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AGRONOMY

Effect of Agro-ecology on Nutrient Content, Yield and Digestibility of Forage oat (*Avena sativa* L.) Varieties

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ABSTRACT

Effect of agro-ecologyon nutrient content, yield and digestibility of three oat varieties (Lamptone, CI8235 and CI8237) were evaluated. Two agro ecologies, which varied in altitude, were selected for the experiment. Gummer site was 2925 masl while Albazer was 2400masl. Representative soil samples at the depth of 20cm were collected from randomly selected spots (20 cm depth) of both the sites. The samples were then sent to the laboratory. Plots were prepared and assigned for each of the each variety randomly using RCBD design. Seeds were sown at 100 kg/ha rate on 7, July, 2015 with replication. Di-ammonium phosphate and urea were applied in the similar rate. From the two fertilizers, urea was applied in two levels. Plots were regularly weeded and supervised for the disease. At maturity, the whole plant from each plot was cut 2cm above the ground. Seed with its husk (SH) and straw were separated. Values were extrapolated to hectare. Similar to the soil sample, forge representative samples were sent to the laboratory. Soil type at Gummer was silt, acidic, with lower cation exchange capacity (CEC) and higher exchangeable acidity (EA) whereas at Albazer it was clay, alkaline with higher CEC and lower EA. Soil organic carbon (OC), dry matter (DM), organic matter (OM), total nitrogen (TN) and available phosphorus (AP) were more at Gummer than Albazer. Crop maturation period was varying between the two agro ecologies. At Gummer, maturation was 161days on average but at Albazer it was141 days in average. Straw had similar DM but more OM at Gummer than Albazer. The lowest DM and OM content SH was from Lamptone but highest from CI8235 and CI8237 at Albazer. Crude protein (CP) content of oats was more at Albazer than Gummer. Highest straw CP was obtained from Lamptone at Albazer than Gummer. CI8237 at Albazer had highest EE but Lamptone at Gummer had the lowest. SH at Gummer had higher EE than at Albazer. Lamptone's SH was lowest in NDF at Albazer but highest at Gummer. Higher DM, OM and CP yields were from Gummer than Albazer. Interaction was observed between agro-ecology and the varieties for nutrient content and yield. Albazer had better CP content whereas Gummer was efficient in yield. CI8235 at Albazer hadlowest IVDMD while CI8237 at both sites had the highest. Thus, before introducing oats to a new area, determining soil physiochemical characteristics for suitability is recommended.

Highlights

- Optimum oat DM and nutrient yields and *in vitro* DM digestibility were obtained in Gummer which has silt and acid (pH of 5.45) soil with better OM, OC, TN and AP
- Variety CI8235 was more productive and profitable followed by Lamptone

Keywords: Soil property, oat varieties, straw, seed with husk, nutrient content, nutrient yield

Oat (*Avena sativa*) grows well in dry wet lands, cultivated ground, meadows and heavier soils although it prefers sandy or loamy soils. It requires good drainage but can grow in acidic soil (Tom and Patrick 2006).

According to Tom and Patrick (2006), oat straw contains protein (gluten), saponins, flavonoids, alkaloids, steroidal compounds, vitamins B1, B2, D, E, carotene, starch, fat, minerals such as calcium, magnesium, and iron and trace elements like silicon and potassium. Oat is produced as a cash and feed crop. Usually oat has an economic advantage if used for livestock feed as hay or silage (Donald *et al.* 2002).

According to Tom and Patrick (2006), oat straw is important for dairy, for the reduction of nutrient/energy/moisture density, and for the alteration of dietary cation to anion ratio in dry cow diets since it contain low potassium and the inclusion of low potassium forages can aid in the prevention of milk fever in transition dairy cows. Straws are typically high in fiber and low in crude protein and energy making them excellent forage in situations where dietary energy or protein dilution is desired. Muhammad *et al.* (2013) reported that oat has high DM yield (7.77 to 8.47ton/ha).

Southern Nations, Nationalities and Peoples Regional State has large livestock number but their production and reproductive performance are too low mainly because of the lack of quality feed (Kiwuwa *et al*. 1983). According to CSA (2013/14), major feed sources are: green fodder (grazing about 69.63%) crop residue (23.17%) hay (1.82%) and by-products (1.18%). On the other hand, very small amount of improved forage (0.39%) is used as animal feed.

Sample survey in three Districts of Worabe Research Center mandate area has shown that 368 cattle, 411 sheep, 129-goat and 84-donkey died due to feed and water scarcity and 25697 cattle and 11897sheep couldn't recover from the hardship (ARSLMW 2014). The condition is serious in highland areas because of the scarcity of land, crop residue and green feed.

Efforts have been made by the Regional Bureau of Agriculture together with Southern Agricultural Research Institute (SARI) to improve the quality and the quantity of feed through evaluation of the adaptability of different forage crops such as oat (*Avena sativa*) in different agro-ecologies (mid and high altitude) through participatory testing.

This experiment was thus conducted to determine the effects of fertilization, agro-ecology and soil physiochemical traits on adaptability, nutrient yield, dry matter digestibility and disease tolerance of oats.

MATERIALS AND METHODS

The study was conducted in Southern Nations, Nationalities and People's Regional State (SNNPRS) on two sites: Gummer which is located in Gummer District (about 210 km south of Addis Ababa) of Gurage Zone and Albazer is in Hulbareg District (about 180 km south of Addis Ababa) of Siltie Zone. Gummer is 2925 m.a.s.l (cool) and receives between 1200-1400 mm rainfall with 16-21^{o}C mean annual temperature. Hulbareg is 2400m.a.s.l (moist and dry) receiving 700-830 mm rainfall with 18-26^{o}C mean annual temperature. Both Districts have two rainy seasons: between June-September and February-April. Gummer District has 18 rural administrative Kebeles among which, 2 are towns, whereas Hulbareg has 13 rural and one town Kebele.

Representative soil samples were taken from Gummer and Albazer using auger. At different topography and slope gradient, the experimental plots were demarcated on each site and five sub samples were collected from each spot randomly and the composite samples were formed. Soil samples were collected at 20cm depth and were kept in labeled plastic bags. Physico-chemical analysis of soil samples was done at the Wolkite Sample Testing and Soil Fertility Improvement Center.

In both experimental sites**,** 22 M^{2}gross lands were demarcated. Topography difference of the two sites was minimized using land slop calculation. Demarcated land was ploughed twice monthly using oxen and the third and last plough was done by digging using manpower for the purpose of loosening the coarse soil texture.

Three oat varieties (CI8235, CI8237 and Lamptone) were collected from Holeta Research Center. The seed were tested for germination using petridish. Inert materials, broken and deformed seed were separated manually from the seed. Clean seed was kept in plastic bags until the sowing date.

Nine plots (3m × 2 m) were prepared at each site. Each plot was randomly assigned to each variety using RCBD design. The spacing between rows was 30cm apart and the sowing depth was 2cm. For each plot,60 g seed, 60gDAP for single application and 60g urea in two levels of application were used (half was on the sawing date and the left dressed on 35th date at dusk). Sowing was conducted on 7, June, 2015. Seeding was by drilling. The three inputs were covered by loose soil manually. Plots were protected from water logging using small water path furrow.

The whole oats were harvested 2cm above the ground on 161th and 141th days after sowing at Gummer and Albazer respectively. The whole material was weighed and then sun-dried. Two days later, the harvest was thrashed separately on a plastic sheet. The total weight of the straw and the seed was recorded. At both sites from each variety, composite sample was prepared. From the composite sample, 1kg of the straw and 1kg of the seed were collected in separate sacks for laboratory analysis.

Dry matter (DM), organic matter (OM), ash, crude fiber (CF), crude protein (CP), ether extract (EE) and calcium (Ca) of forage samples were analyzed according to AOAC (1990) in the laboratory of National Veterinary Institute whereas, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and *in vitro* dry matter digestibility (*IVDMD*) were determined in Holeta Research Center. The representative samples were dried at 65°C and ground in Thomas–Wiley Laboratory mill (Model 4) to pass through 1mm sieve for chemical analyses and 2mm sieve for *in vitro* studies. The N content was determined by the Kjeldhah method and the CP content was calculated as N × 6.25. Neutral detergent fiber (NDF), ADF and ADL were analyzed according to Van Soest *et al*. (1991). Calcium and phosphorus were determined by spectrophotometric method. The IVDMD was determined using the two stages *in vitro* Tilley and Terry procedure (1963) as modified by Van Soest and Robertson (1985). The soil chemical analysis was conducted using ISRIC (2002).

The three land types were assessed for comparative advantages based on the sample taken on 100M^2 of land. The labor cost for land preparation, cost for seed and management and the estimated selling price were collected from the market. In addition, the variable cost for each plot was recorded. Using the procedure of Upton (1979), partial budget analysis was calculated for measuring the profit margin for oat production in two agro ecologies. Net income (*NI*) was the amount of money left when the total variable cost (*TVC*) was subtracted from the total return (*TR*). Change in net income (ΔNI) was calculated by subtracting the change in the total variable cost (ΔTVR) from the change in total return (*ΔTR*). Marginal rate of return (*MRR*) was taken for the advantage to measure the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) and was calculated as *MRR* = (ΔNI/ ΔTVC) × 100).

The DM and OM yields from the plots were converted to hectare-basis using the correction factor 10,000 for hectare. The data on chemical composition, nutrient yield and *in-vitro* studies and soil mineral content were subjected to analysis of variance using General Linear Model (Univariate and multivariate) procedures of SPSS Version 22 (SPSS 2014). Means were separated using Duncan's multiple range tests and were declared significant at $p<0.05$.

The model used for statistical analyses of the chemical composition of oat straw and seed from two varieties which were grown in the two agro-ecologies was : $Y_{ij} = \mu + \alpha_i + \theta_j + e_{ij}$; where: Yij = DM, OM, ash, CP, EE, NDF, ADF, ADL, CF, Ca content DM, OM and CP yield and *IVDMD*; μ = overall mean; αi = effect of ith variety on nutrient content and yield (i= CI8235, CI8237 and Lamptone);θj = effect of jth agro-ecology (j= Gummer for high altitude and Albazer for middle altitude); eij = random error.

RESULTS AND DISCUSSION

The texture and the mineral content of the soils of the two experimental sites were different (Table 1). The soil pH and the cation exchange capacity (CEC) were higher but organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorus (AP) and exchangeable acidity (EA) were lower in Albazer than Gummer. Gummer has sandy and silt type of soil with less clay content than Albazer.

Less acidic soil was in favor of CEC but not of EA. Albazer was relatively less acidic than Gummer. The higher the OC content the higher the OM and TN but less in moisture content (MC). Higher amount of AP was found in silt than clay soils with higher TN and OC. Soil having higher OM also had higher TN. Moderate acidic and silt type soil at Gummer with higher OC, OM, TN, and AP gave better DM, OM and CP yields of oat per hectare. CI8235, CI8237 and Lamptone were more efficient in DM, OM and CP yields. Only one third of the nutrient yields of the varieties at Gummer were obtained at Albazer. The study of Muhammad *et al*. (2013) in Egypt showed that the effect of season on pH, OM,TN and Pin 2011-2012 produced more (8.1, 0.77%, 0.042% and

7.2ppm) than in 2010-2011 (7.8, 0.73%, 0.039% and 6.6ppm, respectively). From their study, it was seen that the DM yield was much greater in 2010-2011 than 2011-2012 (8.47t vs 7.77t) but the re-growth cut of 2010-2011 was much lower than 2011-2012(3.87t vs. 4.73t). The result exhibited that relatively lower pH(not acidic) value was in favor of DM,N and OM. The acidic soil (5.45 vs 5.6 pH) in our study area was very close to the pH value that produced high DM, OM and CP yields. The higher DM yield reported by Muhammad *et al*. (2013) could be related to the differences in rain fall (7.04mm vs 3.45mm) received during the growing period of 2010-2011 than 2011-2012. The variability of DM yields from the two cuttings and years when compared with the result in this study may be related to the differences in the varietal potential adaptability.

Larry and Mark (2013) and Silveira *et al*. (2007) added that as soil pH drops below 5.5, it not only restricts the toxicity of aluminum and manganese but also affects the microbe activity that have roles in the recycling of soil nutrients through mineralization of organic matter and N fixation associated with forage legumes. Hence, they recommended soil pH of 5.5 to 7.0 for optimum oat yield. Soil at Albazer was more of clay than at Gummer and hence probably more aluminum was found which could have hampered the growth of oat forage.

Table 1: Physicochemical composition (Mean+ SD) of soil at Gummer and Albazer experimental sites

Soil mineral and texture	Experimental sites	
	Gummer	Albazer
pH-H_2O(1:2.5)	5.45±0.004	5.6±0.022
Soil buffer pH	5.80±0.002	6.53±0.002
Cation exchange capacity (meq/100g)	14.46±0.001	16.36±0.001
Exchangeable acidity (meq/100g)	0.70±0.002	0.34±0.004
Organic carbon (%)	2.86±0.024	1.56±0.025
Organic matter (%)	4.93±0.033	2.69±0.101
Total nitrogen (%)	0.24±0.016	0.13±0.017
Moisture content (%)	3.96±0.070	4.71±0.110
Available phosphorus (mg/l)	0.72±0.025	0.40±0.025
Sand %	44.00±0.820	42.30±3.458
Clay %	16.00±0.819	31.70±2.120
Silt %	39.65±2.458	31.00±2.531

Row values with different superscript letters are significantly different (p<0.05); SE = standard error

Ross *et al*. (2013) reported that adequate P results in rapid growth and early maturity, which is important in areas where frost is a concern. Frequently, P enhances the quality of vegetative and root growth by increasing utilization of soil nutrients and moisture. The quantity of P in the soil solution was in the range of 0.3 to 3.0 kg/ha (0.3 - 3.0 lb/ac). Rapidly growing crops will absorb about 1 kg/ha (1.0 lb/ac) of P per day. Even though the quantity of P in the soil is more, its availability is determined by the soil pH. In more acidic soils (pH <6.0), iron and aluminum increase causes either a fixing or the removing of P from the soil solution. This action greatly limits the availability of inorganic P to plants at soil pH less than 5.0. Generally, soil P is slightly more available to plants in a pH range of 6.0 to 7.5. Not only the pH value but the moisture and temperature also affects the soil P availability. In cool, wet soils, P availability and movement are reduced. As a result, phosphate fertilizers are less accessible to crops in cool, wet spring conditions than in warmer, drier spring conditions.

Phosphorus was more available at Gummer than Albazer and might have helped soil microorganisms in Gummer to produce more TN and DM in oat forage per plot of land. Haque *et al.* (1984) also reported that in acid soils most of the applied P is sorbed by various constituents and P sorption increases with depth within the profile due to the increase in the clay contents. Thus P often increases nodulation and hence increases DM yield, crude-protein content, P concentration or uptake by plants, especially in legumes.

As shown in Table 2 differences in DM content of straws grown in the two agro-ecologies and among varieties were not significant (p>0.05). The DM content of oat straw at both sites was greater than the earlier reports (Tom and Patric, 2006; Redden, 2012). The OM content of straw and SH of the three varieties' were significantly different (p<0.05). Lowest OM content was obtained from Albazer CI8237 but the highest was in Lamptone and CI8237 at Gummer. Organic matter content of the straw of all varieties was higher at Gummer than at Albazer. Crude protein content of straw of all varieties at Gummer and particularly Lamptone was lower than that of Albazer. The CP content of the three varieties at the two sites was much lower than earlier reports (McCartney and Vaage

Table 2: Nutrient contents and *in vitro* dry matter digestibly of three varieties of oat straw grown in two agro-ecologies

Nutrient (% DM)	Sites						SEM	P-value
	Gummer			Albazer				
	Lamptone	CI8235	CI8237	Lamptone	CI8235	CI8237		
Dry matter (%)	97.77[b]	97.47[ab]	97.87[b]	97.40[ab]	97.47[ab]	97.20[a]	0.159	0.098
Organic matter	92.65[d]	91.76[c]	92.247[d]	88.97[b]	89.09[b]	88.49[a]	0.150	0.000
Ash	5.11[a]	5.711[b]	5.62[b]	8.429[c]	8.379[c]	8.711[d]	0.040	0.000
Crude protein	1.89[a]	2.12[a]	4.39[b]	7.47[e]	6.62[d]	5.64[c]	0.202	0.000
Ether extract	1.11[a]	2.71[c]	1.84[b]	3.12[d]	1.87[b]	6.85[e]	0.044	0.000
Crude fiber	47.26[e]	36.22[d]	34.23[c]	31.42[b]	33.96[c]	27.37[a]	0.090	0.000
NDF	79.16[a]	79.54[b]	79.78[b]	80.77[c]	79.62[b]	81.69[d]	0.114	0.000
ADF	51.39[c]	50.5[b]	49.91[a]	49.95[a]	50.57[b]	49.98[a]	0.115	0.000
Lignin	4.35[b]	4.61[c]	4.85[d]	4.38[b]	4.01[a]	4.75[d]	0.039	0.000
Calcium	1.36[a]	1.62[b]	1.36[a]	1.54[ab]	1.54[ab]	1.54[ab]	0.065	0.072
IVDMD (%DM)	45.30[b]	46.29[c]	47.49[d]	45.22[b]	44.09[a]	47.24[d]	0.201	0.000

ADF = acid detergent fiber; IVDMD = in vitro dry matter digestibility; NDF = neutral detergent fiber; Row values with different superscript letters are significantly different (p<0.05)

(1994). The CP content of CI8237 at Gummer was nearly the same as the earlier report (Rossi, 2008 and Redden, 2012). Lowest EE was obtained from Lamptone straw at Gummer but the highest from CI8237 at Albazer. The EE of CI8235 at Gummer, and Lamptone and CI8237 at Albazer were greater than the earlier report (2.1) of Rossi (2008) but the rest of the varieties had less than this value. The NDF content of Lamptone at Gummer was the lowest but that of CI8237 at Albazer was the highest. All the NDF contents of the three varieties at all sites were greater than the earlier reports (Rossi, 2008; McCartney and Vaage 1994). Acid detergent fiber content of CI8237 at Gummer, and Lamptone and CI8237 at Albazer were lowest but that of Lamptone at Gummer was the highest. The ADF content of oat measured before and after ensiling (McCartney and Vaage, 1994) is much lower than the ADF contents of oat varieties in this study but they agree with the report of Redden (2012). The lignin content of CI8235 at Albazer was the lowest but that of CI8237 at Gummer and CI8237 at Albazer were the highest. Lignin content of all oat varieties from the different sites were greater than the results reported by McCartney and Vaage (1994) but nearly agrees with that of oat after ensiling as reported by the same authors.

There was an interaction effect between oat varieties and experimental site on the nutrient content of the straw. The Ca content of all the varieties at the two sites was greater than the earlier report (Rossi, 2008 and Redden 2012). The DM content of the straw of the three varieties was nearly similar while the OM and CP content of the straw and SH were significantly different. Straw at Gummer had higher OM but at Albazer it had higher CP, especially of Lamptone. Seeds with husk of both CI8235 and CI8237 at Albazer had better DM, OM and CP.

The straw of CI8235 at Albazer had the lowest digestibility coefficient but that of CI8237 at Gummer and Albazer had the highest. The apparent digestibility of oat reported by McCartney and Vaage (1994) was greater than the values obtained in this study. The amount and level of lignin content in straw in all varieties at the two sites were negatively correlated with IVDMD.

Differences in nutrient content of SH amongst varieties between agro-ecologies were significant ($p<0.05$; Table 3). The lowest DM and OM contents of SH were from Lamptone but the highest were from CI8235 and CI8237 at Albazer when compared to Gummer. More ash was found in straw than in SH. There was significant difference ($p<0.05$) between sites in the nutrient content of SH. The

Table 3: Nutrient contents and *in vitro* drymatter digestibly of seed with husk (SH) of the three oat varieties grown in two agro-ecologies

Nutrient content (% DM)	Sites						SEM	*P*-value
	Gummer			Albazer				
	Lamptone	CI8235	CI8237	Lamptone	CI8235	CI8237		
Dry matter (%)	95.53^{b}	95.37^{b}	95.53^{b}	94.50^{a}	98.10^{c}	97.67^{c}	0.273	0.004
Organic matter	92.39^{c}	91.38^{b}	92.43^{c}	89.81^{a}	94.02^{d}	93.23^{d}	0.204	0.000
Ash	3.34^{a}	3.98^{b}	3.10^{a}	4.69^{c}	4.08^{b}	4.42^{bc}	0.164	0.000
Crude protein	10.90^{c}	8.29^{a}	10.92^{c}	9.26^{b}	12.78^{e}	11.54^{d}	0.128	0.000
Ether extract	6.06^{b}	6.73b^{c}	6.93^{c}	5.31^{a}	5.34^{a}	5.34^{a}	0.222	0.000
Crude fiber	15.25^{d}	12.06^{b}	13.29^{c}	9.21^{a}	13.46^{c}	13.12^{c}	0.248	0.000
NDF	42.02^{d}	39.46^{b}	38.84^{ab}	38.33^{a}	40.18^{c}	39.46^{b}	0.213	0.000
ADF	15.15^{a}	15.86^{b}	15.63^{ab}	15.77^{ab}	15.37^{ab}	15.60^{ab}	0.205	0.225
Lignin	3.80	4.23	4.05	4.17	3.93	4.09	0.172	0.545
Calcium	1.57^{bc}	1.40^{b}	1.92^{d}	1.76^{cd}	1.19^{a}	1.19^{a}	0.065	0.000
IVDMD	77.52^{c}	76.57^{a}	77.32^{bc}	76.94^{ab}	77.54^{c}	77.08^{abc}	0.165	0.009

ADF = acid detergent fiber; IVDMD = in vitro dry matter digestibility; NDF = neutral detergent fiber; Row values with different superscript letters are significantly different (p<0.05)

lowest CP content was in CI8235 at Gummer but the highest was in CI8235 at Albazer. Straw had lower CP content than that of SH in all varieties at both sites. Gummer was suitable for CP production of SH in Lamptone and CI8237 at Gummer. High amount of CP was found in straw and SH of CI8235 and CI8237. Crude protein of the straw from all varieties was better at Albazer than at Gummer. Generally, Albazer was better than Gummer for CP content of both straw and SH. Ether extract (EE) contents of the three varieties were similar but CI8235 and CI8237 at Gummer had highest EE. Ether extract of SH was greater than that of straw. Seed with husk had higher EE at Gummer than Albazer.

The highest NDF was found in Lamptone at Gummer followed by CI8235 at Albazer but the lowest was found in Lamptone at Albazer. The lowest Ca content was in both CI8235 and CI8237 at Albazer while the highest in CI8237 at Gummer and Lamptone at Albazer. The CF, NDF and ADF contents of SH was nearly one third of that of straw. The greater CF content of straw was at Gummer than Albazer but CF in SHwas similar at both the sites. Lignin content of straw and SHat both sites was nearly similar.

Variation in IVDMD of SH was significant. CI8235 at Albazer had lowest SH digestibility coefficient but that of CI8237 at both sites was more digestible. The more digestible the straw is the better digestible the SH. Straw and SH of C18237 were highly digestible but it was less influenced by soil and altitude.

Nutrient yield of oats between the experimental sites was variable (p<0.05, Table 4). The lowest total DM yield was observed in CI8237 at Albazer but the highest was observed in CI8235 at Gummer. All the DM yields obtained from the varieties at both sites were greater than the earlier reports (Meyer *et al.* 1958; Muhammad *et al.* 2013). Lowest OM yield was in CI8235 at Albazer while the highest was in CI8237 at Gummer. Lowest CP yield was in CI8235 and CI8237 at Albazer and the highest in Lamptone at Gummer.

Better CP content in SH of Lamptone and C18237 at Gummer and CI8235 and CI8237 at Albazer improved SH digestibility. On the contrary, low CP content in CI8235 at Gummer and Lamptone at Albazer reduced SH digestibility. Generally, the nutrient yields were better at Gummer than Albazer. This may be due to higher TN, OM, OC and AP contents and the silt texture of the soil at Gummer. There was a significant (p<0.05) interaction effect between the experimental site and the variety on nutrient yields. Nutrient yield was dependent on the total forage biomass production of the varieties.

Varieties at Albazer site during the flowering stage were affected by crown rust, also known as leaf

Table 4: Dry matter, organic matter and crude protein yields (kg/ha) of straw and seed from three oat varieties grown in two agro-ecologies

Nutrient yield (kg)	Sites						SE	*P*-value
	Gummer			Albazer				
	Lamptone	CI8235	CI8237	Lamptone	CI8235	CI8237		
Straw (DM/ha)	28707^{e}	32960^{f}	14339^{d}	9073^{c}	8882^{b}	8661^{a}	5.95	0.000
Seed (DM/ha)	8899^{d}	8111^{e}	7544^{c}	2384^{b}	2296^{a}	2769^{b}	2.33	0.000
Total (DM/ha)	37606^{d}	41071^{e}	21884^{f}	11457^{c}	11178^{b}	11429^{a}	7.49	0.000
Straw(OM/ha)	27205^{d}	31030^{e}	34931^{f}	8288^{c}	8118^{b}	7884^{a}	2.36	0.000
Seed (OM/ha)	8606^{f}	7772^{e}	7300^{d}	2285^{b}	2182^{a}	2644^{c}	2.58	0.000
Total (OM/ha)	35811^{d}	38802^{e}	42231^{f}	10572^{c}	10301^{a}	10572^{b}	4.46	0.000
Straw (CP/ha)	5550^{f}	723^{d}	1662^{e}	696^{c}	603^{b}	503^{a}	2.88	0.000
Seed (CP/ha)	1017^{f}	705^{d}	862^{e}	311^{b}	325^{a}	327^{c}	1.16	0.000
Total (CP/ha)	6567^{e}	1428^{c}	2525^{d}	1006^{b}	828^{a}	830^{a}	3.21	0.000

Row values with different superscript letters are significantly different (p<0.05)

Table 5: Cost-benefit analysis of the three oat varieties cultivated in two agro-ecologies

Parameters	Sites					
	Gummer			Albazer		
	Lamptone	CI8235	CI8237	Lamptone	CI8235	CI8237
Land rent (Birr)	4500	4500	4500	4000	4000	4000
Wage for preparation (Birr)	4000	4000	4000	3600	3600	3600
Wage for weed control (Birr)	3200	3200	3200	5470	5470	5470
Wage for harvest (Birr)	2400	2400	2400	3200	3200	3200
Wage for farm keeper (Birr)	3600	3600	3600	3600	3600	3600
a. Sum of investment cost (Birr)	17700	17700	17700	19870	19870	19870
b. Income tax (2%)	1858	2161	903	319	210	218
Medicine cost (Birr)				1000	1000	1000
Sprayer wage (Birr)				120	120	120
c. sum of variable cost(Birr)				1120	1120	1120
DM yield (kg/ha)	37606	41071	21884	11457	11178	11429
DM content (%)	20.40	19.60	20.90	19.20	22.10	22.30
Estimated fresh weight (kg)	184343	209546	104708	59672	50579	51251
d. Gross income (0.6Birr/kg fresh oat)	110606	125728	62825	35803	30348	30751
e. Gross revenue (d-a)	92906	108028	45125	15933	10478	10881
f. net income (NI=e-(b+c))	91048	105867	44222	14494	9148	9543
Δ NI	89928	104747	43102	14494	9148	9543
ΔTVC				1120	1120	1120
MRR				1294	817	852

DM= dry matter; MRR= marginal rate of revenue; NI= net income; Δ NI= change in net income; ΔTVC= change in total variable cost

rust, caused by a fungus, *Pucciniacoronataf avenae.* According to USDA (2008), the fungus is specific to cultivated oat, wild oat, and a few other wild grasses. The rust reduces oat yield and causes thin kernels with low test weight; factors which greatly reduce milling quality. USDA stated that late planting of oats followed by humid warm weather are the most favorable conditions for fungal development.

The partial budget analysis is presented in Table 5. CI8235, Lamptone and C18237 at Gummer were 11, 6 and 4.6 times more profitable than the corresponding varieties at Albazer, respectively. The net income earned from the three oat varieties at Gummer was 7.1 times more profitable than at Albazer. Moreover, Variety CI8235 was the most profitable of all varieties followed by Lamptone at Gummer.

CONCLUSION

In Gummer the dry matter and the organic matter content of Lamptone improved but that of C18237 had no change because it had sandy and silt,low clay and moisture but higher OC, OM, TN and AP. Albazer's soil with low OC, OM, TN, and AP but more clay and moisture increased DM and OM contents in the seeds of CI8235 and CI8237; it had also improved CP in straws of CI8237 and seeds of CI8235. Digestibility of CI8237's straw at both sites was comparable but was higher than that of the seed of Lamptone at Gummer and CI8235 at Albazer. Because of higher CP content of seed of CI8235at Albazer, digestibility improved. When compared to Gummer, the Albazer straw and seed of all oat varieties had better CP content except that of Lamptone's seed. In each sites, better CP content of the seed was closely associated with digestibility. More clay but less sandy soil textures and low pH (<5.6), OM, TN and AP are not suitable for oat production. Gummer was more suitable for oat production; CI8235 had higher DM and nutrient yields, digestibility and profitability followed by Lamptone. Variety selection and soil physiochemical analysis are thus necessary before cultivating oat.

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