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CHARACTERIZATION OF TEF (*Eragrostis tef* Zucc. Trotter [cv. *Magna*]) IN MINJAR SHENKORA DISTRICT OF CENTRAL ETHIOPIA

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ABSTRACT

Tef (*Eragrostis tef* Zucc. Trotter) is a major cereal crop in Ethiopia and performs well in altitudes ranging from 1700 to 2400 m above sea level. Tef "cv. *Magna*" exhibits high variability in quality and productivity per unit area in different parts of the country, hence it gives different market prices accordingly. This variety, also known as "*Minjar magna Tef*"" in the study area, is intensely preferred by the consumers than produced elsewhere thought the country. Thus, participatory variety characterization trial was conducted in 2015 and 2016 in Minjar Shenkora *district* of central Ethiopia to characterize Tef "cv. *Magna*" variety so as to obtain and create a primary platform for the branding of the variety in the future. Forty-five (45) farmers were selected purposively for the study at nine Tef "cv. *Magna*" producing sub-districts: *Arerti, Agirat, Ameti, Adama, Bolo Giorgis, Bolo Silase, Chele, Kombolcha and Korma.* A quadrant (1m x 1m) was used by throwing at five different locations per farmer field, and ten plants were randomly selected as experimental plants. Results revealed that the mean days were found to be 6.78, 42.44 and 100.89 for 50% emergence, 50% heading, and 50% maturity, respectively. The results of the present study show that the mean plant height and panicle length of the crop were 1.24m and 0.46m, respectively. The average tiller number, weight of main panicle and main panicle seed weight of Tef "cv. *Magna*" was found to be 4.49, 1.58 gm and 1.03 gm, respectively. Furthermore, the mean yield and shoot biomass were found to be 19.49 Qt/ha and 123 Qt/ha, respectively. The proximate compositions of Tef "cv. *Magna*" were 11.09% moisture content, 2.49% ash content, 74.07% carbohydrate, 1.75% crude fiber, 9.08% crude protein, 3.27% crude fat and 361.98 Kcal/mole energy. The mineral contents of Tef "cv. *Magna*" was Na: 49.99, K: 5686.54, P: 2935.23, Fe: 115.79, Cu: 6.36, Zn: 26.22, Ca: 1741.24 and Mg: 1427.08 mg/Kg. Though characterization of the variety at the molecular level and comparative study with different varieties of the crop should be done in the near future, our study forms a primary platform for further activities to give a brand name for Tef "cv. *Magna*".

Key words: Brand, Characterization, Minerals, Proximate composition, Tef 'cv. *Magna*'

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INTRODUCTION

Tef (*Eragrostis tef* (Zucc). Trotter) is a major cereal crop in Ethiopia and has been grown in other North Eastern African countries (Eritrea, Djibouti, south eastern Sudan, and northern Kenya) as a hay crop. It is an annual C4 grass that belongs to the family *Poaceae* [1]. In Ethiopia, it occupies about 2.6 million hectares (23% of the grain crop area) of land, which is more than any other major cereals such as maize (16%), sorghum (14%) and wheat (13%) [2]. Tef withstands low moisture conditions and is often considered a rescue crop that survives and grows with remaining low moisture in the season when early planted crops such as maize, fail due to low moisture. Moreover, the ability of Tef to tolerate and grow on Vertisols with drainage problems makes it a preferred cereal by farmers. The crop exhibits high variability within regions of cultivation and between plants of the same accession [3].

In Ethiopia, Tef performs well in '*Weina dega'* agro-ecological zones or medium altitude (1700-2400m above sea level) [4, 5]. The mean temperature and optimum rainfall during the growing season for the crop range from10^{o}C – 27^{o}C and 450 to 550 mm, respectively [5]. The length of growing period (LGP) or the number of days to maturity of Tef, considering rainfall and evapotranspiration of 2-6 mm/day range from 60 to 180 days (depending on variety and altitude) with an optimum of 90 to 130 days [5].

The nutritional value of the Tef grain is similar to that of traditional cereals. The plant, which has a relatively short growing season, produces tiny seeds, similar to millet, that are traditionally ground into flour. This flour can be used as a base for semi-leavened bread (such as the traditional Ethiopian *Injera,* a major food staple), added as a thickening agent to soups and sauces, fermented to make beer and ethnic beverages, or made into porridge and puddings. Recently, the flour is also gaining popularity as both a naturally gluten-free alternative to wheat flour and a nutrient-rich ingredient in the baby food industry. Tef is considered to have an excellent amino acid composition [6]. Its lysine levels are higher than those of wheat and barley but slightly lower than those of rice and oats. Tef is also higher in iron and calcium than wheat, barley and sorghum [6]. It is considered gluten-free [7]. Apart from the use of the grains for human consumption, the Tiff's bagasse is also nutrient rich and makes excellent fodder for livestock [8].

Tef is largely produced in Ethiopia, for market mainly because of its high market value and absence of alternative cash crops (such as coffee, tea or cotton) in the major Tef producing areas of Gojam (Amhara) and Shewa (Oromiya) (which have different agro-ecological conditions). Assemblers in village markets and wholesalers in regional markets pay significant attention to the quality of Tef. There are three general color based grades of Tef: white, mixed, and red; with the white fetching the highest price and red the lowest. There are also important sub-grades within each grade such as magna (very white) which is grown in East Shewa and is sold at a premium price [9]. The author also indicated that, compared to other staples, the price of Tef has increased at a faster rate in recent years, hence the price gap between Tef and other staples is widening. In particular, the price gap between Tef and maize has widened considerably since 2008 [10].

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Tef (*Eragrostis tef* Zucc. Trotter) "cv. *Magna*" exhibits high variability in quality and productivity per unit area in different parts of the country, hence it gives different market price accordingly. This variety (Tef "cv. *Magna*") produced in the study area is intensely preferred by the consumers than the same variety and other varieties of the same crop produced elsewhere throughout the country. Even though the study area has a high potential for Tef "cv. *Magna*" production, there is no work which has been done to characterize and document information about its nutritional and mineral composition. In addition, due to different constraints such as unavailability of a brand name (formal grades and standards), lack of reliable market information, lack of adequate warehouse facilities, and inadequate contract enforcement mechanisms, the farmer does not obtain significant benefits from Tef production.

Therefore, this work was initiated with the objective to characterize Tef "cv. *Magna*" through phenological, growth, yield and nutritional composition at Minjar Shenkora District, North Shewa Zone, Ethiopia, which will assist in obtaining and creating a primary platform for the branding of the crop in future.

MATERIALS AND METHODS

Description of the study area: The experiment was conducted in the 2015 and 2016 main cropping season at Minjar Shenkora District, which is located South-west of Addis Ababa at approximately 138 Kms. Minjar Shenkora District is characterized by tepid to cool sub-humid agro-ecological zone with an average altitude of 1770 meters above sea level. The soil is Vertisol type having clay textural class. The area has annual rainfall ranging between 800 and 1000 mm.

Experimental materials and methodology: Tef "cv. *Magna*" (DZ-01-196)'' also known as "*Minjar magna Tef*"' by the users and growers was used for the study. It was selected because of its well adapted, high consumer preference, widely grown in the area by smallholder farmers and attains high market price. Forty-five farmers were selected from nine sub-districts viz. Arerti, Agirat, Ameti, Adama, Bolo Giorgis, Bolo Silase, Chele, Kombolcha and Korma. The selection was done purposively based on their potential to cultivate the selected variety with the help of district administration and agriculture office experts for the study.

Experimental field management: All agronomic management and other practices like seed source and selection, harvesting and all common pest control measures were implemented according to farmer's experience and production technical support by district and sub-district agricultural experts on Tef production at the study area.

Data recording: For phenological, growth, yield data and samples to take for laboratory analysis, a quadrant (1m X 1m) was used by throwing at five different locations per farmer and ten plants were randomly selected.

Phenological data: Days to 50% emergence, days to 50% heading and days to 50% maturity were recorded in each. Forty-five selected farmer's field when the plants attained their respective growth stages.

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Growth and yield data: Plant height, panicle length, panicle weight, main panicle seed weight, shoot biomass, grain yield, and Harvest Index were recorded, computed and reported.

Laboratory analysis: For laboratory analysis, samples collected from five farmers per each sub-district were mixed (composite sample per sub-district were made), packed, tagged with important information and were sent to JIJE LABOGLAS Pvt. Limited company for analyses of nutritional and mineral compositions. Different chemical and mineral compositions of Tef "cv. *Magna*"; the methods of analyses are listed in Table 1.

Statistical Data Analysis: The qualitative data sets were coded and entered into a statistical package for social science (SPSS version 17) and quantitative data subjected to analysis of variance (ANOVA) using SAS version 9.2 computer software (SAS Institute Inc., 2008). Descriptive statistical tools (mean, range, ratio, and percent) were used to analyze the quantitative data and the statistical measure of means and percentages used to categorize data.

RESULTS AND DISCUSSION

Phenological data: Table 2 presents the important phonological data recorded of Tef "cv. *Magna*''. On average Tef "cv. *Magna*" took 6.78 days, 42.44 days and 100.89 days for 50% emergence, 50% heading and 50% maturity, respectively. Even though, it is dependent on and is influenced by seed rate comparative results for 50% days for emergence and 50% days for heading for Tef were documented [11, 12, 13]. Fifty percent (50%) heading of Tef "cv. *Magna*" was found to be within a similar range (32 to 48) as that of Tef germplasm tested in western and southern parts of Ethiopia from a study by Yu *et al*. [14]. In addition, comparable results (94.27 days for 50 % maturity) of Tef were documented in Assefa *et al*. and Yu *et al*. [13, 14]. Furthermore, the number of days for 50% maturity of Tef "cv. *Magna*" ranged from 80 to 113 illustrated by Bekabil *et al*. [15]. But, Tef variety DZ-Cr-37 (*Tsedey*) takes only a maximum of 60 days for 90% maturity [16]. This might be because different varieties may take different days for heading and maturity as the experiment was done in different agro-ecological zones.

Growth and Yield Data: According to the respondents (Tef growers) of this study, a majority (57.4%) of Tef growers in the study area tilled their land four times (Table 3). Tef has high tillage frequency compared to other cereals, and tillage frequency in Ethiopia for Tef production ranged from 3 to 12 times and depending on soil type and rainfall pattern of the area as indicated by Bart *et al*. [17]. The reason for high tillage frequency for Tef production is because the Tef seed is very small and thus germination is difficult in heavy and unbroken soil.

In the study area, though there are many improved varieties of Tef, "cv. *Magna*" was the most preferred and used variety by the farmers (72.6%) (Table 3). Similar reports showed that most Tef growers in the study area prefer Tef "cv. *Magna*", and the importance of the variety is increasing over time compares to other varieties [18]. This is mainly possible due to consumer preferences and high market attractiveness of Tef "cv. *Magna*".

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As reported by the interviewed farmers, most of the farmers in the study area used a broadcasting method of sowing than row planting and applied a seed rate up to 25 Kg/ha (Table 3). In line with our study, farmers use a broadcasting method for the planting of Tef and apply about 30 to 48 kg for Tef seed per hectare, and only a few farmers are aware of the benefits of Tef row planting [19]. From Tef farmers interviewed in the study area, it was learned that there is a possibility to obtain a yield of greater than 12Qt/ha from Tef "cv. *Magna*".

The mean plant height, panicle length, tiller number of Tef "cv. *Magna*" in the study area were 1.24 meter, 45.56 cm and 4.49, respectively (Table 4). In contrast to the results of this study, the tiller number of Tef may reach up to 18 toughs; and is influenced by population density, the variety of the crop and other edaphic factors, and agro-ecology [13]. This might be due to the difference in the time of tiller number counting. In this study we counted the tiller number of the crop at physiological maturity but Assefa *et al*. [13] counted at both flowering time and physiological maturity.

The study also revealed that, the mean value for the weight of Tef "cv. *Magna*" main panicle, main panicle seed weight, shoot biomass and yield were found to be 1.58 gm, 1.03 gm, 123Qt/ha and 19.49 Qt/ha, respectively (Table 4). Even though, it is dependent and affected by different factors like the varieties used for production and areas of production; comparable results were also registered and documented by different researchers [17, 19]. Accordingly, it is possible to obtain a mean yield of up to 37 Qt/ha from Tef variety DZ-Cr-37 (cv. *Tsedey*), and it is greatly dependent on seed rate, variety and agroecology [12].

Proximate analysis of Tef "cv. *Magna*" in this study, mean moisture content (11.09%), ash content (2.49%), carbohydrate (74.07%), crude fiber (1.75%), crude protein (9.08%), crude fat (3.27%) and energy (361.98 Kcal/mole) are comparable with study results documented for Tef grains studied by different scholars [19, 20, 21]. In addition, Tef "cv. *Magna*" was characterized by having different minerals like Na: 49.99, K: 5686.54, P: 2935.23, Fe: 115.79, Cu: 6.36, Zn: 26.22, Ca: 1741.24 and Mg: 1427.08 mg/Kg (Table 6). Consistent to our finding, Tef is an excellent source of fiber and iron and has higher quantities of calcium, potassium and other essential minerals found in an equal amount of other grains [19]. Furthermore, Tef grain has high nutritional value: carbohydrates, vitamin A and C, calcium, chloride, chromium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, zinc and the eight essential amino acids (isoleucine, leucine, methionine, lysine, phenylalanine, threonine, tryptophan and valine) [21].

CONCLUSION

The current study characterizes Tef "cv. *Magna*" (DZ-01-196)] based on different phenological, morphological, growth, yield and laboratory nutritional and mineral analysis. The result of our study forms a primary platform and gives firsthand information for further activities to give a brand name for Tef "cv. *Magna*". However, further work is needed in the characterization of Tef "cv. *Magna*" at the molecular level,

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and comparative agronomic studies with different varieties of the same crop before giving a brand name for the studied Tef "cv. *Magna*". By doing this, it is possible to maintain and improve the profitability of Tef "cv. *Magna*" producers and increase the number of users of the product (Tef "cv. *Magna*") both at national and international levels.

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Conflict of Interest

The authors declare no conflict of interest.

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Table 1: Parameters assessed and methods used for analysis of Tef [cv. *Magna* (DZ-01-196)]

S/No.	Parameters tested	Test methods used
1	Moisture Content	AOAC Official Method 925.10
2	Crude Fat	AOAC Official Method 920.39-Soxhlet/ Gravimetric
3	Crude Protein	ES ISO 1871:2013
4	Crude Ash	AOAC Official Method 923.03
5	Crude Fiber	AOAC Official Method 962.09-Acid-Base Digestion/Gravimetric.
6	Carbohydrate (CHO)	By Difference.
7	Energy	By Calculation.
8	Sodium (Na) and Potassium (K)	AOAC Official Method 923.03- Flame Photometer.
9	Phosphorous (P)	Modified AOAC Official Method 986.24.
10	Iron (Fe), Zinc (Zn), Copper (Cu), Calcium (Ca) and Magnesium (Mg)	Modified AOAC Official Method 985.35 FAAS.

Table 2: Important phonological data of Tef [cv. *Magna* (DZ-01-196)]

S. No.	Keble name	Days to emergence (50%)	Days to heading (50%)	Days to maturity (50%)
1	Adama	6	40	92
2	Agirat	6	41	94
3	Ametti	7	44	97
4	Areriti	8	46	102
5	Bolo Giorgis	7	44	110
6	Bolo Silasie	8	43	108
7	Chelle	6	39	94
8	Kombolcha	7	43	106
9	Korma	6	42	105
	Mean	**6.78**	**42.44**	**100.89**

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Table 3: The percentage share of farmers' responses to different agronomic practices included in preliminary questions

	Number of Observations	Unit (Share (%)
Land used for Tef Production	45	
All		0.00
Half		84.10
Quarter		9.10
<quarter		6.80
Tillage frequency	45	
<three times		0.00
Three times		16.70
Four times		57.40
>four times		25.90
Seed source	45	
Home		73.10
Market		5.80
Research centers		9.60
Cooperatives		11.50
Varieties used	45	
Magna (Nebar)		72.60
Other (Quncho, Key Tef, etc)		27.40
Seed rate used kg/ha	45	
<10		0.00
10-15		43.90
16-20		22.00
21-25		9.80
>25		24.40
Yield obtained Qt/ha	45	
<12		0.00
12-16		15.00
17-20		42.50
21-24		20.00
25-28		17.50
>28		5.00
Yield use (Market : Home)	45	
100%:0%		0.00
75%:25%		47.50
50%:50%		50.00
25%:75%		2.50
0%:100%		0.00
Marketing	45	
Wholesaler		43.10
Retailor		20.70
Cooperatives		32.80
Unions		3.40

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Table 4: Important growth, morphology and yield data of Tef [cv. *Magna* (DZ-01-196)]

S. No.	Keble name	PH (m)	PL (cm)	TN	MPW (gm)	MPSW (gm)	Yld (Qt/ha)	SBm (Qt/ha)	HI
1	Adama	1.15	37.81	3.92	1.25	0.98	25.20	115.00	0.22
2	Agirat	1.29	45.32	5.58	1.58	0.93	16.60	105.00	0.16
3	Ametti	1.27	47.44	3.52	1.38	0.84	15.16	111.00	0.14
4	Areriti	1.29	50.15	6.67	1.05	0.62	32.92	200.00	0.16
5	Bolo Giorgis	1.22	44.09	3.15	1.66	1.05	23.89	115.00	0.21
6	Bolo Silasie	1.39	50.62	4.05	2.65	1.79	18.30	123.00	0.15
7	Chelle	1.10	42.84	4.13	1.45	0.91	15.47	90.10	0.17
8	Kombolcha	1.32	47.20	4.59	1.59	1.05	18.64	132.00	0.14
9	Korma	1.15	44.60	4.79	1.57	1.06	9.23	113.00	0.08
	Mean	**1.24**	**45.56**	**4.49**	**1.58**	**1.03**	**19.49**	**123.00**	**0.15**

Where: PH: Plant height, PL: Panicle length, TN: Tiller number, MPW: Main panicle weight, MPSW: Main panicle seed weight, Yld: Yield, SBm: Shoot biomass and HI: Harvest index

Table 5: Proximate composition (% dry weight) and Energy (Kcal/mole) of Tef [cv. *Magna* (DZ-01-196)]

S. No.	Keble name	Moisture (%)	Ash (%)	Carbohydrate (%)	Crude fiber (%)	Crude protein (%)	Crude fat (%)	Energy (Kcal/mole)
1	Adama	11.10	2.62	74.27	2.17	8.97	3.04	360.29
2	Agirat	10.92	2.36	76.48	1.87	6.76	3.48	364.29
3	Ametti	11.56	2.41	72.69	2.04	9.87	3.47	361.45
4	Areriti	10.96	2.13	73.01	1.72	10.56	3.33	364.28
5	Bolo Giorgis	11.22	2.59	74.08	0.79	8.73	3.38	361.65
6	Bolo Silasie	11.12	2.44	74.78	2.25	8.55	3.11	361.33
7	Chelle	10.92	2.21	73.73	2.25	9.88	3.26	363.77
8	Kombolcha	11.04	2.44	75.64	1.24	7.70	3.18	362.02
9	Korma	11.02	3.22	71.96	1.42	10.66	3.15	358.77
	Mean	**11.09**	**2.49**	**74.07**	**1.75**	**9.08**	**3.27**	**361.98**

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Table 6: Major mineral contents (mg/kg dry weight) of Tef [cv. *Magna* (DZ-01-196)]

S. No.	Keble name	Mineral mg/Kg							
		Na	K	P	Fe	Cu	Zn	Ca	Mg
1	Adama	52.49	6374.20	3438.32	61.68	6.90	25.54	1567.30	1583.80
2	Agirat	44.90	5987.13	3226.03	37.46	6.23	27.60	1728.78	1432.42
3	Ametti	52.77	5559.32	3276.70	97.09	6.77	28.97	16.58.37	1343.28
4	Areriti	43.05	5147.50	2843.76	47.70	6.48	25.27	1811.92	1358.94
5	Bolo Giorgis	48.81	5725.76	1405.74	111.23	5.95	23.70	1652.02	1685.06
6	Bolo Silasie	50.63	5438.04	3041.09	140.17	6.09	23.67	1485.15	1534.65
7	Chelle	44.90	5238.74	2876.63	94.02	7.15	28.77	2058.08	1185.45
8	Kombolcha	46.84	6463.58	3298.77	105.85	5.25	26.23	1566.25	1483.81
9	Korma	65.56	5244.62	3010.04	346.99	6.46	26.22	2060.39	1236.33
	Mean	**49.99**	**5686.54**	**2935.23**	**115.79**	**6.36**	**26.22**	**1741.24**	**1427.08**

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