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Biomass Yield and Nutritional Quality of Different Oat Varieties (Avena sativa) Grown Under Irrigation Condition in Sodo Zuriya District, Wolaita Zone, Ethiopia

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Abstract

The objective of this study was to evaluate the performance of five forage oat varieties (CI- 8237, Lampton, CI- 8235, CV-SRCP X 80Ab 2291 and CV-SRCP X 80Ab 2806) under irrigation condition in Wolaita Zone, Sodo Zuriya Worda, at Kokate Farmers association, during off season in the year 2017. The experiment was laid out in a randomized complete block design with three replications. Data were collected at 50% flowering stage. The major data recorded were date of emergence, plant height, number of leaves per tiller, number of leaves per plant, number of tillers per plant, fodder yield and chemical composition at 50% flowering stage respectively and grain and straw yield at maturity stage. The varieties differed in yield and yield related parameters. The varieties showed variations in terms of number of leaves per tiller, number of tillers per plant, number of leaves per plant, fodder and dry matter yield at 50% flowering stage and straw yield. Variety CV-SRCP X 80Ab 2291 produced lower ($p < 0.05$) number of leaves per plant, number of leaves per tiller and plant height than the rest of the varieties. However, CV-SRCP X 80Ab 2291 produced significantly higher ($p < 0.05$) amount of green forage (42.4t ha-1) and dry matter (12.2t ha-1) yield at 50% flowering stage. All tested oat varieties had similar grain and straw yield. CV-SRCP X 80Ab 2806 had lower NDF (41.6%), ADF (22.1%) and ADL (1.98g per kg) concentrations and the highest CP (15.3%) and IVDMD (73.9%) content. Therefore, it is concluded that, CV-SRCP X 80Ab 2806 and CV-SRCP X 80Ab 2291 were recommended to use in the upper parts of midland and highland areas due to reasonably higher nutritional (CP) value and better forage yield, respectively.

Keywords: Biomass yield; Chemical composition; Lampton; Yield parameters

Abbrevations: DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; ADL: Acid Detergent Lignin; ADF: Acid Detergent Fiber; NDF: Neutral Detergent Fiber; IVDMD: In Vitro Dry Matter Digestibility

Introduction

In Ethiopia, the livestock sub-sector has significant contribution to the national income [1] and for the livelihoods of rural and urban communities. However, productivity of animals remained at low level due to feed shortage and nutritionally unbalanced supply of feeds [2]. A large proportion of livestock feed resources in Ethiopia comes from natural pastures, crop residues and aftermath grazing [3,4], but such feed resources cannot promote increased animal productivity due to their nutritional limitations (such as low crude protein, mineral, vitamins and higher fiber content), lower intake and digestibility [5]. The major problems with livestock feeding occur in developing countries like Ethiopia, particularly during the long dry season, when there is insufficient plant biomass carried over from the wet season to support domestic livestock species [6].

According to Mulualem and Molla [7] when improved forages are integrated and developed at household level in a sustainable manner, animal productivity would be increased. Currently, there has been a rapid governmental dedication which has been implemented through changing livestock improvement strategies to bring a paradigm shift in livestock industry. The strategy promotes enhancing livestock productivity through improving availability and quality of feed resources [1].

Different strategies can be employed to boost feed availability and improve nutritional deficiencies of local feed resources. One of such strategies that receiving attention and has been considered as best options is use of improved forage species for animal feeding [1]. However, the adoption rate of improved forages introduced to farmers level in Ethiopia is usually low and unsatisfactory due to forage seed and land shortage in crop-livestock mixed agriculture [8], reluctance of some smallholder farmers in forage production [1], technical problems such as managing the seedlings, insect damage and poor extension services. Information is also limited on agronomic practices, biomass production, and nutritive value of various improved forage varieties, including oat crop at the farmer's level. CSA [9] report indicated that the contribution of improved forage to livestock feed source is about 0.22%. Effort in extension and research work and strengthening producers' capacity through continuous training on cultivated fodder crops and improved grass species such as oats are not common and well adopted even in highland areas where feed shortage is a crucial problem [8].

Oats (*Avena sativa* L.) is one of the well-adapted and important fodder crops grown in the highlands of Ethiopia, mainly under rain fed conditions. It is also one of the important fodder crops widely grown during the winter season when livestock face green fodder shortage and majority of the feed start declining and finally drying [10]. It is also ranked as sixth in world's cereal production following wheat, maize, rice, barley and sorghum. However, it has been tested under irrigation conditions because rainfall is not reliable most of the years.

Improved varieties of oat can produce a three-fold green fodder 60 to 80t ha^{-1}. This amount can feed double number of animals per unit area compared with the traditional fodder production practices [11]. Straw of oat is soft and its grains are also valuable feeds for dairy cows, horses, young breeding animals and poultry. It can be fed in many forms like green forage or silage to animals. Oat grains have high content of proteins, which is relatively better in quality, compared to other cereals. The contents of Mg, Fe, P, Ca, and vitamins E and B1 are also higher in oats compared with other cereals [12].

Wolaita Zone in general and Sodo Zuriya specifically is known with high human population and small and fragmented land size, thus there is high feed shortage, which has resulted in decreased livestock production and productivity. Cultivation of improved forages like oats is important mainly in highlands and in areas where market-oriented livestock production is practiced supporting the livestock sector through improved production of high amount of feed from small area of land. Furthermore, there is no adequate information on comparative productivity and performance of different oat varieties under Wolaita situation. Therefore, the objective of this study was to evaluate Agronomic performances, yield and Nutritional Quality (chemical composition) of five oat varieties under irrigation condition in the highlands of Sodo Zuriya Woreda, Wolaita Zone, Ethiopia.

Material and Methods

Description of study area

The experiment was conducted in Wolaita Zone, Kokate Farmers administrations, Ethiopia. The site is situated at a latitude and longitude of 39º 36' S and 61º 64' W, respectively, with an altitude of 1916m.a.s.l. The agro-ecology of the district is 5% Dega and 95% Woyna Dega. The mean annual temperature ranges between 18 ºC - 28 ºC. The annual rainfall ranges between 1200-1300mm. Rainfall occurs in two distinct rainy seasons, 'Kiremt' (heavy rainy season) occurs in summer (June, July and August) and 'Belg' rain (light rainy season) occurs in spring (from mid - January to mid - May). The major soil type of the area is sandy - loam with pH value of 6.70. The organic matter percentage (1.52%), total nitrogen content (0.22%) and available phosphorus content (6.33) ppm were also reported.

Treatments and experimental design

The experiment consisted of five treatments of oat varieties namely Lampton, CV-SRCP X 80Ab 2806 (called Acc 2806), 8235-CI, 8237-CI and CV-SRCP X 80Ab 2291 (called Acc 2291) (Table 1). The varieties were selected due to the adaptability and availability of seeds in the area. The experiments were laid out in randomized complete block design (RCBD) with three replications on well prepared seedbed. The plot size was 2m x 3m. The blocks were separated by a space of 1m and plots were spaced 0.50m apart. Each plot had 10 rows spaced 20cm apart and data were collected by 0.25m^2 quadrant. The seed rate used was 100kg ha^{-1} and drill method of sowing was used. NPS fertilizer was applied at sowing time at a rate of 100kg ha^{-1}, respectively [13,14].

Table 1: Selected oat varieties and their respective origins.

No.	Variety	Origin
1	Lampton	Ethiopia
2	CV-SRCP X 80Ab 2806	CIMMYT
3	8235-CI	USA
4	8237-CI	USA
5	CV-SRCP X 80Ab 2291	CIMMYT

Source [10].

Land preparation, management and irrigation practice

The varieties were sown on 28th of December 2016 at the beginning of the light rainy season. Land was ploughed three times before the start of the field experiment. The seed was obtained from Agricultural Research Center and checked for weed seeds and other dead irregular shapes to increase the germination percentage. Then the plots were uniformly fertilized with NPS at a rate of 100kg ha^{-1} (60g of NPS per plot) at the time of sowing [15,16]. Weeding was conducted three times from sowing up to maturity stage. The experimental plots were uniformly irrigated starting from sowing date up to maturity. Two times a day; morning at 12:00 - 1:30hrs and afternoon 11:00 - 12:30hrs were applied up to emergence. After emergence, application of water decreased and applied every two days.

Data collection

Physiological and agronomic data

a. **Growth:** The developmental process such as days to emergence, days to 50% flowering and maturity stage were recorded.

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b. **Plant height (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 [17].

c. **Number:** Counts of plant number, number of leaves per tiller, number of tillers per plant and number of leaves per plant were recorded at 50% flowering stage. Ten plants from each plot in a quadrant ($0.25m^2$) were taken to measure number of tillers per plant, number of leaves per plant and number of leaves per tiller. Average results from each measurement were recorded to evaluate the performance [18].

d. **Biomass yield:** The vegetation from each plot was sampled using a quadrant of $0.25m^2$ (0.5m x 0.5m) sizes during a predetermined sampling period (50% flowering stage). The quadrant was randomly thrown on a plot and the average weight of ten plants 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}). Three adjacent rows from the center of each plot were taken at 50% flowering stage for fodder yield evaluation [19]. The fresh harvested biomass was chopped into small pieces using sickle and a sub-sample of 400 g was taken and partially dried in an oven at 60 °C for 48hrs for further dry matter analysis [18].

$$DM = yield\left(t / ha\right) = \left(10^{*} TFW^{*} SSDW\right) / \left(HA^{*} SSFW\right)$$

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)

e. **Grain and straw yield:** Grain and straw yield were determined at full maturity (100% seed maturity) stage. Plants in a quadrant ($0.25m^2$) 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 [20].

$$DMyield = 10000m^{2} / \left(Y\right) m^{2*} \left(Z\right) kg / 100$$

Where:

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

Y= Area of sampling site in m^2

Chemical composition and *in vitro* dry matter digestibility: The collected and partially dried oat varieties green forage (50% flowering stage) was transported to Hawassa College of Agriculture Animal Nutrition Laboratory for chemical analysis. The samples were dried to a constant dry weight in an oven at 100 ± 5 °C overnight to determine percent dry weight before any analytical procedures [21]. Then the dried samples were ground to 1mm mesh size using Willy mill, packed into paper bags and stored pending to further laboratory works. Chemical composition (Dry matter (DM), Crude protein (CP), Ash, Ether Extract (EE), Acid detergent lignin (ADL), Acid detergent fiber (ADF), neutral detergent fiber (NDF) and *in vitro* dry matter digestibility (IVDMD)) of the forage samples were analyzed. Nitrogen content was determined using Kjeldhal method [21] and then CP content was calculated as N x 5.7 for grain yield. The ash content of the samples was determined by complete burning in a muffle furnace at 550 °C for 3 hours [21]. The NDF, ADF and ADL were determined according to procedures of Van Soest and Robertson [22].

IVDMD of oat was estimated using a Daisy II Incubator on a dry matter basis. Sample of 0.5g from each replication were taken and dried at 39 °C for 48 hours. The dried and ground samples of oat were placed in ANKOM tubes filter bags (F57) made from polyester/polyethylene/extruded filaments. Weigh each F57 filter bag and record weight (W1). Zero the balance and weigh sample (W2) directly into filter bag. Heat seal bag closed and place in the Daisy II Incubator digestion jar (ANKOM Technology Method 3, ANKOM Technology -08/05).

Statistical analysis

Generated data were analyzed using the General Linear Model procedure of statistical analysis system [23]. Means were separated using Least Significant Difference (LSD) at 5% significance level.

$$Y_i = \mu + 1_i + Bj + \varepsilon_{ij}$$

Where Yi = The response variable (i. is agronomic parameters, yield and chemical composition)

μ = Overall mean

l_i = The i^{th} effect of variety (i= 1, 2, 3,4,5)

Bj= Effect of the j^{th} block (j = 1, 2, 3)

ε_{ij}= Random error

Results and Discussion

Physiological and agronomic data

Days to emergence, 50% flowering and maturity stages: The emergence date was relatively similar for all treatments and it took around 14- 21 days in all plots. Relatively prolonged days to emergence in this study was most likely due to sowing season, high temperature and lack of enough moisture. Average emergences of the varieties were 60% at first week and above 95% at second week. Only one variety (CV-SRCP X 80Ab 2291) ($p < 0.05$) reached 50% flowering stage at 62 days than the rest varsities (89 days after sawing). CV-SRCP X 80Ab 2291 variety reached to full maturity early (81 days) as compared to other oat varieties (91 - 99 days) (Table 2). The grain filling period in the present experiment ranged from 81 to 99 days however, the same varieties in previous study [16] reached between 64-80 days, which was shorter than current studied varieties due to differences in sowing season and

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lack of moisture content in the area. Hellewell et al. [24], attested that the major difference in maturity among oat cultivars related to differences in the length of the vegetative growth stage, not the grain filling period and thus the fast growth of early maturing cultivars is explained in terms of a shortened vegetative growth stage rather than a shortened grain filling period. Late maturing varieties tended to have comparatively shorter grain filling period than early maturing varieties as reported by Feyissa [16].

Table 2: Mean performance of different oat varieties under irrigation condition.

	Varieties								
Parameters	Lampton	CV-SRCP X 80 Ab 2291	CV-SRCP X 80 Ab 2806	CI -8235	CI -8237	LSD	CV%	p	SEM
Days to emergence	18^{a}	14^{c}	15^{b}	15^{b}	15^{b}	2.3	1.5	0.0001	0.9
Days to 50% flowering	89^{a}	62^{b}	89^{a}	89^{a}	89^{a}	3.2	2.5	0.0001	1.5
Days to maturity	99^{a}	81^{d}	91^{c}	93^{bc}	97^{ab}	4.3	4.7	0.0001	2.6
Number of leaves per tiller	6.00^{a}	5.23^{b}	6.20^{a}	6.01^{a}	5.89^{a}	0.24	2.4	0.43	0.07
Number of Leaves per Plant	7.00^{a}	6.10^{b}	7.00^{a}	7.00^{a}	7.00^{a}	0.15	1.1	0.001	0.05
Number of Tillers per Plant	11.0^{ab}	10.7^{ab}	12.0^{a}	10.7^{ab}	10.3^{b}	1.5	7.3	0.2	0.46
Plant Height (cm)	123^{a}	100^{b}	112^{ab}	122^{a}	120^{a}	14.3	6.6	0.03	4.39
Fresh fodder yield (t ha^{-1})	28.9^{c}	42.4^{a}	36.2^{b}	34.9^{bc}	29.9^{bc}	6.16	9.5	0.006	1.89
Dry matter yield (t ha^{-1})	9.21^{ab}	12.2^{a}	9.33^{ab}	9.07^{ab}	8.61^{b}	3.12	17.2	0.15	0.96
Dry matter yield (DM %)	28.7^{ab}	31.9^{a}	29.9^{ab}	25.9b	24.7^{b}	0.6	11.7	0.8	4.7
Straw yield (t ha^{-1})	9.12	9.56	9.86	7.79	8.24	1.46	11.8	0.39	0.45
Grain yield (t ha^{-1})	6.08	6.37	6.57	5.19	5.49	1.71	15.3	0.36	0.52

a, b and c in a column with different superscripts differ ($p < 0.05$)

LSD = Least significant differences of means; CV% = Coefficients of variation; SEM = Standard error of means.

Number of leaves per tiller: Number of leaves per tiller at 50% flowering stage is shown in Table 2. Variety CV-SRCP X 80Ab 2291 had statistically lower number of leaves per tiller ($p < 0.05$) than CV-SRCP X 80Ab 2806, CI-8237, CI-8235 and Lampton at 50% flowering stage. This might be due to the early maturity of CV-SRCP X 80Ab 2291 as compared to the rest varieties, the earlier to reach maturity the lower the number of leaves per plant as well. According to Gebremedhn et al. [17], the number of leaves per tiller varied from 6.89 to 4.89 at 50% flowering stage where as in current study it varied from 6-5 which were agreed. Oat varieties, Sargodha-2011 and PD2LV65 produced 6.62 and 5.37 number of leaves [20] per tiller at 50% flowering stage respectively which were comparable with the current findings.

Number of leaves per plant: The number of leaves play vital role in growth and development of plant. The increase or decrease in number of leaves per plant has a direct effect on the yield of forage crops. Significant ($p < 0.05$) variation in the number of leaves per plant was observed at 50% flowering stage (Table 2). The number of leaves per plant at 50% flowering stage were higher for the varieties CV-SRCP X 80Ab 2806, Lampton, CI-8235 and CI-8237, and statistically lower number was recorded for the variety SRCP X 80Ab 2291 (6.10). Varieties that produced maximum number of leaves per plant differed by 15% from the variety (CV-SRCP X 80 Ab 2291) that produced minimum number of leaves per plant. According to Khan et al. [18], the oat varieties; SGD-40, SGD-2011 and SGD-37 produced 7.50, 7.13 and 6.99 numbers of leaves per plant at 50% flowering stage, respectively, which were comparable with the current findings.

Number of tillers per plant: At 50% flowering stage CV-SRCP X 80Ab 2806 produced the highest number of tillers per plant (12.0) followed by Lampton (11.0), CI-8235 (10.7) and CV-SRCP X 80Ab 2291 (10.7) and the lowest was recorded for the variety CI-8237 (10.3) (Table 2). CV-SRCP X 80Ab 2806 variety produced 16.5% more tillers per plant than variety CI-8237 that produced minimum (10.3) number of tiller per plant. In previous study [17], Lampton showed highest number of tillers per plant (14.2) followed by 8237-CI (13.30 tillers per plant) at 50% flowering stage which were higher than the current observations. These results are in line with the finding [17,25] who reported that variation in environmental conditions and genetic makeup cause the variation in plant height and number of tiller per plant. However, currently studied varieties showed better performance than 80-SA-130 variety which produced 9.25 tillers per plant at 50% flowering stage [17]. Varieties F-411 and DN-8 were found to have similar tillering capacity (12 and 11 tillers per plant) respectively [26], which are agreed with the current observations. However, varieties, SGD-3, SGD-50, F-408 and F-301 produced 6.67, 6.33, 7.00 and 7.03 number of tiller per plant at 50% flowering stage, respectively, which were lower than the current varieties [18].

Plant height (cm): Plant height is one of the yield components contributes to green fodder and dry matter yield [27]. Plant height at 50% flowering stage are shown in Table 2. CV-SRCP X 80Ab 2291 had significantly ($p < 0.05$) shorter height than the rest varieties at 50% flowering stage. Lampton produced maximum height (123cm) at 50% flowering stage. In previous studies [17], Lampton produced the maximum height (178cm) followed

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by 8237-CI (170cm). The shorter height in the current observation might be due to difference in environmental condition and the sowing season [28]. However, varieties PD2LV65 (124cm), No.725 (118cm) [29] and SGD-46 (119cm) [18] produced similar result with the present observations at 50% flowering stage. Other varieties such as UPO 2005-1 (135cm), JO 2003 -78 (126cm), OS -6 (126cm), Kent (125cm), JHO-822 (123cm) and SGD Oat-2011(130cm) showed more or less similar results with the current observations [26,30].

Green forage and dry matter yield

The green forage yield is one of the most important traits and the ultimate goal of forage production is to obtain a high biomass with a reasonable quality. The green forage yield (t ha^{-1}) of the varieties were statistically significant ($p < 0.05$) to each other at 50% flowering stage (Table 2). Variety CV-SRCP X 80Ab 2291 produced the highest ($p < 0.05$) green forage yield (42.7t ha^{-1}) followed by CV-SRCP X 80 Ab 2806 (36.2t ha^{-1}) and the lowest was recorded for Lampton (28.9t ha^{-1}). Variety that produced higher green forage yield (CV-SRCP X 80 Ab 2291) was 31.8% higher than lower green forage yield (Lampton) variety. The highest green forage yield of variety CV-SRCP X 80 Ab 2291 might be due to the thick size of the steam than the other tested oat varieties. In previous studies the maximum (47.6t ha^{-1}) and minimum green forage yield 33.3t ha^{-1} were obtained from the oat varieties No.725 and CK1, respectively [29] which were in agreement with the current finding. Relatively higher amount (67.2t ha^{-1}) of Lampton green forage yield than the current observation was reported by Gebremedhn et al. [17] at 50% flowering stage. Similarly, Saleem et al. [20] recorded maximum green forage yield from Sargodha-2011 (72.7t ha^{-1}) and lowest green fodder yield from Varity PD2LV65 (62.4t ha^{-1}). The lowest fodder yield observed as compared to previous findings might be due to environmental influence such as sowing month variation and high temperature during practical field work in the area. But, current study was in agreement with Muhammad et al. [31] which produced PD2LV65 (41.0t ha^{-1}) and F-411 (45.9t ha^{-1}) green forage yields.

Similarly, the maximum dry matter yield was produced by the variety CV-SRCP X 80Ab 2291 (12.2t ha^{-1}) ($P < 0.05$) than CI-8237 (8.61t ha^{-1}) at 50% flowering stage (Table 2). According to Khan et al. [18], the dry matter yield of SGD-3 (9.73t ha^{-1}) were agreed with current CI-8237, CI-8235, Lampton and CV-SRCP X 80Ab 2806 varieties. Varieties Avoni, Ravi, CK-1, F-311 and F-411 also produced 10.5, 10.1, 10.9, 11.1 and 9.1t ha^{-1} [31] which were similar with the present observations.

Grain and straw yield

Grain and straw yield of oat varieties were presented in Table 2. The grain and straw yield among oat varieties were not statistically different ($P > 0.05$). However, numerically the highest grain and straw yield was recorded for the variety CV-SRCP X 80Ab 2806 (6.57t ha^{-1} and 9.86t ha^{-1}), respectively which relatively produce 26.6% and 17.5% more grain and straw yield than the lowest grain and straw producing variety CI-8235 (5.19t ha^{-1} grain and 7.79t ha^{-1} straw). According to Feyissa et al. [16], Coker SR res 80 SA 130 gave exceptionally higher grain yield (10.6t ha^{-1}) than CV-SRCP X 80 Ab 2291 (8.64t ha^{-1}) and CV-SRCP X 80 Ab 2806 (8.60t ha^{-1}) varieties which were higher than the current observation. The variation might be due to sowing season, where the current experiment was conducted on the dry season in irrigation bases while the previous once was in the main rainy season. The varieties Lampton, CI-8235 and CI-8237 that were produced 6.52, 6.68 and 6.84t ha^{-1} grain yield in previous studies [16] was in agreement with the current study. Whereas, according to Siloriya et al. [30] varieties NDO-1 and Kent produced 3.64t ha^{-1} and 3.52t ha^{-1}, respectively, which were lower than the current grain yield.

According to Feyissa et al. [16], relatively higher straw yield than the current finding were observed by CI-8235, CV- SRCP X 80 Ab 2806, CI-8237, Lampton and CV- SRCP X 80 Ab 2291 varieties which were 14.1t ha^{-1}, 14.1t ha^{-1}, 12.7t ha^{-1}, 12.7t ha^{-1} and 13.1t ha^{-1} respectively. Variety OS-6 (10.6t ha^{-1}) followed by JO 2003 -78 (10.2t ha^{-1}) also produced higher straw yields [30]. The variations in grain and straw yield might be due to differences in planting seasons, plant height and number of tillers per plant. Whereas, varieties 79 Ab 382 (TX) (80 SA 94), SRCP X 80 Ab 2764 and PI-338517 produced 9.95t ha^{-1}, 9.90t ha^{-1} and 9.86t ha^{-1} straw yield [16] were in agreement with current observations. According to Nazakat et al. [32], varieties PD2LV65, Swan, Tibour and Scott produced 2.44, 2.40, 1.11 and 0.81t ha^{-1} grain yields respectively, which were lower than the current finding.

Chemical Composition and in vitro dry matter digestibility

Table 3 indicates chemical composition of five oat varieties. The highest mean ($P < 0.05$) DM percentage were obtained in CI-8235 (93.3%), CI-8237 (93.2%), Lampton (93.1%) and CV-SRCP X 80Ab 2291 (92.8%) and the lowest was recorded for CV-SRCP X 80 Ab 2806 (91.5%). Variety CV-SRCP X 80 Ab 2291 possessed the highest ash contents ($p < 0.05$) as compared to the rest tested varieties. Variation in concentration of minerals might be affected by factors like varieties Gezahegn et al. [33], growth stage, morphological fractions, climatic conditions, soil characteristics, seasonal conditions McDonald et al. [34] and fertilization regime.

Crude protein (CP) content is one of the very important criteria in forage quality evaluation Khan et al. [18]. The mean CP content ranged from 11.78% to 15.3% (Table 3). Variety CV-SRCP X 80 Ab 2806 showed better CP (15.3%) content followed by Lampton (13.3%) than CV-SRCP X 80 Ab 2291, CI-8237 and CI-8237 varieties. According to Saleem et al. [20] maximum CP was recorded in variety Sargodha-2011 (10.38%) followed by Avon (9.09%) which were lower than CV-SRCP X 80 Ab 2806 in the current study. Relatively lower CP content was also reported in previous studies for the varieties Scott (9.86%), Avon (7.80%) and Ravi (6.7%), Muhammad et al. [31].

Neutral detergent fiber (NDF) content varied between 41.6 and 51.4% (Table 3). The result showed that the NDF content were significantly affected by varietal difference. The highest and

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lowest NDF contents were recorded for CV-8235 (51.4%) and CV-SRCP X 80 Ab 2806 (41.6%), respectively. Geleti [35] indicated that the NDF contents above the critical value of 60% results in decreased voluntary feed intake, feed conversion efficiency and longer rumination time. According to Van soest Robertson [22] the critical level of NDF which limits intake was reported to be 55%. However, the NDF content of all the treatments were observed to be below this threshold level which indicates no effect on digestibility and intake.

Table 3: Mean chemical composition and IVDMD values for five oat varieties.

Chemical Composition and IVDMD								
Varieties	**DM (%)**	**Ash**	**CP**	**EE**	**NDF**	**ADF**	**ADL**	**IVDMD**
Lampton	93.1^{a}	8.63^{b}	13.3^{ab}	2.85^{b}	$45.3b^{c}$	24.0^{bc}	2.25^{ab}	72.9^{ab}
CV-SRCP X 80Ab 2291	92.8^{a}	9.99^{a}	12.6^{b}	3.12^{b}	45.1bc	24.7^{bc}	2.52^{a}	68.8^{b}
CV-SRCP X 80Ab 2806	91.5^{b}	8.67^{b}	15.3^{a}	4.32^{a}	41.6^{c}	22.1^{c}	1.98^{b}	73.9^{a}
CI-8235	93.3^{a}	8.73^{b}	11.8^{b}	2.97^{b}	51.4^{a}	28.0^{a}	2.30^{ab}	68.6^{b}
CI-8237	93.2^{a}	8.48^{b}	12.2^{b}	3.06^{b}	49.4^{ab}	26.4^{ab}	2.55^{a}	69.3^{b}
LSD	1.01	1.06	2.48	0.61	4.45	2.57	0.48	4.08
CV%	0.6	6.3	10.1	9.9	5.1	5.5	10.9	3.1
p	0.02	0.06	0.07	0.003	0.007	0.007	0.13	0.05
SEM	0.31	0.32	0.76	0.19	1.37	0.79	0.15	1.25

a, b and c in a column with different superscripts differ ($p < 0.05$)

DM= Dry matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF =Acid detergent fiber; SEM= Standard error of mean; LSD = Least significant differences; CV%= Coefficients of variation; EE = Ether extract; ADL = Acid detergent lignin; IVDMD = In-vitro dry matter digestibility.

Acid detergent lignin (ADL) content ranged from 1.98 to 2.55g per kg DM. The mean ADL content of CV-SRCP X 80 Ab 2806 was significantly ($P < 0.05$) lower (1.98g per kg DM) than CI-8237 (2.55g per kg DM) and CV-SRCP X 80 Ab 2291 (2.52g per kg DM) varieties. The higher the ADL content, the lower will be the digestibility of the feed.

Acid detergent fiber (ADF) is the percentage of indigestible and slowly digestible material in a feed or forage [34]. This fraction includes cellulose, lignin and pectin. Acid detergent fiber has a positive relationship with the ages of the plant [36]. In the present study ADF content of CV-SRCP X 80 Ab 2806 was lower (22.1%) and the highest was observed in CI-8235 (28.0%) and CI-8237 (26.39%) varieties. The lower ADF content indicates that it is more digestible and more desirable, which agrees with previous report of Negash et al. [37] that observed 23.7% of CV-SRCP X 80 Ab 2806 variety. Digestibility decreased as age advanced and this could be linked to the increased fiber concentration in plant tissue and increased lignifications during plant development [38]. Kellems and Church [39] characterized roughages with less than 40% ADF as high quality and above 40% as low quality. Hence, current varieties were comparatively lower value of ADF values, this could be indicative of its better digestibility.

The *in vitro* dry matter digestibility values (IVDMD) had greater than 65% indicated good nutritive value, and values below this level result in reduced intake due to lowered digestibility [40]. Hence, the IVDMD values of studied oat varieties were higher than 65% value. Variety CV-SRCP X 80Ab 2806 (73.85%) produced maximum IVTDMD and CI-8235 (68.55%) relatively minimum IVDMD yield.

Conclusion and Recommendation

High human population and the associated land shortage and feed scarcity both in quality and quantity is one of the challenges for livestock production in Wolaita Zone. Cultivation of improved forages with high biomass yield with reasonable quality that can reach to maturity within a short period of time is essential. The findings of the present study indicated that the studied varieties had significantly different ($p<0.05$) number of leaves per plant, number of leaves per tiller, number of tiller per plant, green and dry matter yield at 50% flowering stage. CV-SRCP X 80 Ab 2291 variety had yield variations in number of leaves per tiller and number of leaves per plant from the rest varieties at 50% flowering stage. Grain and straw yield of all varieties had similar results; however, variety CV-SRCP X 80 Ab 2806 produced 26.6 % and 17.5% more grain and straw yield than CI-8235 variety.

Planting of CV-SRCP X 80 Ab 2806 variety followed by CV-SRCP X 80 Ab 2291 produced higher grain and straw yield than other varieties. Higher CP, IVDMD, lower fiber and ADL contents were also recorded for the variety CV-SRCP X 80 Ab 2806. On the other hand, variety CV-SRCP X 80 Ab 2291 was early emerging, reach early to 50% flowering stage, early maturing ability and also significantly higher fresh biomass yield than the rest varieties. This Early maturing ability and higher fresh biomass yield at short period of time increase livestock production and productivity by

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proving enough amount of feed for livestock. Therefore, it is recommended that farmers in high land areas of Sodo Zuriya Woreda and other areas having similar agro-ecology and soil type could use CV-SRCP X 80Ab 2806 for higher crude protein, IVDMD, EE and for lower ADL, NDF and ADL contents. However, CV-SRCP X 80Ab 2291 variety was better for early maturity, fresh forage and dry matter yield (t ha^{-1}).

Conflict of Interest

I declare that there is no economic or any other conflict of interest among authors.

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