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Adaptation Trial of Oat (*Avena sativa*) Varieties in Two Agro-ecologies of Buno Bedele and Ilu Aba Bor Zones, South Western Oromia, Ethiopia

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Abstract

Shortage of feed is a critical problem for livestock production in Ethiopia. Thus, production of oat varieties that can be performed better at different agro-ecologies is very important to mitigate the feed shortage problem in study areas. The experiment was conducted to evaluate oat varieties for their herbage dry matter yield, seed yield and other agronomic traits under two agro ecologies of Buno Bedeleand Ilu Aba Borzones, South Western Oromia, Ethiopia. The trial was carried out at Gechi and Hurumu districts and Chora and Mettu districts which were purposely selected to represent highland and midland agro-ecologies, respectively for two consecutive years of 2020 and 2021 in the main cropping season. Seven oat varieties (Lamptom, CI-2806, Bonsa, Bate, CI-2291, Jassery and CI-8251) were laid out in randomized complete block design with three replications. Data on stand and vigor, plot cover percentage, dry matter yield, plant height, leaf to stem ratio, disease score, maturity date and seed yield were collected and subjected to general linear model procedures of Genstat software version 18.1 and least significance difference for data analysis and mean separation were employed respectively. The varieties had responded differently ($P<0.05$) at both highland and midland areas in dry matter yield, leaf to steam ratio, plant height and disease score but the seed yield and maturity date were not significantly difference in highland and midland areas respectively. The dry matter yield of seven oat varieties ranged 10.6-15.4 t ha^{-1} at highland and 9.5-13.8 t ha^{-1} at midland areas. Based on the study result, better dry matter yield and seed yield performances were recorded from varieties Bonsa, CI-2291, and CI-2806. Generally, Bonsa, CI-2291, and CI-2806 oat varieties were well adapted and performed in the study areas. Therefore, Bonsa, CI-2291, and CI-2806 oat varieties were recommended for further demonstration and scaled-up for the study areas and similar agro-ecologies.

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Keywords

Dry matter yield, Leaf to stem ratio, Oat, Plant height, Seed yield, Varieties.

Introduction

The livestock sector is a significant contributor to Ethiopia's economy at the national and household level. In Ethiopia, livestock is an integral component of the agricultural sector with a large bovine population which includes 59.5 and 60.9 million cattle and shoat, respectively (CSA, 2017). In addition to direct income benefits, livestock provides indirect benefits, such as fuel and fertilizer from animal manure and draught power for farm production. In spite of its significant contribution, the country's livestock productivity is low. In addition to animal health problems, lack of adequate quantity and quality of feed is a major factor in poor livestock

productivity. Animal feed shortage remains the main constraint on herd size and productivity in both mid and highlands. The farmers face fodder deficiency in winter when they have only dry stalks of cereal fodder or dry summer grasses. Therefore, there is a direct need to maximize fodder production per acre which could be increased by adopting improved varieties and agronomic practices.

Substantial efforts have been made so far to resolve the feed shortage problem in the Ethiopian highlands, aiming at improving feed availability and thereby improve livestock productivity. The available fodder supply is 1/3 less than the actual needs of animals (Younas and Yaqoob, 2005). So that more nutritious and high yielding fodder varieties are needed to run an efficient livestock industry. Utilizing improved forage varieties like fodder oat has several advantages. Oat (*Avena sativa* L.) is one of the most important well-adapted fodder crops grown in the highlands of Ethiopia. It is dual purpose forage in many parts of the world (Mekonnen Yirga and Ali Seid, 2013). The improved varieties of oats have potential to produce three-fold green fodder i.e. 60-80 t ha^{-1} and could feed double the number of animals per unit area as against the traditional fodder crops (Haqqani *et al.,* 2003). With the introduction of new high yielding oat varieties, the farmers have recognized oat as important fodder crop for filling the fodder gap (Habib et al., 2003).On average, it contains around 10-12% protein, 5% fat, 12-14% fiber and 64% carbohydrate. Many oat cultivars have high feeding value if cut at its best harvesting time (50% flowering stage) and can meet the demand of rapidly growing livestock industry of Ethiopia. Oat variety fatua harvested at 50 percent flowering stage produced the highest green fodder and dry matter yields (Hussain *et al.,* 2002). It is produced by some pre-urban dairy cattle producers and smallholder farmers who own crossbred dairy cows. It is early maturing, palatable, succulent and energy rich crop. It can also be used as bedding for animals. Therefore, the current study was conducted with the objective to identify the adaptable and superior oat varieties under mid and high altitudes of Buno Bedele and Ilu Abba Bor Zones of South Western Oromia, Ethiopia.

Materials and Methods

Description of the Study Areas

The experiment was conducted under rain-fed conditions during 2020 and 2021 of main cropping season in highlands and midlands of Buno Bedele (Chora and Gechi districts) and Ilu Aba Bor (Hurumu and Mettu districts) Zones, South Western Oromia, Ethiopia. Two districts were selected purposively based on altitude, Gechi and Humuru districts from highland areas and Chora and Mettu were also selected from midland areas.

Gechi district lies at an altitude of 2014 m above sea level, whereas Hurumu district lies 1796-2580m above sea level. Annual precipitation Gechi district ranges from 1500 to 2200 mm with 6 to 9 months of rainfall and daily temperature of the district varies from 12 to 35°C. The mean annual areal rainfall of Hurumu district is 1698.3 mm with an average temperature of 23 °C. Chora and Mettu districts are situated at an altitude of 1962 m above sea level and 1605 m above sea level respectively.

Experimental treatments and design

The study was designed to identify the best adapted and superior oat varieties. The experiment consisted of seven oat varieties namely: Lamptom, CI-2806, Bonsa, Bate, CI-2291, Jassery and CI-8251. The experiment was laid out in randomized block design with three replications on well prepared and leveled field. All the treatments were randomly allocated to different plots in each replication.

A plot size of 3 m x 1.8 m (5.4 m^2) was used. The spacing between rows and blocks were 30 m and 1 m, respectively. Each plot had 6 rows and the rows were 3 meters long and data was collected from the middle four rows and the two rows were served as a border. Drill method was used for seed sowing at a rate of 100 kg/ha. NPS fertilizer was uniformly applied at the rate of 100 kg ha^{-1}at sowing and urea was also uniformly applied once at the rate of 100 kg ha^{-1} after the establishment.

Agronomic Data Collection

Data was collected from two central rows for all parameters including emergency date, stand and vigor percentage, days to 50% flowering, plant height, falling percentage, dry matter yield, plot cover percentage, leaf to steam ration, disease/insect(1-5score), maturity date and seed yield.

Statistical Data Analysis

The data recorded were analyzed using the Genstat software version 18.1and significant means separated by using least significance difference (LSD) at 5% probability level.

Results and Discussion

Dry Matter Yield

The result of combined analysis showed that herbage dry matter yield was significantly ($p<0.05$) affected by oat varieties. Bonsa and CI-2291varieties were produced the maximum dry matter yield of 15.4 t ha^{-1} and 14.4 t ha^{-1}at highlands of the study areas, respectively (Table1).

Yet again, Bonsa and CI-2291 oat varieties produced optimum dry matter yield of 13.8 t $ha^{-1}$and 12.7 t ha^{-1} at midlands of the study areas (Table 2). Jassery variety was produced lower herbage dry matter yield at both highland and midland agro ecologies of the study areas.

Leaf to stem Ratio

The result of this study revealed that oat varieties have significant ($p<0.5$) difference in leaf to stem ratio at both agro-ecologies. There is a significant difference among the oat cultivars regarding green forage yield (Nawaz *et al.,* 2004). The maximum leaf to stem ratio was recorded for CI-2291 (0.90), Bonsa (0.88) and followed by CI-2806 (0.85) whereas minimum leaf to stem ratio was recorded for Bate variety (0.56) at midland of the study areas (Table 2). Plant leaves play a great role in growth and development of plants thereby influence forage biomass yield (Gebremedhn Beyene *et al.,* 2015).

Plan Height

Plant height is a major factor contributing towards forage yield of different crops. There was significant variation recorded for plant height among oat genotypes in 2020 and 2021 cropping seasons (Table 1 and 2). The result obtained was in agreement with the reported significant differences among the oat varieties regarding plant height (Chohan *et al.,* 2004).

The differences among varieties in plant height were due to differences in genetic makeup and it is a foremost feature contributing towards forage biomass yield (Gebremedhn Beyene *et al.,* 2015). Lamptom variety showed the highest plant height (128.3 cm) followed by Bate variety (127.7 cm) while the lowest plant height (109.2 cm) was recorded by Jassery variety at highland areas of Gechi and Hurumu districts. Lamptom was also produced the highest plant height (111.2 cm) followed by Bate variety (109.6 cm) while the lowest plant height (94 cm) was recorded by Jassery at midland areas of Chora and Mettu districts.

Occurrence of disease and pests

The occurrence of disease was measured in 1-5 scale during the experimental period. Leaf rust was occurred on Bate, Jassery and Lamptom varieties. Based on 1-5 scale, Bate, Jassery and Lamptom varieties scored a mean of 2.8, 2.6 and 2, respectively for leaf rust disease at highland areas of Gechi and Hurumu districts (Table 1). Therefore, Bonsa, CI-2291 and CI-2806 varieties were scored 1 and relatively have resistant to leaf rust disease in the study areas (Table 1 and 2).

Seed Yield

The result of combined analysis showed that seed yield did not significantly ($p>0.05$) affected by oat varieties at highland areas (Gechi and Hurumu districts), while the tested varieties were showed a significant ($P<0.5$) differences on seed yield at midland areas (Chora and Mettu districts)(Table 1 and 2). Even though the seed yield was not differ significantly ($p>0.05$) between oat varieties at highland areas, optimum seed yield of 31.02, 30.14 and 28.58were recorded for variety CI-2291, CI-2806 and Bonsa, respectively at highland areas of Gechi and Hurumu districts (Table 1). Similar trends were observed at midland areas of Chora and Mettu districts, in that optimum seed yield of 26.01, 23.76 and 21.82qt/ha were recorded in that order (Table 2). The lowest seed yield was recorded by Bate (15.15 qt/ha), Lamptom (16.23 qt/ha) and CI-8251 (16.3qt/ha) varieties at midland areas of Chora and Mettu districts (Table 2). The mean seed yields of CI- 2806 variety obtained in highland areas of Gechi and Hurumu districts were higher than the result recorded 24.5 qt/ha (Atumo Tessema and Kalsa Getinet, 2020).

Stability of Performance/Adaptability

The forage yield stability parameters for tested oat varieties for two years at highland areas of Gechi and Hurumu districts and midland areas of Chora and Mettu districts were studied. Analysis of result of the dry matter yield using the comparison GGE Biplot shows that Bonsa and CI-2291 varieties were the most stable and desired varieties as compared to the other varieties at highland areas (Gechi and Hurumu districts) (Fig.1). Bonsa and CI-2806 varieties were mostly stable and desired varieties in dry matter yield as compared to the other varieties at midland areas (Chora and Mettu districts) (Fig.2). This resulted in a good adaptability compared to the remaining tested varieties in the test environments and similar agro-ecologies (Fig.1 and 2).

Table.1 Combined analysis of variance for Dry matter yield of seven oat varieties tested in two agro-ecologies of Buno Bedele and Ilu Aba Bor Zones

Source of Variation	DF	Sum of square	Mean squares	F-value	p-value
Replication	2	170.22	85.11	7.10	
Varieties	6	310.23	51.71**	4.31	0.001
Location	3	437.51	145.84**	12.17	0.001
Varieties *Location	18	91.26	5.07	0.42	0.981
Error	138	1654.18	11.99		
Total	167	2663.41			

Table.2 Combined mean performance of forage yield and yield related components of Oats at Highland areas of Gechi and Hurumu Districts in 2020 and 2021

Varieties	Stand and vigor (%)	Plot cover (%)	Dry matter yield (t/ha)	Leaf stem ratio	Plant height (cm)	Disease incidence (1-5)	Maturity date	Seed yield (qt/ha)
Bonsa	83.7^{ab}	87.1^{abc}	15.4^{a}	0.85^{abc}	124.3^{a}	1^{c}	132.2^{ab}	28.58
Bate	80.6^{ab}	84.7^{bc}	12.5^{ab}	0.65^{c}	127.7^{a}	2.8^{a}	126.6^{b}	25.33
Lamptom	83.3^{ab}	89.4^{abc}	12.9^{ab}	0.84^{abc}	128.3^{a}	2.0^{b}	130.2^{ab}	26.97
CI-2806	88.2^{a}	92.0^{a}	13.9^{ab}	0.87^{ab}	118.9^{ab}	1^{c}	132.6^{ab}	30.14
CI-2291	87.2^{a}	92.9^{a}	14.4^{a}	0.78^{abc}	109.4^{b}	1^{c}	133.2^{a}	31.02
Jassery	78.8^{b}	83.2^{c}	10.6^{b}	0.66^{bc}	109.2^{b}	2.6^{a}	136.0^{a}	24.71
CI-8251	87.2^{a}	90.4^{ab}	14.1^{ab}	0.88^{a}	124.8^{a}	1^{c}	132.3^{ab}	28.53
Mean	84.2	88.5	13.4	0.79	120.4	1.62	131.87	27.90
CV (%)	11.9	9.7	33.7	31.9	12.4	20.9	5.8	30.7
LSD (5%)	8.14	7.01	3.67	0.20	12.17	0.27	6.23	6.96
P- value	*	**	*	*	**	**	*	NS

Table.3 Combined mean performance of forage yield and yield related components of Oats at Midland areas of Chora and Mettu Districts in 2020 and 2021

Varieties	Stand and vigor (%)	Plot cover (%)	Dry matter yield (t/ha)	Leaf stem ratio	Plant height (cm)	Disease incidence (1-5)	Maturity date	Seed yield (qt/ha)
Bonsa	80.2^{ab}	83.2^{ab}	13.8^{a}	0.94^{a}	106.2^{ab}	1.0^{c}	133.1	21.82^{ab}
Bate	82.8^{ab}	86.8^{ab}	10.8^{bcd}	0.63^{b}	109.6^{a}	2.3^{a}	129.2	15.15^{c}
Lamptom	84.8^{ab}	88.5^{a}	10.1^{cd}	0.82^{ab}	111.2^{a}	1.9^{b}	131.7	16.23^{c}
CI-2806	87.2^{a}	88.2^{ab}	11.6^{abc}	0.89^{a}	109.3^{a}	1.1^{c}	131.8	23.76^{a}
CI-2291	85.4^{a}	87.7^{ab}	12.7^{ab}	0.97^{a}	101.6^{ab}	1.0^{c}	133.4	26.01^{a}
Jassery	76.4^{b}	79.4^{b}	9.5^{d}	0.79^{ab}	94.0^{b}	2.3^{a}	133.8	18.25^{bc}
CI-8251	85.2^{a}	88.9^{a}	11.9^{abc}	0.87^{a}	110.7^{a}	1.0^{c}	133.3	16.13^{c}
Mean	83.2	86.1	11.41	0.85	106.1	1.52	132.32	19.62
CV (%)	12.5	12.7	21.8	30.2	14.3	28.6	5.3	34.5
LSD (5%)	8.48	8.92	2.03	0.21	12.34	0.35	5.71	5.51
P- value	*	*	**	*	**	**	NS	**

Fig.1 GGE Biplot analysis of Dry matter yield (t/ha) at highland areas Gechi and Hurumu districts

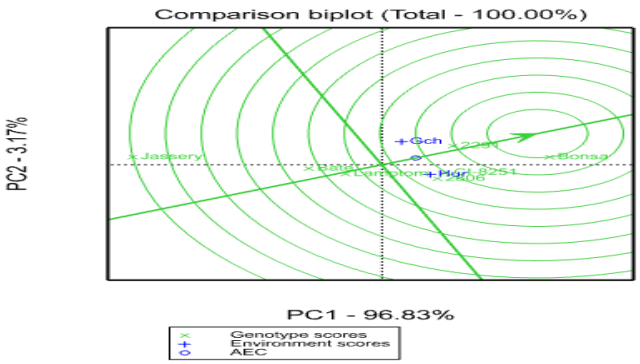
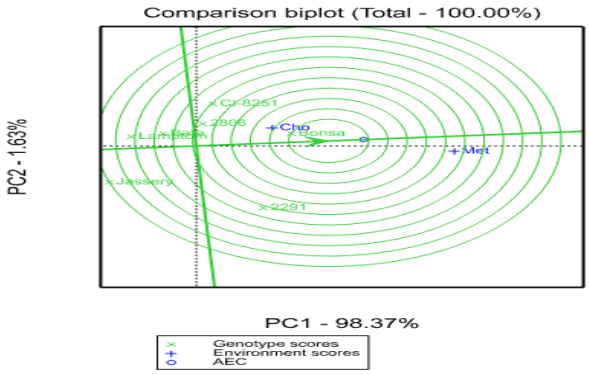


Fig.2 GGE Biplot analysis of Dry matter yield (t/ha) at Midland areas Chora and Mettu districts



Recommendations

Seven oat varieties were evaluated for herbage yield and yield related components during 2020 and 2021 main cropping season in highlands and midlands of Buno Bedele and Ilu Aba Bor zones, South Western Oromia, Ethiopia. The result of combined mean performance shows that the tested oat varieties were varied significantly ($p<0.05$) on dry matter yield, leaf to steam ratio, plant height and disease score in both highland and midland agro ecologies of study areas. The mean value of seed yield in the highland agro ecologies of Gechi and Hurumu districts shows not significantly difference. The result of analyzed mean value shows that Bonsa, CI-2291 and CI- 2806 varieties records the maximum dry matter yielder than the other oat varieties at highland areas of Gechi and Hurumu districts and midland areas of Chora and Mettu districts. The maximum leaf to stem ratio was recorded for CI-2291, Bonsa and followed by CI- 2806 whereas minimum leaf to stem ratio was recorded for Bate variety at midland of the study areas. The highest plant height was recorded by Lamptom and Bate variety while the lowest plant height was recorded by Jassery variety at both highland and midland of the study areas. Leaf rust was occurred on the varieties of Bate, Jassery and Lamptom. Bonsa, CI-2291 and CI-2806 varieties were more tolerant to the major diseases at highland and midland agro ecologies of the study areas. The result of the combined mean value of CI-2291, CI- 2806 and Bonsa varieties shows the high seed yielder when compared to the other oat varieties in both highland and midland agro ecologies of study areas. The lowest seed yielder was recorded by Bate, Lamptom and CI-8251 varieties at midland areas of Chora and Mettu districts.

The result of the study revealed that Bonsa, CI-2292 and CI-2806 varieties proved to be the highest yielder varieties and it was found to be the highest in dry matter yield and seed yield which reflects its better product of fodder varieties. Based on the result of the study, Bonsa, CI-2291, and CI-2806 proved to be superior varieties with respect to getting the higher dry matter yield and seed yield in the study areas. The seed yield variation among the tested oat varieties that grown in similar environments may be due to genetic potential of the varieties and their adaptability. Therefore, Bonsa, CI-2291, and CI-2806 varieties could be recommended to the best technology options for green fodder, dry matter and seed yields in the study areas and similar agro-ecologies of Buno Bedele and Ilu Abba Bor Zones.

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