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The Effect of Different Seeding and Fertilizer Rates on Agronomic traits, Yield and Yield Components of Two Fodder Oat *(Avena Sativa)* Varieties in Highlands of North Shewa, Oromia, Ethiopia

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Abstract: The experiment was conducted to evaluate the effect of seed and fertilizer rates on biomass yield and other agronomic treats of two oat varieties (Bona-bas and Bate) at Kuyu sub-site of Fitche Agricultural Research Center during 2022. Four levels of Nitrogen fertilizer rates (0, 23, 46 and 69 $kgha^{-1}$) and three levels of seed rates (60, 80 and 100 $kgha^{-1}$) with two oat varieties (Bona-bas and Bate) were using randomized complete block design in factorial arrangement with three replications. Soils samples before and after were collected and analyzed. The analysis of soil samples before planting indicated that the soil pH was strongly acidic (5.16) and after harvest, it raised to strongly acidic level (5.29). The interaction effect of varieties, seed rates and fertilizer rates showed highly significant ($p<0.001$) variation on number of tillers per plant, leaf area per plant, leaf to stem ratio, fresh biomass yield, dry matter yield, days to maturity, and seed yield. The treatment combination of Bona-bas: FR46:SR100 has produced the highest dry matter yield (5.1 t/ha), followed by Bona-bas: FR46:SR60 and Bona-bas: FR69:SR80 which produced the same value of 4.9 t/ha dry matter yield. This study recommends that for better agronomic performance of oat varieties, 46 $kgha^{-1}$ N of fertilizer with 60 $kgha^{-1}$ of seed rate is preferable to use by farmers in the study area and other areas having similar agro-ecologies and soil type. In addition, it is essential to conduct over year-over location to confirm the present findings and the result needs to be supported with animal evaluation trials.

Keywords: bate; biomass; bona-bas; dry matter; nitrogen; oat; seed

1. Introduction

Ethiopia is well known to have the largest livestock population in Africa. Livestock sector has been contributing a considerable share to the economy of the country, and still promising to rally round the economic development of the country (Tulu, 2020). Livestock is an integral part of the farming systems and source of many social and economic values such as food, draught power, fuel, cash income, security and investment in both the highlands and the lowlands/pastoral farming systems. The contribution of livestock to the national economy is estimated to be 30% of the Agricultural Gross Domestic Product and 19% of the export earnings (Yidersal *et al.*, 2020).

Despite the sound contribution of the livestock sector to the national economy, animal productivity is very low mainly due to poor standard of feeding both in terms of quality and quantity as the production performance of an animal often reflects its nutritional status (Gezahegn *et al.*,2021). In most tropical countries, insufficient feed supply is the bottleneck for animal production. This is due to livestock's dependence on naturally available forage resources and the poor development of forage crops for animal feeding (Abebe *et al.*, 2014). Like in other tropical countries, in Ethiopia, most of the areas in the highlands of the country are nowadays put under cultivation of cash and food crops which resulted in keeping large number of livestock on limited grazing areas leading to overgrazing and poor productivity of livestock (Mosissa, 2018). Despite the increased supply of crop residues from expanded cultivation of cereal crops; crop residues could not support reasonable animal productivity because of their low nutritive value. Hence, shortage of nutrients for livestock is increasingly becoming serious issue in Ethiopia (Ramana *et al.*, 2015).

One of the alternatives to improve livestock feeding and thereby enhance productivity of livestock is through the cultivation of improved forages which could be offered to animals during critical periods in their production cycle and when other sources of feeds are in short supply (Yidersal *et al.*, 2020). Oats (*Avena sativa*) 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. Oat is ranked as sixth in world's cereal production following wheat, maize, rice, barley and sorghum (Amanuel *et al.*, 2019). Oat grain makes a good balanced concentrate in the ration for poultry, cattle, sheep and other animals (Mengistu *et al.*, 2016).

Seed rate and fertilizer rate are key factors contributing to oat yield and quality. These conditions are very different in the agro-ecological areas. The application of appropriate fertilizer rate definitely improves the dry matter, biomass yield and quality of forage. Oat crop responds significantly to application of nitrogen. Application of nitrogen resulted in significant increase in plant height and yield. As the dose of nitrogen increases, there is increase in green and dry matter yield (Devi *et al.*, 2019). The oat varieties and fertilizer application and oat seed rate have effects on oat forage yield and nutritional quality. Different scholars reported oat varieties has effect on biomass yield and nutritional quality (Amanuel *et al.*, 2019), seeding and fertilizer rates to determine the response of oat varieties (Molla *et al.*, 2018).

Even though the adaptation of oat varieties in the current study area has been conducted and the two oat varieties (*Bona-bas and Bate)* were recommended, the appropriate fertilizer and seeding rates that give high yields were not yet determined for these adapted varieties. Therefore, it is felt important to determine the appropriate seed rate and fertilizer rate for optimum performance of these oat varieties in the existing agro-ecological condition to alleviate feed shortage both in quantity and quality, and thus increase the production and productivity of livestock for both small scale and large scale producers.

Objectives

- To determine appropriate seeding rate for optimum performance of oat varieties in terms of biomass yield
- To determine appropriate fertilizer rates for optimum performance of oat varieties.
- To determine the economic feasibility of inorganic urea on yield oat varieties.

2. Materials and Methods

2.1. Description of the Study Area

This study was conducted in Kuyu district (Figure 1). Kuyu is one of the 13 rural districts of North Shewa Zone of Oromia. Garba Guracha town is the administrative center of the district and is located at 42 km from Fiche (the zonal capital), and 156 km from Addis Ababa. It has an astronomical location of 9^{0}35`- 9^{o}49′N latitude and 38^{o}03′-38^{o}31′E longitude. The total area of the District is about 982 square kilometers, accounting for about 10.92 % of the zonal area.

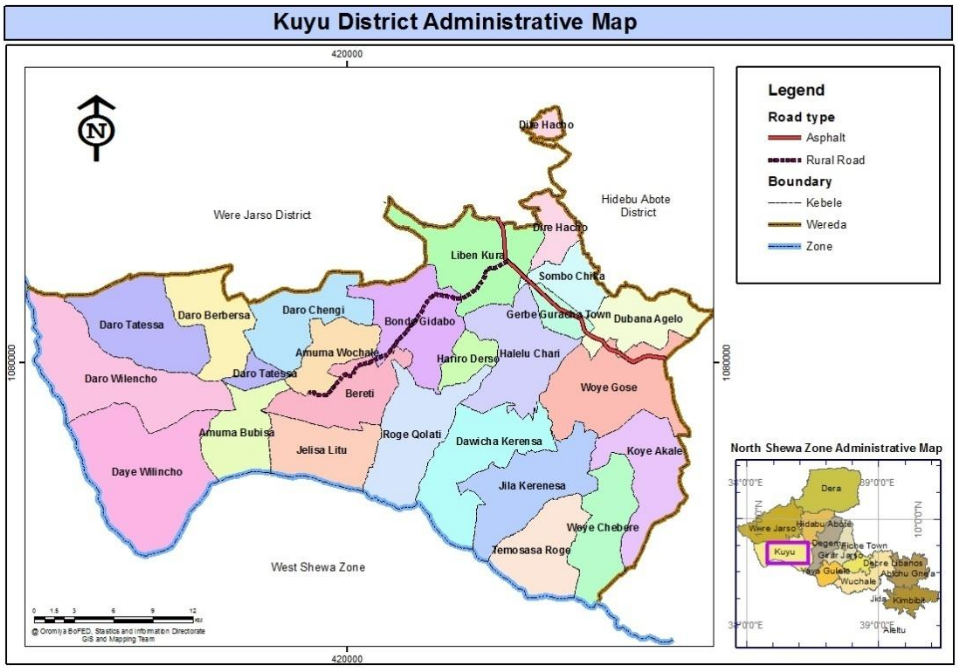

Figure 1. Kuyu District Administrative Map (2022).

The topography of Kuyu is characterized by plateaus, hills and plains steep slope and valleys. The major peaks are Kesi (2757m), Kurfo (2646m) and Fale (2604m). The highest and lowest elevations are 2757 and 1390 meters above sea level, respectively. The agro-climatic zones of Kuyu District by their altitudinal ranges are Highland which is greater than 2,300 meters above sea level and accounting for about 50%, Midland which ranges from 1,500-2,300 meters above sea level and sharing 40% and Lowland which is less than 1,500 meters above sea level and accounting for 10% of the District total area. The average annual rainfall of the district ranges from 1,600-1,800 mm, while the average annual temperatures vary between 15^{o}c and 18^{o}c. The rainy season covers from May to September in the study area.

2.2.. Experimental Materials

Released Oat varieties (*Bona bas and Bate*) were selected based on adaptability to the area as planting materials. The varieties require 800-1200 mm rainfall and grow at an altitude of 1500-3000 meters above sea level. The rates of nitrogen in the form of Urea (46%) were used.

2.3. Experimental Design and Treatments

The experiment was laid out as a Randomized Complete Block Design (RCBD) in a factorial arrangement and replicated three times (Table 1). The treatments consisted of four level of N (0, 23, 46 and 69 kgha^{-1}) and three levels of seeding rates (60, 80 and 100 kgha^{-1}) with two improved Oat varieties (*Bona bas and Bate*). The experimental fields were ploughed and harrowed to a fine seedbed. Land preparation, planting, weeding and harvesting was made according to the recommendations. Plot size was 1.4 m x 2 m (2.8 m^{2}), space between plot, block and rows were 0.5 m, 1.5 m and 20 cm. Five middle rows were used as sampling rows (Yidersal *et al.*, 2020).

Table 1. Treatment details.

Factor I – Nitrogen level	**Factor II** –Seeding rates	**Factor III** –Varieties
1. Nitrogen 0 kg ha^{-1}	1. Seeding rates 60 kg ha^{-1}	1.Bona bas
2. Nitrogen 23 kg ha^{-1}	2. Seeding rates 80 kg ha^{-1}	2.Bate
3. Nitrogen 46 kg ha^{-1}	3. Seeding rates 100 kg ha^{-1}	

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4. Nitrogen 69 kg ha^{-1}

2.4. Methods of Data Collection

2.4.1. Soil Sampling and Analysis

A first representative soil sample was collected from a depth of 0-30 cm from entire plot in a zigzag pattern according to standard method. The sample was air dried, ground, sieved through a 2 mm sieve and used for analysis. Soil samples after harvest of the crops was also collected from a depth of 0-30 cm near a root zone at four points from all plots except the control and the physico-chemical properties of the prepared samples was analyzed at Fitche Agricultural Research center soil test laboratory. Soil texture was determined by Bouyoucons Hydrometer method and the soil pH was determined in 1:2.5, soil water suspension by glass electrode using digital pH meter (Piper, 1966).

Estimation of organic carbon in soil was determined by Walkley and Black method (1934) and expressed in percentage. The total nitrogen content of soil samples was determined by Modified Kjeldahl method and expressed in percentage (Jackson, 1962). Available phosphorus content of soil samples was estimated by Olsen's method (Jackson, 1967) and expressed in ppm. Exchangeable potassium was estimated by a flame photometer from the extract of neutral normal ammonium acetate (Jackson, 1967) and expressed in cmol (+)/kg soil.

2.4.2. Germination Rate (%)

Germination is the development of the seedling to a stage where the aspect of its essential structures indicates whether it is able to develop further into a satisfactory plant under favorable conditions (The International Seed Testing Association-ISTA, 2004). Germination rate was estimated using peak Value, the point whose tangent has the steepest slope on the germination curve. The Peak value is presented as the peak germination percent / peak count (Kolotelo, 2002).

2.4.3. Days to 50% Flowering and Maturity

Days to flowering is the period of time taken by the plant to reach 50% flowering, recorded days from the date of sowing. The single continuous flowering period was calculated from the opening of the first flower to the time when lowering finished in almost all the plants (Rajesh, 2011). Days to maturity is the number of days from the date of sowing up to the date when 90% of the crop stands in a plot changed to light yellow color and it helps to determine when to harvest the crop for seed production. (Bekalu & Arega, 2016).

2.4.4. Plant Height (cm) and Number of Tillers per plant

Plant height in cm is the height of ten main shoots measured from sampling units and averaged. The height measurement was taken from ground level to the base of the fully opened youngest leaf before heading and to the tip of panicle after heading. Number of tillers is the total number of shoots (tillers) from demarcated ten sampling units, counted and expressed as average tiller number per plant from net plot area (Yidersal *et al*, 2020).

2.4.5. Number of Leaves per Plant and Leaf Area per Plant

To determine the number of green leaves per plant the total number of fully opened green leaves per plant was counted from five plants and their average was taken as number of green leaves per plant. Visual counting of leaf on randomly taken plants were recorded/counted for each plant by using hands and every visible leaf on the plant, including the tips of new leaves (Bewuket & Shewaye, 2020). Maximum length and width of 3rd leaf from the top of each of the five plants were recorded. The product of length x breadth was multiplied by total number of green leaves per plant and the multiplication factor of 0.747 was used to calculate the total leaf area per plant (Sticker *et al*., 1961).

2.4.6. Leaf to Stem Ratio

Leaf to stem ratios for oats at each harvesting stage was measured and calculated for each plot on dry matter basis (Molla *et al*, 2018). Leaves to stem ratio is the ratio of dry weight of leaves to the dry weight of stems. Higher leaves to stem ratio is generally an indication of better nutritional value of the crop (Aklilu and Alemayehu, 2007).

L: S = Dry weight of leaves (g)

Dry weight of stem (g)

2.4.7. Grain Yield (kg/ha)

Grain yield was determined by harvesting all plants from the five rows of each plot and expressed in quintals per hectare and yield from research plot (Bekalu & Arega, 2016).

2.4.8. Herbage Yield Determination

The fresh weight was taken in the field using field balance. Fresh subsamples were taken from each plot separately, weighed and chopped into short lengths (2-5 cm) for dry matter determination. The weighed fresh subsample (FWss) was oven dried at 60^{o}C for 72 hours and reweighed to get an estimate of dry matter weight (DWss). The dry matter production (tone/ha) was calculated as:

10 x Tot FW x (DWss / HA x FWss) (Tarawali *et al.*, 1995).

where: Tot FW = total fresh weight from plot in kg

DWss = Dry weight of the sample in grams

FWss = Fresh weight of the sample in grams.

HA = Harvest area meter square and

10 = A constant for conversion of yields in kg m^2 to tone/ha

2.4.9. Partial budget analysis

A partial budget analysis of dry matter yield for the selection of the economically feasible and profitable levels/rates of inorganic fertilizer applied to the soil was done according to the CIMMYT procedure (CIMMYT, 1988). To estimate economic parameters DM yield was valued at an average open market price of 100kg = 220 ETB/kg and the cost of urea fertilizers were 100kg = 3968 ETB/kg. The potential responses of the grass toward the added inorganic urea ultimately determine the economic feasibility of fertilizer application (CIMMYT, 1988).

2.5. Methods of Data Analysis

Data was analyzed using (ANOVA) by the General Linear Model procedure of the SAS (SAS, 2002) version 9.0. Mean was separated using Least Significant Difference (LSD) at 5 % significant level and Duncan multiple range. The model for data analysis was;

Y_{ijk} = μ+ Si + Fj +Vk + SFVijk + eijk

where, Yijk = Individual observation

μ = overall mean

S_i = i^{th} seed rate

Fj = j^{th}fertilizer rate

VK= k^{th} Vari*eties*

SFij = ijkth seed rate x fertilizer rate x Vari*eties*

e_{ijk} = random error

3. Results and Discussion

3.1. Physio-Chemical Properties of the Soil Prior to Planting

The pH and chemical contents of soil before planting and after forage harvesting are shown in (Table 3). PH value of the soil of the composite samples before planting was 5.16 indicating that the soil was strongly acidic based on the rating suggested by Tekalign *et al*., (1991). Organic carbon, organic matter, total nitrogen contents of the soils in the study area before planting were 1.16%, 1.97% and 0.10%, respectively, indicating that the soils had low organic carbon, organic matter and nitrogen content as rated by Tekalign *et al*., (1991). The available phosphorous in the soils of the study area was

7.65 ppm which is rated as low based on the classification by Waugh, (1973) that categorizes a relative range of extractable phosphorous of 0-5 ppm (very low), 6-10 ppm (low), 11-15 ppm (medium), 16-20 ppm (high) and 21-25 ppm (very high). The available potassium content of the soil in the study area was 95.78 ppm, which is rated as low (Tekalign *et al.*, 1991). The result of soil analysis revealed that the study area is clay with sand, silt and clay in the proportion of 30%, 30% and 43%, respectively.

3.1.1. Soil Chemical Properties after Forage Harvest

The present results for soil parameters after harvesting of the forage indicated that the pH of the soil was somewhat higher compared to the values before planting (Table 3). This could be because of planting material, fertilizer and seed rates. The pH of the soil analyzed after harvesting was found to be different for oat varieties, seed rates, level of nitrogen application and their interactions. The increase in soil pH might be due to planting material, organic matter contents, soil condition and residual effect of organic fertilizer. As per the soil pH rating scale of Tekalign *et al*., (1991), the soil of the study area after forage harvesting can be considered as strongly acid (5.29).

In all treatments, the soil organic carbon content was higher for the soil samples taken after harvesting compared to pre planting soil samples. Accordingly, the organic carbon content of all soil samples after harvest in the study area were categorized in the range of medium according to the rating criteria set by Tekalign *et al*., (1991). Soil organic matter can help to raise soil pH thereby correcting soil acidity partly. Soil OM content of the soil samples taken after forage harvest increased compared to the pre planting soil samples (Table 3). The OM contents of the soil samples taken after harvest can be categorized in the range of medium to high.

Table 2. Soil Fertility Influenced by Variety, Seed Rate, Fertilizers Level and Their Interactions before and After Forage Harvest**.**

Factors			**Soil parameters**					
Variety	Seed rate (kg)	N level	PH 1:1.5 H_2o	OC (%)	OM (%)	TN (%)	AP ppm	AK ppm
	Before sowing		5.16	1.16	1.97	0.10	7.65	95.78
	After sowing							
Bate	60	0	5.12^{lm}	4.49^{h}	7.73^{h}	0.39^{ef}	7.32^{q}	59.12^{q}
		23	5.28^{gh}	4.78^{g}	8.24^{g}	0.41^{de}	11.17^{i}	56.93^{u}
		46	5.62^{b}	4.78^{g}	8.24^{g}	0.41^{de}	10.13^{l}	61.60^{o}
		69	5.25^{hi}	2.83^{m}	4.87^{m}	0.24^{hi}	12.42^{b}	57.28^{t}
	80	0	5.37^{e}	2.44^{q}	4.27^{q}	0.21^{i}	11.83^{e}	62.35^{m}
		23	5.57^{c}	2.83^{m}	4.87^{m}	0.24^{hi}	11.16^{i}	57.58^{s}
		46	5.35^{ef}	3.80^{k}	6.56^{k}	0.33^{g}	11.71^{g}	59.56^{p}
		69	5.13^{lm}	3.90^{j}	6.72^{j}	0.34^{g}	7.80^{p}	61.75^{n}
	100	0	5.24^{hi}	2.83^{m}	4.87^{m}	0.24^{hi}	9.58^{m}	58.27^{r}
		23	5.42^{d}	5.46^{d}	9.41^{d}	0.47^{bc}	11.76^{f}	62.54^{l}
		46	5.28^{gh}	4.88^{f}	8.40^{f}	0.42^{de}	10.47^{k}	52.51^{w}
		69	5.23^{ij}	4.19^{i}	7.23^{i}	0.36^{fg}	11.45^{h}	63.39^{k}
Bona-bas	60	0	5.19^{jk}	3.90^{j}	6.72^{j}	0.34^{g}	13.36^{a}	64.33^{j}
		23	5.19^{jk}	3.22^{l}	5.55^{l}	0.28^{h}	12.04^{c}	65.03^{h}
		46	5.16^{kl}	5.75^{c}	9.92^{c}	0.50^{ab}	11.18^{i}	68.06^{c}

		69	5.26^{hi}	2.83^{m}	4.87^{m}	0.34^{g}	11.90^{d}	64.88^{i}
	80	0	5.32^{fg}	2.63^{o}	4.54^{o}	0.23^{i}	9.60^{m}	65.33^{f}
		23	5.27^{hi}	5.85^{b}	10.09^{b}	0.50^{ab}	9.31^{o}	62.54^{l}
		46	5.14^{ml}	2.54^{p}	4.37^{p}	0.22^{i}	9.46^{n}	65.08^{g}
		69	5.36^{ef}	3.22^{l}	5.55^{l}	0.28^{h}	10.16^{l}	65.72^{e}
	100	0	5.24^{hi}	2.34^{r}	4.03^{r}	0.02^{j}	11.74^{fg}	56.73^{v}
		23	5.26^{hi}	6.05^{a}	10.42^{a}	0.52^{a}	6.74^{r}	69.45^{b}
		46	5.11^{m}	2.73^{n}	4.71^{n}	0.24^{hi}	11.03^{j}	69.94^{a}
		69	5.72^{a}	5.27^{e}	9.08^{e}	0.45^{cd}	7.32^{q}	66.17^{d}
		Overall mean	5.29	3.89	6.71	0.32	10.44	62.33
		CV	0.52	0.77	0.43	7.93	0.26	0.04
P-value		Variety	***	***	***	***	***	***
		Seed rate	***	***	***	***	***	***
		N level	***	***	***	***	***	***
		Interaction	***	***	***	***	***	***

Note: Means with same letters in a column not significantly different (P>0.05). PH= hydrogen ion, OC= organic carbon, OM= Organic Matter, TN=Total Nitrogen, AP=available Phosphorus, AK=available potassium, CV = Coefficient of variance.

Total nitrogen is often more deficient than any other essential elements in soils in general and acidic soils in particular (Abebe, 2007). The TN content of the soil after harvest showed variation. This might be due to variation in variety, fertilizer levels and seed rates. Comparing treatments which received N fertilizer with the no N fertilizer treatments; higher total N was observed from fertilized plots. The values of total nitrogen of the soil increased after harvest compared to pre planting values. The total nitrogen content of the soil samples after harvest is classified as very high as rated by Tekalign *et al*., (1991).

The AP for soil samples after harvest was higher than the phosphorous level of the soil before planting. According to Tekalign *et al*., (1991) rating, such values of AP is categorized as medium. This might be due to the fact that there was less utilization of phosphorous by the grass planted and due to the addition of fertilizer. The AP value of the soil after forage harvest was higher for Bate variety sown at lower seed rate with 46% N application. The higher AP value (13.36 ppm) was obtained from Bona-bas variety at 60% seed rate without N application, followed by Bate variety at 60 kgha^{-1} seed rate with 46% N application which was 12.42 ppm. The lower value (6.74 ppm) was obtained from Bona-bas variety at 100 kgha^{-1} seed rate with 23% N application (Table 3). This might be attributed to the fact that the grasses seeded with lower seed rate must have extracted less P in the soil as compared to the grasses with higher seed rate.

The AK for soil samples after harvest was lower than the potassium level of the soil before planting. This indicates that there was high utilization of potassium by the forage grasses. The available K value of the soil after forage harvest was higher for Bate variety sown at lower seed rate with 46% N application. The higher AK value (69.94 ppm) was obtained from Bona-bas variety at 100% seed rate with 46% N application, followed by the same variety at 100% seed rate with 23% N and at 60% seed rate with 46% N for which values of 69.45 and 68.06 ppm respectively were registered. The lower AK value (52.51 ppm) was obtained from Bate variety at 100% seed rate with 46% N application (Table 3). This indicates that Bona-bas variety utilized more available potassium in the soil compared to Bate variety at various seed and nitrogen rates, and this could be attributed to the differences in variety, seed and fertilizer application rates. The soil available K after harvest in this study area was classified as low.

3.1.2. Days to 50% Flowering and Days to Maturity

Days to 50% flowering and Days to maturity was significantly (p<0.001) affected by the main effect of Nitrogen application rate, seed rate and varietal differences (Table 4). The shortest and longest days to 50% flowering were recorded for Bona-bas and Bate varieties with values of 101.5 days, and 109.3 days, respectively. In terms of Nitrogen application rate, the longest days to 50% flowering was recorded for 69% N whereas the shortest days to 50% flowering was recorded for 0% N and 23% N. This result is similar with the reports by Gezahegn *et al.*, (2021) in which 89.0 to 107.3 days were recorded, but higher than the values of 62 to 89 days to 50% flowering reported by Amanuel *et al.*, (2019). and shorter days to 50% flowering as Nawaz *et al.*, (2004) reported from 150.33 to 133.33 days to 50% flowering and Tamrat *et al.*, (2019) from 113.25 to 127.0 days. Days taken to 50% flowering in the varieties differed probably due to their varietal characteristics and adaptability. From the present finding, as N_2 rate increased from 0 to 69%, days to 50% flowering increased. In contrast to the present finding, Mebrate *et al.*, (2022) reported that as Nitrogen fertilization increased from 21 $kgha^{-1}$ to 63 $kgha^{-1}$, the days to heading decreased. On the other hand, similar finding by Derebe *et al.*, (2018) indicated that increasing levels of N_2 fertilizer from control (0 kg N/ha) to the highest (54 kg N/ha), increased days to heading of malt barley consistently which might be attributed to the behavior of increased N_2 fertilizer that increased the vegetative growth of crops, thereby delaying heading time.

Seed rate also caused the variation in dates of 50% flowering. Seed rate of 60 $kgha^{-1}$ produced the longest days and 100 $kgha^{-1}$ recorded the shortest days to 50% flowering. As seed rate increased from 60 $kgha^{-1}$ to 100 $kgha^{-1}$, days to 50% flowering decreased linearly. Similar finding was reported by Mebrate *et al.*, (2022) due to competition for resources such as water, nutrients, and sunlight. Days to heading of oats decreased linearly by 1.06% as the seed rate increased from 100 to 150 $kgha^{-1}$. Senait *et al.*, (2020) also reported that the increment in seed rate of malt barley from 100 to 175 $kgha^{-1}$ decreased the days to 50% heading by 6%. Significant difference for days to forage harvest or day to 50% flowering in oat genotypes have been reported by other authors (Gezahegn *et al.*, 2021; McCabe and Burke 2021). Days to maturity was not significantly affected by the main effects of seed rate, Nitrogen application and varietal differences (Table 4) similar result easy reported by (Mebrate *et al.*, 2022).

Table 3. The Main Effects of Seed Rate, Nitrogen and Varieties on Phenology and Growth Traits of Fodder Oats.

Factors	**Parameters**					
Varieties	FD	DSM	LSR	NLPP	LL	LA
Bona-bas	101.5[b]	158.25	1.64	5.28	24.58[b]	18.18[b]
Bate	109.3[a]	165.14	1.31	5.68	46[a]	63.51[a]
Mean	105.39	161.69	1.47	5.48	35.29	40.85
CV	1.31	11.52	10.73	13.61	6.81	3.99
LSD	0.65	8.84	0.75	0.35	1.14	0.77
P-value	<.0001	0.513	0.4677	0.0836	<.0001	<.0001
Fertilizer level($kgha^{-1}$)						
0	104.72[b]	164.50	1.25	5.34	32.31[d]	39.73[c]
23	105.0[b]	162.94	1.32	5.72	36.19[b]	40.17b[c]
46	105.61[ab]	155.73	2	5.46	34.17[c]	40.91[b]
69	106.22[a]	163.61	1.32	5.4	38.49[a]	42.57[a]
Mean	105.38	161.69	1.47	5.48	35.29	40.85
CV	1.31	11.52	10.73	13.61	6.81	3.98
LSD	0.92	12.5	1.0602	0.5	1.61	1.09
P-value	<.0001	0.4135	0.4621	0.0552	<.0001	<.0001

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					Seed rate (kgha-1)	
60	107.0[a]	163.4	1.26	5.3	36.4[a]	42.4[a]
80	105.2[b]	164.8	1.29	5.6	35.9[a]	43.0[a]
100	103.9[c]	156.9	1.87	5.5	33.6[b]	37.1[b]
Mean	105.38	161.69	1.47	5.48	35.29	40.85
CV	1.31	11.52	10.73	13.61	6.81	3.98
LSD	0.8	10.83	0.92	0.43	1.39	0.95
P-value	<.0001	0.4606	0.489	0.06	<.0001	<.0001

Note: FD =days to 50% flowering, DSM= days to maturity, PH =plant height in cm, NLPP = number leaf per plant, LL =leaf Length in cm, LA=leaf area in cm^2, LSR =leaf to stem ratio, CV = Coefficient of variation, LSD = Least significance difference.

3.1.3. Leaf Area and Leaf Length

The leaf area and leaf height varied significantly ($p<0.001$) due to seed rate, Nitrogen application rate and varietal differences. The leaf area in the present study ranged from 15.0 to 80.8cm^2 with the mean of 40.71 cm^2 in line with the finding of Shankar *et al.,* (2022) in which a leaf area per plant of 17.32 to 32.48 cm^2 was reported.

Bate: FR46:SR80 (T17) treatment combination produced the largest leaf area per plant (80.8 cm^2) followed by Bate: FR69:SR60 (T22) which was 72.6 cm^2, whereas the combination that produced the lowest leaf area was Bona-bas: FR23:SR80 (T8) followed Bona-bas: FR0:SR60 (T1) were 15 cm^2 and 15.2 cm^2, respectively (Table 5). Bate variety combination with different seed rate and Nitrogen application rate generally produced highest leaf area per plant than Bona-bas variety. Fertilizer application also caused the variation in leaf area per plant of oats. The highest leaf area per plant (42.57 cm^2) was recorded for 69% N application followed by 46% N and 0% N for which was 40.91 cm^2 and 39.73 cm^2 were, respectively recorded (Table 4). The leaf length in the present study ranged from 17 to 50.5 cm with a mean of 35.56 cm. The longest leaf length (50.5 cm) was recorded for treatment combination of Bate: FR69:SR80 followed by Bate: FR69:SR60 which recorded 50.1 cm, whereas the shortest leaf length was recorded for treatment combination of Bona-bas: FR46:SR100 followed by Bona-bas: FR0:SR60 which recorded 20.1 cm (Table 5). From the results it can be seen that the highest fertilizer application resulted in increment of leaf length.

3.1.4. Leaf to Stem Ratio and Number of Leaf per Plant

The statistical result showed non-significant difference ($p>0.05$) for leaf to stem ratio and number of leaf per plant with different fertilizer levels and seed rate (Table 5). The highest leaf to stem ratio was recorded for treatment combination Bona-bas: FR69:SR100 and Bate: FR23:SR100 which recorded equal values of (1.44) followed by Bate: FR69:SR60 combination which recorded 1.42. This value is greater than the values of 0.78 and 0.84 reported for Bona-bas variety by Dawit and Teklu (2011) and Firaol (2022), respectively. The lowest leaf to stem ratio was recorded for treatment combination of Bona-bas: FR69:SR60 with a value of 1.11 followed by Bona-bas: FR46:SR60 and Bate: FR0:SR100 combination which recorded equal values of 1.14 (Table 5).

The highest number of leaf per plant was recorded for treatment combination Bona-bas: FR23:SR80 which recorded 7.1 followed by Bate: FR46:SR100 which recorded 6.5. This result is higher than the finding reported by Firaol (2022) for Bona-bas and Bate varieties which were 5.5 and 5.34, respectively. The lowest number of leaf per plant was recorded for treatment combination of Bona-bas: FR0:SR100 which was 4.5 (Table 5).

Table 4. The Interaction effects on Phenology and Growth Traits of fodder oat.

Var: FR:SR	DF	NLPP	LL	LA	LSR	DSM
Bona-bas:FR0:SR60	102.3[gh]	5.1[b-d]	20.1[hi]	15.2[m]	1.18[j]	164.3[a]

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Bona-bas:FR23:SR60	102[gh]	5.2[b-d]	27.1[g]	15.7[lm]	1.33[c-e]	159.3[a]
Bona-bas:FR46:SR60	103[g]	5.4[b-d]	27.3[g]	17.5[k-m]	1.14[k]	163[a]
Bona-bas:FR69:SR60	104[fg]	5.3[b-d]	26.9[g]	30.2[i]	1.11[k]	161.3[a]
Bona-bas:FR0:SR80	100[hi]	5.1[b-d]	21.7[gh]	16.4[lm]	1.22[h-j]	164.3[a]
Bona-bas:FR23:SR80	100.3[hi]	7.1[a]	26.3[g]	15.0[m]	1.31[ef]	163.3[a]
Bona-bas:FR46:SR80	102[gh]	5[cd]	24.2[gh]	19.6[jk]	1.24[g-i]	164.3[a]
Bona-bas:FR69:SR80	101.7[g-i]	5.1[b-d]	26.6[g]	18.5[j-l]	1.33[c-e]	164.3[a]
Bona-bas:FR0:SR100	99.3[i]	4.5[d]	21.8[gh]	14.9[m]	1.34[cd]	163.3[a]
Bona-bas:FR23:SR100	101.7[g-i]	5.1[b-d]	27.7[g]	20.9[j]	1.25[gh]	159.3[a]
Bona-bas:FR46:SR100	100[hi]	5.1[b-d]	17[i]	16.8[k-m]	1.27[fg]	111[b]
Bona-bas:FR69:SR100	101.7[g-i]	5.3[b-d]	28.3[g]	17.4[k-m]	1.44[a]	161[a]
Bate:FR0:SR60	112[a]	5.3[b-d]	49.3[a-c]	63.5[de]	1.23[g-i]	164[a]
Bate:FR23:SR60	110.7[ab]	5.7[b-d]	47.2[a-d]	71.9[b]	1.36[b-d]	164.7[a]
Bate:FR46:SR60	110.7[ab]	4.9[cd]	43.6[de]	52.8[g]	1.30[ef]	165a
Bate:FR69:SR60	111.7[a]	5.7[b-d]	50.1[ab]	72.6[b]	1.42[a]	165.3[a]
Bate:FR0:SR80	108.7[b-d]	5.7[b-d]	44.1[de]	66.1[cd]	1.4[ab]	165.7[a]
Bate:FR23:SR80	108.7[bd]	5.4[b-d]	45.8[b-e]	60.8[e]	1.20[ij]	166.3[a]
Bate:FR46:SR80	110.3[ab]	5.7[b-d]	47.7[a-d]	80.8[a]	1.25[gh]	164.3[a]
Bate:FR69:SR80	109.7[a-c]	5.9[a-d]	50.5[a]	66.9[c]	1.37[bc]	165.3[a]
Bate:FR0:SR100	106[ef]	6.4[a-c]	36.9[f]	62.3[e]	1.14[k]	165.3[a]
Bate:FR23:SR100	106.7[de]	5.8[a-d]	43.1[e]	56.6[f]	1.44[a]	164.7[a]
Bate:FR46:SR100	107.7[c-e]	6.5[ab]	45.2[c-e]	57.9[f]	1.36[b-d]	166.3[a]
Bate:FR69:SR100	108.7[b-d]	5.1[b-d]	48.6[a-c]	49.7[h]	1.22[h-j]	164.3[a]
Mean	105.39	5.48	35.56	40.71	0.040	163.89
CV	1.44	14.44	2.98	2.20	1.92	1.02
LSD	2.49	1.23	3.95	2.67	0.04	30.6
P-Value	<.0001	0.0904	<.0001	<.0001	<.0001	<.0001

Note: Var= Variety, FR= Fertilizer rates, SR= Seed rates, FD =days to 50% flowering, NLPP = number leaf per plant, LL =leaf Length, LA=leaf area, LSR =leaf to stem ratio, DSM= days to maturity, CV = Coefficient of variation, LSD = Least significance difference.

3.1.5. Plant Height and Number of Tillers Per Plant

Plant height was significantly ($p<0.001$) affected by varietal differences, but the main effects of seed rate and Nitrogen application rate did not have effects ($p>0.05$) on plant height. The highest plant height (139.37cm) was recorded for Bate variety and Bona-bas gave the lowest (117.12 cm) plant height with a mean of 128.24 cm (Table 6). The present result is in line with findings of Tamrat *et al.*, (2019) and Gezahegn *et al.*, (2021) who reported plant heights ranging from 93.33 to 156cm and from 121.8 cm to 189.6 cm, respectively. The main cause of those differences in plant height was the differences in genetic makeup of the oat varieties/accessions. Zaman *et al.*, (2006) explained that plant height may differ in varieties due to environmental conditions which in turn cause variation in hormonal balance and cell division rates. Even though fertilizer application rate did not show a significant variation, numerically highest plant heights of 131.78 cm and 131.73 cm were recorded for 69 and 46 N application rates, respectively and the shortest (124.13 cm) was recorded for 23 N application. Similar to the report presented by Mahendra and Jain (2022), plant height was found to be responsive to Nitrogen application as each successive increase in Nitrogen dose produced taller plants. On the other hand, the longest treatment combination of Bate:FR46:SR80 and Bate:FR0:SR80 produced plant heights of 151.9 cm and 146.5 cm, respectively, while the shortest plant height (107.5

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cm) was registered by treatment combination of Bona-bas:FR0:SR60 with a mean of 128.25 cm (Table 7). Even though there was no consistence, lower rate of fertilizer application produced the shortest plant height while the highest fertilizer rates produced the longest plant height. This is in line with the findings of Yidersal *et al.,* (2020) who reported that the application of higher Nitrogen levels resulted in significantly higher plant heights and lowest plant height was recorded for lower seed rate and Nitrogen levels.

Number of tillers per plant was significantly affected ($p<0.001$) by seed rate, Nitrogen rates and varieties (Table 6). Highest number of tillers per plant (10.48) was recorded for Bona-bas variety than for Bate variety, and the highest number of tillers per plant (8.31) was recorded for application rate of 69 N followed by Nitrogen application rates of 46 N for which 8.17 was recorded. The lowest number of tillers per plant (7.58) was recorded for 0 N application rates. Number of tillers per plant increased linearly as Nitrogen application rate increased from 0 to 69 N. In terms of seed rate, the highest tiller per plant (8.8) was recorded from 60 $kgha^{-1}$, but 80 $kgha^{-1}$ and 100 $kgha^{-1}$ do not have statistical variation. From the present results, as seed rate increased from 60 $kgha^{-1}$ to 100 $kgha^{-1}$, number of tillers per plant decreased (Table 6) which is contrary to the findings of Yidersal *et al.,* (2020) in which number of tillers per plant appeared to increase with increased in seed rate. The variations might be due to the variation in soil, temperature, varietal and other factors which influence tillers per plant. Different scholars reported tillers per plant ranging from 12.0 to 10.3 (Amanuel *et al.,* 2019) which is higher than what is obtained in the present findings and the values of 4.2 to 8.2 reported by Yidersal *et al.,* (2020) was lower than the present findings. The combination of the seed rate, fertilizer rate and variety showed a significant ($p<0.001$) variation on number of tillers per plant (Table 7). The treatment combination of Bona-bas: FR0:SR80 and Bona-bas: FR69:SR60 produced the highest tillers per plant of 13.2 and 11.7, respectively; whereas the lowest tillers per plant was recorded for treatment combination of Bate: FR23:SR80 which was 4.7. Generally, 46% Nitrogen application relatively produced the highest tiller numbers per plant which has a direct relationship with fresh biomass and dry matter yields.

Table 5. The Main Effects of Seed Rate, Nitrogen and Varieties on Yield and Yield Components of the Fodder Oats**.**

Factors	**Parameters**				
Varieties	PH	NTPP	DM (tha^{-1})	FBM (tha^{-1})	sy ($qtha^{-1}$)
Bona-bas	117.12^{b}	10.48^{a}	5.9	55.84^{a}	32.99
Bate	139.37^{a}	5.45^{b}	3.76	50^{b}	27.07
Mean	128.24	7.97	4.83	52.92	30.04
CV	8.92	5.79	12.34	12.54	25.05
LSD	5.43	0.22	2.83	3.15	7.63
P-value	0.0054	<.0001	0.3827	<.0001	0.0825
Fertilizer level ($kgha^{-1}$)					
0	125.35	7.58^{b}	3.91	49.47^{b}	23.43^{b}
23	124.13	7.81^{b}	3.98	53.72^{ab}	33.54^{ab}
46	131.73	8.17^{a}	7	53.08^{ab}	36.66^{a}
69	131.78	8.31^{a}	4.44	55.42^{a}	26.52^{ab}
Mean	128.24	7.96	4.83	52.92	30.04
CV	8.92	5.79	12.34	12.54	25.05
LSD	7.68	0.31	4.0017	4.45	10.79
P-value	0.0575	<.0001	0.3279	<.0001	0.1207
Seed rate ($kgha^{-1}$)					
60	125.1	8.8^{a}	4	57.9^{a}	29.3

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80	129.9	7.7^{b}	4.1	49.9^{b}	27.9
100	129.7	7.5^{b}	6.4	50.9^{b}	32.9
Mean	128.24	7.96	4.83	52.92	30.04
CV	8.92	5.79	12.34	12.54	25.05
LSD	6.65	0.27	3.46	3.86	9.35
P-value	0.0515	<.0001	0.3377	0.0001	0.0552

Note: NTPP =Number of tillers per plant, FBM =Fresh biomass yield, DM =Dry matter yield, sy =Seed yield, CV = Coefficient of variation, LSD = Least significant difference.

Table 6. Mean of Yield and Yield Components of fodder oat affect by interaction seed rates, fertilizer rates and oat varieties.

Var: FR:SR	PH	NTPP	FBM(tha^{-1})	DM(tha^{-1})	Syqt
Bona-bas:FR0:SR60	107.5^{h}	7.3^{fg}	$58.3^{a\text{-}c}$	4^{fg}	26.4
Bona-bas:FR23:SR60	110.3^{h}	11.5^{b}	$59.6^{a\text{-}c}$	4.3^{de}	25.8
Bona-bas:FR46:SR60	115.2^{gh}	10.5^{cd}	68.3^{a}	4.9^{bc}	42.5^{b}
Bona-bas:FR69:SR60	110^{h}	11.7^{b}	64.6^{ab}	4.3^{de}	19.9
Bona-bas:FR0:SR80	$124.7^{b\text{-}h}$	13.2^{a}	$50.8^{c\text{-}e}$	4.3^{de}	26.7
Bona-bas:FR23:SR80	$117.5^{f\text{-}h}$	11.5^{b}	51.6^{cd}	4.1^{fg}	34.4^{c}
Bona-bas:FR46:SR80	$119.9^{f\text{-}h}$	11.2^{bc}	$54.2^{b\text{-}d}$	3.9^{gh}	18.9
Bona-bas:FR69:SR80	$126.1^{b\text{-}h}$	11.5^{b}	52.1^{cd}	4.9^{ab}	30.9^{d}
Bona-bas:FR0:SR100	109.1^{h}	8^{ef}	56.7^{bc}	4.5^{d}	16.9
Bona-bas:FR23:SR100	$122.2^{c\text{-}h}$	10.3^{d}	$58.8^{a\text{-}c}$	4.8^{bc}	48.7^{a}
Bona-bas:FR46:SR100	$121.1^{d\text{-}g}$	8.7^{e}	37.3^{g}	5.1^{a}	26.5
Bona-bas:FR69:SR100	$121.9^{c\text{-}h}$	10.5^{cd}	$57.9^{a\text{-}c}$	4.7^{c}	32.9c
Bate:FR0:SR60	$134.2^{a\text{-}g}$	4.8^{kl}	$39.6f^{g}$	3.6^{i}	20.8
Bate:FR23:SR60	$138.7^{a\text{-}f}$	5.1^{kl}	57.4^{bc}	3.4^{j}	42.5^{b}
Bate:FR46:SR60	$140.9^{a\text{-}e}$	$5.7^{i\text{-}k}$	56.7^{bc}	3.4^{j}	28.4^{d}
Bate:FR69:SR60	$144.1^{a\text{-}c}$	5^{kl}	$59.2^{a\text{-}c}$	4.1^{fg}	28^{de}
Bate:FR0:SR80	146.5^{ab}	6.7^{gh}	51.4^{cd}	4.4^{de}	25.1
Bate:FR23:SR80	109.5^{h}	4.7^{l}	$50^{c\text{-}f}$	3^{k}	26.5
Bate:FR46:SR80	151.9^{a}	5^{jkl}	$44.6^{d\text{-}g}$	4^{fg}	36.8^{c}
Bate:FR69:SR80	$143.3^{a\text{-}d}$	6.2^{hi}	$45^{d\text{-}g}$	4.3^{de}	23.9
Bate:FR0:SR100	$137.7^{a\text{-}g}$	$5.5^{i\text{-}l}$	$40^{e\text{-}g}$	3^{k}	24.6
Bate:FR23:SR100	$139.4^{a\text{-}f}$	$6^{h\text{-}j}$	$45^{d\text{-}g}$	3.8^{hi}	23.5
Bate:FR46:SR100	$141.3^{a\text{-}e}$	$5.7^{i\text{-}k}$	$57.5^{a\text{-}c}$	3.8^{hi}	21.3
Bate:FR69:SR100	145.3^{ab}	5^{kl}	$53.8^{b\text{-}d}$	4.2^{ef}	23.4
Mean	128.25	7.97	53.68	4.13	28.14
CV	8.86	5.53	3.29	2.91	0.06
LSD	18.66	0.76	10.9	0.19	2.6
P-Value	<.0001	<.0001	<.0001	<.0001	<.0001

Note: Var= Variety, FR= Fertilizer rates, SR= Seed rates, PH =plant height in cm, NTPP =Number of tillers per plant, FBMtha =Fresh biomass yield tone per hectare, DMtha =Dry matter yield tone per hectare, syqt =Seed yield quintal per hectare, CV = Coefficient of variation, LSD = Least significance difference.

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3.1.6. Fresh Biomass yield and Dry Matter yield

The interaction of Nitrogen application rate, seed rate and variety showed significant ($p<0.001$) variations on fresh biomass yield (Table 6). Bona-bas variety gave higher fresh biomass yield than Bate variety. The highest fresh biomass yield (55.84 t/ha) of Bona-bas variety was recorded at 69% N application (55.42 t/ha) which is higher than the value of 38.01 t/ha reported for Bona-bas by Firaol, (2022); whereas the lowest value was 49.47 t/ha recorded for 0% N application in the current findings. Fresh biomass yield increased linearly as Nitrogen rate increased from 0% N to 69% N and it is similar with the results of Yidersal *et al*., (2020) which indicated that the treatment combination with the highest level of seed rate and Nitrogen resulted in the highest green forage yield. In terms of seed rate, the highest fresh biomass yield (57.9 t/ha) was recorded for 60 $kgha^{-1}$; while the lowest was recorded for 80 $kgha^{-1}$ and 100 $kgha^{-1}$ with values of 49.9 and 50.9 $kgha^{-1}$, respectively (Table 6). Highest fresh biomass yields of 68.3 and 64.6 t/ha was recorded from treatment combinations of Bona-bas: FR46:SR60 and Bona-bas: FR69:SR60, respectively; while the lowest biomass yields of 37.3 and 39.6 t/ha were recorded from treatment combinations of Bona-bas: FR46:SR100 and Bate: FR0:SR60 respectively (Table 7). Fresh biomass yield obtained in the present study is higher than the values 28.9 to 42.4 t/ha reported by Amanuel *et al*., (2019), 42.22 to 55.5 t/ha reported by Mahendra and Jain (2022), but lower than the values of 54.40 to 105.60 t/ha reported by Usman *et al*., (2018) and it is in line with the values of 67.2 to 44.5 t/ha reported by Gebremedhn *et al*., (2015) and 36.93 to 66.67 t/ha reported by Tamrat *et al*., (2019). Fresh biomass yield linearly increased as fertilizer rate increases from 0 to 46 but decreased at 69 Nitrogen applications for almost for treatment combinations. This is in line with the findings of Yidersal *et al*., (2020) in which green forage yield of oat increased significantly with the increases in Nitrogen rates.

The dry matter yield of oat varieties did not vary significantly ($p>0.05$) due to variation in rates of Nitrogen application, seed rates and variety (Table 6). Numerically, the highest dry matter yield (5.90 t/ha) was recorded for Bona-bas and, Bate variety produced lower (3.76 t/ha) dry matter yield. Regarding Nitrogen application rate, 46% N application produced the highest (7.0 t/ha) dry matter and the lowest (3.91 t/ha) was recorded from 0% N application. Even though, seed rate did not show statistical differences with regard to dry matter yield, relatively the highest yield (6.4 t/ha) was recorded for 100 $kgha^{-1}$ application and the lowest (4 t/ha) was recorded for 60 $kgha^{-1}$ (Table 6). Similar to the report of Yidersal *et al*., (2020), seed rate has non-significant effect on dry matter yield of oats. On the other hand, there were significant ($p<0.001$) variations among the treatments in dry matter yield (Table 7). Treatment combination of Bona-bas: FR46:SR100 has produced the highest (5.1 t/ha) dry matter yield followed by Bona-bas: FR46:SR60 and Bona-bas: FR69:SR80 which produced equal values of 4.9 t/ha. The lowest dry matter yield was recorded for Bate: FR0:SR100 and Bate: FR23:SR80 which produced equal values of 3 t/ha. The present result is lower than the 6.40 to 13.60 t/ha reported by Yidersal *et al*., (2020), 11.5 to 15.6 t/ha reported by Gezahagn *et al*., (2021); and 8.61 to 12.2 t/ha reported by Amanuel *et al*., (2019), but higher than the 2.35 to 3.58 t/ha reported by Shankar *et al*., (2022) and similar with the values of 4.7 to 7 t/ha report by Gezahagn *et al*., (2016). In contrast to the present finding, Dawit & Teklu (2011), and Firaol (2022) reported dry matter yields of 10.1 and 9.95 ton/ha, respectively. Mekonnen *et al*., (2020) and Firaol (2022) reported 8.56 and 8.94 ton/ha DMY, respectively, for Bate variety at recommended fertilizer rates. As to the present finding, the application of 46 N fertilizer resulted in maximum production of dry matter. Even though there is no consistence in increment of dry matter yields, most of the treatment combinations gave higher dry matter yields as fertilizer application rates increased from 0 to 69. Similar results were reported by Iqbal *et al*., (2009); Dawit & Teklu (2011); Yidersal *et al*., (2020). The higher fertilizer rates promote vigorous plant growth and a larger leaf area that contribute to the high dry matter yield of the fodder oats (Ayub *et al*., 2013).

3.1.7. Seed Yield

Seed yield was significantly ($p<0.001$) affected by the main effect of Nitrogen application rates. On the other hand, there were no significant ($p>0.05$) differences observed for varietal and seed rate effects. Significantly, the highest grain yields (36.66 qt/ha) were recorded for 46% Nitrogen

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application followed by 23% and 69% Nitrogen application rates with values of 33.54 and 26.52 qt/ha, respectively. The lowest seed yield (23.43 qt/ha) was recorded for zero Nitrogen application (Table 6). In terms of varieties, Bona-bas gave relatively higher seed yield than that of Bate variety. This might be due to their genetic variation, Atumo and Kalsa (2020) reported seed yield variation among oat genotypes grown in similar environment as a result of the difference in their genetic potential and their adaptability. Numerically, the highest seed yield was recorded at seed rate of 100 $kgha^{-1}$. The combination of seed rate, fertilizer rate and variety showed significant ($p<0.001$) impact on seed yield among the treatments. Seed yield obtained ranged from 16.9 qt/ha to 48.7 qt/ha with a mean of 28.14 qt/ha.

Combination which produced the highest (48.7 qt/h) seed yield was Bona-bas: FR23:SR100 followed by Bona-bas: FR46:SR60 and Bate: FR23:SR60 with equal values of 42.5 qt/ha; whereas the combination which produced the lowest (16.9 qt/ha) seed yield was Bona-bas: FR0:SR100 followed by Bona-bas: FR46:SR80 and Bona-bas: FR69:SR60 with values of 18.9 qt/ha and 19.9 qt/ha, respectively (Table 7). The highest and lowest seed yield were recorded for Bona-bas variety at different seed and fertilizer rates showing that the variety has responded for specific seed rate and fertilizer rate than Bate variety. The present seed yield is lower than the report of 51.9 qt/ha to 65.7 qt/ha by Amanuel *et al*., (2019), 23.46 qt/h to 56.93 qt/ha by Usman *et al*., (2018), and 21.40 qt/ha to 61.50 qt/ha by Yidersal *et al*., (2020), but higher than the reports of 15.39 qt/ha to 28.85 qt/ha by Tamrat *et al*., (2019), and 14.6 qt/ha to 32.1 qt/ha by Gezahagn *et al*., (2021).

3.2. Partial Budget Analysis

Partial Budget Analysis is estimated to compare marginal returns among treatments. Table (10) depicts financial analysis of growing the oat varieties for all treatments considered. Without considering common costs such as land rent and labor costs, the highest marginal return of 148,676 ETB per hectare was obtained from Bona-bas variety on treatment FR23:SR100 followed by Bona-bas variety on treatment FR46:SR60 for which 130,712 ETB per hectare was obtained.

Table 7. Financial Analysis of oat varieties tested with different seed and fertilizer rate.

Treatments	Fertilizer cost/ha	Seed cost/ha	Total cost/ha	seed Yield /ha (Kgha-1)	DMY /ha (Qt/ha)	Total Revenue	Marginal Returns	Ranks
Bona-bas:FR0:SR60	0	3600	3600	2640	40	88000	84400	10
Bona-bas:FR23:SR60	1984	3600	5584	2580	43	86860	81276	12
Bona-bas:FR46:SR60	3968	3600	7568	4250	49	138280	130712	2
Bona-bas:FR69:SR60	5952	3600	9552	1990	43	69160	59608	22
Bona-bas:FR0:SR80	0	4800	4800	2670	43	89560	84760	9
Bona-bas:FR23:SR80	1984	4800	6784	3440	41	112220	105436	5
Bona-bas:FR46:SR80	3968	4800	8768	1890	39	65280	56512	23
Bona-bas:FR69:SR80	5952	4800	10752	3090	49	103480	92728	7
Bona-bas:FR0:SR100	0	6000	6000	1690	45	60600	54600	24
Bona-bas:FR23:SR100	1984	6000	7984	4870	48	156660	148676	1
Bona-bas:FR46:SR100	3968	6000	9968	2650	51	90720	80752	13
Bona-bas:FR69:SR100	5952	6000	11952	3290	47	109040	97088	6
Bate:FR0:SR60	0	3600	3600	2080	36	70320	66720	20
Bate:FR23:SR60	1984	3600	5584	4250	34	134980	129396	3
Bate:FR46:SR60	3968	3600	7568	2840	34	92680	85112	8
Bate:FR69:SR60	5952	3600	9552	2800	41	93020	83468	11
Bate:FR0:SR80	0	4800	4800	2510	44	84980	80180	14
Bate:FR23:SR80	1984	4800	6784	2650	30	86100	79316	15

Bate:FR46:SR80	3968	4800	8768	3680	40	119200	110432	4
Bate:FR69:SR80	5952	4800	10752	2390	43	81160	70408	18
Bate:FR0:SR100	0	6000	6000	2460	30	80400	74400	16
Bate:FR23:SR100	1984	6000	7984	2350	38	78860	70876	17
Bate:FR46:SR100	3968	6000	9968	2130	38	72260	62292	21
Bate:FR69:SR100	5952	6000	11952	2340	42	79440	67488	19

4. Conclusion

The present study was aimed at evaluating the effects of seed and nitrogen fertilizer rate on biomass yield and other agronomic treats of oat varieties. Pre and post-harvest of soil sample of experimental site was found to be clay in texture. The interaction effect of varieties, seed rate and fertilizer application rate showed highly significant ($p<0.001$) variation on most evaluated parameters. Treatment combination Bate: FR46:SR80 produced the longest plant height and the longest leaf height was recorded for Bate: FR69:SR80. Treatment Bona-bas: FR46:SR100, Bona bas: FR46:SR60 and Bona-bas: FR23:SR100 was produced the highest dry matter yield, fresh biomass yield and seed yield respectively.

5. Recommendations

Based on the above result the following recommendations were forwarded:

- For better agronomic performance of oat varieties (Bona-bas and Bate), 46 $kgha^{-1}$ N of fertilizer with 60 $kgha^{-1}$ of seed rate can be recommended for use by farmers in the study area and other areas having similar agro-ecologies and soil type.
- This activity was conducted at single location in one cropping season. It is important to conduct over year-over location to confirm the present findings.
- To make the current finding valued, the result needs to be supported with animal evaluation trials.

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