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The potential for growing Tef (*Eragrostis tef* [Zucc.] Trotter) in Thailand

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Abstract

Tef (*Eragrostis tef* [Zucc.] Trotter) is a cereal crop grown in Ethiopia. It has been introduced to Africa and America where it is cultivated as a forage crop. Replicated pot trial was performed with 6 accessions of tef, the objectives were to assess agronomic characters and nutritive values. BGRCNR2771 was the latest genotype (39 d) while BGRCNR2770 and BGRCNR2771 took the longest time from flowering to blooming (19 d). Time to harvest was the highest in BGRCNR2770 and BGRCNR2771. There were significant differences in plant height, peduncle length, panicle length, length of first and second internodes, seed yield per plant, seed number per plant, 1,000-seed weight, hay produced and total dry biomass per plant ($P<0.01$). Highest protein and carbohydrate content per plant were found in BGRCNR2773.

Keywords: tef, *Eragrostis tef*, forage, hay, agronomic characters, nutritive values

Introduction

Tef (*Eragrostis tef* [Zucc.] Trotter) is a cereal crop grown in Ethiopia. Its grain is used to make a variety of food products. Tef grain is ground into flour, eaten as porridge or used to brew alcoholic beverages. Tef can be substituted for seeds, nuts or other small grains when baking, used as a thickener for soups, stews, gravies and puddings, in making grain burgers, and in stir-fries and casseroles. Tef consists mainly of bran and germ, and contains no gluten, a source of food allergies. Tef contains high levels of calcium, phosphorous, iron, copper, aluminum, barium and thiamin, and is a good source of protein, amino acids (especially lysine), carbohydrates, fat and fiber [5]. Tef produces the smallest grain in the world. It is day length sensitive and flowers best during 12 hours of daylight [8]. It can adapt to both drought and water logged conditions. Tef grass is grown as forage for cattle in Ethiopia. It has been introduced to Africa and America where it is cultivated as a forage crop for horses and cattle [5].

Tef is unknown in Thailand. Exploitation of tef, an underutilized crop, is destined to mitigate shortages of protein sources. A large number of variety are known in tef growing countries [1], [2], [3], [4], [9]. These differ in their period of maturity and productivity. This research was undertaken to study the response of 6 tef accessions under Phitsanulok condition. The specific aims of the work were to investigate agronomic characters and nutritive values; and to identify genotype that can be used in crop stability.

Materials and Methods

Plant materials

Plant materials were obtained from the Federal Center for Breeding Research on Cultivated Plants, Plant Genetic Resources Collections, Braunschweig, Federal Republic of Germany. A total of 6 tef germplasm accessions were evaluated at experimental farm of Department of Agronomy, Rajamangala University of Technology Lanna, Phitsanulok Campus, Thailand in 2007. Black plastic pots, with perforated bottoms, 33 cm in radius and 22 cm in height were used. The pots were filled with clay loam soil. The seeds were germinated and transplanted into pots in January 2007. Healthy five-day-old seedlings of tef accessions were transplanted into each pot with the rate of four seedlings per pot. Two weeks after transplanting, NPK fertilizer ratio of 24-9-19 was applied in solution form, 1 g dissolved in 500 ml water, once a week for 6 weeks. Each pot was maintained to field capacity. Weeds were controlled manuall when due during the season to eliminate competition.

Traits evaluation

Observation was recorded for individual plant. Thirteen agronomic characters were recorded during investigation at physiological maturity. The following measurements were taken: (1) *Days to flowering*: number of days from planting to 50% of the plants in the pots showed panicle emergence. (2) *Days to maturity*: number of days from planting to the day when 50% of the plants in the pot reached physiological maturity. (3) *Days from flowering to blooming*: number of days from flowering to the time when pollen was first shed from anthers. (4) *Plant height*: distance in cm from the soil surface to the tip of the tallest flag leaf. (5) *Peduncle length*: length in cm between last node and the bottom of the panicle. (6) *Panicle length*: in cm from the base of the panicle to the tip. (7 and 8) *1st Internode Length* and *2nd Internode length*: measured as the length in cm of the culm section from the crown up to the base of the first node and second node, respectively. (9 and 10) *Grain yield* and *Dry shoot biomass*: total weight in grams of all the seed harvested from each plant and the remaining dried plant biomass after harvest, respectively. (11) Seed number per plant: total number of seeds produced per plant. (12) *1000-seed weight*: weight in g of 1000 seeds. (13) *Total dry biomass per plant*: determined as the combined total of grain yield and shoot biomass per plant. Tops of the plants were harvested, oven-dried (70◦C; 72 h) and total dry weight determined.

Fifty g of grain samples from each replication were analyzed for carbohydrate and protein contents. Samples also taken from 10 shoots of each genotype and oven dried to determine moisture and calculate dry matter yield. Dried samples were ground to 0.5 mesh-sieve size in a Mill (Brook Crompton series 2000) before being analyzed to determine chemical composition.

Experimental design and statistical analysis

There were 40 pots of each accession, four replications per treatment in a randomized complete block design. Analysis of variance was performed using the Microquasp program (The University of Queensland) for all the characters observed.

Results and discussion

All transplanted seedlings had 100% survived in the pots. The results revealed that all 6 tef accessions expressed considerable range of variation. Table 1 shows that nine out of thirteen traits studied were significantly different ($P<0.01$).

Table 1. Variations in some agronomic and morphologic characters of 6 tef accessions

Character observed	Tef accession					
	BGRCNR 2770	BGRCNR 2771	BGRCNR 2773	BGRCNR 2774	BGRCNR 2776	BGRCNR 2783
Days to flowering	36	39	37	35	23	35
Days from flowering to blooming	16	16	15	15	14	14
Days to maturity	72	72	64	53	49	57
Plant height (cm)	70.12 a*	71.34 a	65.56 b	58.73 cd	18.26 e	60.91 c
Peduncle length (cm)	8.23 c	17.83 a	13.81 b	14.29 b	8.88 c	10.50 c
Panicle length (cm)	47.66 a	47.01 a	42.42 b	37.83 c	19.65 e	33.06 d
Length of 1st internode (cm)	7.21 a	7.83 a	6.55 a	8.14 a	3.89 b	6.52 a
Length of 2nd internode (cm)	15.45 a	14.74 ab	13.97 ab	12.45 b	8.15 c	13.82 ab
Seed yield per plant (g)	2.04c	2.33bc	5.28a	5.88a	1.89c	4.86ab
Shoot biomass (g)	13.48 b	14.10 ab	16.49 a	14.13 ab	9.28 c	12.00 b
Seed number per plant	6,077.03 f	9,877.44 e	17,678.38 c	21,602.27 b	12,862.54 d	23,032.68 a
1000-seed weight (g)	0.33	0.23	0.3	0.26	0.15	0.21
Total plant biomass (g)	15.08 c	15.82 bc	20.00 a	18.23 ab	10.85 d	15.51 c

***means sharing similar letter (s) in a column do not differ significantly at P<0.01**

Days to flowering and maturity

The longest number of days to flowering was recorded for BGRCNR2771 (39 d) and the shortest for BGRCNR2776 (23 d) , whereas BGRCNR2773, BGRCNR2770, BGRCNR2774 and BGRCNR2783 showed moderated numbers of 37, 36, 35 and 35 d respectively (Table 1). Days from flowering to blooming varied from 14 to 16 d while BGRCNR2770 and BGRCNR2771 were the longest (Table 1). Days to maturity of BGRCNR2770 and BGRCNR2771 were the highest (72 d) followed by BGRCNR2773, BGRCNR2783,

BGRCNR2774 and BGRCNR2776 (64, 57, 53 and 49 d respectively). Tef grown in Africa was also found to mature within 7-8 weeks [7].

Plant Height

Plant height of 6 genotypes were significant different (P<0.01; Table 1). The highest was observed in BGRCNR2771 and BGRCNR2770 (71.34 and 71.12 cm respectively) followed by BGRCNR2773 (65.56 cm); BGRCNR2783 and BGRCNR2774 (60.91 and 58.73 cm), while BGRCNR2776 was the shortest (18.26 cm).

Peduncle length

There was considerable variation among the tested genotypes (P<0.01; Table 1). BGRCNR2771 produced the longest peduncle (17.83 cm) while BGRCNR2773 and BGRCNR2774 ranked second (14.29 and 13.81 cm respectively) whereas BGRCNR2770, BGRCNR2776 and BGRCNR2783 produced the shortest peduncle.

Panicle length

BGRCNR2770 and BGRCNR2771 produced the longest panicle (47.66 and 47.01 cm respectively) followed by BGRCNR2773, BGRCNR2774 and BGRCNR2783 (42.42, 37.83 and 33.06 cm respectively). As expected, the panicle length of BGRCNR2776 was the shortest (19.65 cm). These results followed the finding reported that the panicle lengths of tef were between 11-63 cm [7].

Length of 1st and 2nd internodes

The length of 1st and 2nd internodes of BGRCNR2776 were significantly shortest as expected. There were no significant differences among the rest of 5 tested genotypes for the length of 1st internode. BGRCNR2770, BGRCNR2771, BGRCNR2773 and BGRCNR2783 produced longest 2nd internodes.

Seed yield per plant

For seed yield under Phitsanulok condition, BGRCNR2774 and BGRCNR2773 produced the significantly highest yield (5.88 and 5.28 g; Table 1) where as BGRCNR2771, BGRCNR2770 and BGRCNR2776 gave the least seed yield (2.33, 2.04 and 1.89 g respectively).

Dry shoot biomass per plant

Dry shoot biomass per plant was highest in BGRCNR2773, BGRCNR2774 and BGRCNR2771 (16.49, 14.13 and 14.10 g respectively) followed by BGRCNR2770 and BGRCNR2783 (13.48 and 12.00 g respectively) and the lowest in BGRCNR2776 (9.28 g).

Seed number per plant

BGRCNR2783 produced the highest seed number (23,032 seeds) which was significantly higher than that produced by all other tested genotypes. The seed number per plant followed the order of BGRCNR2774, BGRCNR2773, BGRCNR2776, BGRCNR2771 and BGRCNR2770.

1000-seed weight

The highest 1000-seed weight was produced by BGRCNR2770 and BGRCNR2773 (0.33 and 0.3 g), they were observed to be two folds larger than that of BGRCNR2776 which weight

only 0.15 g. Results showed that BGRCNR2770 and BGRCNR2773 produced bigger seeds than that produced by the rest of 4 genotypes.

Total dry matter

Under Phitsanulok condition, BGRCNR2773 and BGRCNR2774 produced the significantly highest total dry matter ($P<0.01$; Table 1) where as BGRCNR2776 produced the least. These highest yielding genotypes also produced the highest yield of seeds and hay per plant.

Carbohydrates and protein contents

Chemical compositions of dried tef seeds are shown in Table 2. BGRCNR2776 produced highest crude fiber content (7.08%), while the rest were not much different. Although BGRCNR2770 and BGRCNR2771 produced higher crude protein (21.23 and 19.64%) but the protein content per plant of BGRCNR2773 and BGRCNR2774 was found to outperform the previous two genotypes (Table 2). NFE values were 25.56-63.24%, where BGRCNR2773 gave the highest value indicated the more digestibility of this genotype than other genotypes studied. The values of fat, moisture and ash contents were in the ranges of 15.51-47.37, 8.05-11.19 and 2.33-4.20% respectively.

Chemical composition of tef hay is presented in Table 3. Crude protein of tef genotypes followed the order of BGRCNR2770, BGRCNR2771, BGRCNR2773, BGRCNR2783, BGRCNR2774 and BGRCNR2776 (6.61, 5.23, 5.03, 4.96, 3.55 and 1.44% respectively). A similar crude protein value (5.02%) were reported by Lulseged and Jamal [6]. However, Protein contents per plant were highest in BGRCNR2770 and BGRCNR2773 (0.89 and 0.83 g; Table 3). NDF and ADF values were 76.41-85.28 and 49.19-57.89% respectively. These values were similar among genotypes tested. Hemicellulose contents were highest in BGRCNR2770 (33.99%) but the rest of genotypes were not much different (25.86-33.99%). BGRCNR2771 and BGRCNR2774 tended to have high cellulose while BGRCNR2770 produced the least (21.78%). Moisture was more or less the same for all genotypes tested.

Table 2. Chemical composition of tef seeds from 6 tef accessions (% dry matter)

Chemical composition	Tef accession					
	BGRCNR 2770	BGRCNR 2771	BGRCNR 2773	BGRCNR 2774	BGRCNR 2776	BGRCNR 2783
Crude fiber	4.04	3.60	4.07	3.24	7.08	3.25
Crude protein	21.23	19.64	14.86	13.14	15.79	14.63
Protein content per plant (g)	0.30	0.32	0.55	0.54	0.21	0.50
Fat	17.45	29.82	15.51	29.44	47.37	35.97
Moisture	8.05	11.19	8.77	8.04	9.12	8.64
Ash	3.48	3.61	2.33	2.60	4.20	3.73
Nitrogen free extract (NFE)	53.80	43.33	63.24	51.58	25.56	42.42

Table 3. Chemical composition of tef hay from 6 tef accessions (% dry matter)

Chemical composition	Tef accession					
	BGRCNR 2770	BGRCNR 2771	BGRCNR 2773	BGRCNR 2774	BGRCNR 2776	BGRCNR 2783
Crude protein	6.61	5.23	5.03	3.55	1.44	4.96
Protein content per plant (g)	0.89	0.74	0.83	0.50	0.13	0.60
Neutral detergent fiber (NDF)	85.28	76.41	84.98	78.11	84.52	81.53
Acid detergent fiber (ADF)	51.29	49.19	57.25	50.52	57.89	55.68
Hemicellulose	33.99	27.22	27.72	27.59	26.63	25.86
Cellulose	21.78	31.85	25.29	30.87	25.26	28.09
Moisture	3.47	4.05	5.01	4.40	4.78	4.70

Tef has the potential to be a viable alternative forage crops [1], [2], [3], [4], [9]. BGRCNR2773 showed superiority over all other genotypes in yield and chemical composition. Of 6 tef genotypes studied, seed yield and hay produced (shoot biomass) per plant were between 1.89-5.88 and 9.28-16.49 g (Table 1) respectively, while crude protein of seed and hay per plant were 0.21-0.55 g (Table 2) and 0.13-0.89% (Table 3) respectively. BGRCNR2773 produced significantly highest total dry biomass (20.00 g; Table 1) and crude protein per plant (1.38 g; Tables 2 and 3). It also showed moderate height (65.56 cm) which resisted to lodging. In addition, its NFE was also highest. These indicated the advantage of BGRCNR2773 over the other genotypes under Phitsanulok environment.

Conclusions

The response of tef genotypes under Phitsanulok condition was studied. The interest in this work is to find genotype that can produce economic yield. This genotype is expected to posses traits that could be utilized further. The study revealed that BGRCNR2773 were superior to the other genotypes, it produced the highest seed yield and demonstrated the greatest biomass production among all genotypes. BGRCNR2773 gave the highest carbohydrate and protein per plant. Average nutritive values of BGRCNR2773 were in a good level viz highest value in NFE and protein content per plant (Tables 2 and 3). Tef appeared promising as an alternative annual forage grass and grew well under Phitsanulok weather. The differences found among the six accesssions suggest that BGRCNR2773 would be better suited for forage and biomass production in Phitsanulok, being a higher producer than other genotypes. However, further evaluation of this genotype in the field is needed.

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