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Description of new high yielding forage *Avena Sativa* L. cultivar 'Super Green Oats'

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Abstract

Oat [*Avena sativa* (L.)] cultivar "Super Green Oats" was developed through conventional breeding methods by the Fodder Research Institute, Sargodha, and released as general cultivar in 2020. Commercial cultivar is an advanced line of "FRI-03" which is derived from cross of parental accessions (No. 668 × No. 632) and subsequent selections in various segregating populations (F_2 - F_6), through pedigree methods having uniformity > 99%. Cultivar had 9% and 15% forage yield advantage over commercial check "Sargodha-Oat 2011" during 2014 and 2015 station trials while it gave 9% higher fodder yield during 2016-17 during zonal trials over commercial check.. It is green, tall, multi-tillering, with slight later in maturing cultivar and produce light brown seed. It has many desirable forage quality traits, including high palatability (82%), protein content (10%) and had resistance to biotic and abiotic stresses. It flower about 10 days later than standard check variety. Moreover, it has higher stability (coefficient of regression bi = 1.06) calculated over 3 environments for 2 years. Its robust yield combine with high palatability and high protein contents than standard check and resistance to biotic and abiotic stress show that Super Green Oat will be highly useful cultivars in both irrigated and arid region of Punjab Province. Moreover, the cultivar will be potential parent for the development of new pedigrees for the genetic improvement of oat germplasm.

Keywords: abiotic stresses, protein contents, silage, sustainable yield

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Introduction

Oat (*Avena sativa* L.) is an important cereal forage crop grown under irrigated and arid regions of Pakistan. The species is fast growing, with the capacity to produce highly palatable, succulent, and nutritious fodder crop. It has wider adaptability and contained resistance to abiotic stresses (Niazi et al., 2020). Generally it is fed in green but may also be fermented for silage production or dried to produce hay to use during fodder deficit period. Oat fodder has high palatability due to soft texture and high nutrition for animals.

Crop is harvested for green fodder at 50% flowering, or at later stage to get maximum green fodder yield with a consequent lesser loss in quality. It also helps maintaining body weights, improves the health and enhance milk yield of milking cattle which otherwise decline sharply during the winter forage lean periods (Favre et al., 2019).

Its straw is soft and superior in nutritional quality to wheat and barley. The oats grain is also valuable feed for horses, dairy cows, poultry and young breeding animals (Ahmad et al., 2020). The farmers face fodder deficiency in winter when they have only dry stalks of kharif cereal fodder or dry summer grasses. There is a dire need to maximize fodder production per acre, which could be increased 2-3 fold by adopting improved varieties and agronomic practices (Gorash et al., 2017).

At present, there is a great demand of high fodder yielding oats variety by the dairy farming community. For this purpose, Fodder Research Institute, Sargodha has developed a variety namely 'Super Green Oats' having high fodder yield and also comparatively better in nutritional value. Manuscript is, therefore, written to describe Super Green Oats characters and usefulness for its general cultivation in the Punjab. Approved variety under consideration will be beneficial to the fodder growers. It has great potential to impart positive impact on milk and meat production capabilities of livestock that will also improve the economic condition of fodder growers and dairy farming community.

Methods

Sargodha-Oat (FRI-03) was derived through pedigree selection of various segregating populations (F_2- F_6) obtained from a cross between parental accessions No.668 × No.632. A brief over view of number of selected plants in each generation and various developmental stages of cultivar has been given in Table 1. Spikes of selected plants were self pollinated by covering with Kraft paper bags to achieve higher degree of homozygosity in each generation. High uniformity among selected progenies was achieved at F_6 generation. A comparison of various progenies showed superior characteristics of advanced breeding line coded as "FRI-03" which was further compared in station and zonal trials conducted during 2014 to 2016 along with standard checks. It was compared with check variety 'Sgd. Oats.2011' under adaptation yield trials at different locations of the Punjab province during 2016-2017.

Seed of promising line 'FRI-03' along with check variety 'Sgd.Oats.2011' was supplied to the Deputy Director Federal Seed Certification and Registration Department, Sargodha to conduct "DUS" trials during the years 2016-17 and 2017-18. The Coordinator Fodder, NARC Islamabad tested the promising line 'FRI-03' in National Uniform Fodder Yield Trials at different locations during 2017-18 & 2018-19.

The promising line 'FRI-03' was sown at Fodder Research Institute, Sargodha from 1st September to 15th December at 15 days intervals during the crop years 2016-2017 and 2017-18 to find out its optimum sowing time for fodder production. The response of 'FRI-03' to different fertilizer doses, seed rates, and row spacing was studied during years 2016-17, 2017-18 and 2018-19.

Several morphological, fodder yield and quality traits of FRI-03 were obtained and compared with standard checks. Fodder yield traits including green fodder yield (tons ha^{-1}), plant height (cm), leaf area (cm^2), number of tillers $plant^{-1}$, days to 50% flowering while fodder quality traits included palatability, protein contents (%), and crude fiber (%).

Table 1. **History and pedigree method leading to the development of advanced breeding lines "FRI-03"**

Year	Activity
2007- 08	Cross was made (No.668 × No.632)
2008 - 09	F_1 generation was space planted and harvested in bulk to obtain enough seed for F_2 generation.
2009 -10	F_2 generation was space-planted and 150 individual plants were selected among them and their seed were harvested separately.
2010 -11 to 2011-12	In F_3 to F_4 generation, individual plant progenies were space planted in row and then again superior plants were selected.
2012-13	In F_5 generation individual selected plant were planted in multi rows progenies, superior progenies were identified.
2013 -14	Uniform family was selected in F_6 generation
2014 -15 & 2015-16	Tested in replicated yield trials (Station Green Fodder Yield Trials)
2016-17	Zonal/Adaptability Green Fodder Yield Trial/ 1st DUS Testing/Agronomic Trials
2017-18 & 2018-19	National Uniform Green Fodder Yield Trials/ 2nd DUS Testing/Agronomic Trials

Characteristics of cultivar

"FRI-03' is green forage with superior morphological and forage yield contributing traits. Mean values for the yield contributing traits has been shown in Table 2. Data on morphological traits show that advanced line "FRI-03" was superior in characteristics when compared with standard check (Table 2). Overall result showed that "FRI-03" had

tall, multi-tillering plants, which produce large leaf, with thick succulent stem when compared with standard check.

Table 2. Comparison of green fodder yield contributing traits of 'FRI-03' with check variety 'Sgd.Oats.2011'

Characters	Advance Line FRI-03	Sgd.oats.2011 (Check)
Plant height (cm)	$145^{a} \pm 4.19$	$138^{b} \pm 3.65$
No. of leaves tiller^{-1}	$9.12^{a} \pm 1.13$	$7.11^{b} \pm 0.87$
Leaf area (cm^{2})	$98.8^{a} \pm 8.19$	$70.5^{b} \pm 9.51$
Leaf colour	Green	Green
No. of tillers plant^{-1}	$14.0^{a} \pm 2.31$	$9.0^{b} \pm 2.94$
Stem thickness (cm)	$0.9^{a} \pm 0.21$	$0.6^{b} \pm 0.15$
Days to 50% flowering	$110^{a} \pm 6.11$	$100^{b} \pm 4.72$

* means were compared with through least significant difference at $P \leq 0.05$

Forage Yield Trials

On an average, the line 'FRI-03' out yielded the check variety 'Sgd.Oats.2011' producing 9.06 % higher green fodder yield than the check variety during station trials (Table 3). The line 'FRI-03' gave 14.88 % higher green fodder yield than the check variety 'Sgd.Oats.2011'. On the basis of average of four locations, the line 'FRI-03' surpassed the check variety 'Sgd.Oats.2011' by producing 8.55 % higher green yield in zonal trials (Table 3). Moreover, "FRI-03" showed a yield advantage of 3.5% and 8% in national uniform yield trials during years 2017-19 over standard check variety (Table 4). Stability parameters also showed 'FRI-03' as highly adaptable cultivar when compared with standard check (Table 5). Coefficient of regression (bi) was close to unity and Kang ranking (KR) ranked it "3" as compared to "7" showing more stable than standard check (Table 5).

Table 3. Performance of FRI-03 in Station Yield at Fodder Research Institute Sargodha during 2014-15 and 2015-16 and zonal trials during 2016-17

Name of Variety	**Station yield (Tons ha^{-1})**		**Zonal Trial (Tons ha^{-1})**			
	2014-15	**2015-16**				
FRI-03	88.80 ± 4.14	90.20 ± 6.54	95.38 ± 5.93	87.10 ± 4.56	55.20 ± 2.18	92.89 ± 3.38
Sgd.oats.2011 (Check)	81.42 ± 3.97	78.51 ± 5.57	83.70 ± 6.57	81.84 ± 5.37	53.60 ± 1.65	85.40 ± 3.67

Table 4. Performance of Oats Line 'FRI-03' for Green Fodder Yield at Punjab Locations under National Uniform Fodder Yield Trial (NUFYT) during 2017-18 and (2018-19)

Entry	Average Green Fodder Yield (tons ha^{-1}) (2017-18)			
	AARI, Faisalabad	**FRI, Sargodha**	**AZRI, Bahawalpur**	**Average (t/ha)**
FRI-03	53.70 ± 1.52	75.00 ± 6.18	28.87 ± 2.35	52.52
Sgd.oats.2011 (Check)	56.17 ± 2.13	65.43 ± 5.19	30.53 ±1.35	50.71
Average Green Fodder Yield (tons ha^{-1}) (2018-19)				
FRI-03	91.97 ± 1.12	132.72 ± 6.13	41.33 ± 1.82	88.67
Sgd.oats.2011 (Check)	90.74 ± 1.03	116.05 ± 4.89	38.33 ± 1.53	81.70

Table 5. Stability parameters of two cultivars estimated from the NUFYT trials 2017-2019

Genotype	**Y**	**W_i^2**	**σ^2_i**	**s^2d_i**	**b_i**	**CVi**	***K*R**
FRI-03	70.60	68.30	18.21	4.07	1.08	53.82	3
Sgd.oats.2011 (Check)	66.21	68.30	18.21	4.07	0.92	48.88	7

* Y= mean fodder yield (tons ha^{-1}),

Agronomic Trials

The results presented in Figure 1 indicated that the promising line 'FRI-03' sown on 1st October to 15th October produced the highest green fodder yield as compared to other dates of sowing. Seed rates and row spacing trial showed that the highest forage yield was obtained with 80 kg ha^{-1} seed rate and row spacing of 15 cm during both years 2016-17 and 2017-18 (Fig 2).

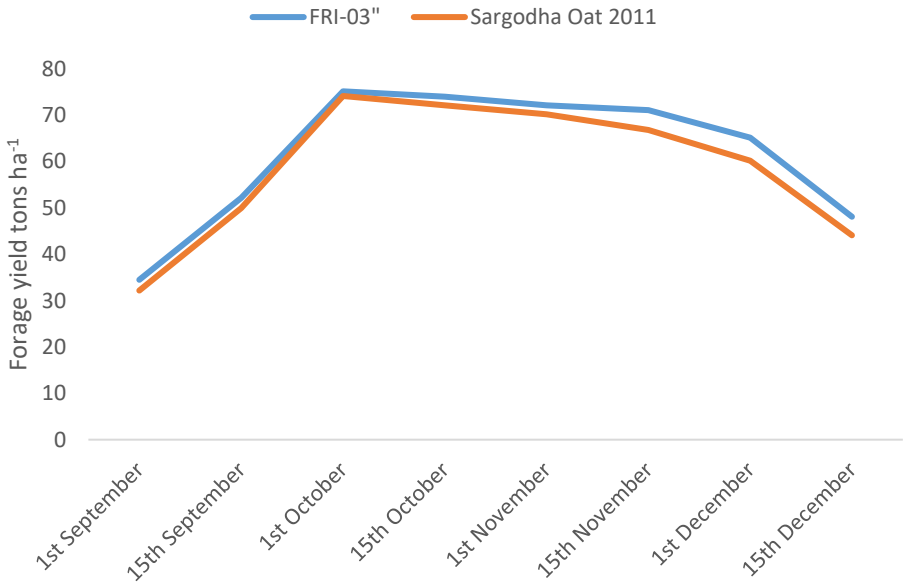

Figure 1. Effect of Date of Sowing on Green fodder Yield of "FRI-03"

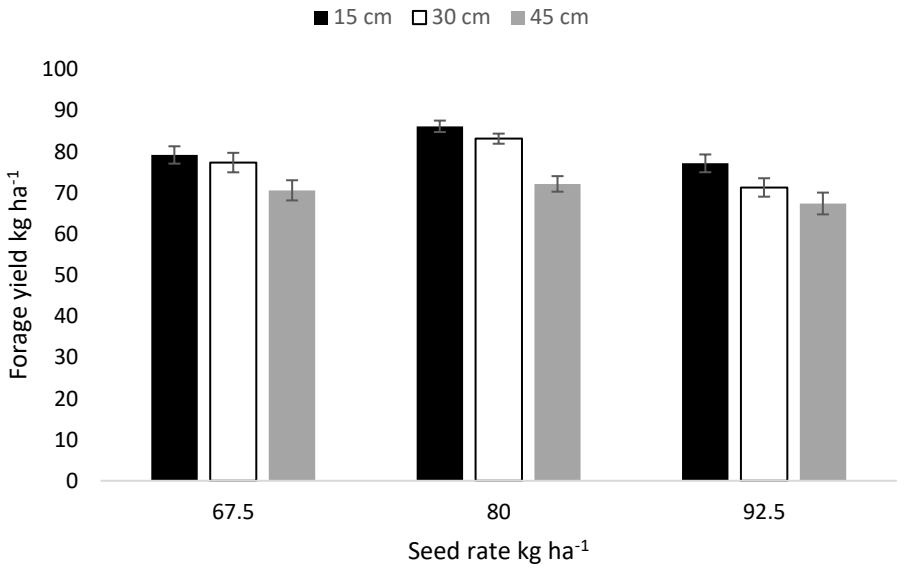

Figure 2. Effect of seed rate and row spacing on forage yield tons ha^{-1} of 'FRI-03'

The response of promising line 'FRI-03' to different fertilizer doses was studied during the years 2017-18 and 2018-19 and the results obtained are shown in Table 10.

Table 6. Effect of Different Fertilizer Levels on Green Fodder Yield of "FRI-03"

Fertilizer Level (kg/ha)			Green Fodder Yield (t/ha)		Average
N	**P**	**K**	**2017-18**	**2018-19**	
100	74	54	81.85 ± 3.19	52.22 ± 2.74	67.03
107	79	58	83.33 ± 2.89	61.11 ± 1.67	72.22
114	84	62	85.74 ± 4.12	63.33 ± 3.13	74.53
121	89	66	84.93 ± 3.65	62.04 ± 2.17	73.48
128	94	70	84.50 ± 2.89	60.18 ± 192	72.34

The green fodder yield data (Table 6) show that the promising line 'FRI-03' was more responsive to fertilizer dose of 114-84-62 NPK kg ha^{-1} as it produced the highest green fodder yield of 74.53 t ha^{-1}.

Forage quality trait

The promising line 'FRI-03' along with local check variety 'Sgd.Oats.2011' were analyzed for dry matter, crude protein, crude fiber, and Ash (Table 7). The results show that the promising line 'FRI-03' hds higher nutritive value than the check variety 'Sgd.Oats.2011' as crude protein and ash is higher than the check (Table 7). Moreover, the variety had higher palatability than standard check (Table 7),

Table 7. Forage quality traits analyzed through proximate method

Entry	Dry Matter (%)	Crude Protein (%)	Crude Fibre (%)	Ca (%)	Mg (%)	Zn (ppm)	Palatability %
FRI-03	27.50	10.20	29.30	0.46	0.15	20.50	82
Sgd.oats.2011 (Check)	26.60	7.65	32.08	0.36	0.10	19.50	80

Discussion

Development of high yield forage cultivars with better forage intake and nutrition value is an important breeding objective of forage cultivars (Rauf et al. 2016). However current scenario of global climate change require the nee cultivars to heat and drought stress

resilient (Niazi et al. 2020). Heat resistant cultivars tend to remain green for longer period of time and could provide forage longer time than susceptible cultivars (Niazi et al. 2015). Although oat is a winter forage but frequent spell of water stress during establish or tillering phase and high temperature during terminal reproductive phase could reduce its total growth period and may cause reduction in forage yield and quality (Niazi et al. 2020). A biotic stresses such as drought and heat stress may reduce tillering ability, plant height and total leaf area of the cultivar, which subsequently reduce the forage yield (Rauf et al. 2016).

A yielding cultivar was developed through conventional pedigree method by selection of progenies under targeted condition for sustainable yield under irrigated and arid condition. The developed cutivar named as "Super Green Oats" had higher resistance to abiotic stress (Niazi et al. 2020) and thus out yielded the adaptable cultivar "Super Green Oats 2011". Similar strategies has also been proposed by the breeders to develop climate resilient varieties to directly progenies on the basis of various criteria under targeted condition (Rauf et al. 2016).

Forage cultivars are evaluated on the basis of several quality traits which may helpful in increasing the forage intake and improving health of animals (Rauf et al. 2016; Gorash et al. 2017). High palatability is direct indicator of forage intake, which is generally obtained by calculating the amount of forage consumed during given period of time (Niazi et al. 2015). The developed cultivar had higher forage palatability than commercial check. Several traits such as high leafiness, succulent stem, and higher soluble sugar increase forage intake or palatability (Rauf et al. 2016). Moreover, leaf nutritional value was also known to be ehnaced when it was enriched with higher concentration of protein. 'FRI-03' had higher protein contents than commercial checks.

In conclusion to the above discussion, it is summarized that developed cultivar 'Super Green Oats' will out yield the current cultivars under subtropical condition and may provide highly nutritious and palatable forage for the animal which may improve their overall health and milk yield.

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