Rate determination of Nitrogen and Phosphorous Fertilizer for Better Production of Teff

Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia

TECHNICAL REPORT OF EXPERIMENTAL ACTIVITIES

JUNE 2016

Implemented by

ICARDA
Science for Better Livelihoods in Dry Areas

In collaboration with

ARARI

BOKU

Funded by

AUSTRIAN DEVELOPMENT COOPERATION

Contributes to

CGIAR
RESEARCH PROGRAM ON
Dryland Systems

About the Project

Implemented By

International Center for Agricultural Research in the Dry Areas (ICARDA)
Project Agreement No. 100202

Funded by

Austrian Development Agency (ADA)
Project Reference No. 2012/04

Duration

01 April 2013 to 30 June 2016

Project coordinator

Dr. Claudio Zucca

Partners

Dept. of Water, Atmosphere and Environment, Institute of Hydraulics and Rural Water Management, BOKU - University of Natural Resources and Applied Life Sciences, Vienna Austria

Amhara Region Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia

Ethiopia Institute of Agriculture Research (EIAR), Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia

Cover photo: Field performance of Nitrogen and Phosphorus rate determination for teff experiment, in light soils of Dinzaz village | 22 September 2015 | Muuz Gebretsadik

About ICARDA

The International Center for Agricultural Research in the Dry Areas (ICARDA) is the global agricultural research Center working with countries in the world's dry and marginal areas, supporting them for sustainable agriculture development to help increase their productivity, raise incomes for smallholder farmer families, improve rural nutrition and strengthen national food security. With partners in more than 40 countries, ICARDA produces science based-solutions that include new crop varieties (barley, wheat, durum wheat, lentil, faba bean, kabuli chickpea, pasture and forage legumes); improved practices for farming and natural resources management; and socio-economic and policy options to enable and empower countries to improve their food security. ICARDA works closely with national agricultural research programs and other partners worldwide in Central Asia, South Asia, West Asia, North Africa, and Sub-Saharan Africa.

International Center for Agricultural Research in the Dry Areas (ICARDA)
PO Box 950764, Amman 11195, JORDAN
www.icarda.org

Synthesis

Activity type: Technology generation

Report submitted by: Baye Ayalew

Summary Report

In the framework of the project 'Reducing land degradation and farmers' vulnerability to climate change in the highland dry areas of north-western Ethiopia', an experiment was conducted at Gondar Zuria woreda, Abakaloye and Dinzaz villages, Gumara-Maksegnit watershed with the objective of determining biologically economically optimum level of N and P rates for better yield of teff. The experiment was done on two groups of homogeneous sites i.e. Vertisols (heavy soil) and Cambisols of the area. To investigate nitrogen and phosphorus rates on yield and yield components of teff. Four levels of nitrogen (0, 46, 69 and 92 kg N ha-1) and Four levels of phosphorus fertilizer (0, 46, 69 and 92 kg ha-1) were combined in 4*4 factorial arrangement in randomized complete block design with three replications. Data collected on growth and yield parameters were analysed using SAS computer software. Application of 46kg/ha P_2O_5 and 46kg/ha N significantly increased grain yield and biomass yield. The results showed that there was statistically significant difference among treatments in both biomass and grain yield ($p < 0.05$). The treatment with better grain yield was found economically optimal. Therefore, 46kg/ha P_2O_5 and 46kg/ha N are recommended to teff production. It can be concluded nitrogen (46kg ha-1) and phosphorus (46kg ha-1) can be used for optimum production of teff variety Quncho (DZ-cr-387-RILI) in the study area.

Schematic summary of information

Location (locality, town, province….):	Abera's farm in Abakaloye village and on Dessie's farm in Dinzaz village
For Cambisols in Dessie's and Tajebe's farms:	
Easting:	0349106
Northing:	1373852
Elevation:	2078m a.s.l.
For Vertisols in Abera's farm:	
Easting:	0345829
Northing:	1373479
Elevation:	1980m a.s.l.
Period of implementation:	February, 2014 to December, 2015
Duration of trials:	Two years
Activity leader(s):	Meron L., Baye A. and Ayalew A.
Other researchers involved:	Muuz Gebretsadik

1 Background and rationale

Nitrogen, phosphorous and potassium are the essential elements required for plant growth in relatively large amounts. However, deficiencies of nitrogen and phosphorus are common. Soil nutrients become depleted due to leaching of nitrogen, fixation of phosphorous, soil erosion, and removal by crops (Oldeman et al., 1991; Jarvis, 1996; Zobeck et al., 2000, Holmgren & Scheffer, 2001). To maintain high crop production level, the nutrient status of the soil has to be maintained through crop rotation, addition of manures or application of inorganic fertilizers (WRI, 1997; Weltz et al., 1998). Inorganic fertilizers are important inputs in any agricultural production system because they supply the required nutrients in a readily available form for immediate plant use.

Teff is the most important cereal crop serving millions of people as a staple food in Ethiopia. Doris (2002) reported that teff contains 11% protein and is an excellent source of essential amino acids, especially lysine, the amino acid that is most often deficient in grain foods. Teff contains more lysine than barley, millet, and wheat and slightly less than rice or oats. He further mentioned that teff is also an excellent source of fibre and iron, and has many times the amount of calcium, potassium and other essential minerals found in an equal amount of other grains. He also noted that teff is nearly gluten free and alternative grain for persons with gluten sensitivity. Teff may also have applications for persons with Celiac Disease. It contains 11% total carbohydrates, 24% dietary fibre, 10% thiamine, 2% riboflavin, 4% niacin, 8% calcium and 20% iron and is free from saturated fat, sugar and cholesterol (Purcell Mountain Farms, 2008). Gilbert (1997) indicated that teff straw from threshed grains is considered to be excellent forage, superior to straws from other cereal species. As cited by Gilbert (1997); Boe et al. (1986) and Eckhoff et al. (1993) reported that forage yields vary from 9.0 to 13.5Mg/ha depending upon moisture levels during the growing season. Teff straw provides an excellent nutritional product in comparison to other animal feed and is also utilized to reinforce mud or plasters used in the construction of buildings (Doris, 2002). Although teff is adapted to a wide range of environments and diverse agro climatic conditions, it performs excellently at an altitude of 1800-2100 m a s l, annual rainfall of 750-850 mm, growing season rainfall of 450-550 mm, and a temperature of 10 0C-27 0C (Seifu Ketema, 1993). It does well on clay loam and clay soils, which retain moisture during growing seasons. Teff is well suited on soils with a moderate fertility level and can tolerate a moderate water logged conditions (National Soil Service, 1994). It is also widely grown in Southern Region of Ethiopia, where early varieties like Dhabi and Bunigne are commonly produced during belg (March-June) rainy season, whereas medium to late varieties are dominantly produced during the main rain/meher (July- October) season The average yield per unit area of According to CSA

(1999), teff, covers the largest cultivated land as compared to cereals, pulses and oils, with average annual production of 1.87 million tonnes. Out of the estimated total cultivated land (8.216 million ha), it covered 31% in 1996/1997 (Doris, 2002), 32% in 1997/1998 (CSA1999), and 25.84% in 2000/01 (CSA, 2002). From the figures above one can understand that, although the percentage of land under teff gradually decreases, the total area still continued to increase as a result of more and more new land is being cleared and put under cultivation each year. Despite the large-scale production and various merits, teff production and productivity have been far below the potential. Currently the average national productivity is 0.92 t ha- 1, which is very low as compared to other small grain cereals grown in Ethiopia. This is because of many yield-limiting factors of which poor soil fertility being among the most important (Mwangi, 1995). Teff is produced in large plots, which is difficult to farmers to apply organic fertilizers to improve soil fertility. To feed the ever increasing population and generate income, continuous cultivation of land became a common practice in major teff producing areas, which eventually led to soil fertility decline and subsequent reduction of crop yields. Thus, as noted by Mwangi (1995) the use of inorganic fertilizer is critical to increase crop yield. Gruhn et al. (1995) suggested that, the levels of the fertilizer being used are very low and this must be increased to meet the demand for food with population growth. In many cases farmers are being forced to either not use or use low rates of fertilizer due to high fertilizer costs. Use of blanket recommendation rate irrespective of soil variations, however was found to be one of discouraging factors to farmers producing teff on relatively fertile soils. Thus, cost effective use of fertilizers on teff, which is low yielder and at the same time the most grain crop in Ethiopia, is very crucial. Fertilizer recommendations are site, crop and soil specific; hence fertilizer rates should also be established for each crop.

There are different blanket fertilizer recommendations for various soil types of Ethiopia for teff cultivation. For heavy soils (Vertisols) and sandy clay loam soils (Andosols), 55/30 and 60/26 N/P kg/ha, respectively are recommended (AUA, 1994). Nonetheless, N/P recommendation rates by the Ministry of Agriculture were set at 55/30, 30/40, and 40/35 N/P kg ha-1 for teff crop on Vertisols, Nitisols, and Cambisols, respectively across the country (Seyfu, 1993). However, 100 kg DAP ha-1 and 100 kg urea ha-1 were set by the Ministry of Agriculture and Rural Development later (Kenea et al., 2001).

2 Objective

The main objective of this research activity was to determine economically optimum rates of Nitrogen and phosphorous fertilizers for maximum yield of teff in Gondar.

3 Experimental Methods

Treatments

Four levels of nitrogen rates kg N ha-1 (0, 46, 69 and 92); and four levels of phosphorus fertilizer rates kg ha-1 (0, 46, 69 and 92) were used. After setting the Nitrogen and Phosphorus rates factorial, one additional treatment of NPS (38, 76, and 14) was included as a satellite treatment. The teff variety is called Quncho (DZ-Cr-387-RILI.

Factorial combinations of nitrogen and phosphorous fertilizer, and NPS as satellite treatment laid out in a Randomized Complete Block Design (RCBD) with 3replications. Plot size was 3 m x 3 m and adjacent plots and blocks were spaced 1m and 2 m apart, respectively. The net harvestable area was 6.25 m2. Teff seeds were sown in rows at spacing of 20 cm between rows and were thinly covered with soil. Composited soil sample was taken before planting and after harvesting by auguring to 30cm.

The experiment was done on two groups of homogeneous sites i.e. Vertisols (heavy soil) and Cambisols of the woreda.

4 Statistical aspects

Statistical analysis: the collected data were analysed using SAS software. Whenever significant differences between treatments are detected, mean separation was done using least significant difference (LSD). Partial Budget Analysis (PBA) was done to separate the best economically feasible rates of these fertilizers.

5 Results

The results showed that there was statistically significant difference among treatments of biomass and grain yield ($p < 0.05$). Both grain yield and biomass yield were significantly affected with the application of N and P2O5.

As shown in table 1: and table 2: in Cambisols and Vertisols, 46kg/ha of N and 46kg/ha of P2O5 gave economically feasible and optimum teff yield.

As a result, the selected treatments in terms of biological yield are selected as economically feasible. 46kg/ha P2O5 and 46kg/ha N has a MRR (%) of 469 and 320(%) for Vertisols and Cambisols respectively for Gondar Zuria woreda areas. Therefore, 46kg/ha P2O5 and 46kg/ha N rates are recommended to Gondar Zuria woreda for teff production.

Table 1: Result of Vertisols chemical analysis, after planting in 2014

Treatments P2O5 (kg/ha), N (kg/ha)	PH (H2O)	EC (ms/cm)	TN (%) Kjeldhal	Available P (PPM)	O.M (%) Walkely
(0,0)	6.97	0.04	0.07	8.05	1.94
(46,0)	6.97	0.03	0.07	12	2.25
(69,0)	6.98	0.03	0.07	17	1.92
(92,0)	6.98	0.03	0.08	21.5	2.35
(0,46)	7	0.03	0.06	7.18	1.92
(46,46)	6.95	0.03	0.07	7.61	2.28
(69,46)	6.97	0.04	0.08	10.5	1.58
(92,46)	6.88	0.04	0.08	16.2	2.52
(0,69)	6.97	0.04	0.08	12.5	2.11
(46,69)	6.94	0.04	0.07	6.32	1.97
(69,69)	6.91	0.03	0.07	10.6	2.3
(92,69)	7.01	0.03	0.07	16	2.47
(0,92)	6.88	0.07	0.08	6	1.94
(46,92)	6.95	0.04	0.07	7.49	2.06
(69,92)	6.89	0.04	0.08	9.81	2.04
(46,92)	6.97	0.03	0.07	13.1	114
(69,92)	6.96	0.04	0.07	12.5	1.94

Table 2: Effect of N and P2O5 rate on yield of teff in Vertisols of Gondar zuria woreda.

N (kg/ha)	Year2014		Year 2015		Two Years' Combined	
	Biomass yield (kg/ha)	*Grain yield (kg/ha)*	*Biomass yield (kg/ha)*	*Grain yield (kg/ha)*	*Biomass yield (kg/ha)*	*Grain yield (kg/ha)*
0	1343	421	5404	1615	3374	1018
46	6080	1440	9019	1816	7550	1789
69	6837	1559	9561	1944	8199	1751
92	7102	1411	9576	2139	8340	1613
Mean	6673	1208	8390	1879	6866	1543
LSD	855	198	1116	186	625	141
P2O5(kg/ha)						
0	3972	860	7508	1674	5740	1267
46	5653	1263	8223	1891	6938	1577
69	5568	1328	8871	1947	7219	1637
92	6170	1680	8958	2001	7564	1691
Mean	5341	1283	8390	1878	7240	1543
LSD	855	198	1025	186	625	141

Table 3: Partial budget analysis to determine optimum N and P2O5 rate determination for maximum yield of teff in Vertisols of Gondar zuria woreda.

P2O5 rate (kg/ha)	N rate (kg/ha)	Total variable cost (ETB)	Grain yield (kg/ha)	Gross income (ETB)	Net income (ETB)	MRR (%)
0	0	0	784	4189	4189	-
0	46	1151	1356	11623	10472	546
46	0	1352	950	6350	4998	-
0	69	1727	1472	13130	11404	162
69	0	2028	1045	7585	5557	-
0	92	2302	1203	9635	7333	-
46	46	2503	1812	17551	15048	469
38N, 76P2O5, 14S		2604	1762	15761	13157	-
92	0	2704	1089	8153	5449	-
46	69	3079	1676	15785	12707	-
69	46	3179	1749	16736	13557	-
46	92	3654	1556	14229	10575	-
69	69	3755	1701	16119	12364	-
92	46	3855	1885	18502	14647	-
69	92	4330	1725	16428	12098	-
92	69	4431	1807	17490	13059	-
92	92	5006	1644	15378	10372	-

Table 4: Effect of N and P2O5 rate on yield of teff in Cambisols of Gondar zuria woreda

N (kg/ha)	Year2014		Year 2015		Two Years' Combined	
	Biomass yield	*Grain yield*	*Biomass yield*	*Grain yield*	*Biomass yield*	*Grain yield*
0	1577	496	5185	1269	4283	1075
46	4816	1056	7463	1550	6802	1449
69	5583	1376	8667	1584	7865	1532
92	5502	1129	8653	1572	7896	1461
LSD	1203	226	612	119	486	100
P2O5 (kg/ha)						
0	2280	618	6382	1226	5357	1074
46	4811	1081	7884	1589	7116	1462
69	4924	1059	7826	1529	7100	1412
92	5463	1298	7875	1662	7272	1571
LSD	1203	226	612	119	486	100

Table 5: Partial budget analysis to determine optimum N and P2O5 rate determination for maximum yield of teff in Cambisols of Gondar zuria woreda.

P2O5, N (kg/ha)	N rate (k ha-1)	Total variable cost (ETB)	Grain yield (kg/ha)	Gross income (ETB)	Net income (ETB)	MRR (%)
0	0	0	805	3942	3942	-
0	46	1151	1050	6968	5817	163
46	0	1352	1131	7968	6616	398
0	69	1727	1289	9919	8193	421
69	0	2028	1060	7091	5063	-
0	92	2302	1153	8240	5938	-
46	46	2503	1553	13180	10677	320
38N, 76P2O5, 14S		2604	1456	11982	938	
92	0	2704	1306	10129	7425	-
46	69	3079	1596	13711	10632	-
69	46	3179	1547	13105	9926	-
46	92	3654	1569	13377	9723	-
69	69	3755	1540	13019	9265	-
92	46	3855	1648	14353	10498	-
69	92	4330	1500	12525	8195	-
92	69	4431	1675	14686	10256	-
92	92	5006	1624	14056	9050	-

***NOTE**: The data presented in this report are currently being elaborated for scientific publication, thus some of them are not final. The aim of this report is to summarize the nature and quality of the activities conducted and of the dataset generated, and to illustrate the main results obtained.*

Project Manager

Claudio Zucca
Soil Conservation/Land Management Specialist
CGIAR Research Program on Dryland Systems
ICARDA
Marrakesh, Morocco
C.Zucca@cgiar.org

Science for Better Livelihoods in Dry Areas