>1</sub> date sown crop. The least plant height of this cultivar was recorded in the 3 Jan (D<sub>7</sub>) date sown crop. The cv. ASB 22 (V<sub>2</sub>) exhibited the tallest plants in the 19 Jan (D<sub>8</sub>) sowing and the shortest plants of this cultivar were found in the 3 Jan (D<sub>7</sub>) sowing. The cv. KDS 726 (V<sub>3</sub>) recorded the tallest plant with 3 Nov (D<sub>3</sub>) sowing and the least plant height was recorded in 3 Oct (D<sub>1</sub>) date sown crop. These results indicated that the differential response of cultivars to its growing environment. The differential response of varieties in terms of plant height to different sowing dates was also reported by several researchers (Aziz *et al.*, 2021, Kalhor *et al.*, 2019, Yari *et al.*, 2013, Karaaslan *et al.*, 2012, Futules *et al.*, 2011, Soliman *et al.*, 2007).

## 2. Biomass (g plant<sup>-1</sup>)

The total dry biomass accumulation measured at 75% pods dry stage was influenced by the interaction effects of varieties and sowing dates (Table 2). The total dry biomass accumulation measured at 75% pods dry stage was influenced by the interaction effects of varieties and sowing dates (Table 2). Among the cultivars, the cv. KDS 726 accumulated significantly more biomass (8.93 g plant<sup>-1</sup>) over cv. JS 335 (5.87 g plant<sup>-1</sup>) & cv. ASB 22 (5.56 g plant<sup>-1</sup>) in 19 Oct (D<sub>2</sub>). However, the biomass accumulated by these two cultivars was comparable to each other. Similar trend was also reflected in D<sub>4</sub>, D<sub>7</sub> and D<sub>8</sub> date sowings. There was no significant difference among the cultivars in biomass accumulation was observed D<sub>3</sub>, D<sub>5</sub>, D<sub>6</sub> and D<sub>9</sub> date sowings. The individual varietal performance under different dates of sowing showed that, the JS 335 (V<sub>1</sub>) did not differ significantly in biomass accumulation across the sowing dates barring to the 3 Oct (D<sub>1</sub>) sowing where it was recorded significantly inferior biomass to all other dates of sowing. The cv. ASB 22 (V<sub>2</sub>) sown on 3 Oct (D<sub>1</sub>) accumulated maximum biomass of 6.31 g plant<sup>-1</sup> which was comparable with D<sub>2</sub>, D<sub>5</sub>, D<sub>8</sub>, and D<sub>9</sub> and significantly more over rest of the date sown crop. The lowest biomass accumulation of this cultivar was recorded in the 3 Jan (D<sub>7</sub>) sown crops. The cv. KDS 726 (V<sub>3</sub>) accumulated the maximum biomass (8.93 g plant<sup>-1</sup>) in 19 Oct (D<sub>2</sub>) sowing. However, it was comparable with D<sub>4</sub> and D<sub>8</sub> date sown crops at 75 % pods dry stage. Further, the least biomass accumulation (4.86 g plant<sup>-1</sup>) was recorded in 3 Dec (D<sub>5</sub>) sowing. The favourable weather conditions have positive influence on biomass accumulation was reported by several researchers (Mohodet *et al.*, 2023, Nathet *et al.*, 2017, Naidu *et al.*, 2016, Neenuet *et al.*, 2017). Further Kumar *et al.* (2005) reported that early sowing provides long vegetative and reproductive growth periods thereby, facilitating the crop to produce more biomass and late sowings may produce lower biomass and yield due to a variety of reasons including shortening of growth period, less accumulation of photosynthetically active radiation and less number of heat units and thermo-thermal units.

**Table 1 Plant height (cm) of soybean varieties at 75% pods dry stage as influenced by dates of sowing during the off-season**

Varieties/ Dates of sowing	(D <sub>1</sub> ) 3 Oct	(D <sub>2</sub> ) 19 Oct	(D <sub>3</sub> ) 3 Nov	(D <sub>4</sub> ) 19 Nov	(D <sub>5</sub> ) 3 Dec	(D <sub>6</sub> ) 19 Dec	(D <sub>7</sub> ) 3 Jan	(D <sub>8</sub> ) 19 Jan	(D <sub>9</sub> ) 3 Feb	Mean
(V <sub>1</sub> ) JS 335	23.8	27.2	27.0	27.2	27.0	29.3	22.4	25.6	25.2	26.1
(V <sub>2</sub> ) ASB 22	24.0	26.7	25.6	24.7	23.3	20.9	19.5	27.5	27.0	24.4
(V <sub>3</sub> ) KDS 726	23.2	34.4	35.2	27.5	28.1	25.7	29.7	31.3	29.4	29.4

Mean 23.7 29.4 29.3 26.4 26.1 25.3 23.9 28.2 27.2

Test statistics	Varieties	Dates of sowing	Two horizontal means at the same level of vertical factor	Tow vertical means at the same level of horizontal factor
SEm±	0.8	0.9	1.5	1.4
CD (p=0.05)	3.1	2.8	4.7	4.2
CV (%)	15.2	10.5	8.8	8.8

**Table 2 Biomass accumulation (g plant<sup>-1</sup>) of soybean varieties at 75% pods dry stage as influenced by dates of sowing during the off-season**

Varieties/ Dates of sowing	(D <sub>1</sub> ) 3 Oct	(D <sub>2</sub> ) 19 Oct	(D <sub>3</sub> ) 3 Nov	(D <sub>4</sub> ) 19 Nov	(D <sub>5</sub> ) 3 Dec	(D <sub>6</sub> ) 19 Dec	(D <sub>7</sub> ) 3 Jan	(D <sub>8</sub> ) 19 Jan	(D <sub>9</sub> ) 3 Feb	Mean
(V <sub>1</sub> ) JS 335	3.32	5.87	5.50	5.60	5.63	5.47	5.27	6.40	5.73	<b>5.42</b>
(V <sub>2</sub> ) ASB 22	6.31	5.56	4.58	4.62	5.46	4.44	3.69	5.94	5.91	<b>5.17</b>
(V <sub>3</sub> ) KDS 726	4.89	8.93	6.08	8.35	4.86	6.10	6.95	8.87	5.40	<b>6.72</b>
<b>Mean</b>	<b>4.84</b>	<b>6.79</b>	<b>5.39</b>	<b>6.19</b>	<b>5.32</b>	<b>5.34</b>	<b>5.30</b>	<b>7.07</b>	<b>5.68</b>	

  

	Varieties	Dates of sowing	Two horizontal means at the same level of vertical factor	Tow vertical means at the same level of horizontal factor
SEm±	0.16	0.31	0.55	0.56
CD (p=0.05)	0.62	0.94	1.64	1.62
CV (%)	14.23	16.26	16.90	16.90

### 3. Number of pods plant<sup>-1</sup>

The number of pods plant<sup>-1</sup> was influenced by the interaction effect of varieties and sowing dates (Table 3). Among the cultivars the cv. JS 335 (V<sub>1</sub>) recorded more number of pods over cv. ASB 22 (V<sub>2</sub>) and cv. KDS 726 (V<sub>3</sub>) in 19 Oct (D<sub>2</sub>), 3 Nov (D<sub>3</sub>), 19 Nov (D<sub>4</sub>), 3 Dec (D<sub>5</sub>) and 3 Jan (D<sub>7</sub>) sowings. However, it was comparable with cv. ASB 22 and significantly more over cv. KDS 726 in D<sub>2</sub>, D<sub>7</sub> date sowings. Whereas, in D<sub>1</sub> and D<sub>9</sub> dates sowings the cv. ASB 22 recorded significantly more number of pods plant<sup>-1</sup> over cv. JS 335 (V<sub>1</sub>) and cv. KDS 726 (V<sub>3</sub>). There was no significant difference among the cultivars in number of pods plant<sup>-1</sup> was observed in 19 Dec (D<sub>6</sub>) date sown crop. The individual varietal performance under different dates of sowing showed that, the cv. JS 335 (V<sub>1</sub>) recorded the highest number of pods plant<sup>-1</sup> of 31.1 in 19 Oct sowing (D<sub>2</sub>) which was significantly more than its preceding and succeeding dates sowings. The lowest number of pods plant<sup>-1</sup> of 9.9 of this variety was recorded in 19 Jan (D<sub>8</sub>) sowing. The cv. ASB 22 (V<sub>2</sub>) recorded the maximum number of pods plant<sup>-1</sup> (40.1) in 3 Oct (D<sub>1</sub>) sowing which was significantly more over rest of the date sown crop. However, the lower number of pods plant<sup>-1</sup> (11.7) of this cultivar was observed in 3 Jan (D<sub>7</sub>) sown crop. The cv. KDS 726 (V<sub>3</sub>) recorded the highest number of pods plant<sup>-1</sup> (21.7) in 3 Nov (D<sub>3</sub>) sowing which was comparable with 19 Oct (D<sub>2</sub>) sowing and significantly more than rest of the sowing dates. Further, the lowest number of pods plant<sup>-1</sup> (9.7) of this variety was recorded in 3 Jan (D<sub>7</sub>) sowing. These results in conformation with the findings of Kaushiket *al.* (2014) who concluded that the variation between different varieties in terms of their interaction with different growing environments which was imposed through sowing of crop under different dates may be due to the inherent

genetic potential of individual varieties. The difference among the soybean varieties in producing number of pods plant<sup>-1</sup> with different dates of sowings was also reported by several researchers (Karaaslan *et al.*, 2012, Meshram *et al.*, 2012, Rani *et al.*, 2008)

#### 4. Number of seeds pod<sup>-1</sup>

The number of seeds pod<sup>-1</sup> was influenced by interaction effect of varieties and sowing dates (Table 3). Among the cultivars the cv. KDS 726 (V<sub>3</sub>) recorded the highest number of seeds pod<sup>-1</sup> of 3.0 which was comparable to cv. JS 335 (V<sub>1</sub>) and significantly more over cv. ASB 22 (V<sub>2</sub>) when it was sown on 19 Oct (D<sub>2</sub>). The cv. JS 335 (V<sub>1</sub>) recorded more number of seeds pod<sup>-1</sup> of 2.6 which was significantly more over cv. ASB 22 (V<sub>2</sub>) and cv. KDS 726 (V<sub>3</sub>) when it was sown on 3 Jan (D<sub>7</sub>) and comparable with cv. KDS 726 and significantly more over cv. ASB 22 in 3 Oct sowing. The cv. ASB 22 (V<sub>2</sub>) recorded higher number of seeds pod<sup>-1</sup> of 1.3 in 19 Jan sowing which was on par with cv. JS 335 and significantly more over cv. KDS 726. The number of seeds pod<sup>-1</sup> were not differed between the cultivars when the crop sown on 3 Nov (D<sub>3</sub>), 19 Nov (D<sub>4</sub>), 3 Dec (D<sub>5</sub>), 19 Dec (D<sub>6</sub>) and 3 Feb (D<sub>9</sub>). The individual varietal performance under different dates of sowing showed that, the cv. JS 335 (V<sub>1</sub>) recorded the highest number of seeds pod<sup>-1</sup> of 2.8 at 19 Oct sowing (D<sub>2</sub>) which was comparable to its preceding 3 Oct (D<sub>1</sub>) and succeeding 3 Nov (D<sub>3</sub>), 19 Nov (D<sub>4</sub>), 3 Dec (D<sub>5</sub>) and 3 Jan (D<sub>7</sub>) sowings and it was significantly more over remaining sowing dates. The lowest number of seeds pod<sup>-1</sup> of 1.1 of this variety was recorded at 3 Feb (D<sub>9</sub>) sowing. The cv. ASB 22 (V<sub>2</sub>) recorded the highest number of seeds pod<sup>-1</sup> of 2.6 when it was sown on 19 Dec (D<sub>6</sub>) which was comparable to its preceding dates of sowings from 19 Oct (D<sub>2</sub>) to 3 Dec (D<sub>5</sub>) and significantly more over rest of the sowing dates. However, the lowest number of seeds pod<sup>-1</sup> of 0.7 of this variety was observed in 3 Feb (D<sub>9</sub>) sowing. The cv. KDS 726 (V<sub>3</sub>) recorded the highest number of seeds pod<sup>-1</sup> of 3.0 when it was sown on 19 Oct (D<sub>2</sub>) which was at par at D<sub>3</sub> and D<sub>4</sub> dates sowings and significantly more over remaining sowing dates. Further, the lowest number of seeds pod<sup>-1</sup> (0.7) of this variety was recorded in 3 Feb (D<sub>9</sub>) sowing. The unfavourable weather conditions have negative influence on number of seeds pod<sup>-1</sup> was reported by several researchers (Saqib *et al.* (2022), Aziz *et al.* (2021), Lokesh *et al.* (2020), Kaushik *et al.* (2014), Yagoub and Hamed (2013). The variation in number of seeds pod<sup>-1</sup> recorded by varieties sown at different dates was also reported by (Miah *et al.*, 2020 and Waghmare *et al.*, 2019).

#### 5. Test weight (g)

The test weight (g) was influenced by interaction effect of varieties and sowing dates (Table 3). Among the cultivars the cv. KDS 726 (V<sub>3</sub>) recorded significantly more test weight (g) over cv. JS 335 (V<sub>1</sub>) and cv. ASB 22 (V<sub>2</sub>) from 19 Oct (D<sub>2</sub>) to 3 Jan (D<sub>7</sub>) sowings. However, it was comparable with cv. ASB 22 (V<sub>2</sub>) and significantly more over cv. JS 335 (V<sub>1</sub>) in 3 Oct (D<sub>1</sub>) sowing. The test weight recorded by the cultivars JS 335 (V<sub>1</sub>) and ASB 22 (V<sub>2</sub>) in 19 Jan (D<sub>8</sub>) sowing were comparable to each other and significantly more over the cv. KDS 726 (V<sub>3</sub>). Whereas in 3 Feb (D<sub>9</sub>) date sowing, the cv. JS 335 recorded the highest test weight which was comparable with the cv. KDS 726 (V<sub>3</sub>) and significantly more over cv. ASB 22 (V<sub>2</sub>). The individual varietal performance under different dates of sowing showed that, the cv. JS 335 (V<sub>1</sub>) recorded the highest test weight (12.9 g) in 19 Oct (D<sub>2</sub>) sowing which was comparable with its preceding 3 Oct (D<sub>1</sub>) and succeeding 3 Nov (D<sub>3</sub>) to 19 Dec (D<sub>6</sub>) dates of sowings and significantly more over rest of the dates sown crop. The lowest test weight (9.5 g) of this cultivar was recorded in 3 Feb (D<sub>9</sub>) sowing. The cv. ASB 22 (V<sub>2</sub>) recorded the highest test weight (12.7 g) in 3 Oct (D<sub>1</sub>) sowing which was comparable with 19 Oct (D<sub>2</sub>) and 3 Nov (D<sub>3</sub>) sowings and significantly more over rest of the date's sown crop. However, the lowest test weight (7.5 g) of this cultivar was observed in 3 Feb (D<sub>9</sub>) sown crop. The cv. KDS 726 (V<sub>3</sub>) recorded the highest test weight (16.0 g) when it was sown on 19 Oct (D<sub>2</sub>) which was comparable with 3

Comment [A2]: ?

Nov (D<sub>3</sub>) sowing and significantly more over rest of the sowing dates. Further, the lowest test weight (7.3 g) of this cultivar was recorded in 19 Jan(D<sub>8</sub>) sowing. This might be due to unfavourable weather conditions. The differential effect of weather conditions on test weight of soybean cultivars with different dates of sowings were reported by several researchers. (Azizet *al.*, 2021, Miah *et al.*, 2020, Yari *et al.*, 2013, Karaaslan *et al.*, 2012).

## 6. Seed yield (kg ha<sup>-1</sup>)

The seed yield (kg ha<sup>-1</sup>) was influenced by interaction effect of varieties and sowing dates (Table 3). Among the cultivars the cv. ASB 22 (V<sub>2</sub>) recorded the highest seed yield of 753 kg ha<sup>-1</sup> which was significantly more over cv. JS 335 (V<sub>1</sub>) and cv. KDS 726 (V<sub>3</sub>) when it was sown on 3 Oct (D<sub>1</sub>). But, at subsequent sowing dates *i.e.*, 19 Oct (D<sub>2</sub>), 3 Nov (D<sub>3</sub>), 19 Nov (D<sub>4</sub>), 19 Dec (D<sub>6</sub>) and 3 Jan (D<sub>7</sub>) the variety JS 335 (V<sub>1</sub>) recorded significantly more yield over cv. ASB 22 (V<sub>2</sub>) and cv. KDS 726 (V<sub>3</sub>) and it was comparable with cv. KDS 726 (V<sub>3</sub>) and significantly more over cv. ASB 22 (V<sub>2</sub>) in 3 Dec (D<sub>5</sub>) sowing. The seed yield of soybean cultivars sown on 19 Jan (D<sub>8</sub>) and 3 Feb (D<sub>9</sub>) were remained significantly inferior to all its preceding dates of sowings. The individual varietal performance under different dates of sowing showed that, the cv. JS 335 (V<sub>1</sub>) recorded the highest seed yield of 665 kg ha<sup>-1</sup> in 19 Oct (D<sub>2</sub>) sowing which was significantly more than its preceding and succeeding date's sowings. The lowest seed yield of 14 kg ha<sup>-1</sup> of this variety was recorded in 3 Feb (D<sub>9</sub>) sowing. The cv. ASB 22 (V<sub>2</sub>) recorded the highest seed yield of 753 kg ha<sup>-1</sup> when it was sown on 3 Oct (D<sub>1</sub>) which was significantly more over all its succeeding dates of sowings. However, the lowest seed yield (14 kg ha<sup>-1</sup>) of this cultivar was observed in 3 Feb (D<sub>9</sub>) sown crop. The cv. KDS 726 (V<sub>3</sub>) recorded the maximum seed yield (526 kg ha<sup>-1</sup>) in 19 Oct (D<sub>2</sub>) sowing which was significantly more than its preceding and succeeding date's sowings. Further, the lowest seed yield (11 kg ha<sup>-1</sup>) of this variety was recorded in 19 Jan (D<sub>8</sub>) and 3 Feb (D<sub>9</sub>) sowings. These results indicate that, the medium duration cv. ASB 22 sown on 3 Oct produced maximum grain yield as compared to short (JS 335) and long (KDS 726) duration cultivars. The superiority of this cultivar in terms of accumulating higher biomass, more number of pods plant<sup>-1</sup> and higher test weight over other cultivars under investigation were contributed to maximum grain yield in 3 Oct sowing. Further, the short duration cv. JS 335 recorded maximum grain yield over ASB 22 and KDS 726 when it was sown on 19 Oct (D<sub>2</sub>), 3 Nov (D<sub>3</sub>), 19 Nov (D<sub>4</sub>), 19 Dec (D<sub>6</sub>) and 3 Jan (D<sub>7</sub>) indicates the suitability of short duration plant type to fit into a set of weather conditions prevailed at different growth stages. The long duration cv. KDS 726 did not exhibit any superiority over short and medium duration cultivars in terms of grain yield across the dates of sowings which shows that, the cultivar inefficiency to utilize available growing conditions during the off-season.

## 7. Haulm yield (kg ha<sup>-1</sup>)

The Haulm yield (kg ha<sup>-1</sup>) was influenced by interaction effect of varieties and sowing dates (Table 3). Among the cultivars the cv. ASB 22 (V<sub>2</sub>) recorded the highest haulm yield of 1599 kg ha<sup>-1</sup> which was significantly more over cv. JS 335 (V<sub>1</sub>) and cv. KDS 726 (V<sub>3</sub>) when it was sown on 3 Oct (D<sub>1</sub>). But, at subsequent sowing dates, *i.e.*, 19 Oct (D<sub>2</sub>), 19 Nov (D<sub>4</sub>), 3 Dec (D<sub>5</sub>) and 19 Dec (D<sub>6</sub>) the cv. JS 335 (V<sub>1</sub>) recorded significantly more haulm yield over cv. ASB 22 (V<sub>2</sub>) and cv. KDS 726 (V<sub>3</sub>). The haulm yield of soybean cultivars in 3 Nov (D<sub>3</sub>), 3 Jan (D<sub>7</sub>), 19 Jan (D<sub>8</sub>) and 3 Feb (D<sub>9</sub>) sowings did not differ

Comment [A3]: Biomass?

significantly. The individual varietal performance under different dates of sowing showed that, the cv. JS 335 ( $V_1$ ) recorded the highest haulm yield of  $1226 \text{ kg ha}^{-1}$  in 19 Oct ( $D_2$ ) sowing which was significantly more than its preceding and succeeding date's sowings. The lowest haulm yield of  $264 \text{ kg ha}^{-1}$  of this variety was recorded in 3 Feb ( $D_9$ ) sowing. The cv. ASB 22 ( $V_2$ ) recorded the significantly highest haulm yield of  $1599 \text{ kg ha}^{-1}$  when it was sown on 3 Oct ( $D_1$ ) which was significantly more over all its succeeding dates sown crop. However, the lowest haulm yield ( $240 \text{ kg ha}^{-1}$ ) of this cultivar was observed in 3 Feb ( $D_9$ ) sown crop. The cv. KDS 726 ( $V_3$ ) recorded the highest haulm yield ( $943 \text{ kg ha}^{-1}$ ) 19 Oct ( $D_2$ ) sowing which was comparable with 3 Nov ( $D_3$ ) sowing and significantly more over rest of the sowing dates. Further, the lowest haulm yield ( $221 \text{ kg ha}^{-1}$ ) of this variety was recorded in 3 Feb ( $D_9$ ) sowing. These results shows that the haulm yield of soybean was closely in association with grain yield. The cv. JS 335, ASB 22 and KDS 726 were recorded the highest haulm yield in October month was due to more number of pods plant<sup>-1</sup> recorded during October month. The steady decrease in haulm in November to February sowings is mainly due to drastical reduction of number of pods plant<sup>-1</sup> in all the cultivars. The variation in haulm yield of soybean with dates of sowings was also reported by Azizet *al.* (2021), Raghuwanshi *et al.* (2017).

## CONCLUSIONS

The present investigation proved that the soybean crop can be cultivated with cv. ASB 22 with the first week of Oct sowing during the off-season in the Northern Telangana zone in India.

Comment [A4]: The conclusion is too brief

**Table 3. Yield attributes and yields of soybean varieties influenced by different dates of sowing during the off-season**

Varieties/ Dates of sowing	(D <sub>1</sub> ) 3 Oct	(D <sub>2</sub> ) 19 Oct	(D <sub>3</sub> ) 3 Nov	(D <sub>4</sub> ) 19 Nov	(D <sub>5</sub> ) 3 Dec	(D <sub>6</sub> ) 19 Dec	(D <sub>7</sub> ) 3 Jan	(D <sub>8</sub> ) 19 Jan	(D <sub>9</sub> ) 3 Feb	Mean	Test Statistics	Varieties	Dates of sowing	Two horizontal means at the same level of vertical factor	Tow vertical means at the same level of horizontal factor
<b>Number of pods plant<sup>-1</sup></b>															
(V <sub>1</sub> ) JS 335	23.5	31.1	26.0	24.9	23.4	11.9	14.3	9.9	16.6	20.2	SEm±	0.5	0.6	1.1	1.1
(V <sub>2</sub> ) ASB 22	40.1	27.8	20.9	15.2	14.8	13.7	11.7	13.9	27.3	20.6	CD (p=0.05)	1.9	1.9	3.4	3.1
(V <sub>3</sub> ) KDS 726	14.2	21.5	21.7	16.8	14.5	13.7	9.7	15.1	13.5	15.6	CV (%)	13.7	10.1	9.6	9.6
Mean	25.9	26.8	22.9	19.0	17.5	13.1	11.9	13.0	19.1						
<b>Number of seeds pod<sup>-1</sup></b>															
(V <sub>1</sub> ) JS 335	2.7	2.8	2.7	2.7	2.6	2.4	2.6	1.2	1.1	2.3	SEm±	0.1	0.1	0.1	0.1
(V <sub>2</sub> ) ASB 22	2.2	2.5	2.3	2.4	2.4	2.6	2.0	1.3	1.1	2.1	CD (p=0.05)	NS	0.2	0.4	0.3
(V <sub>3</sub> ) KDS 726	2.5	3.0	2.7	2.7	2.6	2.6	2.1	0.8	0.7	2.2	CV (%)	14.2	10.6	8.2	8.2
Mean	2.5	2.8	2.6	2.6	2.5	2.5	2.2	1.1	0.9						
<b>Test weight (g)</b>															
(V <sub>1</sub> ) JS 335	11.5	12.9	12.2	11.9	11.3	11.2	10.8	10.4	9.5	11.3	SEm±	0.2	0.4	0.6	0.6
(V <sub>2</sub> ) ASB 22	12.7	12.3	11.2	10.7	10.4	10.3	10.2	10.0	7.5	10.6	CD (p=0.05)	0.9	1.2	1.7	1.8
(V <sub>3</sub> ) KDS 726	13.7	16.0	14.6	14.1	13.5	13.6	12.6	7.3	8.2	12.6	CV (%)	10.4	10.7	8.2	8.2
Mean	12.6	13.7	12.6	12.2	11.7	11.7	11.2	9.2	8.4						
<b>Seed yield (kg ha<sup>-1</sup>)</b>															
(V <sub>1</sub> ) JS 335	471	665	568	561	400	300	191	17	14	354	SEm±	8	10	14	15
(V <sub>2</sub> ) ASB 22	753	572	371	365	158	137	129	25	14	281	CD (p=0.05)	30	31	45	43
(V <sub>3</sub> ) KDS 726	152	526	469	375	361	142	74	11	11	236	CV (%)	14	11	8	8
Mean	459	588	469	434	306	193	131	18	13						

## REFERENCES

- Aziz, A., Asif, M., Khan, M., Javaid, M.M., Nadeem, M.A., Raza, A., Akhtar, N., Iqbal, N., Ashraf, M., Adnan, M and Babar, B.H. 2021. Evaluation of soybean (*Glycine max* L.) cultivars productivity in relation to different sowing dates under semi-arid conditions. *Journal of Agricultural Research*. 59(2): 141-150.
- Calvino, P.A., Sadras, V.O and Andrade, F.H. 2003. Quantification of environmental and management effects on the yield of late-sown soybean. *Field crops research*. 83(1): 67-77.
- Futules, K.N., Toungos, M.D and Bake, I.D. 2011. Influence of varieties and planting dates on the performance of soybean (*Glycine max* L. Merr) in Mubi, Adamawa state Nigeria. *Knowledge Engineering Review*. 23: 9-13.
- Indiastat. 2021. <https://www.indiastat.com/data/agriculture>
- Kalhor, R.B., Laghari, G.M., Jamro, G.M and Keerio, M.I. 2019. Effect of different sowing dates on growth, yield and quality of soybean varieties. *International European Extended Enablement in Science, Engineering & Management*. 7(8): 47- 59.
- Karaaslan, D., Hakan, M., Ekinci, R and Boydak, E. 2012. The impact of different seeding dates on seed yield of soybean. *Journal of Animal and Plant Sciences*. 22: 175-182.
- Kaushik, D.K., Chandrawanshi, S.K., Patel, S.R., Lakpale, R and Chaudhary, J.L. 2014. Effect of sowing date and types of varieties on yield attributes of soybean in the Chhattisgarh plains zone. *Ecology, Environment and Conservation*. 20:237-240.
- Kumar, M.S., Singh, D and Rao, V.U.M. 2005. Effect of planting dates on yield and yield components of soybean genotypes. *Haryana Journal of Agronomy*. 21(2): 202-205.
- Lokesh, K., Reddy, M., Suhas, P.D., Makanur, B and Shekar, G.C. 2020. Effect of planting windows for seed production of soybean (*Glycine max* L.) in off season under Kaylan Karnataka region. *Current Journal of Applied Science and Technology*. 39(32): 130-138.
- Meshram, K., Upadhyaya, S.D., Agrawal, K.K., Upadhyay, A and Khan, N.A. 2012. Influence of staggered date of sowing on eco-physiological studies of soybean varieties combating climate change under Kymore plateau zone of Madhya Pradesh, India. *JNKVV Research Journal*. 46 (1): 47-51.
- Miah, A.A., Karim, M.A., Mamun, M.A.A., Khan, M.A.R., Akter, N and Haque, M.M. 2020. Planting time effect on phenology and yield of early maturing dwarf soybean genotypes. *Bangladesh Journal of Ecology*. 2:19-24.

- Mohod, N.B., Verma, A.K., Paslawar, A.N., Seema Nemade, S.G., Magar, A.S and Patil, S.P. 2023. Evaluation of different sowing dates and spacing on soybean varieties for seed production during *rabi* season. *The Pharma Innovation Journal*. 12(8) : 1000-1003.
- Naidu, C.R., Reddy, G.K., Sumathi, V and Reddy, P.V.M. 2016. Influence of sowing date and varieties on growth and yield of soybean (*Glycine max* L. Merrill). *The Journal of Research ANGRAU*. 44(1&2) : 74-78.
- Nath, A., Karunakar, A.P and Kumar, A. 2018. Study of the relationship between various weather variables and final seed yield of soybean crop during different phenological stages in the Akola region of Vidarbha, India. *International Journal Current Microbiology Applied Sciences*. 7(9): 1027-1031.
- Neenu, S., Ramesh, K and Ramana, S. 2017. Dry matter partitioning and yield of different varieties of soybean (*Glycine max* (L.) Merrill) under aberrant climatic conditions in central India. *International Journal of Plant & Soil Science*. 14(6): 1-9.
- Raghuwanshi, S., Vyas, M and Maravi, P. 2017. Effect of sowing dates on growth, yield attributes and productivity of soybean [*Glycine max* (L.) Merrill] genotypes under rainfed conditions. *Soybean Research*. 15(2): 58-60.
- Rani, B.P., Ramana, M and Krishnaveni, B. 2008. Performance of soybean [*Glycine max* (L.) Merrill] varieties under different sowing dates during *rabi* in vertisols of Krishna Zone in Andhra Pradesh. *Soybean Research*. 6: 21-24.
- Sadeghi, S.M and Niyaki, S.A. 2013. Effects of planting date and cultivar on the yield and yield components of soybean in north of Iran. *Journal of Agricultural and Biological Science*. 8(1): 81-85.
- Sadiq, A.A., Abubakar, I.U., Kamara, A.Y., Hussain, Y., Tofa, A.I and Ahmed, A. 2020. Response of soybean [*Glycine max* (L.) Merr.] varieties to inoculation and sowing date in Guinea Savanna, Nigeria. *Nigeria Agricultural Journal*. 51(2): 513-520.
- Soliman, M.M., Rabie, E.M and Ragheb, S.B. 2007. Response of soybean yield to late sowing dates. *Arab Universities Journal of Agricultural Sciences*. 15(1): 51-59.
- Waghmare, S. V. Kharbade, S. B. Shaikh, A. A and Sthool V. A. 2019. Growth and yield of soybean varieties as influenced by different soybean varieties and sowing windows. *Indian Journal of Pure Applied and Biosciences*. 7(6): 270-278.
- Yagoub, S.O and Hamed, M.H.A. 2013. Effect of sowing date on two genotypes of soybean (*Glycine max*. Merrill.) grown under semi-desert region. *Universal Journal of Agricultural Research*. 1(3): .59-64.

Yari, V., Frnia, A., Maleki, A., Moradi, M., Naseri, R., Ghasemi, M and Lotfi, A. 2013. Yield and yield components of soybean cultivars as affected by planting date. *Bulletin of Environment, Pharmacology and Life Sciences*. 2(7): 85-90.

UNDER PEER REVIEW