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Evaluation of Biomass and Grain Yield of Oat Varieties at Debremarkos University Demonstrartion Site

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Abstract

The study was conducted in Debre Markos university demonstration site to evaluate biomass and grain yield of oat varieties. To study the biomass and grain yield of oat varieties the experiment was laid out in randomized complete block design with replicated three times. The five oat varieties namely CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 used in this experiment. The leaf length, leaf width, leaf area, number of tillers per plant, panicle length, number of spikelets per panicle, forage dry matter and seed yield of oat varieties significantly affected by varieties. Varieties CI-2291, CI-2596, and CI-8251 had significantly higher ($p<0.05$) plant height and number of tillers per plant than as compared to CI-1506 and CI-2806. Variety of CI-8251 and CI-2596 was significantly higher ($p<0.05$) in leaf length, panicle length andnumber of spikelets per panicle than varieties of CI-2291, CI-1506 and CI-2806. Variety CI-2291 and CI-2596 was significantly higher ($p<0.05$) in leaf width and forage dry matter than variety of CI-8251, CI-1506 and CI-2806. Variety CI-2596 was significantly higher ($p<0.05$) in leaf area than varieties CI-8251, CI-2291, CI-1506, and CI-2806. Oat variety CI-2291 and CI-8251 produced the significantly higher seed and straw yield followed by CI-1506, CI-2596, and CI-2806.

Keywords: Biomass; Oat varieties; Seed yield

Introduction

Inadequate feed in quality and quantity, animal diseases, and low genetic quality of most indigenous breed are the main constraints of livestock production and productivity in Ethiopia [1]. Shortage of feeds in terms of quantity and quality especially during the dry season is highly significant factor which affect livestock production and productivity [2]. Similarly, the availability of feed resources in quantity and quality is a major problem in the east Gojjam zone where the study was conducted [3].

Most of the feed in the Ethiopian highlands is obtained from the natural pasture and crop residues [4]. At this time the natural grazing land become reduced due to fast growth of the country's population with increasing land demand for crop cultivation. The remaining uncultivated pasture land also reduced in forage production because of over grazing and reduction of soil fertility [5]. Now the main feed resource for livestock in traditional production system is crop residue which is low quality (high fiber content, low digestibility) as a result the livestock productivity decreased [6].

Good quality forage production in large quantities ist he basic requirement for a more efficient and productive livestock industry [7]. Because improved forage can be important to the limited quantity and quality of feeds and continued feed supply during the dry season, more efficient utilization of low quality cereals through the addition of high quality forages [8].

Thus, oat crop is used as fodder for animals and cultivated in different regions of the country due to its diverse adaptability; it can be grown in a wide range of soil types, rainfall situations, and altitudes. Oat belongs to the family Poaceae and ranks as the fourth most important cereal crop worldwide. The oat plant can produce four to five culms with diameters of 0.32 cm to 0.625 cm and heights ranging from 60 cm to 150 cm [9]. Oats contain 9.23% fat, 3.56% protein, 30.44% fiber, 0.82% calcium, and 0.27% phosphorous. Its leaves and grains are a rich source of carbohydrates and carotene. Oat scan be used as a forage crop because it has a finer stem, higher palatability, and fast-growing properties; if harvested at the boot stage, it becomes a good source of silage crop. However, the biomass and grain yield of Avena sativa in study was not evaluated. Therefore, this study will be initiated with the objectives to evaluate biomass and grain yield of Avena sativa in Debre Markos university demonstration site.

Specific objectives

- To evaluate biomass yield of Avena sativa in Debre Markos university demonstration site.
- To evaluate grain yield of Avena sativa in Debre Markos university demonstration site.

Materials and Methods

Description of the study area

The research was conducted in Debre Markos university (DMU) demonstration site which is located at a geographical location between 100 20’N latitude and 370 43’E longitude having an altitude of 2420 meter above sea level. It has maximum and minimum temperatures of 27 and 10°C, respectively and a mean annual rainfall of 1380 mm [10].

Treatments and experimental design

The experiment was conducted at the demonstration site of the DMU at 2021 to evaluate the biomass and grain yield of oat varieties. The experiment was laid out in Randomized Complete Block Design (RCBD) with replicated three times. The five oat varieties namely CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 used in this experiment were provided by Holeta national research center. The varieties were selected due to the adaptability and availability of seeds in the area. The seed was sown at the rate of 80-100 kg ha^{-1}. Diammonium Phosphate (DAP) was used as the P source. Nitrogen was applied in the form of urea in single split doses after established. The plot was 2 × 3 m^2 on well prepared seedbed and the intra and inter spacing was 15 and 25 cm respectively. The blocks were separated by a space of 1 m and plots were spaced 0.50 m apart.

Land preparation and management

The varieties were sown on July 2021 at the beginning of the rainy season. Land was ploughed four times before the start of the field experiment. The seed was obtained from Holeta agricultural research center and checked for weed seeds and other dead irregular shapes to increase the germination percentage. Weeding was conducted uniformly four times from sowing up to maturity stage for all the treatments.

Data collection

Plant height at harvest (cm): 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 [11,12]. Leaf length: Leaf length was measured from base of leaf to leaf tip, using a ruler from ten randomly selected plants.

Leaf area: The ten plants were selected randomly from the middle rows and the leaf areas were measured and calculated using the following formula. Leaf area=Leaf length × Leaf width. Leaf width was obtained by measuring the leaf from the bottom, mid and tip then take the average. 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. Number of Spikelet per panicle were counted from each panicle.

Biomass yield: The vegetation from each plot was sampled using a quadrant of 0.5 × 0.5 m^2) at 50% flowering stage [13,14]. The quadrant was randomly thrown on a plot and the average weight from the quadrant was used to determine the biomass yield. The average weight of the fresh fodder was used and extrapolated into dry matter yield per hectare (t ha^{-1}). The fresh harvested biomass was taken and partially dried in an oven at 60 °C for 72 hours for dry matter analysis [15].

DM (t/ha)=(10 × TFW × SSDW)/(HA × SSFW)

Where:

10=Constant for conversion of yields in kg/m^2 to t/ha

TFW=Total Fresh Weight from harvesting area (kg)

SSDW=Sub-Sample Dry Weight (g)

HA=Harvest Area (m^2)

SSFW=Sub-Sample Fresh Weight (g)

Grain and straw yield: Grain and straw yield were determined at full maturity (100% seed maturity) stage. Plants in a quadrant (0.5 × 0.5 m^2) size were taken as a whole tied, dried and straws and grains collected separately. Then grain and straw obtained from each quadrant were measured and converted to tones per hectare [16].

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

Were:

Z=Yield obtained from sampling area (kg/m^2)

Y=Area of sampling site in m^2

Data analysis

General liner model procedure was used to analyze biomass and grain yield by using SPSS (VERGION 25). Means were separated using Least Signi icant Difference (LSD) at 5% signi icance level.

Results and Discussion

Plant height of oat varieties

Plant height is one of the yield components contributes to dry matter yield [17,18]. Plant height in oats was affected by varieties. 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 (1.1.04 m) and CI-1506 (0.93 m). Varieties CI-2596, CI-8251 and CI-2291 had signi icantly taller ($p<0.05$) than as compared to CI-1506 and CI-2806. This is con irmed with the report of where the height of CI-2596, CI-8251 and CI-2291 had signi icantly taller ($p<0.05$) than the height of CI-1506 and CI-2806. This resulted in high biomass yield of oat varieties and the main cause of these differences in plant heights are due to differences in genetic makeup of oat varieties [19]. However, the mean heights of the all oat varieties in the current study were shorter than the reports of which might be due to variation season of sowing, soil fertility and environmental condition of the study areas [20].

On the other hand, 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) 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). 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) [21]. This variation might be due to difference in environmental condition and the sowing season, soil type and genetic makeup of varieties [22]. As explained by Zaman and Lodhi, et al., plant height may differ in varieties due to environmental conditions which in turn cause variation in hormonal balance and cell division rate [23].

Number of tillers per plant

Variety CI-2291 produced the highest number of tillers per plant (7.9) followed by CI-8251 (7.4), CI-2596 (6.1), CI-1506 (4.8) and the lowest was recorded for the variety CI-2806 (3.9) (Table 1). However, there is no significant (p>0.05) difference of number of tillers among variety CI-2596, CI-8251 and CI-2291 and between oat variety of CI-1506 and CI-2806. Varieties of CI-2596, CI-8251 and CI-2291 had significantly higher (p<0.05) number of tillers per plant than CI-1506 and CI-2806. This resulted in high biomass yield of oat varieties and the main cause of these differences in plant heights are due to differences in genetic makeup of oat varieties [24].

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

	Oat varieties					
Parameters	**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	$117. \pm 65^a$	$53..92 \pm 5.81^c$	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	$27.28 \pm 0.93b^c$	29.89 ± 1.32^{ac}	26.89 ± 1.32^{bc}	30.89 ± 1.32^{ac}	$28.30 \pm 1.32a^c$
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 oat varieties.						

However, varieties Lampton (11.0), CV-SRCPX80Ab2291 (10.7), CV-SRCP Ab 2806 (12.0), CI-8235 (11.0) and CI-8237 (10.7) 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) produced higher number of tillers per plant than this study. These differences might be due to variation in environmental conditions and genetic makeup which cause the variation in number of tillers per plant [25].

Length and width of leaf of oat varieties

The result shows that statistically significant differences (P<0.05) in leaf length and width among oat varieties. 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 variety of CI-1506 (34.9 cm). The leaf length of oat varieties in the current study was comparable to the report of Amanullah, et al. the leaf length of oat 42.7 cm.

Variety CI-8251 and CI-2596 was significantly higher (p<0.05) in leaf length than varieties CI-2291, CI-1506 and CI-2806 and variety CI-1506 was significantly lower (p<0.05) than varieties CI-2291 and CI-2806. Variety CI-2291 and CI-2596 was significantly higher (p<0.05) in leaf width than varieties CI-8251, CI-1506 and CI-2806; and variety CI-2806 was significantly lower (p<0.05) than variety CI-8251 and CI-1506. However, there is no significant (p>0.05) difference between variety CI-1506 and CI-8251 and between CI-2291 and CI-2596 in leaf width.

Leaf area of oat varieties

The results demonstrated that statistically significant differences (P<0.05) in leaf area among varieties. Leaf area of oat varieties varied from 53.92 cm^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 of 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 ofAmanullah, et al., the leaf area per plant of oat 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 [26].

Variety CI-2596, CI-8251 and CI-2291 were significantly higher (p<0.05) in single leaf area than varieties of CI-1506 and CI-2806. The variation in leaf area in different oat varieties may be variation in genetic make-up and adaptability of these varieties to different environmental conditions. However, there is no significant (p>0.05) difference between variety CI-1506 and CI-2806; and among variety CI-2596, CI-8251 and CI-2291. Kim and Seo reported that high yielding varieties tended to be upright with broad leaves than low yielding varieties.

Panicle length and spikelet numbers of oat varieties

Panicle length of oat varieties varied from 26.9 cm (CI-2806) to 30.9 cm (CI-8251) which was statistically significant among varieties. Variety of CI-2596 and CI-8251 had significantly higher (p<0.05) panicle length than varieties of CI-2291, CI-1506 and CI-2806. Spikelet numbers of oat varieties were ranging from 10.4 (CI-1506) to 21.9 (CI-8251) in this study.

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.

Variety of CI-2596 and CI-8251 had significantly higher (p<0.05) number of spikelets per panicle than varieties CI-2291, CI-1506 and CI-2806. This resulted in the significantly higher (p<0.05) amount seed yield for variety CI-8251 (Table 2).

On the other hand, variety CI-1506 was significantly lower (p<0.05) number of spikelet per panicle than other varieties. The spikelet numbers of CI-8251 (21.9) in this study slightly greater than the spikelet number of CI-8251 (17.8) in the previous study.

Table 2: Grain and straw yield 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						

Dry matter yield of oat varieties

Dry matter yields of oats varieties significantly (P<0.05) varied which ranged from 8.4 to 14.2 ton/hectare. Maximum dry matter yield 14.2 ton/hectare was obtained from CI-2596 followed by CI-2291 and CI-8251. Minimum dry matter yield 8.4 ton/hectare was observed in CI-1506. Variety CI-2291 and CI-2596 was significantly higher (p<0.05) dry matter yield than varieties of CI-8251, CI-1506 and CI-2806; and variety of CI-1506 and CI-2806 was significantly lower (p<0.05) than varietyCI-8251. This might be due to observed that high seed yielding varieties of oats tended to gain more plant height than low yielding varieties and also stated that higher yields of fodder in oats cultivars can be attributed to their greater leaf area and plant height responsible for more photosynthetic activities, having high capacity to store assimilative products of photosynthesis.

The dry matter yield of the current study was varied with the study of Kebede, et al. which the dry matter yield of variety CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 were 14.4, 15.4, 14.3, 14.9, and 14.6 tones per hectares respectively were greater than the results of the current study. The variation in dry matter in different varieties may be attributed to varying fertilizer rate, harvesting stage an d environmental adaptability of varieties.

Seed and straw yield of oat varieties

The seed yield of oat varieties ranged from 0.75-2.40 with a mean of 1.58 t ha^{-1}. Oat variety CI-2291 produced the highest seed yield followed by CI-8251, CI-1506, CI-2596, and CI-2806. The variability among the oat varieties in seed yield performance was mainly due to their genetic difference (panicle weight, number of spikelets, number of tillers and seed weight per panicle) and their varied response to the growing environments. The significant effect of oat varieties on seed yield performance in the present study varied with the findings. The difference could be due to 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 of CI-2291 and CI-8251 attributed to better interception, absorption and utilization of radiation energy leading to 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. The seed yield of crop had strong possible correlation with number of tillers/m^2.

However, mean seed yield of variety of CI-2596 significantly) lower (p<0.05 than variety of CI-2291 and CI-8251, which might be due to lower panicle weight and grains per panicle of variety CI-2596. Moreover, the seed yield of the current study was varied with the study of Kebede, et al. which the seed yield of variety of CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 were 2.1, 2.76, 2.4, 3.21, and 2.66 tons per hectares respectively. This variation may be attributed to varying of seed and fertilizer rate, and environmental adaptability of varieties.

The plant height, leaf length, leaf area, leaf width, panicle length and number of spikelets affect the straw yield of oat varieties. The straw yield of variety CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 was 10.3, 16.0, 6.0, 5.0 and 15.5 tons per hectares, respectively. This varied with the study of Kebede, et al. which the straw yield of variety CI-1506, CI-2291, CI-2596, CI-2806 and CI-8251 was 12.1, 7.7, 10.3, 11.7, and 10.1 tons per hectares, respectively. The variation in dry matter in different varieties may be attributed to varying dry matter production, 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 number of tillers/m^2.

Conclusion

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

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