International Journal of Bioorganic Chemistry
2024, Vol. 9, No. 2, pp. 14-18
https://doi.org/10.11648/j.ijbc.20240902.11

Research Article

Effects of Time Based Integrated Organic and Mineral Fertilizer Rate Application on Improved Coffee Cultivar Yield at Awada South Ethiopia

Leta Ajema Gebisa*

Ethiopian Institute of Agricultural Research, Wondo Genet Agricultural Research Center, Awada Agricultural Research Sub-center, Yirgalem, Ethiopia

Abstract

Coffee Production plays a significant role in Ethiopian economy, even though the productivity at farm level is among the lowest as compared to other coffee producing country. Soil degradation is one of the most challenging problems in coffee growing areas of Ethiopia. Declining soil fertility is a fundamental problem to agricultural growth and a major reason for slow growth of food production. Therefore, this activity was designed to determine optimum application time of integrated organic and inorganic fertilizers under coffee growing areas and to assess the effects of temporal application effects of integrated organic and inorganic fertilizers on coffee yield and yield stability performance of coffee cultivar. The experiment was conducted with RCBD design with four replications and ten treatments settled from integrated organic and inorganic inputs at Awada Agricultural research sub-center starting from 2013-2023 for the last 10 consecutive years. The result demonstrated that, application of 200kgha^{-1}N, 77kgha^{-1}P and 12.5ton ha^{-1} integrated nutrient application at each cropping season resulted statically significant higher yield result as compared to the other nutrient applications. The plot treated with the recommended NP + recommended decomposed coffee husk application per year (200kgha^{-1}N, 77kgha^{-1}P and 12.5ton ha^{-1}) indicated over all yield advantage over the other plots by 22.07% or 345kg/ha of clean coffee yield over the recommended (200kgha^{-1}N, 77kgha^{-1}P) applied alone per year and 33.39% or 522kg/ha of clean coffee yield over the plots treated with recommended decomposed coffee husk (12.5ton ha^{-1}) alone application per each cropping season.

Keywords

Coffee, Compost, Integrated Nutrient, Mineral Fertilizer, Temporal Variation

1. Introductions

Ethiopia stands in respect not only as the birthplace of coffee (*Coffea arabica* L,) with wide genetic diversity, and important and leading coffee producer 1st exporter from Africa and 5th worldwide, but the country is also the highest coffee consumer still with a significant domestic market increment. In addition to that, Ethiopia has immense production potential and opportunity because of favorable agro-climatic conditions. Coffee is a major source of export revenue generating about 30-35 percent of the country's total export earnings. Currently around 1,062,034.00 hector of land

*Corresponding author: letajema@gmail.com (Leta Ajema Gebisa)

Received: 2 October 2024; **Accepted:** 28 October 2024; **Published:** 20 November 2024

is covered by coffee cultivation that yields (761,500.00MT) during 2022/2023 cropping season with very low productivity not more than (7.17Q/ha) [1, 14]. In 2023/24 total production is forecasted to be 8.35 million 60 kg bags (501,000 MT). The coffee industry in Ethiopia is the driving force of the country's economy, socio-cultural, life of Ethiopian people. Even though coffee plays a significant role in Ethiopian economy, productivity at farm level is among the lowest in the world in the last decade. Soil degradation is one of the most challenging problems in coffee growing areas of the Ethiopia [2]. Soil fertility decline is the main issue in African agriculture in general and in Ethiopian in particular [3]. Farmers in most parts of the country work hard, in seasons of the year when the rainfall is favorable for their cropping. Declining soil fertility is a fundamental problem to agricultural growth and a major reason for slow growth of food production [4]. The soils are exposed to nutrient leaching over a long period of time resulting in low organic matter content and require careful management to support good crop yields. However, 95% of Ethiopian coffee farmers don't use inorganic fertilizers while the rest add it at levels significantly below the recommended rate [5].

As a result, productivity of coffee in the country remains very low demanding much more vigorous technological intervention in the sector [6]. Many agricultural soils of the world are deficient in one or more of the essential nutrients needed to support healthy plants. Additions of fertilizers and organic inputs amendments are essential for a proper nutrient supply and maximum yields. Developing nutrient managements against to soil fertility problem is very important and a serious challenge for crop production and productivity. Additionally, considering temporal and spatial aspects for developing more efficient and relevant methods of evaluating the yield of perennial crops can contribute to their better operational use [7, 8]. Therefore, this activity was designed to determine optimum application time of integrated organic and inorganic fertilizers under coffee growing areas and to assess the effects of temporal application effects of integrated organic and inorganic fertilizers on coffee yield and yield stability performance of coffee cultivar.

2. Materials and Methodology

Descriptions of the Study Area

The experiment was conducted at Awada Agricultural Research Sub-Center. The area has a semi-bimodal rainfall distribution with an average precipitation of 1354 mm per annum, while the annual average minimum and maximum air temperatures are 6 ℃ and 28.8 ℃, respectively. Since the area has bimodal nature of rain fall and continues through the year, the probability to occur drought as well as flood is relatively very low (Figure 1).

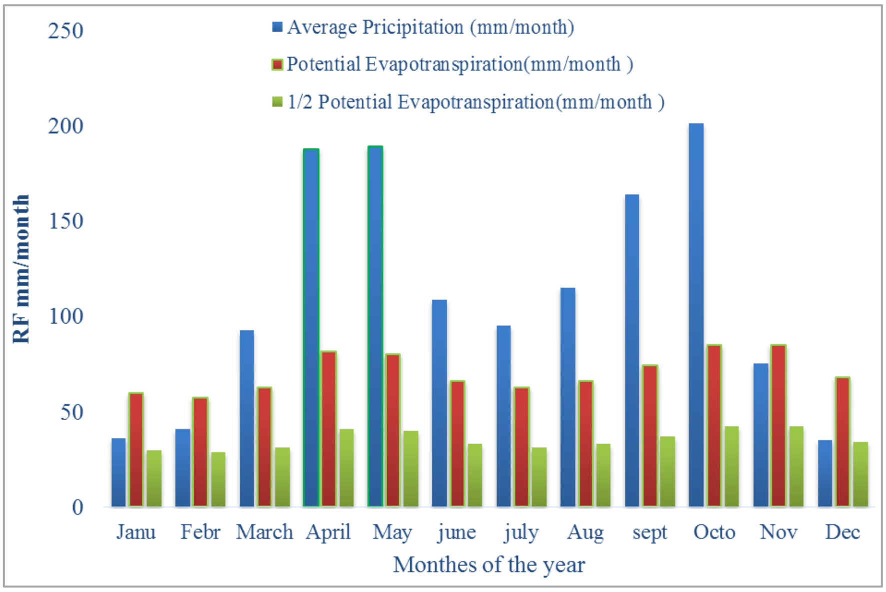

Figure 1. *Fain fall distribution throughout the year at the study area starting from (2013-2023).*

3. Treatment Descriptions

The treatments were superimposed on the already established coffee trees planted in April 2014. An open type of canopy class (Angafa) coffee cultivar was used for this activity. The treatments include the recommended rates of mineral fertilizer and decomposed compost to be applied with temporal variations described in the table below (Table 1). Compost was also prepared from locally available materials: maize straw, ash, and farmyard manure following the conventional compost preparation method (Solomon, 2006). A pit with 1m width and 1m depth was prepared to prepare the compost. Maize straw was added at the bottom of the prepared pit for keeping good ventilation; immediately on the maize straws, fresh coffee husk and pineapple residue was added to a thickness of about 20cm. and repeated up to the required amount.

The experiment was conducted using a randomized complete block design (RCBD) with four replications. The treatments applications were conducted with temporal variations, in all application season. Agronomic management's practices were also applied as per recommendation. Soil samples were collected from each experimental unit and set to lab analysis. Coffee yield and growth parameter data were collected in standard. The collected Yield data was analyzed and presented in the following table 1. The mineral fertilizer rate was adjusted settled based on the recommendation conducted by [9] at each coffee growing area of the country.

Table 1. *Adjusted treatment for Time based integrated organic and inorganic fertilizer applications.*

	Adjusted treatment	Treatments Amount ton/ha
1	Full Compost/year	12.5ton ha^{-1}
2	Half Compost/year	6.25ton ha^{-1}
3	Full Compost/two year	12.5ton ha^{-1}
4	Half Compost/two year	6.25ton ha^{-1}
5	Full NP/year	200kgha^{-1}N, 77kg ha^{-1}P
6	Half NP/year	100 kg ha^{-1}N 38.5kg ha^{-1}P
7	Full NP + Full Compost/two year	200kgha^{-1}N, 77kgha^{-1}P and 12.5ton ha^{-1}
8	Half NP + Half Compost/two year	100 kg ha^{-1}N 38.5kg ha^{-1}P and 6.25ton ha^{-1}
9	Half NP + Half Compost/year	100 kg ha^{-1}N 38.5kg ha^{-1}P and 6.25ton ha^{-1}
10	Full NP + Full Compost/year	200kgha^{-1}N, 77kgha^{-1}P and 12.5ton ha^{-1}

Composite soil sample was randomly collected from the experimental area before the treatment application and analyzed based on the soil lab setup and the result indicated within the following (Table 2). Compost preparation was also conducted based on the conventional compost preparation manual recommendation from locally available organic matter like coffee husk and 10% topsoil enhanced by animal manur, and ash to facilitate the decomposition process [13].

Data Analysis

All the measured coffee yield and growth parameters were summarized and subjected to analysis of variance (ANOVA) or one way ANOVA appropriate to RCBD using the General Linear Model (GLM) of Statistical Analysis System (SAS) software version 9.3 [10]. List Significant difference (LSD) at 5% probability level was used for mean separation.

4. Results and Discussion

Soil Sample Result

Table 2. *Soil lab. Result of decomposed local material with coffee husk at different season in piles with 10% topsoil after (60days) and composite soil sample collected from exp. Area.*

Compost Chemical Properties	Unit	Compost Sample		Composite soil sample
		2019	2020	
pH	pH scale	7.36	8.31	5.21
OM	%	15.46	15.53	4.84
OC	%	8.97	9.01	2.81
N	%	0.77	0.78	0.31
P	Ppm	9.2	11.8	19.03
C: N	Ratio	11.65	11.55	9.06

5. Clean Coffee Yield

The statically result indicates as the recommended application of integrated organic and inorganic fertilizer per year bear the highest yield and agronomic characteristics followed by recommended application of NP/years. The plot treated with the recommended mineral fertilizer (200kgha^{-1}N, 77kg ha^{-1}P) applied per year with the addition of full dose of recommended decomposed coffee husk (12.5ton ha^{-1}) application at each application time or per year, resulted the maximum over mean yield of clean coffee 1563kgha^{-1} in sequence by maintaining significantly higher yield and yield stability of the crop as compared to the other plot treated with less amount and longer (biennial) time of application (Table 3). The results inline with the experiment conducted at southwest part of the country by combining 50%recommended NP mineral fertilizer (172 and 77kg ha^{-1} NP, respectively) with 75% recommended decomposed coffee husk (10ton ha^{-1} or 4kg tree) and 50% recommended mineral fertilizer rate integrated with 50% recommended decomposed coffee husk yielded significantly higher average yields of 1752.2 and 2083.5 kg ha^{-1} clean coffee at Haru and Agaro, respectively [11]. The timing of application is critically significant, as the same quantity of treatment (200kgha^{-1}N, 77kgha^{-1}P) and the prescribed quantity of decomposed coffee husk (12.5tonha^{-1}) applied at differing intervals (biannual application) generates statistically lower outcomes, specifically 775kgha^{-1} (refer to Table 3), as it is different to the same treatment applied yearly. This could be because of harvesting coffee yield will remove huge amount of soil plant nutrients from the soil, that also previously indicated in the other research reports, producing a ton of Arabica coffee beans removes 135, 16 and 120 kg of N, P and K from the soil [12]. The plot treated with the recommended NP + recommended decomposed coffee husk per year (200 kgha^{-1}N, 77 kgha^{-1}P and 12.5ton ha^{-1}) indicated over all yield advantage over the other plots specifically 22.07% or 345 kg/ha of clean coffee yield over the recommended (200 kgha^{-1}N, 77 kgha^{-1}P) applied alone per year and 33.39% or 522kg/ha of clean coffee yield over the plots treated with recommended decomposed coffee husk (12.5 ton ha^{-1}) alone application per each cropping season. other options could be (200 kgha^{-1}N, 77 kg ha^{-1}P) mineral fertilizer rate application per each cropping season as it was able to bear 1218kgha^{-1} of clean coffee followed by the highly performing treatments. Nitrogen is an essential plant nutrient that the coffee tree requires for vegetative growth. When compared to other nutrients, it is required in large quantities by the coffee plant [12].

On the other hand, the lowest average mean yield result (589kgha^{-1}) and also the lowest yield at each cropping season was resulted from the plot treated with the half of the recommended compost application per two year as the nutrient deficiency symptom like branch dieback, and necking was also aggressively damaged coffee trees established on the plot (Table 3), followed by 663 kgha^{-1} harvested from the plot treated with half amount of recommended compost per year application. The result indicates that, it is very critical to focus on the integrated nutrient application that economically visible and technically applicable by coffee producer to enhance coffee yield and yield stability problem at the study area. These findings also illustrate the potential use of locally available organic and inorganic fertilizer sources integration for sustainable soil fertility amendment and promotion of sustainable coffee production at south Ethiopia.

Table 3. *Effects of time based Integrated organic and inorganic fertilizer application on mean yield of clean coffee (kun/ha).*

	Treatment	**2012**	**2013**	**2014**	**2015**	**OYMean**
1	Full Compost/year	5.97^{cd}	15.68^{b}	16.03^{ab}	3.97^{bc}	10.41^{c}
2	Half Compost/year	5.79^{d}	8.04^{def}	10.40^{cd}	2.30^{c}	6.63^{ef}
3	Full Compost/two year	7.58^{bcd}	8.70^{cde}	10.57^{cd}	3.19^{c}	7.51^{de}
4	Half Compost/two year	6.56^{bcd}	6.54^{f}	7.86^{d}	2.61^{c}	5.89^{f}
5	Full NP/year	9.34^{ab}	20.48^{a}	13.35^{bc}	5.55^{b}	12.18^{b}
6	Half NP/year	9.15^{abc}	7.38^{ef}	7.40^{d}	3.93^{bc}	6.97^{def}
7	Full NP + Full Compost/two year	6.62^{bcd}	10.31^{c}	11.68^{c}	2.4^{c}	7.75^{de}
8	Half NP + Half Compost/two year	7.10^{bcd}	8.64^{cdef}	8.27^{d}	3.69^{cb}	6.93^{ef}
9	Half NP + Half Compost/year	8.73^{abc}	9.58^{cd}	11.71^{c}	3.18^{c}	8.30^{d}
10	Full NP + Full Compost/year	11.02^{a}	22.17^{a}	17.87^{a}	11.48^{a}	15.63^{a}
LSD		3.28	2.12	3.32	1.88	1.34
CV (%)		29.10	12.45	19.88	30.75	10.51

6. Conclusion and Recommendation

Integrated organic and inorganic nutrient management for coffee production is a critical target for organic and sustainable coffee production for a long time and to solve the biannuality problem that is a major coffee sustainability constraint at the study area. In this trial, plot treated with the recommended NP with recommended decomposed coffee husk per year (200 kgha^{-1}N, 77 kgha^{-1}P and 12.5 ton ha^{-1}) showed a significant variation and have over all yield advantage over the other plots by 22.07% or 345 kg/ha of clean coffee yield over the recommended (200 kgha^{-1}N, 77 kgha^{-1}P) applied alone per year and 33.39% or 522 kg/ha of clean coffee yield over the plots treated with recommended decomposed coffee husk (12.5 ton ha^{-1}) alone application per each cropping season. The other plots treated with the same amount but, with different time of application need distinct/critical attention for sustainable coffee production. Therefore, the result indicates that, the previously recommended organic and/or inorganic as well as the integration of the recommended organic and inorganic nutrient application needs the further study to update the current soil fertility condition.

Abbreviations

OC	Organic Carbon
N	Nitrogen
OM	Organic Matter
P	Phosphorus

Author Contributions

Leta Ajema Gebisa is the sole Author. The author read and approved the final manuscript.

Acknowledgments

I would like to thank Ethiopian Institute of Agricultural Research (EIAR) for the financial support and Awada Agricultural Research Sub-Center for providing the experimental field for this study. I gratefully thank Mr. Amare Boku, Mr. Demeke W/Mariam and Mr. Abiyot Betessa for their unreserved technical and field assistants while working.

Conflicts of Interest

The author declares that there are no conflicts of interest.

References

[1] Overview of Ethiopian Coffee and Tea Authority (ECTA) Coffee Production and Productivity status published at April, 2023.

[2] Netsere, A. and Takala, B., 2021. Progress of soil fertility and soil health management research for arabica coffee production in Ethiopia. *Plant*, *9*(3), pp. 70-80.

[3] Taminaw Zewdie. Review on effects of integrated soil fertility management on sustainable crop production in Ethiopia. Int J Res Agron 2019; 2(1): 48-54. https://doi.org/10.33545/2618060X.2019.v2.i1a.67

[4] Bikila T, 2023. Integrated Nutrient Management for Improved Coffee Production at West and Southwest Ethiopia. A Review. Journal of Environment and Earth Science www.iiste.org ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol. 13, No. 2.

[5] Paulos Dubale. 1994. Ecology and soils of the major coffee growing regions of Ethiopia. In: PaulosDubale (ed.), Mineral Fertilization of Coffee in Ethiopia, Institute of Agricultural Research, Addis Ababa, Ethiopia.

[6] Solomon Endris. Tesfu, K. And Tesfaye, Y. 2008. Inorganic fertilizer management and coffee production. In: Coffee Diversity and knowledge (Girma, A; Bayetta, B; Tesfaye, S; Endale, T. and Taye, K. Edds). Proceedings of a National workshop four decades of coffee research and development in Ethiopia. Pp. 217-225.

[7] Zhu, Y., Yang, G., Yang, H., Guo, L., Xu, B., Li, Z., Han, S., Zhu, X., Li, Z., & Jones, G. (2022). Forecastingregional apple rst owering using the sequential model and gridded meteorological data withspatially optimized calibration. Computers and Electronics in Agriculture, 196, 106869. https://doi.org/10.1016/j.compag.2022.106869

[8] Sartore, L., Rosales, A. N., Johnson, D. M., & Spiegelman, C. H. (2022). Assessing machine leaningalgorithms on crop yield forecasts using functional covariates derived from remotely sensed data. Computers and Electronics in Agriculture, 194, 106704. https://doi.org/10.1016/j.compag.2022.1067041000387637331

[9] IAR (Institute of Agricultural Research). 1996. Recommended production technologies for coffee and associated crops, IAR, Addis Ababa.

[10] SAS (2012). Version 9.3SAS Institute Inc.

[11] Jimma Agricultural Research Centre (JARC). 2020. Progress report for the year 2019. EIAR/JARC, Jimma, Ethiopia.

[12] Wintgens J. N. 2004. Coffee: Growing, Processing, Sustainable Production. A guide for growers, traders, and researche.

[13] Solomon E (2006). Accelerated composting of coffee processing by products: an organic option for soil fertility management in the coffee-based cropping system of southwestern Ethiopia. Proceeding of 21st International scientific conference on coffee science (ASIC), Montpelier, France, pp 1084-1089.

[14] FAO-UNESCO, Soil maps of the world: 1: 50,000,000 Africa 6, Paris: UNESCO. 1977: 299.