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Determination of Optimum Seed and Nitrogen Fertilizer Rate of Oat (Bareda) Variety for West Hararghe Zone, Oromia, Ethiopia

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ABSTRACT

The study was initiated to determine the optimal seed and fertilizer rates for the Bareda oat variety for herbage and grain production. The experimental design was a factorial randomized complete block with three replications. Four seed rate levels (60, 80, 100, and 120 kg/ha) and four nitrogen rate levels (50, 100, 150 kg/ha) were arranged in a factorial combination. All agronomic data were collected and analyzed. A significant variation was observed for most parameters due to different seed and fertilizer rate applications. Plant lodging showed significant variation only due to different fertilizer rate application, but not for seed rate. Different seed and fertilizer rate application was did not show significant variation for seed yield production, disease occurrence, and plant height. The highest oat seed rate with different rates of N showed early 50% flowering and maturity, while the lowest seed rate with different rates of N showed the longest date of 50% flowering and maturity. Mean dry matter production ranged from 8.46 to 14.08 t/ha. Dry matter production increased significantly as nitrogen rate increased from 50kg/ha to 150 kg/ha. The longest plant height is recorded from 60kg/ha seed rate with 150kg/ha N fertilizer combination, while as the seed rate increases from 60 to 120kg/ha, plant height decreases. In terms of economic marginal returns, the highest returns were obtained from the treatment combination for an 80kg/ha seed rate with 100kg/ha nitrogen fertilizer. Based on seed quality, 80kg/ha with 100kg N/ha was the best combination for the Bareda oat variety to produce a reasonable grain yield.

Keywords: Bareda variety, Fertilizer rate, oat, seed rate, West Hararghe

1. INTRODUCTION

Ethiopia has abundant livestock resources and is ranked first in Africa and fifth globally in terms of livestock population. The livestock population estimated over 71 million cattle, 43 million sheep, 54 million goats, 57 million poultry/chickens, 13.33 million equines, and 7 million bee colonies (Begna, 2023). Agriculture is the backbone of Ethiopia's economy (Atsbaha and Bekele, 2011). Agriculture contributes about 40% GDP, 80% of exports and 75% workforce. On the other hand, livestock shares 45% of agricultural GDP, 19% of the country's GDP, 16–19% of foreign exchange, and employs more than 30% of the agricultural labor force (Statista, 2022). Despite the livestock sector's contribution to the national economy, animal productivity is very low, mainly due to poor feed quality and quantity. In most tropical countries, inadequate supply of animal feed is the bottleneck for livestock production (Negash et al., 2017) as livestock depend on naturally available feed resources Dawit and Wegi (2014). To solve these problems, the cultivation of improved livestock feed is a crucial solution.

The newly introduced improved animal forages in West Hararghe were Napier grass, Desho grass, Rhodes grass, Bracharia grass, and oats are some important and popularized forage types. The most oat growing area in Ethiopia are North Shewa and West Shewa Zones and a considerable scale in other parts of the country, like Arsi, Bale, and Gojam (Mosissa, 2018) and white colored grain type can also be processed for human food consumption (Tamrat et al., 2022). This crop is rapidly increasing in recent years as a result of its serum cholesterol lowering properties, preventing heart-related thereby problems (Price *et al.,* 1987). But it is a very newly introduced forage grass in West Hararghe and used as animal feed only. The crop is grown and used for multipurpose (feed-food) in different parts of the country. It is used for human diet under different forms like bread, biscuits, beverages, pasta, milk, yogurt made from oat milk, as a fat substitute, stabilizer for ice-cream, and the raw material. Oats are an annual grass, cultivated in the highlands of Ethiopia primarily under rain-fed conditions for grain, forage, and fodder. It is fast growing, palatable and important energy rich and nutritious fodder for ruminant livestock Mukesh and Prabhu (2016), well-adapted to a wide range of soil types Kebede *et al*. (2016) and Demeke *et al*. (2017). Oat grows from medium to high altitudes (1600-3000m) on heavy soils (vertisols) where temperate grasses and other improved forages are difficult to establish (Kaur and Goyal, 2017).

Similar to other food crop, seed rate and fertilizer rate has to be determined and recommended for forage including oat varieties. Different seed and nitrogen fertilizer rates are key factors that contribute to better yield and quality oats (Irfan *et al.,* 2016). The application of nitrogen fertilizer improves dry matter production and forage quality (Dawit and Wegi, 2014). Appling higher and lower seed rate could have a negative impact on herbage DMY and seed yield of forage crops. Different scholars were recommended different amount of seed and fertilizer rate for different oat varieties. For example Tamrat *et al.* (2022) recommended 150 kg/ha seed rate and of 63 kg/ha N, and the optimum seed rate level to get reasonable DM yield at seed rate of 100 kg/ha by using100 kg NPS while if the target is for seed production, seed rate of 75 kg/ha 100 kg/ha NPS, Dawit and Wegi, (2014) found to get reasonable DM yield at a seed rate of 80 kg/ha with a combination of 50 kg/ha UREA and 100 kg/ha DAP, if the for forage seed production, 70 kg/ha seed combination with a fertilizer rate of 50 kg/ha UREA and 100 kg/ha DAP.

Most soils vary in nutrients contents that required by the plants. Studies conducted in different part of world showed a significant increase in oat grain yield and quality as fertilizer application increases. May *et al.,* (2004) and Hamill (2002) stated that the application of nitrogen up to 80 kg/ha increased grain yields in different areas and Islam *et al.,* (2020) recommended the application of 90 kg N/ha for oat production in Bangladesh. Therefore, it is critical to define the appropriate seed and fertilizer rates as oats production is affected by the different amounts of seed and fertilizer rates. Therefore, determining the appropriate seeding and different levels of fertilizer rates with feasible economic returns for the Bareda oat variety is important.

1.1. Objectives

- To determine the optimum seed rate the Oat (Bareda) variety for herbage and grain production
- To determine the optimum fertilizer level the Oat (Bareda) variety for herbage and grain production

2. MATERIALS AND METHODS

2.1. Study Area Description

The experiment was carried out in West Hararghe Zone for two consecutive years at three locations (Mechara On station, Bareda FTC, and Arba Rakate FTC), (Table 1).

Table 1. Description of the study area

Parameter	On station	Bareda FTC	Arba Rrakate FTC	References
Latitude (N)	08°60′	08°85′	2285	GPS reading
Longitude (E)	040°31′	040°63′	09°04′	GPS reading
Altitude (masl)	1787	1748	040°91′	GPS reading
Distance from Addis Ababa (km)	434	375	243	
Distance Chiro (km)	111	55	15	

Agro ecology	Midland	Midland	Highland	
Mean annual rainfall (mm)	1120	967	876	Gizaw, 2021(unpublished)
Mean maximum temperature (°C)	28	27	13	Gizaw, 2021(unpublished)
Mean minimum temperature (°C)	15	13	28	Gizaw, 2021 (unpublished)
Textural class	Sandy clay loam	Sandy silt	Sandy silt	
pH (1:1 H_2O)	5.65	6.68	6.67	
Total OC (%)	2.15	1.95	2.15	
Total nitrogen (%)	0.18	0.17	0.18	Pre-sowing Lab analysis result
Available phosphorus (ppm)	5.92	3.20	3.16	
CEC (meq/100 gm soil)	26.97	40.39	52.67	

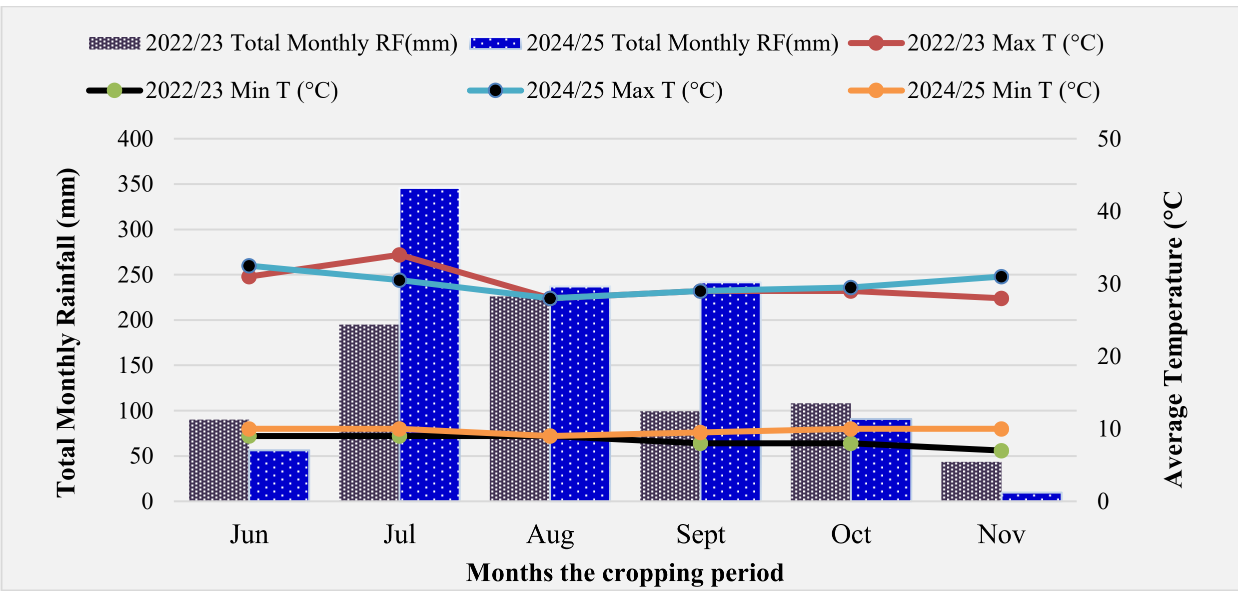

Figure 1. Mean monthly rainfall and maximum and minimum temperatures at Mechara on station

2.2. Treatments set up and experimental design

Bareda oat variety is used as the experimental material. It was released from Mechara agricultural research center during 2020. The treatments were arranged in a factorial RCBD design with three replications arranged in twelve treatments as listed in the table 2.

Table 2. Treatment arrangement

Treatment Arrangements			
No	Treatments	No	Treatments
1	60kg x 50kg N ha-1	7	100kg x 50kg N ha-1
2	60kg x 100kg N ha-1	8	100kg x 150kg N ha-1
3	60kg x 150kg N ha-1	9	120kg x 50kg N ha-1
4	80kg x 50kg N ha-1	10	120kg x 100kg N ha-1
5	80kg x 100kg N ha-1	11	120kg x 150kg N ha-1
6	80kg x 150kg N ha-1	12	100kg x 100kg N ha-1 **(standard)**

The plot size was 2 x 1.8 m with a total area of 3.6 m^2. The distance between replication, plot and rows were 1m, 1m, and 30cm respectively. Seed drilling techniques used to sow the treatments. 50 kg NPS ha^{-1} uniformly applied for all an experimental plots at time of sowing. Weed control was managed with frequent hand weeding throughout the experimental period.

2.3. Data collection and management

2.3.1. 50% flowering and Maturity date: - The day of 50% flowering was measured as the length of days from emergence to a period of 50% flowering duration for each experimental plot. Days to maturity counted from emergence day to when 90% physiological experimental plot mature observed and calculate as days of plant maturity.

2.3.2. Forage Herbage yield: - Herbage yield determination was estimated at the stage of 50% flowering days. Considering the middle points of each plot, a quadrant of 0.5 m × 0.5 m = 0.25 m^2 area is used to harvest the forage. The harvested forage was weighted by a sensitive balance to determine the weight of fresh biomass for the harvested area. The harvested herbage is measured and recorded. Then 220 gm. of the subsample from the harvested herbage was weighed again and sun-dried for 3-5 days. The weighed fresh subsample (FWss) was oven-dried at 60 ^{O}C for 72 hours and reweighed (DWss) to give an estimate of dry matter production. Then the dry matter yield (t/ha) was calculated as (10 x TotFW x (DWss / HA x FWss))
Where: TotFW = total fresh weight from plot in Kg
DWss = dry weight of the sample in grams
FWss = fresh weight of the sample in grams.
HA = Harvested area in square meters and
10 = is a constant for the conversion of yields in kg m^2 to tons/ha

2.3.3. Plot cover and Stand vigor: - Plot cover data was recorded based on plant plot coverage in percentage. The treatments produced highest ground cover plot coverage received 100% of the plot cover value and the rest was obtained the values accordingly. Plant vigor is estimated from the standing vigor point of view. Plant stand vigor is recorded on a scale of (1 – 5) with 1 = best, 2 = very good, 3 = good, 4 = fair, and 5 = poor.

2.3.4. Diseases and Pest Occurrence: - Diseases and insect data collection here continuously collected throughout the experimental period for both years. Disease severity recorded on the scale followed by CIMMYT methods using 1-5 scoring scale. 1 = highly resistance, 2 = Resistance, 3 = Moderate resistance, 4 = susceptible, 5 = highly susceptible (Jakhar *et al.*, 2017).

2.3.5. Plant height and panicle length: - Plant height data recorded from the ground of the main plant (not branch) to the tip of the plant. To measure the height, ten randomly selected plants from each plot were selected when plants reached 90% physiologically maturity. The total sum value of the ten plants was then divided by ten to determine the average plot plant height.

2.3.6. Plant lodging and Leaf to steam ratio: - Data on leaf to stem ratio were recorded when the plant was 50% flowered on the same date with data collection for herbage yield determination. A total of 100 gm. forage sample was weighed then leaf and stem separated manually. The leaf-stem ratio were calculated by dividing the leaf weight by the stem weight.

2.3.7. Grain yield: - Grain yield data were collected from each plot after harvesting. A total plot sample was threshed, and grain yield was separated from straw by wind. Then, the threshed grain was dried by the sun, adjusted to 12.5% moisture content, and weighed. The weighted grain yield per plot was converted to grain yield quintal per hectare.

2.4. Forage Laboratory Analysis

The sample used for determination of chemical composition and in-vitro organic matter digestibility were oven-dried at temperature of 65°C for 72 hours. The dried samples are then ground to pass a one millimeter (mm) sieve, and used for laboratory analysis. The samples analyzed on a DM (%) basis for in-vitro dry matter digestibility (IVDMD), crude protein, total ash fiber fractions (NDF, ADF, and ADL). Total ash content was determined by igniting the dried sample in a muffle furnace at 550°C for 6 hours. Nitrogen (N) content was determined following the micro-Kjeldahl digestion, distillation, and titration procedures (AOAC, 1990), and the CP content was estimated by multiplying the N content by 6.25. The fiber fractions (NDF, ADF, and ADL) was determined according to the Van

Soest, (1991). The in-vitro dry matter digestibility was determined according to Tilley and Terry, (1963). Hemicellulose was calculated by subtracting the ADF from the NDF content while cellulose was determined by subtracting the ADL from the ADF content.

2.5. Soil Laboratory Analysis

Two years pre-sowing and post-sowing soil analysis results are presented in (Table 3). The pre- sowing soil analysis result of pH at on station ranged from 5.65 to 6.83, at Bareda FTC 6.68, and at Arba Rakate FTC ranged from 6.60 to 6.67 and was found to be moderately to slightly acidic as rated by Tadesse (1991). Oats performs better than other cereals on clay soils, tolerating acid and low fertile soils, with a pH between 4.5 and 8.6 (Duda *et al.*, 2021). The total N percent on station ranged from 0.18 to 0.20%, at Bareda FTC 0.17%, and at Arba Rakate FTC varied from 0.18 to 0.22%, which is classified as low range by Tadesse (1991). The organic carbon on station ranged from 1.46 to 2.15%, at Bareda FTC 1.95%, and at Arba Rakate FTC varied from 1.76 to 2.15%, which is classified as low to medium by Tadesse (1991). The CEC the at on station range from 24.90 to 26.97 meq/100 gm soil, at Arba Rakate FTC varied from 52.67 to 54.57 meq/100 gm soil, and at Bareda FTC it was 40.39 meq/100 gm soil, classified as very high (Pam & Brian, 2016). CEC is the major indicator of soil fertility parameters and nutrient retention capacity. Accordingly, soils high in CEC content are considered agriculturally fertile.

Table 3. Pre-sowing soil analysis result

Pre sowing analysis	pH	Av. P (ppm)	OC (%)	TN (%)	CEC (meq/100 gm soil)	Texture
On station 2023	5.65	5.92	2.15	0.18	26.97	
On station 2025	6.83	4.04	1.46	0.20	24.90	
Bareda FTC 2023	6.68	3.20	1.95	0.17	40.39	Sandy Clay
Arba Rakate 2023	6.67	31.59	2.15	0.18	52.67	
Arba Rakate 2025	6.60	19.42	1.76	0.22	54.57	

2.6. Economic analysis

The economic analysis to investigate the economic feasibility of the average main effects of seed rate and N rates following the CIMMYT (International Maize and Wheat Improvement Center) procedures. The price of fertilizer is obtained from the Mechara Agricultural research center finance process, and the price of seed yield during sowing and harvesting is obtained from the zone agriculture office for two experimental years. Accordingly, variable costs included the cost of seed during sowing (June) which was estimated at 30 Ethiopian Birr (ETB) per kg, and during yield harvesting (March) which was 20 Ethiopian Birr (ETB) per kg, while the official prices of N fertilizers were estimated at 38.95 ETB per kg. A treatment having higher total costs that vary and a lower net benefit than the immediate preceding treatment with lower total costs that vary and a higher net benefit was considered to be dominated and was eliminated from further analysis.

2.7. The linear model

Yijk = m + ai + bj + ¡k + a¡ik + eijk Where, Yijk = the value of the response variable; m = Common mean effect; ai = Effect of fertilizer rate; bj = Effect of block; ¡k = Effect of seed rate; a¡ik = Interaction effect of seed rate and fertilizer rate and eijk = Experiment error (residual) effect.

2.8. Statistical analysis methods

Analysis of variance was analyzed by SAS software to determine the agronomic difference between different levels of seed and fertilizer rate, interaction between seed and fertilizer rate, and the mean separation carried out using Least Significant difference (LSD) test at 5% level.

3. RESULTS & DISCUSSION

3.1. Analysis of Variance

This activity was conducted with the objectives to determine the optimum seed and optimum fertilizer rate of Bareda Oat variety for reasonable herbage and grain yield production. All first and second-year agronomic data and nutritional quality were collected and analyzed. Two years combined analysis of ANOVA results showed that the important parameters have a significant ($p<0.05$) difference among the treatments (Table 4). The main factors, location, seed and fertilizer rate, showed a significant effect on maturity date, stand vigor, dry matter yield, fresh biomass yield, and Panicle length. Locations also showed a significant variation for all tested parameters. Plant lodging showed significant (P<0.001) variation for different rates of fertilizer application but didn't showed significant variation for different seed rate. 50% flowering showed variation for different seed rates applications but did not show variation for different fertilizer rates. Application of different seed and fertilizer rate did not showed significance (P>0.05) variation in seed yield production, diseases and plant height. The interaction effect of different seed rates with different fertilizer rate, seed rates with location, fertilizer rates with locations, and their interactions did not show variations.

Table 4. Combined Analysis of ANOVA for the Bareda oat variety by different levels of seed

Source Variation	SR	FR	Rep	Loc	SR*FR	SR*Loc	FR*Loc	SR*FR*Loc
DF	3	2	2	2	6	6	4	12
FD	109.6***	11NS	79.4***	2411.1***	21.6***	14.9**	3.5NS	5.83NS
MD	22.7**	21.6*	7.3NS	14355.8***	5.7NS	10.2NS	5.5NS	4.99NS
PC	54.8NS	364.7***	304.1***	172.8*	45.6NS	20.9NS	25.7NS	15.03NS
Diseases	0.03NS	0.03NS	0.04NS	0.09**	0.02**	0.03NS	0.03NS	0.013NS
SV	1.31*	8.23***	1.6*	14.02***	0.62NS	0.47NS	2.3***	0.12NS
FBMYtha	282.9*	1590.3***	645.3**	7138.8***	107.2NS	32.1NS	158.4NS	61.94NS
DMYtha	14.26***	53.7***	2.95NS	33.03***	5.01NS	4.17NS	6.29NS	1.56NS
PH	18.58NS	34.5NS	3.03NS	4558.9***	59.4NS	17.4NS	18.1NS	48.26NS
Lodge	504.9NS	2467.4***	1895.7***	7526.6***	280.6NS	296.6NS	374.5NS	230.28NS
SYQtha	11.79NS	73.19NS	30.5NS	2587.9***	55.9NS	27.38NS	5.3NS	14.83NS
PL	72.4***	46.5**	51.6**	163.9***	9.6NS	0.78NS	23.6*	10.89NS

DF= Degree freedom, FD=days to 50% flowering, MD = maturity date, PC = plot cover, SV = stand vigor, PH =plant height, FBMtha =fresh biomass yield tone per hectare, DMYtha=Dry matter yield tone per hectare, MD = days to maturity, SYQtha =seed yield quintal per hectare, FR= Fertilizer rate, SR=Seed rate, Loc = location, PL = panicle length

3.2. Days to 50% Flowering and Maturity

The result of 50% flowering and physiological maturity date for bareda oat variety presented in (Table 5). The statistical (p<0.05) variation was observed for 50% flowering (forage harvesting) date and physiological maturity date among the treatments. The mean 50% flowering date ranged from 63.6 to 68.8 days. The highest (120 kg/ha) seed rate combination with different fertilizer rate showed earlier 50% flowering (shortest forage harvesting day) while lowest (60kg/ha) seed rate with different rate of N combination showed longest days of flowering. It indicate that the highest seed rate application takes shortest days to forage harvesting (50% heading) than the lowest seed rate. It might be due to competition for resources and sunlight that similar findings reported by Tamrat *et al.* (2022) stated that oats days to heading decreased as the seed rate increased from 100 to 150 kg/ha due to competition for resources such as water, nutrients, and sunlight. The present result of days to 50% flowering was shorter than the findings of Tessema and Getinet, (2020) from 98.3 to 147 days, from 89.6 to 109.5 as reported by Kebede *et al*. (2021), Tamrat *et al.* (2022) reported average 94.7 days of 50% flowering.

Mean seed maturity date ranged from 118.1 to 120.6 days. The lowest seed rate with different N rate combination relatively produced the longest days to maturity while the highest seed rate with different N rate combination produced shortest days to maturity. The present result of seed maturity day is similar with Bareda oat variety to the period of registration mean of 126 days, but shorter than days to maturity reported by Dinkale *et al.*, (2020) from 118.33 to 160 days, Nawaz *et al*., (2004) from 179 to 210 days and Tamrat *et al*., (2022) on average 154 days.

3.3. Dry matter yield

The result of dry matter yield production is presented in (Table 5). A significance (p<0.001) variation were observed among the treatment for dry matter yield production. Combination of 80 kg/ha seed rate with 150kg N/ha produced the maximum dry matter yield (11.6t/ha) while the combination of 60 kg/ha seed rate with 50kg N/ha produced minimum dry matter yield (6.7t/ha). Dry matter production increased significantly with increases in nitrogen rates from 50 to 150 kg/ha. Similar findings with Erega *et al*. (2020) and

Iqbal *et al*. (2009) reported that fertilizers promote vigorous plant growth and a larger leaf area that contribute to the dry matter yield of the fodder oat. The mean production of current dry matter yield is 9.46 t/ha. Similar findings reported by Erega *et al.* (2020) 9.54t/ha, Koushal *et al.*, (2024) 9.74 to 11.48t/ha, Bedeke, (2022) from 9.37 to 13.26t/ha, Ahmed *et al*. (2020) from 7.63 to 9.6t/ha, Tessema and Getinet, (2020) varied from 5.47 to 13.14t/ha, Kebede *et al*., (2021) ranged from 5.4 to12.7t/ha but lower than the findings of Dawit and Wegi (2014) varied from 11.4 to 15.0t/ha. The present result showed that the highest and lowest seed rate produced minimum dry matter yield that highest seed rate caused high resources competition while lower seed rate underutilization of resources.

3.4. Mean plant Height (cm) and Panicle length (cm)

The results of plant height and panicle length are presented in (Table 5). There was a significance ($P<0.05$) variation among treatments regarding plant height and panicle length. The tallest plant height was recorded from a 60kg/ha seed rate with 150kg N/ha application, and as the fertilizer rate increases, plant height increases. It is might be as the nitrogen rate increases, promote plant growth and increases the number of internodes and the length of the internodes. Similar findings reported by Tamrat *et al*. (2022) that the tallest plant height was obtained at the highest N rate. Islam *et al.* (2020), and Erega *et al.* (2020) also reported that the height of the tallest plants height of oats was recorded at the highest nitrogen rate with the lowest seed rate combination. The present result of plant height ranged from 124.9 to 130.5 cm, with a mean of 127.84 cm. Different scholars reported different plant heights for different oat varieties. Tessema and Getinet, (2020) reported plant height ranged from 69.6 to 147 cm, Dinkale *et al*. (2020) from 93.33 to 156 cm and Kebede *et al*. (2021) reported from 121.8 to 189.6cm. Therefore, Bareda Oat variety is categorized under a medium plant height variety and so, it is a suitable variety for forage production.

The mean panicle length in the present result is ranges from 25.2 to 29.6 cm with a mean of 27.57cm. The tallest panicle length was recorded from a 60kg/ha seed rate with 100kg/ha N fertilizer combination, and the shortest panicle recorded from a 120kg/ha seed rate and a 100kg/ha N fertilizer combination. The present finding of panicle length is taller than the report of Atumo nd Kalsa (2020) from 18 to 27.33 cm and similar to the report of Koushal *et al*., (2024) from 26.9 to 29.6 cm.

3.5. Mean plot cover and stand vigor

Ground plot cover and stand vigor results are presented in (Table 5). There was a significant ($P<0.05$) variation for ground plot cover and stand vigor among the treatments due to different seed and fertilizer rate applications. The highest ground plot cover was recorded from the treatment combination of 60kg/ha seed rate and 150kg/ha N rate.

The highest stand vigor was recorded from an 80kg/ha seed rate with 100 kg/ha and 150kg/ha of N application. This might be due to the optimum seed rate responding to sand vigor of the plant at highland than midland agro ecology.

3.6. Mean grain yield and plant lodging

The nitrogen × seed rate for grain yield showed significant ($p<0.05$) variation among the treatment combinations. The highest grain yield (44.7 quintal/ha) was obtained from an 80kg/ha seed rate with 100kg N/ha combination, while the minimum grain yield (38.3 quintal/ha) was obtained from a 60kg/ha seed rate and a 50kg N/ha rate. The lowest grain yield was obtained from a 50kg N/ha application with a different seed rate. The grain yield obtained was in line with the report of Dawit and Wegi (2014) from 36.8 to 44.8 quintal/ha, but higher than Bedeke, (2022) from 2.38 to 3.41 t/ha, Kebede *et al.* (2021) reported from 25.8 to 33.9 Quintal/ha Tessema and Getinet, (2020) reported from 596 to 2450 kg/ha, Dinkale *et al*. (2020) reported from 15.36 to 28.85 quintal/ha. Based on seed quality, an 80kg/ha seed rate with 100kg N/ha is the best combination for the bareda oat variety to produce a reasonable grain yield. From the present results, it would be concluded that West Hararghe is suitable for oat production.

3.7. Plant lodging

Plant lodging results are presented in (Table 6). A significance ($P<0.05$) variation was observed among the treatments for plant lodging due to the application of different seed and fertilizer rates applications. Plant lodging was not observed on station for the first year, but at a higher fertilizer rate with a higher seed rate application causes the highest lodging during the second year. Higher seed and fertilizer rate application causes the highest plant lodging both years at Arba Rakate and Bareda FTC that similar to findings with the report of Dawit and Wegi (2014) higher fertilizer rates causes in higher lodging of oat, while higher seed rate reduces seed size and quality. Erega *et al.* (2020) also reported that excessive fertilization caused lodging, which could reduce biomass yield.

Table 5. Mean agronomic and yield performance of fodder oat under different seed and fertilizer rates over three locations

Treatments Seed R	Fertilizer R	50FD	MD	PC	SV	Log	HL	FBMtha	DMtha	PH	SYQth
60	50kg N/ha	68.6[a]	120.6[a]	91.3[d]	2.8[a]	13.8[c]	28[ab]	41.9[c]	6.7[d]	125.9	38.3
	100kg N/ha	67.1[ab]	119.9[ab]	93.7[abcd]	2.1[abcd]	20[bcd]	28.4[ab]	52.8[abcd]	10.2[ab]	129.7	43.6
	150kg N/ha	66.3[b]	118.8[bc]	96.4[ab]	1.6[bcd]	32.8[abc]	29.6[a]	61.9[ab]	10.5[ab]	130.5	43.8
80	50kg N/ha	67.6[ab]	119.2[abc]	93.8[abcd]	2.1[abcd]	26.7[a-d]	27.5[abc]	46[cd]	8.7[bcd]	127.1	43.6
	100kg N/ha	67.3[ab]	119.1[abc]	95.8[ab]	1.3[d]	31.1[a-d]	26.9[abc]	54.6[abc]	10.9[ab]	129.2	44.7
	150kg N/ha	66.1[bc]	118.4[bc]	96.6[ab]	1.3[d]	35.6[ab]	28.8[ab]	63.5[a]	11.6[a]	125.6	38.9
100	50kg N/ha	67.4[ab]	119.6[ab]	93.2[bcd]	2.2[abc]	16.7[cd]	28.2[ab]	47.1[cd]	9.8[abc]	130.4	44.3
	100kg N/ha	66.6[b]	120[ab]	96.6[ab]	1.4[cd]	40[a]	27.1[abc]	51.1[bcd]	9.9[ab]	127.4	40.6
	150kg N/ha	64.7[cd]	118.8[bc]	94.7[abc]	1.8[bcd]	36.1[ab]	26.2[bc]	53.6[abcd]	9.6[abc]	127.2	43.5
120	50kg N/ha	64.2[d]	119[abc]	92.2[cd]	2.3[ab]	15.8[cd]	26.3[bc]	43.8[cd]	7.1[cd]	128.9	40.8
	100kg N/ha	63.6[d]	118.6[bc]	94.25[a-d]	1.8[bcd]	27.1[a-d]	25.2[c]	44.1[cd]	8.5[bcd]	127.3	43.3
	15kg N/ha	66.4[b]	118.1[c]	96.9[a]	1.4[cd]	37.2[ab]	28.6[ab]	54.2[abc]	10[ab]	124.9	40.3
Mean		66.32	119.17	94.62	1.84	27.74	27.57	51.23	9.46	127.84	42.14
CV		2.59	1.41	2.98	37.98	58.91	9.54	20.42	20.67	4.05	12.51
LSD		1.62	1.58	2.66	0.65	15.5	2.5	9.85	2.14	4.86	4.97
P-Value		*	***	**	**	***	***	***	***	*	*

Table 6. Mean lodging of fodder oat as affected by the interaction of different seed and fertilizer rates

Treatments		Lodging (%)				
		On Station		Arba Rakate FTC		Bareda FTC
Seed R	Fertilizer R	2023	2025	2023	2025	2023
60	50kg N/ha	0	13.3[bcd]	33.3[cde]	0[b]	8.0[b]
	100kg N/ha	0	10[d]	28.3[de]	4[ab]	31.7[ab]
	150kg N/ha	0	26.7[ab]	56.7[abcd]	4.7[ab]	41.7[ab]
80	50kg N/ha	0	10[d]	35.0[abcd]	4.7[ab]	45.0[ab]
	100kg N/ha	0	16.7[abcd]	63.3[ab]	0[b]	30.0[ab]
	150kg N/ha	0	25[abc]	68.3[a]	5[ab]	38.3[ab]
100	50kg N/ha	0	11.7[cd]	6.7[e]	0[b]	43.3[ab]
	100kg N/ha	0	23.3[abcd]	70.0[a]	10[ab]	50.0[a]
	150kg N/ha	0	15[bcd]	55.0[abcd]	10.77[a]	53.3[a]
120	50kg N/ha	0	15[bcd]	31.7[cde]	10[ab]	22.5[ab]
	100kg N/ha	0	13.3[bcd]	45.0[abcd]	3.7[ab]	36.3[ab]
	150kg N/ha	0.	30[a]	58.3[abc]	6[ab]	53.3[a]
Mean		0	17.5	45.96	4.91	38.17
CV		-	47.51	37.715	156.82	54.13
LSD		0	14.079	29.359	10.66	34.98
P-Value		-	0.0504	0.0456	0.0462	0.0410

3.8. Interaction of Different Seed and Fertilizer Rates on Growth and Yield Components

The effect of different levels of seed rate shows significant (P<0.05) variation on fresh biomass yield, dry matter yield, 50% flowering, maturity date, plant stand vigor, and plant panicle length, but did not show significant (P>0.05) variation for plant height, plot cover, plant lodging, and grain yield (Table 7). The maximum fresh biomass and dry matter yield was recorded from seed rates of 80kg/ha followed by 100kg/ha while the lowest fresh biomass and dry matter yield was recorded from seed rates of 60kg/ha. Relatively, the highest grain yield was recorded from 100kg/ha and 80kg/ha seed rates. As seed rate increases from 60kg/ha to 120kg/ha, plant panicle length, 50% flowering, and maturity date decrease while plant vigor, plot cover and plant lodging increase. Different fertilizer applications show significant (P<0.05) variation for all tested parameters except plant height and 50% flowering date. The highest fresh biomass and dry matter yield was recorded from 150kg/ha followed by 100kg/ha urea application, while the lowest was recorded from 50kg/ha urea application. It might be the higher fertilizer application causes more vegetative results increasing of forage yield. The highest grain yield was recorded from 100kg/ha urea application followed by 150kg/ha and the lowest was recorded from 50kg/ha urea application. The highest lodging recorded from 150kg/ha followed by 100kg/ha urea application while the lowest lodging was recorded from 50kg/ha urea application. The optimum fresh biomass yield, dry matter and grain yield were produced from a 80kg/ha seed rate and 100kg/ha urea (Tables 8 to 10).

Table 7. Growth and yield parameters of Bareda as influenced by different seed rate and nitrogen rates

Treatments		50%FD	MD	PH (cm)	PC	SV	PL	Lodge (%)	FByt/ha	DMyt/ha	Gryqt/ha
Locations	On station	68.02[b]	118.76[b]	118.74[c]	89.4[b]	2.09[a]	28.43[ab]	8.75[c]	36.75[c]	8.49[c]	31.52[c]
	A/Rakate FTC	76.55[a]	138.03[a]	133.89[a]	89.3[b]	1.33[b]	29.2[ab]	25.04[b]	54.89[a]	9.31[b]	41.69[a]
	Bareda FTC	59.91[c]	102.30[c]	123.82[b]	97.19[a]	1.47[b]	29.92[a]	38.16[a]	44.58[b]	10.45[a]	37.02[b]
	Mean	68.16	119.7	125.48	91.96	1.63	19.21	23.98	45.41	9.42	36.74
	LSD (5%)	0.849	0.8917	2.439	2.558	0.248	1.179	5.96	3.719	0.7151	2.02
	P-Value	<.0001	<.0001	<.0001	0.0243	<.0001	<.0001	<.0001	<.0001	0.0002	<.0001
Seed Rate	60	71.71[a]	124.2[a]	126.68	89	1.96[a]	30.93[a]	17.22	45.54[ab]	8.58[c]	35.87
	80	70.6[b]	122.4[b]	125.64	91.6	1.51[b]	28.78[b]	22.75	48.87[a]	9.88[a]	36.78
	100	69.04[c]	123.2[ab]	126.05	91.5	1.62[b]	28.56[b]	23.26	45.12[ab]	9.42[ab]	37.32
	120	67.91[d]	122.9[b]	124.91	91.6	1.58[b]	27.87[b]	21.31	42.75[b]	8.96[bc]	36.76
	Mean	69.815	123.17	125.82	90.93	1.67	29.04	21.14	45.57	9.21	36.68
	LSD (5%)	0.93	0.977	2.671	2.8	0.272	1.29	6.53	4.07	0.783	2.215
	P-Value	<.0001	0.0078	0.7150	0.3070	0.0295	0.0001	0.1089	0.0346	0.0088	0.7399
N rate	23	70.25	123.63[a]	124.9	88.1[b]	2.07[a]	28.49[b]	14.38[c]	40.69[c]	8.28[b]	35.5[b]
	46	69.6	123.43[a]	125.7	91.52[a]	1.57[b]	28.69[b]	21.63[b]	50.93[a]	10.01[a]	37.84[a]
	69	69.6	122.46[b]	126.8	93.2[a]	1.36[b]	29.92[a]	27.4[a]	45.09[b]	9.34[a]	36.72[ab]
	Mean	69.82	123.17	125.8	90.94	1.67	29.03	21.13	45.57	9.21	36.68
	LSD (5%)	0.806	0.845	2.3136	2.427	0.235	1.118	5.657	3.528	0.678	1.918
	P-Value	0.1137	0.0217	0.4334	0.0005	<.0001	0.0094	<.0001	<.0001	<.0001	0.0486

50%FD = 50% flowering date, MD = maturity date, PH(cm) = plant height in centimeter, PC = plot coverage, SV = plant stand vigor, PL =panicle length, FByt/ha = fresh biomass yield tone per hectare, DMyt/ha = dry matter yield tone per hectare, Gryqt/ha = grain yield quintal per hectare

Table 8. Soil influenced by the seed and fertilizers rates and their interactions at on station

Treatments	2023					2025				
	pH	Av. P (ppm)	OC (%)	TN (%)	CEC (meq/100 gm soil)	pH	Av. P (ppm)	OC (%)	TN (%)	CEC (meq/100 gm soil)
120kgx50kgN/ha	5.84	3.01	1.76	0.15	25.84	6.70	3.16	1.46	0.13	22.67
120kgx100kgN/ha	5.86	3.54	1.56	0.13	22.63	6.54	9.79	1.37	0.12	22.08
60kgx150kgN/ha	5.75	4.17	1.85	0.16	24.52	6.4	4.12	1.56	0.13	21.79
100kgx50kgN/ha	5.96	3.44	1.85	0.16	24.33	6.35	4.12	1.37	0.12	19.84
80kgx50kgN/ha	5.76	3.79	1.76	0.15	24.52	6.32	4.26	1.46	0.13	19.48
60kgx100kgN/ha	5.88	3.43	2.15	0.18	24.71	6.34	6.12	1.27	0.11	21.24
120kgx150kgN/ha	5.95	4.24	1.76	0.15	23.20	6.37	3.98	1.37	0.12	20.73
80kgx150kgN/ha	5.90	3.84	1.56	0.13	25.08	6.31	4.22	1.66	0.14	19.70

100kgx150kgN/ha	5.97	3.40	1.46	0.13	26.78	6.33	4.47	1.66	0.14	17.65
100kgx100kgN/ha	5.87	8.50	1.56	0.13	23.95	6.34	4.24	1.56	0.13	15.01
80kgx100kgN/ha	5.82	4.28	2.34	0.20	23.39	6.33	6.64	1.37	0.12	19.99
60kgx50kgN/ha	5.91	7.85	1.95	0.17	25.84	6.30	2.71	1.66	0.14	19.57
Pre sowing	5.65	5.92	2.15	0.18	26.97	6.83	4.04	1.46	0.20	24.90

Table 9. Soil influenced by seed and fertilizers rates and their interactions at Bareda FTC

Treatments	2023				
	pH	Av. P (ppm)	OC (%)	TN (%)	CEC (meq/100 gm soil)
120kgx50kgN/ha	6.38	9.33	2.05	0.18	54.13
120kgx100kgN/ha	6.58	5.35	1.95	0.17	57.33
60kgx150kgN/ha	6.72	4.94	1.56	0.13	54.51
100kgx50kgN/ha	6.68	5.54	2.05	0.18	54.88
80kgx50kgN/ha	6.64	4.93	1.76	0.15	52.62
60kgx100kgN/ha	6.70	5.94	1.27	0.11	52.24
120kgx150kgN/ha	6.73	5.49	0.98	0.08	53.56
80kgx150kgN/ha	6.61	5.53	1.17	0.10	53.37
100kgx150kgN/ha	6.60	7.01	2.15	0.18	52.43
100kgx100kgN/ha	7.02	7.36	0.49	0.04	46.96
80kgx100kgN/ha	6.74	5.52	0.68	0.06	51.68
60kgx50kgN/ha	6.73	5.04	0.78	0.07	52.62
Pre sowing	6.68	3.20	1.95	0.17	40.39

Table 10. Soil influenced by seed and fertilizers rates and their interactions at Arba Rakate FTC

Treatments	2023					2025				
	pH	Av. P (ppm)	OC (%)	TN (%)	CEC (meq/100 gm soil)	pH	Av. P (ppm)	OC (%)	TN (%)	CEC (meq/100 gm soil)
120kgx50kgN/ha	6.69	23.64	2.24	0.19	46.33	6.42	17.12	1.46	0.12	52.46
120kgx100kgN/ha	6.67	21.19	1.85	0.16	45.54	6.49	24.78	1.95	0.17	49.88
60kgx150kgN/ha	6.66	14.54	1.46	0.13	50.09	6.60	22.58	1.85	0.16	57.95
100kgx50kgN/ha	6.64	14.62	2.24	0.19	54.65	6.63	16.30	1.76	0.15	53.18
80kgx50kgN/ha	6.63	9.78	1.95	0.17	48.51	6.60	25.88	1.95	0.17	49.02
60kgx100kgN/ha	6.59	19.14	2.54	0.22	48.91	6.62	18.70	1.46	0.13	54.68
120kgx150kgN/ha	6.54	17.25	1.37	0.12	47.32	6.62	17.28	1.66	0.14	51.40
80kgx150kgN/ha	6.65	20.89	2.44	0.21	42.37	6.60	24.01	1.66	0.14	53.30
100kgx150kgN/ha	6.60	17.84	2.93	0.25	51.88	6.63	15.53	1.56	0.13	48.64
100kgx100kgN/ha	6.61	24.70	2.24	0.19	50.89	6.62	18.21	1.85	0.16	47.96
80kgx100kgN/ha	6.61	23.50	1.56	0.13	54.05	6.70	22.38	1.95	0.17	54.59
60kgx50kgN/ha	6.60	21.94	1.76	0.15	56.03	6.69	17.19	1.66	0.14	56.58
Pre sowing	6.67	31.59	2.15	0.18	52.67	6.60	19.42	1.76	0.22	54.57

3.9. Chemical composition

The results of the chemical composition are presented in (Table 11). A significant ($P>0.05$) variation not observed among the treatments for chemical composition due to different seed and fertilizer rates applications as well as their interaction. It indicated that the constitution of the walls of the tissues is similar for Bareda oat variety that did not changed chemical composition due to different seed rate, fertilizer rate and there interaction.

Table 11. Effect of different Seed and N on chemical composition in the first year results

Factors	Parameters (%)									
	DM	Ash	OM	CP	NDF	ADF	ADL	IVDMD	Hcelu	Celu
Fertilizer level (kgha^{-1})										
50 Kg/ha	90.49	9.88	89.88	6.94	73.737	49.02	8.23	51.51	24.71	40.795
100 Kg/ha	90.22	10.12	90.12	6.74	72.33	48.88	8.39	51.01	23.44	40.48
150 Kg/ha	90.33	9.51	90.50	6.75	73.02	49.48	8.25	53.34	23.54	41.22
Mean	90.35	9.84	90.17	6.81	73.03	49.13	8.29	51.95	23.90	40.83
CV	0.52	8.94	0.98	9.0	4.0	3.08	32.08	8.05	11.23	6.77
LSD	0.2985	0.7813	0.783	0.5785	2.1068	1.4457	2.3423	3.1644	2.2431	2.1593
P-value	0.6009	0.2507	0.2407	0.8276	0.4505	0.7446	0.9852	0.1491	0.6347	0.9000
Seed rate (kgha^{-1})										
60 Kg/ha	90.31^{ab}	9.90	90.09	6.92	73.12	49.38	8.653	54.21	23.74	40.72
80 Kg/ha	90.33^{ab}	9.79	90.21	6.44	72.94	49.70	8.530	50.71	23.23	41.17
100 Kg/ha	90.17^{b}	10.044	89.95	6.78	72.81	48.64	6.951	51.34	24.17	41.68
150 Kg/ha	90.55^{a}	9.63	90.38	6.777	73.08	48.77	9.056	51.46	24.31	39.71
Mean	90.34	9.84	90.16	6.73	72.99	49.12	8.30	51.93	23.86	40.82
CV	0.389	9.35	1.02	10.02	3.40	3.46	33.26	7.17	11.07	6.23
LSD	0.3438	0.9001	0.9024	0.6665	2.4271	1.6655	2.6984	3.6454	2.584	2.4875
P-value	0.0425	0.8902	0.8836	0.9493	0.9589	0.6107	0.4288	0.1867	0.8655	0.7012

DM = dry matter percentage, CP = crude protein, OM = Organic matter, = NDF = Neutral detergent fiber, ADF = ADL = Acid detergent lignin, Acid detergent fiber, IVDMD = In vitro Dry Matter Digestibility; Hcelu = Hemi cellulose and Celu = cellulose

3.10. A Partial Budget Analysis estimates

Partial Budget Analysis is estimated to compare marginal returns among treatments. Table 12 depicts financial analysis estimates for all treatment combinations considered for the economic returns of grain yield and dry matter based on local and near market prices. Without considering common costs such as land rent and labor costs, the highest marginal return of 100,109 ETB per hectare was obtained from the treatment combination for an 80kg/ha seed rate with 100kg N/ha nitrogen fertilizer followed by a 120kg/ha seed rate with 100kg/ha nitrogen fertilizer, for which 99,303 ETB per hectare. The lowest marginal returns was recorded from the treatment combination of 60kg/ha seed rate with 50kg/ha nitrogen fertilizer, which was 84,184.5 ETB.

Table 12. Partial budget analysis of fertilizers and seed rate for Bareda grain and dry matter yield

Treatments		Grain yield (kg/ha	GB (ETB)	Fert.Appl Cost (ETB)	Seed Appl cost (ETB)	DMY t/ha	GB (ETB)	TR (ETB)	TVC	TMR (ETB)	Ranks
60	50kg N/ha	33.26	66512	1947.5	1800	7.14	21420	87932	3747.5	84184.5	12
	100kg N/ha	37.46	74892	3895	1800	8.85	26550	101442	5695	95747	4
	150kg N/ha	36.93	73852	5842.5	1800	9.77	29310	103162	7642.5	95519.5	7
80	50kg N/ha	36.66	73312	1947.5	2400	8.72	26160	99472	4347.5	95124.5	8
	100kg N/ha	38.07	76134	3895	2400	10.09	30270	106404	6295	100109	1
	150kg N/ha	35.64	71272	5842.5	2400	10.84	32520	103792	8242.5	95549.5	6
100	50kg N/ha	38.0	76008	1947.5	3000	9.39	28170	104178	4947.5	99230.5	3
	100kg N/ha	35.95	71902	3895	3000	9.43	28290	100192	6895	93297	9
	150kg N/ha	38.03	76064	5842.5	3000	9.46	28380	104444	8842.5	95601.5	5
120	50kg N/ha	34.12	68246	1947.5	3600	7.88	23640	91886	5547.5	86338.5	11
	100kg N/ha	39.88	79768	3895	3600	9.01	27030	106798	7495	99303	2
	150kg N/ha	36.29	72572	5842.5	3600	9.99	29970	102542	9442.5	93099.5	10

TMR = Total marginal Revenue, ETB = Ethiopian birr, kg N/ha = kilogram Nitrogen per hectare, Fert.Appl Cost (ETB)= fertilizer application cost; Seed Appl cost (ETB)= seed application cost, Oats price for sale birr/kg = 20 birr, Oats seed during sowing price 30birr/kg, Urea cost of 1kg = 38.95ETB, Dry matter 1kg = 3 ETB

4. CONCLUSION

From the present study, different seed and nitrogen rates have a significant variation in most studied parameters. Year and location have a main effect on all tested parameters. 50% flowering and maturity days took longer time at a lower seed rate. Dry matter production increased significantly with increases in nitrogen rates from 50 to 150 kg/ha. The highest and lowest seed rate applications produced the minimal dry matter yield. Low seed rate with different rates of N produced the lowest grain yield. A combination of 80kg/ha seed rate and 100kg/ha urea produced the highest forage herbage yield and grain. Sowing of different seed rates with different rates of urea fertilizer didn't affect the nutritional quality of the Bareda oat variety. The highest marginal return of 100,109 ETB per hectare was obtained at an 80kg/ha seed rate with a combination of 100kg/ha nitrogen fertilizer. 80kg/ha seed rate and 100kg N/ha is the best combination for reasonable production of the Bareda oat variety.

Recommendation

An 80kg/ha seed rate and a 100kg N/ha combination are recommended for the Bareda oat variety to produce reasonable forage and grain yield production, so that end users can use.

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Author Contributions

Tamrat Dinkale is working from proposal development, data collection, data entry, result analyses and manuscript full write up. He is the responsible person to correct every comment and suggestion throughout manuscript edition.
Lensa Urgesa has a contribution during proposal development, data entry, data collection and data analysis.
Jibrail Hassen has a contribution during data collection.
Sudi Dawud has a contribution of experimental supervision and correction data set up.

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Conflict of interest

The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval

All methods used in this research complied with the relevant institutional, national, and international guidelines and legislation. In addition, since this study does not involve wild plant materials, hence, any formal identification of plant material was not required.

Informed consent

Not applicable.

Data availability

All data associated with this study will be available upon reasonable request to the corresponding author.

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