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Row Spacing and Fertilizer Rate on Yield and Yield Components of Tef Eragrostis Teff (Zucc.) Trotter) under Transplanting Planting Method

Fekremariam Asargew, Yayeh Bitew, Mitiku Asfaw, Minale Liben and Wudu Getahun
Adet Agricultural Research Center, P.O.Box 08, Bahir Dar, Ethiopia
E-mail of the corresponding author: Fikruas2005@yahoo.com

Abstract
Low productivity of tef in Amahara region is mainly attributed to lack of improved agronomic practices. Broadcast method of sowing has been predominantly used in the past years and new agronomic practices should be in place to increase the productivity of the crop. Transplanting young tef seedlings is one of the promising planting techniques proved to boost the yield of tef. An experiment was done at Adet agricultural research center experimental site to determine appropriate row spacing for tef transplanting and to simultaneously see the effect of N and P doses on growth and yield of tef. Four row spacings (15cm,20cm,25cm and 30cm) and two fertilizer rates (100/100 and 50/100 UREA/DAP kg/ha) were tested in factorial RCBD with three replications. Broadcast planting with 25 kg/ha seeding rate was included as a control. In all growth and yield parameters except biomass yield, the broadcasting control had an inferior performance over the transplanting treatments. The widest row spacing (30cm) gave the highest tillers per hill (14) while the lowest tillers per hill (11) was counted at 20 cm row spacing. Transplanting tef gave a yield advantage ranged from 29.2-39.3 % over broadcasting method. Application of 100 kg/ha UREA gave better yielding and growth performance than application of 50 kg/ha UREA. The highest grain yield of 24.4 Q/ha was obtained when 15 cm distance between rows was used. This study revealed that the optimum row spacing for tef transplanting was found to be 15 cm at Adet.
Keywords: seedlings, broadcast, tiller

1. Introduction

Tef is a major staple crop that shares 18.3 % of the total grain production in Ethiopia (CSA, 2014) and provides over two-thirds of the human nutrition in the country (Lacey and Llewellyn, 2005; Stallknecht et al., 1993). In the country 40 % of tef production is found in Amhara region. It is leading a leading crop both in area coverage and grain production volume dominant over any other crops produced in Amahara region. However it productivity remained limited for the past many years.

Since tef is the staple food of most Ethiopian people, the present production system cannot satisfy the consumers' demand. This is because the agronomic practices that farmers use are backward which is not supported by modern technologies (Tareke Berehe *et al*, 2013). When tef is compared to other cereals, it has more value than others cost wise as well as cultural values. But it is the lowest in yield of all the cereals grown in the country. The local people commonly use broadcasting system rather than using row planting. In Ethiopia, the recommended seed rate for broadcasting tef is 25 to 30 kg/ha (ESE, 2001), but farmers often use 40–50 kg/ha, because it is difficult to distribute the seed evenly, the viability of farmers' own seed is reduced (i.e. uncertainty of the germination percentage), and to suppress weeds at early stages (Tefera & Belay, 2006).

Broadcasting method that farmers commonly use these days which contributes to the insufficiency and poor productivity of tef, to transplanting young tef seedlings that increases the productivity of tef (Tareke Berehe *et al*, 2013). The yield of transplanted tef has a fourfold increase, moreover it increases tiller number, producing strong tiller culms and it increases number and quality of seeds (Tareke Berehe et al, 2013). Since tef transplanting technology is a new breakthrough in the country as well as in Amhara region the agronomic components (row spacing, spacing between hills, seedling age, fertilize rate, etc) should be optimized for each specific agro ecology, soil type and tef variety. Therefore, this research activity is designed to identify appropriate row spacing for contrasting fertilizer rates in Northwestern Amhara region.

2. Materials and Methods

The study was conducted in 2012 and 2013 cropping seasons at experimental station of Adet Agricultural Research center. A total of four row spacing levels (15cm,20cm,25cm,30cm) and two fertilizer rates 100/100 and 50/100 kg/ha N/P_2O_5) were tested in factorial RCBD with three replications. Broadcast planting with 25 kg/ha seeding rate broadcast planting of each fertilizer rate was included as a control. All DAP and half of the urea was applied at good seedling establishment a week after transplanting. The remaining urea was applied at tillering stage of the crop. The plot size for each plot was 5 m length x 3 m width. However, all necessary data was taken in central 14 rows of 15cm, 10 rows of 20cm, and 8 rows of 25cm and 7rows of 30cm of 5 m length of

each plot. For broadcast planting the harvested plot size of 5 m length x 2 m width was used.
Tef nursery was raised on a wooden flat or on well prepared raised bed condition near by the vicinity of the selected experimental site before 20 to 30 days of the actual tef planting time. The plot size of the nursery was 1m x 2m with 10 cm raised bed having better soil fertility condition and the seed bed was watered as necessary till transplanting time. When the seedling was ready (about three - four leaf stage or 10 cm high), three seedlings per hill with 15cm spacing of each hill was transplanted into the proper experimental field as per the treatment. Data of plant height, tiller number, stand count, biomass yield and grain yield was taken and analyzed using SAS software to perform Analysis of variance (ANOVA) and LSD mean separation procedures.

3. Result and Discussions

The analysis of variance (Table 1) showed that except biological yield row spacing was significantly ($P\leq0.01$) influenced plant height, tiller number biological yield and grain yield. Only tiller number and biological yield were significantly ($P\leq0.01$) different for fertilizer rates tested. None of the interactions (spacing by fertilizer and spacing by fertilizer by year) were significant to affect any of tef yield and growth parameters (Table 1).
Relatively the shortest plant heights (125.5cm and 124.7cm) were recorded from the two spacing extremes 15cm and 30cm respectively while tallest plants (129.5cm and 129.1cm) were from relatively medium row spacings 20 cm and 24cm (Table 3). However all were superior over the control (broadcasting) in terms of plant height.
Tiller number was highly significant for row spacing (Table 2 and 3). Broadcast planting gave the lowest tiller number compared to transplanting of various row spacing (Table 3). The widest row spacing (30cm) gave the highest tiller number of 14 per hill. This is due to better access to space, nutrient, water and light in wider spacing than narrow spacing between rows. Applying 100/100 UREA/DAP kg/ha gave more numbers of tiller count than using 50/100 UREA/DAP kg/ha since nitrogen enhances tillering capacity of cereal crops including tef. Currently used fertilizer rate for tef was made for tef broadcasting; this result showed a green light for future research works to test more doses of nitrogen for tef transplanting to catch maximum yield benefit obtained from trasplanting method.
Since tef straw has comparable importance to its grain yield, highlighting the result of biomass yield got logical attention it was not statistically significant for row spacing. Relatively biomass yield was higher for the narrowest spacing (15 cm) than wider spacing since more plant stands per unit area. Broadcasting tef relatively gave better biomass compared to transplanting methods that may penalize its yield advantage.
The result revealed that transplanting tef gave a yield advantage ranged from 29.2-39.3 % over broadcasting method. Tef yield can be increased 3-4 folds by using drill and transplant method of planting (Tareke Berehe *et al*, 2013) due to better tillering capacity and reduced lodging index. It also reduces the seed rate from the broadcasting method that a farmer uses 25-50 kg/ha tef but in the new method 2-2.5kg/ha. From the two years result, grain yield was ranged from 6 Q/ha to 33.1 Q/ha) with an overall average of 21.1 Q/ha.The highest grain yield of 24.4 Q/ha was obtained when 15 cm distance between rows was used. Generally, the yield and growth performance of tef was reduced in 2012 cropping season than 2013 cropping season since there was a moisture stress immediately after transplanting at Adet district.

4. Conclusion and Recommendation

Tef transplanting can increase yield significantly compared to common practice of broadcasting tef. It will boost tiller number, producing strong tiller culms and it improves number and quality of seeds. The optimum spacing between rows for transplanted tef is found to be 15 cm. Furthermore, the yield of transplanted tef can be improved by providing appropriate N and P fertilization. The recommended fertilizer rate previously made for broadcast method should be revised since different growth habit, nutrient, water and light utilization is expected in tef transplanting. Transplanting is labor taking and requires water access to raise seedlings, Therefore; further works on the economics of the practice should be studied in comparable with broadcasting method even with row planting of tef.

5. Reference

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Table 1 Result of analysis of variance for yield and growth components of tef transplanting

Source of variation	PH	TN/hill	BY	GY
Spacing	*	**	ns	**
Fertilizer	Ns	**	**	ns
Year	**	**	**	**
Spacing x fertilizer	ns	Ns	ns	ns
Spacing x fertilizer x year	ns	Ns	ns	ns
Spacing x year	ns	Ns	ns	ns
Fertilizer x year	ns	Ns	ns	ns

PH=plant height TN=tiller number BY= biomass yield GY= grain yield

Table 2 The effect of row spacing on yield and growth of transplanted tef in 2012 and 2013 cropping seasons

Row Spacing	PH (cm)		TN/hill		BY(Kg/ha)		GY(Q/ha)	
	2013	2012	2013	2012	2013	2012	2013	2012
15cm	130.4	120.5	13.6B	10.8A	13667	342.3A	33.1A	15.7A
20cm	128.7	130.2	13.9B	9.7A	12656	238.7C	32.1A	13.4A
25cm	131.7	126.6	12.5B	10.1A	11933	356.9A	27.5B	14.3A
30cm	131.5	117.9	17.2A	11.6A	11133	266.6B	29.3AB	16.1A
BC	121.0	109.7	8.7C	6.4B	13667	24.7D	23.5C	6.0B
Mean	128.6	121.0	13.2	9.7	12611.1	245.9	29.1	13.1
CV	5.7	11.4	19.5	26.6	14.4	8.3	10.7	23.3
$P_{0.05, 0.01}$	0.10	0.13	0.0004	0.02	0.1	<.0001	0.0003	0.02

PH=plant height TN=tiller number BY= biomass yield GY= grain yield BC= broadcast

Table 3 The effect of row spacing on yield and growth performance in transplanted tef combined over years

Row Spacing	PH(cm)	TN/hill	BY(Kg/ha)	GY(Q/ha)	% advantage over BC
15cm	125.5A	12.2B	7004.5	24.4A	39.3
20cm	129.5A	11.8B	6447.2	22.7A	34.8
25cm	129.1A	11.3B	6145.1	20.9A	29.2
30cm	124.7A	14.4A	5700.0	22.7A	34.8
BC	115.3B	7.6C	6845.7	14.8B	-
Mean	124.8	11.5	6428.5	21.1	
CV	8.9	22.5	20.07	21.7	
$P_{0.05, 0.01}$	0.02	<.0001	0.11	<.0001	

PH=plant height TN=tiller number BY= biomass yield GY= grain yield BC= broadcast

Table 4 the effect of NP fertilizer rate on tef yielding performance under tef transplanting in 2012 and 2013 cropping seasons under tef transplanting method

Urea /Dap (Kg/ha)	PH (cm)		TN/hill		BY (Kg/ha)		GY (kg/ha)	
	2014	2013	2014	2013	2014	2013	2014	2013
50/100	127.1	122.7	11.7B	8.9	10840.0B	215.1B	27.7B	12.5
100/100	130.2	119.2	14.7A	10.6	14382.2A	276.6A	30.5A	13.7
$P_{0.05, 0.01}$	0.26	0.49	0.0047	0.09	<.0001	<.0001	0.001	0.03

PH=plant height TN=tiller number BY= biomass yield GY= grain yield BC= broadcast

Table 4 the effect of NP fertilizer rate on tef yielding performance under tef transplanting combined over years under tef transplanting method

Urea /Dap (kg/ha)	PH (cm)	TN/hill	BY(Kg/ha)	GY (Q/ha)
50/100	124.9	10.3B	5558.3B	20.1
100/100	124.7	12.6A	7298.7A	22.1
$P_{0.05, 0.01}$	0.94	0.0012	<.0001	0.09

PH=plant height TN=tiller number BY= biomass yield GY= grain yield BC= broadcast