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Fodder Yield and Nutritive Values of Hydroponically Grown Local Barley Landraces

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በዋነኛነት በኢትዮጵያ ከጊዜ ወደ ጊዜ እየጨመረ የመጣውን የህዝብ ብዛት ለመመገብ በመሬት ላይ ባለው ጫና ምክንያት ከፍተኛ የመኖ ምርትን በቀላሉ ዕውን ማድረግ አልተቻለም:: ከጊዜ ወደ ጊዜ እየጨመረ የመጣውን የአረንጓዴ መኖ ፍላጎት ለማሟላት አማራጮች አንዱ ሃይድሮፖኒክ (መኖን ከአፈር ይልቅ በውኃ ማብቀያ ዘዴ) መጠቀም ነው:: በሦስት ሀገር በቀል ገብስ ዘሮች ማለትም ጥቁር፣ ሞስኖ እና ነጭ ገብስ የተለያዩ የውኃ ማጠጣት ሰዓታት ልዩነት፣ የመከር መሰብሰብ ቀን ልዩነትና የዘር ልዩነት በምርት እና ንጥረ-ነገር ይዘቶች ላይ የሚያደርሱትን ተፅዕኖ ለመገምገም ጥናት ተካሂዷል:: ሦስቱም ሃገር በቀል የገብስ ዝርያዎች ለ12 ተከታታይ ቀናት በሙከራ ቤት (ሳት ሃዉስ) በ2፣ 3 እና 4 የውኃ ማጠጫ ሰዓታት ልዩነት በቅለዋል:: መኖው የታጨደዉ በ6ኛ፣ 8ኛ፣ 10ኛ እና 12ኛው የዕድገት ቀን ነው:: የየመከር መሰብሰብያ ቀናት ልዩነት በመኖ ምርትና ተያያዥነት ያላቸው የምርት ክፍሎች መካከል ከፍተኛ ልዩነቶችን ፈጥሯል:: ከፍተኛው የመኖ ዕድገት ከተዘራ በ12ኛው ቀን ታይቷል፣ ከፍተኛው የደረቅ ቁስ ምርት ግን በ6ኛው የዕድገት ቀን ተመዝግቧል:: የጥቁር፣ ሞስኖ እና ነጭ ገብስ አማካይ የደረቅ ቁስ ምርት በቅደም ተከተል 23.3ቶን—ሄክታር፣ 18.78 ቶን—ሄክታር እና 19.85ቶን—ሄክታር ነዉ:: የክሩድ ፕሮቲን እና የሴል ዎል ይዘቱ ለበቀለ ገብስ ከእህሉ ከፍ ያለ ነው:: የገብስ እህል ደረቅ ቁስ ይዘት 93.6በመቶ ሲሆን በ12ኛ ቀን ወደ 91.7በመቶ ቀንሷል:: የበቀለ ገብስ የተሰበሰበበት 6ኛው ቀን እንቪትሮ ድራይ ማተር ይዘት ከፍተኛ ውጤት ያስገኛል ምክንያቱም ገና የበቀለበት ደረጃ ላይ ስለነበር እና ብዙ ያልበቀለ እህል ስላለው:: የክሩድ ፕሮቲን ይዘቱ እየጨመረ የመጣ አዝማሚያ ነበረው እና በ12ኛው ቀን መሰብሰብ ከፍተኛ ሆኖ ታይቷል:: ስለዚህ ሞስኖ ለሚባል የአገባኒ ገብስ ዓይነት ከፍተኛው የቅጠላማነት ባዮማስ ምርት እና ምርትን ተዛማጅ ክፍሎች መገኘቱን መደምደም ይቻላል:: በ12ኛው ቀን የመኸር መሰብሰብያ ከፍተኛ የሃይድሮፖኒክ መኖ ምርትና ጥራት ለማግኘት በአካባቢው የገብስ ዘሮችን ለመሰብሰብ አመቺ ጊዜ እንደሆነ ተለይቷል:: የበቀለ ሀገር በቀል ገብስ ዘሮች ከፍተኛ የክሩድ ፕሮቲን እና የሴል ዎል ይዘቶች ሲኖራቸው ያልበቀለው የገብስ እህል ተጓዳኝ ግን ትንሹን ይይዛል:: ስለዚህ ከተዘራ በኂላ በ12ኛው ቀን የሚታጨደዉ ጥቁር ገብስ በዚህ ሙከራ መሠረት በአካባቢው ከሚገኙ የገብስ ዘሮች መካከል በሃይድሮፖኒክ (መኖን ከአፈር ይልቅ በውኃ ማብቀያ ዘዴ) ለማምረት ይመከራል:: ለወደፊትም እንስሳትን በመመገብ ተጨማሪ ሙከራ ተሠርቶ የወተት ይዘቱን፣ የሥጋ ምርቱን እና/ወይም የምጣኔ ሀብት ጠቀሜታዉን ማየት ቢቻል መልካም ነዉ ተብሎ ይመከራል::

Abstract

Significant fodder production cannot easily be realized mainly due to the pressure on land for the production of staple food crops to feed the ever increasing human population in Ethiopia. To meet the parallel increasing demand for green fodder, one of the alternatives is hydroponic fodder to supplement the meager pasture resources. A study was conducted at Wollega University to evaluate the effect of watering interval, harvesting dates and landraces on fodder yield and nutritive values of *three local barley landraces viz: black barley, Mosno, and white barley under hydroponic systems. All three landraces were grown for 12 consecutive days in lath house at 2, 3 and 4h watering intervals. The fodder was harvested at 6th, 8th, 10th and 12th days of growth. There were significant differences (P<0.05) among dates of harvesting on hydroponic fodder yield and yield related components of all the landraces. The highest fodder growth was observed at 12th days after sowing, whereas the highest dry matter (DM) yield was recorded at the 6th day of growth. The average dry matter yield for the landraces were 23.3t/ha, 18.78t/ha and 19.85t/h^2 for black barley, Mosno and white barley, respectively. The crude protein (CP) and cell wall contents were higher for sprouted barley landraces than its grain. The DM content of the barley grain was 93.6% and decreased to 91.1% for sprouted barley at 12th day of harvesting. The 6th date of harvesting of sprouted barley resulted in higher In vitro-dry matter digestibility. The CP content had increasing trend and remained highest on 12th day of harvesting. Therefore, it can be concluded that watering at 4h interval had resulted in the highest biomass yield and yield related components of barley grown under hydroponic system. Among the landraces used in this experiment, Mosno was found to be best variety for green fodder biomass yield and as well for better nutritive values. The 12th date of harvesting was identified as optimum time of harvesting for highest hydroponic fodder yield and yield related components. Sprouting barley had highest CP, cell wall contents (NDF, ADF and ADL) and ash contents compared to its grain counterpart. The IVDMD and DM percentage were higher in barley grain than sprouted barley fodder landraces. Watering at 4 h interval and harvesting at 12th day could be recommended for applications for the production of optimum fodder with better nutritive values from hydroponically grown barley. On the basis of this finding, it is also very important to undertake feeding experiments to see dairy performances of cows and/or other feeding trials for evaluating animal performances and economic returns.*

Keywords: Digestibility; fodder yields; hydroponic; local barley; nutritive value

Introduction

Hydroponic fodder production practice dates back to the 1800s (Kerr *et al*., 2014), or earlier, from the 'Hanging Gardens of Babylon'era, when European dairy farmers fed sprouted grains to their cows during winter to maintain milk production and improve fertility (Anonymous, 2008). There is renewed interest in this technology due to shortage of green fodder in most of the Middle East, African and Asian countries. Fodder production cannot easily be increased due mainly to ever increasing human pressure on land for production of cereal grains, oil seeds and pulses. To meet the increasing demand for green fodder, one of the alternatives is hydroponic fodder production to supplement the meager pasture resources (Bakshi *et al*., 2017).

Fodder produced hydroponically is of a short growth period (7–10 days) and does not require high-quality arable land, but only a small piece of land for production to take place (Al-Karaki, 2011). It is of a high feed quality, rich in proteins, fiber, vitamins, and minerals (Lorenz, 1980). All these special features of hydroponic system, in addition to others make it one of the most important agricultural techniques currently in use for green forage production in many countries especially in arid and semiarid regions of the world (Al-Momani, 2010) as well as in urban areas where land and water scarcity is prominent. Hydroponic fodder production is a boon for farmers whose soil is rocky and infertile and is also a viable alternative technology for landless farmers for fodder production.

Different types of fodder crops *viz.* barley (Reddy *et al*., 1988), oats, wheat (Snow *et al*., 2008); sorghum, alfalfa, cowpea (Al-Karaki and Al-Hashimi, 2012) and maize (Naik *et al.,* 2011; Naik *et al*., 2012) can be produced by hydroponics technology (Jemimah *et al*., 2015). However, the choice of the hydroponics fodder to be produced depends on the geographical and agro-climatic conditions and availability of seeds. Forage barley has good yield and has been found to have higher nutritive value and lower fiber concentration than other small grains (Brink and Marten, 1986). Moreover, in a study conducted by Al-Karaki and Al-Hashimi (2010) to compare five forage crops (alfalfa, barley, cowpea, sorghum and wheat) for green fodder production and water use efficiency under hydroponic conditions, the results indicated that higher fodder production and better water use efficiency was recorded for barley.

In Ethiopia, urban growth is increasing at an alarming rate at the expense of surrounding farmlands which made land size per household very limiting for conventional way of forage production. Hydroponic system of fodder production can solve the problem of feed for urban livestock owners and landless smallholder farmers. Therefore, this study was initiated to evaluate the effect of watering interval, harvesting dates and landraces on fodder yield and nutritive values of selected local barley landraces under hydroponic systems.

Materials and Methods

Experimental Site

The study was conducted at Wollega University, located 328 km to west of Addis Ababa in East Wollega Zone of Oromia Regional State, Western Ethiopia. Its geographical coordinates are 10° 0' 0" N latitude and 37° 30' 0” E longitude. The average air temperature of the area is 21°C while that of lath house average room temperature was 28°C with 83% humidity. The area receives the minimum and maximum annual rainfall of approximately 1376 mm and 2037 mm, respectively (Zemadim, 2011).

Preparation of tray and shelf

Trays made of plastic materials were purchased from the market at Nekemte town. Trays have holes at the bottom to allow drainage of excess water from irrigation. Strong shelves made of metals were arranged inside the lath house. Three shelves were made side by side in the shade or lath house. The holders of the trays on shelves were fixed above one meter height to allow proper drainage, enough ventilation system and light.

Seed collection, preparation and germination

Grains of the barley landraces were purchased from *Gabaa sanbataa* market of *Abee Buukkoo* area in Horro district. These grains/seeds were sundried for a day to remove moisture for temporary storage and proper germination. The impurities were manually cleaned and normal seeds were selected. After weighing, the seeds were washed with fresh water to make them dust free. Then seeds were placed in to fresh water for 12 hours. After 12 hours seeds were removed and allowed to breathe for 1 hour for enhancing their proper germination (Al-Hashmi, 2008). Then, the seeds were placed on trays with the density equivalent to seed rate of 4.5 kg/m^2 (Al-Hashmi, 2008).

Treatments and experimental design

Two experiments were conducted non- simultaneously. The first experiment was to evaluate effect of watering interval on barley landraces via manual watering using tap water for 30 seconds at 2, 3 & 4h intervals for twelve consecutive days. The second experiment was harvesting days of fodder from the barley landraces grown using the selected watering interval *viz.*, 4hrs watering intervals and harvesting at 6th, 8th, 10th and 12th days after planting to identify proper harvesting dates for optimum biomass yield and nutritive values. Since the experiment was done in green house, all other factors were assumed to be controlled and CRD was used to examine the effects of watering interval and harvesting dates on performance of the landraces.

Agronomic Data

Seeding rate: This is weight of pure seeds laid on each tray before starting of watering. The weight of empty tray was taken first (W1). Then pure seeds of barley were added to the tray and weighed together again (W2). The weight of the seeds before the initiation of germination was computed as the difference (W2-W1).

Seeding date: The date at which all barley landraces were prepared and arranged for seeding which was 27th of November 2019.

Germination date: the date at which all (100%) of the seeds were germinated. In this experiment the date at which the seeds started to germinate and completed the germination was almost similar for the different barley landraces. All landraces started to germinate on the 2nd day and completed germination on the 4th day.

Plant height at harvest: at the end of 12th day of sprouting, the height of the plant (cm) was taken using transparent glass ruler. For this purpose, the heights of ten plants were randomly taken from four different segments of the tray and the average was recorded.

Leaf weight (grams): During harvesting, the weight of total fodder (sprout with a tray) was taken first (W1). Then the leaves were trimmed using razor blade, and the tray and root together were weighed again (W2). The weight of the fresh leaf was then computed as a difference (W1-W2).

Root weight: After removal of the leaf, weight of tray and root together minus tray weight was considered as root weight.

Leaf to root ratio: Was calculated by dividing total leaf weight to total root weight.

Total fodder yield: At harvesting, total weight of the green fodder was calculated by taking the fodder and the tray weight together. Tray weight was recorded for all treatments at planting time. Total fodder weight = fodder and tray weight - tray weight.

During harvesting, the following data were recorded per tray: total fresh and dry matter yield of fodder and ratio of green fodder to the initially planted seeds weight was computed. Representative fresh plant samples (about150 grams) from every tray were taken at harvest and dried at 105°C in forced air draft oven for 48 hours for DM yield determination.

DM yield (t/ha) = (10*TFW*SSDW) / (HA*SSFW) (James, 2008).

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

TFW = total fresh weight from the harvested area (kg);

SSDW = sub-sample dry weight (g)

HA = harvested area (m^2), and

SSFW = sub-sample fresh weight (g)

Chemical Analysis

Both the grain and herbage (sprouted) parts of the hydroponically grown barley landraces were chemically analyzed in the laboratory. The composite samples for each landraces of the grains were taken separately before sprouting. The need for taking some parameters of barley grain was to describe and to quantify the changes in nutrient contents of the landraces of barley before and after sprouting. Chemical analysis of forage samples was determined at Holetta Agricultural Research Center (HARC). Partial DM of each barley landraces was determined by drying the fodder samples at 60°C in air forced oven for 48h (Fazaeli *et al*., 2012). After drying, the samples were ground to pass through 1 mm sieve pore size and stored pending to chemical analysis and determination of *in vitro* DM digestibility (Hande *et al*., 2014). The DM and ash contents were analyzed according to the procedures of AOAC, 2000. The Nitrogen (N) content was computed by Micro Kjeldahl method and the crude protein (CP) was calculated as N×6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al*. (1991).

In vitro DM digestibility of the samples was determined according to two-stage (Tilley and Terry 1963) technique as modified by VanSoest *et al*. (1991), where a second stage (Rumen liquor-pepsin digestion) was substituted by neutral detergent extraction to simulate true digestibility.

Statistical analysis

Data on biomass yield and yield related components, chemical compositions and *in vitro* DM digestibility were analyzed using the General Linear Model (GLM) procedure of statistical analysis system (SAS, 2008) version 9.2. Duncan's Multiple Range Test (DMRT) was employed for mean comparison at $\alpha=0.05$. There were two separate experiments conducted which the first was on watering interval and the second on harvesting dates as treatment. The model used in both separate treatments was:

$Y_{ij} = \mu + t_i + e_{ij}$ Where,

μ= the overall mean

t_i= the i^{th} treatment effect

e_{ij}= the error term

Results and Discussion

Effect of Watering Interval on Fodder Yield of Local Barley Landraces

The effect of watering interval on hydroponic fodder yield and yield related components of barley landraces was given in Table 1. The results showed no significant differences ($p>0.05$) between treatments (watering interval) in all fodder yield and yield related components. The average fresh yield was 72.58, 78.63 and 90.57 t/ha for 2hrs, 3hrs and 4hrs watering intervals, respectively. These results showed that the fresh yield was increased 2.9 times, 3.2 times and 3.7 times of the original seed weight at 2hrs, 3hrs and 4hrs watering intervals, respectively after sprouting for 12 days. This increase in fresh weight of green fodder might be attributed to the intake of high amount of water during germination and growth of the plants. The fresh fodder yield under 4h watering interval is in line with the finding of Dung *et al*. (2010a) who have indicated 3.7 times increase in fresh weight on 7 days for hydroponics barley fodder using 2h watering interval. But it was lower than the report of Ghazi *et al*. (2011) who reported 4.5 times increase in fresh weight of green fodder after sprouting barley grain for 6 days by spraying seeds manually with tap water twice a day (Early in the morning and late in the afternoon) in hydroponic barely. The discrepancy in fresh weight might be due to difference in verities, weather condition, weight (g) of seed used at sowing, seed quality, light intensity, water quality, pH, seeding density and temperature (Dung *et al.,* 2010a; Fazaeli *et al.,* 2011; Naik *et al*., 2013a).

The average dry matter yield (DMY) was 20.00, 20.51 and 21.42 t/ha for 2h, 3h and 4h watering intervals, respectively. The total average initial seeds weight was 2.43 kg/m^2 and was higher than its dry fodder weights indicating that DM yield of fodders decreases upon sprouting. The DM yield recorded in this study is in agreement with findings of Fazaeli *et al*. (2012) who have reported DM content of the fodder was decreased due to the sprouting when compared to the original seeds. Similarly, Sneath and McIntosh (2003) also reported that during sprouting of the seeds, there is an increase in the fresh weight and a consequent decrease in the DM content. This was mainly attributed to the imbibition of water (leaching) and enzymatic activities (oxidation) that depletes the food reserves of the seed endosperm without any adequate replenishment from photosynthesis by the young plant during short growing cycle.

The average fodder plant heights were 15.34, 16.34 and 16.14 cm under 2, 3 and 4h watering intervals, respectively. The mean value of plant height for current study is in the range of values reported by Dung *et al.* (2010b), Naik *et al.* (2011) and Naik *et al*. (2014) who have indicated that depending upon the landraces of grains, the hydroponic fodder looks like a mat of 11-30 cm height by the end of the germination period of about 8-days. In contrary to the above, plant height recorded in current study was lower than values (18-20cm) reported by Al-Hashmi (2008). This could be attributed to other factors under which the experiment was conducted which could affect growth of fodder under hydroponic system (El-Deeba *et al*., 2009) and difference in landraces.

The average dried leaf weights were 1.18, 1.19 and 1.28 t/ha under 2h, 3h and 4h watering interval, respectively. The results showed that the dried leaf yield was increased with shorter watering interval. This could be due to leaching that depletes the food reserves of the seed endosperm which otherwise could have helped for continuous plant growth.

The average dried root weight was 20.14, 19.41 and 19.01 t/ha under 2h, 3h and 4h watering interval respectively. In opposite to dried leaf weight, the weight of dried root was decreased longer watering interval. The mean LRR was 0.064, 0.067 and 0.140 t/ha for 2h, 3h and 4h watering interval respectively. The results showed that LRR was increased with the increase of plant leaf weight.

Table 1: Effect of watering interval on biomass yield and related agronomic traits of hydroponically grown local barley landraces

Parameters	Watering interval			SEM	P-value
	2 hours	3 hours	4 hours		
Seed weight (t/ha)	24.29	24.29	24.29	0.091	1.0000
Plant height (cm)	15.34	16.34	16.14	0.415	0.2655
Fresh yields (t/ha)	72.58	78.63	90.57	4.064	0.4955
Root weight (t/ha)	20.14	19.41	19.01	0.766	0.5002
Leaf weight (t/ha)	1.18	1.19	1.28	0.178	0.2916
LRR (t/ha)	0.058	0.061	0.104	0.016	0.3336
DMY (t/ha)	21.28	20.51	21.42	0.68872	0.5327

LRR = leaf to root ratio; DMY = Dry matter yield; SEM = Standard error of mean; t/ha = tone per hectare; cm = centimeter; a b c = Means with different superscript letters within rows differ at p<0.05.

Effect of Harvesting Dates on Fodder Yield of Local Barley Landraces

The effect of harvesting date on hydroponic fodder yield and yield related components of local barley landraces was presented in Table 2. The results showed that all the parameters measured were significantly ($p<0.05$) affected by difference in harvesting date. The average fresh yields at 6th, 8th, 10th and 12th days of harvesting were 41.98, 43.80, 51.09 and 61.88 t/ha, respectively. It has been shown that increased date of harvesting resulted in increased fresh fodder yield. On the 12th day the fodder was fully grown and had higher fresh fodder yield which showed 2.5 times increase from the initial seed weight. This was lower than the results of Hillier and Perry (1969), who reported fresh yield of 2.8-8 folds in 6-8 days. According to Peer and Leeson (1985), fresh weight increased 5.7 times the original seed weight after sprouting for 7 days. This discrepancy exhibited in current study might be due to the difference in crops landraces, other weather conditions and management factors (Fazaeli *et al.*, 2011; Naik *et al*., 2013a; Naik *et al*., 2013b).

The mean dry fodder yield at 6th, 8th, 10th and 12th days of harvesting were 22.03, 23.14, 21.34 and 12.31 t/ha, respectively. Dry fodder yield of the treatments was decreased with prolonged harvesting date. Accordingly, the fodder yield on the 8th day (23.14 t/ha) showed the highest value than 6th day (22.03 t/ha) of harvesting day. The inconsistency for lower result revealed on 6th day (22.03 t/ha) than on the 8th day (23.14 t/ha) could be due to activation of chloroplasts for photosynthesis that in turn reduce accumulation of DM, because photosynthesis commences around day-5 when the chloroplasts are activated and this does not provide enough time for DM accumulation around day 5 (Dung *et al.*, 2010b). Apart from inconsistency exhibited between 6th and 8th day the result is in agreement with finding of (Fazaeli *et al.*, 2012; Naik *et al.*, 2012; Naik *et al.*, 2014), who have indicated the DM content of fodder is decreased from 89.7% to 13.4% as harvesting date progressed. This decrease in DM yield at 12th date could be due to the decrease in the starch content because during sprouting, starch is catabolized to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis (Fazaeli *et al*., 2012; Naik *et al.*, 2012; Naik *et al.*, 2014).

The average plant heights at 12th days of harvesting had tallest value of all other dates in the treatment. This might be due to longer harvesting time that enhanced the plant use nutrient in the seed and continued to increase in height. The plant heights in the current study which ranges between 3.16 and 12.27cm was, lower than other reports (Al-Hashmi, 2008) for hydroponic barley green fodder which was between 18 and 20 cm. This might be due to difference in environmental and management factors which affected growth of the fodder (El-Deeba *et al*., 2009).

The mean dry leaf weight at 6th, 8th, 10th and 12th days of harvesting were 0.23, 0.34, 0.63 and 1.21 t/ha respectively. The result showed that as time of harvesting increased photosynthesis continued until nutrient in the seed lost. As photosynthesis continued growth of plant leaf also increased. This means longer harvest time could bring higher plant leaf production.

In contrary to leaves yield, the average dry root weight was consistently decreased with increase in harvesting time. The values recorded at 6th, 8th, 10th and 12th days of harvesting were 23.84, 22.23, 21.09 and 12.18 t/ha in one production cycle, respectively. Such decreasing results may be mainly because of high moisture content of the root than leaf during sprouting.

LRR values were increased with advancing time of harvest mainly due to increasing leaf yield. With prolonged harvesting time, higher leaf weight was recorded than root weight and the fodder had higher LRR at 12th day of harvest.

Table 2: Effect of harvesting date on biomass yield and yield related components of hydroponically grown local barley landraces

Parameters	Days after planting				SEM	P-value
	6th day	8th day	10th day	12th day		
Seed weight (t/ha)	24.29	24.29	24.29	24.29	0.07869	1.0000
Plant height (cm)	3.16^{c}	3.42^{c}	7.81^{b}	12.27^{a}	0.71036	0.0001
Fresh yield (t/ha)	41.98^{b}	43.80^{b}	51.09^{b}	61.88^{a}	1.98437	0.0043
Root weight (t/ha)	23.84^{a}	22.23^{b}	21.09^{b}	12.18^{c}	1.32165	0.0001
Leaf weight (t/ha)	0.23^{b}	0.34^{b}	0.63^{b}	1.21^{a}	0.11024	0.0420
LRR (t/ha)	0.007^{b}	0.016^{b}	0.031^{b}	0.099^{a}	0.00924	0.0049
DMY (t/ha)	24.03^{a}	23.14^{a}	21.34^{a}	13.31^{b}	0.92227	0.0001

LRR = leaf to root ratio; DMY = Dry matter yield; SEM = Standard error mean; t/ha = tone per hectare; cm = centimeter; a b c = Means with different superscript letters within rows differ at p<0.05.

Figure 1: Hydroponically grown barley fodder of Mosno variety at different growing stages (dates)

Local Barley Biomass Yield as Affected by Landraces

Landraces biomass yield and yield related components of hydroponically grown local barleys were shown in Table 3. All the measured parameters were significantly affected ($p<0.05$) by landraces. The average green fodder yields were 68.49, 104.77 and 68.50 t/ha for black barley, Mosno and white barley, respectively. Mosno variety had the highest green fodder yield (104.78 t/ha) than black (68.49 t/ha) and white (68.51 t/ha) barley landraces. The highest green fodder yield of Mosno landraces could be attributed to availability of adequate light for photosynthesis as it is grown using residual moisture after the rainy season, which is traditionally practiced by farmers in Wollega particularly in the Horro-Guduru province. This indicates that Mosno could be potential or preferable local barley for hydroponic fodder production. The average fresh green fodder yield to initial planted seed weight was 2.9 times, 4.3 times and 2.8 times for black barley, Mosno and white barley, respectively. This result is lower than the finding of Al-Karaki (2010) who reported 8 times of original seed weight for fresh green fodder of hydroponically produced barley at the 8th day of growth. The differences could be attributed to the differences in landrace and/or conditions under which the experiments were conducted.

The average dry fodder yields were 23.30, 18.78 and 19.85 t/ha for black barley, Mosno, and white barley, respectively which were lower than the initial weight of seed. This result is in agreement with other findings (Fazaeli *et al*., 2011 and Morgan *et al*., 1992).

The highest mean value of barley fodder height in this study was 18.34cm at one production cycle for the Mosno variety. The result was in line with report of Al-Hashmi (2008) who reported fodder height of hydroponic barley between 18 and 20 cm.

The average dry leaf weight was 0.96, 2.48 and 0.98 t/ha for black barley, Mosno and white barley, respectively with the highest value recorded for the Mosno variety. Generally, the Mosno local variety had got best hydroponic fodder production potential among the other landraces in the current study.

While the seed weight of Mosno attained middle value compared to Black barley and White barley, its root weight became the least of all indicating that this landrace was best on sprouting and shifting to herbage part. This was what was observed in its fresh yield, its leaf weight and leaf root ratio (LRR).

Table 3: Biomass yield and related agronomic traits of hydroponically grown local barley landraces at 12th harvesting date

Parameters	Black barley	Mosno	White barley	SEM	P-value
Seed weight (t/ha)	23.67^{c}	24.44^{b}	24.78^{a}	0.0913	0.0001
Plant height (cm)	14.72^{b}	18.34^{a}	14.76^{b}	0.4150	0.0001
Fresh yield (t/ha)	68.49^{b}	104.77^{a}	68.50^{b}	4.0641	0.0001
Root weight (t/ha)	22.34^{a}	16.30^{c}	19.02^{b}	0.7662	0.0046
Leaf weight (t/ha)	0.96^{b}	2.48^{a}	0.98^{b}	0.1781	0.0001
LRR (t/ha)	0.051^{b}	0.184^{a}	0.036^{b}	0.0164	0.0001
DMY (t/ha)	23.30^{a}	18.78^{b}	19.85^{b}	0.6887	0.0188

LRR = leaf to root ratio; DMY = Dry matter yield; SEM = Standard error mean; t/ha = tone per hectare; cm = centimeter; a b c = Means with different superscript letters within rows differ at p<0.05.

Nutrient Composition and In Vitro DM Digestibility of Local Barley Landraces

Fodder and grain chemical composition and *in-vitro* DM Digestibility (IVDMD) of hydroponically grown local barley landraces were shown in Table 4. All the measured parameters significantly differed between sprouted and the non-sprouted barley grains ($p<0.05$). The average crude protein (CP) content of the grain was 12.92%, while 16.07%, 17.58% and 15.75% were recorded for the sprouted barley landraces black barley, Mosno and white barley, respectively with the highest value recorded in the fodder of the Mosno (17.58%). The results revealed that growing barley hydroponically improves the CP content of the fodder than the grain counterpart. The CP value recorded in current study was comparable with the report of Sneath and McIntosh (2003) who noted CP values ranging from 11.38 to 24% for sprouted barley. For all sprouted landraces in this study, the overall mean CP content (16.46%) was also comparable with result obtained by Snow *et al.* (2008) who reported 16.13% CP for hydroponically produced barley fodder. But it was higher than those reported by Al-Ajmi *et al*. (2009) in that CP content was increased from 10.8 at day 4 to 14.9 percent at day 8 in hydroponically grown barley fodder. Even though the harvesting date were varied here, it was inevitable that growth was ceased in both cases and comparing was reasonable.

In this study, the DM percentage of the partially dried sprouted barley compared with its grain was lower as mentioned in the earlier sections. The increase in protein content may be attributed to the complete change of dry weight (seed form) into herbage and increasing in protein proportions (Fayed, 2011). Chavan and Kadam (1989) found the nutrients changes in sprouting grains by enhancing the time of sprouting, the higher organic matter, particularly starch consumed to support the metabolism and energy requirement for the growing into leaf part.

Ash contents of the grain and hydroponically grown local barleys were 3.84%, 5.24%, 5.65% and 4.04% for barley grain and sprouted fodder of black barley, Mosno and white barley, respectively which showed differences among the grain and its sprouted landraces. Other reports (Morgan *et al.*, 1992) also confirmed this result in that ash content of sprouts was increased corresponding with the extension of the root, which allowed mineral uptake. They also reported that Ash content was increased from 2.1 in original seed (barley) to 3.1 and 5.3 at day 6 and 8, respectively that were relatively comparable with our result. The overall mean ash content (4.98%) of the hydroponic barley fodder was higher than that of the grain. However, this was higher than the findings of Fazaeli *et al*. (2012) and Intissar *et al.* (2004) who reported 4.11% and 3.6% ash content after day 6 and day 8, respectively. This might be due to increased day of harvesting.

The fiber contents (NDF, ADF and ADL) differed significantly ($p<.0001$) between the fodder produced from sprouted local barley landraces and the composite grain of the landraces. Accordingly, the average values of NDF were 33.38%, 51.49%, 46.82% and 43.54% for barley grain and sprouted fodder of Black barley, Mosno and White barley, respectively. This result showed that sprouting cereal grains enhances fiber content of the fodder. The highest (51.5%) fiber (NDF) content of Black barley in this study while its herbage part was lower compared to Mosno barley landraces indicated that its fiber content was mainly due to its root but not its leaf part. According to Singh and Oosting (1992), feeds containing NDF values of less than 45% are classified as high, those with values ranging from 45% to 65% as medium, and those with values higher than 65% as having low quality. The NDF values for White barley was less than 45%, the amount which was belied quality fodder and that of Mosno barley was (46.8%) not much more than the value classified as quality and hence this landrace also was able to produce nearly quality hydroponic fodder. This was an advantage for ruminants such as dairy cows which depend partially on quality roughages for production of specific nutrients like fat content of the milk. The NDF content in the present study was higher than the results of Fazaeli *et al*. (2012) and Fazaelil *et al*. (2011) who reported 35.40 % and 31.25% for hydroponic barley fodder in respective years. This difference might be due to difference in landraces. This confirms that the hydroponic barleys fodder produced in the present study was expected to result in high animal intake.

The ADF values for sprouted barley fodder range from 17.58 to 21.02 %, with the highest value recorded for black barley and the lowest for white barley. The current result is higher than the findings of Fazaeli *et al*., 2011 who reported 14.35 ± 0.21% ADF. The ADF value of white barley in the current study is comparable with the value (17.15%) reported by Fazaeli *et al*. (2012).

The average ADL content was 3.23%, 6.49%, 7.11% and 6.52% for barley grain and hydroponically grown fodder of black barley, Mosno and white barley, respectively. These results showed that sprouting the barley grain hydroponically increased the ADL content of the fodder (herbage). This result was in agreement with Emam *et al*. (2018) who reported that the ADL values in hydroponic green fodder barley was higher compared to original barley seeds.

The overall mean IVDMD for the grain (81.09%) was higher than the mean value recorded for sprouted barley (65.99%). The result is in agreement with the report of Peer and Leeson (1985) who reported significant losses in DM digestibility of sprouted barley grain, which was declined progressively during 7 to 8-day growth period. The IVDMD of hydroponically grown barley in the current study (63.12-68.99%) is lower than the range of values 72-76% reported in other studies (Mansbridge and Gooch, 1985; Grigor'ev *et al.*, 1986 and Cuddeford, 1989). This might be due to differences in types of landraces or varieties of barleys the researchers used to grow hydroponic fodder during germination. In addition length of sprouting days and other factors not mentioned in their report may contribute to variation of the results. However, the result of the current study is in line with the findings of Fazaeli *et al*. (2012) who reported that, the fiber contents such as ADF were increased but non-fiber or soluble components contents decreased in hydroponic green fodder compared to the initial barley grain and this might had reduced its IVDMD. Mesfin *et al*. (2020) also reported similar impression, the decrease in IVDMD with sprouting of different maize landraces.

Table 4: landraces Chemical composition and IVDMD of hydroponically grown local barley landraces

Parameters	Grain	Black barley	Mosno	White barley	SEM	P-value
DM (%)	93.617^{a}	91.582^{b}	91.952^{b}	91.670^{b}	0.17328	0.0001
Ash (%)	3.8400^{b}	5.2450^{a}	5.6550^{a}	4.0400^{b}	0.20174	0.0005
CP (%)	12.920^{c}	16.073^{ab}	17.583^{a}	15.750^{b}	0.40473	0.0001
NDF (%)	33.380^{C}	51.498^{a}	46.822^{b}	43.548^{b}	1.30540	0.0001
ADF (%)	14.603^{b}	21.020^{a}	19.705^{a}	17.582^{ab}	0.78774	0.0165
ADL (%)	3.233^{b}	6.490^{a}	7.112^{a}	6.527^{a}	0.48782	0.0138
IVDMD (%)	81.090^{a}	63.120^{b}	65.880^{b}	68.997^{b}	1.64163	0.0001

DM = Dry matter; CP = crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin; IVDMD = In-vitro dry matter digestibility; SEM = Standard error means; $^{a\ b\ c}$ Means followed by different superscript letters within a row/treatments differ at p<0.05

Nutritive Values of Local Barley Landraces as Affected by Harvesting Dates

Chemical composition and IVDMD of the barley grain and sprouted barley as affected by harvesting dates were shown in Table 5. The results showed that all the measured parameters significantly (p<.0001) differ between barley grain and sprouted barley. The DM content of sprouted barley was significantly reduced with increasing growing periods from 6 to 12 days. Accordingly, the highest mean DM content for the fodder was recorded at 6th day of harvesting. This might be due to the fact that carbohydrates were assimilated for metabolic activity and contributing to energy used for growth and development during germination. The current result is in line with the findings of Anonymous (2011) who reported that because the dry matter could not be substituted by the photosynthesis, sprout weight is decreased by the time photosynthesis is accelerated. Tudor *et al.* (2004) and Fazeli *et al.* (2012) also reported that DM content of the seeds was decreased during the sprouting.

The CP content of hydroponically grown barley landraces was increased with increasing time of harvesting. In this regard, the lowest CP content was recorded in sprouted barley at 6th day (14.78%) and increased to the maximum mean value at 12th day (17.90%). It showed that increasing dates of growth increased herbage (leaf) component of the fodder and thereby increased the CP composition more than its grain counterpart. The result is in agreement with the report of Hande *et al.* (2014) and Flynn *et al.* (1986) who reported higher CP content with increasing harvesting days. The present result is also in agreement with the findings of Tudor *et al.* (2004) and Fazeli *et al.* (2012) who reported that CP content of the seeds were increased during the sprouting. This might be due to decreased DM content during sprouting, and this was in line with the report of Lorenz (1980) who noted increasing concentration of nutrients during germination depending on proportional decrease in DM.

The ash content of hydroponic barley fodder was increased by the prolonged harvesting date. This was confirmed by the report of Naik *et al*. (2012) who indicated that the ash content of the seeds was increased during the sprouting. This could be associated with the decrease in organic matter for providing energy for sprouting, in other terms the alterations are based on changing of proportion of the organic matter and the mineral matter (ash) contents (Chavan and Kadam, 1989).

The fiber contents (NDF, ADF and ADL) of hydroponically grown barley landraces were increased with increasing harvesting date. Hoffman *et al*. (2003) also indicated higher of cell wall constituents with increasing growth stage of barley. The highest NDF content of hydroponically grown barley fodder was recorded at 12th day of harvesting. This implies that the NDF content was increased with prolonged harvesting time which is in line with the reports of Fazeli *et al.* (2012) and Naik *et al.* (2012) who indicated that with the progress of harvesting period, the plants cell wall components were increased. The ADF content of hydroponically grown barley fodder was increased from 14.91% at day 6 to 24.38% at day 12. Similarly, the ADL content of the fodder was increased from 3.83% to 9.68% by with extended growing period from day 6 to day 12.

The IVDMD of hydroponically grown barley fodder was decreased with increasing harvesting date. This might be due to the change in components occurred during sprouting, and was in agreement with the report of Fazaeli *et al.* (2012) who indicated that the reduction in digestibility could be due to changes in the components in green fodder where the non-fiber carbohydrate was decreased but fiber fractions were increased during growth. The findings of Peer and Leeson (1985) also witnessed similar observations where losses in DM digestibility of the hydroponic fodder occurred upon on sprouting, which progressively declined during 7 to 8-day growth cycle compared to its grain counterpart.

Table 5: Chemical composition and in vitro DM digestibility of hydroponically grown local barley landraces as affected by harvesting dates

Parameters	Grain	Harvesting date				SEM	P-value
		6^{th} day	8^{th} day	10^{th} day	12^{th} day		
DM (%)	93.62^{a}	92.70^{b}	92.21^{c}	91.84^{c}	91.15^{d}	0.14257	0.0001
Ash (%)	3.840^{c}	3.89^{c}	3.91^{c}	5.05^{b}	5.97^{a}	0.18049	0.0001
CP (%)	12.92^{d}	14.78^{c}	15.03^{bc}	16.47^{ab}	17.90^{a}	0.34533	0.0001
NDF (%)	33.38d	42.55^{c}	44.70^{bc}	47.78^{b}	52.37^{a}	1.15211	0.0001
ADF (%)	14.60^{c}	14.91^{c}	15.16^{c}	18.75^{b}	24.38^{a}	0.68395	0.0001
ADL (%)	3.23^{c}	3.83^{c}	4.08^{c}	6.35^{b}	9.68^{a}	0.41148	0.0001
IVDMD (%)	81.09^{a}	77.07^{b}	74.47^{b}	66.77^{c}	56.75^{d}	1.39868	0.0001

DM = Dry matter; CP = crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin; IVDMD = In-vitro dry matter digestibility; SEM = Standard error of means; $^{a\ b\ c}$ Means followed by different superscript letters within a row/treatments differ at $p<0.05$

Conclusion

Watering at 4h interval, relatively, had resulted in the highest biomass yield and yield related components of barley grown under hydroponic system. Among the landraces used in this experiment, Mosno was found to be best variety for green fodder biomass yield and as well for better nutritive values. The 12^{th} date of harvesting was identified as optimum time of harvesting for highest hydroponic fodder yield and yield related components. Sprouting barley had highest CP, cell wall contents (NDF, ADF and ADL) and ash contents compared to its grain counterpart. The IVDMD and DM percentage were higher in barley grain than sprouted barley fodder landraces. According to this experiment, Mosno barley landrace can be used for highest fodder harvest and for more nutritive values of the fodder under hydroponic system.

Watering at 4 h interval and harvesting at 12^{th} day could be recommended for applications for the production of optimum fodder with better nutritive values from hydroponically grown barley. On the basis of this finding, it is also very important to undertake feeding experiments to see dairy performances of cows and/or other feeding trials for evaluating animal performances and economic returns.

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