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Research Article

Effects of organic manures on yield and yield attributes of coffee (*Coffea arabica* L.) genotypes

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ABSTRACT

An experiment was carried out to determine the effects of organic sources of fertilizers on yield and yield parameters of five coffee (*Coffea arabica*) genotypes at Gulmi district in 2015 to 2021. Five different source of organic manures (mustard cake @ 2 kg/plant, poultry manure @ 2.5 kg/plant, vermi compost @ 3 kg/plant, goat manure @ 4 kg/plant and FYM/cattle manure @ 5 kg/plant) was applied on five coffee genotypes (Chhetradip Local, Gulmi Local, Selection-10, Syangja Special and Yellow Cattura). Field experiment was laid out in factorial randomized complete block design with three replications. Irrespective of genotypes, the length of cherry was found maximum (15.3 mm) in mustard cake applied plants which was followed by poultry manure applied plants (15.2 mm). The average cherry length was found longest (15.3 mm) in Yellow Cattura and Syangja Special which was followed by genotype Chhetradip Local (15.1 mm). The highest diameter of cherry (12.7 mm) was obtained with the use of mustard cake followed by poultry manure (12.4 mm). The application of mustard cake produced the highest cherry yield (3.55 kg/plant) followed by poultry manure (3.43 kg/plant). Yellow Cattura produced the highest fresh cherry yield (3.34 kg/ha) followed by Selection-10 (3.07 kg/plant). Results indicate that poultry manure and Yellow Cattura are most effective for higher production of coffee.

Keywords: Coffee, organic manure, genotypes, interaction, yield

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INTRODUCTION

Coffee is one of the most important cash crops with high export value grown in the mid hill regions of Nepal. It is second important commodity in the world trade after petroleum product (Chadha, 2013) and it has high export value from Nepal (Chaudhary *et al*., 2008). It is used in respectable drinking material and contains 0.1- 0.3 % caffeine in instant coffee which stimulates and brings refreshers to human being after drink (Gautam & Dhakal, 1994). It is believed that firstly coffee seed introduced in the year 1943 and propagated at Aampchaur of Gulmi district. With the existence of favorable climatic condition along with coffee plants that grow well on rainfed uplands which is less suitable to other crops, the smallholder farmers are being positively attracted toward coffee farming in Nepal (Shrestha *et al.,* 2008). At present, it is cultivated in 44 out 77 districts of Nepal and has been commercialized in about 20 to 22 hills districts throughout countries (NTCDB, 2022).

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Generally, *arabica* and *robusta* species of coffees are commercially grown for bean production (Kuit *et al.*, 2004). In Nepal, 90% of coffee growing areas covered by *arabica* species. Similarly, almost 70% of total coffee production of coffee comes from *arabica* in world because it contains low caffeine thereby high quality and fetch higher price in the national and international markets rather than others (Wintgens, 2004). *arabica* species thrives very well in low to mid hills (600 to 1600 masl.) of Nepal (Kattel *et. al.,* 2010). Coffee plantation utilizes unutilized fallow land and shady areas. It also conserves the soil erosion and provides 20-25 % extra income from the companion intercropping tree species. Its cultivation is more labor intensive than most of the alternative crops grown on same land: providing additional employment opportunity to rural people (PACT, 2012) and therefore contribute to livelihood, income generation and economic growth (Helvetas, 2014). NTIS (2016) has also identified coffee as potential agriculture products for exports.

Therefore, Government of Nepal prioritized the coffee as a high value commodity. Coffee occupies 3057 ha land and produces 314.5 mt with an average productivity 103.21 kg/ha (MoALD, 2019/20) which is very low as compared to other countries. For example, the productivity of Costarica is 1582, Vietnam is 1477 and India is 947 kg/ha (Chadha, 2013). The inadequate agronomic techniques are the main causes of low productivity in coffee (Eshetu *et al*., 1999; Workafes & Kassu, 1999). The reason for the low productivity is the lack of stable varieties that display broad adaptation across a variety of conditions. Numerous studies (Yigzaw, 2005; Kassahun *et al*., 2007; Kebede & Bellachew, 2008) have documented the presence of significant genetic variation in Ethiopian arabica coffee germplasms. There is no adequate varietal research in response to organic fertilization in coffee in Nepal. The use of organic fertilizer enhances the soil's quality and the availability of nutrients for coffee trees. It also encourages water infiltration, holds onto more water, and enhances microbial activity in the soil (Simon, 2022). One of the fundamental components of sustainable agriculture is the use of organic methods for soil fertilization. In order to compet the global market against oversupply and price fluctuations, which in some years lead to a coffee price crisis, sustainable production is increasingly essential for the coffee industry (Chemura, 2014).

Since last 10 years coffee yield is drastically decreased but number of farmer's involvement in coffee farming is almost same.Therefore this investigation was done to identify suitable high yielding varieties and organic manures for increasing production and productivity of coffee and to promote the export trade in Nepal.

MATERIALS AND METHODS

The experiment was conducted at the research block of Coffee Research Program (CRP), Bhandaridanda. Rurukshera Rural Municipality,Gulmi district of of Nepal (27^{o}56'17.85"N, 83^{o}25'29.21"E and 895 masl). The Experimental block was established on 27^{th} March, 2015. The experiment was designed as 5 × 5 factorial Randomized Complete Block Design (RCBD) with three replications. There was five source of organic manures (1. mustard cake @ 2 kg/plant; 2. poultry manure @ 2.5 kg/plant; 3. vermicompost @ 3 kg/plant; 4. goat manure @ 4 kg/plant; and 5. FYM/cattle manure @ 5 kg/plant) and five coffee genotypes (1. Chhetradip Local; 2. Gulmi Local; 3. Selection-10; 4. Syangja Special; and 5. Yellow Cattura). The source of these genotypes is Coffee Research Program (CRP), Gulmi, Nepal. Organic manures were considered as factor A and genotypes were considered as factor B. The soil of the experimental site was sandy loam with pH moderately acidic, medium to low organic matter, medium in nitrogen and potash but high phosphorus content. The experimental site was located at the subtropical humid climate condition of Nepal. The area has sub-humid type of weather condition with cool winter and hot summer. Approximately

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16 months old and 1.5 feet tall seedlings of coffee were planted at 50 × 50 × 50 cubic cm pit at 2 m × 2 m spacing and 4 plants of each genotype were maintained in each plot of 16 square meters under natural mixed shade conditions and maintained 40-50% shade. All organic manures were applied at basal dose during planting and 25% dose of all organic manures were increased from 3rd year and applied twice in a year 1st after harvest and 2nd at fruit maturation stage. All the cultural practices were performed as per needed. Observations were taken when plants were full mature stage from 4th year onward (December, 2019 to March, 2021) on physiological and yield attributing parameters in consecutive two years. The collected data was processed and analyzed for ANOVA. Mean comparison of the treatments was done using least significance difference (LSD). Statistical software GenStat discovery 18th Edition (VSNi, 2015) was used to analyze the data.

RESULTS AND DISCUSSION

RESULTS

Length of fresh cherry

The effect of organic manures on length of fresh cherry of five coffee genotypes is given in Table 1. The organic manure, genotypes and their interaction were found significant for length of fresh cherry (Table 1). The highest length of fresh cherry was found with the application of mustard cake (15.3 mm) followed by poultry manure (15.2 mm). Yellow Cattura and Syangja Special produced the highest length of fresh cherry (15.3 mm) followed by Chhetradip Local (15.1 mm).

Table 1: Effect of organic manures on length (mm) of mature ripe fresh cherry of five coffee genotypes during 2019 to 2021

Organic manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	15.2	15.1	15.5	15.7	15.3	15.3
Poultry Manure	14.9	15.4	15.4	15.1	15.3	15.2
Vermi Compost	15.4	14.7	14.6	15.2	15.2	15.0
Goat Manure	15.0	15.1	15.0	15.2	15.2	15.1
FYM/Cattle Manure	15.1	14.6	14.7	15.2	15.4	15.0
Mean of genotype	15.1	15.0	15.0	15.3	15.3	
Mean of the year	1st year: 14.5		2nd year: 15.7			
Significance of factor	F-test		Significance of factors		F-test	
Factor A	**		Year × Factor A		NS	
Factor B	**		Year × Factor B		NS	
Factor A × B	**		Year × Factor A ×Factor B		NS	
Year	**					
CV (%): 4.2						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

Diameter of fresh cherry

The effect of organic manures on diameter of fresh cherry of five coffee genotypes is given in Table 2. The effect of organic manure and genotypes were found significant (P<0.01) in fresh cherry diameter. The interaction between organic manure and genotypes was found non-significant. The highest diameter of fresh cherry was found with the application of mustard cake (12.7 mm) which was followed by poultry manure (12.4 mm). Selection-10 and Syangja Special produced the highest length of fresh cherry (12.6 mm) which as followed by Yellow Cattura (12.1 mm).

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Table 2: Effect of organic manures on diameter (mm) of fresh cherry of five coffee genotypes at the time of harvesting during 2019 to 2021

Organic manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	12.4	12.3	12.9	13.7	12.1	12.7
Poultry Manure	12.0	12.2	13.1	12.4	12.5	12.4
Vermi Compost	11.9	12.0	12.4	12.1	11.9	12.0
Goat Manure	12.1	12.0	12.4	12.3	12.0	12.2
FYM/Cattle Manure	11.5	12.3	12.2	12.4	12.8	12.2
Mean of genotype	12.0	12.1	12.6	12.6	12.3	
Mean of the year	1st year: 12.12		2nd year: 12.42			
Significance of factor	F-test		Factors significance		F-test	
Factor A	**		Year × Factor A		NS	
Factor B	**		Year × Factor B		NS	
Factor A×B	NS		Year × Factor A × Factor B		NS	
Year	NS					
CV (%): 4.2						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

Total soluble solid (%) and moisture content (%) of fresh cherry

The effect of organic manures on total soluble solid (%) of five coffee genotypes is given in Table 3. The interaction effect of organic manure and genotypes in total soluble solids (TSS%) were found non-significant. The total soluble solid (%) was found from 13.6 to 14.3 irrespective of genotypes. Selection-10 and Syangja Special produce the highest total soluble solid (%) (13.9%) followed by Gulmi Local (13.6%).

Table 3: Effect of organic manures on total soluble solid (%) of fresh cherry of five coffee genotypes during 2019 to 2021

Organic manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	14.3	14.4	14.2	14.4	14.2	14.3
Poultry Manure	13.5	13.2	14.5	12.9	15.0	13.8
Vermi Compost	14.0	12.6	13.5	13.7	14.2	13.6
Goat Manure	12.8	13.9	13.5	14.6	13.1	13.6
FYM/Cattle Manure	14.2	14.1	13.6	13.7	14.4	14.0
Mean of Genotype	13.7	13.6	13.9	13.9	14.2	
Mean of the year	1st year: 12.10		2nd year: 15.61			
Significance of factor	F-test		Factors significance		F-test	
Factor A	NS		Year × Factor A		NS	
Factor B	NS		Year ×Factor B		NS	
Factor A×B	NS		Year × Factor A × Factor B		NS	
Year	**					
CV (%): 4.2						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

The effect of organic manures on moisture content (%) of coffee genotypes is given in Table 4.The organic manure and genotypes were found non significant for moisture content (%) of fresh cherry. The interaction between organic manure and genotypes was found non-significant. The average moisture content of fresh cherry ranges from 49.4 % to 52.3% in different manure applied plants where as it ranges from 50.1% to 51.3% in different coffee genotypes.

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Table 4: Effect of organic manures on moisture content (%) of fresh cherry of five coffee genotypes at the time of harvesting during 2019 to 2021

Organic manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	49.5	47.9	47.3	50.9	51.3	49.4
Poultry Manure	50.5	50.0	52.0	50.0	50.3	50.6
Vermi Compost	50.6	51.4	49.3	50.5	52.9	50.9
Goat Manure	49.5	52.1	50.0	51.1	49.4	50.4
FYM/Cattle Manure	52.3	53.2	51.8	51.8	52.4	52.3
Mean of genotypes	50.5	50.9	50.1	50.8	51.3	
Mean of the year	1st year: 47.71		2nd year: 53.72			
Significance of factor	F-test		Factorssignificance		F-test	
Factor A	NS		Year × Factor A		NS	
Factor B	NS		Year × Factor B		NS	
Factor A×B	NS		Year × Factor A × Factor B		NS	
Year	**					
CV (%): 7.6						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

Number of low graded (fallen and dry) cherry

The effect of organic manures on number of dry plus fallen cherry/plant of five coffee genotypes is given in Table 5. The organic manure and genotypes were found significant (P<0.01) for number of dry plus fallen cherry/plant (Table 5).

Table 5. Effect of organic manures on number of dry plus fallen of cherry per plant of five coffee genotypes during 2019 to 2021

Organic manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	110	403	180	191	220	221
Poultry Manure	117	227	122	152	162	156
Vermi Compost	114	100	67	88	74	89
Goat Manure	77	119	249	161	157	153
FYM/Cattle Manure	70	155	236	295	197	191
Mean of genotype	98	201	171	177	162	
Mean of the year	1st year: 155		2nd year: 168			
Factors significance	F-test		Factors significance		F-test	
Factor A	**		Year × Factor A		**	
Factor B	**		Year × Factor B		**	
Factor A×B	**		Year × Factor A × Factor B		**	
Year	NS					
CV (%): 32.0						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

The interaction between organic manure and genotypes was found significant (P<0.01). The highest number of dry plus fallen cherry/plant was found with the application of mustard cake (221) followed by FYM/cattle manure (191). Gulmi local produced the highest number of dry plus fallen cherry/plant (201) followed by Syangja Special (177).

Production of number of fresh cherry

The effect of organic manures on number of fresh cherry production/plant five coffee genotypes is given in Table 6. The organic manure and genotypes were found significant (P<0.01) for number of fresh cherry production/plant. The interaction between organic

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manure and genotypes was found non significant. The highest number of fresh cherry produciton/plant was found with the application of poultry manure (2655) followed by goat manure (2484). Yellow Cattura produced the number of fresh cherry produciton/plant (2507) followed by Selection-10 (2102) .

Table 6: Effect of organic manures on number of fresh cherry per plant of five coffee genotypes during 2019 to 2021

Organice manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	2562	1976	2497	2320	2953	2462
Poultry Manure	2610	2216	2564	2716	3170	2655
Vermi Compost	1607	1264	1165	1204	1606	1370
Goat Manure	2581	2166	2642	2415	2613	2484
FYM/Cattle Manure	1089	855	1643	1386	2194	1433
Mean of genotype	2090	1696	2102	2008	2507	
Mean of the year	1st year: 1374		2nd year: 2788			
Factors significance	F-test		Factors significance		F-test	
Factor A	**		Year × Factor A		**	
Factor B	**		Year × Factor B		**	
Factor A×B	NS		Year × Factor A × Factor B		**	
Year	**					
CV (%): 19.2						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

Yield of fresh cherry

The effect of organic manures on fresh cherry yield (kg/plant) of five coffee genotypes is given in Table 7.

Table 7: Effect of organic manures on fresh cherry yield (kg/plant) of five coffee genotypes during 2019 to 2021

Organic manure (Factor A)	Genotypes (Factor B)					
	Chhetradip Local	Gulmi Local	Selection -10	Syangja Special	Yellow Cattura	Mean of OM
Mustard Cake	3.71	2.71	4.16	3.03	4.13	3.55
Poultry Manure	3.44	2.86	3.69	3.38	3.79	3.43
Vermi Compost	2.10	1.48	1.98	2.3	2.32	2.04
Goat Manure	3.34	2.54	3.61	2.93	3.65	3.21
FYM/Cattle Manure	1.61	1.08	1.89	1.72	2.82	1.82
Mean of genotype	2.84	2.13	3.07	2.67	3.34	
Mean of the year	1st year: 1.91		2nd year: 3.72			
Factors significance	F-test		Factors significance		F-test	
Factor A	**		Year ×Factor A		**	
Factor B	**		Year × Factor B		NS	
Factor A×B	NS		Year × Factor A ×Factor B		NS	
Year	**					
CV (%) : 22.7						

CV: Coefficient of Variation, NS: Non-Significant, **P<0.01

The genotypes and organic manures were found significant (P<0.01) for fresh cherry yield whereas organic manure produced the non significant difference in the second year. The interaction between organic manure and genotypes was found non significant. The highest fresh cherry yield was found with the application of mustard cake (3.55 kg/plant) followed by

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poultry manure (3.43 kg/plant). Yellow Cattura produced the highest fresh cherry yield (3.34 kg/ha)) followed by Selection-10 (3.07 kg/plant).

DISCUSSION

In our experiments, organic manures influenced various yield attributing traits of coffee i.e., length of fresh cherry (Table 1), diameter of fresh cherry (Table 2) and number of fresh cherry production/plant (Table 6). The yield of coffee is greatly affected by genotypes and sources of organic manures (Table 7). Yellow Cattura yielded the highest cherry (3.34 kg/plant) followed by Selection-10 (3.07 kg/plant) which was also reported by other researchers.These results are similar with the results given in annual reports of 2019/20 and 2020/21 of Coffee Research Program, Gulmi, Nepal (CRP, 2019/20; CRP, 2020/21). Chaudhary *et al.* (2008) and Chaudhary *et al.* (2022) have found genotypic variation among the coffee cultivars. The use of organic fertilizers is one of the key elements in organic/sustainable coffee farming. Because organic matter serves as a water reservoir, a source of nutrients, and an enhancement to the physical soil qualities, coffee plants need a lot of it in their soil. The negative impacts of using chemical fertilizers are lessened by using organic manures. Continuous usage of chemical fertilizers can result in the buildup of heavy metals in a plant's tissues, which will ultimately affect the quality of its fruit (Shimbo *et al.*, 2001). Organic fertilizers that are used to produce coffee cherry are appropriate agroecological options because they support the physical, chemical, and biological features of the substrate and allow for adequate plant growth and development when combined with soil. In our experiments, five source of organic manures namely mustard cake, poultry manure, vermicompost, goat manure and FYM/cattle manure were applied. Cattle manure/FYM has the potential to be used as an organic source of nutrients in the coffee production (Chemura *et al*., 2010; Lekasi *et al*., 2001; Njoroge *et al.,* 1990). Due to its high concentration of essential nutrients like N, P, and K, poultry manure is an excellent organic fertilizer (Farhad *et al.*, 2009). Since urine and solid excreta are combined in poultry droppings, neither nitrogen nor uric acid is lost by urine, which is why poultry manure is referred to as a distinctive organic waste. Mustard cake fertilizer, which is high in protein, is great for producing coeffee. Application of goat manure reduces soil acidity and acts as a soil acidity alleviating agent. Goat manure improves soil texture, which increases plant uptake of nitrogen and increases water usage efficiency. Goat manure contented higher amounts of phosphorus and potash were also released which improved the production of more berries, increased their weight, and increased the yield of coffee (Govindappa *et al*., 2022).

CONCLUSION

The genotypes and different organic manures affected the yield and yield parameter of coffee. The highest fresh cherry yield was found with the application of mustard cake followed by poultry manure. Yellow Cattura produced the highest fresh cherry yield followed by Selection-10. Therefore farmers can miximize their coffee produciton through the application of poultry manure and mustard cake and cultivating coffee genotype Yellow Cattura.

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Authors' contribution

J.N. Chaudhary designed and conducted the experiment, recorded and analyzed data and wrote the manuscript. K.B. Thapa, Y.R. Bhusal, T.P. Gotame, K.B. Thapa and D.S. Shrestha gave idea in conducting the experiment and data analysis. J. Shrestha edited the manuscript and contributed for the final preparation of the manuscript. All authors listed have made a substantial, direct and intellectual contribution to the study, and approved it for publication.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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