Journal of Animal Research: v.6 n.1, p. 15-20. February 2016
DOI: 10.5958/2277-940X.2016.00003.

Adaptation Trial of Oat (*Avena sativa*) Varieties in Dehana District, Northern Ethiopia

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Received: 06 November, 2015 **Accepted:** 18 January, 2016

ABSTRACT

The experiment was conducted in Dehana District to identify the adaptable and high yielding oat accession (s). Data on dry matter yield (kg × m^{-2}), dry matter (percentage), grain yield (kg × m^{-2}), plant height (centimeter) and fresh weight (kg × m^{-2}) were taken for the accessions of oat used (579-D-27, CI-8237, CI-8235, DZF- 00551 and 6710). A significance difference ($p<0.05$) was observed in the parameters of dry matter yield, grain yield and fresh weight but the other parameters did not show significant differences. The mean dry matter yield of CI-8237 (0.735 kg × m^{-2}) was significantly higher than 579-D-27 (0.562 kg × m^{-2}), 6710 (0.533 kg × m^{-2}) and CI-8235 (0.506 kg × m^{-2}) varieties. The mean fresh weight yield of CI-8237 (2.446 kg × m^{-2}) was significantly higher than 6710 (1.819 kg × m^{-2}) and CI-8235 (1.774 kg × m^{-2}). The mean grain yield of DZ-00551 (0.283 kg × m^{-2}) was significantly higher ($p<0.05$) than all the other varieties. At the end of the experiment a field day was prepared and all the participants of field day (100%) prefer the variety CI-8237 for its biomass yield. Hence, it can be concluded that the oat variety CI-8237 should be recommended to farmers of Dehana District and of similar climatic conditions in order to enhance livestock feed production.

Keywords: Dry matter, grain, yield, Oat

One of the bottleneck of livestock production in Ethiopia is feed shortage. Climate change is playing a major role in challenging to the development of feed resources (Dineshsingh *et al.* 2014). The major feed resource in developing countries is crop residues. However, crop residues are low in protein, energy and other important micronutrients essential for animal production (Ramana *et al.* 2015). As a result, animals hardly meet their nutritional requirements and livestock productivity, in terms of meat and milk, is very low, draft power from oxen is minimal which thereby affects food crop production under smallholder crop/livestock farming systems. Integration of food and forage crops is a useful practice in area where both crop and livestock farming are simultaneously practiced (Lulseged *et al.* 1986). Activities in the fields of forage seed production and research are relatively underdeveloped throughout Ethiopia. But forage research in national programmes and in regional research centers has gained momentum in the last three decades, and many pasture development schemes have been implemented in the regions.

Forage crops and livestock husbandry are two productive systems greatly linked with each other. In fact, only the availability of choice forage can warrant the quality and healthfulness of livestock production. In this context the role of improved forage and grasses is very important, because of their high dry matter yield, quality and feeding value.

Feed is available in the rainy season where as a critical shortage in the dry season is a common phenomenon, provided quality forage for animals in the dry season is one of the biggest problems in animal production in Ethiopia. During the dry season, livestock feed is normally in short supply and is also of poor quality. Residues from cereals and pasture roughages are the main source of forage but these are low in crude protein and have poor digestibility. Therefore production of adequate quantities of good quality dry season forages to supplement crop residues and pasture roughages is the way to overcome the dry season constraints affecting livestock production in Ethiopia and the study area in particular (Alemayehu 2002).

To overcome the feed shortage problem, some grass and legume forage species have been tested under rain fed condition without application of fertilizer at national level as most farmers of the country do not practice irrigation agriculture and application of fertilizer. Among the forage grasses, oat (*Avena sativa*) is the best adapted and productive forage with minimum input usage. *Avena sativa* varieties have high dry matter yields (Hogan and Weston 1969). It can be used for making hay and for grazing (Wheeler 1981). Although, oat varieties should be tested for quality and productivity under the different climatic conditions, to date such studies did not carried out in the study area. This study was, therefore, designed to evaluate and identify the adaptable and high yielding oat variety (s) in Dehana District of northern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

Waghimra zone is one of the 11 administrative zones in Amhara National Regional State of Ethiopia and comprises of six districts. Dehana is one of the six districts in the zone. Dehana district which is located in the eastern part of the Amhara Region is identified to be potential area for livestock production but the area is getting degraded and deforested from time to time which negatively affect the subsector (DDAO, 2010). Cattle, sheep & goats ('shoats') and equines are the main livestock reared. Shoat and cattle sales are the main source of cash income for the middle and better off households. Grazing is free on communal land but insufficient, and most livestock are sold at the immature stage, as fodder is scarce and expensive (SC-UK, 2007).

Agro-ecology of Dehana District

The area is characterized by a moderate sub-moist and partly by hot to warm sub moist agroecology and a very rugged topography of mountains, hills and gorges (SC-UK, 2007). The vegetation is mainly scattered bushes and shrubs and acacia species.

Forage and crop production is highly affected by frequently erratic rainfall in the single, summer, rainy season that lasts not longer than two months - July and August. In the moderate sub-moist, the soil is predominantly sandy loam type but clay soil is found in some parts where as in the hot to warm sub moist agroecology the soil types are a mix of sandy and clay and soils are mostly of low to moderate fertility (SC-UK, 2007). This is a food deficit area in which agricultural performance is also reduced by environmental degradation and shallow soils often of low fertility.

Treatments and Experimental Design

The study was conducted using completely randomized block design (CRBD) with three replications. The experimental treatment groups used were five accessions of oat (T1=579-D-27, T2=CI- 8237, T3=CI- 8235, T4= DZF 00551 and T5=6710). The plot size was 2 m x 2 m for all accessions. There were 0.5 meter spaces between plots and 1 meter between replications. Five rows per plot were used in the experiment. Data on the parameters: DM yield, DM percentage, seed yield, fresh weight and plant height were taken.

Management Practices

The experimental plots were well ploughed until fine seedbed is obtained. Weeds and other materials were removed before sowing in order to decrease the rate of weed infestation. Seeding was done according to recommended seeding rate of the species (Seed rate: 0.01 kg × m^{-2}). Regular cultivation and weeding were done uniformly for all plots. No fertilizer was applied for all treatments. This is done purposely because farmers of the area do not practice fertilizer application at a normal condition not only for forage but also for food crop production due to different reasons.

In the first year of the experiment (2011), the sowing date was on July 14, 2011 and the harvesting date for seed collection was on October 7, 2011. In the second year of the experiment the sowing date was on July 10, 2012 and the harvesting date for seed collection was on October 2, 2012.

Dry Matter (DM) and Seed Yield

Optimum plant cutting stage for grasses which is 50% flowering was used for the DM analysis. Forage samples were oven dried until constant weight for DM yield determination. The middle rows in each plots was harvested at the time of 50% flowering for DM yield determination and the rest four rows was left for the seed yield determination. From the fresh gram weight, a sample weight of 0.100 kg was taken and dried in an oven for DM yield determination.

Statistical Analyses

Analysis of variance (ANOVA) was carried out using SAS by the General Linear Models (GLM) procedure. When there is a significance difference, mean separations were tested using least significance difference (LSD) at a significance level of 5%.

RESULTS AND DISCUSSION

Productivity of the Oat varieties

The experiment is done in two consecutive years (2011 and 2012). Therefore, the productivity of the oat varieties is indicated across years as follows.

The productivity of Oat varieties in the first sowing year (2011)

The Dry matter yield in tone per ha, dry matter percentage, grain yield in tone per ha, plant height in centimeter and fresh weight in tone per ha of the five oat varieties (579-D-27, CI 8237, CI 8235, DZF 00551 and 6710) of 2011 adaptability trail is indicated in Table 1. A significance difference ($p<0.05$) was observed in all parameters.

The dry matter percentage of the variety DZF 00551 (32%) was significantly higher ($p<0.05$) than the varieties CI 8235 (28.9%) and 579-D-27 (27%) and the variety CI 8237 (31.3%) was significantly higher than the variety (27%). Others were not significantly different. The mean (30.1%) dry matter percentage of the varieties is higher than the mean figure reported by Arelovich *et el.* (1994) (17.1%).

A significant difference was observed among the five oat varieties in grain yield. The grain yield of DZF 00551 (0.37 kg × m^{-2}) is found higher than CI 8237 (0.35 kg × m^{-2}), 579-D-27 (0.29 kg × m^{-2}), CI 8235 (0.26 kg × m^{-2}) and 6710 (0.25 kg × m^{-2}). The grain yield of DZF 00551 (0.37 kg × m^{-2}) was significantly higher ($p<0.05$) than all the other varieties. The mean grain yield (0.3 kg × m^{-2}) of the varieties is within the range of mean grain yield reported (0.15 to 0.3 kg × m^{-2}) by AARC (2002) progress report and it is higher than (0.224 kg × m^{-2}) the report of Arelovich *et el.* (1994). It is also higher than the report of Yehalem (2012) (0.291 kg × m^{-2}) in irrigation areas at Ribb River.

The mean dry matter yield of the oat varieties was 0.67 kg × m^{-2}. This is higher than the figure reported by Arelovich *et el.* (1994) (0.117 kg × m^{-2}) but it is lower than the report of Yehalem (2012) (0.858 kg × m^{-2}) in irrigation areas at Ribb River. The grain yield of CI 8237 (0.9 kg × m^{-2}) was found higher than DZF 00551 (0.71 kg × m^{-2}), 579-D-27 (0.62 kg × m^{-2}), 6710 (0.56 kg × m^{-2}) and CI 8235 (0.54 kg × m^{-2}).

The mean fresh weight yield (biomass) of the oat varieties was 0.22 kg × m^{-2}. The grain yield of CI 8237 (2.89 kg × m^{-2}) was found higher than 579-D-27 (2.28 kg × m^{-2}), DZF 00551 (2.16 kg × m^{-2}), CI 8235 (1.88 kg × m^{-2}) and 6710 (1.8 kg × m^{-2}).

Table 1: The productivity of oat varieties in Dehana District in 2011

Varieties	2011 planting				
	DM (%)	**DMY (kg × m^{-2})**	**Grain yield (kg × m^{-2})**	**Plant height (m)**	**Fresh weight (kg × m^{-2})**
579-D-27	27^{c}	0.62^{ab}	0.29^{a}	0.57^{a}	2.28^{ab}
CI 8237	31.3^{ab}	0.9^{a}	0.35^{b}	0.463^{ab}	2.89^{a}
CI-8235	28.9^{bc}	0.54^{b}	0.26^{c}	0.459^{ab}	1.88^{b}
DZF 00551	32^{a}	0.71^{ab}	0.37^{d}	0.454^{ab}	2.16^{ab}
6710	31.4^{ab}	0.56^{ab}	0.25^{e}	0.53^{b}	1.8^{b}
Mean	30.1	0.67	0.3	0.495	2.2
LSD (0.05)	3	0.34	0.5	11.4	9.9
CV (%)	5.1	2.56	2	11.5	22.6

Means in the same column with the same letter are not significantly different.

A mean height of the oat varieties was 0.495 meter. This is lower than the figure reported by Yehalem (2012) (1.065 m) in irrigation areas at Ribb River using fertilizer. The mean height of 579-D-27 (0.57 m) was higher than 6710 (0.53 m), CI 8237 (0.463 m), CI 8235 (0.459 m) and DZF 00551 (0.454 m).

The productivity of Oat varieties in the second sowing year (2012)

The dry matter yield in kg × m^{-2}, dry matter percentage, grain yield in kg × m^{-2}, plant height in meter and fresh weight in kg × $m^{-2}$of the five oat varieties (579-D-27, CI 8237, CI 8235, DZF 00551 and 6710) of the 2012 adaptability trial is indicated in Table 2. A significance difference (p>0.05) was not observed in all the parameters listed above.

The mean dry matter yield of the oat varieties was 0.514 kg × m^{-2}. This is higher than the figure reported by Arelovich *et el.* (1994) (0.117 kg × m^{-2}) but it is lower than the report of Yehalem (2012) (0.858 kg × m^{-2}) in irrigation areas at Ribb River. Although there was no significant difference in the dry matter yield among the oat varieties, CI 8237 was higher than DZF 00551, 579-D-27, 6710 and CI 8235 as in 2011 planting period.

The mean fresh weight yield (biomass) of the oat varieties was 1.85 kg × m^{-2}. Although there was no significant difference in the fresh weight yield (biomass) among the oat varieties, CI 8237 was higher than 579-D-27, DZF 00551, 6710 and CI 8235.

Table 2: The productivity of oat varieties in Dehana District in 2012

Varieties	2012 planting				
	DM (%)	**DMY (kg × m^{-2})**	**Grain yield (kg × m^{-2})**	**Plant height (m)**	**Fresh weight (kg × m^{-2})**
579-D-27	27.8	0.51	0.09^{b}	0.777	1.88
CI 8237	28.8	0.57	0.16^{ab}	0.79	2.01
CI-8235	28.3	0.47	0.22^{a}	0.713	1.67
DZF 00551	27.8	0.52	0.198^{ab}	0.63	1.85
6710	27.5	0.503	0.197^{ab}	0.693	1.84
Mean	28.07	0.514	0.173	0.72	1.85
LSD (0.05)	11.5	1.8	1.1	29	7.5
CV (%)	20.4	17.8	31.08	20.1	20.4

Means in the same column with the same letter are not significantly different.

The mean height of the oat varieties was 0.72 meters. This is lower than the figure reported by Yehalem (2012) (1.065 m) in irrigation areas at Ribb River using fertilizer. Although there was no significant difference in the mean height among the oat varieties, CI 8237 was higher than 579-D-27, CI 8235, 6710, and DZF 00551.

The Combined yield of the Oat varieties (2011 and 2012)

The dry matter yield in kg × m^{-2}, dry matter percentage, grain yield in kg × m^{-2} plant height in meter and fresh weight in kg × $m^{-2}$of the five oat varieties (579-D-27, CI 8237, CI 8235, DZF 00551 and 6710) of the combination of 2011 and 2012 adaptability trial is indicated in Table 3. A significance difference (p>0.05) was observed in DM yield, grain yield and fresh weight but the other parameters did not show significant difference.

The mean dry matter yield of the oat varieties was 0.589 kg × m^{-2}. This is higher than the figure reported by Arelovich *et el.* (1994) (0.117 kg × m^{-2}) but it is lower than the report of Yehalem (2012) (0.858 kg × m^{-2}) in irrigation areas at Ribb River. The dry matter yield of CI 8237 (0.735 kg × m^{-2}) was significantly higher than 579-D-27, 6710 and CI 8235. The mean dry matter percentage of the oat varieties was 29.09% but no significant difference was observed among the oat varieties in dry matter percentage. The mean (29.09%) dry matter percentage of the varieties is higher than the mean figure reported by Arelovich *et el.* (1994) (17.1%).

A mean fresh weight yield (biomass) of the oat varieties was 2.025 kg × m^{-2}. The fresh weight yield of CI 8237 (2.446 kg × m^{-2}) is significantly higher (p<0.05) than 6710 and CI 8235.

The mean grain yield of the varieties was 0.238 kg × m^{-2}. The grain yield of DZF 00551 (0.283 kg × m^{-2}) was found to be significantly higher (p<0.05) than CI 8237 (0.252 kg × m^{-2}), CI 8235 (0.242 kg × m^{-2}), 6710 (0.221 kg × m^{-2}) and 579-D-27 (0.193 kg × m^{-2}). The grain yield of DZF 00551 was significantly higher (p<0.05) than all the varieties. The mean grain yield (0.238 kg × m^{-2}) of the varieties is within the range of mean grain yield reported (0.15 to 0.3 kg × m^{-2}) by AARC (2002) progress report and it is higher than (0.224 3 kg × m^{-2}) the report of Arelovich *et el.* (1994). It is also higher than the report of Yehalem (2012) (0.291 kg × m^{-2}) in irrigation areas at Ribb River.

The mean height of the oat varieties was 0.607 meter. This is lower than the figure reported by Yehalem (2012) (1.065 m) in irrigation areas at Ribb River using fertilizer. Although there was no significant difference in the mean height among the oat varieties, 579-D-27 (0.673 m) was higher than CI 8237 (0.626 m), 6710 (0.61 m), CI 8235 (0.586 m) and DZF 00551 (54.22cm).

Table 3: Yields (kg × m^{-2}) of oat varieties evaluated in Dehana District in 2011 and 2012

	Combination of 2011 and 2012				
Varieties	**DM (%)**	**DMY (kg × m^{-2})**	**Grain yield (kg × m^{-2})**	**Plant height (m)**	**Fresh weight (kg × m^{-2})**
579-D-27	27.45	0.562^{b}	0.193^{d}	0.673	2.082^{ab}
CI 8237	30.05	0.735^{a}	0.252^{b}	0.626	2.446^{a}
CI-8235	28.61	0.506^{b}	0.242^{bc}	0.586	1.774^{b}
DZF 00551	29.93	0.612^{ab}	0.283^{a}	0.542	2.001^{ab}
6710	29.43	0.533^{b}	0.221^{c}	0.611	1.819^{b}
Mean	29.09	0.589	0.238	0.607	2.025
LSD(0.05)	5.28	1.72	0.21	13.85	5 .54
CV (%)	14.43	23.19	7.17	18.12	21.77

Means in the same column with the same letter are not significantly different.

Occurrence of disease and pests

In 2011, there was not any disease and pest occurrence in the experiment. But in 2012, there was rat pest although it is controlled before it causes damage in the trial.

Field days on the Technology

At the end of the trial, a field day has been arranged and conducted by the research center (SDARC) and the study area's Agricultural Office. In the field visit the attendants were farmers, researchers, development agents and experts of the study area's agricultural office (Table 4). A total of 684 participants had visited the trial. The field participants were made to select from the varieties by their biomass yield and seed yield independently. As a result, all of the participants (100%) preferred the variety DZF-00551 for seed yield as it set seed earlier and produces better seed than the other varieties. For the biomass yield to livestock, all of them (100%) again preferred the variety CI-8237 as it was with great number of tillers and wide and long leaf.

Table 4: Field days on oat varieties in Dehana District

No	Participants	Number of participants			Variety Preference	
		Male	**Female**	**Total**	**CI-8237**	**DZF-00551**
1	Farmers	600	45	645	645	645
2	Development agents	6	0	6	6	6
3	Expertise	25	0	25	25	25
4	Researchers	7	1	8	8	8
	Total	640	46	686	686	686

CONCLUSION

Based on the result, it can be concluded that the oat variety CI-8237 is the best variety followed by DZF 00551 in dry matter yield and the variety DZF 00551 is the best variety in seed yield followed by CI-8237 in Dehana District. Hence, it can be concluded that the oat variety CI-8237 should be recommended to farmers of Dehana District and of similar climatic conditions in order to enhance the production and productivity of animals.

ACKNOWLEDGEMENTS

My thank goes to Amhara Agriculture Research Institute (ARARI) of Ethiopia for funding the project.

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