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Effect of time of sowing, seed rate, and variety on seed yield of oat

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Abstract
A field experiment was conducted to find out suitable sowing time, optimum seed rate, and right cultivar of oat for Telangana at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University Rajendranagar Hyderabad. The treatments consisted of 16 combinations with four times of sowing (first fortnight of October, second fortnight of October, first fortnight of November, and second fortnight of November), two seed rates (80 and 100 kg/ha), and two oat varieties (JHO 822 and Kent). The experiment was conducted in a split-plot design and replicated thrice in a sandy loam soil. Two-year (2016-17 & 2017-18) pooled data analysis results revealed that seed yield was significantly (p=0.05) higher with the crop sown during the first fortnight of November (25.3 q/ha) followed by the second fortnight of October (21.4 q/ha). Whereas seed yield was 17.0 q/ha and 18.7 q/ha for October first fortnight sown and November second fortnight sown oat respectively. Statistically no significant difference was observed among the two seed rates for number of tillers per meter row length, number of grains per spike, test eight, and also grain yield. Varieties are also followed the similar trend with that of seed rate for the entire seed yield parameters and seed yield. All the interaction effects were found to be non significant. The best sowing window was found to be from the second fortnight of October to the first fortnight of November for obtaining higher oat grain yield in Telangana.

Keywords: Oat, date of sowing, seed rate, variety, seed yield

Introduction
Oat (*Avena sativa* L.) is a well-known dual-purpose (both fodder and grain) winter cereal crop grown in many parts of the world. Oat can provide quality fodder and feed for livestock and nutritious and healthy food for human consumption. Oat's nutritional value sustains by its dietary fibers, which are an essential part of the human diet. Oat production for human consumption has been increased in recent decades worldwide because people recognized the health benefits of eating food products of oats. Oat can be grown in acidic soils to saline soils and relatively low fertile soils compared to other cereals. Oat thrives well in areas where winter temperatures range between 15 ^{0}C and 25 ^{0}C, and it requires a long winter season for growth and development. Punjab, Haryana, and Uttar Pradesh states grow extensive oat production in India due to their ideal climate for oat in the rabi season. Other states in India like Madhya Pradesh, Orissa, Bihar, and West Bengal grow oats in limited areas. Fodder shortage is a big problem in Telangana State during rabi because only a few fodder crops are available to grow in the rabi season. During the rabi season, low temperatures prevail in many parts of Telangana for few months that make it fit for producing fodder oats or grain oats. Hence oat is one of the best alternative crops for Telangana during the rabi season because it can be grown as a dual-purpose crop: harvest the crop at 45-50 days after sowing for green fodder purposes and following crop regrowth could be kept for grain production.

May *et al.* (2004) [1] reported that early seeding and optimum N fertilizer application largely determine the seed yield and test weight in oat. They have also reported optimum sowing time was early in the growing season on the Canadian prairies; they found delayed sowing immensely reduced the seed yield. As oat crop is generally sown in November in Telangana, the effect of early and delayed sowing on green fodder and grain yield needs to be studied to identify the ideal date of sowing or sowing window for exploiting the full production potential. Optimum seed rate is vital for obtaining optimum plant population for producing higher fodder yield or seed yield. Duda *et al.* (2021) [2] reported that a higher oat seed yield of 56.1 q/ha when sown at a seed rate of 150-180 kg/ha in 12.5 cm spaced rows which were 4.7 q/ha higher than when planted with 75-90 kg/ha seed rate and 25.0 cm row-spacing.

Faris and De-Pauw (1980) [3] reported that the higher the potential yield of a cultivar, the higher the seeding rate required realizing its potential. Higher tiller number, number grains per spike, test weight, and grain yield was significantly higher when oat sown in November 15th at 20 cm row spacing compared to late sowing such as December 1st or December 15th sown crop at a row spacing of 20 and 25 cm wide (Al-Dulaimi *et al*., 2021) [4]. Li *et al.* (2018) [5] reported a higher plant density of 480 plants/m^2 obtained using the higher seed rate of 600 seeds /m2 suppressed weed infestation and increased biomass and grain yield in oat. Bazzo. *et al*. (2021) [6] found early sown (May 5th) oat produced seeds with good vigor compared to late sown (June 24th) oats in Londrina, Brazil. They further reported higher plant densities using a higher seed rate of 300 seeds/m^2 reduced the seed vigor when sown late in oats. Begum *et al*. (1999) [7] recorded in barley that the November 30thsowing produced longer spikes than November 20thand December 10thsown barley. In Ireland, early sown (Autumn) oats produce good grain yields even at low seed rates. Low plant populations due to low seed rates compensate for grain yields through the number of grains per panicle increase. However, grain quality did not change with a wide range of seeding rates (Finnan *et al*., 2018) [8].

Choice of sowing date is a crop factor (genotype) that largely influences the crop growth, yield, and seed quality after interacting with the environment. Its fodder or grain yield and quality are reduced due to hot and dry weather conditions though it can tolerate frost to some extent. Under restricted growth conditions (fluctuations in temperatures and length of the winter season) of Telangana, there is a need to identify high-yielding genotypes to increase the fodder yield or grain yield. A field experiment was initiated in rabi 2016-17 in the experimental field of All India Coordinated Research Project on Forage Crops & Utilization Center at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University Rajendranagar, Hyderabad, with the following objectives:

1. To identify a suitable time of sowing (sowing window) and establish a relationship with climatic factors on productivity in Telangana.
2. To identify an optimum seed rate for getting optimum plant population for production of higher grain yield
3. To identify suitable variety for Telangana which produce higher grain yield

Materials and Methods

A field trial was carried out during rabi 2016-17 and repeated in rabi 2017-18.The experimental location is situated at 17°19' 18" N latitude, 78°24' 18" E longitude and at an altitude of 527m above mean sea level in the Southern Telangana Agro climatic Zone in Telangana State India.The average annual rainfall of the area was 750 mm and maximum and minimum temperatures ranged between 24.6 to 34.1^0 C and7.6 to 18.6^0 C respectively during the crop growth period. Experimental site was well drained moderately deep sandy loam soil with pH of 7.8 and EC of 0.22 dS m-1. Soil texture analysis was carried out with Bouyoucos hydrometer method and soil pH and EC were measured using pH meter and EC meter respectively. The experimental field was low in available N (152 kg ha^{-1}), medium in phosphorus (26.0 kg ha^{-1}) and high in potash (293.0 kg ha^{-1}). Available nitrogen, phosphorus, and potassium in soil were measured using Kjeldahl, Olsen, and Spectrophotometer methods respectively. The experiment was conducted in a split-plot design with three replications. In the field layout four times of sowing were applied to four main plots (4 main blocks) and seed rates in combination with varieties were randomly allotted to sub plots within each main plot. Recommended dose of nitrogen, phosphorus, and potassium @ 100, 40, and 40 kg/ha was applied in the form of urea, single super phosphate (SSP), and muriate of potash (MOP) respectively. Full dose of SSP and MOP were applied to the experimental plots as basal dose and half of the total nitrogen applied as basal and remaining half was top dresses at 30 days after sowing. The crop was evaluated for number of tillers/meter crop row at 50% flowering stage, spike length (cm), number grains per spike, 1000-seed weight (g), and seed yield q/ha. The number of tillers counted in a meter row length taken in 3 rows randomly in each plot and converted into average of three samples. Spike length and number of seed per spike was taken randomly on three plants in each plot. Test weight (100-seed weight) was calculated by taking 100 seed from three randomly collected plant samples and weighed in grams. The crop was harvested plot-wise and seed yield was recorded in kg/plot, later it was converted into quintals per hectare. The collected data was statistically analysed by analysis of variance (ANOVA) for split plot design. Critical differences were worked out at five percent probability level in LSD ($P<0.05$), if treatments were significantly differed and if not; NS was denoted (Gomez and Gomez, 1984) [9]. Two years data was pooled and statistically analysed using OPSTAT software for the interpretations of results (Sheron *et al*., 1998) [10].

Details of the treatments

Main plot Treatment (Times of sowing: 4)

1. T1: First fortnight of October
2. T2: Second fortnight of October
3. T3: First fortnight of November
4. T4: Second fortnight of November

Sub plot Treatment (Seed rates: 2)

1. S1:80 Kg/ha
2. S2: 100 kg/ha

Sub plot Treatment (Cultivars: 2)

1. V1: JHO-822
2. V2: Kent

The total number of treatments was 4x2x2 = 16

Results and Discussion

Number of tillers per meter row length

The number of tillers per meter row length significantly differed with times of sowing. Fodder oats sown in the first fortnight of November produced a higher number of tillers per meter row (167.0), followed by the second fortnight of October sown oats (158.6). These two sowing dates were significantly higher than the first fortnight of October and the second fortnight of November sown oats with 140.0 and 135.6 tillers per meter row respectively (Table 1). This higher tiller number may be due to favourable weather occurred during October 16th to November 15th that promoted vegetative growth and tiller number in oat. November 1st fortnight and October 2nd fortnight sown fodder oats didn't differ significantly in tiller number per meter row length. Rabi 2016 and rabi 2017 results individually also followed a similar trend. These results were similar with Al-Dulaimi *et al*. (2021) [4] who recorded significantly higher tiller number

in November 15th sown oats; Amrjeet *et al*. (2020) [11] who reported October 20th and November 16th sown barley produced higher number of tillers than December 10th sown barley; Hameed *et al*. (2003) [12] reported higher tiller number with October 25th sown wheat. Two seed rates (80 and 100 kg/ha) and two cultivars (JHO-822 and Kent) didn't influence the number of tillers per meter row length significantly. No interaction effect was found significant in affecting the tiller number. In contrast Iqbal *et al.* (2020) [13] reported increase in seed rate increased number of tillers and varieties also differed in producing number of tillers in wheat. Nakano and Morita (2009) [14] also reported that the number of spikes per m^2 were significantly lower at low seeding rate, 50 seeds/ m^2 than that of 150 seed/m^2 in wheat. Increase in seeding rate increased number of spikes per m^2 that lead to higher seed yield in wheat (Coventry *et al*., 1993) [15].

Spike length (cm)

The two year pooled analysis results revealed that spike length is significantly influenced by time sowing. Early sown (October first fortnight) oats produced longer spikes (24.6 cm) than the other three times of sowing such as October second fortnight, November first fortnight, and November second fortnight with spike lengths of 23.9, 23.6, and 21.4 cm respectively (Table 1). Similar to our results, Baloch *et al*. (2010) [16] found that spike length was more when oat sown on October 25th and November 10th compared to November 25th and December 10th sown oat. Seed rate and varieties didn't influence spike length significantly (Table 1). However, Yadi *et al*. (2016) [17] reported in contrast to our results that spike length increased significantly by delayed sowing and seed rate increased in wheat.

Number of grains per spike

According to the two-year pooled data analyses, the number of grains per spike was significantly higher, with November first fortnight sown oat (30.5) followed by the October second fortnight sown oat (27.9). A similar trend was also observed, with rabi 2016-17 and rabi 2017-18 results (Table 1). Previous studies have reported similar results of date of sowing had significant effect on number of grains per spike (Zecevic *et al*., 2014; Al-Dulaimi *et al*., 2021) [18, 4]. Seed rate and varieties didn't differ significantly in influencing the number of grains per spike (Table 1). These results conform to that of Amarjeet *et al*. (2020) [11], who reported that seed rate didn't affect the number of grains per spike significantly in barley. But, Chauhdary *et al*. (2016) [19] found the 100 kg/ha seed rate produced more grains per spike (42.16) than the 160 kg seed rate (34.25).

Test weight (100 grains) (grams)

Two year pooled analyses results indicated that time of sowing had significant effect on test weight of oat. Higher test weight was recorded with November first fortnight sown oat (4.22 g) followed by October second fortnight sown oat (4.13 g). Seed rate and varieties had no significant effect on test weight (Table 1). These results agree with that of Amarjeet *et al*. (2020) [11] in the case of test weight. In contrast, Zecevic *et al*. (2014) [18] reported that the test weight of wheat increased with the planting of 650 germinating seeds per m^2 to 500 germinating seeds per m^2. Earlier studies had shown that higher seed rate decreased test weight in oats (Bazzo *et al*., 2020) [6] in wheat (Baloch *et al*., 2010; Iqbal *et al*., 2020) [16, 13].

Grain yield (quintals/ha)

Two year pooled analysis results shown that time of sowing had a significantly influenced the seed yield attributing parameters and thereby seed yield. November first fortnight sown oats produced higher yield of 25. 5 q/ha followed by October second fortnight sown oats with 21.4 q/ha. However, October 1st fortnight sown and November 2nd fortnight sown oats produced 17.6 q/ha and 18.7 q/ha respectively (Table 1). Al-dulaimi *et al*. (2021) [4] also reported November 15th sown oats produced higher seed yield than late sown oats (December 1st and December 15th sown). Two seed rates didn't influence seed yield significantly, the seed rates 80kg/ha and 100 kg/ha have produced 20.0 q/ha and 20.3 q/ha respectively. No significant difference between the two varieties JHO-822 and Kent was found in producing the seed yield. No interaction effect was found significant in affecting the seed yield. Spink *et al*. (2005) [20] reported that dates of sowing and seed rates significantly influences seed yield in wheat. Previous studies found that there was no significant difference between seed rates in affecting seed yield in wheat (Nakano and Morita, 2009; Yadi *et al*., 2016) [14, 17] in barley (Amarjeet *et al*., 2020) [11]. However, Iqbal. *et al*. (2020) [13] reported increase in seed rate from 125 kg to 150 kg/ha had increased seed yield by 3-4% in wheat. Good weather conditions prevailed during the October 15th to November 15th period might have promoted yield parameters and grain yield of oat. It may be due to better accumulation and distribution of photosynthetic assimilates from source to sink. Seed rate didn't influence grain yield significantly because increased number of tillers per unit area and number of grains per spike compensated for reduced plant density.

Table 1: Effect of times of sowing, seed rate, and cultivar on yield parameters and yield of oat

Treatments	No. of Tillers/m row at 50% flowering			Spike length (cm)			No. of grains per spike			Test weight/100 seed-weight (g)			Seed Yield (Q/Ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plot: Times of sowing (4)															
T1: First fortnight of October	453.2	383.5	430.2	24.2	25.1	24.6	24.8	24.2	24.5	3.52	3.54	3.53	17.2	18.0	17.6
T2: Second fortnight of October	552.1	423.4	478.4	24.3	23.5	23.9	28.0	27.8	27.9	4.10	4.19	4.14	22.8	20.1	21.4
T3: First fortnight of November	564.6	448.3	525.5	23.9	23.4	23.6	31.8	29.3	30.5	4.17	4.28	4.22	26.4	25.2	25.8
T4: Second fortnight of November	379.2	369.6	373.8	21.4	21.5	21.4	26.4	26.0	26.2	4.08	4.01	4.04	19.7	17.8	18.7
S.Em+	15.2	13.7	13.9	0.3	0.6	0.4	1.2	1.4	1.3	0.09	0.16	0.12	0.9	0.8	0.8
CD (*P*< 0.05)	55.8	47.2	47.8	1.1	2.2	1.6	3.9	4.8	4.3	0.31	0.52	0.41	2.7	2.7	2.7
Sub plot: Seed rates (2)															
S1: 80 Kg/ha	495.3	405.8	445.5	23.0	23.5	23.2	27.7	26.6	27.1	3.96	3.91	3.93	21.9	18.3	20.0
S2: 100 Kg/ha	504.2	415.8	464.7	22.9	22.4	22.6	30.1	25.6	27.8	3.98	4.01	3.99	22.5	18.0	20.3
S.Em+	8.8	8.2	8.2	0.21	0.4	0.3	0.5	0.8	0.6	0.05	0.14	0.09	0.3	0.4	0.3
CD (*P*< 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot: Varieties (2)															

V1: JHO-822	490.1	405.8	405.8	23.0	23.3	23.1	29.7	25.9	27.8	3.94	4.10	4.02	21.8	18.4	20.1
V2: Kent	509.4	415.8	455.2	22.9	22.5	22.7	30.1	26.1	28.1	4.08	3.91	3.99	22.6	17.9	20.2
S.Em+	8.8	7.6	8.2	0.2	0.9	0.5	0.5	0.8	0.67	0.05	0.14	0.09	0.25	0.4	0.3
CD (P< 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: All the Interactions (T x S, T x V, S x V, and T x S x V) were found to be non-significant (NS)

Conclusions

November 1st fortnight sown oat crop produced significantly higher yield attributing parameters such as number of tillers per meter row length, spike length, number grains per spike, and 100-seed weight which was followed by second fortnight of October sown oats. These two sowings were superior over the other two times of sowing (October 1st fortnight and November 2nd fortnight sown crop). These seed yield parameters contributed in obtaining significantly (P< 0.05) higher seed yield when oat sown in first fortnight of November (25.3 q/ha) followed by October second fortnight sown oat (21.4 q/ha). Hence the best sowing window for seed oat in Telangana is from October 15th to November 15th. No significant difference was observed among two seed rates for number of tillers per meter row length, longer spikes, number grains per spike, and test weight. Varieties were also not significantly differed in yield attributes and seed yield. All the interaction effects were found to be non significant.

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