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ORIGINAL RESEARCH ARTICLE

Effects of different fertilizers on the growth and yield of okra (*Abelmoschus esculentus* L.) in summer season in Chitwan, Nepal

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ABSTRACT

An experiment was conducted in the Horticulture Farm of Agriculture and Forestry University to demonstrate the effects of different fertilizers on the yield and yield parameters of okra (var. Arka Anamika). The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of seven treatments and three replications. The various treatments used in the experiment were goat manure, sesame cake, mustard cake, synthetic fertilizer (NPK), poultry manure, vermicompost and untreated control. The required dose of nitrogen was fulfilled by the fertilizer itself whereas insufficient amount of phosphorous and potassium was fulfilled by addition of single super phosphate and muriate of potash respectively. The fertilizers were applied on the basis of recommendation given by the Nepal Agriculture Research Council (NARC). The effect of poultry manure on number of open flowers and number of fruits at 40 DAS was found superior. The effect of poultry manure on plant height, number of leaves, plant diameter was found superior at 50 DAS. Goat manure produced the superior result on number of open flowers at 50 DAS. Poultry manure on the number of leaves and plant height produced the significant result at 60 DAS. Synthetic fertilizer responded well to number of fruits at 60 DAS. Sesame cake produced the superior results at 70 DAS on number of buds. Poultry manure responded well to all the parameters and produced the yield of 200 qt./ha with the BC ratio of 1.77. This experiment suggests the farmers to use the poultry manure to get the highest economic return. Vermicompost and mustard cake producing the superior and significant yield in this research are not recommended as they have low BC ratio unless effective measures are encouraged to reduce the cost of this fertilizers.

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INTRODUCTION

Okra *(Abelmoschus esculentus)* is an important summer vegetable of Nepal which belongs to family *Malvaceae* (Maurya *et al*., 2013). It was originated from Africa and spread to tropics, subtropics and warmer part of temperate region. Okra is the rich source of carbohydrate, amino acids, vitamin which have multipurpose use like fresh or cooked consumption, as fodder to animal, medicinal and industrial use (Farinde *et al*., 2007; Kumar *et al*., 2017). Okra response very well to fertilizer application and an effective fertilizer use is the key to its higher growth and yield (Buob, 2008; Kumar, 2019).

Mineral fertilizers only assure the rapid and short-term growth and yield improvement (Ware and Collum, 1980) but become unable to ensure sustainability of agricultural production (Titiloye *et al*., 1985). The application of organic manure could ameliorate the acidic condition of soil to improve crop production (Akande *et al*., 2003). Poultry manure in comparison to

other supplies more nutrient to plant (Garg and Bahl, 2008). In addition to releasing nutrients, poultry manure is rich in organic matter which improves the physical properties of soil (Ayeni, 2011). Poultry manure increases plant height (Aniefiok, 2013). Earthworm manures is known to restore the destructive effect of chemical fertilizers and improve soil properties and facilitates the growth of the crops (Sinha, 2009). Continuous use of vermicompost reclaims the soil and rejuvenates it. The growth, number of pods and yield of okra increased with increasing amount of goat manure (Awodun, 2007). Various plant originated manures like mustard oil cakes, sesame oil cakes, peanut cakes, castor cakes helps in plant growth and increase yield by reducing the incidence of phytonematodes (Frederick, 2015; Sumbul, 2015). In this investigation, the effect of different organic and inorganic fertilizers on the growth and yield of okra were studied.

MATERIALS AND METHODS

Experimental site

It was carried out in the horticulture farm of Agriculture and Forestry University. The latitude and longitude of the research site is 27°37' and 84°37', respectively. The experiment was conducted from April 7, 2018 to July 2, 2018 and took 85 days from sowing to economic harvesting. It is located at an altitude of 250 meters above sea level. The soil status of the experimental site during field preparation was obtained by soil analysis report from Agriculture Technology Center, Lalitpur, Nepal (Table 1).

Experimental design

This experiment was carried out in Randomized Control Block Design (RCBD). It consists of 7 treatments and is replicated 3 times. The spacing of 50cm × 30cm and wide spacing of 1m around the research plot was used. Spacing of 75cm was used to separate the treatments and replications. The area of the plot is 2.5m × 1.8m and thus covering 4.5m^2. The research filed covers the entire area of 210.1 m^2.

Table 4. Effect of different fertilizers on performance of okra at 10 DAS.

Treatments	10 DAS	
	Plant height (cm)	Number of leaves
Vermicompost	6.733333	3.066667
Sesame cake	6.800000	3.000000
Synthetic fertilizer	6.400000	3.000000
Goat manure	7.300000	2.933333
Mustard cake	6.333333	2.933333
Poultry manure	6.600000	2.933333
Control	6.433333	2.866667
SEM(±)	0.15	0.02
LSD (0.05)	1.05	0.168
CV (%)	8.86	3.18
F-test	NS	NS

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant.

Table 1. Description of soil status of the research field.

Description	Properties
Soil texture	Sandy Loam
Organic matter percentage	3.5
Soil pH	5.54
Electrical conductivity (mmho/cm) at 25©	0.13
Nitrogen percentage	0.17
P_2O_5 (Kg/ha)	55.09
K_2O (Kg/ha)	342.58
Sand percentage	76.4
Silt percentage	18.67
Clay percentage	6.04

Brassica oleracea var. botrytis was grown last season in this research field. Arka Anamika is resistant to yellow vein mosaic virus.

Table 2. NPK content of different fertilizers.

Manures	N%	P%	K%
Goat manure	3	1	2
Sesame cake	6.61	2.1	1.1
Mustard cake	4.52	1.78	1.4
Poultry manure	1.2	0.45	0.8
Vermicompost	2.35	1.6	1.5

Table 3. Amount of different fertilizer added in the research field.

Manures	Applied manures (for N) kg	SSP (g)	MOP (g)
Goat manure	3.000	318.75	-
Sesame cake	1.361	327.56	20.03
Mustard cake	1.991	284.75	-
Poultry manure	7.500	295.31	-
Vermicompost	3.829	123.25	-
Synthetic fertilizer (NPK)	126.74 g Urea	176.08 g DAP	45
Control	-	-	-

Treatment and trial management

There are seven different treatments used in the experiment. They are: T1: Goat manure, T2: Sesame cake, T3: Mustard cake, T4: Synthetic fertilizers (NPK), T5: Poultry manure, T6: Control and T7: Vermicompost. The field was prepared 5 days before sowing and seed was sown after soaking for 24 hrs. Required dose of fertilizer application was given by Nepal Agriculture Research Council (NARC) i.e. 200:180:60 kg NPK/ha which accounts 90:81:27 g NPK/ 4.5 m^2. The NPK content different fertilizer determined by animal science laboratory of AFU is given in Table 2.

The manures were applied to fulfill the required dose of nitrogen. Insufficient dose of phosphorous and potassium were applied through single super phosphate (SSP) and muriate of potash (MOP) respectively. The applied manures per plot are given in the Table 3.

Data collection

There were altogether 30 plants in each plot. There were 18 border plants and 12 inner plants. Out of the 12 inner plants, 5 plants were sampled by using randomizer application and the data were collected on the following parameters.

Estimation of vegetative parameters

Plant height: The plant height was measured in 10DAS, 20DAS, 30DAS, 40DAS, 50DAS and 60 DAS. It was measured using the measuring tape from the base to the tip of the plant.

Plant diameter: The data for the plant diameter was measured in 20DAS, 30DAS, 40DAS, 50DAS and 60DAS. The plant diameter was measured just below the 1st node from the ground.

Number of leaves: The number of fully leaves was measured in 10DAS, 20DAS, 30DAS, 40DAS, 50DAS and 60 DAS.

Reproductive parameters

Number of pods: The total number of pods was counted in 40DAS, 50DAS, 60 DAS and 70 DAS.

Number of fruits: The total number of fruits was counted in 40DAS, 50DAS, 60DAS and 70 DAS.

Number of flowers: The total number of fully opened flowers was counted in 40DAS, 50DAS, 60DAS and 70 DAS.

Yield: Okra fruits were collected in every 3 days by multiple harvesting from 45 DAS and they were picked 20 times up to economic production level.

Statistical analysis

The data were collected and recorded in MS-Excel (Office Package 2007) and subjected to statistical analysis according to one-way ANOVA using R-stat (version: 3.4.2).

Economic analysis

BC ratio of various treatments was calculated. The cost of various materials involved in the research was: Goat manure: NRs 5/kg, Sesame cake: NRs 25/kg, Mustard cake: NRs 30/kg, Poultry manure: NRs 5/kg, Vermicompost: NRs 18/kg, Urea: NRs 20/kg, DAP: NRs 45/kg, SSP: NRs 18/kg, Okra seed: NRs 3500/kg, MOP: NRs 60/kg, Labour: NRs 600/day, NRs 30/kg of the produce. It was calculated by adding all the cost except fertilizers to obtain the common cost (Table 12). The common cost was added to the cost of manures to obtain the total cost (Table 13). The yield was multiplied by the average value of the produce to obtain the benefit (Table 14). Thus BC (Table 14) ratio was calculated.

Meteorological data during the investigation from April 7 to July 2

National Maize Research Program (NMRP) under Nepal Agriculture Research Council (250 m far from the research site) provided required meteorological data of the entire cropping period. The maximum temperature ranges from 27.2 °C to 38.01°C and the minimum temperature ranges from 27.02°C to 29.8°C. The research field received 385mm rainfall during the entire cropping period (Figure 1).

RESULTS AND DISCUSSION

The effect of plant height and number of leaves at 10 DAS was found non-significant (Table 4). Similarly, the effect of plant height, number of leaves and plant diameter at 20 DAS was found non-significant (Table 5). Same result continues with the okra plant at 30 DAS (Table 6).

In 40 DAS, the effect of plant height, number of leaves, plant diameter and number of buds was found non-significant. But, the data for the number of open flowers and number of fruits was found significant at 1% and 5% level of significance respectively (Table 7). Poultry manure and vermicompost was found superior in case of number of buds whereas poultry manure, goat manure, vermicompost and mustard cake were found superior in case of number of fruits. The result corresponds with the findings of (Ajari *et al.*, 2003) in which Poultry manure was found superior in comparisons to other organic manure.

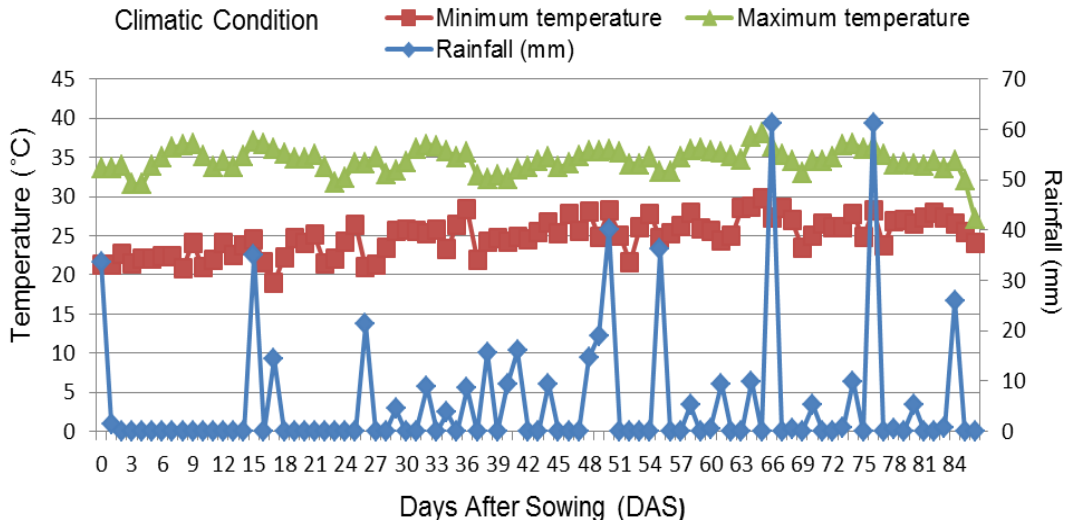

Figure 1. *Meteorological data during the investigation from April 7 to July 2.*

Table 5. Effect of different fertilizers on performance of okra at 20 DAS.

Treatments	20 DAS		
	Plant height (cm)	Number of leaves	Plant diameter (cm)
Goat manure	7.300000	5.466667	0.5400000
Sesame cake	6.800000	5.266667	0.5500000
Vermicompost	6.733333	5.600000	0.5133333
Poultry manure	6.600000	5.866667	0.5666667
Synthetic fertilizers	6.400000	5.600000	0.6133333
Mustard cake	6.333333	5.400000	0.5866667
Control	6.300000	5.633333	0.5466667
SEM(±)	0.15	0.1	0.01
LSD (0.05)	0.801	0.911	0.893
CV (%)	6.78	9.23	8.97
F-test	NS	NS	NS

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant.

Table 6. Effects of different fertilizers on performance of okra at 30 DAS.

Treatments	30 DAS		
	Plant height	Number of leaves	Plant diameter
Mustard cake	26.93333	7.466667	0.7266667
Synthetic fertilizers	26.93333	8.333333	0.7066667
Poultry manure	24.90000	8.666667	0.7000000
Sesame cake	26.13333	7.400000	0.6800000
Goat manure	26.26667	8.466667	0.6133333
Vermicompost	25.13333	8.666667	0.6066667
Control	23.46667	7.600000	0.5933333
SEM(±)	0.44	0.2	0.02
LSD (0.05)	3.26	1.57	0.128
CV (%)	7.15	10.9	10.9
F-test	NS	NS	NS

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant.

Table 7. Effects of different fertilizers on performance of okra at 40 DAS.

Treatments	40 DAS					
	Plant height	Number of leaves	Plant diameter	Number of buds	Number of open flowers	Number of fruits
Vermicompost	53.66667	17.46667	1.19333	5.066667	0.3666667^{a}	0.8666667^{a}
Poultry manure	59.20000	17.13333	1.27333	5.866667	0.6333333^{a}	0.9666667^{a}
Mustard cake	55.33333	15.53333	1.26667	5.066667	0.3666667^{b}	0.9333333^{a}
Synthetic fertilizers	60.86667	15.00000	1.28000	6.466667	0.3000000^{b}	0.6000000^{ab}
Sesame cake	61.40000	14.80000	1.28000	5.133333	0.3666667^{b}	0.6666667^{ab}
Goat manure	60.20000	14.20000	1.24000	4.466667	0.3000000^{b}	0.9333333^{a}
Control	51.76667	14.00000	1.20333	5.033333	0.2666667^{b}	0.4000000^{b}
SEM(±)	1.17	0.72	0.03	0.24	0.03	0.06
LSD (0.05)	8.96	5.47	0.21	2.07	0.154	0.38
CV (%)	8.76	19.9	9.44	21.9	23.4	27.8
F-test	NS	NS	NS	NS	**	*

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant, *: 5% level of significance, 1% level of significance.

In 50 DAS, the vegetative parameters such as plant height, number of leaves and plant diameter was found significant at 5% probability level. The reproductive parameters such as number of buds and number of open flowers were found non-significant. The data for the number of fruits was found significant at 5% probability level (Table 8). In all the cases poultry manure was found superior except in the number of buds, where goat manure was found superior. In 60 DAS, the effect on plant height was found non-significant. Whereas, the data for the number of leaves and plant diameter was found significant at 5% and 1% probability level respectively. In both the cases, poultry manure was found superior. The effect on number of fruits was found significant at 5% probability level (Table 9). Synthetic fertilizer was found superior followed by poultry manure, vermicompost, sesame cake, goat manure, mustard cake and control. The effect on the number of fruits was found non-significant (Table 9). In 70 DAS, the effect on number of buds was found statically significant at 5% probability level. Sesame cake produced the superior number of buds followed by poultry manure, synthetic fertilizers, goat manure, mustard cake, vermicompost and untreated control. The effect on number of open flowers and number of fruits was found non-significant (Table 10).

Table 8. Effects of different fertilizers in performance of okra at 50 DAS.

Treatments	50 DAS					
	Plant height	Number of leaves	Plant diameter	Number of buds	Number of open flowers	Number of fruits
Poultry manure	88.73333^{a}	26.73333^{a}	1.960000^{a}	5.666667	0.6666667^{ab}	2.066667
Vermicompost	87.13333^{a}	24.93333^{a}	1.833333^{ab}	6.800000	0.6666667^{ab}	1.400000
Sesame cake	84.20000^{abc}	19.73333^{bc}	1.746667^{abc}	8.200000	0.3333333^{c}	1.333333
Goat manure	54.66676^{ab}	22.06667^{abc}	1.586667^{abc}	6.933333	0.8000000^{a}	1.466667
Mustard cake	77.46667^{bcd}	18.80000^{c}	1.500000^{bc}	6.600000	0.4666667^{bc}	1.733333
Synthetic fertilizers	75.20000^{cd}	17.93333^{c}	1.343333^{c}	8.666667	0.4666667^{bc}	1.666667
Control	72.36667^{d}	17.00000^{c}	1.336667^{c}	6.466667	0.3333333^{c}	1.466667
SEM(±)	1.65	0.93	0.07	0.33	0.05	0.11
LSD (0.05)	9.11	5.3	0.401	2.16	0.261	0.74
CV (%)	6.29	14.2	14	16.2	27.5	26.2
F-test	*	*	*	NS	*	NS

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant, *: 5% level of significance.

Table 9. Effects of different fertilizers on performances of okra at 60 DAS.

Treatments	60 DAS					
	Plant height	Number of leaves	Plant diameter	Number of buds	Number of open flowers	Number of fruits
Poultry manure	118.6000	44.60000^{a}	2.200000^{a}	10.566667	0.8	3.666667ab
Sesame cake	117.7333	35.66667^{ab}	1.773333^{bc}	9.8000000	0.8	3.100000abc
Vermicompost	111.6667	31.73333^{b}	1.846667^{b}	8.833333	0.9	3.100000abc
Synthetic fertilizers	111.2000	30.73333^{b}	1.676667^{bc}	9.200000	0.6	4.100000a
Goat manure	109.3333	34.86667^{ab}	1.936667^{ab}	10.100000	0.6	2.900000bc
Mustard cake	107.1333	29.60000^{b}	1.740000^{bc}	9.400000	0.5	2.400000c
Control	103.6667	25.06667^{b}	1.436667^{c}	8.933333	0.6	2.333333c
SEM(±)	1.65	1.63	0.06	0.5	0.04	0.2
LSD (0.05)	11.8	10.4	0.325	3.65	0.28	1.1
CV (%)	5.96	17.6	10.2	21.9	22.9	20.1
F-test	NS	*	**	NS	NS	*

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant, *: 5% level of significance, **: 1% level of significance.

Table 10. Effect of different fertilizer on performance of okra at 70 DAS.

Treatments	70 DAS		
	Number of buds	Number of open flowers	Number of fruits
Sesame cake	**15.033333^{a}**	**1.6000000**	**2.333333**
Poultry manure	14.40000^{ab}	1.2000000	2.466667
Synthetic fertilizers	12.200000^{abc}	0.9333333	2.533333
Goat manure	11.266667^{bc}	1.1333333	2.600000
Mustard cake	10.933333^{bc}	1.1333333	2.266667
Vermicompost	10.133333^{c}	1.1333333	2.933333
Control	9.466667^{c}	1.0666667	2.266667
SEM(±)	0.74	0.08	0.12
LSD (0.05)	3.43	0.575	1.1
CV (%)	16.2	27.1	24.8
F-test	*	NS	NS

Note: Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, NS: Non-significant, *: 5% level of significance.

The effect of different fertilizer on the yield was found significant at 1% probability level. Poultry manure producing 20 mt/ha was found superior (Table 11). It was followed by vermicompost, goat manure, sesame cake, mustard cake, synthetic fertilizers and untreated control. The effects of different fertilizers on different growth parameters like plant diameter, height, number of leaves and yield was found highest in Poultry manure which corroborates with the findings of (Fagwalawa and Yahaya, 2016). The increase in yield of Okra was due to the easy Solubilization effect and high nitrogenous contents of Okra and it agrees with the findings of (Sanwal *et al.*, 2007) in turmeric and (Premsekhar and Rajashree, 2009) in Okra in which they respond organic manure improves the physical properties of soil. The BC ratio was highest in poultry manure followed by goat manure, sesame cake, synthetic fertilizers, vermicompost, untreated control and mustard cake (Table 13). Vermicompost produced the comparatively superior yield but due to the high cost of the manure, the BC ratio seems to be quite low. In case of synthetic fertilizers, though they produced the fewer yields but due to the low cost of the fertilizers, they have quite superior BC ratio.

From the above experiment, Poultry manure was found to be superior among all the seven treatments on different growth parameters like plant diameter, height, number of leaves and yield except the number of buds at 70DAS (on significant cases) which corroborates with the findings of Fagwalawa and Yahaya (2016). Benefit Cost ratio was highest in poultry manure followed by goat manure, sesame cake, synthetic fertilizers, vermicompost, untreated control and mustard cake. Hence, it can be concluded that usage of Poultry manure improves the performance of growth parameters and finally increases the yield (200 qt./ha) and have high BC ratio (1.77). It has been estimated that the application of poultry manure releases the nutrient easily and improves the nutrient status of the soil by easy solubilization effect and high-water holding capacity of it. Thus, increases the overall growth parameters of the crop. This result agrees with the findings of Sanwal *et al.* (2007); Premsekhar and Rajashree (2009).

Table 11. Effects of different fertilizers on yield.

Treatments	Average Yield (mt/ha)
Poultry manure	20.00000[a]
Vermicompost	17.386667[ab]
Goat manure	16.728889[ab]
Sesame cake	16.622222[ab]
Mustard cake	14.644444[bc]
Synthetic fertilizers	12.506667[cd]
Control	9.613333[d]
SEM(±)	0.82
LSD (0.05)	3.86
CV (%)	14.1
F-test	**

Note: mt= metric ton (1000kg), Means with the same letter are non-significant at p=0.05 by DMRT, SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation,**: 1% level of significance.

Table 12. Estimation of common-cost of various components.

Particulars	Amount (NRs/ha)
Rental value of land	105,000
Field preparation	6,000
Seed cost	23,089
Irrigation cost	66,000
Manuring (Labour)	1,800
Weeding	18,000
Harvesting	24,000
Total	243,889

Note: NRs: Nepalese Rupees.

Table 13. Estimation of cost of different components.

Treatments	Common cost (NRs/ha)	Cost of fertilizers (NRs/ha)				Total cost (NRs/ha)
		Respective manures	Single Super Phosphate	Diammonium phosphate	Muriate of potash	
Poultry manure	243,889	83,333	11,812	-	-	339,034
Vermicompost	243,889	153,160	4,390	-	-	401,979
Goat manure	243,889	33,333	12,750	-	-	289,972
Sesame cake	243,889	75,611	13,102	-	2670	335,272
Mustard cake	243,889	132,733	113,90	-	-	388,012
Synthetic fertilizers	243,889	5632	-	17,608	6,000	273,129
Control	243,889	-	-	-	-	243,889

Note: NRs: Nepalese Rupees, ha: hectare.

Table 14. Benefit-Cost (BC) ratio of the cultivation of okra.

Treatments	Benefit (NRs/ha)	Total cost (NRs/ha)	BC ratio
Poultry manure	600,000	339,034	1.77
Vermicompost	521,580	401,979	1.30
Goat manure	501,840	289,972	1.73
Sesame cake	498,660	335,272	1.49
Mustard cake	439,320	388,012	1.13
Synthetic fertilizers	375,180	273,129	1.37
Control	288,390	243,889	1.18

Note: Selling Price estimated at NRs. 30 per kg okra, BC: Benefit-cost, NRS: Nepalese Rupees, ha: hectare.

Conclusion

From this study, it was concluded that, highest benefit cost ratio of 1.77 was found in the case of poultry manure with the productivity of 20 Mt/ha. This study identifies the poultry manure is superior in almost all the vegetative and reproductive parameters of the plant. Hence, use of poultry manure was observed beneficial in terms of economical and production perspectives. Further multi trial and multi-location research should be carried out to suggest the most suitable dose of poultry manure to obtain the maximum profit. Vermicompost, producing the significant superior yield and have less BC ratio, so suitable research should be carried out to prepare cost efficient vermicompost to obtain the better results.

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