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Effect of Seed Rate on Yield and Yield Components of Tef ((Eragrostic Tef) Trotter) at Konso and Arbaminch, Southern Ethiopia

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Abstract
Field experiment was conducted during 2015 and 2016 cropping season to determine the optimum seed rate to enhance growth and yield of tef on Konso and Arbaminch zuria woreda, Southern Ethiopia. Five seeding rates (5, 10, 15, 20 and 25 kg ha^{-1}) were arranged in Randomized Complete Block Design with four replications. Seed rate had significantly affected plant height, number of tiller, total biomass, straw yield, grain yields. But days to emergency, days to heading, maturity and harvest index had not significantly affected. Seeding with the rate of 5 kg ha^{-1} had contributes 9.88cm increment in height than seeded with the rate of 25 kg ha^{-1} and it has been enhancing the number of tillers by 15 %, 31%, 42% and 34% compared with seed rate sown in 10, 15, 20 and 25 kg ha^{-1} respectively. Additionally use of 5kg ha^{-1} seed rate contributed to enhanced the aboveground dry biomass yield of 9%,15.6%,27.3% and 27.4% over 10kg ha^{-1} ,15kg ha^{-1} ,20kg ha^{-1} and 25kg ha^{-1} respectively. Tef sown with the rate of 25 kg ha^{-1} minimized thousand seed weight by 28 % comparing with seed rate sown by 5 kg ha^{-1}. Tef which, sown with the seed rate of 5 were increased grain yield significantly by 12.3 %, 29%, 29.5% and 31.7% than seeded at the rate of 10, 15, 20 and 25 kg ha^{-1} respectively. Use of seed rate 5kg ha^{-1} resulted in the maximum grain yields of the crop at shelle (1.83 tone ha^{-1}), but not significantly different as compared to gumayde (1.79 tone ha^{-1}), respectively. It could, thus, be concluded that cultivating tef at the seed rates of 5kg ha^{-1} at both location is most important economical for smallholder farmers in the study area.
Keywords: Tef, Seed rate, Grain yield

1. Introduction

Tef (*Eragrostis tef* (Zucc) Trotter) is a small seeded cereal indigenous to Ethiopia and originated in Ethiopia between 4000 and 1000 BC. It is the main Ethiopian cereal annually grown on 3.2 million ha, and accounts for 27 per cent of total acreage and 18 percent of gross cereal production (CSA, 2015). The crop has both its origin and diversity in Ethiopia, and plays a vital role in the country's overall food security. The straw is an important cattle feed source, and the high market prices of both its grains and the straw make it a highly valued cash crop for tef-growing smallholder farmers. Tef is a highly versatile crop with respect to adaptation to different agro-ecologies, with reasonable resilience to both drought and water logging (Assefa et al., 2010).

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 major constraints in tef husbandry are low productivity (national average about 1t ha^{-1}) and susceptibility to lodging. Scientific research on tef began in the late 1950s, and over the years a number of improved varieties (about 30 at the national level) and management practices have been developed (Assefa et al; 2011). 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 0.9 t ha^{-1} (CSA 2015).

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 Arbaminch 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). Thus, the objective of this study was to evaluate the effect of seed rate on growth and yield of tef.

2. Materials and Methods

2.1. Description of the Study Area

The field experiment was conducted in crop growing season at Addis Gebere and Shele kebele, Konso Woreda and Arba Minch zuria woreda during 2015 and 2016 respectively. The experimental site Addis Gebere has an altitude of 1680 m.a.s.l. and annual rainfall of 597 mm and 823 mm during 2015 and 2016 cropping seasons. The dominant soil type is light vertisol; the temperature was ranged from 13.07-26.75^{o}C.The study area shele was located at an altitude 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. (AZWA, 2015).

2.2. Experimental treatments and design

The treatments were five seed rates consist of 5, 10, 15, 20 and 25 kg ha^{-1} (kg ha-1).The experiment was laid out as Randomized Complete Block Design (RCBD) and replicated four times.

2.3. Experimental procedure

The tef variety Quncho [(974 × 196)-HT′-387 (RIL355)] was used as a test crop in this study. It was developed by Debre Zeit Agricultural Research Center (DZARC) by combining the high yield of DZ-01-974 and the seed quality trait of DZ-01-196. Quncho was then developed as a single-seed descent-derived recombinant inbred line and, after series of multi-environment yield tests in various major tef-growing regions of the country, was officially released in 2006 *(moARD, 2008).*which is most widely grown the first popular tef variety in Ethiopia *(Assefa et al; 2011).* The experimental field was prepared by using oxen plow and plowed four times, before planting. The experimental plot size was 4 m × 4 m (16 m^{2}) 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% head emergence: This was determined by counting the number of days from sowing to the time when in 50% of the plants started to emerge through visual observation.

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: Days to maturity was determined as the number of days from sowing to the time when the plants reached maturity based on visual observation. It will be estimated when the leaves started to senescence as well as the grains came out free from the glumes upon when pressed between the forefinger and thumb.

2.4.2. Growth data

Plant height: Plant height was measured at physiological maturity from the ground level to the tip of panicle from randomly selected five plants each plot area.

Panicle length (cm): - length of the panicle was measured by selecting five plants randomly and measuring from the node (the first panicle branch started) to the tip of the panicle.

2.4.3. Yield and yield components

Total number of tillers: It was determined by counting the total number of tillers from pre tagged ten plants from the net plot area.

Thousand seed weight: The weight of 1000 seed was determined by carefully counting 1000 seeds and weighing them using a sensitive balance.

Grain yield: Grain yield was measured by harvesting the crop from the net plot area. The grain moisture was adjusted to 11.5%.

Aboveground dry biomass yield: At maturity, the aboveground dry biomass was measured after drying the harvested produce from the plot area till a constant weight.

Straw yield (kg): - was measured by subtracting grain yield per plot from the total above ground biomass.

Harvest index: Harvest index was calculated by dividing grain yield by the total aboveground dry biomass yield.

2.5. 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.

2.6. Partial Budget Analysis

Economic analysis was made following CIMMYT methodology (CIMMYT, 1988). The cost of 100 kg urea (1216 birr) and tef grain price of 1200 birr per 100 kg used for the benefit analysis. Marginal rate of return was calculated as change of benefit divided by change of cost.

3. Result and Discussion

3.1. Crop Phenology

3.1.1. Days to emergence

Number of days to 50% emergency was not significantly affected by seed rate and year, whereas location had significant effect ($p<0.05$) (Table 1). The minimum days for 50% heading was observed in location shelle (5.07). This result indicated that increase or decrease of seed rate has no variation on seed emergency and in shelle seed emergence days enhanced compared to Gumayde (Table 1). This result could be due to the effect of temperature variation between two locations, which might have encouraged early seed emergency.

3.2.2. Days to heading

Number of days to 50% heading was not significantly affected by seed rate and year, whereas location had highly significant effect ($p<0.05$) (Table 1). The minimum days for 50% heading was observed in location shelle (33.65). Number of days to 50% heading reduced in location Shelle compared to Gumayde (Table 1). This result could be due to the effect of temperature variation between two locations, which might have encouraged early days to 50% heading.

3.2.3. Days to maturity

Days to 90% physiological maturity was not significantly affected by seed rate and year, whereas location had highly significant effect ($p<0.05$) (Table 1). The minimum days to 90% physiological maturity was observed in location shelle (89.65). Early Days to 90% physiological maturity was recorded in Shelle compared to Gumayde (Table 1). This result could be due to the effect of temperature variation between two locations, which might have encouraged early days to 90% physiological maturity.

Table1. Effect of seed rate on the days to emergence, heading and maturity of tef during in 2015 and 2016 at Konso and Arbaminch, southern Ethiopia.

Treatments(seed rate)	Date of emergency	50% Date of heading	90% Maturity
5 kg ha^{-1}	5.38a	34.38a	93.63a
10 kg ha^{-1}	5.31a	34.31a	92.88a
15 kg ha^{-1}	5.06a	34.19a	93.31a
20 kg ha^{-1}	5.31a	34.13a	93.38a
25 kg ha^{-1}	5a	34.06a	93.69a
LSD (5%)	NS	NS	NS
year			
2015	5.12a	34.02a	93.33a
2016	5.3a	34.4a	93.43a
LSD (5%)	NS	NS	NS
Location			
Shelle	5.07b	33.65b	89.65b
Gumayde	5.35a	34.77a	97.1ba
LSD (5%)	0.24	0.41	0.93
CV	10.58	2.73	2.24

Means followed by the same letters were not significantly different at LSD 5% level of significance. NS= Not significant; CV (%) = coefficient of variation.

3.3. Growth Parameters

3.3.1. Plant height

The result showed that plant height was significantly ($P < 0.05$) affected by Seed rate, but year and location had very highly significant ($P \leq 0.001$) effect on plant heights. Seeding with the rate of 5 kg ha^{-1} had contributes 9.88cm increment in height than seeded with the rate of 25 kg ha^{-1} .But, the differences in plant height between seed rate 5 kg ha^{-1} , 10 kg ha^{-1}, 15 kg ha^{-1} and 20 kg ha^{-1} were observed to be statistically at par (Table 2). Similarly *Amare et al., (2015)* results revealed that seed rates led to significant enhancements in plant height of teff across years on black soil. 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. The experiment which conducted in 2015 and Shelle had increased plant height by 7.1 % and 11.81% compared with planted in 2016 and Gumayde respectively (Table 2). Inadequate and less uniform rain in 2016 resulted for reduction in plant height, this because plant height directly affected by environmental factor such as amount of available nutrients and water.

3.3.2. Panicle number

The analysis of variance showed that Panicle number was affected highly significantly (P< 0.001) by seed rate, year and location. Panicle number is one of the yield attributes of tef that contribute to grain yield. Crops with higher panicle number could have higher grain yield. (Table2). An decrease of seed rate from 25 to 5 kg ha^{-1} increase the tef panicle number. The maximum (26.48) and minimum (19.87) panicle number were recorded under seed rate of 5 kg ha^{-1}and 25 kg ha^{-1} respectively. Seeding with the rate of 5 kg ha^{-1} had contributes 3.17, 4.47 and 6.61 increment in number than seeded with the rate of 15 kg ha^{-1},20 kg ha^{-1} and 25 kg ha^{-1} respectively. The difference between seed rate 5 kg ha^{-1} and 10 kg ha^{-1}was statistically at par (Table 2).

Similar to plant height the experiment which conducted in 2015 and Shelle had increased Panicle number by 8 % and 13.6% compared with planted in 2016 and Gumayde respectively (Table 2). Inadequate and less uniform rain in 2016 resulted for reduction in plant height, this because plant height directly affected by environmental factor such as amount of available nutrients and water.

Table 2. Effect of seed rate on growth parameter of tef during in 2015 and 2016 at Konso and Arbaminch, southern Ethiopia

Treatments(seed rate)	Plant height	Panicle number	Panicle Length (cm)
5 kg ha^{-1}	106.38a	26.48a	36.55a
10 kg ha^{-1}	104.98a	24.65ab	33.49ab
15 kg ha^{-1}	103.67a	23.31cb	31.91b
20 kg ha^{-1}	104.62a	22.01cd	31.85b
25 kg ha^{-1}	96.50b	19.87d	30.88b
LSD (5%)	6.48	2.29	3.16
year			
2015	107.07a	24.25a	35.71a
2016	99.39b	22.28b	30.16b
LSD (5%)	4.1	1.44	2
Location			
SHELLE	109.71a	24.97a	35.15a
GUMAYDE	96.75b	21.56b	30.72b
LSD (5%)	4.1	1.44	2
CV	8.9	13.96	13.62

Means followed by the same letters were not significantly different at LSD 5% level of significance. NS= Not significant; CV (%) = coefficient of variation.

3.3.3. Panicle length

Panicle length was significantly (P<0.01) affected by the seed rate (Table 2). The highest panicle length (36.55cm) was recorded under seed rate of 5 kg ha^{-1}; however it was statistically at par with 10 kg ha^{-1} treatment. Seeding with the rate of 5 kg ha^{-1} had contributes 4.64cm,4.7cm and 5.67cm increment in length than seeded with the rate of 15 kg ha^{-1},20 kg ha^{-1} and 25 kg ha^{-1} respectively. There was no significant difference in panicle length among seed rate 10 kg ha^{-1}, 15 kg ha^{-1}, 20 kg ha^{-1} and 25 kg ha^{-1} (Table 2).

Similar to Panicle number the experiment which conducted in 2015 and Shelle had increased Panicle length by 15.5 % and 12.6% compared with planted in 2016 and Gumayde respectively (Table 2). Inadequate and less uniform rain in 2016 resulted for reduction in plant height, this because plant height directly affected by environmental factor such as amount of available nutrients and water.

3.4. Yield and yield components

3.4.1. Tillers

Seed rate of tef and year had highly significantly (P<0.01) affected the number of tillers, but location had significantly (P<0.05) affected the number of tillers. Seeding 5 kg ha^{-1} has been enhancing the number of tillers by 15 %, 31%, 42% and 34% compared with seed rate sown in 10, 15, 20 and 25 kg ha^{-1} respectively (Table 3). Similarly *Amare et al., (2015)* results revealed that seed rates led to significant enhancements in number of tillers of tef across years on black soil. These might be due to maximum number of plant population in larger seed rats, results for less tillering (Loveras *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).

The experiment which conducted in 2015 had increased number of tillers by 17 % compared with planted in 2016 (Table 3), however the experiment which conducted in Gumayde had maximum (19.17) number of tillers compared with Shelle (17.07) (Table 3).

Table 3. Effects of seed rate on yield and yield components of tef during in 2015 and 2016 at Konso and Arbaminch, southern Ethiopia

Treatments(seed rate)	TILL	TBM(tha^{-1})	SY(tha^{-1})	TSW(g)	YD(tha^{-1})	HI
5 kg ha^{-1}	23.9a	8.81a	6.53a	0.68a	2.27a	0.26a
10 kg ha^{-1}	20.31b	8.01b	6.01ab	0.57bc	1.99b	0.25a
15 kg ha^{-1}	16.96c	7.43b	5.75b	0.60b	1.67c	0.23a
20 kg ha^{-1}	13.73d	6.40c	4.80c	0.52c	1.60c	0.25a
25 kg ha^{-1}	15.719cd	6.39c	4.84c	0.49c	1.55c	0.25a
LSD (5%)	2.94	0.65	0.66	0.07	0.24	ns
year						
2015	19.85a	7.64a	5.75a	0.57a	1.88a	0.24a
2016	16.39b	7.16b	5.41a	0.56a	1.75a	0.24a
LSD (5%)	1.86	0.41	ns	ns	ns	ns
Location						
SHELLE	17.07b	8.08a	6.25a	0.57a	1.83a	0.22b
GUMAYDE	19.17a	6.72b	4.92b	0.56a	1.79a	0.27a
LSD (5%)	1.86	0.41	0.42	ns	ns	0.02
CV	23	12.53	16.87	17.66	18.89	21.81

Means followed by the same letters were not significantly different at LSD 5% level of significance. NS= Not significant; CV= Coefficient of Variations, TBM = Total Bio Mass, SY = Straw Yield, GY = Grain Yield and HI=Harvest Index

3.4.2. Total biomass

Analysis of variance for above ground dry biomass yield was highly significantly (P<0.001) influenced by seed rate and location, but significantly (<0.05) affected by year (Table 3). The maximum (8.81 t ha^{-1}) and minimum (6.39t ha^{-1}) above ground dry biomass yield was record from seed rate of 5kg ha^{-1} and 25kg ha^{-1} .so the use of 5kg ha^{-1} seed rate contributed to enhanced the aboveground dry biomass yield of 9%,15.6%,27.3% and 27.4% over 10kg ha^{-1} ,15kg ha^{-1} ,20kg ha^{-1} and 25kg ha^{-1} respectively. Similarly *Amare et al., (2015)* results revealed that seed rates led to significant enhancements in biomass yield of tef across years. 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

Analysis of variance indicate that straw yield was highly significantly (P<0.001) influenced by seed rate and location, but not significantly affected by year (Table 3). The maximum (6.53t ha^{-1}) and minimum (4.84t ha^{-1}) straw yield was record from seed rate of 5kg ha^{-1} and 25kg ha^{-1}. so the use of 5kg ha^{-1} seed rate contributed to enhanced the straw yield by 8%, 12%, 26% and 26% over 10kg ha^{-1} ,15kg ha^{-1} ,20kg ha^{-1} and 25kg ha^{-1} respectively. Similarly with above ground biomass sowing of tef with small seed rate makes agronomic management easy and enable for efficient utilization of applied nutrients (Tefera.H; 2008).

3.4.4. Thousand Seed weight

The analysis of variance showed that seed rate had significant ($p < 0.001$) effect on thousand seed weight of tef. But location of planting and year had no significant effect on thousand seed weight. Tef sown with the rate of 25 kg ha^{-1} minimized thousand seed weight by 28 % comparing with seed rate sown by 5 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

Analysis of variance indicated that Seed rate had highly significantly (P< 0.001) affected grain yield. But location of planting and year had no significant effect on grain yield of teff (Table 3). The maximum (2.27 t ha^{-1}) and minimum (1.55 t ha^{-1}) grain yield of teff was recorded by seed rate of 5 kg ha^{-1} and 25 kg ha^{-1} respectively. Tef which, sown with the seed rate of 5 were increased grain yield significantly by 12.3 %, 29%, 29.5% and 31.7% than seeded at the rate of 10, 15, 20 and 25 kg ha^{-1} respectively (Table 3). Similarly *Amare et al., (2015)* results revealed that seed rates led to significant maximum grain yield of teff across years and they observed that the main reason was plant population was increased through number of tillers m^{-2} and effective tillers m^{-2} and vigorous plant height. Fanuel et al., (2012), also indicate that the lowest seed rate level of teff gave the highest grain yield as compared to the highest seed rates on black and red soil condition. They also indicated that, the lodging percentages of the lowest seed rate levels were becoming low as compared to the highest seed rate levels and finally this contributes to get higher grain yield for teff. 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 seed rate obtained maximum yield. Therefore small seeding rate positively contribute for increment in grain yield in tef (Seyfu K.; 1997). Use of seed rate 5kg ha^{-1} resulted in the maximum grain yields of the crop at shelle (1.83 t ha^{-1}), but not significantly different as compared to gumayde (1.79 t ha^{-1}), respectively. It could, thus, be concluded that cultivating tef at the seed rates of 5kg ha^{-1} at both location is most important economical for smallholder farmers in the study area.

3.4.6. Harvest index

Harvest index was not significantly affected by seed rate of tef and year, however it affected by location. Tef which, sown in Gumayde were increased Harvest index by 18.5% over tef sown in Shelle (Table 3). The term "harvest index" is used in agriculture to quantify the yield of a crop species versus the total amount of biomass that has been produced. On the other hand it also describes variation on biomass across to location (Growth parameters such as plant height, panicle length, panicle number and bio mass at shelle better than Gumayde).

3.5. Partial Economic Analysis

The average grain yield of teff significantly influenced by seeding rate. Partial economic analysis (Table 4) was carried out to evaluate the economic performance of different seeding rates. Economic analysis indicated that seeding rates showed differences the gross returns, net returns and benefit: cost ratio (Table 4). The highest net benefit (40750birr/ha) and benefit: cost ratio (370.4) was recorded from treatment receiving 5kg/ha (Table 5). Total variable cost in treatment receiving 25kg/ha was higher (550 birr/ha) and Least cost (110 birr /ha) was recorded from 5kg/ha (Table 4). Partial economic analysis result in general revealed that 5 kg/ha were economically feasible for teff production in the study area. Thus, tef sown 5 kg ha^{-1}is economically beneficial for farmers compared to the other treatments.

Table 4. Results of the economic analysis for tef seed rate during in 2015 and 2016 at Konso and Arbaminch, southern Ethiopia.

treatments	Av.Y (t ha-1)	ADTY (t ha-1)	GFB (birr ha-1)	Total variable cost (Birr ha-1)	**Net benefit**	Benefit: cost
5 kg ha	2.27	2.043	40860	110	40750	370.4
10kg ha	1.99	1.791	35820	220	35600	161.8
15 kg ha	1.67	1.503	30060	330	29730	90.0
20 kg ha	1.6	1.44	28800	440	28360	64.4
25 kg ha	1.55	1.395	27900	550	27350	49.7

4. Conclusions

A field experiment was carried out during the 2015 and 2016 main cropping season from July to November in Konso and Arba Minch district at a farmer's filed with the objectives of determining the optimum seed rate on tef production in the study areas. The experiment was laid out as a randomized complete block design with four replications. The treatments consisted of five seed rate level (5kg/ha, 10kg/ha, 15kg/ha, 20kg/ha and 25kg/ha)

Days to emergence, date to heading, date to maturity and harvest index was not significantly affected by the seed rate and year in tef production, but location had significantly affected the parameters. Seed rate significantly to affected plant height, number of tillers, total biomass, straw yield, thousand seed weight and grain yield. In the seed rate of 5 kg ha^{-1} obtained maximum the grain yield as compared to other treatments. This might be due to very thin stem growth which can lead to easily lodge by high rain-fall and wind, however the seed rate 5kg ha^{-1} we observed vigorous thick stem growth which prevents lodging as compared to the higher seed rate, so this also affected the grain yield of tef. On the other hand yield attributes parameters such as plant height; panicle number, panicle length and biomass are factors which lead to grain yield difference among treatments. The maximum number of effective tillers was recorded in the seed rate at 5kg ha^{-1} and followed by 10kg ha^{-1}, while the minimum number of effective tillers was obtained from plots treated with 15kg ha^{-1}, 20kg ha^{-1} and 25 kg ha^{-1}. In general, all the yield and yield components of tef (biomass yield, grain yield, straw yield and thousand seed weight) were significantly influenced by seed rate. Biomass yield increased significantly with the decreasing seed rate. The highest biomass yield (8.8 tone ha^{-1}) was obtained for plot supplied with seed rate of 5kg ha^{-1}, whereas the lowest biomass yield (6.3 tone ha^{-1}) was obtained from seed rate of 25kg ha^{-1}.

In general, in this study it was found that, seed rate had significant effect on growth and yield of tef. Especially tef sown at 5 kg ha^{-1} gave both maximum biological and economic yield. It had a net benefit of 40750 birr ha^{-1} from grain yield. Use of seed rate 5kg ha^{-1} resulted in the maximum grain yields of the crop at shelle (1.83 t ha^{-1}), but not significantly different as compared to gumayde (1.79 t ha^{-1}), respectively. It could, thus, be concluded that cultivating tef at the seed rates of 5kg ha^{-1} at both location is most important economical for smallholder farmers in the study area. 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 areas. 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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