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Comparative Performance Evaluation of Oat (*Avena sativa*) Varieties for Dry Matter Production and Chemical Composition in South Ari Woreda, South Western Ethiopia

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Abstract: The five oat varieties *were evaluated for their* dry matter yield, crude protein, Neutral detergent fiber, Acid detergent fiber and Ash at Geza kebele of South Ari Woreda in South Omo Zone during 2018 *cropping season. The study was conducted in randomized complete block design with three replications* per variety. *Data on forage* dry matter yield, plant height, Leaf to stem ratio and *nutritional qualities were analyzed using the General Linear Model procedures of SAS and least significance difference was used for mean comparison. From the study the highest (P<0.001) dry matter yield (23.49 t ha^{-1}) was recorded for Jassary variety and whereas, lowest dry matter yield (16.67 t/ha^{-1}) was for CI-2806 variety. Conversely, significantly higher (P<0.01) Crude protein (103.7g/Kg, DM) recorded for CI-2291 and whereas, significantly lowest (P<0.01) Crude protein (72g/Kg, DM) for CI-8237 variety. Therefore, based on findings from this study we concluded that farmers who living in high land areas of South Omo Zone and other areas having comparable agro-ecology could plant Jassary oat variety followed by CI-8237 for higher dry matter yield and whereas, for crude protein content it was recommended that farmers could plant CI-2291 variety followed by CI-8251 and CI-2806 oat varieties respectively.*

Keywords: Dry Matter Yield, Chemical Composition, Varieties

1. Introduction

Ethiopia has large livestock population in Africa possessing 60.39 million Cattle, 31.30 million sheep, 32.74 million goats, 2.01 million horses, 8.85 million donkeys, 0.46 million mules, camels 1.42 million and 56.06 million poultry population [1]. However, the livestock contribution to the Ethiopian economy and small holder livelihood is generally very low [2]. Among the livestock production and productivity impediments in to Ethiopia, the feed supply and quality is the most limiting determinants [1, 2]. Likewise, in study region the livestock feeding system is completely natural pasture based feeding system [3, 4]. It is obvious that the natural pasture based feeding system is greatly influenced by feed supply and nutritional dynamics of pasture forages [2, 5]. This is triggering to increase high mortality, longer calving intervals and substantial weight loss in livestock [2, 4, 6] and will be made the herders minimum benefits from livestock production. In this regard, it is not imagined the surplus production from the livestock unless the immediate action undertaken to improving dry matter supply and feed quality issues in to study areas [5]. Therefore, testing locally adaptable and producing adequate quality forages to supplement pasture based feeding system is only way to overwhelm feed shortage in to study area [3, 7]. Among the promising improved forage species, Oat (*Avena sativa*) is one of the potential annual forage crops commonly cultivated in the highland agro-ecologies and well adapted to wide range of soils and relatively tolerant to moisture stress, water logging and frost [8, 9]. Oats are used for livestock feeding in the form of green and conserved as hay or silage for dry season and are important as a source of carbohydrate as supplementation [8, 10]. The previous study indicated that different oat varieties have different dry matter production potential. Accordingly, the study reported by [10] had demonstrated that oat varieties called Lampton and CI-8237 were produced 6.2 and 5.9 t/ha dry matter yield respectively. Moreover, the study reported from the Southern Ethiopia by [8] shown that oat variety Lampton produced 67.2 t/ ha and while, Jasari produced the 44.5 t ha^{-1} green forage yield. Furthermore, Understanding the chemical composition of feed stuff before feeding to livestock is an important strategy to improve livestock production [11]. The previous study reported by [8] revealed that oat varieties have 3.27 and 59.49%, 5.41 and 57.91%, 3 and 54.64%, and 4. 25 and 65.58% of CP and DOMD for Lampton, Jarso, CI-8251 and CI-8235 respectively. Likewise, the study reported by [25] had demonstrated that oat variety CV-SRCP X 80Ab 2806 have 15.3%, 41.6%, 22.1% and 73.9% of CP, NDF, ADF and IVDMD respectively. However, with this promising potential, the different oat varieties not have evaluated for dry matter production and chemical composition in study regions. Therefore, this study was initiated with objective of identifying the best dry matter yielding and qualified oat variety for study regions.

2. Material and Methods

2.1. Description of Study Site

The field experiment was conducted at the farmer training center of Gaza kebele in South West, South Ari Woreda in South Omo Zone. The study site is situated at 036° 53′E longitude and 06° 03′N latitude, and has altitude 1373m above sea level. The average long term (AALTRF) for ten years and annual distribution in 2018 in to study area are displayed in figure 1 below.

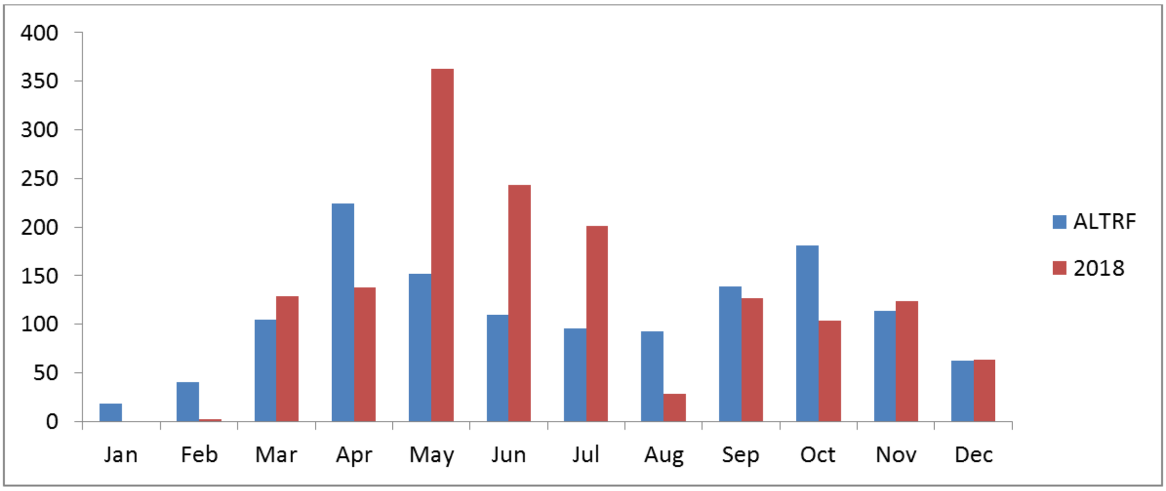

Figure 1. *Cumulative amount of rain fall (mm) in to study area during trial period.*

The soil is loam and has 4.95 soils PH, 0.1 total nitrogen and 1.115 organic carbons. The mean temperature and cumulative precipitation (mm) for 2018 growing year illustrated in figure 2 below.

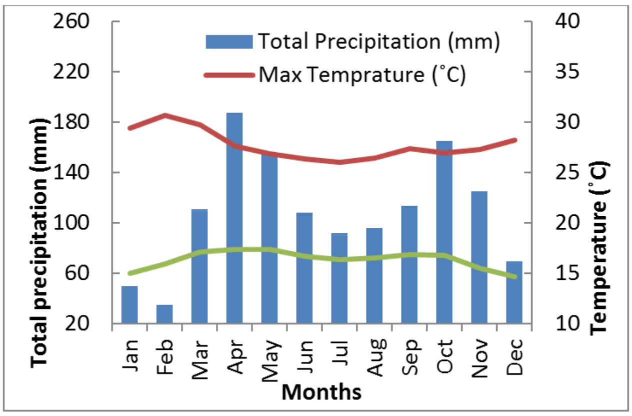

Figure 2. *The mean temperature (Temp (C°)) and cumulative precipitation (mm) in to study area during trial year.*

2.2. Experimental Design and Treatments

The Oat varieties such as CI-2806, CI-2291, CI-8251, CI-8237 and Jassary were planted on plot area of 4m×3m=12m^2 under rain fed condition. The experimental design used in this study was randomized completed block design comprising three replications per variety. The detachment between plots and replication were 1m and 1m respectively and plots in each block were randomly assigned to each tested variety. The 25kg ha^{-1} seed was drilled with no fertilizer application at the planting time for oat varieties. Two planting seasons per year (Season1 = September, October and November and whereas, Season2 = April, May and June) were evaluated in order to identify suitable seasons for oat variety production in to study area.

2.3. Data Collection and Site Managements

The site managements and harvesting was done according to the recommendations of [12]. The growths data like plant height (cm) and leaf to stem ration were measured when plant was at 50% flowering by taking five plants from middle of two rows per plot according to recommendation of [13]. The average plant height was measured from ground to the tip of the main stem. The measurement was done by taking ten random plants at 50% flowering stage from each plot [15]. Conversely, in order to measure, dry matter yield at 50% flowering, the sample per variety was taken by randomly placing three quadrants per plot which had an area 0.5m x 0.5m = 0.25m^2 by using the sickle. The harvested samples were measured right in trial site by spring weight balance and 1000g subsample per plot was brought to Jinka Agricultural Research Center and chopped in to pieces and 300g sampled sample was placed in to oven dried at 105°C for overnight for dry matter determination and dry matter yield (t/ha) was calculated by using recommended formula by [15]. The dry matter yield (t/ha) = TFW x (DWss /HA x FWss) x 10; where TFW = total fresh weight kg/plot, DWss = dry weight of subsample in grams, FWss = fresh weight of subsample in grams, HA = Harvest plot area in square meters and 10 is a constant for conversion of yields in kg/m to t/ha. Leaf to stem ration (LTSR) for each tested oat variety was calculated by separating stem and leaf carefully after oven dried and then divided weight of each to weight of whole oven dried sample from oven.

2.4. Chemical Analysis

The laboratory analysis was done at Debre Birehan Agricultural Research Center, Debre Birehan, Ethiopia. Forage samples of two seasons were oven dried (65°C, 72h) and ground to pass through 1mm sieve size screen for chemical analysis. Analysis was made for the different nutritional parameters (DM, Ash, CP, NDF, ADF and Ash). DM, CP and Ash were analyzed according to pr°Cedures of [16]. The NDF value was calculated according to [17] and whereas, the ADF and ADL values was analyzed pr°Cedures of [18].

2.5. Data Analysis

The data such as plant height, leaf to stem ratio, dry matter yield chemical composition and were subjected to analysis of variances (ANOVA) using the General Linear Model (GLM) pr°Cedure of Statistical Analysis System (SAS) software. The significant differences among the means of Oat varieties were declared at P $\leq$0.001 and means were separated by using Duncan's Least Significant Difference (LSD) test with model of Yijk = μ + Vi + Sj + Vi*S + eijk, where; yijk = all dependent variables; μ = overall mean; Vi = the effect of variety; Sj = the effect of Seasons; Vi*Sj = the interaction effects of variety and seasons and eijk = random error.

3. Results and Discussion

3.1. Dry Matter Yield Affected by Tested Varieties

The effect of tested Oat varieties on dry matter yield (t/ha) was presented in Table 1. The result from this study revealed that the lowest dry matter yield t/ha^{-1} was observed for CI-2806 variety and whereas, significantly highest (P<0.001) dry matter yield (t ha-^{1}) was for Jassary variety. However, dry matter yield was not significantly (P>0.001) varied among Jassary, CI-2291, CI-8251 and CI-8237. Likewise, the plant height and leaf to stem ratio (LTSR) were not significantly differed (P>0.001) among all varieties, but there is significantly (P<0.001) longer leaf height (cm) was measured for CI-2806 than CI-2291, CI-8251, Jassary and CI-8237 varieties. The lower dry matter yield from this study for CI-2806 is ass°Ciated to low genetic make-up of variety to the tested agro ecology. The previous study reported by [8, 10, 19] shown that the wider range of dry matter yield difference between forage species could be attributed due to differences in genetic potential of varieties. Moreover, the yielding ability of genotype is the result of its interaction with the environment and environmental factors such as soil characteristics, moisture and temperature over year have an impact on yield performance of forage species [20]. The result for dry matter yield from our study is comparable to previously scholars [10, 21]. However, similarity in plant height and leaf to stem ration among the varieties from this study might be similar in genetic make-up of varieties. Values from our study for leaf to stem ration and plant height for oat varieties CI-8237 and CI-8251 lower than values of 1.07 and 0.99, and 174cm and 181.16cm reported by [10] and [8] respectively.

Table 1. *The effect of varieties on dry matter yield (MDY), plant height (PH) and leaf to stem ratio (LTSR).*

Parameters	Tested Oat varieties					CV	LSD (%5)
	CI-2806	CI-2291	CI-8251	Jassary	CI-8237		
DMY	16.67^{b}	20.71^{ab}	20.24^{ab}	23.49^{a}	22.25^{a}	4.6	5.52
LTSR	0.63	0.61	0.67	0.65	0.67	8.2	0.06
PH (cm)	118.08	123.57	120.50	115.08	120.75	5.9	8.58
LL (cm)	43.11^{a}	32.23^{b}	33.26^{b}	32.52^{b}	33.56^{b}	19	8.12

(Means with the same letter (a, b) in across row for DMY, PH and LTSR at 50% flowering stage are insignificant each other; CV= coefficient of variation; LSD = Least significant difference)

3.2. Dry Matter Yield, Plant Height and Leaf to Stem Ration Affected by Cropping Seasons

The effect of planting seasons on dry matter yield, leaf to stem ration and plant height were presented in Table 2. The findings from this study revealed that there were significantly (P<0.001) higher dry matter, leaf to stem ratio and plant height were observed in cropping season2 (Beligi in Ethiopia) than season1 (Meher in Ethiopia). However, length of leaf was not significantly (P>0.001) affected by cropping seasons. The higher dry matter yield, Leaf to stem ratio and plant height were observed in cropping season2 is due to higher rainfall availability in cropping season2 than cropping season1 which shown in figure 1. It is apparent that sufficient amount of rainfall make faster plant growth and triggering more tiller per plats which are responsible for more dry matter yield. In supports to the findings from our study the previous study reported by different scholars had been confirmed that dry matter yield of forage species greatly influenced by weather conditions such as rainfall, temperature and precipitations [8, 10, 21, 22].

Table 2. *The effect season on dry matter yield (t/ha), Plant height (cm) and LTSR for Oat varieties.*

Parameters measured	Testing Seasons		LSD
	Season1	Season2	
DMY (t/ha)	15.15^{b}	26.20^{a}	3.49
LTSR	0.51^{b}	0.78^{a}	0.04
PH (cm)	114.85^{b}	124.35^{a}	5.35
LL (cm)	36.19	33.68	2.12

(Means with the different letter (a, b) in across row for DMY, PH and LTSR at 50% flowering stage are significant each other)

3.3. Cropping Seasons by Varieties Interaction Effect on Dry Matter Yield and Leaf to Stem Ratio

Table 3. *The Seasons by Varieties interaction effect on dry matter yield (t/ha) and LTSR for tested Oat varieties.*

Varieties	Seasons	Parameters measured	
		DMY (t/ha)	LTSR
CI-2806	Season1	11.23^{e}	0.47b^{c}
	Season2	22.11^{bc}	0.78^{a}
CI-2291	Season1	17.756^{cde}	0.45^{c}
	Season2	23.67^{abc}	0.77^{a}
CI-8251	Season1	12.29^{e}	0.56^{b}
	Season2	28.22^{ab}	0.793^{a}
Jassary	Season1	20.58^{bcd}	0.53b^{c}
	Season2	26.39^{ab}	0.78^{a}
CI-8237	Season1	13.886^{de}	0.55^{b}
	Season2	30.61^{a}	0.795^{a}
	LSD (%5)	7.80	0.09

(Means with the same letter (a, b, c, d, e) in across column for DMY and LTSR at 50% flowering stage are insignificant each other

The results of season and variety interaction effect on dry matter yield and leaf to stem ratio were presented in Table 3. The results on dry matter and leaf to stem ration revealed that significantly higher (P<0.001) dry matter yield and leaf to stem ration were obtained from the planting season2 for all varieties than planting season1. Accordingly, significantly higher (P<0.001) dry matter yield (26.32 t/ha) for Jassary variety than CI-2806 and CI-8237 variety but it was significantly similar (P>0.001) for CI2291 and CI-8237 in cropping season1 (Table 3). However, significantly lowest (P<0.001) dry matter yield (11.23t/ha) recorded for variety CI-2806 than the others in cropping season1. Pertaining to cropping season2, results on dry matter is revealed that significantly higher (P<0.001) dry matter yield (30.61t/ha) obtained for CI-8237 than CI-2806 but it was insignificant (P>0.001) among CI-2291, CI-8251 and Jassary varieties. The better dry matter yield for all oat varieties obtained in cropping season2 than cropping season1 is indicated that the genetic make-up of varieties influenced by environmental factors which is clearly exhibited that different varieties have differential response to different cropping seasons. Likewise, also, the better dry matter and leaf to stem ration for all tested oat varieties in cropping season2 than cropping season1 is due to better distribution and amount of rainfall, temperature and precipitation. The previous study reported by [20] demonstrated that relatively warmer climatic condition, better distribution and amount of rainfall are the major reasons for getting better dry matter yield and other growth parameters in forage species.

3.4. Season by Variety Interaction Effect on Plant Height and Leaf Length for Tested Oat Varieties

Plant height is an important component which helps in the determination of growth potential of forage species [23]. The results of variety and season interaction effect on plant height and leaf length were shown in Table 4 below. The variety and season interaction effect on plant height and leaf length from this study demonstrated similar trends as season and variety interaction effect for dry matter and LTSR displayed in Table 3 above. The higher plant height (124cm) was observed for CI-2291 and lower (104.3cm) was for Jassary in season1, while, higher (129.2cm) was for CI-8237 and lower (116.33cm) was CI-8251 in season2 Table 4 below. Generally, from this study we observed that variety by season interaction effect on dry matter, LTSR and plant height for all tested oat varieties best performed in cropping season2 than cropping season1. This is due to during trial periods in to study area higher amount and better distribution of rainfall in season2 than season1. The previous study reported by [9] and [24] were demonstrated that variety by environment interaction is the result of changes in cultivar's relative performance across environments due to differential responses of the genotypes to various edaphic, climatic and biotic factors. Moreover, also, the results on interaction effects between variety and seasons help to identifying suitable genotype for specific planting seasons.

Table 4. *Season by Varieties interaction effect on plant height and leaf length for tested Oat varieties.*

Varieties	Seasons	Parameters measured	
		PH (cm)	LL (cm)
CI-2806	Season1	113.17^{cde}	52.28^{a}
	Season2	123.00^{abcd}	33.93^{b}
CI-2291	Season1	119.80^{abcd}	28.10^{b}
	Season2	127.33^{ab}	36.36^{b}
CI-8251	Season1	124.67^{abc}	30.36^{b}
	Season2	116.33^{bcde}	36.15^{b}
Jassary	Season1	104.30^{e}	30.76^{b}
	Season2	125.87^{ab}	34.26^{b}
CI-8237	Season1	112.30^{de}	33.65^{b}
	Season2	129.20^{a}	33.46^{b}
	LSD (%5)	12.14	11.49

(Means with the same letter (a, b, c, d, e) in across column for PH and LL at 50% flowering stage are insignificant each other

3.5. Chemical Composition of Tested Oat Varieties

The chemical compositions of tested oat varieties were presented in Table 5. Protein is a key nutrient that must be considered both in amount and type for various animal diets [11, 26]. Crude protein is used because rumen microbes can convert non-protein nitrogen to microbial protein which can be used by the animal. The findings from this study for CP is revealed that significantly higher (P<0.01) crude protein (10.37%) recorded for CI-2291 than CI-8237 and Jassary but it was not significantly varied (P>0.01) to CI-2291 and CI8251 varieties. The similarity in CP content among the tested oat variety in to study area is due to similarity in make-up to accumulate similar nitrogen contents in a given environments. The variability for tested varieties in crude protein is attributed to each variety may be variation in CP contents within variety when shoots leaves and twigs were compared. The results of CP obtained from our study for Jassary, CI-8251 and CI-8237 varieties were higher than the previous study reported by [8] and but lower than reported value by [26] for CI-8237. Generally, the CP content for all oat varieties from our study is above the recommended minimum maintenance CP requirement (7.2%) of ruminants [27] except CI-8237 variety. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) are frequently used as standard for forage quality testing. NDF approximates the total cell wall constituents and is used to predict intake potential in livest°Ck and whereas, ADF primarily represents cellulose and lignin and is often used to calculate digestibility of feeds [11]. The findings obtained from this study revealed that the NDF and ADF content was significantly higher (P<0.01) for CI-8237 than CI2806, CI-2291 and CI-2251 but similar to Jassary variety. Conversely, significantly higher (P<0.01) Ash content was noted for CI-8237 than CI-2806, CI-2291 and Jassary but not significantly (P>0.01) varied to CI-8251 variety. The NDF content had been obtained from our study for Jassary, CI-8251 and CI-8237 varieties were relatively comparable to the previous study reported by [8] and but, the ADF and Ash content were higher than what [8] values. Furthermore, the NDF content for all tested oat varieties had fallen under poor quality forages (NDF = >65) according to classification of Singh and Oosting [28].

Table 5. *The chemical composition of tested oat varieties.*

Varieties	Parameters measured			
	CP	NDF	ADF	Ash
CI-2806	9.06^{a}	70.67^{bc}	57.19^{ab}	7.16^{bc}
CI-2291	10.37^{a}	70.47^{bc}	56.59^{ab}	6.50^{c}
CI-8251	9.79^{a}	67.76^{c}	52.79^{b}	8.22^{ab}
Jassary	7.51^{b}	74.39^{ab}	60.07^{a}	7.43^{bc}
CI-8237	7.20^{b}	78.29^{a}	61.50^{a}	8.89^{a}
LCD	1.42	5.44	5.10	1.34

(Means with the different letter (a, b, c) in across column for CP, NDF, ADF and Ash contents at 50% flowering stage are significant each other at P<0.001).

3.6. Effect of Seasons on Chemical Composition of Varieties

The effects of cropping seasons on chemical composition of tested oat varieties were displayed in Table 6. The results on chemical composition for tested oat varieties from this study had demonstrated that significantly higher (P<0.01) CP, NDF and ADF were noted in planting season1 than season2 and whereas, the Ash content was not significantly (P>0.01) affected by cropping seasons. The higher CP and NDF for all tested oat varieties in planting season1 than season2 are due to high temperature and low rainfall. It is apparent that high temperature increases lignin deposition, fast growth rates and maturation of the forage crops which promotes higher fiber accumulations. The results of this study for crude protein contents show that different oat variety can respond differently to changing seasons. The previous study reported by [29] shown that the period of active growth for most forage species is the rainy season, it is often assumed that CP concentrations fall and fiber levels increase as the season advances from the rainy season towards the dry season. The higher NDF levels reported during the dry season than in the rainy season which was similar to earlier reported studies [29, 30]. Furthermore, [31] and [32] observed decreases in both NDF and ADF concentrations in browse species in the dry season than rain season which crossholdings to findings from our study.

Table 6. *The effect seasons on chemical composition for tested Oat varieties.*

Parameters measured	Testing Seasons		LSD
	Season1	Season2	
CP	9.28^{a}	8.28^{b}	0.53
NDF	74.44^{b}	70.19^{a}	2.80
ADF	55.43^{b}	59.83^{a}	2.55
Ash	7.64	7.64	0.40

(Means with the different letter (a, b) in across row for CP, NDF, ADF and Ash at 50% flowering stage are significant each other at P<0.001).

4. Conclusion and Recommendation

From the study the highest dry matter yield (t ha^{-1}) was recorded for Jassary variety and whereas, lowest dry matter yields t/ha^{-1} was for CI-2806 variety. The other agronomic and yield parameters like, plant height and leaf to stem ratio (LTSR) are not significantly affected (P>0.001) by tested varieties, but there is significantly (P<0.001) longer leaf length was measured for CI-2806 variety than CI-2291, CI-8251, Jassary and CI-8237. Pertaining to season effect on tested varieties, all tested varieties higher dry matter yield was noted in season2 than season1. Moreover, in relation to variety and season interaction effect, significantly the lowest (P<0.001) dry matter yield obtained from the CI-2806 variety in planting season1 but it was significantly similar (P>0.001) when compared dry matter obtained from the other oat varieties planted in season2 except oat variety CI-8237 which yielded higher dry matter yield. Conversely, significantly higher (P<0.001) CP recorded for CI-2291 than Jassary and CI-8237 but similar (P>0.001) to CI-2806 and CI-8251 varieties. Therefore, based on findings from this study we concluded that farmers who live in high land areas of South Omo Zone and other areas having comparable agro-ecology could plant Jassary oat variety followed by CI-8237 for higher dry matter yield and whereas, for crude protein content farmers could plant CI-2291 variety followed by CI-8251 and CI-2806 oat varieties in cropping season2 (Beligi season).

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Conflict of Interest

We declare that no conflict of interest.

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