Advances in Crop Science and Technology

Abebe and Workayehu, Adv Crop Sci Tech 2015, 3:2
http://dx.doi.org/10.4172/2329-8863.1000168

Thesis Open Access

Effect of Method of Sowing and Time of Di-Ammonium Phosphate (DAP) Fertilizer Application, on Yield and Yield Components of Tef ((*Eragrostic tef) Trotter*) At Shebedino, Southern Ethiopia

Bekalu Abebe[1]* and Tenaw Workayehu[2]

[1]*Arbaminch Agricultural Research Center, Ethiopia*
[2]*Hawassa Agricultural Research Center, Ethiopia*

Abstract

Time of DAP application and sowing method vary from farmer to farmer. Therefore, there is a need to determine time of DAP and sowing method recommendations for tef (Eragrostis tef (Zucc) Trotter). Accordingly, an experiment was conducted to evaluate the effect of sowing method and time of DAP application on yield and yield components of tef at Shebedino, Southern Ethiopia in 2012 cropping season. DZ-37 tef variety was used as a test crop. A factorial combination of planting method (row planting and broadcasting) and five times of DAP fertilize application (at planting, two, four, six and eight days before planting) was laid out in Randomized Complete Block design (RCBD) with four replications. Row sowing and DAP applied two days before planting had significantly affected days to heading and maturity, plant height, first growth rate, number of tiller and panicle, thousand seed weight, grain, straw and total biomass yields and harvest index. Days to emergence and panicle length were significantly affected by broadcasting and application of fertilizer two days before planting. Row sowing hastened heading and maturity by 1 day and increased growth rate by 23.46% than broadcasting; and DAP applied two days before planting hasten days to heading and maturity by 4 and 5 days, respectively, than DAP applied eight days before planting. Row sowing had 10, 24.8 and 23.8% more panicles, grain and biomass yields respectively, than broadcasting. DAP applied two days before sowing increased panicles, grain and biomass yields by 41.7, 62.1 and 59.6% respectively, than DAP applied eight days before sowing. Interaction of row sowing and DAP applied at the time of sowing, had 54.7 and 1.07% more 1000 seed weight and harvest index respectively, than broad casting and DAP applied at the time of sowing. Row sowing was found to be economically acceptable with Marginal Rate of Return (MRR) of 627.7% with 6775.6 Birr ha^{-1} more income from grain yield than broadcasting. Row sowing and DAP applied two days before planting had 80.85 Birr ha^{-1} more additional income from straw than broadcasting. Therefore, row sowing and DAP application two days before planting could be recommended as an economically feasible choice for the study area.

Keywords: Sowing method; Row seeding; Broadcasting; Time of fertilizer/DAP application before planting

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 [1].

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 [2].

Tef ranks the lowest yield compared with other cereals grown in Ethiopia. The cause for lower productivity is lodging, method of planting and fertilizer application. Meantime the combined effect of those factors result up to 22% reduction in grain and straw yield [2].

The most common way of planting tef is by broadcasting the small seed at the rate of 25-30 kg ha^{-1} [3]. This sowing method results in lodging; which is the main cause for low yield of tef due to high plant density [4]. To minimize the problem of lodging on tef, low seed rate, row planting late sowing, application of plant growth regulators, appropriate rate and timing of fertilizer application [5,6].

There is much advantage from early application [7]. But the right time of fertilizer application before planting is not known; due to limited research work on early application. Therefore, there are controversies among Ethiopian farmers regarding appropriate time of DAP fertilizer application before planting. Some farmers prefer to apply DAP four days before planting, while others prefer to apply three days before planting, the remaining prefer to apply two and one day before planting; which might result on loss of fertilizer and reduction in yield [8]. Hence, this study was initiated with the following objectives:

To evaluate the effect of sowing method and time of Di-Ammonium Phosphate (DAP) fertilizer application on growth and yield of tef

To see the interactive effect of sowing method and time of DAP fertilizer application on growth and yield of tef

To identify the optimum sowing method & time DAP fertilizer application in tef production

Materials and Methods

Site description

This study was conducted at Taremessa Kebele of South Ethiopia.

***Corresponding author:** Bekalu Abebe, Arbaminch Agricultural Research Center, Ethiopia, Tel: 251-934074616; E-mail: bekaluabebe41@yahoo.com

Received January 23, 2015; **Accepted** April 27, 2015; **Published** April 29, 2015

Citation: Abebe B, Workayehu T (2015) Effect of Method of Sowing and Time of Di-Ammonium Phosphate (DAP) Fertilizer Application, on Yield and Yield Components of Tef ((*Eragrostic tef) Trotter*) At Shebedino, Southern Ethiopia. Adv Crop Sci Tech 3: 168. doi:10.4172/2329-8863.1000168

The kebele is situated at 7° 4'N and 44°E with an elevation of 1980 masl; which are ideal for the production of tef. The mean annual rain fall varies from 900-1500 mm. The dominant crops growing around the experimental area are enset (*Ensete ventricosum*), maize (*Zea mays* L.), tef, different vegetables and Chat (Khat *edulis*) [9].

Experimental treatments and design

The experiment consisted of two factors, method of sowing and time of fertilizer application; arranged in randomized complete block design (RCBD). Times of fertilizer (DAP) application (0, 2, 4, 6 and 8 days before planting) and methods of sowing (broad casting and row sowing), were arranged as factorial with four replications.

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 [10].

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 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; and Urea was applied at the rate of 50 $kgha^{-1}$; in which 1/3 at planting and 2/3 at stem elongation. The seed rates of tef used were 25 kg ha^{-1} and 5 kg ha^{-1} for broad casting and row sowing respectively.

Soil sampling and analysis

Sixteen random soil samples (0-20 cm depth) from the experimental field were thoroughly mixed to make a composite. The sample was air dried and ground to pass 2 mm sieve and necessary parameters such as soil texture, available P, pH and CEC were determined. For the determination of OC and N 1 mm sieve was used. Soil texture was analyzed by Bouyoucos hydrometer method [11]. Available P was extracted with a sodium bicarbonate solution at pH 8.5 following the procedure described by Olsen method [12]. The pH of the soil was measured potentiometrically in the 1:2.5 soil: water mixture by using a pH meter and organic carbon was determined following Walkely and Black wet oxidation method method [13]. Cation Exchange Capacity (CEC) was determined by Ammonium Acetate method [14].

Data collection

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.

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=Δ DW$\div$ ΔT] [14].

Growth rates (GR_1, GR_2 and GR_3) were calculated according to (Echarte et al.), as following [14]:-

GR_1= [H_2-$H_1$$\div$ [T_2-T_1] GR_2= [H_3-$H_2$$\div$ [T_3-T_2] GR3= [H_4-$H_3$$\div$ [T_4-T_3]

Where,

$GR_{1=}$First growth rate	T_1=20 days after emergence
$GR_{2=}$ Second growth rate	T_2=40 days after emergence
$GR_{3=}$ Third growth rate	T_3=60 days after emergence
H_1=Height of plant at time t_1	T_4=80 days after emergence
H_2=Height of plant at time t_2	
H_3=Height of plant at time t_3	
H_4=Height of plant at time t_4	

Tillers number (m^{-2})**:** - to determine the capacity of tillering per hectare, 10 cm×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 [15]. Finally the difference between the first and second count was taken as number of tiller in 10 cm × 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.

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].

Economic analysis

For economic analysis, a simple partial budget analysis was employed using CIMMYT approach [16]. For partial budget analysis, the factors with significant effect were considered. The yield was adjusted by subtracting 10% from average gain yield. Than after, gross yield benefit was obtained by multiplying the adjusted yield by the price of grain (13 birr kg^{-1}). Net benefit was calculated, by subtracting labor cost from gross yield. Finally marginal rate of return (MRR) was obtained, by dividing marginal net benefit to the marginal cost and expressed as percentage (CIMMT). The mean market price of tef was obtained by assessing the market at harvest (2012 cropping season).

Data analysis

The various agronomic data were analyzed using the general linear model (GLM) procedures of the SAS statistical software (SAS Institute) 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.

Results and Discussion

Physicochemical properties of the experimental soil

The results indicated that the experimental soil was clay loam textured; having organic carbon content (OC) of 2.54% (Table 1). The soil had high OC in accordance with Sahlemedhin, who rated OC between 1.74-2.90% as high. The CEC of the soil was 23.87 cmol kg^{-1}, which could be considered as medium [13]. According to Olsen et al. P rating (mg kg^{-1}), P content of <3 is very low, 4 to 7 is low, 8 to 11 is medium, and >11 is high. Thus, the experimental site of available P content is high. The pH of the soil was 4.98, which is within the range of 4 to 8 suitable for tef production [17]. Total N of the soil (0.16 %), is medium; as rated by Havlin et al. who rated total N between 0.15 to 0.25% as medium [18].

Crop Phenology

Days to emergence: Days to 50% crop emergence was significantly affected both by method of sowing and time of fertilizer application (P ≤ 0.001). However, their interaction did not have any significant effect on crop emergence.

Broadcasting shortened days to emergency by 3-days than row sowing (Table 2). The result agrees with the finding of Klosterboer and Turner, who indicated rice in the broadcast, emerges earlier than row sowing [19]. The row sown tef was placed relatively deeper than that of broadcasted tef. The finding was in contrast to the report of Evert et al., who found earlier emergence of tef on the surface compared to deeper planted tef [20]. Because of poor seed to soil contact.

Fertilizer applied eight days before sowing delayed emergency by 2-days than that applied two days before sowing (Table 2). This might be attributed to the high loss of DAP fertilizers from the earlier application before it is used by the plant. Especially N, which is highly soluble and may be lost from the soil-plant system by leaching, de-nitrification, volatilization and erosion [21].

Days to heading: Both method of sowing and time of fertilizer application had a significant (P ≤ 0.001); but interaction did not have a significant effect on days to heading. Row sowed tef was head 1-day earlier than broadcasted (Table 2), which may be due to little weed competition and efficient use of fertilizer than broadcasted one [22].

Days to heading was enhanced by 4 days on DAP applied two days before sowing, compared to that of DAP applied eight days before sowing (Table 2). Thus days to heading for application of DAP two days before sowing is smaller; due to minimum loss fertilizer contributes for growth of crop [23].

Days to maturity: Days to 90% maturity were significantly (P ≤ 0.001) affected by both sowing method and time of fertilizer application; but their interaction not significant.

Row sowed tef matured 1-day earlier than broadcasted (Table 2). The result is in line with Delesa, who reported rice planted by broadcasting matured later than rows [24]. The possible reason is that, less weed infestation and better use of fertilizer in row planting as compared to broadcast; specially P enhanced maturity [23,25] Application of fertilizer at planting resulted in 1-day delay and 4-days earlier mature compared to those applied two and eight days before sowing, respectively (Table 2). Thus, applying fertilizer two days before sowing enhanced maturity and this was because of time of application is one of the factor influencing crops phonology and growth [26].

Growth parameters

Plant height: Both sowing method and time of fertilizer application had very high significant (P ≤ 0.001) effect on plant heights.

However the interaction effect did not have significantly affect plant height.

Depth (cm)	pH (H_2o)	CEC (cmol kg^{-1})	OC (%)	Total N (%)	Av.P (mg kg^{-1})	Particle size distribution (%)			Textural
						sand	clay	silt	Class
0-20	4.98	23.87	2.54	0.16	27.4	32	30	38	Clay loam

CEC: Cation Exchange Capacity; OC: Organic Carbon; Av.P: Available phosphorous

Table 1: Physio-chemical properties of the experimental soil.

Treatments	50% Emergence	50% Heading	90 % Maturity
Method of sowing			
Broad casting	7b	46a	68a
Row sowing	10a	45b	67b
LSD (5%)	0.24	0.55	0.80
CV (%)	4.32	1.87	1.84
Time of fertilizer application			
At planting	8c	45cd	66cd
2-DBP	8c	44d	65d
4-DBP	9b	46bc	67bc
6-DBP	9b	47b	68ab
8-DBP	10a	48a	70a
LSD (5%)	0.54	1.25	1.80
CV (%)	4.32	1.87	1.84

DBP: Days before Planting, the same letter in a column of each factor shows a non-significant difference at 5 probability level.

Table 2: Effect of method of sowing and time of DAP application on the days to emergence, heading and maturity of tef.

Row sowing had batter heights, at all of four measurements (PH_1, PH_2, PH_3 and PH_4) than broadcasting and also contributed for 15, 24, 12 and 3% increments in plant heights, respectively (Table 3). These are due to smaller space among plants in broadcast resulting in higher competition for nutrients; while in row sowing there was wider space and thus relatively less plant competition for nutrients [27]. Also, Caliskan et al., reported taller and more branched plants at the lower plant densities of sesame.

Application of fertilizer two days before sowing had 25% more plant height than DAP applied at sowing on the first measurement. Whereas application of fertilizer two days before sowing had 42, 25.6 and 8.7% higher plant height than that of applied eight days before sowing on PH_2, PH_3 and PH_4, respectively. These were because of maximum use of N and P with minimum loss resulting in maximum growth in height on fertilizer applied two days before sowing [21,28].

Growth rate: Sowing method, time of fertilizer application and their interaction were not significant effect on all growth rates; except method of sowing had significant ($P \leq 0.05$) effect on the first growth rate. Row sowing had 23% more fast growth than broadcasting on first growth rate (Table 3). The non-significant effect on others growth rate were due to efficient utilization of applied DAP fertilizer at earlier growth stage. Especially N is a constituent of chlorophyll, proteins and nucleic acids, which are essential for plant growth [29].

Panicle length: Sowing method and time of fertilizer application significantly ($P \leq 0.001$) affected panicle length, but their interaction was not. Broadcasting increased panicle length by 11% more than row sowing (Table 3). Because less tillering on broadcasting due to many weed density [25]. This contributes to growth of panicle length due to minimum competition for nutrients among tillers. Meantime the number of tiller negatively correlated with panicle length on [30].

Fertilizer applied two days before sowing had 16% more and 13% less panicle length than fertilizer applied eight days earlier sowing and at time of sowing, respectively. This might be due to maximum utilization of nutrients on fertilizer applied two days before sowing and at the time of sowing. Because time and rate of fertilizer application has significant effect on both growth and yield [31].

Panicle number: Sowing method and time of fertilizer application significantly ($p \leq 0.001$) affected number of panicles per plant; but their interaction was not significant. Row sown had 10% more panicle numbers than broadcasted (Table 3), because of better root growth in the case of row planting. This favors the growth and contributes to panicles per a plant [26,32].

Application of DAP eight days before sowing and at time of sowing had 42 and 8% less panicle number, respectively, than applied two days before sowing (Table 3). These because of the time of fertilizer application, particularly those containing N and P affects panicle number [33].

Tillers: Sowing method, time of fertilizer application and their additive effect significantly ($P<0.001$) affected the number of tillers.

The additive effect of row sowing and DAP applied two days before sowing had 5% more tillers than the additive effect of row sowing and DAP applied at the time of sowing. Whereas the additive effect of broadcasting and DAP applied eight days before sowing had delayed the growth by 83% compared with additive effect of row sowing and fertilizer applied at sowing (Table 4). These might be due to maximum loss of N, when DAP was applied eight days earlier to sowing, which could result to less tillering; because N stimulates tillering due to its' effect on cytokinin synthesis [31].

Yield and yield components

Total biomass: Sowing method and time of fertilizer application significantly ($p \leq 0.001$) affected biomass yield; although their interaction were not significant. Row sowed tef yielded 23.8% more biomass than broadcasted (Table 5). Because of better growth in row sowing, due to easy absorption of photo synthetically active radiations [34].

Application of DAP at the time of sowing resulted in 52.5 % more biomass than the treatment with DAP applied eight days prior to sowing. Whereas applying of DAP at the time of sowing 15 % less biomass than DAP applied two days before sowing (Table 5), this might be due to maximum use of applied fertilizer on fertilizer applied two days prior sowing. Because of efficient utilization of applied fertilizer increased vegetative growth, which resulted for higher biomass production [35].

Straw yield: Time of fertilizer application significantly ($p \leq 0.5$) affected biomass yield; although sowing method and interaction of time of fertilizer application and sowing method were not significant.

Treatments	**PH_1**	**PH_2**	**GR_1**	**PH_3**	**GR_2**	**PH_4**	**GR_3**	**PL**	**PN**
Method of sowing									
Broad casting	11.54b	29.80b	0.98b	67.84b	1.89	94.00b	1.32	20.79a	9b
Row sowing	13.56a	39.17a	1.28a	77.30a	1.90	97.32a	1.50	18.51b	10a
LSD (5%)	1.14	3.39	0.23	3.66	0.21	1.58	1.04	2.31	0.34
CV (%)	14.00	15.13	31.30	7.78	17.54	2.54	11.3	5.86	5.54
Time of fertilizer application									
At planting	11.48b	38.16ab	1.32	77.95ab	2.00	97.77ab	2.69	23.75a	11b
2-DBP	15.40a	43.00a	1.38	84.00a	2.05	100.15a	1.34	20.61b	12a
4-DBP	14.60a	35.80ab	1.05	71.50bc	1.78	95.45bc	1.20	18.94bc	10c
6-DBP	11.37b	30.58bc	0.96	66.90cd	1.82	93.75cd	0.82	17.63c	8d
8-DBP	9.89b	24.97c	0.90	62.50d	1.87	91.40d	1.01	17.33c	7e
LSD (5%)	2.58	7.63	0.51	8.24	0.48	3.56	2.33	1.68	0.77
CV (%)	14.00	15.13	31.30	7.78	17.54	2.54	11.3	5.86	5.54

DBP: Days Before Planting; PH: Plant Height (PH_1- was measured 20 days after emergence; PH_2-measured 40 days after emergence; PH_3-measured 60 days after emergence and PH_4- was measured 80 days after emergence); GR: Growth Rate (GR_1-calculated from PH_1& PH_2; GR_2-calculated from PH_2& PH_3, GR_3-calculated from PH_3& PH_4); 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.

Table 3: Effect of time of DAP application and sowing method on growth of tef.

Time of fertilizer application	Number of tillers	
	Broad casting	**Row sowing**
At planting	20.4	43.2
2DBP	26.1	45.6
4DBP	15.0	18.9
6DBP	8.7	14.4
8DBP	7.2	9.3
LSD (5%)	**5.21**	
CV	**17.09**	

DBP: Days before Planting; LSD: Least Significant Difference and CV: Coefficient of Variations.

Table 4: Additive effect effects of time of fertilizer application and sowing method on tef tillering.

Treatments	TBM	SY	GY
	Kg ha^{-1}		
Sowing Method			
Broad casting	1092.5b	97.05	995.45
Row sowing	1432.5a	108.5	1324.0
LSD (5%)	**97.0**	**11.6**	**149.9**
CV (%)	**19.5**	**17.4**	**19.9**
Time of fertilizer			
At planting	1525.0ab	110.0ab	1415.0a
2-DBP	1793.8a	117.5a	1676.3ab
4-DBP	1331.3b	101.3ab	1230.0b
6-DBP	937.5c	95.0ab	842.5c
8-DBP	725.0c	90.1b	634.9c
LSD (5%)	**359.9**	**26.1**	**337.5**
CV (%)	**19.5**	**17.4**	**19.9**

DBP: Days before Planting; CV: Coefficient of Variations; TBM: Total Bio Mass; SY: Straw Yield and GY: Grain Yield.

Table 5: Effects of time of DAP application and sowing method on yield and yield components of tef.

Application of DAP at the time of sowing and two days before sowing resulted in 18 and 23.3% more straw yield, respectively than the treatment with DAP applied eight days prior to sowing (Table 5). This might be due to maximum use of applied fertilizer, with little loss on applied at the time of sowing and two days prior to sowing. Because of efficient utilization of applied fertilizer increased vegetative growth, which contribute to higher straw yield [34].

Grain yield: Sowing method and time of fertilizer application ($P<0.001$) had significant effect on grain yield; but no interaction effect. Row sown increased grain yield by 24.8% over broadcasted (Table 5). This might be uneven seed distribution on broadcasting, which results in excess nutritional competition at certain areas and no competition on other areas of the field and thus less grain yield productivity [24].

Application of DAP two days before sowing increased grain yield by 15.6% over DAP applied at the time of sowing, whereas DAP applied eight days before sowing decreased grain by 55.1% compared to application at sowing (Table 5). These could attributed by minimum loss through leaching and volatilization on DAP applied two days before sowing and which resulted in better growth (Figure 1) [35].

Thousand Seed weight: Sowing method, time of fertilizer application and their additive effect had significant ($p \leq 0.001$) effect on thousand seed weight). Additive effect of row sowing and DAP applied two days before sowing had 26.7% more thousand seed weight than additive effect of row sowing and DAP applied at sowing. Whereas as the additive effect of broad casting and DAP applied eight days prior sowing was weighted 82.4% less compared in weight to row sowed and DAP applied at sowing (Table 6). These might be because of combined effect of row sowing, which enhances efficiently utilization of applied fertilizer [36] and appropriate rate of N fertilizer at correct time, which optimizes grain yield and quality [37].

Harvest index: Main effects and additive effect had significant effect on harvest index. Combined effect of row sowing and fertilizer application two days before sowing had 17.2% more harvest index than additive effect of broadcasting and application of DAP eight days prior to sowing (Table 4). These might be due to; row sowing had less weed competition and efficient use of applied fertilizer [38]. This results for increment vegetative growth by applied N, which in turn increase grain yield by improving cumulative solar radiation intercepted by the crop [12].

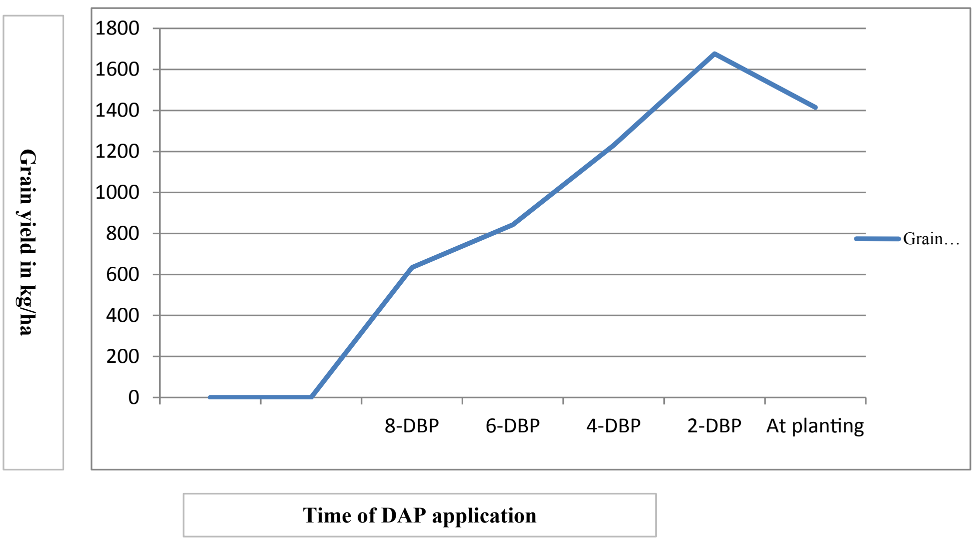

Figure 1: Effect of time of DAP application on Grain yield of tef.

Time of fertilizer	TSW(g)		HI	
	Broadcasting	Row sowing	Broadcasting	Row sowing
At planting	0.67	1.48	0.92	0.93
2-DBP	1.19	2.02	0.93	0.93
4-DBP	0.44	0.85	0.91	0.92
6-DBP	0.25	0.36	0.88	0.90
8-DBP	0.26	0.32	0.77	0.90
LSD	**0.12**		**0.05**	
CV	**10.53**		**4.3**	

DBP: Days before Planting; LSD: Least Significant Difference and CV: Coefficient of Variations CV: Coefficient of Variation; TSW: Thousand Seed Weight and HI: Harvest Index.

Table 6: Additive effects of method of sowing and time of DAP application on thousand seed and harvest index of tef.

	PH1	PH2	PH3	PH4	GR1	GR2	GR3	TN	PN	PL	TSW	GY	SY	TBM	HI
PH1	1.0	0.56***	0.80***	0.82***	0.81 ns	-0.09ns	-0.75***	0.48**	0.64***	-0.49**	0.59***	0.60***	0.14***	0.56***	0.43**
PH2		1.0	0.80***	0.82***	0.82ns	-0.09 ns	-0.75***	0.78***	0.76***	-0.71***	0.79***	0.69***	0.30*	0.62***	0.52***
PH3			1.0	0.94***	0.59***	0.51***	-0.98***	0.84***	0.83***	-0.69**	0.89	0.72***	0.37 *	0.66***	0.48**
PH4				1.0	0.59***	0.39*	-0.84***	0.78***	0.81***	-0.68***	0.82***	0.70***	0.34*	0.22***	0.49
GR1					1.0	-0.19 ns	-0.56***	0.62***	0.49**	-0.49**	0.60***	0.51***	0.29 ns	0.53***	0.01 ns
GR2						1.0	-0.55***	0.28 ns	0.29 ns	0.38**	0.35*	0.21 ns	0.18 ns	0.63 ns	0.06 ns
GR3							1.0	-0.83***	-0.79***	0.66***	-0.88***	-0.69***	-0.37*	-0.64***	-0.43*8
TN								1.0	0.86***	-0.77***	0.93***	0.80***	0.31*	0.75***	0.49**
PN									1.0	-0.49	0.59***	0.60***	0.14ns	0.56***	0.43***
PL										1.0	-0.71	-0.75***	-0.22 ns	-0.69***	-0.62***
TSW											1.0	0.81***	0.42 ns	0.76***	0.45 ns
GY												1.0	0.43 ns	0.97 ns	0.52***
SY													1.0	0.46 *	0.04*
TBM													1.0	0.46 *	0.04*
HI															1.0***

Ns: not significant; * ** &*** significant at 0.05, 0.01and 0.001 respectively; $PH_{1,}$ $PH_{2,}$ PH_3 &PH_4: first, second, thread & fourth Plant Height respectively; $GR_{1,}$ GR_2 & GR_3: first, second & third growth rates, respectively; TN: Tillers in Number; PL: Panicle Length; TBM: Total biomass; GY: Grain Yield; SY: straw yield; TSW: Thousand Seed Weight and HI: Harvest Index.

Table 7: Correlation between yield and yield components of tef.

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 (%)
				DFM	Unit labor cost	Total labor cost		
Method of sowing	-	-	-	-	-	-	-	-
Broad casting	19.87	17.88	23,244	90	12 birr	1,080	22,164	
Row planting	26.58	23.92	31,098.6	180	12 birr	2,160	28,938.6	627.7

Av.Y: Average Yield; ADTY: Adjusted Yield; GFB: Gross Field Benefit; DFM: Days of Farm Management; MRR: Marginal Rate of Return.

Table 8: Partial budget analysis of tef as influenced by sowing method.

Association of grain yield with yield and yield components

Stepwise multiple linear correlation analyses were carried out using treatment means to determine the effects of method of sowing and time of fertilizer on the grain yield formation. 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 7).

Grain yield was positively and significant (P<0.001) associated with plant heights taken at four different times, first growth rate, number of tillers and panicle, panicle length and thousand seed weight, r=0.60, 0.69, 0.72, 0.70, 0.51, 0.8,0.6 and 0.81, respectively. Similar correlations were reported in barley by Mekonnen and Alam et al. On the other hand, grain yield was associated negatively with thrid growth rate (r=$^-$0.69***) and panicle length ($^-$0.75***); which was in line with the report of Getachew on bread wheat.

Partial budget analysis

The return obtained from row planting was above the minimum acceptable marginal rate of return (100%) [16], which is 627.7% and contributes to 6775.6 Birr ha^{-1} more income as compared to broadcasting. The combination of row sowing and fertilizer applied two days prior to sowing had increased straw yield 60% more than broadcasting and application of DAP eight days before sowing (Table 8), which contributed more 80.85 birr ha^{-1} than broad casted and eight days earlier applied. Thus, in order to obtain benefit from straw and grain, row sowing and fertilizer application two days before sowing could be recommended for farmers in this area.

Conclusion

The economic analysis indicated that row sowing had acceptable MRR (627.7%); and 6775.6 Birr ha^{-1} more grain yield income than broadcasting tef. Combination of row sowing and DAP applied two days prior to sowing had additional income from straw (80.85 birr ha^{-1}) companied to broadcasting and application of DAP eight days before sowing. Thus, it is possible to recommend that, row sowing and DAP application two days before planting for tef production 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.

References

1. Central Statistical Agency (CSA) (2012) Agricultural sample survey 2007/2008. Report on Statistical Bulletin, Addis Ababa, Ethiopia. pp. 45.
2. Gebretsadik H, Haile M, Yamoah CF (2009) Tillage frequency, Soil Compaction and N-Fertilizer Rate Effects on Yield of Tef (Eragrostis tef (Zucc) Trotter) in Central Zone of Tigray, Northern Ethiopia. Agron.J 1: 82-94.
3. Berhe T, Zena N (2008) Results in a trial of System of Tef Intensification (STI) at Debre Zeit. In: Proceedings of Annual Research Review Workshop, pp. 16-17, Debre Zeit, Ethiopia.
4. Berhe T (2009) Recent Developments in tef, Ethiopia's most important cereal and gift of the world. CIIFAD Forum Seminar, Addis, Abeba.
5. Hundera F, Bogale T, Tefera H, Assefa K, Kefyalew T, et al. (2001) Agronomy research on tef, Tef Research and Development. Proceedings of the International Workshop on Tef Genetics and Improvement, Debre Zeit, Ethiopia, pp. 167-176.
6. Grant CA, Peterson GA, Campbell CA (2002) Nutrient considerations for diversified cropping systems in the northern Great Plains. Agron. J. 94:186-198.
7. Clain J (2011) Nutrient Uptake Timing by Crops to assist with fertilizing decisions.Book of Soil Science, Montana State University. pp. 67-78.
8. ATA (Agricultural Transformation Agency) (2012) Innovations to help our country grow.
9. Shebedino Woreda Agriculture and Rural Development Office (SWARDO) (2013)(Unpubelished)
10. Tiruneh K (2000) Genotype×Environment Interaction in Tef. In: Hailu T, Getachew B, Sorrells M (eds.) Narrowing Rift: Tef Research and Development. Proceeding of International Workshop on Tef Genetics and Improvement, pp. 45 Addis Ababa, Ethiopia.
11. Day PR (1965) Hydrometer method of particle size analysis. In: Back CA (ed.), Method of Soil Analysis. Amer. Soc. Agron. Madison, Wisconsm . Agron. No 9, Part 2. pp. 562.
12. Osman A, Coverdale SM, Ferguson R, Watson K, Fox G, et al. (2001) The causes of low barley protein modification. Proceedings of the 10th Australian Barley Technical Symposium, Canberra, Australia.
13. Walkley A, Black A (1934) An examination of Degtjareff Method for Determine Soil Organic Matter and Proposed Modification of the Chromic Acid Titration Method. Soil Science 37:29-38.
14. Echarte L, Rothstein S, Tollenaar M (2008) The response of leaf photosynthesis and dry matter accumulation to nitrogen supply in an older and a newer maize hybrid. Crop Sci. 48:656-665.
15. Lafarge T, Tubana B, Pasuquin E (2004) Yield advantage of hybrid rice induced by its higher control in tiller emergence. In: proceedings of the 4th International Crop Science Congress. pp. 16-17, Brisbane, Australia.
16. CIMMYT (International Maize and Wheat Improvement center) (1988) An Economic Training Manual: from agronomic data recordation. CYMMT. Mexico. pp. 79.
17. Food And Organization (FAO) (2000) Fertilizers and Their Use 4th ed. International fertilizer industry association, FAO, Rome, Italy, pp. 34.
18. Havlin JL, Beaton JD, Tisdale SL, Nelson WL (1999) Functions and forms of N in plants, IN Soil Fertility and Fertilizers. (6thed) Prentice Hall, New Jersey.
19. Klosterboer AD, Turner FT (2002) Rice production guidelines. Texas Cooperative Extension, USA, pp. 63
20. Evert S, Staggenborg S, Olson LS (2008) Soil temperature and planting depth effects on tef emergence. Short Communication. Journal of Agronomy and Crop Science.
21. Vaughan B, Westfall DG, Barbarick KA (1990) Nitrogen rate and timing effects on winter wheat grain yield, grain protein, and economics. Prod. Agric. J. 3:324-328.
22. Mehdi PK, Roghayyeh ZM, Shahzad JS, Ajid K (2010) Interaction effect of plant densities and nitrogen fertilizer on durum Wheat. American-Eurasian J. Agric. & Environ. Sci 9: 263-268.
23. Brady NC, Weil RR (2002) The Nature and Properties of Soils (13thedn.) Pearson Education Ltd, USA., pp. 621.
24. Angassa D (2007) Effect of sowing method and seeding rate on yield and yield components of rain fed rice (Oryza sativa L.) varieties in Woliso, South west Shoa of Oromia region. MSc. Thesis, Haramyaya University, Haramaya. pp. 56-60.
25. Farooq M, Shahzad MA, Basra AS, Basharat AS (2006) Direct seeding method popular among rice farmers, DAWN Group of News letter, Sri Lanka. 89: 11-28.
26. Mugwe J, Mugendi D, Kungul J, Mucheru M (2007) Effect of plant bio mass, manure and inorganic fertiliser on maize yield in the central highlands of Kenya. African Crop Science Journal 15: 111 - 126.
27. Henderson TL, Johnson BL, Schneiter AA (2000) New crops row spacing, plant population, and cultivar effects on grain amaranth in the Northern Great Plains. Agron. J. 92: 329-336.
28. Taylor, Francis (2005) Root Growth, Nodulation, Grain Yield, and Phosphorus Use Efficiency of Lentil as Influenced by Phosphorus, Irrigation, and Inoculation. Saskatchewan. J of Food and Agri 89: 13-14.
29. Rashid A, Khan UK, Khan DJ (2007) Comparative effects of verities and fertilizer levels on barley (Hordum vulgare L.), Pakistan.
30. Caliskan S, Arslan M, Arioglu H, Isler N (2004) Effect of planting method and plant population on growth and yield of sesame (Sesamum indicum L.) in Mediterranean type of environment. Asian J. Plant Sci 3:610-613
31. Lloveras J, Lopez A, Ferran J, Espachs S, Solsova J (2001) Bread making quality of wheat and soil nitrate as affected by nitrogen fertilization in irrigated Mediterranean conditions. Agron. J. 93:1183-90.
32. Balesh T, Bernt AJ, Breland T (2007) Availability of organic nutrient sources and their effects on yield and nutrient recovery of tef [Eragrostis tef (Zucc.) Trotter] and on soil Properties. Journal of Plant Nutrition and Soil Science 170: 543–550.
33. Gezu G (2003) Yield and quality response of bread (Triticum aestivum L.) Varieties to rate and time of Niterogen fertilizer application in Kulumsa, South eastern Ethiopia. M.Sc. Thesis, Alemaya University, School of Graduate Studies pp. 48-53.
34. Ahmad R, Mahmood T, Farrukh MS, Ahmad S (2002) Comparative performance of two sesame (Sesamum indicum L.) varieties under different row spacing. Asian J.Plant Sci.1: 546-547
35. Erkossa T, Teklewold H (2009) Agronomic and Economic Efficiency of Manure and Urea Fertilizers Use on Vertisols in Ethiopian Highlands. Agricultural Science in India 8: 352
36. Liben M, Asefa A, Tanner DG, Tolessa T (1999) The response of bread wheat to N and P application under improved drainage on Bichena Vertisols in North-Western Ethiopia Agronomy Journal 94: 1-6
37. Woyema A (2009) Effect of different rate of Nitrogen on yield, yield related trait and quality of durum wheat (Triticum turgidum L.Var Durum) cultivars in the highland of bale. MSc. Thesis, Alemaya University, pp. 53.
38. Thakur AK, Roychowdhury S, Kund DK, Singh R (2004) Evaluation of planting methods in irrigated rice, Water technology centre for Eastern Bhubaneswar Orissa, India. Journal of Agricultural Science 50: 31-49.

Citation: Abebe B, Workayehu T (2015) Effect of Method of Sowing and Time of Di-Ammonium Phosphate (DAP) Fertilizer Application, on Yield and Yield Components of Tef ((*Eragrostic tef) Trotter*) At Shebedino, Southern Ethiopia. Adv Crop Sci Tech 3: 168. doi:10.4172/2329-8863.1000168