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# Performance Evaluation of Oat (*Avena sativa*) Varieties for Growth, Yield, and Yield Components in Southwest Ethiopia

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**Abstract**

*The improved feed shortage is the main bottleneck of livestock production and productivity in Southwest Ethiopia. A study was conducted in Southwest Ethiopia in Kaffa zone, Gimbo district, in 2017 and 2018 cropping seasons to identify the adaptable and high-yielding oat variety(s). The trial consisted of five oat varieties (CI-8250, CI-8237, CI-2291, CI-2806, and ICARDA 6710), which were laid out in a randomized complete block design with three replications. Results showed that variety CI-2291 had a higher number leaf and spikelets per plant, number of seeds per spike, and biomass yield in both cropping seasons, whereas variety CI-8237 had a higher number of tillers, number of leaves, and harvest index than other varieties in both seasons. Higher seed yield was obtained from variety CI-2291 in 2017 and from ICARDA-6710 in the 2018 cropping season. Hence, variety CI-2291 showed better performance in some basic growth parameters, dry matter, and seed yield from the tested varieties in the study area. So, CI-2291 is recommended for the studied areas and similar agro-ecology. In addition, the adoption of this variety could contribute to sustainable livestock production by improving forage availability during critical feed shortage periods. The findings also provide valuable baseline information for future forage research and variety improvement programs in the region. Further on-farm validation and economic analysis are suggested to strengthen dissemination and enhance farmer adoption under smallholder production systems.*

**Keywords:** *Avena sativa*, biomass, growth, traits, varieties, yield

## INTRODUCTION

In Ethiopia, the livestock subsector makes a significant contribution to national income [1]. and livelihoods of rural and urban communities. Even if there is a vast livestock population and suitable environmental conditions, the current production of livestock is too low. Inadequate and poor-quality feed supply has been identified as a major limiting factor in livestock development [2]. Feed shortages are more serious during the dry seasons of the year for animals, depending on natural pasture, crop residue, or extensive management systems [3]. Additionally, [4] reported that the productivity of animals remained low owing to inadequate food in terms of both quality and quantity. Similarly, [5, 6] reported that nutritional factors, both in quantity and quality, are the most limiting determinants of livestock production in Ethiopia.

Livestock production and productivity are determined by adequate and high-quality feed. Improved forage is a major and economical resource for fulfilling the dietary needs of livestock.

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Ethiopia has large potential areas with diverse altitudes, climates, soil types, and farming systems for the production of diverse forage species [5]. Among the most improved forage crops, oats (*Avena sativa* L.) are one of the most important well-adapted fodder crops grown in the highlands of Ethiopia, mainly under rain-fed conditions. It is an early-maturing, palatable, succulent, and energy-rich crop that is mostly used as silage and is preferred by animals because of its high palatability and softness. Its grains are also a valuable feed for dairy cows, horses, young breeding animals, and poultry. Based on Central Statistical Agency (CSA) data from 2004 to 2021, the oat production area has decreased from 45,131 hectares to 22,000 hectares [7]. In Southwest Ethiopia, the improved forage production trend is too low, and due to this, forage production and planting material availability, together with poor resource capacity of the farmers in the survival production system, have slowed down forage development in the area [8].

Likewise, Fayisa et al. [9] showed that feed shortage, both in quantity and quality, was the major problem constraining livestock production and productivity in southwestern Ethiopia. Therefore, it is necessary to evaluate and identify these improved oat varieties that are more adapted and well-adapted to the existing agro-ecological conditions to alleviate feed shortage in the study area, thus increasing the production and productivity of livestock for both small-scale and large-scale producers. Hence, the objective of this study was to evaluate the growth, yield, and yield components of oat varieties in Southwest Ethiopia.

## MATERIALS AND METHODS

### Description of the Study

The field experiment on the overall performance evaluation of oat (*Avena sativa*) varieties was conducted in the 2017 and 2018 main cropping season (July to November) at the Bonga Agricultural Research Center, Kayakela station (7°17′40″N to 36°13′40″E with an altitude of 1800 m above sea level). The rainfall distribution in the area is a long rainy season, with an annual average rainfall of 1150 mm and annual minimum and maximum temperatures of 15–29°C.

### Experimental Design and Treatments

The experiment contained five (5) oat varieties, and treatments with three replications were laid out in a randomized complete block design (RCBD). The treatments were randomly assigned following the randomization to their respective plots. The five (5) oat varieties (CI-8250, CI-2291, CI-8237, ICARDA-6710, and CI-2806), obtained from the Holeta Agricultural Research Center, were sown in gross plots (m) of 3 × 2 (6 $m^2$) with a net plot area of 2.9 × 1.9 (5.51 $m^2$). The spacing between rows, plots, and blocks was 0.2, 0.5, and 1 m, respectively.

### Management Practices

Field management practices and packages, such as land preparation, weeding, and pest control, were applied in a similar manner for all treatments. The selected experimental land was prepared using oxen, plowed four times, and then seedbed preparation was performed. The 19 kg N, 38 kg $P_2O_5$, and 7 kg S fertilizer per hectare was applied as a basal application, and 46 kg N per hectare in split applications recommended [10]. Weeding was performed manually three times: at initial tillering, at the full vegetative stage, and at the heading initiation stage. From the initial experiment establishment to harvesting, all field management and follow-up were done in the field equally for all treatments.

### Data Collection and Analysis

Crop phenology, growth parameters, yield, and yield component traits of the oat varieties were recorded from the central rows. Days to 50% flowering, plant height, number of tillers per plant, number of leaves per plant, leaf length, panicle length, number of panicles per plant, number of seeds per panicle, biomass yield (t/ha), seed yield, and the harvest index were recorded. All the collected data were checked to meet the basic assumption of Analysis of Variance before they were subjected to analysis using the general linear model procedure of Statistical Analysis System (SAS) version 9.3 [11]. The mean comparison was performed using the Least Significant Difference (LSD) test at a 5% probability level.

 

## RESULTS AND DISCUSSIONS

Days to 50% heading, number of tillers per plant, leaf number per plant, leaf length, panicle length, number of panicles per plant, and seed yield showed significant variation among oat varieties ($P \leq 0.05$) in the 2017 cropping season.

However, the number of panicles per plant and seed yield showed significant variation among oat varieties ($P \leq 0.05$) in both cropping seasons in days to 50% heading. Plant height, biomass yield, number of seeds per panicle, and harvest index showed significant variation among oat varieties ($P \leq 0.05$) in the 2018 cropping season.

Days to 50% flowering were significantly ($P \leq 0.01$) affected by oat variety in both the 2017 and 2018 cropping seasons (Table 1). Varieties CI-2291 and ICARDA-6710 took a short time (79 and 86 days) in 2017 and (78 and 80 days) in the 2018 cropping season to reach 50% flowering, respectively. In contrast, varieties CI-8237 and CI-8250 took long days (93 and 92 days, respectively) to reach 50% flowering in the 2017 cropping season (Table 1). The observed variation among oat varieties in days to 50% flowering could be due to the inherent genetic variation that exists among varieties and weather variation between seasons, which was previously reported [12]. The longer maturity periods in the cropping seasons might have been caused by the promoted vegetative growth due to high soil moisture and high rainfall in the area.

The number of tillers per plant showed significant ($P < 0.05$) variation among the oat varieties in the 2017 and 2018 cropping seasons (Table 1). The maximum number of tillers per plant was produced by CI-8237 (16 and 11) in the 2017 and 2018 cropping seasons, respectively, followed by CI-8250. The lowest number of tillers per plant (5 and 6) was recorded for ICARDA-6710 and CI-2291, respectively. In the 2018 cropping season, no significant ($P < 0.05$) variation was recorded among varieties CI-2291, CI-2806, and ICARDA-6710. Generally, variation in tiller number per plant among oat varieties might be due to differences in genetic makeup among the tested oat varieties and seasonal variation effects. Similarly, reported that there was variation among oat genotypes, which might be due to genetic variation [12]. The oat varieties produced minimum tillers per plant flowered earlier than those varieties that produced maximum tillers, which is in agreement with the findings, who reported that reduced tillering facilitates flowering and maturity [13].

The tested oat varieties showed a significant ($P \leq 0.05$) difference in plant height at the 50% flowering stage between the 2017 and 2018 cropping seasons (Table 1). The tallest plant height at 50% flowering was recorded from variety ICARDA-6710 in both seasons, followed by CI-8250, but ICARDA-6710 did not statistically differ from CI-8250 and CI-2806 (131.7 cm and 116.7 cm) in 2017, whereas the shortest plant height was recorded from CI-8237 in both seasons (Table 1). The differences in plant height among varieties could be due to differences in genetic makeup, which is a basic trait contributing to fodder yield [12].

The tested oat varieties showed a significant ($P \leq 0.05$) difference in the number of leaves per plant at the 50% flowering stage between the 2017 and 2018 cropping seasons (Table 2). The maximum number of leaves (69.7 and 39.7) per plant at 50% flowering was recorded for CI-8237 in both seasons, but CI-8237 did not statistically differ from CI-2291 and CI-2806 in both seasons, whereas the minimum number of leaves per plant was recorded from ICARDA-6710 in both seasons (Table 2). The differences among varieties in the number of leaves per plant could be due to differences in genetic makeup, which plays a significant role in plant growth and development; hence, it is a basic trait contributing to fodder yield [12].

The results of the present study indicate that there was a significant ($P \leq 0.05$) difference in leaf length among oat varieties at the 50% flowering stage in the 2017 and 2018 cropping seasons (Table 2). The longest leaf length (44.4 and 38.8 cm) at 50% flowering was recorded from variety CI-2806 in both seasons, followed by CI-2291, but it was not statistically different from CI-2291 in 2018. No significant differences were observed among CI-8237, CI-8250, and ICARDA-6710 in the 2018 cropping season, while the shortest leaf length was recorded from ICARDA-6710 in both seasons (Table 2). The differences in leaf length among varieties might be due to genetic differences in the tested varieties, and it is also a basic trait for fodder yield.

Panicle length varied from 24.7 to 38 cm among the tested oat varieties and was statistically significant in the current study (Table 2). The longest panicle length (44.4 and 38.8 cm) was recorded for variety CI-2291 in both seasons, followed by CI-2806, but was not statistically different from CI-2806 in both seasons, whereas the shortest panicle length was recorded from ICARDA-6710 in both seasons (Table 2). The differences in panicle length among varieties might be due to physiological differences in the tested varieties [12].

The number of spikelets per plant was significantly ($P \leq 0.01$) affected by oat variety in both cropping seasons (Table 2). The maximum number of spikelets (90.3 and 70.9) per plant was recorded for variety CI-2291 in both seasons, but statistically significant differences were not observed among CI-8237, CI-8250, and CI-2806 in both seasons, whereas the minimum number of spikelets per plant was recorded from ICARDA-6710 in both seasons (Table 2). Differences in the number of spikelets per plant might be due to differences in genetic makeup.

The number of seeds per spikelet was significantly ($P \leq 0.05$) affected by the oat varieties in both cropping seasons (Table 3). The maximum number of seeds (90.3 and 70.9) per spikelet was recorded from CI-2291, followed by CI-2806 in both seasons, but statistical differences were not observed among CI-8237, CI-8250, and ICARDA-6710 in the 2017 cropping season, while the minimum number of seeds per spikelet was recorded from ICARDA-6710 in both seasons (Table 3). Differences in the number of seeds per spikelet in oats and wheat were similarly reported [14, 12]. The quintal seed yield per hectare was significantly ($P \leq 0.05$) different among oat varieties in both cropping seasons (Table 3). The maximum seed yield (23.4 q/ha) was recorded for CI-2291 in 2017, whereas ICARDA-6710 produced the highest seed yield (28.2 q/ha) in the 2018 cropping season. The minimum was produced by ICARDA-6710 in 2017 and CI-8250 in the 2018 cropping season. Differences in yield traits among oat varieties with similar agro-ecologies might be due to genetic variation.

There was significant ($P < 0.05$) harvest index variation recorded among oat varieties in the 2018 cropping season (Table 3), but no significant variation was observed in the 2017 cropping season. In

**Table 1.** Means of 50% flowering, number of tillers per plant, and plant height of oat varieties at the at Kayakela in the 2017 and 2018 main cropping seasons.

| **Varieties** | **50% flowering** | | **NTPP** | | **PH in cm** | |
|---|---|---|---|---|---|---|
| | ***2017*** | ***2018*** | ***2017*** | ***2018*** | ***2017*** | ***2018*** |
| CI-8250 | 92.3ba | 86.3a | 11.33b | 9.83a | 131.7a | 115ba |
| CI-8237 | 93a | 91a | 16.33a | 11.2a | 105b | 96.7c |
| CI-2291 | 86.3c | 80.7b | 11b | 6.7b | 110b | 106.33bc |
| CI-2806 | 89.7b | 86.3a | 9.33cb | 7.33b | 116.7ba | 99.67c |
| ICARDA-6710 | 79.3c | 78b | 7.33c | 5.7b | 133.3a | 120.7a |
| Mean | 88 | 84 | 11 | 8.1 | 119.33 | 107.7 |
| CV | 2 | 3.2 | 15.7 | 14.6 | 7.8 | 5.8 |
| LSD | 3.2 | 5 | 3.27 | 2.2 | 17.4 | 11.7 |

*NTPP, number of tillers per plant (indicates plant productivity (more tillers = better yield potential)); PH, plant height; CV, coefficient of variation; LSD, least significant difference*

*Note: a, b and c represent statistical grouping based on the LSD (least significant difference) test. Same letters → no significant difference; different letters → significant difference; mixed (ba, bc), overlapping groups; a, highest group; b, medium; c, lowest; bc, between b and c (overlap).*

 

**Table 2.** Means of leaves number per plant, leaf length, panicle length, and number of spikelets per plant of oat varieties at Kayakela in the 2017 and 2018 main cropping seasons.

| Varieties | LNPP | | LL | PL in cm | | | NSPP | |
|---|---|---|---|---|---|---|---|---|
| | *2017* | *2018* | *2017* | *2018* | *2017* | *2018* | *2017* | *2018* |
| CI-8250 | 45.3bc | 30.83bc | 33.67c | 31.33b | 29.8c | 26bc | 79.67ba | 63.8b |
| CI-8237 | 69.7a | 39.67a | 33c | 28b | 32.2bc | 27.2bc | 74bc | 63.2b |
| CI-2291 | 64.6a | 31.93ba | 40.8b | 37.7a | 38a | 32.9a | 90.33a | 70.9a |
| CI-2806 | 54.9ba | 37.53ba | 44.4a | 38.83a | 34.9ba | 29.5ba | 76.7bc | 63.9b |
| ICARDA-6710 | 33.7c | 23.33c | 34c | 28b | 30.5c | 24.7c | 67.7c | 56.2c |
| Mean | 53.6 | 32.7 | 37.5 | 32.8 | 33 | 28 | 77.67 | 63.6 |
| CV | 18 | 13.7 | 5 | 6.2 | 6.5 | 8.6 | 7.4 | 4 |
| LSD | 18.4 | 8.4 | 3.3 | 3.8 | 4 | 4.5 | 10.78 | 4.5 |

*LNPP, leaves number per plant; LL, leaf length; PL, panicle length; NSPP, Number of spikelets per plant; CV, coefficient of variation; LSD, least significant difference*
*Note: a, b and c represent statistical grouping based on the LSD (least significant difference) test. Same letters → no significant difference; different letters → significant difference; mixed (ba, bc), overlapping groups; a, highest group; b, medium; c, lowest; bc, between b and c (overlap).*

**Table 3.** Means of harvest index, biomass yield, number of seeds per spike, and seed yield of oat varieties at Kayakela in the 2017 and 2018 main cropping seasons.

| Varieties | HI | | BY t/ha | | NSPS | | SY qt/ha | |
|---|---|---|---|---|---|---|---|---|
| | *2017* | *2018* | *2017* | *2018* | *2017* | *2018* | *2017* | *2018* |
| CI-8250 | 18.27a | 29.63bc | 9.18ba | 6.43cd | 60.6b | 54dc | 19.61b | 19c |
| CI-8237 | 20.3a | 41.84a | 9.87a | 6.1d | 61b | 56.2bc | 14.19c | 25.3ba |
| CI-2291 | 20.77a | 24.65c | 10.33a | 8.07a | 71.3a | 63.5a | 23.4a | 19.85c |
| CI-2806 | 17.63a | 32.28b | 9.43a | 7.1b | 66.5ba | 59.7ba | 21.04b | 22.92bc |
| ICARDA-6710 | 20.43a | 41.9a | 8.23b | 6.73cb | 60b | 51.2d | 13.45c | 28.2a |
| Mean | 19.5 | 34 | 9.4 | 6.9 | 63.9 | 57 | 18.33 | 23 |
| CV | 25 | 8.9 | 6.7 | 4.2 | 5.4 | 4.4 | 6.4 | 10.1 |
| LSD | 9.2 | 5.69 | 1.19 | 0.53 | 6.5 | 4.6 | 2.19 | 4.39 |

*HI, harvest index; BY, biomass yield; NSPS, number of seeds per spike; SY, seed yield;*
*Note: a, b and c represent statistical grouping based on the LSD (least significant difference) test. Same letters → no significant difference; different letters → significant difference; mixed (ba, bc), overlapping groups; a, highest group; b, medium; c, lowest; bc, between b and c (overlap).*

2018, CI-8237 and ICARDA-6710 had a higher harvest index than the others, whereas CI-2291 had a ower harvest index than the other varieties. Increasing the harvest index is a major route to higher yields, and low harvest indices indicate less effective utilization of resources on cultivars [15].

Biomass yield varied significantly among the oat varieties tested in the study area (Table 3). The maximum biomass yield was obtained from variety CI-2291 (10.33 and 8 t/ha) in both cropping seasons. However, CI-2291 did not statistically differ from all tested oat varieties except ICARDA-6710 in the 2017 cropping season, whereas in 2018, it was statistically different from all tested varieties. In contrast, the minimum biomass yield was obtained from ICARDA-6710 and CI-8237 in 2017 and 2018, respectively. Biomass yield differences among oat varieties have been previously reported [8].

## CONCLUSION

Based on the results of this study, CI-2291 proved to be a superior variety with respect to obtaining a consistently higher biomass yield than the other tested oat varieties in the study area. In seed production, the oat variety CI-2291 produced a better yield in the 2017 cropping season, whereas ICARDA-6710 produced a better yield in 2018. Therefore, based on this finding, CI-2291 should be considered for further scaling up in large areas of the study area and similar agro-ecologies for biomass and seed production.

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**Conflict of Interests**

The authors declare no conflict of interest.

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