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# Evaluation of Forage and Seed Yield of Avena Sativa Varieties at Debremarkos University Demonstration Site

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## ABSTRACT

The study was conducted Debre Markos University demonstration site to evaluate the forage and grain yield of Avena sativa varieties. To investigate the forage and grain yield of Avena sativa varieties, the investigation was outlaid in RCBAD replicated three times. The five oat varieties CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 used in this experiment. The leaf length, leaf width, number of spikelet per panicle, panicle length, number of tillers per plant, leaf area, forage dry matter and seed production Avena sativa varieties were significantly influenced by the variety. Varieties CI-2291, CI-2596 and CI-8251 had had significantly higher ($p < 0.05$) number of tillers per plant and plant height than CI-1506 and CI-2806. The varieties CI-2291, CI-1506 and CI-2806 were significantly lower ($p<0.05$) than varieties CI-8251 and CI-2596 in leaf length, number of spikelet per panicle and panicle length. The CI-8251, CI-1506 and CI-2806 varieties had significantly lower ($p<0.05$) leaf width and forage yield than CI-2291 and CI-2596 varieties. The leaf area of the CI-2596 variety was significantly wider ($p<0.05$) than variety CI-8251, CI-2291, CI-1506, and CI-2806 varieties. The oat varieties CI-2291 and CI-8251 produced significantly higher seed and straw yields, followed by CI-1506, CI-2596 and CI-2806.

**Key words:** Avena Sativa, Forage, Seed Yield

## INTRODUCTION

Inadequate feed quality and quantity, animal diseases, and low genetic quality of most indigenous breeds are the main constraints of livestock production and productivity in Ethiopia (Shapiro *et al*., 2017 and Gudeto *et al*., 2020). Inadequate quality and quantity of animal feed, particularly, feed scarcity period, is highly significant factor that affects livestock production and productivity (Hassen *et al*., 2010 and Mengistu *et al*., 2021). Similarly, the accessibility of feed resources in quantity and quality is a main obstacle in the east Gojjam zone where the study was conducted (Firew and Getnet, 2010 and Alemu and Amare 2022).

Most of the feed in the Ethiopian highlands is obtained from natural pasture and crop residues (Worku *et al.*, 2016). The natural pasture land becomes shrink due to the rapid increasing Ethiopian population demand for food crop production. The rest natural pasture land also decreased forage production due to poor grazing management and poor soil fertility (Birhan and Adugna, 2014; Asefa, 2017). Now, the major animal feed resources in the country is crop residue that is inadequate quality (higher fiber, and lower digestibility) which resulted in low livestock production (Birhan and Adugna, 2014 and Asefa, 2017).

Adequate quality and quantity forage production is the fundamental need for more efficient and the most high yielding livestock industry (Worku *et al.*, 2016) and (Rehman *et al.*, 2017). Because improved forage can be important to the limited quantity and quality of feed and continued forage production during feed scarcity period, more efficient utilization of inadequate quality cereals can occur by adding high quality forage (Worku *et al.*, 2016).

Thus, Avena sativa is utilized as forage for livestock and produced in different area of the country because of its diverse adaptability; it is grown in different type of soil, rainfalls and agro ecology. Avena sativa (oat) is grouped to the family of grass and order as the fourth most important cereal crop worldwide. Avena sativa contain 9.2, 3.6, 30.4, 0.8 and 0.3% fat, protein, fiber, calcium and phosphorus, respectively. The grains and leaves of Avena sativa is rich in carbohydrates and carotene. Avena sativa can be used as forage crop due to it has soft stem, high palatability and rapid growing habit; if collected in boot stage, it is good sources of hay and silage crop. However, the forage and

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seed yield of Avena sativa in this study were not evaluated. Therefore, this study will be initiated with the objectives of evaluating the biomass and grain yield of Avena sativa at the Debre Markos University demonstration site.

**Specific Objectives**

To evaluate the biomass yield of Avena sativa at the Debre Markos University demonstration site.

To evaluate the grain yield of Avena sativa at the Debre Markos University demonstration site.

## MATERIALS AND METHODS

**Description of the Investigation Area**

The research was investigated at the Debre Markos University (DMU) demonstration site, which is located at a geographical location between $10^0$ 20' N latitude and $37^0$ 43'E longitude and has an elevation of 2420 meters above sea level (masl). It has minimum and maximum temperature pf 10 and $27^0$c, respectively and mean annual rainfall of 1380 millimeter (DMCA, 2018).

**Treatments and Experimental Design**

The experiment was conducted at the demonstration site of the DMU in 2021 to evaluate the forage and seed yield of Avena sativa varieties. The trial outlaid in a randomly complete block design (RCBD) with 3 replications. The five Avena sativa varieties were use in this trial, namely, CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251, were provided by the Holeta National Research Center. The varieties were The varieties were taken due to the adaptability and availability of the seeds in the areas. The seeds were broadcast at a rate of 80-100 kg per hectare. the nitrogen was applied in the form of urea in single split after establishment of the varieties. The plot was $2 \times 3$ m$^2$ on a well-prepared seedbed, and the intra- and interspacing were 15 and 25 cm, respectively. The space between blocks and plots were 1 and 0.5m, respectively.

**Land Preparation and Management**

The varieties were sown on July 2021 at the starting of rainy season. The land was plowed four times before the start of the field experiment. The sources of seeds were the Holeta agricultural research center and checked for weed seeds and other shapes to enhance percentage of seed germination. Weed control was investigated uniformly four times from sowing to maturity stage for all treatments.

**Data Collection**

**Plant Height (cm) at Harvest**

The plant height was measured from to the base of plant to the tip of main stem. The measurement of plant height was performed by taking ten random plants at the 50% flowering stage from all plot (Beyene *et al*., 2015).

**Leaf Length**

The length of leaf was measured from base of leaf to leaf tip by using a ruler from ten randomly taken plants.

**Leaf Area**

The leaf areas of Avena sativa varieties were measured by taking ten random selected plants from mid rows and calculated by using the following formula. Leaf area = length of leaf x width of leaf. Leaf width was obtained by measuring the leaf from the bottom, mid and tip and then taking the average. The numbers of Tillers per Plant were counted from the ten-sample plant.

**Panicle Length**

Ten panicles were randomly selected from each plot. Each panicle was measured from the base of the panicle to the apex to record the panicle length in cm. The number of spikelets per panicle was counted from each panicle.

**Forage Yield of Avena Sativa**

The varieties from all plot was sampled by 0.25m$^2$ at the 50% flowering stage (Mengistu and Mekasha, 2007). The sample unit was randomly thrown on all plot and the mean weight of all quadrat was used to estimate the forage yield oat varieties. The mean weight of the fresh forage was used and convert into the dry matter yield per hectare. The fresh harvested biomass was taken and partially dried in an oven at 60ºc 72 hours for drymatter analysis (Khan *et al*., 2018).

$$\text{DM (t/ha)} = (10 * \text{TFW} * \text{SSDW})/(\text{HA} * \text{SSFW})$$

Where:

SSDW = subsample dry weight (gram)

TFW = total fresh weight from the harvesting area (kilogram)

SSFW = subsample fresh weight (gram)

HA=harvested area (m$^2$)

10= constant for conversion of yields in kg per area to tones per hectare

**Seed and Straw Yield**

Seed and straw yields were determined at full seed maturity stage (100%). The plants in 0.25m$^2$ area were taken as an entirely tied and dried by sun and straws and seeds were collected separately. Then, the seed and straw yield from each quadrat measured and converted to tons/ha (Saleem *et al*., 2015).

$$\mathbf{DM = 10000\ m^2 / (Y)\ m^2 * (Z)_{kg} / 100}$$

Where DM = dry matter

Y = Area of sample site (m$^2$)

z = yield from the sampling area (kg/m2)

**Data Analysis**

The General Linear Model procedure was used to analyze forage and seed yield by using SPSS (version 25). The mean forage and seed yield of Avena sativa variety was tested by least significant differences at the 5% significance level.

## RESULTS AND DISCUSSION

**Plant Height of Avena Sativa Varieties**

The height of plant is the yield components contributing to forage dry matter production (Dhumale and Mishra, 1979). The height of Avena sativa (oat) influenced by different varieties (Table 1). The tallest plant (1.28 m) was recorded by CI-2596 variety followed by CI-8251 (1.23 m), CI-2291 (1.21 m), CI-2806 (1.04 m) and CI-1506 (0.93 m). Varieties CI-2596, CI-8251 and CI-2291 were significantly taller ($p < 0.05$) than CI-1506 and CI-2806.

**Table 1:** Average performance of different oat varieties in the study areas

| Parameters | Oat varieties | | | | | |
|---|---|---|---|---|---|---|
| | CI-1506 | CI-2291 | CI-2596 | CI-2806 | CI-8251 | Overall |
| Plant height(m) | 0.93±0.06$^{b}$ | 1.21±0.39$^{a}$ | 1.28±0.06$^{a}$ | 1.04±0.06$^{b}$ | 1.23±0.06$^{a}$ | 1.15±0.06$^{b}$ |
| Leaf length (cm) | 34.89±1.95$^{c}$ | 41.50±1.38$^{b}$ | 47.44±1.95$^{a}$ | 40.00±1.95$^{b}$ | 49.44±95$^{a}$ | 42.46±1.38$^{b}$ |
| Leaf width (cm) | 1.94±0.15$^{b}$ | 2.38±0.11$^{a}$ | 2.47±0.15$^{a}$ | 1.32±0.15$^{c}$ | 1.98±0.15$^{b}$ | 2.08±0.15$^{b}$ |
| Leaf area (cm$^2$) | 66.63±5.81$^{c}$ | 99.19±4.11$^{a}$ | 117.±65$^{a}$ | 53.92±5.81$^{c}$ | 97.36±5.81$^{a}$ | 86.95±4.12$^{b}$ |
| Number of tillers per plant | 4.78±1.08$^{b}$ | 7.89±0.76$^{a}$ | 6.11±1.08$^{a}$ | 3.89±1.08$^{b}$ | 7.44±1.08$^{a}$ | 6.33±1.08$^{a}$ |
| panicle length(cm) | 27.56±1.32$^{c}$ | 27.28±0.93$^{bc}$ | 29.89±1.32$^{ac}$ | 26.89±1.32$^{bc}$ | 30.89±1.32$^{ac}$ | 28.30±1.32$^{ac}$ |
| Number of Spikelet per panicle | 10.44 ±1.08$^{c}$ | 15.39±0.77$^{b}$ | 20.22±1.08$^{a}$ | 13.56±1.08$^{b}$ | 21.89±1.08$^{a}$ | 16.00±1.08$^{b}$ |
| Biomass yield (t/ha) | 8.42±2.34$^{c}$ | 13.99±2.34$^{a}$ | 14.19±2.34$^{a}$ | 8.88±2.34$^{c}$ | 10.72±2.34$^{b}$ | 11.24±2.34$^{b}$ |

Means within the same row with different superscript letters are significantly different (P < 0.05) among varieties.

**Table 1:** Grain and straw yields of oat varieties in the study area

| Parameters | varieties | | | | | |
|---|---|---|---|---|---|---|
| | CI-1506 | CI-2291 | CI-2596 | CI-2806 | CI-8251 | Overall |
| Grain yield (t/ha) | 1.54±0.00$^{b}$ | 2.40±0.00$^{a}$ | 0.90±0.00$^{c}$ | 0.75±0.00$^{c}$ | 2.33±0.00$^{a}$ | 1.58±0.00$^{b}$ |
| straw yield (t/ha) | 10.25±0.00$^{b}$ | 16.00±0.00$^{a}$ | 6.00±0.00$^{c}$ | 5.00±0.00$^{c}$ | 15.50±0.00$^{a}$ | 10.55±0.00$^{b}$ |

Means within the same row with different superscript letters are significantly different (P < 0.05) among oat varieties.

This is confirmed with the report of (Kebede *et al*., 2021), where the heights of CI-2596, CI-8251 and CI-2291 were significantly taller ($p < 0.05$) than the heights of CI-1506 and CI-2806. This resulted in a high forage yield of oat varieties, and the main reasons of these variation in plants heights is because of variation in the genetic makeup of oat varieties (Beyene *et al.*, 2015). However, the mean heights of the all-oat varieties in the current study were shorter than the reports of (Kebede *et al.*, 2021), which might be due to the variation season of sowing, soil fertility and environmental conditions of the experimental areas.

On the other hands, the height of oat varieties in the current study was comparable to Lampton (1. 23 m), CV-SRCP X 80 Ab 2291 (1.0 m), CV-SRCP X 80 Ab 2806 (1. 12 m), CI-8235 (1.22 m) and CI-8237 (1.20 m) (Wada *et al*., 2019) and taller than 579-D-27 (0. 57 m), CI 8237 (0.46 m), CI-8235 (0.46 m), DZF 00551 (0.45 m), and 6710 (0.53 m) (Alemu and Amare, 2016). However, the height of all varieties in the current study was shorter than 80-SA130 (1.4 m), 8251-CI (1.4 m), 80-SA95 (168 cm), 8237-CI (1.7 m), Lampton (1.8 m), 8235-CI (1.45 m) and Jasari (1.4 m) (Beyene *et al*., 2015). This variation might be due to differences in environmental conditions and the sowing season, soil type and genetic makeup of varieties (Zaman *et al*., 2006). As reported by (Zaman *et al*., 2006 and Lodhi *et al.*, 2009), height of plant may vary in varieties due to environmental condition which in turn cause variation hormonal balance and cell division rate.

## Number of Tillers per Plant

Variety CI-2291produced the highest number tillers per plant (7.9), followed by CI-8251 (7.4), CI-2596 (6.1), and CI-1506 (4.8), and the lowest number of tillers was recorded for variety CI-806 (3.9) (Table 1). However, the number of tillers was no significantly varied ($p > 0.05$) among variety CI-2596, CI-8251 and CI-2291 or between oat varieties CI-1506 and CI-2806. Varieties CI-2596, CI-8251 and CI-2291 had a significantly higher ($p<0.05$) number of tillers per plant than CI-1506 and CI-2806. This resulted in a high biomass yield of oat varieties, and the main reason these variation in plant heights was because of variation of the genetic makeup of oat varieties (Beyene *et al*., 2015).

However, varieties Lampton (11.0), CV-SRCPX80Ab2291 (10.7), CV-SRCP Ab 2806(12.0), CI-8235 (11.0) and CI-8237 (10.7) (Amanuel *et al*., 2019) and 80-SA130 (9.2), 8251- CI (11.7), 80-SA95 (12.4), 8237- CI (13.3), 8235-CI (14.2) and Jasari (11.9) (Beyene *et al*., 2015) produced a higher number of tillers per plant than this study. These differences might be due to differences in environmental conditions and genetic factors, which cause variation in the number of tillers per plant (Mekasha *et al*., 2008 and Beyene *et al*., 2015).

## Length and Width of Leaf of Oat Varieties

The leaf length and leaf width of oat was significantly varied ($p < 0.05$) among varieties. The leaf length of oat varieties varied from 34.9 cm (CI-1506) to 49.4 cm (CI-8251). Variety CI-2596 (47.4 cm) ranked second in leaf length, followed by CI-2291 (41.5 cm), and the minimum leaf length was recorded for CI-1506 (34.9 cm). The leaf length of oat varieties in the present investigation was comparable to the study of Amanullah *et al*. (2013), in which the leaf length of oat was 42.7 cm.

The leaf lengths of varieties CI-8251 and CI-2596 were significantly higher ($p<0.05$) than those of varieties CI-2291, CI-1506 and CI-2806, and the leaf length of variety CI-1506 was significantly lower ($p<0.05$) than those of varieties CI-2291 and CI-2806. The leaf width of varieties CI-2291 and CI-2596 was significantly higher ($p < 0.05$) than that of varieties CI-8251, CI-1506 and CI-2806, and the leaf width of variety CI-2806 was significantly lower ($p<0.05$) than that of varieties CI-8251 and CI-1506. However, the leaf width was no significantly varied ($p < 0.05$) between CI-1506 and CI-8251 or between CI-2291 and CI-2596.

## Leaf Area of Oat Varieties

The leaf area of oat was significantly varied ($p < 0.05$) among varieties. The leaf area of oat varieties varied from 53.92cm$^2$ (CI-2806) to 117.65 cm$^2$ (CI-2596). Variety CI-2291 (99.2 cm$^2$) ranked second in leaf area, closely followed by CI-8251 (97.4 cm$^2$), and the minimum leaf area was recorded for varieties CI-2806 (66.6 cm$^2$) and CI-1506 (53.9 cm$^2$). The leaf area of oat varieties in the current study varied from the reports of Amanullah *et al*. (2013) and the leaf area per oat plant ranged from 33.2 to 479.9 cm$^2$. This variation may be due to varying genetic make-up, fertilizer rate, measuring stage and environmental adaptability of varieties (Lodhi *et al*., 2017). Variety CI-1506 and CI-2806 was significantly lower ($p<0.05$) in leaf area than variety CI-2596, CI-8251 and CI-2291. The differences in leaf area in different oat varieties may be due to variations in the genetic makeup and adaptability of these varieties to different environmental conditions (Lodhi *et al*., 2017). However, the leaf area was no significantly varied ($p > 0.05$) between CI-1506 and CI-2806 or among CI-2596, CI-8251 and CI-2291. As reported by Kim and Seo (1988) high yielding varieties tended to be upright with broad leaves than low yielding varieties.

**Panicle Length and Spikelet Numbers of Oat Varieties**

The panicle length of oat varieties varied from 26.9 cm (CI-2806) to 30.9 cm (CI-8251), which was statistically significant among varieties (Table 2). The CI-2596 and CI-8251 varieties had significantly higher ($p <0.05$) panicle lengths than the CI-2291, CI-1506 and CI-2806 varieties. Spikelet numbers of oat varieties ranged from 10.4 (CI-1506) to 21.9 (CI-8251) in this study. The maximum number of spikelets was recorded for CI-8251(21.9), whereas the minimum number of spikelets was recorded for CI-1506 (10.4). The average number of spikelets per panicle varied among oat varieties (Table 1). The CI-2596 and CI-8251 varieties had significantly higher ($p<0.05$) numbers of spikelets per panicle than the CI-2291, CI-1506 and CI-2806 varieties. This resulted in a significantly higher ($p<0.05$) seed yield for the CI-8251 variety (Table 2). On the other hand, the CI-1506 variety had a significantly lower ($p<0.05$) number of spikelets per panicle than the other varieties. The spikelet number of CI-8251 (21.9) in this study was slightly greater than the spikelet number of CI-8251 (17.8) in a previous study (Tessema and Getinet, 2020).

**Dry Matter Yield of Oat Varieties**

The dry matter yields of oat varieties were significantly varied ($p < 0.05$) varied, ranging from 8.4 to 14.2 ton/hectare (Table 1). The maximum dry matter yield of 14.2 ton/hectare was obtained from CI-2596, followed by CI-2291 and CI-8251. A minimum dry matter yield of 8.4 ton/hectare was observed in CI-1506. The CI-2291 and CI-2596 varieties had significantly higher ($p < 0.05$) dry matter yields than the CI-8251, CI-1506 and CI-2806 varieties and the CI-1506 and CI-2806 varieties had significantly lower ($p < 0.05$) yields than the CI-8251 variety. This might be because high-seed yielding varieties of oats tended to gain more plant height than low yielding varieties (Kim and Seo, 1988). (Bakhsh *et al.*, 2007) and (Lodhi *et al*., 2017) also reported that higher yields of forage in oat varieties can be attributed to their greater leaf area and plant height responsible for more photosynthesis activities, having high capacities to store assimilative products of food making.

The dry matter yield of the present investigation was varied with the study of Kebede *et al*. (2021), in which the dry matter yields of varieties CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 were 14.4, 15.4, 14.3, 14.9 and 14.6 tons per hectare, respectively, which were greater than the findings of the present study. The differences in dry matter in different varieties may be attributed to varying fertilizer rates, harvesting stages and environmental adaptabilities of varieties (Lodhi *et al*., 2017).

**Seed and Straw Yield of Oat Varieties**

The seed yield of oat varieties ranged from 0.75-2.40, with average of 1.58 tons per hectare. Oat variety CI-2291produed the highest seed yield, followed by CI-8251, CI-1506, CI-2596 and CI-2806. The differences among the oat varieties in seed yield performance was mainly because of their genetic variations (panicle weight, number of spikelets, number of tillers and seed weight per panicle) and their varied response to the growing environment. The effect of oat varieties on seed yield performance in the current study varied with the findings (Villasennor-mir *et al*., 2001; Siloriya *et al*., 2014; Kebede *et al*., 2020 and Kebede *et al*., 2021). The difference could be due to the soil conditions, sowing season, amount and distribution of rainfall and temperatures.

Higher values of plant height, leaf length, leaf area, leaf width and number of tillers for varieties CI-2291 and CI-8251 were attributed to better interception, absorption and utilization of radiation energy leading to a higher photosynthetic rate and finally more accumulation of dry matter by the plants, which helped to improve the accumulation of dry matter by the plants and ultimately resulted in higher seed yield (Siloriya *et al*., 2014). The seed yield of crops has a strong possible correlation with the number of tillers of per meter square (Villasennor-mir *et al*., 2001).

However, the mean seed yield of the CI-2596 variety was significantly lower ($p < 0.05$) than that of the CI-2291 and CI-8251 varieties, which might be due to the lower panicle weight and grains per panicle of the CI-2596 variety (Siloriya *et al*., 2014). Moreover, the seed production of the present investigation varied with the study of Kebede *et al*. (2021), in which the seed yields of the CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 varieties were 2.1, 2.76, 2.4, 3.21, and 2.66 tons per hectare, respectively. This variation may be attributed to variations in seed and fertilizer rates and the environmental adaptability of varieties (Lodhi *et al*., 2017).

The plant height, leaf length, leaf area, leaf width, panicle length and number of spikelets affect the straw yield of oat varieties (Siloriya *et al*., 2014). The straw yields of the CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 varieties were 10.3, 16.0, 6.0, 5.0 and 15.5 tons per hectare, respectively. This varied with the study of Kebede *et al*. (2021), in which the straw yields of varieties CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 were 12.1, 7.7, 10.3, 11.7, and 10.1 tons per hectare, respectively. The variation in dry matter in different varieties may be attributed to varying dry matter yields, lower seed yield, plant height, leaf length, leaf area, leaf width, panicle length, seed and fertilizer rate, and environmental adaptability of varieties. The straw yield had a strong positive relationship with plant height and the number of tillers/$m^2$ (Siloriya *et al*., 2014).

**Conclusion**

Based on the current results, the forage dry matter and seed yield of oat varieties were significantly affected by varieties due to variation in genetic makeup of oat varieties. Plant height, leaf width, number of tillers and leaf area were recorded higher for variety CI-2291 and CI-2596 which resulted in higher forage dry matter accumulation rate over during growing period. The seed and straw yields of the CI-2291 and CI-8251 varieties were significantly higher, which was due to the significantly higher number of tillers per plant, plant height, leaf width and area for variety CI-2291 and due to the significantly higher plant height, leaf length, leaf area, panicle length, number of tillers per plant and number of spikelet per panicle for CI-825.

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**Data availability statement**

The data for this work is available with researchers and will be shared up on request.

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The authors declare that there is no for funding and other issues to the manuscript.

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