International Journal of Research in Agricultural Sciences
Volume 5, Issue 3, ISSN (Online): 2348 – 3997

Effect of Different Rates of Erythrina Biomass Transfer Combined with Different Nitrogen and Phosphorus Rates on Yield and Yield Components of Wheat at Masha Woreda, South-Western Ethiopia

Abiy Gebremichael[1*], Getahun Yakob[2] and Shiferaw Boqe[2]
[1*]Bonga Agricultural Research Centre, Bonga, Ethiopia.
[2]Southern Agricultural Research Institute (SARI), Hawassa, Ethiopia.
[*]Corresponding author email id: gebremichaelaby@gmail.com

Date of publication (dd/mm/yyyy): 23/05/2018

Abstract — **An experiment was conducted at Masha Woreda, Sheka zone, Southwestern Ethiopia for two consecutive years to investigate the effect of Erythrina bruci biomass transfer combined with nitrogen and phosphorus rates on yield and yield components of wheat. Ten rates of combination (two rates of Erythrina bruci biomass calculated based on N equivalence (50% Erythrina and 100% Erythrina in N equivqlence) combined to three rates of NP (50% Rec. NP, 100%Rec. NP and only Rec. P) as well as two controls (negative and positive control) were applied in randomized complete block design with four blocks. Data collected on growth and yield parameters were analyzed using SAS software version 9.2. The result of first year was non-significant on yield and also dry biomass weight. The result obtained at second year was however significant ($p < 0.05$) indicating the effectiveness of using erythrina transferred biomass for soil fertility management. The soil property also showed slight change in content of nutrients as well as texture. Application of 50% Erythrina in N equivalence (2t/ha) has 109% yield increment at first year relative to control and 139% yield increment at second year to be economic organic treatment that could change soil fertility status in the area for sustainable wheat production. However, due to high acidity of soil, the effect of Phosphorous was not explained in this experiment as it was fixed or/ and due to microelements deficiency. Therefore, application of 50% Erythrina in N equivalence (2t/ha wet biomass) should be used in the area in connection to further study on economic importance and acidity problem solving.**

Keywords — **Erythrina Biomass, Soil Fertility, Fertilizer, Biomass Transfer**

I. INTRODUCTION

The fertility of most Ethiopian soils has already declined and continued to decline posing another challenge to crop production. Mining of nutriments due to continuous cropping, abandoning of fallowing, reduced manure application, crop rotation, removal of crop residues to be used as fuel and erosion coupled with low inherent fertility are among the main causes decreasing soil [1] [2].

Decline in soil fertility is the main challenge to crop production in the southern due to continuous cultivation, inadequate application organic nutrient source, soil erosion so on is among others account for reduced soil fertility. Application of inorganic fertilizers is one mean to replenish soil nutrients such as N and P [3].

However, the cost of fertilizers is increasing from time to time becoming unaffordable to subsistent farmers. The use of organic fertilizer such as farmyard manure, compost, green manure and transferred biomass of leguminous tree is an alternative to inorganic fertilizers to improve soil fertility [2]. For instance [4] studied the effect of green manuring of delicos lablab on the yield of wheat at Kokate and Hossana site of SNNPR and found that the yield of wheat was increased by 63% and 97% over the control respectively.

Erythrina species is one such locally available organic nutrient source recently identified it is wide grown at Kafa, sheka and benchmaji zones of south-western parts of Ethiopia that can be exploited as nutrient sources. *Erythrina Bruci* is an N-fixing nutrient rich organic fertilizer which is widely available in the areas as live fence, as farm boundary plant, on communal land so on. Thus, while making an effort to introduce and disseminate exotic leguminous crops to different agro ecological zone for soil fertility management, there is a need to identify locally available organic nutrient source that can serve as organic fertilizers. It is an indigenous N-fixing [5] nutrient rich organic nutrient source adapted to growing in mid altitude areas of southern region. It is fast growing tree that produce abundant biomass in a short period of time and grown as live fence, inside farmlands and on communal lands [6]. The results of chemical analysis of leave and twig samples showed that it has 4.83%N, 0.38% P and 2.24% K [7]. From the study, it was summarized that, application of 5 and 10t/ha of biomass increased the grain yield by 86 and 134%, respectively over the control.

Application rate of *Erythrina* biomass at 10t/ha + half of the recommended rate of NP (N23 P23) for wheat at Kokate area increased the grain yield by 189% suggesting that the cost of inorganic fertilizer could be reduced by half using erythrina biomass as organic supplement while obtaining superior yield of wheat than either source applied alone. Although the *Erythrina* spp. exsist in ample amount, the farmers are not using it as source of organic fertilizer in the western part of the southern region. Thus, there is a need to evaluate *Erythrina* as organic nutrient and recommend it for crop production at areas where the source is ample.

Erythrina brucei is a leguminous tree endemic to Ethiopia. It has potential with symbiotic N-fixing characteristics [8]. *E. brucei* is adapted to grow in areas with an altitude ranging from 1400–2600masl. It fixes atmospheric nitrogen through its leaves in contrast to angiosperms of Rubiaceae and Primulaceae [9]. It is a fast growing tree that reaches up to 3m in height within 6 months of planting [6] and its leaves are source of large quantities of swiftly decomposable litters; it has high coppicing ability as well as rapid recovery after a spell of prolonged drought; branches and leaves are used as animal feed in times of feed shortage [6]. It is propagated both by seed and cuttings. In addition to some zones of the southern region explained by [10], [11], it is also growing in kafa, Sheka and Bench Maji zones of SNNP region, Ethiopia as abundantly live fences, along farm boundary and inside farmlands in alleys as agro-forestry tree. Production of up to 50kg of fodder biomass (Leave + twigs) per tree per year is potential of *Erythrina* relatives [12]. Optimal doses of 10 tons of biomass per hectare of *E. brucei* can easily be obtained from only 200 trees. Therefore the objective of this study was firstly, to evaluate the effects of Erythrina bruci transfered biomass on the yield of wheat and soil properties and secondly,to determine the optimum rate of *Erythrina brucei* biomass for wheat production.

II. Materials and Methods

2.1. Description of Study Area

The experiment was conducted at Sheka zone, Masha Woreda in South western Ethiopia during 2013/2014 main cropping season. Sheka zone has a total area of 2134.13sq km and lies between 7.12-7.89° latitude and 35.24° to 37.90° longitudes, with an elevation ranging 1001-3000masl and situated 951 km away from Hwassa, the capital of region. The zone has 3 Woredas with a total population of 198,406 [13]. Regarding the Agro–ecology of the zone, out of the total land size 55.6% is kolla, 41.4% Weinadega and 3% Dega. The site has an average annual rainfall of 1800-2200mm with bimodal distribution, annual mean temperature of 15-27°C [14]. The soil type of the area is Acrisols [13]. Acrisols are characterized by high Kaolinitic clays, low cation exchange capacity, low base saturation and low pH values. This may be due to hot climate and high rainfall that result in intensive leaching. These soils are deep, well drained and reddish brown when moist and dark red when dry [15].

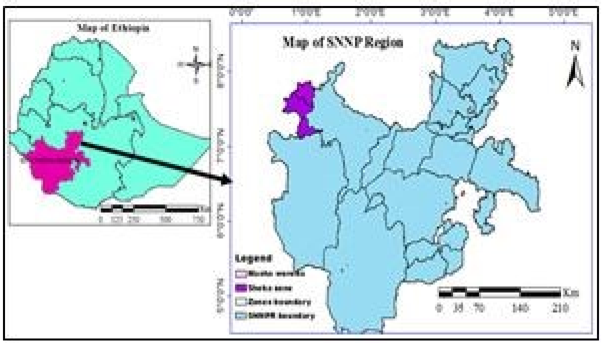

Figure 1. Map of the study area

2.2. Experimental Treatments, Design and Procedures

Wheat variety (*Damphe*) obtained from Masha Agricultural office was used for this experiment. Wheat is one of the potential crops for Masha Woreda. Ten levels of combination of Nitrogen, Phosphorus and Erythrina biomass were used such as; negative control (no fertilizer); positive control Rec. NP (64kg/haN & 20Pkg/ha); 50% Rec. Erythrina in N equivalence + 50% Rec. NP; 50% Rec. Erythrina in N equivalence + Rec. NP; 50% Rec. Erythrina in N equivalence + Rec. P; 50% Rec. Erythrina in N equivalence; Rec. Erythrina in N equivalence + 50% Rec.NP; Rec. Erythrina in N equivalence + Rec.NP; Rec. Erythrina in N equivalence + Rec P. and Rec. Erythrina in N equivalence applied in randomized complete block design with four replications.

The trial was done for two years in the area. The experimental field with four blocks each containing 10 plots of size of 25 m^2 (5mx5m) with 4mx4m harvestable area was used. A distance of 0.75m was maintained between the plots within a block and 1.5m distance was maintained between blocks and 20 cm row spacing was uniformly used. The entire rate of phosphorus and half the rate of nitrogen was applied at the time of planting and the remaining half of nitrogen was applied 45 days after planting. Urea (46% N); DAP and triple super phosphate, TSP (46% P2O5), fertilizers were used as sources of nitrogen and phosphorus. Erythrina was collected and the young leaves and twigs chopped in to small pieces to enhance decomposition. To increase decomposition of material, the chopped part of the plant was incorporated in to the soil one month before planting of wheat.

Soil Samples:

Composite soil sample (20-30 spots) from 0-20 cm soil depth, were taken using auger at (before) planting and after harvesting (from each plot). Samples were subjected for analysis for texture, pH, OC, total N, CEC and available P.

Crop Data:

All agronomic parameters including grain yield, above ground biomass, 1000 seed weight, and plant height, spike length, stand count at emergence and at harvest were collected. Except grain yield and biomass, data were taken from randomly selected 10 plants.

2.3. Data Analysis

Analysis of N Content in Erythrina

The calculation of tha amount of Nitrogen (N in kg) found in Erythrina biomass transfer was done following method of chemical content analysis result of leave and twig of dry biomass of Erythrina bruci as 4.83% N, 0.38% P and 2.24% K [7]. The dry biomass of Erythrina bruci was obtained by using conversion factor of *Dry biomass = 20% wet biomass* [4].

Analysis of Soil Samples

The soil samples were air dried under the shade, ground using pestle & mortar and sieved to pass through 2 mm sieve. Soil bulk density was determined using undisturbed core sampling method following the procedures described in [16]. Particle size distribution (soil texture) was

International Journal of Research in Agricultural Sciences
Volume 5, Issue 3, ISSN (Online): 2348 – 3997

determined by the hydrometer method [17]. Soil pH was determined in a 1:2.5 soil to water suspension following the procedure outlined by [18].

The organic carbon content was analyzed by wet digestion method using the Walkley and Black oxidation method [19]. Soil organic matter (OM) content was calculated by multiplying soil organic carbon content by a factor of 1.724. The total nitrogen (TN) content was determined using the Kjeldahl method [20]; while the available phosphorus (AP) was determined following the Olsen procedure [21]. The Cation Exchange Capacity (CEC) was determined after extraction of the samples with 1 N ammonium acetate [22]. The data collected on agronomic and yield performance was subject to ANOVA using SAS software version 9.2.

III. Results and Discussion

3.1. Soil Analysis Result

The soil sample was collected before and after application of treatments for thorough analysis at second year trial and the result was shown at Table 1 below.

Table1: Soil sample result before and after application of treatments for the second year

S. No	Treatment	pH-H2O	OC%	TN%	CEC (me/100g)	Av.P (ppm)	Texture
1	Before treatment application	4.89	5.23	0.32	23	4.08	SCL
	After treatment application						
1	Control (no fertilizer)	5.05	3.57	0.31	18.4	4.21	SL
2	Recommended NP	5.86	4.81	0.42	25.6	3.67	SL
3	50% Er in N + 50% Rec. NP	6.05	5.00	0.42	23.2	5.05	SL
4	50% Er in N + Rec. NP	5.76	4.28	0.37	21.8	4.68	SL
5	50% Er in N + Rec.P	5.93	4.95	0.42	24	4.87	SL
6	50% Er in N	5.77	3.57	0.31	20.4	3.18	SL
7	100% Er in N + 50% Rec.NP	6.02	5.47	0.48	25.8	4.11	SL
8	100% Er in N +NP rec.	5.94	4.85	0.42	22.8	3.90	SL
9	100% Er in N + P rec.	5.68	4.90	0.42	26	2.59	SL
10	100% Er in N	5.86	3.85	0.34	23.2	4.90	SL

Note: 50% Er in N means, based on NP recommendation in the area,50% of N required is covered by Erythrina dry biomass calculated in N equivalence.
100kg of wet biomass results to 20kg dry biomass (Shiferaw, 2005).
50% Er in N equal to 2t/ha Erythrina wet biomass while 100% Er in N equals to 4t/ha Erythrina wet biomas; Rec. NP = Recommended NP SL = sandy loam; SCL = sandy clay loam

From the result indicated, it is clear that soil texture was changed from sandy clay loam to sandy loam. Although there was no significant difference among soil results of treatments after harvesting, the soil nutrient condition was better modified relative to first result for pH, OC, TN and CEC.

3.2. Uses of Erythrina Species in the Study Area

Farmers who have land holding in the study area uses Erythrina species as farm boundary (Figure 2) although its socio-economic evaluation is not yet done. The reason for using as a fence is that its spiny bark protects animals from entering in to agriculture field. Some farmers also use it for preparation of bee hives at its large tree wood stage by cutting (logging down) it after 4-5 years of planting. Although the aforementioned advantages were primary uses that farmers know, its role in terms of soil fertility management by chopping young leaves and twings and incorporating to soil was not known in the area and therefore, this experiment was applied and produced the result shown at Table 2.

Fig. 2. Erythrina Spp. Planted as fencing and family based chopping it into pieces for incorporation to soil in the area

3.3. The Yield and Yield Components of Wheat

The result of application of Erythrina species transferred biomass at Masha woreda was shown below with successive discussions.

Table 2. The yield and yield components of wheat for the first and second years

Ser. no	Treatments	Year 1		Year 2	
		Yield (kg/ha)	Biomass (kg/ha)	Yield (kg/ha)	Dry Biomass (kg/ha)
1	Control (no fertilizer)	2039.1	1992.2	1439.0a	4070a
2	Recommended NP	2437.5	1757.8	1963.4b	7448b
3	50% Er in N + 50% Rec. NP	2226.6	2343.8	1780.5ab	5233ab
4	50% Er in N + Rec. NP	1500.0	1785.1	1548.8ab	6576ab
5	50% Er in N + Rec.P	1898.0	1851.6	1896.3ab	6860b
6	50% Er in N	2213.7	1734.4	1993.9b	5814ab
7	100% Er in N + 50% Rec.NP	2015.6	1878.5	1939.1ab	6645b
8	100% Er in N + Rec. NP	2062.5	2203.2	1561.0ab	6686b
9	100% Er in N + Rec. P	1828.1	1898.5	1658.5ab	5756ab
10	100% Er in N	1875.0	1875.3	1951.2ab	5529ab
	LSD (0.05)	NS	NS	446.4	1603
	CV %	34.39	29.1	17.35	28.82

Note: 50% Er in N means, based on NP recommendation in the area, 50% of N required is covered by Erythrina dry biomass calculated in N equivalence.
100kg of wet biomass results to 20kg dry biomass (Shiferaw, 2005).
From this, 50% Er in N equal to 2t/ha Erythrina wet biomas while 100% Er in N equals to 4t/ha Erythrina wet biomas; Rec. NP = Recommended NP; SL = sandy loam; SCL = sandy clay loam

From results presented in Table above, it indicates that, both yield and biomass in the first year has no significant difference ($P > 0.05$). At first year, the maximum yield was obtained at Recommended NP and minimum at 50% Er in N + Rec. NP. Regarding the biomass, the maximum was obtained at 50% Er in N + 50% Rec. NP and minimum at 50% Er in N at first year. However, the low result in general was due to drought occurrence in the season which affected the crop at emergency and vegetative stages.

On the other hand, 50% Er in N results higher yield than 100% Er in N which indicated that, the decomposition of biomass takes time than direct application of N because at 50% Er in N, 50% (32kg/ha N) is added but no any amount applied at treatment of 100% Er in N. The role of P was not explained in the result due to acidic situation of the soils or/and the effect of micro nutrients deficiency. Since non-significant result was observed, economically application of Erythrina biomass is better than inorganic inputs as fertilizer inputs costs more than freely available biomass transfer.

In the second year experiment, it was found that there was significant difference between treatments at ($P<0.05$) for both the yield of wheat and biomass.

Although the higher yield was obtained at 50% Er in N than 100% Er in N (2t/ha Erythrina wet biomass) will be better in the area for optimum wheat production with conservative assumption although it should depend on economic analysis.

IV. Conclusion and Recommendation

Application of Erythrina biomass transfer in Masha woreda brought non-significant yield at first year. However, the maximum yield was obtained as 2437.5kg/ha at recommended NP and minimum of 1500kg/ha at 50% Erythrina biomass on N equivalence (2t/ha) + Rec. NP. On the second year, there was significant difference among treatments with maximum yield obtained as 1993.9kg/ha 50% Erythrina biomass on N equivalence (2t/ha) only and minimum of 1439.0kg/ha at control. Although application of Erythrina biomass alone did not influence wheat production significantly at Masha woreda, based on relative yield, better and economic treatment could be 50% Erythrina biomass with N equivalence (2t/ha) only. This is because it has 109% and 139% yield increase relative to control at first and second years respectively. Therefore, it is better to scale up to the area application of Erythrina biomass transfer of 2t/ha with no inorganic fertilizer use in order to keep Soil health as well as to produce wheat in the area. However as the yield was generally less relative to national recommendation, works toward the problem of soil acidity should be focused so as to boost the productivity.

References

[1] Taye B., Yeshanew, A., Balesh, T. and Girma, K. 1996. Soil fertility management in Barley. Pp. 92-103. In: Hailu Gebre and Joop van Leur (eds). Barely Research in Ethiopia past works and Future prospects. Proceedings of the First barely Research Review Workshop, 16-19 October 1993, Addis Ababa: IAR/ICARDA. Addis Ababa, Ethiopia.

[2] Yohannes, U. 1994. The effect of nitrogen, phosphorus, potassium, and sulphur on th yield and yield components of Ensete (*Ensete ventricosum* W.) in Southwest of Ethiopia. Ph.D. Dissertation, Gießen, Germany. 93p

[3] Tisdale, S. T., Nelson, W. L. and J. D. Beaton, J. D. 2007. Soil Fertility and Fertilizers. 4th ed. Macmillan Publishing Company, New York. 499p.

[4] Shiferaw, B. 2005. Progress Report of the natural resources Department, Awassa Agricultural Research Center, Awassa. *Unpublished*

[5] Wassie, H. 2012. Appraisal of Erythrina brucei as a source for soil nutrition on Nitisols of South Ethiopia. Int. J. Agric. Biol., 14: 371–376

[6] Demil, T. 1994. Germination ecology of two endemic multipurpose species of *Erythrina* from Ethiopia. *Forest Ecology and management* 65: 80-87.

[7] Wassie, H., B. Shiferaw and K. Kelsa, 2009. Integrated Soil fertility Management Options for Sustainable Crop Production:

Review of Research Findings from Southern Regional State of Ethiopia. In: ESSS (ed.), Improved Natural Resource Management Technologies for Food Security, Poverty Reduction and Sustainable Development: Proc. 10th Conf. Ethiopian Soc. Soil Sci., pp: 163–175. 25–27 March, 2009 EIAR, Addis Ababa, Ethiopia

[8] Legesse and Negash. 2002. Review of Research advances in some seleccted African tree with special reference to Ethiopia. Ethiop. J. Biol. Sci. 1: 81-126.

[9] Miller, R. O., Jacobsen, J. S. and Skogley, E. O. 1990. Aerial accumulation and partitioning of nutrients by hard red spring wheat. Comm. Soil Sci. Plant Anal. 25: 1891-1911.

[10] Wassie, H. and Boke S. 2009. Mitigation of soil acidity and fertility decline challenges for sustainable livelihood improvement: Evidence from southern Region of Ethiopia. In: Atlaw, A., Y. Saba, M. Alemu and K. Minale (eds.), Proc. National Conf. Sustain. Land Manag. Poverty Alleviation, Co-organised by Environ. Econ. Policy Forum for Ethiopia at Ethiopian Develop. Res. Institute, Sus. Land Use Forum (SLUF), pp: 131–143.Oromia Agricultural Research Institute (ORARI) and College of Agriculture at Hawassa University, Addis Ababa, Ethiopia.

[11] SLU (Sustainable Land Forum), 2006. Indigenous Agro Forestry Practices and their Implications on Sustainable Land Use and Natural Resources Management: The Case of Wonago Woreda Research Report No. 1. Addis Ababa, Ethiopia.

[12] Na-songkhla, B., 1997. Erythrina variegata L. In: Faridah Hanum, I. and L.J.G. Van Der Maesen (eds.), Plant Resources of South-East Asia No. 11 Auxiliary Plants, pp: 130–132. Prosea Foundation, Bogor, Indonesia

[13] CSA (Central Statistical Authority), 2007. Projected population census Report. Bureau of Finance and Economic Development, Ethiopia.

[14] Bedru, B., 2007. Economic evaluation and management of common-pool resources: The case of enclosures in the highlands of Tigray, Northern Ethiopia. Ph.D. Thesis, Catholic University of Leuven.

[15] Berhane, F. and S. Sahelmemedhin, 2003. Assessment of different phosphorus forms in some agricultural soils of Ethiopia. Ethiop. J. Agric., 5: 193-213.

[16] Black CA. 1965. Methods of Soil Analysis. Part I. American Society of Agronomy, Madison, Wisconsin, USA, p 1572

[17] Bouyoucos GJ. 1962. Hydrometer method improvement for making particle size analysis of soils. Agronomy 5:179–186

[18] Sahelemedhin S, Taye B. 2000. Procedures for Soil and Plant Analysis. National Soil Research Center, EARO, technical paper No.74, Addis Ababa, Ethiopia.

[19] Walkley A, Black CA. 1934. An examination of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci 37:29–38

[20] Bremner JM, Mulvaney CS. 1982. Total Nitrogen. In: Page AL, Miller RH, Keeney DR (eds) Methods of Soil Analysis. II. Chemical and Microbiological Properties. American Society of Agronomy, Soil Science Society of America, pp 595–624

[21] Olsen SR, Cole CV, Watanable FS, Dean LA. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Circular 939(1):19

[22] Chapman HD. 1965. Cation Exchange Capacity. In: Black CA, Ensminger LE, Clark FE (eds) methods of Soil Analysis, vol 9. Agronomy inc, Madison, Wisconsin, pp 891–901.

AUTHOR'S PROFILES

Abiy Gebremichael received the BSc degree. in Land Resource Management and Environmental Protection from Mekelle University, Ethiopia in 2005 and MSc. degree in Soil and Water Conservation Engineering from Institute of Technology, Haramaya University, Ethiopia in 2011. During 2007-2016, he stayed in Sou--thern Agricultural Research Institute (SARI), Ethiopia. He is now PhD Candidate at Haramaya University Ethiopia in Soil and Water Conservation Engineering.

Getahun Yakob received the BSc degree. in forestry from Hawasa University, Ethiopia in 2005 and MSc. degree Agroforestry and soil fertility management from Wodogenet forestry college, Hawasa University, Ethiopia in 2011. He stayed from 2006 up to now in Southern Agricultural Research Institute (SARI), Ethiopia and serving now as Director, Natuarl Resource Research Directorate in the same Institute.

Shiferwa Boqe is working as soil fertility management researcher and research project Coordinator for more than fifteen years in Southern Agricultural Research Institute (SARI), Ethiopia and serving now as soil and water research coordinator, Natural Resource Research Directorate in the same Institute.