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Review Article

An Overview of Teff (*Eragrostis teff Zuccagni) Trotter*) as a Potential Summer Forage Crop in Temperate Systems

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ABSTRACT

The production of traditional cool season grasses in temperate regions is becoming hampered during summer seasons due to water deficit. Thus, incorporating water use efficient warm season annual grasses are generally considered to fill the gap of summer season forage reduction that would offer considerable flexibility and adaptability to respond to forage demand. Teff (*Eragrostis teff Zuccagni) Trotter*) is, a C4 drought tolerant warm season annual grass primarily grown for grain production, recently gaining interest for forage production particularly during summer season. Previous reports have showed that teff is palatable and has comparable forage biomass and feed quality as compared to other warm season annual grasses which would make it an alternative forage. However, the available data are not comprehensive to explore the potential of teff as forage, hence further assessment of genotype variability and performance along with compatibility study of teff with forage production system of specific environment is key for future utilization.

(**Key words**: Teff, Feed, Forage crop, Warm season grass)

Ⅰ. INTRODUCTION

Evidence is growing that the production of cool-season forage grasses is being affected by high temperatures and short-term drought stress resulting in growth limitation during the summer months (Dimitra Loka 2018; Kathyryn et al. 2018). For example, forage production in temperate regions has been shown to be below its full potential during summer due to water deficit (Sitzia and Ruiz 2011). These climatic influences on forage production during the summer season in temperate regions could be addressed by introducing various strategies targeted to improve fodder availability/production. One of these potential strategies to improve forage production during the summer season is to introduce warm season annual forage crops, which are more resilient to drought and heat stresses and can produce forage in a short period of time during the summer months, as an alternative option. Several tropical annual species are known to be suitable for summer forage provision. Among these annual warm season crops, teff has gained an interest as an alternative forage particularly to combat drought conditions during the summer (Norberg et al. 2009). Teff is a grass species which is highly drought and heat tolerant crop with good feed nutrition quality that would help to bridge the summer feed gap.

In this review, we provide a brief overview of the potential of teff grass as an alternative forage for production during the summer season in sub-tropical/temperate regions. The main aim of this review is to provide information about the potential adaptation and performance responses of teff in terms of quantity and quality as a forage crop and to indicate opportunities and for further research to enhance the utility of this crop as a summer forage.

1. TEFF AS HUMAN AND ANIMAL FEED

Teff (*Eragrostis tef* (Zuccagni) Trotter) is a self-pollinating warm season C4 annual grass that originated in Ethiopia (D'andrea 2008; Miller 2011). It is a multi-purpose crop where the grain is mainly used to make injera, a staple Ethiopian food, while the crop residue provides a popular livestock feed in Ethiopia (Heuzé et al. 2016). Teff grain is also used to produce

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"Tella" and other traditional alcoholic beverages (Demeke and Di MArcantonio, 2013). It has been reported that teff has about 150 mg of iron per 100 g of whole grain and calcium levels as high as 155 mg per 100 g of whole grain (Abebe et al. 2007). These values of both iron and calcium are significantly higher than the other major cereal crops such as maize, wheat and barley. Teff also has an excellent balance of amino acids, and is known for its high protein and copper contents. Despite such nutritional high quality, the use of teff grain as a staple food has not been known in any other country outside Ethiopia. However, recently it has been popularized as a gluten free flour source for people suffering from Celiac's disease (gluten intolerance), and hence interest in teff has increased in the USA and Europe, mainly due to its very attractive nutritional profile and gluten-free nature of the grain which makes it a suitable substitute for wheat and other cereals in a number of food applications (Gebremariam et al. 2012).

2. TEFF AS AN ALTERNATIVE FORAGE

Teff is primarily produced for grain production with the left over stover used for livestock feed after grain harvest. Stover feed is very common in Ethiopia, where most of the farmers use the stover to feed their livestock during the dry season. Despite its popularity, no teff varieties have been registered and released as a forage crop in Ethiopia and it is only the introduction of teff to other countries, such as USA, South Africa and Europe, that has paved the way to evaluate teff as a forage crop in addition to the traditional grain production (Miller, 2011). Following these studies, teff has gained popularity as a summer forage crop in temperate regions across the world (Norberg et al. 2009; Shawna et al. 2012; Lee et al. 2015). In these temperate regions there is an increasing demand for a summer forage crop that produces high yields with low inputs, without compromising feed quality. Teff has been demonstrated to be a fast-growing crop with the ability to produce high forage yields with excellent quality in a relatively short growing season (Miller, 2010). As a warm season annual grass, it requires a frost-free growing season as frost is the major threat to growing Teff in temperate regions (Norberg et al. 2009).

Previous reports have demonstrated that that teff has high a yielding capacity and good feed nutrition quality when grown in the summer months, compared to cool season grasses such as Timothy grass (*Phleum pratense*), which normally has poor production following the spring harvest (Miller, 2010). Teff is a fine stemmed, leafy and "soft" grass, making it very palatable to livestock, that can be harvested in less than 45 days after sowing (Miller 2010). Farmers often report that their livestock prefer teff hay over other traditional grass hays (Miller 2010). Consequently, the forage value of Teff lies in its palatability, high nutritive value, rapid growth and drought tolerance (Ketema et al. 1997). In addition, milk production was shown to increase when dairy cows were fed teff hay as a sole diet when compared to native grass hay in the USA indicating that teff has the potential to be used as an alternative forage source for lactating dairy cows (Saylor et al. 2018). Thus, recent interest in growing teff as a forage crops has increased in different parts of the world (Davidson 2010). Moreover, the summer production of teff as a forage can be conserved to provide a source of stored feed during the winter months or fed to bridge the summer slump growth period observed in the cool season grass species (Miller 2010). Even though, teff grass is well adapted to produce under a range of soil types it does not do well in waterlogged conditions or highly saline soils, thus the production potential of teff production under paddy field conditions could be hampered.

While teff grass has the potential to fit the needs for forage production during summer droughts, there remains much to be studied to determine the suitability of teff to different agro ecologies of the temperate regions during summer season that are characterized by high temperature and low moisture.

Ⅱ. PERFORMANCE OF TEFF FORAGE GENOTYPES FOR BIOMASS YIELD AND FEED QUALITY

In Ethiopia, teff is primarily grown as a grain crop, thus most feeding trials in Ethiopia have aimed at improving the nutritive value of low-quality teff straw (Mesfin and Ledin 2004). However, forage performance studies on teff in temperate regions, such as in the USA, have reported forage yields as high as 7 tons per hectare in a single cut (Miller 2011). In addition, forage biomass yield evaluations of a range of teff genotypes indicated the adaptability of teff to produce across

Table 1. Teff genotypes forage biomass yields in ton/acre

Statistics	Location	
	USA, Nevada	South Korea, Cheonan
Mean	4.5-9.4	1.64 - 2.47
Range	6.54	2.05
Authors	Davison et al. 2010	Lee et al. 2015

Table 2. Feed nutritional quality

Statistics	Crude protein (Dry matter, %)	Acid detergent fiber (Dry matter, %)	Neutral detergent fiber (Dry matter, %)
USA, Nevada (Davison et al. 2010)			
Range	11-15	36.2-42.8	58-62.8
Mean	13.1	39.8	60.1
South Korea, Cheonan (Lee et al. 2015)			
Range	8.21-9.52	33.5-35.52	63.71-64.75
Mean	8.87	34.51	64.23

a wider range of environments, with forage yields of up to 2.47 tons/acre (t/a) in South Korea and 9.4 t/a in the USA (Table 1) (Davison et al. 2010; Lee et al. 2015). The difference in biomass yields observed between these two locations could attributed to the different genotypes studied, management practices and environmental conditions. Although these observations are not comprehensive, the variability observed among the genotypes for forage biomass productivity indicates that there is the potential to select/ develop teff cultivars specifically to produce forage biomass (Davison et al. 2010).

In general, studies that have investigated the quality of teff grass as a forage have demonstrated that it has comparable nutritive values to cool season forage crops and that it is characterized by its high leaf to stem ratio (Hunter et al, 2007). Variable feed nutrition quality values have been observed by several authors, these could be attributable to varietal differences of environmental effects and it has also been demonstrated that the forage quality is highly dependent on the nitrogen fertilizer application rate, stage of growth at harvest, and the number of cuts (Davison et al. 2010). The crude protein (CP) content of teff has been reported to range anywhere from between 8.5 and 21.5% (Roseberg et al. 2005; Miller 2011; Young et al. 2014). Similarly, the neutral detergent fibre (NDF) concentration, a predictor of intake in ruminants, has been reported to range from 52.5 to 72.5% (Roseberg et al. 2005; Miller 2011; Young et al. 2014). A teff forage quality evaluation conducted in South Korea using two cultivars resulted in lower CP content and higher NDF content than a range of teff genotypes studied in USA (Table 2) (Davison et al. 2010; Lee et al. 2015), indicating that a broader genetic base, as used in the USA study, should be implemented as an initial step to identify material with improved quality. Thus, in order to select teff genotypes with improved forage quality in South Korea, more genotypes need to be initially assessed to determine their nutritive performance.

Overall, significant variations in teff forage nutritive quality have been reported (Young et al. 2014). Given that the productivity of livestock is highly dependent on forage quality, characterization of teff forage quality, as green fodder and hay, needs to be undertaken across a range of potential teff growing areas.

Ⅲ. SUMMARY

Water shortages, particularly during the summer season, limit the productivity of tradition cool season forage crops in higher latitudes of the world. Therefore, in order to improve the forage availability during the summer season, planting warm season annual crops is one of the options that can help to overcome summer forage shortages. These warm season annual species can grow best during the warm months of spring and summer

due to their drought and heat tolerance capacity in order to fill production gaps during periods of drought in temperate regions. Teff is one of these warm-season annual grasses, currently primarily grown for grain production. However, in the recent past there has an increased interest in the suitability of teff grass for forage production in temperate regions. Studies on forage yield and feed quality have indicated that teff showed comparable performance with other warm season annual grasses. However, the variabilities observed in teff performance across different environments indicate the need for further analysis of a broader range of genotypic and environmental effects on the forage performance. To explore the full potential of teff for forage, studying management practices such as cutting intervals and the compatibility of genotypes across a range of forage production systems and specific environments is key for the future utilization of this species.

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Ⅴ. REFERENCES

Abebe, Y., Alemtsehay, B., Hambidge, K.M., Stoecker, B.J., Bailey, K. and Gibson, R.S. 2007. Phytate, zinc, iron and calcium content of selected raw and prepared foods consumed in rural Sidama, Southern Ethiopia, and implications for bioavailability. Journal of Food Composition and Analysis. 20:161-168.

D'andrea, A.C. 2008. Tef (*Eragrostis teff*) in ancient agricultural systems of highland Ethiopia. Economic Botany. 62:547-566.

Davison, J., Mike, L. and Earl, C. 2010. The potential for teff as an alternative forage crop for Irrigated regions. University of Nevada Cooperative Extension fact sheet. 07-29.

Demeke, M., and Di Marcantonio, F. 2013. Analysis of incentives and disincentives for teff in Ethiopia. Technical notes series, MAFAP, FAO, Rome.

Dimitra, L., John, H., Mike, H., and et al. 2018. Impacts of abiotic stresses on the physiology and metabolism of cool-season grasses: A review. Food and Energy Security. 8:1-29.

Gebremariam, M.M., Zarnkow, M. and Becker, T. 2012. Teff (*Eragrostis teff*) as a raw material for malting, brewing and manufacturing of gluten-free foods and beverages: a review. Journal of Food Science and Technology. 51:2881-2895.

Heuzé, V., Thiollet, H., Tran, G., Bastianelli, D. and Lebas, F. 2016. Teff (*Eragrostis teff*) grain. Feedipedia. Food and Agricultural Organization. 13:39.

Hunter, M., Barney, P., Kilcer, T., Cherney, J., Lawrence, J. and Ketterings, Q. 2007. Teff as emergency forage. Cornell University Cooperative Extension, Agronomy Fact Sheet Series, Fact Sheet 24.

Kathryn, E.R., Bradley, J.H., Isaac, J.S., Robert, D.G. and Marshall, D.S. 2018. Comparison of warm season and cool season forages for dairy grazing systems in continuous culture. Translation Animal Science. 2:125-134.

Ketema, S. 1997. Tef. *Eragrostis tef* (Zucc.) Trotter. Promoting the conservation and use of underutilized and neglected crops. 12. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome, Italy.

Lee, S.H., Lee, D.G. and Lee, K.W. 2015. Evaluation of forage production and tissue culture efficiency of two Teff grass (*Eragrostis Teff*) cultivars. Research Journal of Biotechnology. 10:43-47.

Mesfin, R., and Ledin, I. 2004. Comparison of feeding urea-treated teff and barley straw-based diets with hay-based diet to crossbred dairy cows on feed intake, milk yield, milk composition and economic benefits. Livestock Research for Rural Development. 16(104).

Miller, D. 2010. Teff grass, crop overview and forage production guide, 2nd edition.

Miller, D. 2011. Teff grass: crop overview and forage production guide.

Norberg, S., Roseberg, R., Charlton, B. and Shock, C. 2009. Teff: a new warm season grass for Oregon. Oregon State University Extension Service.

Roseberg, R.J., Norberg, S., Smith, J., Charlton, B., Rykbost, K. and Shock, C. 2005. Yield and quality of teff forage as a function of varying rates of applied irrigation and nitrogen. Klamath Exp. Station Annual Report. pp. 119-136.

Saylor, B.A., Min, D.H. and Bradford, B.J. 2018. Productivity of lactating dairy cows fed diets with teff hay as the sole forage. Journal of Dairy Science. 101:5984-5990.

Shawna, M., Mieke, B., Susan, H., Gene, O., Samuel, R., Smith, J. and Laurie, L. 2012. Acceptability of Teff hay by horses. Journal of Equine Veterinary Science. 32:327-331.

Sitzia, M. and Ruiz, F.A. 2011. Dairy farm management systems. Sheep Encyclopedia of Dairy Sciences. pp. 67-76.

Young, A., Earl, C., Dale, Z., Clark, I. and Eun, J.S. 2014. Integrating Teff into livestock operations. Utah State Univ. AG/Forages/2014-01pr.

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