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Effect of Erythrina (*Erythrina bruci*) Biomass Transfer with or Without NP Fertilizer on Wheat Production at Chena District, Kaffa Zone, South-Western Ethiopia

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Abstract **– Integrated use of organic and inorganic fertilizers can improve crop productivity and sustain soil health and fertility. The present experiment was conducted with an objective to study the influence of application of Erythrina biomass transfer in combination with NP chemical fertilizers. Seven treatments: no input (control); Recommended NP (RNP); 50% RNP + 50% Erythrina; 25% RNP + 75% Erythrina; 75% RNP + 25% Erythrina; 100% Erythrina; 50% Erythrina were compared in a randomized complete block design replicated three times. Data on grain and biomass yield, 1000 seed weight, number of tillers per plant, and spike length were collected. The results showed that application of Erythrina and NP either combined or alone significantly improved wheat production than untreated control. Sole application of 50% E. gave equivalent wheat yield with RNP treated plots. Although not significant application of 100% Eryhrina gave a higher wheat grain yield than RNP. Biomass yield followed similar trend. The highest wheat grain yield (3453.1 kg ha-1) was record by application of 25% Erythrina along with 75 % RNP but not have statistical difference with 25% RNP +75 Erythrina, 100% Erythrina and 50% RNP +50% Erythrina. Highest and modest net benefit and Marginal rate of return were also obtained by application of 25% Erythrina along with 75% RNP and 50% Erythrina respectively. Hence, we recommend the application of 25% Erythrina +75 RNP at Chena for improved and sustained wheat production. Since the benefits of organic sources are beyond crop yield increase, 50% Erythrina could be used as an option based on the resource availability in the study area.**

Keywords **– Erythrina Biomass, NP, Wheat Yield, Biomass Transfer, Organic Fertilizer.**

I. INTRODUCTION

Soil fertility decline is a major factor limiting per capital crop production in Ethiopia in general and in SNNPRS in particular [26]. It is quite difficult for smallholder farmers to afford and apply adequate quantities of mineral fertilizers and organic sources, which hinder them to replenish soil fertility. Lack of soil fertility restoring resources, unbalanced nutrient mining, soil erosion, and unequal soil fertility management within family fields have been reported to contribute soil fertility depletion by several researchers [22] [24]. Thus dynamism of soil fertility depletion is enormous in Ethiopia. A recent study has shown that the average annual soil loss from agricultural land is estimated to be 137 tons ha^{-1} per year for the Ethiopian highlands, which is approximately an annual soil depth loss of10 mm [29]. Though farmers are aware of the scenario, they do not use either required amount of mineral fertilizers or amend with organic fertilizer sources to replenish the lost fertilizer nutrients.

Sole application of organic or mineral fertilizers couldn't stand on their own to overcome soil fertility depletion problems. They should also be used together to meet sustainability in soil fertility [14]. Several authors reported appreciable yield increase of crops (sometimes two to three folds) by integrated use of organic

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and inorganic fertilizers [19] [2]. Interventions are needed to create awareness among farmers about the need to apply organic matter in an easily available form in their surrounding areas. Dual-purpose legume crops and shrubs/trees add organic nitrogen (N) to soils through biomass production and biological nitrogen fixation. They add diversity to the food options for farmers and are environmentally sound [23].

Erythrina bruci is one of the endemic N-fixing leguminous trees that can be used to improve soil fertility in Ethiopia [25]. It's a fast-growing tree that produces a lot of biomass in a short period of time, and it's commonly used as a live fence, inside farmland, and on communal lands [8]. Application of 5 tha^{-1} and 10 tha^{-1} *Erythrina* biomass increased the grain yield of wheat by 86% and 134% over the control, respectively, at kokate, Wolayita [25].Although *Erythrina* spp. exist in ample amount, the farmers are not using it as a source of organic fertilizer in the western part of the southern region [2]. Meanwhile *Erythrina* spp. grow around homestead and in the hedge rows of farm boundary of many farmers in the study area. Although it exists in ample amount, they are not using it as a source of organic fertilizer. Therefore, this study was conducted with the objective of evaluating the comparative effects of sole application of *Eyrthrina bruci* biomass and its combined application with mineral fertilizers on Wheat production.

II. Materials and Methods

2.1. *Description of the Experimental Area*

On-farm experiment was conducted for two years (2016/17 and 2017/18) during the Belg season at Koda Kebele, Chena woreda, Keffa Zone, Southwest Ethiopia. The study area lies between 7°05'67" N latitude and 35°42'98" E longitude. The experimental site is located about 530 km away from Addis Ababa; the capital city of Ethiopia along the southwest and about 90 km from the Zonal town of Bonga at an elevation of 2135 meters above sea level. The area received an average annual minimum and maximum Rainfall 1379-1889 mm in a bimodal pattern. The mean monthly temperature ranges from 14-28ºC [6]. The study area has predominantly Nitosols, with a textural class of clay loam. The pH of study soil is 4.71which is strongly acidic in reaction in accordance with [21] rating, that indicate a negative impact on the availability of most essential nutrients. Major crops grown in the study area include enset (*Enset ventricosum*), potato (*Solanum tuberosum*), maize (*Zea mays*), wheat (*Triticum aestivum*), cabbage (*Brassica oleracea*), carrot (*Daucus carota*), and Ethiopian cabbage (*Brassica carinata*). Wheat is extensively grown Cereals in the study area.

2.2. *Experimental Details and Treatment Set-ups*

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with seven treatments. Each treatment was replicated three times and the experiment was conducted for two consecutive years 2016/17. The experiment had seven treatments including: control (no inputs), RNP (64 N, 46 P2O5 kg/ha), 50% *Erythrina* +50% NP, 25% *Erythrina* +75% NP, 75% *Erythrina* +50% NP, 100% *Erythrina* only (6625 kg ha^{-1}), and 50% *Erythrina* only (3312.5 kg ha^{-1}) were used. Plot size used was 3*3 m (9 m^2) and spacing between rows 20 cm. Urea and DAP were used as source of N and P, respectively. Organic source, transferred *Eyrthrina bruci* biomass, also was used as N source. After chopping the leaf and twig part of *Eyrthrina* biomass, it has been distributed and incorporated one month ahead of planting test crop. DAP and half urea fertilizers were applied at planting (drilled in the rows of seed) whereas half of urea fertilizer is top dressed after 30 days of planting. Wheat variety “Dende’a’’ was used as test crop which is released by Kulumsa Agricultural Research Centre in

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2010 [12]. Wheat seed was drilled in the rows of 20 cm after fertilizer application and thin soil cover. All field managements were carried as per the recommendation of the area and all field observations were recorded.

2.3. *Data Collection*

All agronomic parameters including grain yield, above ground biomass, 1000 seed weight, plant height and spike length were collected and subjected to analysis of variance. Except grain yield and biomass, data were taken from 10 plants selected randomly.

2.4. *Data Analysis*

The collected data were subjected to statistical analysis. Analysis of variance (ANOVA) was carried out using SAS version 9.3 statistical software programs [18]. Least significant difference (LSD) at 0.05 level of probability was used to determine whether there was a significant difference between and among treatment means [10].

2.5. *Partial Budget Analysis*

Partial budget analysis was also carried out to evaluate the feasibility of fertilizer treatments for Wheat production by determining the net benefit and marginal rate of return (% MRR) obtained from the application of different organic and inorganic fertilizers. Wheat yield was valued at an average open market value of the local market price of Birr 900 per 100 kg, whereas average price of urea and DAP were Birr 10 and 11.12 per kg. The cost of other production practices like, weeding were assumed to remain the same among the treatments. The yield was down adjusted to reflect the situation in actual production by farmers [7].

III. Results and Discussion

Combined data analysis of the two seasons revealed that there was a highly significant (P = 0.02) difference among the treatment. Application of integrated or single *Erythrina* biomass or RNP significantly improved all tested parameters when compared with that of untreated control. Combined application of 25% *Erythrina* biomass and 75% recommended NP had significantly greater effect on mean wheat grain yield than the effects of untreated control, application of 100 per cent RNP, and application of 50 per cent *Erythtina* biomass (Table, 1).

Application of 100 per cent *Erythrina burci* alone gave similar wheat grain yield with combined application of 50:50, 75:25, 25:75 *Erythrina*: RNP ratio, suggesting the importance of *Erythrina* biomass as alternative nutrient source for wheat production at Chena. On the other hand, application of 50 percent N equivalent *Erythrina* biomass increased mean wheat grain yield by 41.3% over control. Significantly higher yield and other variables of wheat obtained with *E. bruci* biomass incorporated in to the soil compared with the control in this study could probably be due to the availability of nutrients to the crop from the nutrient-rich biomass of *E. bruci* and its N-fixation characteristics [25]. This result is in line with the findings of [2] who reported significant effect of *Erythrina* on grain and biomass yields of wheat at Sheka zone south west Ethiopia.

Again in agreement with, reports indicating that N-fixing biomass from leguminous trees incorporated into the soil as green manure greatly improve yield and yield components of several crops [15]. Biomass of Cajanus cajan applied at a rate of 4 t ha^{-1} increased the grain yield of maize by over 86% compared to the control [1].

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Positive effect of organic sources with or without inorganic fertilizers on different crops production was Reported by different authors [19] [23].

Table 1. Combined mean yield and yield components of Wheat as influenced by NP fertilizer and *Erythrina bruci* bio mass at Chena district.

Treatments	**PH(cm)**	**TPP**	**SL(cm)**	**TSW (gm)**	**BM (ton ha^{-1})**	**GY(kg ha^{-1})**
1. Control	75.62b	4.75c	7.30b	35.32d	5.44c	1958.3c
2. Recommended NP	78.77ab	6.77b	7.78a	42.42ab	7.78ab	2886.6b
3. 50% Ery N equi+50% NP	80.47a	6.90ab	7.77a	42.03ab	7.96ab	2963.0ab
4. 25% Ery N equi+75% NP	80.68a	8.22a	7.85a	44.37a	8.98a	3453.1a
5. 75% Ery N equi+25% NP	76.53b	6.73b	7.66ab	41.62ab	7.67ab	3020.8ab
6.100% Ery N equi only	78.28ab	6.52b	7.52ab	40.40bd	7.68ab	2993.0ab
7. 50% Ery N equi only	77.60ab	6.03bc	7.65ab	37.80cd	7.06ab	2766.2b
Mean	78.28	6.56	7.66	40.56	7.51	2863.03
LSD (0.05%)	1.83	0.72	0.22	1.98	1.94	491..12
CV%	3.68	17.41	4.55	7.69	13.47	15.09

Note: LSD (0.05%): least significant difference at 5% level; CV: coefficient of variation; GY; grain yield; BY; biomass yield; PH: plant height; SL: spike length; TPP: number of tillers per plant; TSW: thousand seed weight means in a column followed by the same letters are not significantly different at 5% level of significance.

It was further found in this study that combined application of 25% Ery N equi+75% NP fertilizers gave significantly higher grain yield of wheat compared to inorganic fertilizer applied alone. This result in line with the findings of [25] who reported that combined applications of organic and inorganic nutrient sources help ameliorate the shortcomings of sole application of either input. Integrated application of organic and inorganic nutrient sources result in synergistic effects on yield [3]. Nutrients applied as inorganic fertilizers along with organic sources are also retained for a long period of time in the soil than applied alone [17].

Plots that received *Erythrina* biomass and recommended NP increased plant height, spike length, tiller per plant and thousand seed weight of wheat as compared to the control (Table 1). However, the highest plant height, spike length, tiller per plant and thousand seed weight were achieved with the application of biomass at the rate of 25% Ery N equi+75% NP (1656.25 kg ha-^{1} *Erythrina* biomass +48N, 35 P_2O_5).

Integrated Application of *Erythrina* biomass with RNP was significant for yield components of Wheat (plant height and tiller per plant) which suggest change in the integrated level of *Erythrina* biomass and RNP alter the mean values of plant height and tiller per plant. In line with this finding [1], reported that the interaction between organic (Cajanus cajan biomass) and inorganic sources of nutrients were significant in yield components of Maize. Where this result contradicts the finding of [25], who reported application of different *Erythrina* biomass rates with RNP was not significant for yield components of wheat. The contradicting result may occur due to the difference in the decomposing rate of *Erythrina* which matters the amounts of nutrients released from *Erythrina* across location.

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Table 2. Partial budget and dominance analysis for NP and *Erythrina* biomass on Wheat at Chena district.

No.	Treatment	GY (Kg ha^{-1})	Adjusted GY (Kg ha^{-1})	GB (ETB ha^{-1})	FC (ETB ha^{-1})	EC (ETB ha^{-1})	FAC (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	% MRR
1	Control	1958.3	1762.2	15859.8	0	0	0	0	15859.8	
7	50% Ery N equi only	2766.2	2489.4	22404.6	0	2500	0	2500	19904.6	161.8%
2	Recommended NP	2886.6	2597.4	23376.6	2603.8	0	300	2903.8	20472.8	140.7%
4	25% Ery N equi+75% NP	3453.1	3107.7	27969.3	1952.9	1250	225	3427.9	24541.45	776.4%
3	50% Ery N equi+50% NP	2963	2666.7	24000.3	1301.9	2500	150	3951.9	20048.4	D
5	75% Ery N equi+25% NP	3020.8	2718	24462	651.0	3750	75	4476.0	19986.05	D
6	100% Ery N equi only	2993	2693.7	24243.3	0	5000	0	5000	19243.3	D

Note: Yield adjustment: 10%, ETB: Ethiopian Birr, GY: grain yield, FC: fertilizer cost, FAC: fertilizer application cost, EC; *Erythrina* cost, TVC: total variable cost, GB: gross benefit, NB: net benefit, D: dominated treatments that are rejected, MRR: marginal rate of return, Ery N equi; *Erythrina* biomass with Nitrogen equivalence.

Table 3. Analysis of net benefit and MRR% of NP and *Erythrina bruci* biomass fertilizers on Wheat after removal of dominated treatments.

Treatment	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR%
1	0	15859.8	
7	2500	19904.6	161.7%
2	2903.8	20472.8	140.7%
4	3427.9	24541.45	776.3%

Partial Economic Analysis

Mean wheat grain yield over years and partial budget analysis indicated better economic yield (3453.13 kg ha^{-1}) and highest net benefits (Eth. birr 24541.45) and % MMR (776.40%) were obtained by combined application of 25% *Erythrina* biomass and 75% RNP. Applications of either 50% *Erythrina* or RNP alone also gave modest net benefit and %MRR. Therefore, based on our current result combined application of 25% *Erythrina* and 75 % RNP (1656.12kg Erythrina +48N, 34.5P2O5 ha^{-1}) is recommended for optimum wheat production in the study area. Application of 50% *Erythrina* alone could also be used as an alternative source by farmers who can't afford inorganic fertilizers and that have access to *Erythrina*.

IV. Conclusions And Recommendations

The effect of organic fertilizer sources is beyond crop yield increment. Soil health, environmental effects and other long-term effects should be considered. Based on our current data significant wheat yield difference was observed by *Erythrina* application either combined or alone from that of control (no input).Better grain yield of

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wheat (3453.13 kg ha^{-1}) and higher net benefit was obtained by combined application of 25% *Erythrina* biomass and 75% recommended NP, though not statistically significant with application of 50:50, 75:25, 25:75 *Erythrina*: RNP ratio. Application of 100 and 50% fresh *Erythrina* improved wheat production when compared with untreated control and gave statistically similar wheat yield with combined applications of *Erythrina* and different ratios of recommended NP.

Partial budget analysis indicated that better economic yield (3453.13 kg ha^{-1}), highest net benefits (Eth. birr 24541.45) and % MMR (776.40%) were obtained by combined application of 25% *Erythrina* biomass and 75% RNP. Applications of either 50% *Erythrina* or RNP alone also gave modest net benefit and % MRR.

Therefore it is better to use 25% *Erythrina* biomass and 75% recommended RNP (1656.12 kg *Erythrina* +48N, 34.5P2O5 ha^{-1}) to get the highest yield and net benefit in the study area. Application of 50 percent *Erythrina* is also highly recommended as an option if labor source is not a problem and sufficient *Erythrina* plants are grown around the farm and in the same agro ecology.

V. Conflict of Interest

The author declared no conflict of interest.

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