

**INCREASING PRODUCTIVITY OF TEF:
New Approaches with Dramatic Results**

By

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Tef at maturity in the Debre Zeit Research Center in 2009

FOREWORD

In early 2008, the author, received a grant of USD 13,000 for exploratory research in tef. Even though he is the Principal Investigator, the plan was to conduct the tef research in collaboration with staff of the Ethiopian Institute of Agricultural Research (EIAR).

A Seminar entitled "UNLESS A MIRACLE HAPPENS, TEF WILL CEASE TO BE A STAPLE FOOD FOR MANY ETHIOPIANS "(Quote from Prime Minister Meles) was presented by the Principal Investigator at SAA Headquarters . Present were:

1. Dr. Kebebew Assefa, EIAR, Debre Zeit Research Center
2. Dr. Getachew Belay, EIAR, Debre Zeit Research Center
3. Dr. Likyelesh Gugsa, EIAR, Holetta
4. Mr. Toshiro Mado, SAA, Addis Ababa
5. Dr. Tesfaye Tessema, SG2000, Addis Ababa
6. Dr. Tareke Berhe, SAA, Addis Ababa

The objective of the seminar was explained as "a search for new and innovative research approaches to increasing productivity of tef". Following the seminar, the Principal Investigator conducted the exploratory research by employing temporary laborers both at Debre Zeit and Holetta research Centers.

Deep gratitude is due though to the Debre Zeit and Holetta Research Directors and their staff for their full cooperation in making the experimental plot area and lath-house / greenhouse facilities easily available. It is hoped that that this cooperation continues. Special thanks also go to Dr. Likyelesh Gugsa, Researcher at Holetta Research Station for providing seeds obtained through gynogenesis for inclusion in our experiments. The main purpose of the exploratory experiments was to obtain results that could convince a donor to provide additional funds for a fully developed Tef Project.

The exploratory research has shown very promising results which are fully explained in this report. Further exploratory research planned for 2009 will be carried out with the sponsorship of Oxfam America.

It is my hope that this report will provide valuable information for future tef research and development.

INTRODUCTION

Tef is the most important cereal of Ethiopia. It is indigenous to the country and therefore, it is part of the culture, tradition and food security of its people. The crop annually occupies over 2.8 million hectares which is 25-30% of the total area covered by cereals (Central Statistics Agency, Sample Survey 2007/2008: Statistical Bulletin 417 (2008)). It is a daily food staple for about 50 million inhabitants (60% of the total population of 80 million). Its excellent nutritional value and high resilience in resisting diverse biotic and a-biotic stresses make it an excellent food security crop. Unfortunately, there is an imbalance between supply and demand. Supply is too insufficient. As a result, tef has become an expensive food crop (900-1,200 USD/tonne). Such high prices are beyond the reach of the majority of Ethiopian households.

So far, there are 16 improved varieties of tef developed through mass selection and conventional cross-breeding. The increase in yield has not exceeded 25%. Therefore, national average yield has stabilized between 800-1,000 kg/ha for the last 3 decades. Total production increases have been mostly from the cultivation of more and more areas. It is high time that drastic measures be taken to improve tef productivity by exploring new and innovative approaches.

NEW APPROACHES TESTED IN THE EXPLORATORY EXPERIMENTS

Several technologies were tested for increasing tef productivity. These were:

- *Eragrostis tef* x *E. curvula* inter-specific crosses
- Spraying with a plant growth hormone (CCC)
- Spraying with foliar fertilizers (yield boosters): NPK + micronutrients
- Gynogenesis – obtaining homozygous plants from doubled haploid gametes
- Spaced transplanting – planted tef seedlings at 20 cm x 20 cm
- Application of granular complete fertilizers (NPK + micronutrients = Zn, S, Mg, etc.)

RESULTS

- ❖ No significant change/increase in productivity was obtained from the first three technologies.
 - 1) No seeds obtained from *E. tef* x *E. curvula* crosses
 - 2) The growth hormone shortened the plants but also shortened the panicles. Hence, no increase in productivity.
 - 3) No yield advantage was observed in plants sprayed once, twice and three times with foliar fertilizers.
- ❖ Promising results were obtained from gynogenesis. Several plants were tested out of which Gyno 8 (DZ-01-196, P28, S1) was selected and tested further.
- ❖ Best results came from spacing (giving individual plants wide space to show their potential) and the use of complete fertilizers.
- ❖ The following experiments summarize the results of the most promising technologies.

EXPERIMENT 1

The first trial was conducted in the field and it was to test if tef yields could be improved by changing the planting method. Tef seedlings were grown on a wooden flat for two weeks and then transplanted into the field (heavy black clay soil) at a spacing of 20 cm x 20 cm, one plant per hill. Plot size was 2 m x 5 m replicated three times. The broadcasting method

[of the farmers] was used as a check. The treatments also included two varieties, untreated seeds and seeds coated (pelleted) with a fertilizer (source: YARA) containing nitrogen, phosphorus and zinc. The results of the first experiment are shown in Table 1.

Table 1. Tef trial with pelleting (Zn + NP = Synergize) and Spacing, Debre Zeit, Ethiopia, 2008

VARIETY	SOWING METHOD	PELLETING	YIELD kg/ha
Cross 37	Broadcast	None	1,014
	Broadcast	Yes	483
	20cm x 20cm	None	3,390
	20cm x 20 cm	Yes	5,109
Cross 387	Broadcast	None	1,181
	Broadcast	Yes	1,036
	20 x 20	None	4,142
	20 x 20	Yes	4,385

The results of the first experiment were very encouraging. The difference between broadcasting and transplanting is huge. Plot yields for the broadcasted plots were 500-1,200 kg/ha while for the transplanted ones it was 3,400–5,100 kg/ha. This is a four-fold increase. Pelletting with a zinc coated fertilizer had a more positive response in transplanted tef but very little effect in the broadcasted plots.

The main effect of transplanting (as indicated in the following figures) was in increasing tiller number, producing strong and fertile tiller culms, and in increasing the number of seeds/panicle.



Figure 1. Photos showing tillering potential of transplanted tef during growth on the left, and after harvest on the right, with a 'normally' grown plant on the right.

EXPERIMENT 2

A second and similar experiment was repeated using large pots in a lath-house during the off-season of 2009. The results were even more promising.

This time the plant spacing was combined with three types of fertilizers: (1) the commonly used fertilizer in Ethiopia, DAP + Urea, (2) DAP coated with Zinc and Copper micronutrients (Source of liquid Zn and Cu = YARA) and a rice fertilizer known as Sucube Sucube commonly used in Mali which contains NPK + Zn + S+ Mg, etc.

The results of the second experiment were even more dramatic. While plots with no fertilizer yielded 900-1500 kg/ha, those with the commonly used fertilizer combination, DAP + Urea, combined with good spacing, yielded 6 t/ha while those that had additional micronutrients such as Zn, Cu, yielded over 8 t/ha. Such high yields for tef are obtained for the first time and demonstrate that the potential of tef is not yet sufficiently explored or exploited. Table 2 and Figure 2 present the detailed results from the second experiment.

Table 2. Impact of intensive agronomic management on the yield of tef in lath-house, Debre Zeit , 2009

VARIETY	TREATMENT	YIELD/REPLICATION			YIELD kg/ha
		I	II	III	
DZ-01-974	DAP + UREA	57	140.7	46.9	6,700.13
	DAP + NP + Zn	56.6	171	57.0	8,143.02
	DAP + NP + Cu	67.6	166.4	55.5	7,923.97
	DAP + NP + Zn + Cu	76.2	180.4	60.1	8,590.65
	SUKUBE SUKUBE + UREA	68.6	184.5	61.5	8,785.89
	CHECK- NO FERTILIZER	5.3	19.7	6.6	938.11
DZ-01-387	DAP + UREA	27.7	127.2	42.4	6,057.26
	DAP + NP + Zn	34.1	90.6	30.2	4,314.37
	DAP + NP + Cu	43.4	129	43.0	6,142.98
	DAP + NP + Zn + Cu	43.7	138.3	46.1	6,585.85
	SUKUBE SUKUBE + UREA	35.7	108.2	36.1	5,152.48
	CHECK- NO FERTILIZER	19.6	31.8	10.6	1,514.32



Figure 2. Drs. Nigusse Shoatatek and Likyelesh Gugsu appreciating tef in lath-house

EXPERIMENT 3

The third experiment used three varieties (DZ-01-Cross 387 = Kuncho, DZ-01-974 and Gyno 8). The same fertilizer treatments were used as in Experiment 2. The difference is that this was a field experiment with plot sizes of 20 m². Tef seedlings were grown in pots for two weeks and then transplanted in rows 20 cm apart with 15 cm between hills. Three seedlings/hill were used in transplanting. The following pictorial figures show the different stages of tef development in this experiment.



Figure 3. Two-week old seedlings being transplanted



Figure 4. Ten days after transplanting



Figure 5. Three weeks after transplanting



Figure 6. Five weeks after transplanting



Figure 7. Grain filling stage



Figure 8. Grain filling stage



Figure 9. Tef at maturity stage



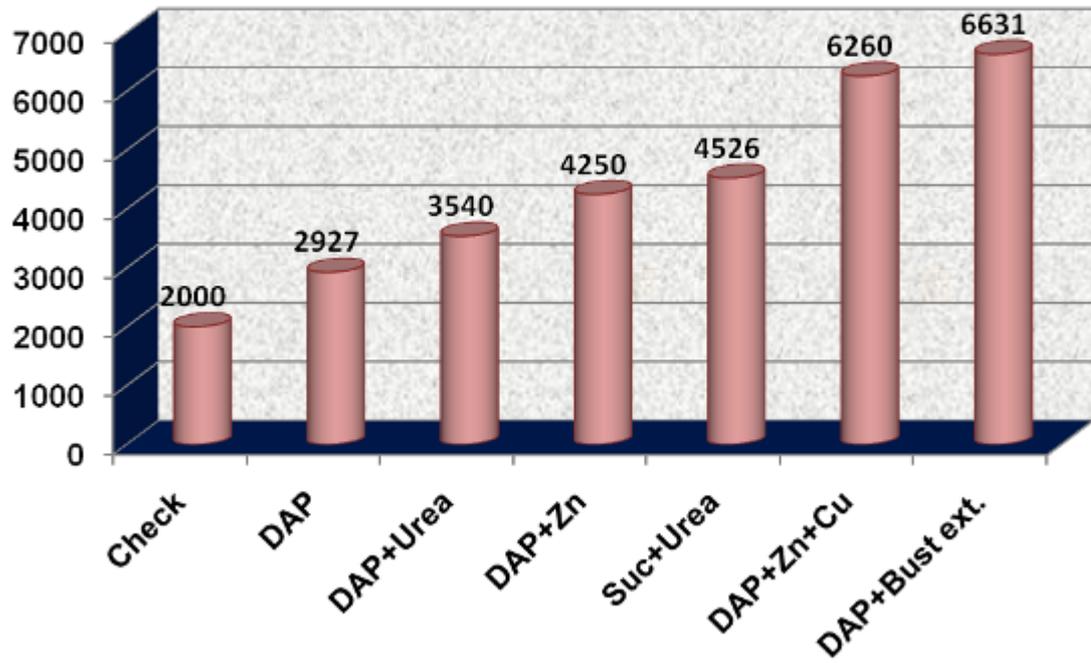
Figure 8. Panicles so heavy with seed that they needed support to prevent lodging

Results of the Third Experiment

Contrary to common belief that tef yields have reached a ceiling, the crop responds well to intensification or precision agriculture. Recent exploratory agronomic experiments by the Project proponent have shown that tef grain and straw yields can be doubled and even tripled (Figures 1 & 2) by (a) drastically reducing plant population and (b) applying fertilizers that contain micronutrients such as zinc and copper. The highest yields of 6.6 tonnes of grain and 25.8 tonnes for straw were obtained from variety DZ-01-874 with complete fertilizer treatment. Next in rank was Kuncho (DZ-Cross 387) with yields of 4.3 tonnes of grain and 17.2 tonnes of straw. The third tested genotype (Gyno 8) yielded 3.3 tonnes and 10.2 tonnes for grain and straw respectively. The average check yields (without fertilizer) were 1.9 tonnes for grain and 7.2 tonnes for straw. Hence, the double and three-fold increases in productivity were both for grain and straw. Tef straw is important for Ethiopian smallholder farmers because it is their preferred source of animal feed during the dry season and, secondly, it is an important cash crop for Ethiopian smallholder farmers since it can be sold for fodder or for construction.

There were some plant stand problems due to drought at transplanting. Hence, final yields were adjusted to 85% of plant stand. Otherwise, yields would have been even higher than what is reported here.

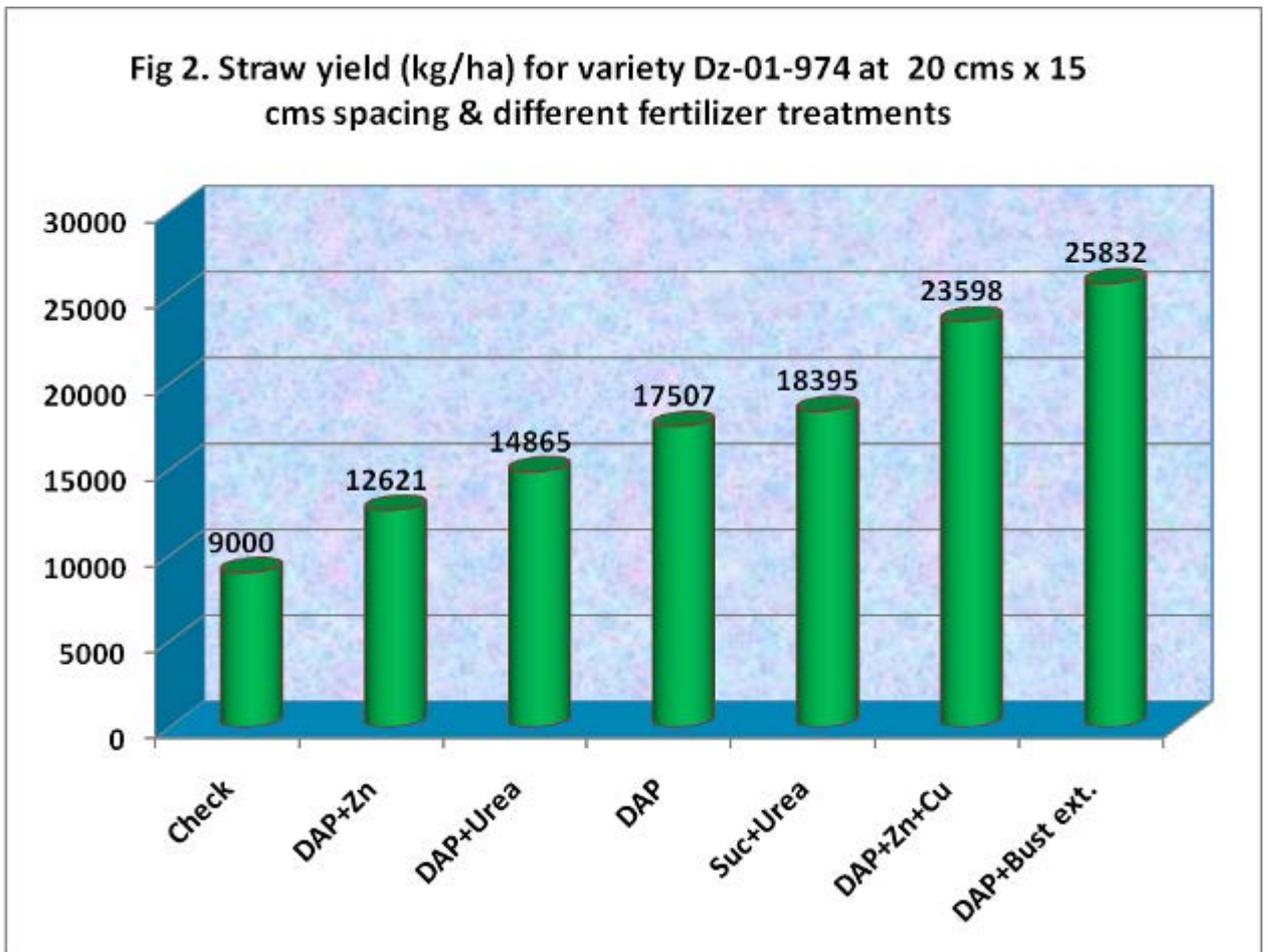
Fig 1. Yield kg/ha for variety Dz-01-974 at 20cms x 15 cms & different fertilizer types



DAP=Di-ammonium Phosphate (18N:46P); Urea = (46N)

Sucube-Sucube= (NPK+S+Zn)-Granular Rice Fertilizer in West Africa

Bust ext = Boost Xtra Foliar Fertilizer Complex (NPK+Mgo+Fe+Mn+Zn+Cu) - applied to root zone at four weeks.



In conclusion, tef varieties respond well to reduced plant density (in this case attained by transplanting) and to fertilizers, particularly those that contain micro-nutrients such as Zn, Cu, Mg, and S.

[In the first half of 2010], similar demonstration trials were conducted off-season using drip irrigation and also adding compost as a fertilizer treatment. The trial was conducted at Debre-Zeit Research Center, and Mekelle University funded by Oxfam America through a grant to the Institute for Sustainable Development and sub-grant to Sasakawa Africa Association.

RECOMMENDATIONS

Since tef has shown a positive response to this new and innovative management system, it is recommended that:

- Agronomic practices that reduce the planting density be promoted
- Complete fertilizers (NPK + micronutrients) be used for tef production
- Row planting techniques be developed to give low plant densities
- An extensive conventional cross-breeding program be supported at Debre-Zeit Agricultural Research Center
- Agricultural University students be encouraged to do their research on tef
- Non-conventional breeding techniques such as gynogenesis, chromosome mapping and mutagenesis be incorporated to speed up the conventional breeding program. Advantage can be taken by the work undergoing at Cornell University, USA, and Institute of International Agriculture, Bern, Switzerland

- Donors give their full support to tef research and development. They cannot support any nobler cause in Ethiopia than this.

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