Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.5, 2015

Determination of Row Spacing and Fertilizer Rate for Transplant Planting Methods on the Growth and Yield of Teff in Eastern Amhara Region, Ethiopia

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Abstract
Teff row spacing by fertilizer rate for transplant planting methods experiment was conducted from the year 2012 to 2013 at Sirinka Agricultural Research Center station on red and black soil condition. The objective of the experiment was to assess the advantages of transplant planting methods over broadcast seeding system of teff for Eastern Amhara Region. The experiment was designed in factorial randomized complete block consisting of two fertilizer levels (F1-50/100 kg urea/DAP ha^{-1} and F2-100/100 kg urea/DAP ha^{-1}) and four row spacing (15, 20, 25 and 30 cm) and broadcast planting with 25 kg ha^{-1} seeding rate was included as a control. The result revealed that the highest grain yield (2858 and 3194 kg ha^{-1}) was obtained with the lowest row spacing (15 cm x 15 cm) on black soil for the years 2012 and 2013, respectively. Mean combined analysis of the two years data also showed these facts. Therefore, application of 15cm row spacing by 15cm plant spacing and 15 to 30cm row spacing by 15cm plant spacing were recommended to teff transplanting method for both black and red soil conditions, respectively. Fertilizer rate of 50 kg urea ha^{-1} and 100 kg DAP ha^{-1} were recommended to black soil conditions while fertilizer rate for red soil condition needs further study at on-farm conditions since this experiment was conducted on-station.
Keywords: black soil, red soil, row spacing, teff, transplant planting

1. Introduction

Teff (*Eragrostis tef* /zucc./Trotter) belonging to the grass family poaceae, it is one of the most important cereal crops in Amhara region that occupies 33.5%, the cultivated land area under cereals and 27.7% of the whole area cultivated to annual field crops by covering about two million hectares of land annually (CSA, 2010). Teff is resistant to extreme water conditions, as it is able to grow under both drought and waterlogged conditions (Teklu and Tefera 2005; Minten *et al*., 2013). Combined with its low vulnerability to pest and diseases, it is considered a low risk crop (Fufa *et al*., 2011; Minten *et al*., 2013). However, productivity of the current cultivars in Amhara region is very low, 12.8 q ha^{-1} under traditional practices (CSA, 2010). Although, research efforts in the last few decades developed important technologies to overcome production constraints and increase productivity (Seyfu Ketema, 1993), it has not yet been raised to satisfactory level as compared to its yield potential.

Teff is a C_4, self-pollinated annual grass, 40–80cm tall (Dejene *et al*., 2012). Amongst the factors that contributing to low productivity of the crop are lodging, poor crop management practices, low soil fertility, insect pests and weeds are some of the major once (Ermias *et al*., 2007). Development of improved and appropriate agronomic practices (seeding rate, seeding methods, seedbed preparation, fertilizer rate and time of application) would greatly contribute for higher productivity of the crop Tarekegne (2010). The most common way of planting teff is by broadcasting method ranged at the seed rate of 25-50 kg ha^{-1}. Due to its high seeding rate the yield of the crop could not expressed as its potential.

However, there is some evidence that increase the productivity of the crop by reducing the seed rate and planting by row or transplanting methods (Berhe *et al*., 2011; Fufa *et al*., 2011). These tests were conducted in the off-season under irrigation in DebreZeit Research Center (DRC), the results of the preliminary work stated that planting of teff by row and transplanted system obtained higher grain yield (about 51q ha^{-1}) as compared to the standard broadcasting planting system (10 q ha^{-1}) Tarekegne (2010), this is a four-fold increase. Similarly, reported teff yield could be improved by two to three-folds in rows rather than random broadcast sowing. By row planting or transplanting the seeds, land management and especially weeding can also be done more readily and the incidence of lodging is reduced (Berhe *et al*., 2011; Chanyalew and Assefa, 2013). Therefore, to confirm earlier preliminary findings and to determine appropriate agronomic practices (row spacing and fertilizer rate) and for increasing the productivity of teff on black and red soils at Sirinka, this research was initiated.

2. Materials and Methods

2.1 Description of the Study Area

The experiment was carried out on black and red soils at Sirinka on-station of Eastern Amhara Region, Ethiopia during the main cropping season (June–September) of two consecutive years (2012 and 2013). Sirinka is located at 11° 45' 00" North latitude and 39 36' 36" East longitude. The altitude of the experimental area is 1850 m a.s.l.

(meter above sea level) at Sirinka. The mean total annual rainfall (which mainly falls in the cropping season of 2012 and 2013) is 1115.3 mm at Sirinka. The rainfall pattern of the area is bimodal and its distribution is erratic; the effective rainy period extends from June to September, with the peak during July. Mean average temperature is 19.5 °C at Sirinka. The analyzed soil physico-chemical properties of the experimental site of red soil was clay textural class with a clay content of 42.5%, silt content of 37.5% and sand content of 20 %. It is slightly acidic (pH 6.05) and the 20 cm soil horizon contains 0.189% total N, 10.5 ppm available P (Olsen), 0.91 cmol (+) exchangeable K·kg·soil^{-1}, 1.8% organic carbon, and 28.2 cmol (+) kg^{-1} CEC. On the other hand, the physico-chemical properties for black soil site was clay textural class with a clay content of 37.5%, silt content of 37.5% and sand content of 25 %. It is slightly acidic (pH 6.18) and the 20 cm soil horizon contains 0.183% total N, 13.5 ppm available P (Olsen), 0.92 cmol (+) exchangeable K·kg·soil^{-1}, 0.98% organic carbon, and 23.64 cmol (+) kg^{-1} CEC.

2.2 Experimental Treatments, Design and Procedures

Teff row spacing by fertilizer rate for transplant planting methods experiment was conducted from the year 2012 to 2013 at Sirinka Agricultural Research Center station on red and black soil condition. Teff seedling nursery was raised on a well prepared raised bed condition near by the vicinity of the selected experimental site before 15 to 20 days of the actual teff 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 is ready (about three-four leaf stage or 10 cm high), three seedlings per hill with 15 cm spacing of each hill was transplanted into the proper experimental field as per the treatment.

The experiment was designed in factorial randomized complete block consisting of two fertilizer levels (F1-50/100 kg urea/DAP ha^{-1} and F2-100/100 kg urea/DAP ha^{-1}) and four row spacing (15, 20, 25 and 30 cm) and broadcast planting with 25 kg/ha seeding rate was included as a control in the study. Composite soil sample for black and red soil types at the time of planting was collected for laboratory analysis. All DAP and half of the urea fertilizer was applied at planting. The remaining urea was applied at tillering stage of the crop. The plot size for each plot was 5m length x 3m width. The row spacing of 15cm, 20cm, 25cm, and 30cm had 20, 15, 12, and 10 rows, respectively. However, all necessary data were taken in central 14 rows of 15cm, 10 rows of 20 cm, 8 rows of 25cm and 7 rows of 30 cm of 5m length of each plot. For broadcast planting the harvested plot size of 5 m length x 2m width was used. Spacing between plots and between replications was 1m and 2m, respectively. For this activity *Zobel* variety of teff was selected. All other agronomic practices were done as recommended. Plant height at maturity (cm) (average of 10 plants plot^{-1}), number of tillers plant^{-1}, number of effective tillers plant^{-1}, lodging (%), shoot fly damage (score 0-5), biomass and grain yield were collected from the net plot area as growth and yield parameters of teff.

2.3 Data Analyses

Important growth and yield parameters data collected during the experimental periods were purified and arranged for further analysis. Data collected were subjected to analysis of variance using SAS software (SAS, 2002) program package version 9.0. Differences among treatment means were delineated using the least significant difference test at the alpha level of 0.05.

3. Results and Discussions

The result indicated that highly significant differences ($p<0.01$) were obtained in teff row spacing by fertilizer rate for transplant planting methods for the main effects of fertilizer levels for instance shoot fly damage and biomass yield on black soil for the year 2012 (Table 1). Application of different row spacing had highly significant differences between number of tillers and effective tillers plant^{-1}, lodging, shoot fly damage and grain yield for black soils for the year 2012 (Table 1). Similarly, significant difference was obtained between biomass yield of teff on black soils in 2012 (Table 1). The highest grain yield (2858 kg ha^{-1}) of teff was recorded with the lowest row spacing of 15cm by plant spacing of 15cm on black soil for the year 2012 (Table 1).

On the other hand, there was significant difference between main effect of fertilizer levels such as biomass yield for red soil in 2012 (Table 2). Application of different row spacing had highly significant difference between number of tillers and effective tillers plant^{-1} and significant differences between shoot fly damage for red soil in the year 2012 (Table 2). Even if grain yield was showed statistically significant between row spacing, there were no significant differences between row spacing of 15 to 30 cm by plant spacing of 15 cm for teff grain yield on red soil in the year 2012.

Fertilizer rate for transplant planting method of teff showed highly significant differences for the parameters of plant height and biomass yield and significant difference was observed on shoot fly damage for the year 2013 on black soil (Table 3). The highest grain yield (2767 kg ha^{-1}) was recorded with application of 100-100 kg urea/DAP ha^{-1} fertilizer rate, respectively on black soil in 2013 (Table 3). On the other hand, highly significant differences were observed between plant height, number of tillers and effective tillers plant^{-1}, lodging,

shoot fly damage and grain yield as main effect of row spacing of teff on black soil in 2013 (Table 3). Similarly, significant differences were observed between row spacing of teff biomass yield. The highest grain yield (3194 kg ha^{-1}) and (2933 kg ha^{-1}) were recorded with the lowest row spacing of 15cm by plant spacing of 15cm and 30cm by 15 cm, respectively on black soil in 2013 (Table 3).

Interaction effect of fertilizer rate by row spacing of grain yield was showed significant on black soil of teff transplant planting method. The highest and economical grain yield (3276 kg ha^{-1}) was recorded with application of 50-100 kg urea/DAP ha^{-1} fertilizer rate and row spacing of 15cm by plant spacing of 15cm (Table 4).

Row spacing for transplant planting method of teff showed highly significant differences for the parameters of plant height, number of tillers and effective tillers $plant^{-1}$, lodging and grain yield for the year 2013 on red soil (Table 5). Even if grain yield was showed statistically significant between row spacing, there were no significant differences between row spacing of 15 to 30 cm by plant spacing of 15cm for teff grain yield on red soil in 2013.

Combined analyses of fertilizer rate for transplant planting method of teff showed highly significant differences for the parameters of shoot fly damage and biomass yield on black soil for the year 2012 and 2013 (Table 6). On the other hand, highly significant differences were observed between plant height, number of tillers and effective tillers $plant^{-1}$, lodging, shoot fly damage, biomass and grain yield as main effect of row spacing for transplant planting method of teff on black soil in 2012 and 2013 (Table 6). The highest grain yield (3026 kg ha^{-1}) of transplanted teff was recorded with the lowest row spacing of 15cm by plant spacing of 15cm on black soil in 2012 and 2013 (Table 6).

Interaction effect of fertilizer rate by row spacing of grain yield was showed significant on black soil of teff transplant planting method. The highest and economical grain yield (3027 kg ha^{-1}) was recorded with application of 50-100 kg urea/DAP ha^{-1} fertilizer rate and row spacing of 15cm by plant spacing of 15cm (Table 7).The present results are in well agreement with reports of (Abay *et al*., 2011; Habtegebrial *et al*., 2007). The System of Teff Intensification (STI) based on the insights of the System of Rice Intensification (SRI) experience (Moser and Barrett, 2006), assessed the impact of different planting methods on teff yield (World Bank, 2012). Experiments in research settings showed that when teff was transplanted in rows and appropriate types of fertilizer were used, teff yields were on average three times higher than yields obtained when using traditional broadcasting. Transplanting improved yields over broadcasting because it increased the number of plant tillers, produced stronger and fertile tiller culms, and the number of seeds per panicle increased (Berhe *et al*., 2011).

Combined analyses of fertilizer rate for transplant planting method of teff showed highly significant differences for the parameters of shoot fly damage on red soil for the year 2012 and 2013 (Table 8). On the other hand, highly significant differences were observed between plant height, number of tillers and effective tillers $plant^{-1}$, lodging and grain yield as main effect of row spacing for transplant planting method of teff on black soil (Table 8). Even if grain yield was showed statistically significant between row spacing, there were no significant differences between row spacing of 15 to 30 cm by plant spacing of 15cm for teff grain yield on red soil in 2012 and 2013 (Table 8).

Generally, shoot fly damage was more sever in row spacing than broadcast sowing this is because of the plants are more succulent for the pest to enter to the plant parts easily than the broadcasted sowing method both on black and red soil conditions. As the fertilizer rate increases, the damage of shoot fly also increases as it was showed from the results of both on black and red soil conditions. This is because of fertilizer application also increases more succulent for the pests to penetrate the plant parts. Number of tillers and effective tillers were increased as the row spacing is wider and decreases in broadcast planting method. The lowest row spacing gave the highest grain yield as compared to the wider row spacing and broadcast method of sowing. The main reason was plant population was directly proportional with grain yield of teff to the lowest row spacing as compared to the wider row spacing. In the case of broadcast sowing method, growth and yield parameters were affected because of more plant population and hence the number of tillers and effective tillers were less due to competition effects of plants for inputs (water, light and nutrients) as a result low grain yield was obtained (Fufa *et al*., 2011). Broadcast method of sowing for teff showed highly lodged than row spacing of teff before heading stage of the crop (Berhe *et al*., 2011), therefore, row spacing for transplant planting is the best technology in terms of lodging as the main problem in teff production system.

The outcome of this experiment was differed from other recommendations given in the country. Forum for Environment (2010), recommended that the best use of fertilizer by row spacing of 20 cm x 20 cm gave 4385 to 5109 kg ha^{-1} grain yield of teff. It is therefore justifiable to conclude that there should be location specific for transplanted teff fertilizer application and row spacing (Ermias, 2010). The present results of teff transplant planting method both on black and red soil conditions showed that application of 15cm row spacing by 15cm plant spacing and 15 to 30cm row spacing by 15cm plant spacing were recommended for both black and red soil conditions, respectively. Fertilizer rate of 50 kg urea ha^{-1} and 100 kg DAP ha^{-1} were recommended

to black soil conditions while urea fertilizer rate for red soil condition didn't show any difference among treatments.

4. Conclusions and Recommendations

To boost the productivity of teff, transplant planting method is a new and promising approach especially in most of governmental organizations and non-governmental partners of Ethiopia. The grain yield varies with fertilizer rate and row spacing for teff transplant planting system. From this study, black soil is one of the best soil types for teff transplant planting method of production as compared to red soil type. Therefore, the choice of appropriate row spacing and fertilizer rates of teff transplant planting method for different soil types is one of the issues to be considered in the future, so as to increase the grain yield of teff in the region. Grain yield of teff is highly influenced by row spacing, fertilizer rate and soil types. The present results best bit the practical importance of adequate row spacing for grain yield of teff transplant planting method and suggest that application of 15cm row spacing by 15cm plant spacing and 15 to 30cm row spacing by 15cm plant spacing were recommended for both black and red soil conditions, respectively. Fertilizer rate of 50 kg urea ha^{-1} and 100 kg DAP ha^{-1} were recommended to black soil conditions while fertilizer rate for red soil condition needs further study at on-farm conditions since this experiment was conducted on-station.

5. Acknowledgements

Financial support to conduct this research was provided by Sirinka Agricultural Research Center. The authors are grateful to Mr. Abirha Alemu and Mr. Asmamaw Yimer for their technical assistance in managing the experiment and for data collection.

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Table 1. Mean main and interaction effects of fertilizer rate and row spacing for transplant planting method on the growth and yield of teff on black soil at Sirinka in 2012

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Number of effective tillers plant^{-1}	Lodging (%)	Shoot fly damage (score 0-5)	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Fertilizer							
50-100 kg Urea/DAP (F1)	103.9	10.7	9.6	37.3	3b	7687b	2427
100-100 kg Urea/DAP (F2)	104.2	11.6	10.3	40	3.4a	8847a	2476
LSD $_{0.05}$	ns	ns	ns	ns	0.3	662.2	ns
Row spacing							
15 x 15cm (S1)	102.5	11.4b	10.1b	32.5b	3.3a	9067a	2858a
20 x 15cm (S2)	106.1	12.9ab	11.6ab	31.7b	3.8a	7833bc	2511b
25 x 15cm (S3)	106.2	12.6b	10.9ab	30.8b	3.5a	7583c	2446b
30 x 15cm (S4)	104.6	16.4a	14.6a	33.3b	3.6a	7933bc	2243b
Broadcast	100.7	2.6c	2.6c	65a	1.8b	8917ab	2201b
LSD $_{0.05}$	ns	3.6	3.9	13.8	0.5	1047	323.3
Fertilizer x Row spacing							
LSD $_{0.05}$	ns	ns	ns	ns	ns	ns	ns
CV (%)	8.4	12.3	15.7	15.3	13.3	10.4	10.9

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 2. Mean main and interaction effects of fertilizer rate and row spacing for transplant planting method on the growth and yield of teff on red soil at Sirinka in 2012

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Number of effective tillers plant^{-1}	Lodging (%)	Shoot fly damage (score 0-5)	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Fertilizer							
50-100 kg Urea/DAP (F1)	113.5	12.2	11.3	50	2.2	7373b	2179
100-100 kg Urea/DAP (F2)	111.5	14	12.8	54.3	2.3	8113a	2273
LSD $_{0.05}$	ns	ns	ns	ns	ns	594.6	ns
Row spacing							
15 x 15cm (S1)	112.8	13.8b	12.6b	53.3b	2.3ab	7700	2337a
20 x 15cm (S2)	112.9	15.3ab	13.9ab	42.5b	2.4a	7600	2330a
25 x 15cm (S3)	110.9	15.2ab	14.1ab	38.3b	2.6a	7617	2482a
30 x 15cm (S4)	111.6	18.9a	17.7a	38.3b	2.2ab	7633	2239a
Broadcast	114.2	2.4c	1.9c	88.3a	1.9b	8167	1744b
LSD $_{0.05}$	ns	4.0	4.3	23	0.4	ns	255.8
Fertilizer x Row spacing							
LSD $_{0.05}$	ns	ns	ns	ns	ns	ns	ns
CV (%)	2.1	2	5	22.6	7.5	4.9	15.1

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 3. Mean main and interaction effects of fertilizer rate and row spacing for transplant planting method on the growth and yield of teff on black soil at Sirinka in 2013

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Number of effective tillers plant^{-1}	Lodging (%)	Shoot fly damage (score 0-5)	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Fertilizer							
50-100 kg Urea/DAP (F1)	130.6b	12.1	10.7	50.9	1.7b	8713b	2525b
100-100 kg Urea/DAP (F2)	135.8a	12.7	11	51.1	2.3a	10127a	2767a
LSD $_{0.05}$	2.9	ns	ns	ns	0.5	867.3	234.7
Row spacing							
15 x 15cm (S1)	141.1a	13.1b	11.3b	42b	2a	10917a	3194a
20 ^{X} 15cm (S2)	136.7a	13.7b	11.8b	41.7b	2.2a	9083b	2704b
25 x 15cm (S3)	138.2a	15.5b	13.5b	39.3c	2.7a	9017b	2779b
30 x 15cm (S4)	139a	18.4a	16.7a	40.3bc	2.2a	9017b	2933ab
Broadcast	111.1b	1.3c	1.1c	91.7a	1b	9067b	1621c
LSD $_{0.05}$	4.6	2.5	2.5	2.2	0.7	1371.4	371.1
Fertilizer x Row spacing							
LSD $_{0.05}$	ns	ns	ns	ns	ns	ns	524.9
CV (%)	2.9	16.3	19.3	3.5	15.0	12.0	11.6

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 4. Mean of interaction effects of fertilizer rate and row spacing for transplant planting method on grain yield (kg ha^{-1}) of teff on black soil at Sirinka in 2013

Row spacing	Fertilizer rates	
	Fertilizer rate one (50-100 kg Urea/DAP (F1))	Fertilizer rate two (100-100 kg Urea/DAP (F2))
15cm x 15cm (S1)	3276a	3112a
20cm x 15cm (S2)	2560b	2847ab
25cm x 15cm (S3)	2539b	3019ab
30cm x 15cm (S4)	2527b	3339a
Broadcast (control)	1723c	1519c
LSD$_{0.05}$	524.9	
Mean	2646	

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 5. Mean main and interaction effects of fertilizer rate and row spacing for transplant planting method on the growth and yield of teff on red soil at Sirinka in 2013

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Number of effective tillers plant^{-1}	Lodging (%)	Shoot fly damage (score 0-5)	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Fertilizer							
50-100 kg Urea/DAP (F1)	130.3	14.6	13.6	46.1	1.5	9107	2651
100-100 kg Urea/DAP (F2)	131	16.5	15	49.4	2	9280	2576
LSD $_{0.05}$	ns	ns	ns	ns	ns	ns	ns
Row spacing							
15 x 15cm (S1)	135.9a	17.3a	16.1a	41.3b	1.8	9500	2854a
20 x 15cm (S2)	138.8a	18a	16.6a	40.8b	2	9733	2898a
25 x 15cm (S3)	137.1a	20.6a	18.8a	39.7b	1.8	9283	2848a
30 x 15cm (S4)	137a	19.3a	18.1a	39.5b	1.7	9300	2903a
Broadcast	104.3b	2.6b	1.9b	77.5a	1.3	8150	1563b
LSD $_{0.05}$	3.9	4.3	4.2	11.9	ns	ns	289.9
Fertilizer x Row spacing							
LSD $_{0.05}$	ns	ns	ns	ns	ns	ns	ns
CV (%)	2.5	10.6	11.4	9.0	23.6	11.0	9.1

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 6. Mean main and interaction effects of fertilizer rate and row spacing for transplant planting method on

the growth and yield of teff on black soil at Sirinka combined 2012 and 2013

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Number of effective tillers plant^{-1}	Lodging (%)	Shoot fly damage (score 0-5)	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Fertilizer							
50-100 kg Urea/DAP (F1)	117.2	11.4	10.2	44.1	2.4b	8200b	2476
100-100 kg Urea/DAP (F2)	120	12.2	10.6	45.5	2.8a	9487a	2622
LSD $_{0.05}$	ns	ns	ns	ns	0.3	544.4	ns
Row spacing							
15 x 15cm (S1)	121.8a	12.2b	10.7b	37.2b	2.7a	9992a	3026a
20 x 15cm (S2)	121.4a	13.3b	11.7b	36.7b	3a	8458b	2607b
25 x 15cm (S3)	122.2a	14.1b	12.2b	35.1b	3.1a	8300b	2613b
30 x 15cm (S4)	121.8a	17.4a	15.7a	36.8b	2.9a	8475b	2588b
Broadcast	105.9b	2c	1.8c	78.3a	1.4b	8992b	1911c
LSD $_{0.05}$	5.5	2.8	2.9	6.7	0.4	860.8	239.6
Fertilizer x Row spacing							
LSD $_{0.05}$	ns	ns	ns	ns	ns	ns	338.8
CV (%)	5.6	13.9	16.8	18.1	19.7	11.8	11.4

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 7. Mean of interaction effects of fertilizer rate and row spacing for transplant planting method on grain yield (kg ha^{-1}) of teff on black soil at Sirinka for the year 2012 and 2013

Row spacing	Fertilizer rates	
	Fertilizer rate one (50-100 kg Urea/DAP (F1))	Fertilizer rate two (100-100 kg Urea/DAP (F2))
15cm x 15cm (S1)	3027a	3025a
20cm x 15cm (S2)	2598abc	2617abc
25cm x 15cm (S3)	2424bcd	2802ab
30cm x 15cm (S4)	2337cd	2838ab
Broadcast (control)	1996de	1826e
LSD$_{0.05}$	338.8	
Mean	2549	

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

Table 8. Mean main and interaction effects of fertilizer rate and row spacing for transplant planting method on the growth and yield of teff on red soil at Sirinka combined 2012 and 2013

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Number of effective tillers plant^{-1}	Lodging (%)	Shoot fly damage (score 0-5)	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Fertilizer							
50-100 kg Urea/DAP (F1)	121.9	13.4	12.4	48.1	1.8b	8240	2415
100-100 kg Urea/DAP (F2)	121.3	15.2	13.9	51.9	2.2a	8697	2425
LSD $_{0.05}$	ns	ns	ns	ns	0.3	ns	ns
Row spacing							
15 x 15cm (S1)	124.4a	15.6b	14.4b	47.3b	2	8600	2595a
20 x 15cm (S2)	125.8a	16.6ab	15.2ab	41.7b	2.2	8667	2614a
25 x 15cm (S3)	124a	17.9ab	16.4ab	39b	2.2	8450	2665a
30 x 15cm (S4)	124.3a	19.1a	17.9a	38.9b	1.9	8467	2571a
Broadcast	109.3b	2.5c	1.9c	82.9a	1.6	8158	1654b
LSD $_{0.05}$	4.2	3	3.1	13.4	ns	ns	185.6
Fertilizer x Row spacing							
LSD $_{0.05}$	ns	ns	ns	ns	ns	1083.2	ns
CV (%)	4.2	12.5	13.9	18.8	16.6	10.9	9.3

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$.

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