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Effect of Seed Rate on Yield and YieldComponents of Tef ((Eragrostic tef) Trotter) at Shebedino, Southern Ethiopia

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Abstract
Majority of the farmers of Arebaminch zuria woreda broadcast 25-30 kg ha^{-1} seed for longer time. So they facing on productivity problem due to, difficulty to mange weeds and lodging. Therefore, there is a need to determine the proper seed rate to enhance growth and yield of tef. Accordingly, an experiment was conducted to evaluate the effect of seed rate on growth and yield of tef on Arebaminch zuria woreda, Southern Ethiopia in 2014 cropping season. Five seeding rates (5, 10, 15, 20 and 25 kg ha^{-1}) were arranged in RCBD. Seed rate had significantly affected days to heading and maturity, plant height, number of tiller, total biomass and grain yields. But days to maturity, panicle length and number, straw yield and harvest index had not significantly affected. Seeding 10 kg ha^{-1} delay the days to emergency by 1-day compared with other seed rates; whereas seeding 15 kg ha^{-1} was head 1-day earlier than seeded 20 and 25 kg ha^{-1}, but delayed by 1-day than seeded 5 and 10 ha^{-1}. Seeding with the rate of 5 kg ha^{-1} had contributes 8.1 cm increment in height and 60 % increment in number of tillers than seeded with the rate of 25 kg ha^{-1}. Tef which, sown 5 kg ha^{-1} yielded 23.8% more biomass than seeded with 10, 15, 20 and 25 kg ha^{-1}. But tef sown with the rate of 25 kg ha^{-1} minimized thousand seed weight by 3.3 % comparing with sown by 5, 10, 15 and 20 kg ha^{-1}. Whearas tef which, sown with the rate of 5 and 10 kg ha^{-1} were increased grain yield by 45.15 % than seeded at the rate of 15, 20 and 25 kg ha^{-1}. Generally sowing of tef with the rate of 5 kg ha^{-1} is effective in attaining higher grain yield and economic benefit.
Keywords: Tef, Seed rate

1. INTRODUCTION

Tef (*Eragrostis tef* (Zucc) Trotter) is a small seeded cereal indigenous to Ethiopia and originated in Ethiopia between 4000 and 1000 BC. Tef is among the major cereal crops in Ethiopia and occupies about 22.6% of the total cereals' land (Zeleke, 2009).

In Ethiopia, tef performs well in medium altitude (1700-2400 masl). The length of growing period considering rainfall of 450 to 550 mm and evapo-transpiration of 2-6 mm day^{-1} ranges from 60 to 180 days. Depending on variety and altitude, tef requires 90 to 130 days for growth (Haftamu *et al*., 2009).

Tef ranks the lowest yield compared with other cereals grown in Ethiopia. The cause for lower productivity is lodging due to lack of knowledge about proper seed rate. Because of this, reduction in 22% grain and straw yield resulted (Kebebew *et al.,* 2001).

Ethiopian farmers grow tef for a number of merits; which are mainly attributed to the socioeconomic, cultural and agronomic benefits (Hailu and Seyfu, 2001); although it ranks the lowest in terms of yield from of all cereals grown in Ethiopia.

The lower productivity of tef might be due to its confinement to Ethiopia in terms of origin and diversification, which limits the chance of improvement like other cereals of international importance (Kebebew *et al.,* 2001). Other factors contributing to its low in productivity are lodging, method of planting and fertilizer application; the combined effect of those factors result up to 22% reduction in grain and straw yield (Hailu and Seyfu, 2001).Therefore, further improvement of product and productivity of tef is highly needed; as even improved varieties of tef are reported to yield only up to 2.2 t ha-^{1} on farmers' field (Hailu and Seyfu, 2001) and the national average yield is 1.17 t ha-1 (CSA 2012).

The most common way of planting tef is by broadcasting the small seed at the rate of 25-30 kg ha^{-1} (Tareke and Nigusse, 2008). This sowing method results in lodging; which is the main cause for low yield of tef due to high plant density (Tareke, 2009). To minimize the problem of lodging on tef, low seed rate, row planting, late sowing and application of plant growth regulators were used (Fufa *et al.,* 2001).

Majority of the farmers of Arebaminch zuria woreda broadcast 25-30 kg ha^{-1} seed for longer time. So they faced productivity problem for longer time due to, difficulty to mange weeds and lodging (Jim, 2011).

Using of proper seed rate enables to improve production and productivity of tef through minimizing of lodging percent (ATA, 2012). Hence, this study was initiated with the following objectives:

- To evaluate the effect of seed rate on growth and yield of tef.

2. MATERIALS AND METHODS

2.1 Site Description

The study will be conducted at one locations of Kolla-Shele Keble in Arbaminch zuria woreda, Gamo-Gofa zone.

The site is located, 7 km away from Arbaminch town. The keble is situated at elevation of 1200-1800 masl. The mean annual rain fall and temperature is between 800 mm-1200 mm and 18^{o}c-37^{o}c respectively. The Woreda consist of three agro climatic zone, namely low land (Kola (33 %)), cool sub humid (Weyna Dega (53%)) and humid (Dega (14%)) (AZWA, 2014) (unpublished).

2.2. Experimental treatments and design

The experiment was done on seed rate and arranged in randomized complete block design (RCBD). Meanwhile seed rate consist of seeding 5, 10, 15, 20 and 25 kg ha^{-1} sown in row which, were replicated four times.

2.3. Experimental procedure

DZ-Cr-37 (Tsedeay) variety was used as a test crop; which is most widely grown variety in the relatively low altitude and moisture prone areas (Truneh *et al.*, 2000). The experimental field was prepared by using oxen plow and plowed four times, before planting. The experimental plot size was 2 m × 2.5 m (5 m2) and the space between plots was 0.5 m; which had 0.2 m intra row space.

DAP fertilizer was used at the rate of 100 kg ha^{-1} as source of N and P at the time of planting; and Urea was applied at the rate of 50 kgha^{-1} at stem elongation.

2.4. Data Collection

2.4.1. Phenological data

Days to 50% emergence: number of days from sowing up to the date when 50% of the plants emerged in a plot.
Days to 50% heading: number of days from sowing up to the date when the tips of the panicles first emerged from the main shoot, on 50% of the plant in a plot
Days to 90% maturity: number of days from the date of sowing up to the date when 90% of the crop stands in a plot changed to light yellow color.

2.4.2. Growth data

Plant height (cm): - It was taken at an interval of 20 days; by taking six randomly selected plants and measured from the base of the main stem to the tip of the panicle.
Growth Rate: - It was the ratio of the differences between two consecutive dry matter production measured at difference time [GR= DW ΔT].
Growth rates (GR1, GR2 and GR3) were calculated according to (Echarte, L. *et al.*, 2008), as following:-
GR1= [H2-H1]÷ [T2-T1] GR2= [H3-H2]÷ [T3-T2] GR3= [H4-H3]÷ [T4-T3]
Where,
GR1=First growth rate T1 = 20 days after emergence
GR2= Second growth rate T2 = 40 days after emergence
GR3= Third growth rate T3 = 60 days after emergence
H1 = Height of plant at time t1 T4 = 80 days after emergence
H2 = Height of plant at time t2
H3 = Height of plant at time t3
H4 = Height of plant at time t4
Tillers number (m^{-2})**: -** to determine the capacity of tillering per hectare, 10 cm X 20 cm area was demarcated and the number of plants existed in that area was counted at the time of emergence. Then the second counting was done at flowering on demarked area; because maximum tillers produced during vegetative phase and senescence occurs at maturity. Finally the difference between the first and second count was taken as number of tiller in 10 cm X 20 cm area and converted into number of tiller per plant, by dividing it to number of plant in the first count.
Panicles per plant: - six plants were randomly taken and the average number of panicles per plant was considered.
Panicle length (cm): - length of the panicle was measured by selecting six plants randomly and measuring from the node (the first panicle branch started) to the tip of the panicle.

4.2.3. Yield and yield components

Total above ground biomass (kg):- Due to lack of oven dryer machine, total above ground biomass was measured after complete sun-drying for two days
Straw yield (kg): - was measured by subtracting grain yield per plot from the total above ground biomass.
Grain yield (kg ha-1):- yield from every plot
Thousand seed weight (g): - the seeds were taken from each plot and 1000 seeds counted by hand and then weighed.
Harvest index: - the ratio of grain yield to the above ground (shoot) biomass. [HI= Grain yield/ above ground biomass].

2.3. Data Analysis

The various agronomic data were analyzed using the general linear model (GLM) procedures of the SAS statistical software (SAS Institute, 2000) to evaluate the effect of sowing method and time of fertilizer application and their interaction. Least Significant Difference (LSD) test at P≤0.05 was used to separate means whenever there were significant differences.

3. RESULTS AND DISCUSSION

3.1. Crop Phenology

3.1.1. Days to emergence

Days to 50% crop emergence was significantly affected by seed rate (P≤0.001). Seeding 10 kg ha^{-1} delay the days to emergency by 1-day compared with other seed rates (Table 1). The result agrees with the finding of Tarekegne (2009), who indicated seed rate has direct effect on emergency and productivity of tef.

Table1:- Effect of seed rate on the days to emergence, heading and maturity of tef.

Treatments	50% Emergence	50% Heading	90 % Maturity
Seed rates			
5 kg ha^{-1}	5.00b	34. 00a	60.00
10 kg ha^{-1}	6. 00a	34. 00a	58.00
15 kg ha^{-1}	5.00b	33.00b	60.00
20 kg ha^{-1}	5.00b	32. 00c	59.00
25 kg ha^{-1}	5.00b	32. 00c	60.00
LSD (5%)	0.64	0.97	2.59
CV (%)	6.74	1.55	2.33

The same letter in a column of each factor shows a non-significant difference at 5% probability level

3.2.2. Days to heading

The seed rate had a significant (P≤0.001) effect on days to heading. Seeding 15 kg ha^{-1} was head 1-day earlier than seeded 20 and 25 kg ha^{-1}, but delayed by 1-day than seeded 5 and 10 k.g^{-ha} (Table 1). This is because of little weed competition due to suitable agronomic management practice; results for fast growth and earlier maturity of crop (Evert *et al.;* 2008).

3.2.3. Days to maturity

Days to 90% maturity were not significantly affected by seed rate.

3.3. Growth Parameters

3.3.1. Plant height

Seed rate had very high significant (P≤0.001) effect on plant heights. Seeding with the rate of 5 kg ha^{-1} had contributes 8.1 cm increment in height than seeded with the rate of 25 kg ha^{-1} (Table 2). These are due larger seed rate resulting in higher competition for nutrients; while in small seed rate less plant competition for nutrients (Shiferaw Tolosa (2012). Also, Caliskan *et al.* (2004), reported taller and more branched plants at the lower plant densities of sesame.

Table-2:- Effect of seed rate on growth of tef.

Treatments	PH	PL	PN
Seed rates			
5 kg ha^{-1}	101.26a	37.33	22.00
10 kg ha^{-1}	99.73ab	36.33	20.00
15 kg ha^{-1}	97.13ab	35.66	16.33
20 kg ha^{-1}	94.20ab	33.66	15.66
25 kg ha^{-1}	93.20b	34.66	14.33
LSD (5%)	7.20	6.37	10.64
CV (%)	2.62	6.35	6.35

PH = Plant Height, PL= Panicle Length and PN= Panicle Number. The same letter in a column of each factor shows a non-significant difference at 5% probability level

3.3.2. Panicle length

Seed rates were not significantly affected the panicle length of tef.

3.3.3. Panicle number

The panicle length of tef did not significantly affected by seed rates.

3.4. Yield and yield components

3.4.1. Tillers

Seed rate of tef had significantly (P<0.001) affected by the number of tillers. Seeding 5 kg ha^{-1} has been enhancing the number of tillers by 60 % compared with sown in 10, 15, 20 and 25 kg ha^{-1} (Table 3). These might be due to maximum number of plant population in larger seed rats, results for less tillering (Lloveras *et al*., 2001). Because as the number of population increase computation for resource also increase and results for less tillering (Farooq.M *et al.;* 2006).

Table: - 3 Effects of seed rate on yield and yield components of tef.

Treatments	TILL	TBM	SY	TSW	GY(Qt)	HI
		Kg ha^{-1}				
Seed rates						
5 kg ha^{-1}	18.66a	5050.0a	1266.7	0.666a	37.83a	0.22
10 kg ha^{-1}	9.00b	3333.3ab	1052.1	0.63ab	22.81ab	0.14
15 kg ha^{-1}	7.33b	2756.7b	1079.1	0.466ab	16.77b	0.13
20 kg ha^{-1}	6.00b	2390.0b	880.8	0.43ab	15.09b	0.12
25 kg ha^{-1}	7.66b	2740.0b	936.7	0.53b	18.03b	0.12
LSD (5%)	9.45	2128.7	609.94	0.23	18.19	0.13
CV (%)	14.43	23.19	20.73	14.75	10.72	10.2

CV= Coefficient of Variations, TBM = Total Bio Mass, SY = Straw Yield, GY = Grain Yield and HI=Harvest Index

3.4.2. Total biomass

Seed rates were significantly ($p < 0.001$) affected biomass yield of tef. Tef which, sown 5 kg ha^{-1} yielded 23.8% more biomass than seeded with 10, 15, 20 and 25 kg ha^{-1} (Table 3). Sowing of tef with small seed rate makes agronomic management easy and enable for efficient utilization of applied nutrients (Tefera.H; 2008). Efficient utilization of applied fertilizer increased vegetative growth which, resulted for higher biomass production (Wakene 2010).

3. 4.3. Straw yield

Seed rate were not significantly ($p < 0.5$) affected straw yield of tef.

3.4.4. Thousand Seed weight

Seed rate had significant ($p < 0.001$) effect on thousand seed weight of tef. Tef sown with the rate of 25 kg ha^{-1} minimized thousand seed weight by 3.3 % comparing with sown by 5, 10, 15 and 20 kg ha^{-1} (Table-3). These might be because of minimum seed rate, which enhances efficiently utilization of applied fertilizer (Minale *et al.,* 1999) and it optimizes grain yield and quality (Abdo, 2009).

3.4.5. Grain yield

Seed rate had significant ($P<0.001$) effect on grain yield of tef. Tef which, sown with the rate of 5 and 10 kg ha^{-1} were increased grain yield by 45.15 % than seeded at the rate of 15, 20 and 25 kg ha^{-1} (Table 3). The tillers, total biomass and thousand seed weight directly contributed for the grain yield (Delassa, 2007). Due to positive contribution of these parameters, grain yield in 5 and 10 kg ha^{-1}. Therefore small seeding rate positively contribute for increment in grain yield in tef (Seyfu K.; 1997)

3.4.6. Harvest index

Harvest index was not significantly affected by seed rate of tef.

3.5. Association of Grain Yield with Yield and Yield Components

Stepwise multiple linear regressions analyses were carried out using treatment means to determine the effects of seed rates. Grain yield considered as dependant, whereas plant height, growth rate, tillers, panicles, panicle length, thousand seed weight, straw yield, total biomass and harvest index were taken as explanatory variables (Table 4).

Grain yield was positively and significant ($P < 0.001$) associated with plant height, tillers, spike length, total biomass, straw and grain yield, thousand seed weight and harvest index, r=0.98, 0.87, 0.88, 0.50, 0.32, 0.97 and 0.35, respectively. Similar correlations were reported in barley by Mekonnen (2005) and Alam *et al.* (2005). On the other hand, grain yield was associated negatively with day to heading and maturity, r=--0.89*** and -0.78*** respectively; which was in line with the report of Getachew (2004) on bread wheat

Table 4:- Correlation between yield and yield components of tef.

X	DH	DM	PH	TN	SL	TBM	SY	GY	TSW	HI
DHD	1.0	0.96***	-0.85***	-0.64***	-0.66***	-0.27*	-0.09^{ns}	-0.89***	-0.8***	-0.36***
DM		1.0	-0.79***	-0.53***	-0.55***	-0.18 ^{ns}	-0.02^{ns}	-0.78***	-0.65***	-0.33***
PH			1.0	0.86***	0.90***	0.47***	0.29*	0.98***	0.94***	0.34***
TN				1.0	0.96***	0.71***	0.58***	0.87***	0.91***	0.25*
SL					1.0	0.65***	0.52***	0.88***	0.93***	0.27*
TBM						1.0	0.94***	0.50***	0.54***	0.15 ^{ns}
SY							1.0	0.32*	0.36***	0.01 ^{ns}
GY								1.0	0.97***	0.36**
TSW									1.0	0.35**
HI										1.0

ns = not significant, * ** &*** significant at 0.05, 0.01and 0.001 respectively, DHD= Date of Heading, DM= Date of Maturity, TN= Tillers Number, SL = Spike Length, TBM = Total biomass, GY = Grain Yield, SY = straw yield, TSW = Thousand Seed Weight and HI= Harvest Index.

3.6. Partial Budget Analysis

The net benefit obtained in response to 5, 10, 15, 20 and 25 kg ha^{-1}seed rates were 61,281, 36,936, 27,140, 24,408 and 29,169 birr respectively. Using of 10, 15, 20 kg ha^{-1} seed rate resulted for negative return. So these treatment which results for negative return eliminated from consideration (CIMMYT, 1988). Tef which sown with seed rate of 25 kg ha^{-1} was higher marginal rate of return, but it has minimum net benefit. The recommendation is not necessarily the treatment with the highest marginal rate of return compared to neither that of next lowest cost, or the treatment with the highest net benefit, nor the treatment with the highest yield. The identification of a recommendation requires a careful marginal analysis using an appropriate minimum rate of return (CIMMYT, 1988). Thus, tef sown 5 kg ha^{-1}is economically beneficial for farmers compared to the other treatments.

Table-5:- Partial budget analysis of tef as influenced by seed rate

Treatment	Av.Y (q ha^{-1})	ADTY (q ha^{-1})	GFB (birr ha^{-1})	Total variable cost (Birr ha-1)	Net benefit (Birr ha-1)	MRR (%)
5 kg ha^{-1}	37.83	34.05	61,290	9	61,281	
10 kg ha^{-1}	22.81	20.53	36,954	18	36,936	-
15 kg ha^{-1}	16.77	15.09	27,167	27	27,140	-
20 kg ha^{-1}	15.09	13.58	24,444	36	24,408	-
25 kg ha^{-1}	18.03	16.23	29,214	45	29,169	52.900

3.7. Conclusion

In this study it was found that, seed rate had significant effect on growth and yield of tef. Especially tef sown 5 kg ha^{-1}, gave both maximum biological and economic yield. It had a net benefit of 61,281 birr ha^{-1} from grain yield. Thus, it is possible to recommend that, sowing of tef with the rate of 5 kg ha^{-1} is effective in attaining higher grain yield and economic benefit in the trail area. However, it is advisable to undertake further research across soil type, years and locations to draw sound recommendation on a wider scale.

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