J. Rangeland Sci., 2026; 16(2): 193-207

Journal of Rangeland Science (JRS)

https://doi.org/10.57647/JRS.2026.1602.18

Research Article

Effects of Cow Manure and Inorganic Fertilizer on Yield and Quality of Walga Oats (*Avena sativa* L.) in Choman Guduru District, Western Oromia, Ethiopia

Bacha Asefa[1], Negasa Tamasgen[2*], Firisa Woyessa [2]

[1]*Livestock and Fisheries Agricultural Office, Choman Guduru, Oromia, Ethiopia*
[2]*Department of Animal Sciences, Wollega University, Nekemte, Ethiopia*

***Corresponding author:** seenaashee@gmail.com

Article History:

Received:
07 February 2025

Revised:
11 Agust 2025

Accepted:
12 September 2025

Published in Issue:
30 June 2026

Abstract

In order to evaluate the effects of cow dung manure and inorganic fertilizer on yield and quality of Walga oats (*Avena Sativa* L.) in Choman Guduru district, during the main cropping seasons, an experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments involved a control and three levels of Nitrogen, Phosphorus and Sulfur (NPS) fertilizer (50, 100, and 150 kg/ha) combined with cow dung manure (5, 10, and 15 ton/ha). Data collected for emergence and flowering, plant height, tiller number, leaf area, leaf number per plant, leaf to stem weight ratios, biomass yield, and quality traits: Dry Matter (DM%), Crude Fiber (CF%), Organic Matter (OM%), Crude Protein (CP%), Ether Extract (EE%), Neutral Detergent Fiber (NDF%), and Acid Detergent Fiber (ADF%). Data were analyzed using Genstat version 15. The highest emergency date (13.3 days) was measured in T0 (control). The application of the highest rate of inorganic and cow dung manure significantly ($p<0.01$) altered the green forage yield and quality attributes of oats. The highest biomass yield (80 t ha^{-1}) was observed for the treatments with 100 kg seed ha^{-1} coupled with 150 kg NPS ha^{-1}. Similarly, the highest ($p<0.01$) tillers number (7.4/plant), plant height (155 cm), leaves number (6.4/plant), leaf area per plant (131.67 cm2), dry matter yield (17.41 t ha^{-1}), crude protein (7.42%), crude fiber (40.49%), and total ash (14.02%) were recorded for T3 (150 kg NPS). There were strong positive correlations between agronomic traits ($p<0.01$). Dry matter yield was positively correlated with DM, CP, OM, EE, and negatively correlated with CF, ADF, NDF, and Acid Detergent Lignin (ADL). Inorganic fertilizer application to cultivate oat forage improved the morphological characteristics with the highest net benefit; however, the use of a high dose of cow dung manure could be an alternative.

Keywords: Biomass yield, Dry matter, NPS fertilizer, Nutrition, Organic fertilizer

Cite this article: Asefa, B., Tamasgen, N. & Woyessa, F., (2026). *Journal of Rangeland Science*, Effects of Cow Manure and Inorganic Fertilizer on Yield and Quality of Walga Oats (*Avena sativa* L.) in Choman Guduru District, Western Oromia, Ethiopia, *16(2),* 193-207. https://doi.org/10.57647/jrs.2026.1602.18

1. Introduction

Ethiopia has the largest livestock population in Africa, comprising 71 million cattle, 43 million sheep, 54 million goats, 7 million camels, and 57 million chickens (CSA, 2022). The function of livestock ranges from livelihood to the national economy. Livestock is an integral part of the farming systems and a source of many social and economic values, such as food, draft power, fuel, cash income, security, and investment in both the highlands and the lowlands/pastoral farming systems (Kebede et al.

2016). The contribution of livestock to the national economy is estimated to be 30% of the agricultural GDP and 19% of the export earnings (Negash et al., 2017). A major problem in livestock production in developing countries like Ethiopia, particularly during the long dry season, is insufficient plant biomass to support livestock productivity (Kebede et al., 2021). According to Abebe et al. (2015) and Gebremariam & Belay (2023), the majority of livestock feed resources are grazing land and crop residue, which are not sufficient for the animals to meet their primary requirements.

Currently, there is less natural grazing land available due to the rapid population growth, which leads the land demand for crop cultivation. Due to overgrazing and a decrease in soil fertility, the amount of fodder produced was decreasing (Gebremedhn et al., 2015), remaining as one of the major factors hindering animal production in Ethiopia. Nowadays, there are different techniques for increasing the production of feed resources to overcome livestock feed shortages. This is to cultivate improved forages and provide them to animals at important stages when other feed sources are limited (Negash et al., 2017). Selecting high-quality forages and adapted to the agro-ecology is mandatory to address the challenges of feed shortages. The use of better-quality and climate-smart forage species is receiving significant acknowledgment as an option to overcome his problem in tropical areas (Ongadi et al., 2020), including Ethiopia (Adnew & Bimrew, 2023).

According to FAO (2016) and Mulualem & Molla (2013), livestock productivity will improve if enhanced forages are sustainably mixed and produced at the household level. The use of cultivated forage crops has received considerable attention for complementing conventional feed resources, especially in areas where feed shortages are the main constraint on livestock productivity (Abate & Wegi, 2014; Irfan et al., 2016). Due to its short life cycle, suitability in crop rotations, and better performance on marginal lands, oat (*Avena sativa* L.) is an excellent fodder for animals. It can grow in a wide range of soil types, rainfall situations, and altitudes. However, moderate and cool climate conditions are ideal for its development (Gebremedhn et al., 2015). Compared to other cereals such as barley and wheat, oats are more resistant to both drought and moisture stress. They are characterized by an erect growth habit and a bunching basal form. It could be a good source of animal feed in the dry season if harvested at the right stage of growth, cured, and stored as hay (Tulu et al., 2020). It is also a quick-growing, palatable, succulent, and nutritious fodder crop (Wada et al., 2019). According to Tulu et al. (2020), oat genotypes in Western Oromia can produce hay yields ranging from 5.07 to 13.57 t/ha, crude protein from 36.2 to 63.5 g/kg DM, Neutral Detergent Fiber (NDF) 685–728.7 g/kg DM, and acid detergent fiber 470–610.4 g/kg DM. Although Eastern Oromia was well known for indigenous bull fattening and milk production practices, the good-quality fodder-like oat was not developed extensively.

Seed rate and level of nitrogen fertilizer are key factors that contribute to the yield and quality of forage oat (Irfan et al., 2016). These conditions vary greatly across the agro-ecological areas (Abate & Wegi, 2014). Higher fodder yields resulting from fertilizer application are attributed to its favorable effects on plant water relations, light absorption, crop density, plant height, leaf area, and nutrient utilization (Neelar, 2011). Hence, there is a need to determine an appropriate level of fertilizer application, especially in soils deficient in nitrogen, and a proper seeding rate to positively affect forage oat production both in terms of yield and quality (Mut et al., 2015). In the study area, grazing resources are severely shrinking, posing a major challenge for free-ranging animals. Producers' efforts to develop improved forage that provides high-quality and sufficient feed for livestock are not well developed. Therefore, this research aims to address the persistent livestock feed shortages by developing improved forages. The objectives are to evaluate the effects of different application rates of cow dung manure and inorganic fertilizer on the maturity stage, biomass yield, and chemical composition of Walga Oats (*Avena sativa* L.) in the Choman Guduru district.

2. Materials and methods

2.1. Study area information

The study was conducted in Choman Guduru district, which is one of the 12 districts of Horo Guduru Wallaga Zone and has 11 rural kebeles. The principal town of the district was situated about 260 km west of Addis Ababa and 78 km east of Shambu town, the capital town of the zone. The administrative boundaries of Choman Guduru district were Gindabarat district from the east, Jima Rare district from the south, Guduru district from the north and Jima Ganati district from the west. The district has two agro-ecological zones: mid-land, which covers 97%, and lowland, which covers 3% of the total area, respectively. The altitude of the areas ranges from 1,500 to 2,350 m above sea level (m.a.s.l). The physical properties of the soil were silt (21.6%), sand (26.4%), and clay (52%). The district receives an average annual rainfall ranging from about 1200 mm to 1350 mm, and the temperature ranges from 18 oC up to 24 oC. The geographical location of the study area was 9°15'0''N to 9°37'0''N and 37°10'0'' E to 37°40'0"E (Figure 1). It is entirely situated in the catchment of Blue Nile at the larger scale and partially in Guder and partially in the Fincha subcatchment at the smaller scale.

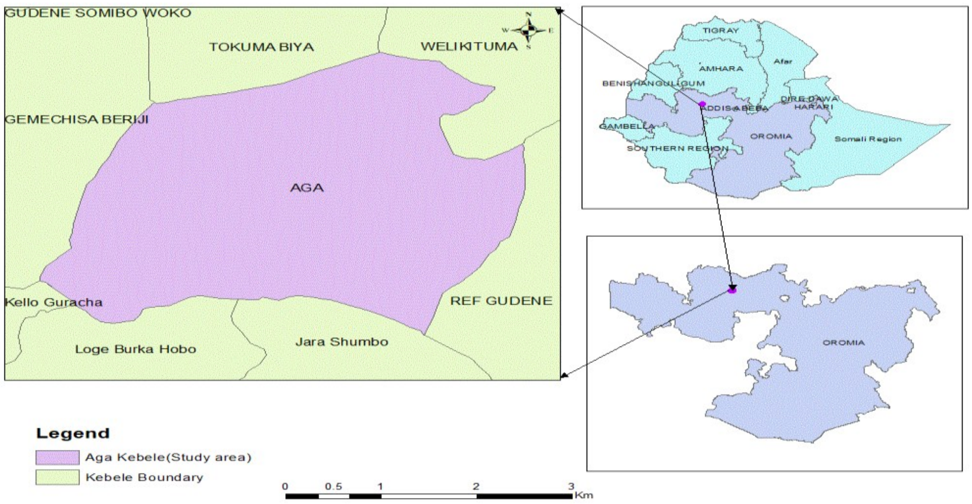

Figure 1. Location Map of the Study Area

2.2. Soil and cow dung manure properties

The soil fertility and cow dung manure were analyzed before the experimental planting season to determine the effects of cow dung manure and soil fertility. The results indicated that the soils were clay soils with modest, moderate, and high concentrations of the majority of nutrients (Table 1). They were also slightly acidic and non-saline. The physical and chemical properties of soil were also determined. Based on that, the physical properties of soil were silt (21.6%), sand (26.4%), clay (52%), and bulky density (1.41 g/cm^3), while the chemical properties of soil were pH (5.6%), organic matter (2.6%), total nitrogen (0.12%), available phosphorus (7.02 mg/kg), available potassium (0.5 mg/kg), and total Sulphur (8.36 mg/kg). The composition of cow dung manure analyzed has pH (7.2), nitrogen (0.927%), phosphorus (0.574%), potassium (1.5%), and organic carbon (26%). When nitrogen availability is at its peak, most crops grow best in a pH range of 6.5 to 7.5 (Yirga et al., 2019). The soil's organic carbon (2.98%) and organic matter (5.14%) were higher before applying farm yard manure (Dinka et al., 2018). Soil's organic carbon and organic matter were found in the high range (Emamu & Wakgari, 2021).

2.3. Experimental design and treatments

The experiment was arranged in a RCBD with seven treatments of three replications. Pre-planting soil and cow dung manure samples were taken to analyze for selected physicochemical properties, mainly textural analysis (sand, silt and clay), soil pH, total nitrogen, available sulphur, organic carbon, and available phosphorus at Fincha sugar factory (Table 1).

The treatments were levels of cow dung manure at three levels; 5, 10, and 15 tons ha^{-1} and Nitrogen, Phosphorous and Sulfur (NPS) fertilizer levels; 50, 100, and 150 kg ha^{-1} , respectively with a control treatment (Table 2) and used 100 kg ha^{-1} walga oats seed for sowing.

The land was ploughed four times before sowing the oat seed to ensure the soil became fine. For this study, land plots were manually prepared using traditional tools such as shovels, axes, and spades, along with animal power. The experiment involved hand-drilling walga oat seed, applying cow dung manure before one month to a given plot to decompose properly and while NPS applied during sowing season. The size of each plot was 2 ×3 m = 6m^2. The total area used in the current study was 8 ×18 m=144 m^2 and the spacing between plots and blocks of 0.5 m and 1 m, respectively. A total of 21 plots with random allocation of treatments were produced by this experimental design. All agronomic practices were done uniformly, as recommended for oats (Tulu et al., 2020). The Walga oat seed selected as the test crop was manually sown at 100 kg ha^{-1}. To ensure successful germination, the sowing was timed to benefit from continuous rainfall. After that, hand rakes were used to cover the seed with topsoil (Adane, 2023). Weeds were physically removed during the early stages of seedling development (Velykis et al., 2009).

2.4. Data collection

2.4.1. *Growth parameters*

The mean value for the days from sowing to emergence (50% emergence) and 50% flowering stage was recorded after visual assessment was conducted for emergence and blooming, respectively. The length of the days of the 50% flowering stage was calculated as the days of the 50% flowering stage minus the emergency date (Gebremedhn et al., 2015). The average plant height was measured from the ground to the tip of the main stem. The measurement was done by taking 10 random plants on the days of the 50% flowering stage from each plot (Gebremedhn et al., 2015) to represent the relationship between the leaves' dry weight and the stem's dry weight.

10.57647/jrs.2026.1602.18

Each sample of the leaf and stem was air-dried, and then, the leaf-to-stem weight ratio (LSR) was estimated by dividing leaf dry weight by stem dry weight according to (Aklilu and Alemayehu (2007).

$$LSR = \frac{Leaf\ dry\ weight\ (g)}{Stem\ dry\ weight\ (g)}$$

The total number of tillers from ten demarcated sampling units was counted, and the average number of tillers per plant was calculated based on the net plot area. The number of leaves per plant was counted from 10 plants selected in each row in the middle rows, and the length of the leaves was measured using a ruler, starting from the ligules (oricle) to the shoot of the plant (Khan et al., 2014). On the designated days, the entire forage in each row was collected, excluding border rows. Using a sickle, the harvest was done by hand, leaving a stubble height of 50% of the flowering, or at the stage of physiological maturity. The number of tillers per plant was counted from the randomly selected sample of 10 plants in the middle row of each plot. To prevent the edge effect, 10 plants must be taken out from the center of each plot to count the number of tillers and leaves of the oats. Each measurement's average result was recorded in order to assess the performance (Khan et al., 2014).

$$\text{Tillers number per plant} = \frac{\text{Total Number of Tillers}}{Total\ Number\ of\ Plants\ Sampled}$$

Leaf area plant was calculated by measuring the length and width of ten representative plants from the tagged plants of each treatment at the time of harvest. The 10 plants were selected randomly from the middle rows and the leaf areas were measured and calculated according to (Mengistu & Mekasha, 2007).

$$Leaf\ area = Leaf\ length\ \times\ Leaf\ width$$

2.4.2. *Biomass yield (tons' ha^{-1})*

At 50% flowering stage or physiological maturity, a quadrant of 0.25 m^2 (0.5 m × 0.5 m) was used to sample the plants from each plot during a predetermined sampling period. The biomass yield of the quadrant was calculated by weighing the average of the harvested plants randomly placed within the plot. To calculate the dry matter yield per hectare (t/ha), the average weight of the fresh feed was used. To evaluate the fodder production, three adjacent rows from the center of each plot should be selected at 50% flowering according to Mengistu & Mekasha (2007). The fresh harvested biomass was chopped into small pieces using a sickle, and a sub-sample of 400 g was taken and partially dried in an oven at 65 ˚C for 72 hours for further dry matter analysis (Khan et al., 2014).

$$DM = Biomass\ yield = \frac{10 \times \text{TFW} \times\ \text{SSDW}}{\text{HA} \times\ \text{SSFW}}$$

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)

2.4.3. *Dry matter yield (ton ha^{-1})*

Dry matter yield (DMY) was determined at the end of every harvesting day of each plot. At each harvest, the three rows in the middle of each plot were cut to 10 cm above the ground. Fresh biomass was measured using a top-loading balance; then, subsamples of about 400 g of fresh plants were taken from the net-harvested plant sample. Finally, the subsamples were air-dried to obtain dry weights, which further then oven-dried at 105oC for overnight. On the basis of these, DM% and fresh biomass yield from the sample area of each plot were used to calculate total dry matter yields for each plot according to (AOAC, 1995) and thereafter converted to tons per hectare.

$$\text{Dry matter (\%)} = \left(\frac{\text{Weight of oven} - \text{dry sample}}{\text{Weight of sample before drying}}\right) \times 100$$

Dry matter yield (DMY) was calculated as follows:

$$\text{DMY (ton/ha)} = \frac{\text{Wt. before dried} - \text{Wt. after dried}}{\text{Wt. before dried}} \times 100$$

2.4.4. *Chemical composition parameter*

Chemical composition was determined by analysis at the Holleta Agricultural Research Centre Animal Nutrition Laboratory. The forage samples were measured using a top-loading balance of grass (oats) that was sorted from each plot, and a 400 g sample of leaf and stem was separated to be packed together in a paper pocket, dried in air and the dry weight was recorded. These samples were dried by air and then ground by a grinder to pass a 1 mm Wiley mill screen and stored in a paper pocket for different preparations of the proximate chemical analysis using the procedure of (AOAC, 2000). The samples were analyzed on a DM (%) basis for ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and Nitrogen (N) content was determined following the micro-Kjeldahl digestion, distillation, and titration procedures (AOAC, 1995), and the CP content was estimated CP%= N%×6.25). Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined according Grabber & Mertens (2006).

2.4.5. *Data analysis*

The various collected data were subjected to an analysis of variance following the statistical procedure of Gomez & Gomez (1984) by using Genstat version 15. The significant differences between and among the means were separated by using the Least Significant Difference (LSD) at a 5% alpha level of probability.

2.4.6. *Partial budget analysis*

The partial budget analysis was done according to CIMMYT (1988). Partial budgeting was performed, utilizing the market prices that were in effect for inputs at planting and outputs at harvesting. Each cost and benefit was estimated in Ethiopian Birr on a per-hectare basis. The economic analysis includes the calculation of variable costs and benefits. The purchase price of each experimental cow dung manure and NPS fertilizers were recorded. Therefore, the selling price of each experimental biomass yield was determined by the demand of owners of dairy cattle in Gabate town during the summer season. For the calculation of variable costs, the expenditures on cow dung manure and NPS were taken into consideration. Net Benefit (NB) was calculated as the amount of money left when Total Variable Costs (TVC) were subtracted from the Growth Field Benefit (GFB)

$$NB = GFB - TVC$$

The changes in Net Benefit (ΔNB) were calculated as the difference between changes in total growth field benefit (ΔGFB) and the change in total variable costs (ΔTVC).

$$\Delta NB = \Delta GFB - \Delta TVC.$$

The marginal rate of return (MRR) that measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) was calculated as given below. The marginal rate of return is MRR= (ΔNB/ΔTVC) ×100; (change of net benefit per change of total variable cost)

3. Result and Discussion

3.1. Phenological and growth parameter

3.1.1. *Day to 50% emergence*

There was a significantly longer ($p<0.01$) days to emergence (13.50 days) recorded in the control treatment, while fewer days to emergence (10 days) were measured in T3 (150 kg NPS), as shown in Table 3. This might be due to soil fertility or a lack of fertilizer application in control treatments. According to Tariku et al. (2018), chemical fertilizers enhanced germination and emergence. Moreover, Tisdale et al. (2002) stated that applying fertilizer near the seeds during planting promotes seed germination and seedling emergence. Additionally, the relatively prolonged days to emergence observed in this study were likely influenced by factors such as the sowing season, high temperatures, fertilizer application rates, and low soil moisture. Minerals are a major limiting nutrient for the growth of forage crops, especially Nitrogen (N), which is externally supplied to soils where deficiency is suspected to improve forage yield (Tena & Beyene, 2011).

3.1.2. *Days of 50% flowering stage*

The early day to 50% flowering (82.33 days) was obtained in treatment T3 (150 kg NPS ha^{-1}). Application of T3 (150 kg NPS ha^{-1}) resulted in early flowering (82.33 days). The current study, early in the days to flowering at 150 kg NPS ha^{-1}, may be due to the high content of NPS fertilizer used; because of this, the chemical fertilizer increased the reaction of germination and emergence compared to control. The main cause of differences in the day to flowering stage is due to the types of fertilizer and rates of application (Abbas et al., 2012). The current result was taken an early day to attain 50% flowering, than the report by Tessema & Getinet (2020), who reported 147 days to 92 days. The minimum days to maturity were due to the availability of a high amount of major nutrients (Joshi et al., 2015).

Table 1. Soil and cow dung manure fertility status of an experimental site before planting

Properties	Parameters	Value
Physical properties of soil	Silt	21.6%
	Sand	26.4%
	Clay	52%
	Texture class	Clay
	Bulk density	1.41 (g/cm^3)
Chemical properties of soil	pH	5.6
	Organic matter	2.6%
	Total Nitrogen	0.12%
	Available phosphorus	7.02 (mg/kg
	Available potassium	0.5 (mg/kg)
	Total sulfur	8.36%
Composition of Cow Dung Manure	pH	7.2
	Nitrogen	0.92%
	Phosphorus	0.57%
	Potassium	1.5%
	Organic carbon	26%

10.57647/jrs.2026.1602.18

Table 2. Treatment combination used in the experiment

Treatments code	Treatments name
T0	Control
T1	50 kg NPS ha^{-1}
T2	100 kg NPS ha^{-1}
T3	150 kg NPS ha^{-1}
T4	5 tons ha^{-1} cow dung manure
T5	10 tons ha^{-1} cow dung manure
T6	15 tons ha^{-1} cow dung manure

3.1.3. *Plant height*

The highest ($p<0.01$) mean plant height (155.33 cm) was observed in T3 (150kg NPS ha^{-1}), followed by T2 (100kg NPS ha^{-1}), which had (142.33 cm) plant height; while the lowest plant height (120.67 cm) was measured in the control (Table 3). This may be due to the rate of fertilizer application, type of fertilizer, soil fertility, or increased absorption of nutrients at a high level (Zhang et al., 2020). The current study found that the treatment with a higher amount of NPS and cow dung manure resulted in significantly taller plants compared to the control and other treatment groups. The values of plant height from current study were lower than the values of 174 cm and 181.16 cm reported by Kebede et al. (2016) and Muhumed et al. (2018), respectively. However, the highest mean value of the present study was in agreement with Gebremedhn et al. (2015), who reported 145 cm from the 8235-CI genotype and 137 cm from Jasari.

Plant height is considered an important factor that contributes to dry matter yield, which is in agreement with Mengistu et al. (2021), who reported that plant height is one of the yield components that contribute to dry matter yield. Taller plants generally indicate better growth and the potential for higher yields, which may be caused by variation in environmental conditions and the genetic makeup of the varieties (Singh et al., 2018). In contrast to the findings of the current study, the study by Berhanu et al. (2017) revealed low values (111.5–118 cm) during the 80th day of harvesting.

According to Sajjad et al. (2014) reported that NPK fertilizer produced the highest plant height values (140 cm), while CI-8251 oat accession produced the lowest plant height values (120 cm) with control or no fertilizer in agronomic practice performance of highland area and other necessary water, sunlight, nutrients, and rain supply was managed and controlled in plant. Specifically, Mangesh (2016) study reported that, compared to applying 60 kg ha^{-1} of nitrogen, using 100 kg ha^{-1} of nitrogen resulted in significantly increased plant height. This implies a positive association between the amount of NPS fertilizer application and the height of the plants. Similarly, Maral et al. (2013) found that in their experiment, the greatest plant height was achieved by applying 98 kg ha^{-1} of nitrogenous fertilizer. (Ayub et al. 2013) identified that the use of nitrogen has also been shown to increase oat plant height.

3.1.4. *Number of tillers per meter row length*

As shown in Table 3, application of 150 kg and 100 kg of NPS per hectare resulted in a highly significant ($p<0.01$) number of tillers compared to other treatments, suggesting that inorganic fertilizer application, especially in the form of NPS, has a positive impact on the tillering of oat plants. The treatments T3 and T2, where inorganic sources of fertilizer (150 NPS kg ha^{-1} and 100 kg NPS) were used, had the maximum number of tillers per meter row length, 132.11 m^2 and 29.44 m^2, respectively, compared to all other treatments. While treatments T0 and T4 statistically resulted in a minimum tiller of (104.66 m^2 and 111.44 m^2), respectively, without fertilizer and 5 tons ha^{-1}, cow dung manure was applied. This may be due to varying germination rates at different fertilizer application levels or inefficient nutrient absorption. The current study was consistent with the findings of Godara et al. (2016), who reported that increasing levels of nitrogen had a significant influence on various growth parameters. Similarly, Jayanthi et al. (2013) revealed that the application of organic and inorganic nitrogen fertilizers recorded a higher number of tillers per meter of row length in oats.

3.1.5. *Number of tillers per plant*

There was a highly significant ($p<0.01$) effect of NPS and cow dung manure fertilization rates on the number of tillers per plant shown in Table 3. The results show that treatment T3 (150 kg of NPS ha^{-1}) and T2 (100 kg NPS ha^{-1}) produced the highest number of tillers 7.43 and 7.2 per plant, respectively, while the lowest number of tillers per plant (4.6) was recorded for control. Treatment T6 (15 tons ha^{-1} cow dung manure) produced the intermediate value of (6.73 tiller/plant). The current finding result was in agreement with Khan et al. (2014), who found that different varieties of SGD-3, SGD-50, F-408, and F-301 produced 6.67, 6.33, 7.00, and 7.03 tillers per plant at the 50% flowering stage, respectively. However, the current studied Walga seed showed less performance than the 80-SA-130 variety, which produced 9.25 tillers per plant (Gebremedhn et al., 2015). Varieties F-411 and DN-8 were found to have similar tillering capacities (12 and 11 tillers per plant, respectively) (Syed et al., 2015), which disagrees with the current observations. The non-significant effect of nitrogen on the number of tillers may be attributed to the fact that nitrogen might not affect germination; therefore, plant density under different levels of nitrogen can be stable.

3.1.6. *Number of leaves per plant*

The highest ($p<0.01$) number of leaves per plant (6.4) was observed in T3 (150 kg ha^{-1} NPS) followed by T2 (100 NPS kg ha^{-1}), which had 6.17 leaves per plant, while the minimum number of leaves per plant was recorded for the control (5.07). According to Gebremedhn et al. (2015), the number of leaves per tiller varied from 6.89 to 4.89 at the 50% flowering stage, which is in agreement with the current study. Oat varieties Sargodha-2011 and PD2LV65 produced 6.62 and 5.37 leaves (Saleem et al., 2015) per tiller, respectively, which were comparable with the current findings. Irfan et al. (2016) reported higher and lower numbers of leaves of forage oat with the highest and the lowest nitrogen (N) application. The yield of the forage crops depends on an increase or decrease in the number of leaves per plant (Khan et al. 2014). According to Tessema & Getinet (2020), plant leaves play a greater role in influencing forage yield. The number of leaves per plant was also affected by the soil fertility stage and the application of nitrogen fertilizer (Ali et al., 2017). The application of inorganic fertilizers produced a higher number of leaves per plant (Ahmed et al., 2015). The significant effect of fertilizer applications on the number of leaves per plant on oat crops has also been reported by Abbas et al. (2012).

3.1.7. *Biomass yield*

As shown in Table 3, treatment (T3) produced the highest ($p< 0.001$) biomass yield (80 ton ha^{-1}) by application of NPS at 150 kg ha^{-1}, followed by T2 (74.2 ton ha^{-1}), where NPS was applied at 100 kg ha^{-1}, while the lowest was recorded for control (53.13 ton ha^{-1}). This may be due to crop density, plant height, leaf area, and nutrient utilization. Similarly, Saleem et al. (2015) recorded the maximum green forage yield from Sargodha-2011 (72.7 ton ha^{-1}) and the lowest green fodder yield from Variety PD2LV65 (62.4 ton ha^{-1}). Ahmad et al. (2011) also reported 74.67 ton ha^{-1} total green fodder yield of oat by applying 150 kg N/ha. The addition of cow dung could have increased the available nutrients in the soil, thus increasing biomass production (Han et al., 2023). Furthermore, a few studies have shown that cow dung contains bacteria that promote plant growth due to their capacity to solubilize nutrients (Qi et al., 2021; Bhatt & Maheshwari, 2020; Naghizadeh et al., 2022). The significant effect of fertilizer on biomass forage yield in the present study was in line with previous findings (Semman et al., 2018). Variation in forage yield among oat varieties may be attributed to differences in environmental conditions, sowing seasons, soil fertility, and the genetic makeup of the varieties (Desta, 2022). The use of combined applications of organic and inorganic fertilizers could be kept at the optimum level of dry biomass yield (Saidu et al., 2012). According to Shiferaw (2014) found the application of all combinations of fertilizers, either alone or combined, significantly increased barley yields over untreated control. Integrated use of organic and inorganic fertilizers for tackling soil fertility depletion and a sustainable increase in forage yields had paramount importance (Getachew & Tilahun, 2017). Similarly, the increasing trend of green forage yield of oat in response to an increasing level of nitrogen fertilizer was observed by many other workers (Abate & Wegi, 2014).

3.1.8. *Dry matter yield*

The highest significant ($p<0.01$) dry matter yield (17.41 tons ha^{-1}) was observed in T3, where 150kg ha^{-1} NPS fertilizer was applied, followed by T2 (100kg NPS ha^{-1}), which had (16.55 tons ha^{-1}) DM yield, while the minimum DM yield was recorded for T0 (12.75 tons ha^{-1}) shown in Table 4. This may be due to soil fertility, type and level of fertilizer and time of harvesting. The present result was higher than the findings reported by Dawit & Mulusew (2017 where the DM yield values ranged from 7.7 to 10.3 ton ha^{-1} and 7.5 to 12.8 tons ha^{-1}, respectively. However, the finding reported by Getnet et al. (2003), who characterized 21 oat genotypes, was similar (10.13 to 15.39 tons ha^{-1}) as compared to the present study. A previous study by Muhumed et al. (2018) showed that the wider range of DMY differences among forage species could be attributed to differences in the genetic potential of the varieties. Moreover, the yielding ability of a genotype is the result of its interaction with the environment and its factors, such as soil characteristics, moisture and temperature (Eshetie et al., 2018).

3.1.9. *Leaf-to-stem ratio*

As shown in (Table 3) the significant ($p<0.01$) leaf to stem ratio was observed in treatment T3 (150 kg ha^{-1}) with a value of (0.923), followed by treatment (T2) with a value of (0.897) where 100kg NPS ha^{-1} were applied, while lowest leaf-to-stem ratio was observed in T0, with a value of (0.672). This may be due to the rate of fertilizer application, type of fertilizer used and the time of harvesting. According to Kebede et al. (2016) and

10.57647/jrs.2026.1602.18

Muhumed et al. (2018), leaf-to-stem ratio varied between 1.07 and 0.99 at the 50% flowering stage, which is in agreement with the current study. The average value of the leaf-to-stem ratio in the current finding was comparable to that reported by Abate and Wegi (2014), which was 0.64 to 0.78, with an overall mean value of 0.72. Leaf-to-stem ratio is an important trait in the selection of appropriate forage cultivars as it is strongly related to forage quality (Befekadu & Yunus, 2015).

A greater supply of balanced nutrition results in increased protein synthesis, which could have permitted a rise in the quantity, size, and succulence of leaves, as well as plant development by these observed higher leaves (Singh et al., 2018). In the current study, leaf-to-stem ratio decreased with the increasing age of plants, which is consistent with the findings of Berhanu et al. (2017), who reported the highest leaf-to-stem ratio at 1.03. According to Sharma et al. (2019), a reduction in the leaf-to-stem ratio with a delay in fodder cutting could be due to an increase in stem biomass owing to more dry matter accumulation in stems than leaves. Yiberkew et al. (2020) demonstrated that the type of soil fertilizer and plant spacing affect the leaf-to-stem ratio, with the highest ratio observed when manure and wider spacing were used.

3.1.10. *Leaf area per plant*

Treatment (T3) highly significant, produced the highest ($p<0.01$) leaf area of 131.7 cm^2 by application of NPS at 150 kg ha^{-1}, followed by T2 (125.67 cm^2) where NPS was applied at 100 kg ha^{-1}, while the lowest was recorded for T0 (106.67 cm^2) where no fertilizer was applied, as shown in Table 3. The variation in leaf area may be due to type of fertilizer, measuring stage, and the adaptability of the oat varieties to the environment. The current results were in line with Ahmad et al. (2011), who concluded that 150 kg ha^{-1} N and 60 kg ha^{-1} phosphorus produce the highest leaf area of 128 cm^2 in forage oat. Moreover, Bewuket (2021) reported that the application of NPS fertilizer significantly affected the leaf area of plants of different crops. According to Anbessa & Juskiw (2012), providing N fertilizer improved the barley's leaf area. The growth and development of plants are greatly influenced by their leaves, which in turn affect the yield of biomass used as feed.

3.2. Chemical composition parameter of oats

3.2.1. *Dry matter content*

The highest ($P< 0.01$) dry matter (DM) (93.3%) was recorded in T3, which received 150 kg ha^{-1} NPS, while the lowest (91.92%) was recorded in the control Table 4. This result is comparable to Wada et al. (2019), who reported 91.5% DM from CV-SRCP X 80Ab 2806 and 93.3% DM from CI-8237. Total DM of oat increased significantly with an increase in NPS and cow dung manure rates from 50 to 150 kg ha^{-1} and 5 to 15 tons ha^{-1}, respectively. DM of fodder Oat increased with increasing level of fertilizer (Ayub et al., 2013). In most forage crops, nitrogen fertilization resulted in a higher DM production (Ayub et al., 2017) with higher protein. Increasing the availability and absorption of nutrients results in increased plant height and the development of vegetative parts due to cell expansion and higher photosynthesis, leading to higher dry matter content and yield (Singh et al., 2018).

3.2.2. *Crude protein*

The highest ($P<0.01$) crude protein (CP%) (7.42%) was observed in T3, but was similar in all other treatments (Table 4). These variations might be induced by the rate of fertilizer. This result was in agreement with the findings in previous studies for the varieties Avon (7.80%) and Ravi (6.7%) (Muhammad et al., 2011). According to Saleem et al. (2015), the maximum CP was recorded in variety Sargodha-2011 (10.38%), followed by Avon (9.09%), which was higher than CV-SRCP X 80 Ab 2806 in the current study. CP is an essential nutrient for livestock and its content not only affects the economic benefits but also affects the milk yield and protein yield of livestock (Li et al., 2022). The crude protein content is also influenced by the maturity stage of the forage plant and crude protein content in leaves and stems decreases as the growth stage of the plant advances (Abdelraheem et al., 2023). Kumar et al. (2017) observed that 80 kg ha^{-1} N resulted in the maximum crude protein yield with 120 kg N ha^{-1}. Khan et al. (2014) concluded that crude protein quality may be affected by N application as it is an essential part of protein, chlorophyll, and protoplas

Table 3. Effect of different levels of Cow dung manure and inorganic fertilizer on growth parameters of walga oat

Treatment	Emergence date	Flowering date 50%	Plant height cm	Tiller no/plant	Tille no/m^2	Leaf area cm^2/plant	Leaf no/plant	Leaf to stem ratio	Biomass Yield t/h	DM yield (t/ha)
T0	13.50 a	89.00 a	120.67 ^{f}	4.60 ^{e}	104.66 ^{d}	106.67 ^{d}	5.07 ^{e}	0.672 ^{c}	53.13 ^{e}	12.75^{c}
T1	13.00 ab	87.00 ab	131.00 ^{d}	5.33 ^{c}	113.33 ^{c}	111.67^{cd}	5.23 ^{e}	0.847 ^{b}	56.47 ^{e}	14.68^{b}
T2	10.33 de	83.00 c	142.33 ^{b}	7.20 ^{a}	129.44^{ab}	125.67 ^{b}	6.17 ^{b}	0.897^{ab}	74.20 ^{b}	16.55^{a}
T 3	10.00 de	82.33 c	155.33 ^{a}	7.43 ^{a}	132.11 ^{a}	131.67 ^{a}	6.40 ^{a}	0.923 ^{a}	80.00 ^{a}	17.41^{a}
T4	11.50 cd	86.00 b	125.00 ^{e}	4.93^{de}	111.44 ^{c}	109.00 ^{d}	5.47 ^{d}	0.799 ^{b}	54.50 ^{e}	13.17^{c}
T5	12.50 b	85.67 b	133.00 ^{c}	5.20^{cd}	117.00 ^{c}	115.33 ^{c}	5.73 ^{c}	0.802 ^{b}	59.97 ^{d}	13.11^{c}
T6	12.00 bc	88.00 ab	138.00 ^{c}	6.73 ^{b}	124.46 ^{b}	121.31^{b}	5.93 ^{c}	0.800 ^{b}	64.67 ^{c}	13.67^{bc}
LSD	1.465	2.435	3.827	0.359	5.847	5.467	0.215	0.098	3.608	1.286
SEM	0.476	0.79	1.242	0.116	1.897	1.774	0.071	0.031	1.655	0.590
CV%	7	1.6	1.6	3.7	2.8	2.6	2.1	6.7	3.2	5.00
p-value	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

a,b,c… significance difference between treatments, LSD= Least significance difference; CV= coefficient of variance

10.57647/jrs.2026.1602.18

3.2.3. *Crude protein yield (ton/ha)*

Crude protein yield was affected (P<0.01) by the application of different type of fertilizer and rates of fertilizer shown in Table 4. The highest mean crude protein yield (1.29 t/ha) was recorded at T3 followed by T2 (1.12 t/ha) and the least (0.82 t/ha) was obtained at T0. In the current study, low CP yield recorded at later harvesting ages might be due to the differences in type and rate of fertilizer application, as well as the loss of leaves and the increase in cell wall constituents, which negatively affect crude protein yield. According to Geleti (2014), crude protein (CP) yield is calculated as the product of total dry matter (DM) yield and the CP concentration in the plant. This relationship is supported by the values obtained for CP percentage and DM yield across the different treatments.

3.2.4. *Crude fiber*

As shown in Table 4, the percentage of crude fiber in oats increases significantly (p<0.01) as the levels of nitrogen, phosphorus and sulfur decrease. The highest level of NPS (150 kg ha^{-1}) produced minimum amount of crude fiber (36.49%) in treatment T3; while the highest amount of crude fiber (40.49%) was seen in T0. This may be caused by the crop's maturity, time of harvest and type of fertilizer used or rate of fertilizer. The fiber content of oat increases as a result of an increase in cellulose and dry matter when maturity of oats increases. Comparable outcomes were noted for cowpea (Hasan et al., 2010).

3.2.5. *Acid detergent fiber*

A maximum significant increase (P <0.01) in acid detergent fiber (ADF) content was observed in T1, as shown in Table 4. The highest (52.83%) ADF was observed in T1, followed by T0, which had (52.11%) ADF, while the minimum ADF was recorded in T3 (48.03%). This may be due to type of fertilizer used, the level of fertilizer used and the time of harvesting. This result is similar to Kebede et al. (2021) who reported ADF values ranging from 45.4 to 52, with a mean of 48.5%.

However, the current result is higher than the result of Wada et al. (2019), who reported ADF mean values ranging from 24.2% to 28%. This may be due to the type and level of fertilizer used, as well as the time of harvesting. High acid detergent fiber is generally considered less desirable and less safe for animal digestion (Fenetahun et al., 2021). Lower ADF content indicates higher digestibility and desirability, which agrees with the report of Negash et al. (2017) who observed 23.7% in the CV-SRCP X 80 Ab 2806 variety. Similar results were reported for fodder oats (Kumari et al., 2014), *Brassica Rapa* L. (Paul et al., 2020), Napier bajra hybrid (Sharma et al., 2012), and Bermuda grass (Kering et al., 2011).

3.2.6. *Neutral detergent fiber*

The highest significant (P<0.01) mean of NDF content was observed for control (71.24%) while the lowest value was recorded for treatment T3 (66.11%) at 150 kgh^{-1} NPS application. The effect of cow dung manure showed an intermediate result between control and NPS fertilizer type in T6 (70.60 %), where cow dung manure applied at 15 tons ha^{-1}. This may be explained by the fact that NPS fertilizer immediately and cow dung gradually improve plant growth and promote the development of new leaves and shoots. The mean NDF content of oats in the current study is nearly comparable with Kebede et al. (2021) who reported a mean value ranging from 70.1 to 74.8. The NDF value is primarily affected by harvesting time (Molla et al., 2018) and by advancing maturity (Ayub et al., 2013). This might be due to an increase in fiber content, which could be accompanied by a decrease in CP content associated with an increase in the proportion of lignified feed structural tissue at a later stage of growth. Balabanli et al. (2010) also reported that NDF content peaked at low fertilizer levels and then decreased with increasing fertilizer rates.

3.2.7. *Acid detergent lignin*

Significant (P>0.01) mean of ADL content was observed in the control T0 (8.00 %) and T4 (7.79%), as shown in Table 4. The effect of cow dung manure had an intermediate value (7.52%) between the control and NPS fertilizer type treatment. The current result was higher than the report of Megersa, (2021), who reported 4.56% to 6.52% for different oat genotypes in the highland of Ethiopia. In contrast, the current result was lower than the report of Kebede et al. (2021) who reported ADL content for different oat genotypes ranging from 9.4 to 11.7 with a mean value of 10.5%. The lower ADL content indicates that it is more digestible and desirable, which agrees with the report of Negash et al. 2017) who observed 23.7% in the CV-SRCP X 80 Ab 2806 variety.

3.2.8. *Ether extract*

Application of 150 and 100 kg NPS ha^{-1} (Table 4) significantly increased (P<0.01) ether extract in T3 (0.874%) and T2 (0.607%), respectively. Whereas, T4 and T0 recorded lower ether extract at 5 tons ha^{-1} (0.323%) and the control (0.243%), respectively. This may be a stage of maturity, type of fertilizer used, the level of fertilizer, and the time of harvesting. Earlier research done by Uddin et al. (2005) reported a significant increase in forage oat ether extract with the increasing level of N fertilizer from 0 to 115 kg N/ha. A similar trend of ether

10.57647/jrs.2026.1602.18

extract content with increasing dose of N fertilization was observed in fodder oats (Kumari et al., 2014) and fodder pearl millet (Meena et al., 2012). However, Saleem et al. (2015) reported significant differences in crude fat content among oat varieties.

3.2.9. *Total ash content*

Application of 150 and 100 kg NPS ha^{-1} recorded higher ash in treatment (T3) 14.02% and (T2) 13.75%, respectively. The minimum ash percentage was significantly recorded in treatments T0 (11.15%) and T6 (12.73%). This might be due to plant development stage, morphological fractions, soil characteristics and fertilizer type. The present finding correlates with that of (Kebede et al., 2021), who reported ash content with a mean of 10.8% and a range of 9.4 to 12.5. On the other hand, Wada et al. (2019) observed a lower ash amount, with a mean of 8.9% and a range of 8.4 to 9.99 from CV-SRCP X 80Ab 2806 and CI-8237, respectively. The genotypes of oats have been reported to differ significantly in their ash concentrations (Khan et al., 2014). This could be caused by variations in how various genotypes of plants absorb nutrients from the soil and use them within the plants. The leaf to stem ratio and maturity stage of the fodder plant affect mineral contents (Kebede et al., 2021). Kebede et al. (2021) suggest that a higher ash percentage in fodder may be a sign of increased mineral concentration. The increased availability of N to the plants and mineral materials may be the cause of the increase in ash content observed with increasing doses of N fertilization.

3.2.10. *Correlation between growth parameter*

The correlation coefficients of plant height, number of tillers per plant, number of tillers per square meter, number of leaves per plant, leaf area per plant, stem-to-leaf ratio, and biomass yield of oats are presented in Table 5. There is a highly significant ($p<0.01$) positive correlation for biomass yield with plant height, number of tillers per plant, number of tillers/m^2, number of leaves per plant, leaf area per plant, and stem to leaf ratio. The positive significant relation of biomass yield with other growth and yield parameters reveals the true relation of parameters and direct selection through this trait could be effective. Thus, those parameters are major contributors to biomass yield as they have a strong positive correlation. This result agrees with Dumlupinar et al. (2012) and Sokoto et al. (2012).

3.2.11. *Correlation between chemical composition*

The simple correlation coefficient for the chemical composition of oat treatments exhibited a significant ($p<0.01$) positive correlation between DM yield and other parameters (Table 6), but a negative correlation with NDF, ADL, and ADF. This indicates that any agronomic practices that positively influence growth and productive characteristics also influence dry matter yield. The true relationship between the parameters was observed through the significant positive correlation between DM yield, CP, and crude fat. This indicates that direct selection using this trait could be successful.

Table 4. Effect of different levels of cow dung and inorganic fertilizer on walga oat forage chemical compositions

Treatment	DM%	DMY (t/ha)	OM%	CP%	CPY (t/ha)	CF%	EE%	NDF%	ADF%	ADL%	ASH%
T0	91.92^b	12.75^c	86.67^c	6.38^b	0.82^c	40.49 ^{a}	0.243^c	71.24^a	52.11^a	8.00^a	11.15^b
T1	92.62^{ab}	14.68^b	88.90^b	6.63^b	0.97^b	38.09 ^{ab}	0.472^b	70.05^c	52.83^a	7.38^b	12.96^b
T2	92.98^{ab}	16.55^a	89.74^a	6.74^b	1.12^a	36.85^b	0.607^{ab}	69.38^{cb}	50.25^{ab}	7.14^c	13.75^{ab}
T3	93.30^a	17.41^a	89.92^a	7.42^a	1.29^a	36.49 ^{b}	0.874^a	66.11^d	48.03^b	7.12^c	14.02^a
T4	92.34^b	13.17^c	87.34^c	6.54^b	0.86^b	38.96^{ab}	0.323^c	70.96^a	51.29^a	7.79^a	12.35^b
T5	92.40^b	13.11^c	88.29^b	6.47^b	0.85^b	38.89^{ab}	0.449^b	70.75^b	50.99^a	7.55^{ab}	13.09^{ab}
T6	92.77^{ab}	13.67^{bc}	88.80^b	6.47^b	0.88^b	39.15^a	0.539^b	70.60^b	50.78^a	7.52^{ab}	12.73^b
LSD	1.777	1.286	0.679	0.471	0.471	2.149	0.389	4.984	2.645	1.042	3.048
SEM	0.816	0.590	0.311	0.216	0.216	0.986	0.1785	2.288	1.0412	0.478	1.399
CV%	1.1	5.00	0.40	4.00	4.00	3.1	28.4	3.5	2.9	7.8	13.3
p-values	NS	0.001	0.001	NS	0.007	0.001	NS	0.01	0.01	NS	NS

a,b,c… significance difference between treatments, LSD= Least significance difference; CV= coefficient of variance, DM=dry matter; DMY=dry matter yield; CF=crude fiber, OM=organic matter; CP= crude protein; EE= Ether extract, , CPY=crude protein yield, NDF= neutral detergent fiber; ADF= acid detergent fiber

Table 5. Correlation coefficient of growth treatments

	Plantheight	Tillerno/plant	Tillerno/m^2	Leaf area/plant	leaf no/Plant	Leaf /stemratio
Tiller no/plant	0.91**					
Tiller no/m^2	0.89**	0.92**				
Leaf area cm^2/plant	0.90**	0.90**	0.91**			
leaf no/ Plant	0.93**	0.91**	0.85**	0.90**		
Leaf /stem ratio	0.77**	0.75**	0.84**	0.80**	0.70**	
Biomass yield	0.94**	0.92**	0.89**	0.90**	0.95**	0.72**

*, **, Significant at 5% and 1% probability levels

10.57647/jrs.2026.1602.18

Table 6. Correlation coefficient of chemical composition of treatments

	DM	OM	CP	CF	EE	NDF	ADF	ADL	ASH
OM	0.54 *								
CP	0.00	0.48 *							
CF	0.30	-0.67 **	-0.53 *						
EE	0.38	-0.66 **	0.54 *	-0.66 **					
NDF	-0.27	-0.57 *	-0.52 *	0.52 **	-0.58 *				
ADF	-0.21	-0.50 *	-0.35	0.41	-0.35	0.56 *			
ADL	-0.30	-0.55 *	-0.42	-0.70 **	0.49 *	0.34	0.18		
ASH	0.27	0.44	0.09	-0.11	0.14	0.00	-0.49 *	-0.04	
DMY	0.49 *	0.82 **	0.56 *	-0.72 **	0.60 **	-0.49 *	-0.48 *	-0.56 *	0.41

*, **, Significant at 5% and 1% probability levels
DM= Dry matter; OM= Organic matter; CP= Crude protein; CF= Crude fiber; EE=Ether extract; NDF= Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin; DMY=Dry matter yield

Table 7. Partial Budget Analysis

Budget components	Cow manure and chemical Fertilizer treatments						
	T0	T1	T2	T3	T4	T5	T6
Labor cost /ha	1800	1950	1950	1950	1950	1950	1950
Seed cost ETB/ha	3500	3500	3500	3500	3500	3500	3500
fertilizer cost ETB/ha	0	2000	4000	6000	1500	3000	4500
TVC (Total variable cost)	5300	7450	9450	11450	6950	8450	9950
GFB (Growth field benefit)	53130	56470	74200	80000	54500	59970	64670
NB (Net benefit)	47830	49020	64750	68550	47550	51520	54720
ΔTVC	_	2150	2000	2000	-4500	1500	1500
Δ GFB	_	3340	17730	5800	-25500	5470	4700
Δ NB	_	1190	15730	3800	-21000	3970	3200
MRR (Marginal rate of return)	_	0.553	7.865	1.90	4.66	2.64	2.133

ETB = Ethiopian Birr (1000 ETB=7 US$)

3.2.12. *Partial budget analysis*

Economic analysis shown in Table 7 was performed for each treatment. Annual forage crops required lower total input cost (TIC) and total labor cost (TLC). The market price of each feed biomass was recorded at the time of purchase, expressed in Birr per kilogram. The average feed yield per hectare was calculated and multiplied by the corresponding market price to determine the feed cost per hectare (Birr/ha) for each treatment. The total variable cost (TVC) was computed as the sum of labor costs, seed costs, and fertilizer costs incurred during the experimental period. Gross field benefit (GFB) was calculated by multiplying the total biomass yield by the market price of the feed. Net benefit was calculated by subtracting the total variable cost from the growth field benefit. The marginal rate of return (MRR) was calculated as MRR=ΔNR/ΔTVC (Atumo et al., 2021). The highest total variable cost (TVC) produced in treatment T3 (11450 Birr) was due to higher fertilizer cost compared to other treatments. While treatments T0 and T1 (5300 and 7450 Birr) had very low costs compared to other treatments due to relatively lower demands for input and labor costs. Income was generated from the sale of forage biomass. The economic analysis also revealed that the highest net benefits of 68550 and 64750 ETB/ha with marginal rates of returns of 1.9 (190%) and 7.865(7.865%) were obtained under a seed rate of 100 kg/ha and a NPS fertilizer rate of 150 &100 kg/ha, respectively.

4. Conclusion

Walga Oat variety was evaluated for biomass yield, maturity stage and chemical composition during the main cropping season at Choman Guduru District. Most of the yield and agronomic parameters were significantly affected by the effects of cow dung manure and NPS fertilizer type. Generally, based on the current results, higher values of plant height, number of tiller/m^2, biomass yield, leaf to stem ratio and number of leaves per plant were recorded by using 150 NPS kg ha^{-1} in (T3), resulting in a higher dry matter accumulation rate over the growing period. In addition to this chemical composition of Walga oats was high in treatment T3. Overall, the findings from the study area suggest that Walga oats have significant potential to address the recurring issue of feed scarcity. The application of 150 kg NPS ha^{-1} fertilizer was recommended for the region, as it provided the highest net benefit. Additionally, the use of high doses of cow dung manure (15 tons per hectare) could serve as a viable alternative to produce high-quality oat fodder with optimal yield.

Acknowledgments

We would like to thank Choman Guduru Agricultural Office and Wallaga University for their unreserved support.

CONFLICT OF INTEREST:
We, authors of the manuscript, declare that the research paper was developed with our consent and no single conflict of interest exists among us upon its publication.

References

Abate, D. and Wegi, T., 2014. Determination of optimum seed and fertilizer rate for fodder oat in Bale Highland, Southeastern Ethiopia. *International Journal of Soil and Crop Sciences*, 2(7), 73-76.

Abbas, G., Iqbal, J, Waheed, A. and Naveed Riaz, M., 2012. Relationship between transformational leadership style and innovative work behavior in educational institutions. *Journal of Behavioural Sciences 22*(3).

Abdelraheem, N., Li, F., Guo, P., Sun, Y., Liu, Y., Cheng, Y. and Hou, F., 2023. Nutrient utilization of native herbage and oat forage as feed for Tibetan sheep (Ovis Aries). *Grassland Science*, *69*(1), 12-22.

Abebe, Y., Tafere, M., Dagnew, S., Tolla, M., Gebreselassie, Y., Amane, A. and Molla, D., 2015. Best fit practice manual for Rhodes grass (*Chloris gayana*) production. *Bdu Cascape*, 17-22.

Adane,A.,2023.Effect of Rhizobia Inoculants and Vermicompost Rates on Soil Physico-Chemical Properties and Yields of Faba Bean (*Vicia faba* L) in Ambo District, West Shewa, Ethiopia (Doctoral Dissertation, Ambo University, Ethiopia.

Adnew, W. and Bimrew, A., 2023. Agronomic Performance, Yield and Nutritional Value of Grasses affected Agro-ecological Settings in Ethiopia. Food and Agriculture Organization of the United Nations. *Advances in Agriculture*, 2023

Ahmad, A. H., Wahid, A., Khalid, F., Fiaz, N. and Zamir, M. S. I., 2011. Impact of organic and inorganic sources of nitrogen and phosphorus fertilizers on growth, yield, and quality of forage oat (*Avena Sativa* L). *Cercetari Agronomice in Moldova (Agronomic Research in Moldavia)* 44(3):39-49.

Ahmed, S. H. E. R., Ansar, M., Muhammad, I. J. A. Z. and Sattar, A., 2015. Proximate analysis of forage Sorghum cultivars with different doses of nitrogen and seed rate. *Turkish Journal of Field Crops*, *21*(2), 276-285.

Ali, I., Zamir, S. I., Hussain, M., Shan, M. D. and Ajmal, M., 2017. Agro-economic studies of different oat (*Avena sativa* L.) cultivars under varying nitrogen levels. Journal of Environmental and Agricultural Sciences, 13:31–39.

Aklilu, M. and Alemayehu, M., 2007. Measurements in pasture and forage cropping systems. Technical manual 18, EIAR, Addis Ababa, Ethiopia. Website: http://www.eiar.qov.et

Anbessa, Y. and Juskiw, P., 2012. Strategies to increase nitrogen use efficiency of spring barley. *Canadian Journal of Plant Science*, *92*(4), 617-625.

AOAC (Association of Official Analytical Chemists)., 1995. Official methods of analysis. 15th ed. Washington, DC, 69-88. USA.

AOAC (Association of Official Analytical Chemists)., 2000. Official methods of analysis. Gaithersburg, MD, USA.

Atumo, T.T., Heliso, M.F., Hibebo, D.K., Tunkala, B.Z. and Mekasha, Y., 2021. Top dressing of fertilizers: A way forward for boosting productivity and economic viability of grasslands. In *Grasses and Grassland-New Perspectives*. IntechOpen.

Ayub, M., Ahmad. R., Nadeem, M.A., Ahmad, B. and Khan, R.M.A., 2017. Effect of Different Levels of Nitrogen and Seed Rates on Growth, Yield and Quality of Maize Fodder. Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. *Pakistan Journal of Agricultural Science 40: 3-4.*

Ayub, M., Shoaib, M., Zamir, M. S. and Akhtar, M. J., 2013. Dry Matter Yield of Oat-Egyptian Clover Mixture under Varying Proportions and Different Growth Stages of Oat. *International Journal of Agriculture and Biology*, *15*(4).

Balabanli, C, Albayrak, S. and Yuksel, O., 2010. Effect of nitrogen, phosphorus and potassium fertilization on the quality and yield of native rangeland. *Turkish Journal of Field Crops*, *15*(2), 164-168.

Befekadu, C. and Yunus, A., 2015. Evaluation of biomass yield and growth performance of Alfalfa and Oat cultivars in the High Land of Arsi, Ethiopia. *Livestock Research for Rural Development*, *27* (6).

Berhanu, Y., Lars O., Ajebu N., Ayana A. and Jens B. A., 2017. Methane emissions from ruminant livestock in Ethiopia: Promising forage species to reduce CH_4 emissions. Agriculture, 9(6), 130.

Bewuket, G., 2021. Evaluation of Different Rates of NPS on Growth and Yield Performances of Garlic (*Allium sativum* L.) in Cheha District, Gurage Zone, Ethiopia. *International Journal of Agronomy*. https://doi.org/10.1155/2021/7742386

Bhatt, K. and Maheshwari, D. K., 2020. Zinc solubilizing bacteria (Bacillus megaterium) with multifarious plant growth promoting activities alleviate growth in Capsicum annuum L. *3 Biotech*, *10*(2), 36.

CIMMYT Economics Program,1988.From agronomic data to farmer re commendations: *an economics training manual* (No. 27). Completely revised edition. Mexico, D.F.

CSA (Central Statistical Agency)., 2022. Agricultural sample survey. Report on livestock and livestock characteristics (private peasant holdings). Central Statistical Agency (CSA): Addis Ababa, Ethiopia, p 194.

Dawit, A. and Mulusew, F., 2017. Performance of fodder oat (*Avena sativa*) genotypes for yield and yield attributes in the highlands of Bale. *Journal of Biology, Agriculture and Healthcare*, *7*(19).

Desta, A. G., 2022. Evaluation of Forage and Seed Yield of *Avena Sativa* Varieties at Debremarkos University Demonstration Site. International Journal of Agriculture and Biosciences, 11(2), 90-94.

Dinka, T.B., Goshu, T.A. and Haile, E.H., 2018. Effect of integrated nutrient management on growth and yield of food barley (Hordeum vulgare) variety in toke kutaye district, west showa zone, Ethiopia. *Advances in Crop Science and Technology*, *6*(3), pp.1-8.

Dumlupinar, Z., Kara, R., Dokuyucu, T. and Akkaya, A., 2012. Correlation and Path Analysis of Grain Yield and Yield Components of Some Turkish Oat Genotypes. Pakistan Journal of Botany. 44(1): 321-325.

Emamu, T. and Tesfaye, W., 2021. The effect of application of Vermicompost and NPS fertilizer on selected soil properties and yield of maize (*Zea mays* L.) at Toke Kutaye, Ethiopia. *International Journal of Applied Agricultural Sciences*, *7*(5), 247-257.

Eshetie, A., Berhanu, A. and Yeshambel, M., 2018. Evaluation of biomass yield and nutritional quality of oats–vetch mixtures at different harvesting stages under residual moisture in Fogera District, Ethiopia, Agric & Food Secure, 7 (88).

FAO, 2016. Agriculture Organization of the United Nations: FAO's role in livestock and the environment. Rome, Italy.

Fenetahun, Y., Yuan, Y., Xinwen, X. and Yongdong, W., 2021. Effect of grazing enclosure on species diversity, phenology, biomass and carrying capacity in Borana Rangeland, Southern Ethiopia Frontiers in Ecology and Evolution, 8, 623627

Gebremariam, T. and Belay, S., 2023. Livestock nutrition & feed balance on smallholder farms in Tanqua Abergelle district, northern Ethiopia. *Heliyon*, 9(11).

Gebremedhn, B., Alemu A. and Haylay G., 2015. Evaluation of different oat varieties for fodder yield and yield-related traits in Debre Berhan Area, Central Highlands of Ethiopia. Livest Res Rural Dev 27:1-7.

Geleti, D., 2014. Agronomic and nutritional evaluation of selected forage legumes and locally available feedstuff, and characterization of forage and dairy innovation systems in Bako and Nekemte Peri-Urban Areas, Oromia, Ethiopia. Ph.D. dissertation, Addis Ababa University, Ethiopia.

Getachew, A. and Tilahun, A., 2017. Integrated soil fertility and plant nutrient management in tropical agro-ecosystems: a review, *Pedosphere*. 27 (4):662–680.

Getnet, A., Fekede, F., Abreham, G. and Muluneh, M., 2003. Characterization of selected oats varieties for their important production traits in the highland of Ethiopia, *Proceedings of the 11th Annual Conferences of the Ethiopian Society of Animal Production (ESAP)*, Addis Ababa, Ethiopia, 305–314.

Godara, A. S., Duhan, B. S. and Pahuja, S. K., 2016. Effect of different nitrogen levels on forage yield, quality and economics of oat (*Avena sativa* L.) genotypes. *Forage Research*, *41*(4), 233-236.

Gomez, K.A. and Gomez, A.A., 1984. *Statistical Procedures for Agricultural Research* (2nd ed.). New York: John Wiley & Sons.

Grabber, J. H. and Mertens, D. R., 2006. Direct versus sequential analysis of acid-detergent insoluble nitrogen in forage legume hays [abstract]. In: Proceedings of the ADSA and ASAS Annual Meeting, July 9-13, 2006, Minneapolis, Minnesota. CD-ROM.

Han, Z., He, W., Shi, H., Wang, C., Liu, C. and Feng, Y., 2023. Effects of the integrated use of dairy cow manure on soil properties and biological fertility. *Sustainability*, *15*(15), p.11693.

Hasan, M. R., Akbar, M. A., Khandaker, Z. A. and Rahman, M. M., 2010. Effect of nitrogen fertilizer on yield contributing character, biomass yield and nutritive value of cowpea forage. Bangladesh Journal of Animal Science, 39(1 & 2), 83-88.

Irfan, M., Ansar, M., Sher, A., Wasaya, A. and Sattar, A., 2016. Improving forage yield and morphology of oat varieties through various row spacing and nitrogen application. Journal of Animal and Plant Sciences, 26(6).

Jayanthi, N., Pinkham, C., Dugas, L., Patrick, B. and La Bella, C., 2013. Sports specialization in young athletes: evidence-based recommendations. *Sports Health*, *5*(3), 251-257.

Joshi, B.K., Thapa, D.B. and Bhatta, M.R., 2015. Genetic parameters of common wheat, *Journal of Nepal Agricultural Research Council*, 1:9-13.

Kebede, G., Mulisa, F., Fekede, F., Kedir, M., Getnet, A., Diriba, G. and Muluneh, M., 2021. Yield and nutritional quality of Oat (*Avena sativa*) genotypes under vertisols conditions in the central highlands of Ethiopia. *Journal of Agro Environment Science*, 6(2), 1–16.

Kebede, G., Fekede, F., Getnet, A., Alemayehu, M., Tadesse, T. and Muluneh, M., 2016. Study on current production and utilization status and further prospects of Oats (*Avena sativa*) in mixed farming systems of the central highland areas of Ethiopia. *Academic Research Journal of Agricultural Science and Research*, *4*(5), 164-173.

Kering, M. K., Guretzky, J., Funderburg, E. and Mosali, J., 2011. Effect of nitrogen fertilizer rate and harvest season on forage yield, quality, and macronutrient concentrations in midland Bermuda grass. Communications in soil science and plant analysis, 42(16), 1958-1971.

Khan, A., Anjum, M.H., Rehman, M.K.U., uz Zaman, Q. and Ullah, R., 2014. Comparative study on quantitative & qualitative characters of different oats genotypes under agro climatic conditions of Sargodha. *American Journal of Plant Sciences*. 5(20), p. 3097.

Kumar, B.S., Singh, R.V., Gupta, A.K. and Ravinder, J., 2017. Effect of Nitrogen Levels and Cutting Management on Nitrogen Content, Protein Content and Protein Yield of Oat (*Avena sativa* L.). *International Journal of Current Microbiology and Applied Science*. 6(7): 2077-2083.

Kumari, A., Kumar, P., Ahmad, E., Singh, M., Kumar, R., Yadav, R.K., Datt, C. and Chinchmalatpure, A., 2014. Fodder yield and quality of oat fodder (*Avena Sativa*) as influenced by salinity of irrigation water and applied nitrogen levels. *Indian Journal of Animal Nutrition*. 31(3): 266-71.

Li, T., Peng, L., Wang, H., Zhang, Y., Wang, Y., Cheng, Y. and Hou, F., 2022. Multi-cutting improves forage yield and nutritional value and maintains the soil nutrient balance in a rain-fed agro-ecosystem. *Frontiers in Plant Science*, *13*, 825117.

Mangesh, S.S., 2016. Effect of different levels of nitrogen on performance of fodder oat (*Avena sativa* L.) varieties under lateritic soil of Konkan region. M.Sc. Thesis, Dr. Balasahed Sawant Konkan

Krishi Vidyapeeth, Dapoli (Agricultural University), Ratnagiri (Maharashtra), India.

Maral, H., Dumlupinar, Z., Dokuyucu, T. and Akkaya, A., 2013. Response of six Oat (*Avena sativa* L.) cultivars to nitrogen (*Pennisetum glaucum*) cultivars under irrigated conditions of North-Western Rajasthan.

Megersa, T., 2021. Assessment and utilization practices of oat (*Avena sativa*) as feed and food resources and chemical evaluation of its silage in Kimbibitwereda of north Shewa zone, Ethiopia. Debra Berhan University, 6

Mengistu, A. and Mekasha, A., 2007. Measurements in pasture and forage cropping systems. Ethiopian Institute of Agricultural Research.

Mengistu, S., Ajebu, N., Adugna, T., Melkamu, B., Abera, A., Endalkachew, W. and Mesfin, Z., 2021. Livestock production challenges and improved forage production efforts in the Damot Gale District of Wolaita Zone, Ethiopia. *Advances in Agriculture*, *2021*, 1-10.

Molla, E.A., Wondimagegn, B.A. and Chekol, Y.M., 2018. Evaluation of biomass yield and nutritional quality of oats–vetch mixtures at different harvesting stage under residual moisture in Fogera District, Ethiopia. *Agriculture & Food Security*, *7*(1), p.88.

Muhammad, A. M.A., Muhammad Shehzad, M.S., Nadeem, M.A., Muhammad Pervez, M.P., Muhammad Naeem, M.N. and Naeem Sarwar, N.S., 2011. Comparative study on forage yield and quality of different oat (Avena sativa L.) varieties under agro-ecological conditions of Faisalabad, Pakistan.

Muhumed, O. A., Zewdu, D.T. and Ameha, D.N., 2018. *Effect of Harvesting Stage on Agronomic Traits, Herbage Yeild and Nutritive Value of Sudan Grass (Sorghum Sudanense L.), Mixed with Lablab (Lablab purpureus l.) in Faafan Zone, Ethiopia* (Doctoral dissertation, Haramaya University).

Mulualem, T. and Molla, M., 2013. Production Constraints, Farmers' Preferences and Participatory on-Farm Evaluation of Improved Forage Technologies in Selected Districts of Southern Ethiopia. Greener Journal of Agricultural Sciences, 3 (9): 628-635.

Mut, Z., Akay, H. and Erbas, O. D., 2015. Hay yield and quality of oat (*Avena sativa* L) genotypes of worldwide origin. International Journal of Plant Production, 9(4), 507-522.

Naghizadeh, M., Klaver, L., Schönherz, A. A., Rani, S., Dalgaard, T. S. and Engberg, R. M., 2022. Impact of dietary sodium butyrate and salinomycin on performance and intestinal microbiota in a broiler gut leakage model. Animals, 12(1), 111.

Neelar, A., 2011. Response of oat genotypes to seed rate and nitrogen levels on forage yield and quality under irrigation. *MSc. (Ag) thesis submitted to the Department of Agronomy, College of Agriculture, Dharwad, University of Agricultural Sciences,* Dharwad, India.

Negash, D., Getachew, A., Mengistu, U. and Solomon, M., 2017. Chemical composition and nutritive value of oats (*Avena sativa*) grown in mixture with vetch (*Vicia villosa*) with or without phosphorus fertilization in East Shoa Zone, Ethiopia. *Journal of Nutrition and Food Sciences*, 7(4).

fertilization for agronomical traits. Turkish Journal of Field Crops, 18(2), 254-259.

Meena, S. N., Jain, K. K., Prasad, D. and Ram, A., 2012. Effect of nitrogen on growth, yield and quality of fodder pearl millet

Ongadi, M., Mpolya, E., Gachuiri, C., Muyekho, F. and Lukuyu, A., 2020. Effects of season variation on water, feed, milk yield and reproductive performance of dairy cows in smallholder farms in eastern Africa. *Tropical Animal Health and Production, 52*(6), 3039–3048.

Paul, B. K., Koge, J., Maass, B. L., Notenbaert, A., Peters, M., Groot, J.C. and Tittonell, P., 2020. Tropical forage technologies can deliver multiple benefits in Sub-Saharan Africa. A meta-analysis. *Agronomy for Sustainable Development*. *40*, 1-17.

Qi, X., Gou, J., Chen, X., Xiao, S., Ali, I., Shang, R., Wang, D., Wu, Y., Han, M. and Luo, X., 2021. Application of mixed bacteria-loaded biochar to enhance uranium and cadmium immobilization in a co-contaminated soil. *Journal of Hazardous Materials*, *401*, p.123823.

Saidu A., Ole K. and Leye B. O., 2012. Performance of Wheat (*Triticum aestivum L.*) as influenced by complementary use of organic and inorganic fertilizers, *International Journal of Science and Nature*. 5: 532–537.

Sajjad, A., Munir, H., Ahmed Anjum, S., Tanveer, M., Rehm Abate, D. and Wegi, T., 2014. Determination of optimum seed and fertilizer rate for fodder oat in Bale highland, Southeastern Ethiopia. International *Journal of Soil and Crop Sciences*, 2(7), 73-76.

Saleem, M., Zamir, M. S. I., Haq, I., Irshad, M. Z., Khan, M. K., Asim, M. and Rehman, S., 2015.Yield and quality of forage oat (*Avena sativa* L.) cultivars as affected by seed inoculation with nitrogenous strains. *American Journal of Plant Sciences*, 6(19), 3251.

Semman, U., Bedasa, E. and Tamirat, D., 2018. Performance Evaluatio n of Improved Oat Varieties/Accessions at the Highland of Guji Zo ne, Bore, Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 8(17).

Sharma, A., Sharma, K., Bharat, R.K. and Rai, R., P.K., 2012. Effect of different levels of nitrogen, organic manure and planting time on yield and quality of hybrid Napier. *Indian Journal of Animal Nutrition*, *29*(1), 33-39.

Sharma. A., Sharma, G.D., Kumar, N., Chahal, A. and Sankhyan, N.K., 2019. Studies on the performance of promising varieties of oat under different cutting regimes in mid-hill conditions of Himachal Pradesh. *Journal Pharmacology and Phytochemistry, 8 (2):728 – 731.*

Shiferaw, B., 2014. Effect of Organic and Inorganic Fertilizer Application and Seedbed Preparation on Potato Yield and Soil Properties on Alisols of Chencha. *International Journal of Natural Sciences Research*. 2(8): 123-132

Singh, V. K., Sinha, A. K., Takawle, P. S., Shindey, D. N. amd Srivastav, M. K., 2018. Evaluation of different oat varieties for green fodder and seed production yields. *International Journal of Advanced Multidisciplinary Research. 5*, 3668-3670.

Sokoto, M.B., Abubakar, I.U. and Dikko, A.U., 2012. Correlation Analysis of some Growth, Yield, Yield Components and Grain Quality of Wheat (*Triticum aestivum* L.). Nigerian Journal of Basic and Applied Science. 20(4): 349-356.

Syed, A., Sajid. S., Lal, H., Akhtar, R. Minhas, M.S., Bukhari, M.S. and Ghani, A., 2015. Evaluation of different oat (*Avena sativa L.*) varieties for forage yield and related Characteristics. Sci Lett 3(1): 13-16.

Tariku, B., Tolera, A. and Ermiyias, H., 2018. Effect of Integrated Nutrient Management on Growth and Yield of Food Barley (*Hordeum vulgare*) Variety in Toke Kutaye District, West Showa Zone, Ethiopia. Advanced Crop Science Technology; 6: 365.

Tena, W., Sheleme, B., 2011. Identification of growth-limiting nutrient (s) in Alfisols: soil Physico-chemical properties, nutrient concentrations and biomass yield of maize. *American journal of plant nutrition and fertilization technology*, *1*(1), 23-35.

Tessema, A. and Getinet, 2020. Evaluation of oats (*Avena sativa*) genotypes for seed yield and yield components in the highlands of Gamo, Southern Ethiopia. *Ethiopian Journal of Agricultural Sciences*, *30*(3), 15-23.

Tisdale, S. L., Nelson, W. L. and Beaton, J. D., 2002. Soil Fertility and Fertilizers. Collier Macmillan Publishers.

Tulu, A., Mekonnen, D. and Worku, T., 2020. Evaluation of Seven Oat (*Avena Sativa*) Genotypes for Biomass Yield and Quality Parameters under Different Locations of Western Oromia, Ethiopia. Advances in Agriculture, 2020, 1-7.

Uddin, M. M., Khandaker, Z. H. and Sultana, M. N., 2005. Effect of levels of nitrogen with or without phosphorus fertilizer on oat (*Avena sativa*) forage production harvested at various ages: II. Nutritive value and macro mineral contents. *Bangladesh Journal of Animal Sci*ence. *34*(1-2), 63-71.

Velykis, A., Maiksteniene, S., Arlauskiene, A., Kristaponyte, I. and Satkus, A., 2009. Mechanical weed control in organically grown spring oat and field pea crops. Agronomy Research. 7 (Special Issue 1), 542-547.

Wada, A., Kassa, S. and Deribe, G., 2019. Biomass yield and nutritional quality of different oat varieties (*Avena sativa*) grown under irrigation conditions in Sodo Zuriya district, Wolaita zone, Ethiopia. Agricultural Research & Technology: *Open Access Journal*. 20(4), 197–204.

Yiberkew, N., Yeshambel, M. and Bimrew, A., 2020. Effects of Fertilizer Types and Plant Spacings on Plant Morphology, Biomass Yield and Chemical Composition of Brachiaria Hybrid Mulato II Grass Grown in Lowlands of Northwest Ethiopia. Scientific Papers: *Animal Science and Biotechnologies*. 53 (1).

Yirga, C., Erkossa, T. and Agegnehu, G., 2019. Soil acidity management. Ethiopian Institute of Agricultural Research (EIAR). Addis Ababa, Ethiopia.

Zhang, X., Davidson, E. A., Mauzerall, D. L., Searchinger, T. D., Dumas, P. and Shen, Y., 2020. Managing nitrogen for sustainable development. *Nature*, 528(7580), 51–59.