EFFECT OF VERMICOMPOST ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L. cv. Barista) UNDER DIFFERENT MULCH CONDITIONS AT CHITWAN, NEPAL

Bigya Sapkota[1], Ganesh Lamsal[2] and Raj Kumar Adhikari[3]
[1]Nepal Polytechnic Institute, Purbanchal University, Chitwan, Nepal
[2]Faculty of Agriculture, Agriculture and Forestry University, Chitwan, Nepal
[3]Heifer International Nepal, Kathmandu, Nepal
Corrosponding Author: bigyasapkota1@gmail.com
Bigya Sapkota: https://orcid.org/0009-0009-5236-6999
Ganesh Lamsal: https://orcid.org/0000-0001-6218-5598
Raj Kumar Adhikari: https://orcid.org/0000-0003-3736-8688

ABSTRACT

Okra (*Abelmoschus esculentus* L.) is one of the popular vegetables in Nepal which holds a significant health and nutritional value. To address major bottleneck for lower productivity of okra mainly due to inadequate nutrient management, weed management and soil moisture management, an experiment was conducted at Chitwan, Nepal during March to June 2023 to assess the effects of vermicompost on growth and yield of okra under different mulch conditions. The experiment was laid out in two factorial RCBD design with three replications. Factor A comprised of vermicompost (control, 5t/ha, 10t/ha, 15t/ha, 20t/ha) and factor B was mulching conditions (No Mulch and Plastic Mulch). The collected data were tabulated in Microsoft Excel and analyzed using R Stat version 4.3.1. Means were separated using Duncan's Multiple Range Test (DMRT) at a significance level of 5%. The results revealed that the effect of vermicompost was significant on most of the growth and yield parameters in mulched conditions. The yield parameters like fruit length (12.37cm), average fruit weight (17.97g), fruit diameter (17.78mm), number of fruits per plant (25.64), yield per plant (426.47g) and yield per hectare (14.83t/ha) were significantly higher under 20t/ha vermicompost. Similarly, the yield parameters like fruit length (12.37cm), average fruit weight (18.02g), fruit diameter(17.82mm), number of fruits per plant (28.73), yield per plant (478.84g), yield per hectare (16.62t/ha) were significantly higher in plastic mulch. The interaction effect indicated that the number of fruits per plant (33.45), yield per plant (530.93g) and yield per hectare (18.62 t/ha) were significantly high in the treatment 20t/ha vermicompost under plastic mulch, and 15t/ha vermicompost and plastic mulch. So, based on this study, combining plastic mulch with vermicompost at 15t/ha could be the most fruitful strategy for farmers among different treatments administered in the study.

Keywords: Okra, Productivity, Plastic mulch, RCBD, Vermicompost

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), commonly known as lady's finger, is a nutritious vegetable rich in vitamin C and minerals like calcium, magnesium, potassium, and iron (Ijoyah & Usman, 2013). Some of the health benefits of this vegetable include improving food digestion, promoting healthy pregnancies, shielding the body from radiation exposure, and easing respiratory conditions like constipation and cough (Mehata et al., 2023). Okra is a flowering, herbaceous, hairy, annual plant of the Malvaceae family, widely cultivated in tropical and subtropical regions. Despite its potential, the annual production of okra in Nepal stands at 110,565 metric tons (t) from 9,584 hectares (ha), with an average yield of 11.54 t/ha (MoALD, 2022). This yield is significantly lower than both the potential yield (24–32 t/ha) reported at research stations in Nepal (MoALD, 2022) and the average farm yield in India (12 t/ha) (Kumar et al., 2019).

The low productivity of okra in Nepal can be because of various factors, including high temperatures, drought, weeds, pests, diseases, poor cultural practices, and low soil fertility caused by nutrient leaching (Adhikari et al., 2023). There exists a significant challenge related to the improper use of fertilizers. While farmers rely on synthetic chemical fertilizers for nutrient supply, leading to some yield improvement, this practice has long-term consequences (Selim, 2020). Moreover, many farmers lack awareness of appropriate fertilizer doses, critical for achieving optimal yields. Insufficient nutrient supply results deficiencies and reduced yields, while excessive fertilizer use leads to nitrate leaching and phosphorus runoff. Effective nutrient management that integrates organic fertilizers and improves fertilizer use efficiency is still underutilized (Verma et al., 2020).

Vermicompost is a nutrient-rich organic fertilizer derived from the decomposition of organic waste by earthworms. Applying vermicompost aids in sustaining soil productivity by raising the soil's organic matter content (Gupta et al., 2011). When added to soil, vermicompost, a stable organic material with fine grains, aerates and loosens the soil. The mucus associated with the cast absorbs water because of its hygroscopic nature and hence may stop water logging and increase water storage capacity of the soil (Sundari & Gandhi, 2013). Vermicompost is a great organic fertilizer and a more environmentally friendly substitute for chemical fertilizers because it is a great soil supplement and a biocontrol agent (Joshi et al., 2015).

Another critical aspect of okra cultivation is ensuring optimal soil temperature, moisture, fertility, nutrients, irrigation, and weed management. Mulching is a beneficial practice that helps retain soil moisture, reduces fertilizer leaching, stabilizes soil temperature, and ultimately improves crop growth and yield (Jha et al., 2018). Ashrafuzzaman et al. (2011) found mulching boosted the number of fruits per plant and yield while producing fruits with the highest chlorophyll-a, chlorophyll-b, and total chlorophyll levels. Mulching raises soil temperature of soil by 3 to 6^0C (Rajablariani et al., 2012) resulting faster crop development and harvest. Different mulching materials are being used in farm conditions; however, black and silver plastic mulches are commonly used at commercial scale. Puri et al. (2022) revealed that silver plastic mulch reflects more radiation and is better for okra growth and yield because it alters the soil's natural conditions, improving crop stand and okra production.

Literatures reveal that implementing practices like vermicompost application and using plastic mulch, alone or in combination, can increase productivity and help mitigate production issues faced by Okra farmers. Under this backdrop, this study aimed to explore the effect of different doses of vermicompost with mulching practice in Okra and provide evidence-based recommendations to farmers.

MATERIALS AND METHODS

Location of the experimental site

The research was conducted at Organic producer Center located at Bharatpur, Chitwan. The experimental field lies at North latitude 27° 38' 27.2688", East longitude 84° 22' 11.9172" and altitude of 157.00 masl (meters above sea level).

Description of the materials

The research material i.e., seed of okra (variety: Barista) and mulching plastic (silver) were sourced from Agro-Input dealer whereas required amount of vermicompost was sourced from registered Agro-firm in Chitwan district.

Physico-chemical properties of soil of the experimental site

Composite soil samples were taken randomly from the experimental field from different locations on experimental layout to record the initial fertility status of the field. Sample was sent to the Soil and Fertilizer Testing Laboratory located in Hetauda, Makwanpur, Nepal and following results were obtained.

Table 1. Properties of soil in the experimental field at Bharatpur, Chitwan, 2023

S.N.	Soil components	Value	Methods
1.	pH	5.5	pH meter
2.	Organic matter (%)	2.69	Walkley-black method
3.	Nitrogen (%)	0.13	The Kjeldhal method
4.	Available phosphorous (kg/ha)	139.86	Modified Olsen method
5.	Available potash (kg/ha)	225.1	Acetate method
6.	Soil texture	Sandy loam	Hydrometer method

Table 2. Properties of vermicompost used in the experiment at Bharatpur, Chitwan, 2023

S.N.	Soil components	Value	Methods
1.	pH	7.41	pH meter
2.	Nitrogen	1.8%	Potentiometry method
3.	Phosphorous	3.25%	Phosphomolybdate blue method
4.	Potassium	1.87%	Absorption spectrophotometer
5.	Calcium	0.7%	Absorption spectrophotometer
6.	Magnesium	0.7%	Absorption spectrophotometer

Experimental design and layout

The experiment was conducted during spring-summer season. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 10 treatments replicated three times. This experiment covered a total of 210 m^2 experimental space. There were a total of 30 experimental units. A single plot measured 1.8 x 2 meters (3.6m^2). The experiment was conducted from 1st March, 2023 to 5th June, 2023. The plant-to-plant distance was 50 cm and row to row distance was 30 cm where 24 plants were planted in each plot and inner 6 plants were selected for observation.

Treatment details

Randomized complete block design (RCBD) was applied for the investigation with two factors and 3 replications. Factor A comprised vermicompost (control, 5t/ha, 10t/ha, 15t/ha, 20t/ha) and factor B was plastic mulch and non-mulch. The calculated vermicompost dose for the treatments 5t/ha, 10t/ha, 15t/ha and 20t/ha are 1.8kg, 3.6kg, 5.4kg and 7.2kg respectively per plot (3.6m^2) area. Plastic mulch was applied in those plots receiving mulched condition.

Table 3. The treatment combination of vermicompost and plastic mulch used in the experiment

S.N.	Treatment combinations	Notation
	Control (no mulch +no vermicompost)	T_1
	No mulch + 5t/ha vermicompost	T_2
	No mulch + 10t/ha vermicompost	T_3
	No mulch + 15t/ha vermicompost	T_4
	No mulch + 20t/ha vermicompost	T_5
	Plastic mulch + no vermicompost	T_6
	Plastic mulch + 5t/ha vermicompost	T_7
	Plastic mulch + 10t/ha vermicompost	T_8
	Plastic mulch + 15t/ha vermicompost	T_9
	Plastic mulch + 20t/ha vermicompost	T_{10}

Details of field operations

The field was ploughed with a mould board plough. Harrowing was done to break the clods and leveled. Three blocks with ten plots in each were made and calculated dose of vermicompost was mixed with soil according to treatment allocated in each plot. Plastic mulch was placed according to allocated treatment. The treatment was placed randomly in each plot. The size of each plot was 1.8m in length and breadth 2m. The seed was soaked overnight, and shade dried for 30min before sowing. Seed sowing was done on March 1st, 2023.

Observations, measurement, and analysis

In the experiment, the morphological/growth characters like plant height, number of leaves per plant, leaf area, stem diameter, primary branches were recorded. Similarly, yield contributing characters like fruit length, fruit diameter, fruit weight, fruit number per plant, fruit yield per plant, fruit yield per ha from six tagged plants were also recorded. All these parameters were recorded at every thirty-day interval starting 30 days after sowing. Microsoft Excel and RSTAT software package (R version 3.5.3) were used for the analysis of different parameters.

RESULTS

Effect of vermicompost and mulch condition on growth parameters

There was a significant effect of vermicompost and mulching condition on plant height, number of leaves per plant, number of primary branches and stem diameter at final harvest (Table 4). Plastic mulching resulted in significantly earlier germination (2 days) compared to non-mulch (2.27 days). At final harvest plants were significantly taller under vermicompost 20t/ha (80.41cm) and plastic mulch (83.15cm) while significantly shorter under control (71.93cm) and non-mulch (70.10cm). At final harvest, the highest number of leaves per plant (39.00) was significantly observed in 20t/ha vermicompost under plastic mulch, whilst the lowest number of leaves per plant (30.33) was found on control under non- mulch conditions (Table 5). At final harvest, the number of primary branches per plant was found to be significantly the highest in 15t/ha vermicompost (3.80) followed by 20t/ha vermicompost (3.74), whereas the lowest number of primary branches per plant was observed in control (3.47). Significantly highest stem diameter was observed in 15t/ha vermicompost under plastic mulch (20.32mm) whereas the lowest stem diameter was observed in 10t/ha

under non mulch (18.01mm) at final harvest. The highest leaf area was observed in 20t/ha vermicompost (204.57cm^2) whereas lowest leaf area was found in control (183.31cm^2). Significantly the highest leaf area was observed in plastic mulch (213.81cm^2) and the lowest leaf area was observed in non-mulch (177.34cm^2) at final harvest (Table 4).

Table 4. Effect of vermicompost on growth parameters of okra (*Abelmoschus esculentus* L.) under different mulch condition at Chitwan, Nepal, 2023

Treatments	Growth Parameters					
	Days to 50% Germination ± SEM	Plant Height (cm) ± SEM	Number of Leaves/ Plant ± SEM	Number of Primary Branches ± SEM	Stem Diameter ± SEM	Leaf Area (cm²) ± SEM
Vermicompost (Factor A)						
Control	2.00 ± 0.00	71.93^{b} ± 0.13	30.99^{c} ± 0.13	3.47^{c} ± 0.08	18.36^{c} ± 0.06	183.31 ± 9.39
5 t/ha	2.00 ± 0.00	74.70^{ab} ± 0.14	31.82^{bc} ± 0.14	3.70^{ab}± 0.09	18.93^{bc} ± 0.06	199.90 ± 10.15
10 t/ha	2.33 ± 0.33	75.98^{ab} ± 0.16	33.37^{b} ± 0.16	3.61^{bc} ± 0.10	19.06^{bc} ± 0.07	190.43 ± 10.43
15 t/ha	2.16 ± 0.33	80.11^{a} ± 0.19	36.61^{a} ± 0.18	3.80^{a} ± 0.10	19.60^{ab} ± 0.08	199.65 ± 10.43
20 t/ha	2.16 ± 0.33	80.41^{a} ± 0.19	36.82^{a} ± 0.18	3.74^{ab} ± 0.10	19.92^{a} ± 0.08	204.57 ± 11.38
Plastic mulch (Factor B)						
Non-mulch	2.27^{a} ± 0.25	70.10^{b} ± 0.15	32.92^{b} ± 0.14	3.53^{b} ± 0.08	18.78^{b} ± 0.06	177.34^{b} ± 8.38
Plastic mulch	2.00^{b} ± 0.25	83.15^{a} ± 0.19	34.93^{a} ± 0.17	3.79^{a} ± 0.10	19.57^{a} ± 0.08	213.81^{a} ± 10.77
LSD (0.05)	0.39	6.02	1.98	0.13	0.81	17.02
CV (%)	15.36	6.48	4.81	3.12	3.5	7.17
F-test	NS	*	***	***	**	NS
Grand Mean A×B	2.13 ± 0.25 NS	75.96 ± 0.19**	33.92 ± 0.19*	3.66 ± 0.10*	19.17 ± 0.12*	195.57 ± 7.11 NS

Treatments means followed by the common letter(s) within column are non- significantly different among each other based on DMRT at 5 % level of significance. DAS= Days after sowing, LSD=Least significant difference, CV= Coefficient of variation, SEM=Standard error of mean

Table 5. Interaction effect of vermicompost on growth parameters of okra (*Abelmoschus esculentus* L.) under different mulch condition at Chitwan, Nepal, 2023

Treatments	Growth Parameters					
	Days to 50% Germination	Plant Height (cm)	Number of Leaves per Plant	Number of Primary Branches	Stem Diameter (cm)	Leaf Area (cm²)
Interaction (Vermicompost × Plastic mulch)						
Control × non-mulch	2	67.44^{d} (±1.89)	30.33^{c} (±0.61)	3.27^{c} (±0.12)	18.43^{c} (±0.36)	173.83 (±4.81)

Control × plastic mulch	2	74.43^{bcd} (±1.89)	31.75^{c} (±0.61)	3.66^{b} (±0.12)	18.29^{c} (±0.36)	192.79 (±4.81)
5t/ha × non-mulch	2	69.18^{cd} (±1.89)	30.78^{c} (±0.61)	3.69^{b} (±0.12)	18.87^{bc} (±0.36)	173.14 (±4.81)
5t/ha × plastic mulch	2	80.22^{b} (±1.89)	32.86^{bc} (±0.61)	3.70^{b} (±0.12)	18.99^{bc} (±0.36)	224.66 (±4.81)
10t/ha × non-mulch	2.67	74.53^{bcd} (±1.89)	33.39^{bc} (±0.61)	3.55^{b} (±0.12)	18.01^{c} (±0.36)	167.11 (±4.81)
10t/ha × plastic mulch	2	77.43^{bc} (±1.89)	33.36^{bc} (±0.61)	3.67^{b} (±0.12)	20.11^{ab} (±0.36)	213.75 (±4.81)
15t/ha × non-mulch	2.33	69.94^{cd} (±1.89)	34.44^{b} (±0.61)	3.61^{b} (±0.12)	18.87^{bc} (±0.36)	183.60 (±4.81)
15t/ha × plastic mulch	2	90.28^{a} (±1.89)	38.77^{a} (±0.61)	4.00^{a} (±0.12)	20.32^{a} (±0.36)	215.71 (±4.81)
20t/ha × non-mulch	2.33	69.43^{cd} (±1.89)	34.64^{b} (±0.61)	3.50^{b} (±0.12)	19.71^{ab} (±0.36)	189.02 (±4.81)
20t/ha × plastic mulch	2	93.37^{a} (±1.89)	39.00^{a} (±0.61)	3.94^{a} (±0.12)	20.14^{ab} (±0.36)	226.13 (±4.81)
LSD (0.05)	0.56	8.52	2.8	0.21	1.15	24.07
CV (%)	15.36	6.48	4.81	3.36	3.5	7.17
F-test	NS	**	*	*	*	NS
Grand Mean	2.13 ± 0.07	75.96 ± 1.89	33.92 ± 0.61	3.66 ± 0.12	19.17 ± 0.36	195.57 ± 4.81

Treatments means followed by the common letter(s) within column are non- significantly different among each other based on DMRT at 5 % level of significance. DAS= Days after sowing, LSD=Least significant difference, CV= Coefficient of variation, SEM=Standard error of mean

Fruit quality parameters

Vermicompost showed significant effect on fruit length, weight, and diameter (Table 6). Significantly the highest fruit length (12.37cm), fruit weight (17.97g) and fruit diameter (17.78mm) was found in 20t/ha vermicompost, whereas significantly the lowest fruit length (11.82cm), fruit weight (17.13g) and fruit diameter (17.18mm) was found in control. Similarly, significantly the highest fruit length (12.37cm), fruit weight (18.02g) and fruit diameter (17.82mm) was observed under plastic mulch whereas significantly the lowest fruit length (11.83cm), fruit weight (16.99g) and fruit diameter (17.11mm) was observed under non-mulch. The interaction effect of vermicompost and plastic mulch was non-significant on fruit length and fruit diameter however, were highest in 20t/ha vermicompost under mulch (12.76cm), (18.19mm) respectively whereas lowest fruit length (11.72) in 5t/ha vermicompost under non-mulch and lowest fruit diameter (17.00mm) in control under non-mulch. On the other hand, interaction showed significant effect on fruit weight and was significantly the highest in 20t/ha vermicompost under plastic mulch (18.65g) which was statistically at par with 15t/ha vermicompost× plastic mulch (18.34g). Significantly the lowest fruit weight (16.77g) was found on control under non-mulch (Table 7).

Table 6. Effect of vermicompost on fruit length, fruit weight and fruit diameter of okra (*Abelmoschus esculentus* L.) under different mulch condition at Chitwan, Nepal, 2023

Treatments	Fruit Length (cm) ± SEM	Fruit Weight (g) ± SEM	Fruit Diameter (mm) ± SEM
Vermicompost (Factor A)			
Control	$11.82^{b} \pm 0.11$	$17.13^{c} \pm 0.07$	$17.18^{b} \pm 0.06$
5 t/ha	$12.07^{ab} \pm 0.11$	$17.38^{bc} \pm 0.06$	$17.31^{b} \pm 0.06$
10 t/ha	$12.06^{ab} \pm 0.11$	$17.41^{bc} \pm 0.06$	$17.36^{b} \pm 0.06$
15 t/ha	$12.17^{a} \pm 0.11$	$17.63^{b} \pm 0.07$	$17.50^{ab} \pm 0.06$
20 t/ha	$12.37^{a} \pm 0.11$	$17.97^{a} \pm 0.07$	$17.78^{a} \pm 0.07$
LSD (0.05)	0.29	0.28	0.37
CV (%)	2.01	1.35	1.76
F-test	*	***	*
Plastic mulch (Factor B)			
Non-mulch	$11.83^{b} \pm 0.10$	$16.99^{b} \pm 0.06$	$17.11^{b} \pm 0.05$
Plastic mulch	$12.37^{a} \pm 0.10$	$18.02^{a} \pm 0.06$	$17.82^{a} \pm 0.06$
LSD (0.05)	0.18	0.18	0.23
CV (%)	2.01	1.35	1.76
F-test	***	***	***
Grand Mean A×B	12.10 ± 0.07 NS	17.51 ± 0.06 *	17.42 ± 0.05 NS

Treatments means followed by the common letter(s) within column are non- significantly different among each other based on DMRT at 5 % level of significance. DAS= Days after sowing, LSD=Least significant difference, CV= Coefficient of variation, SEM=Standard error of mean

Table 7. Interaction effect of vermicompost on fruit length, fruit weight and fruit diameter of okra (*Abelmoschus esculentus* L.) under different mulch condition at Chitwan, Nepal, 2023

Treatments	Fruit Length (cm) ± SEM	Fruit Weight (g) ± SEM	Fruit Diameter (mm) ± SEM
Interaction (Vermicompost × Plastic mulch)			
Control × non-mulch	11.73 ± 0.14	$16.77^{e} \pm 0.13$	17 ± 0.12
Control × plastic mulch	11.9 ± 0.14	$17.49^{bc} \pm 0.14$	17.36 ± 0.14
5t/ha × non-mulch	11.72 ± 0.12	$16.99^{de} \pm 0.14$	17.08 ± 0.12
5t/ha × plastic mulch	12.42 ± 0.17	$17.77^{b} \pm 0.16$	17.54 ± 0.14
10t/ha × non-mulch	11.82 ± 0.13	$16.99^{de} \pm 0.14$	17.04 ± 0.12
10t/ha × plastic mulch	12.3 ± 0.14	$17.83^{b} \pm 0.14$	17.68 ± 0.13
15t/ha × non-mulch	11.89 ± 0.13	$16.93^{de} \pm 0.13$	17.06 ± 0.12
15t/ha × plastic mulch	12.45 ± 0.14	$18.34^{a} \pm 0.13$	17.93 ± 0.14
20t/ha × non-mulch	11.98 ± 0.13	$17.29^{cd} \pm 0.14$	17.36 ± 0.13
20t/ha × plastic mulch	12.76 ± 0.17	$18.65^{a} \pm 0.17$	18.19 ± 0.15
LSD (0.05)	0.41	0.4	0.52
CV (%)	2.01	1.35	1.76
F-test	NS	*	NS
Grand Mean A×B	12.1 ± 0.11 NS	17.51 ± 0.14 *	17.42 ± 0.10 NS

Treatments means followed by the common letter(s) within column are non- significantly different among each other based on DMRT at 5 % level of significance. DAS= Days after sowing, LSD=Least significant difference, CV= Coefficient of variation, SEM=Standard error of mean

Yield and yield attributing characters

The effect of vermicompost, mulching and their interaction on number of fruits per plant, yield per plant and yield per hectare were significant (Table 8). Significantly the highest number of fruits per plant (25.64) was obtained in 20t/ha vermicompost, while significantly the least number of fruits per plant (20.43) was observed in control. Plastic mulching recorded significantly the highest number of fruits (28.73) while non- mulch recorded the lowest number of fruits (17.26). Okra grown on 20t/ha vermicompost produced significantly the highest fruit yield (14.83t/ha) while significantly the least yield (11.97t/ha) was obtained from control. Similarly, okra grown under plastic mulch produced significantly the highest fruit yield (16.62t/ha) while non-mulch produced significantly the least fruit yield (10.44t/ha).

Table 8. Effect of vermicompost on number of fruits per plant, yield per plant and yield per hectare of okra (*Abelmoschus esculentus* L.) under different mulch condition at Chitwan, Nepal, 2023

Treatments	Number of Fruits per Plant	Yield per Plant (g)	Yield per Hectare (t/ha)
Vermicompost (Factor A)			
Control	$20.43^{d} \pm 0.56$	$349.27^{d} \pm 9.59$	$11.97^{c} \pm 0.36$
5t/ha	$22.00^{cd} \pm 0.56$	$375.50^{c} \pm 9.59$	$12.87^{b} \pm 0.36$
10t/ha	$22.71^{bc} \pm 0.56$	$391.75^{bc} \pm 9.59$	$13.43^{b} \pm 0.36$
15t/ha	$24.18^{ab} \pm 0.56$	$415.57^{ab} \pm 9.59$	$14.56^{a} \pm 0.36$
20t/ha	$25.64^{a} \pm 0.56$	$426.47^{a} \pm 9.59$	$14.83^{a} \pm 0.36$
LSD (0.05)	**1.79**	**25.06**	**0.75**
CV (%)	**6.44**	**5.27**	**4.61**
F-test	***	***	***
Plastic Mulch (Factor B)			
Non-mulch	$17.26^{b} \pm 0.53$	$304.58^{b} \pm 8.64$	$10.44^{b} \pm 0.31$
Plastic mulch	$28.73^{a} \pm 0.53$	$478.84^{a} \pm 8.64$	$16.62^{a} \pm 0.31$
LSD (0.05)	**1.16**	**16.18**	**0.48**
CV (%)	**6.44**	**5.27**	**4.61**
F-test	***	***	***
Grand Mean	**22.99 ± 0.56**	**391.71 ± 9.59**	**13.53 ± 0.36**
A × B	**	*	**

Treatments means followed by the common letter(s) within column are non- significantly different among each other based on DMRT at 5 % level of significance. DAS= Days after sowing, LSD=Least significant difference, CV= Coefficient of variation, SEM=Standard error of mean

Interaction effect of vermicompost and mulching condition on yield parameters

The interaction of vermicompost and plastic mulch had significant effect on number of fruits, yield per plant and yield per hectare (Table 9). Okra grown on vermicompost 20t/ha under plastic mulch produced significantly the highest number of fruits per plant (33.45), which is statistically similar with 15t/ha vermicompost under plastic mulch (31.17) while significantly the least number of fruits per plant was observed in control under non mulch (16.52).Okra grown on vermicompost 20t/ha under plastic mulch produced significantly the highest fruit yield (18.62t/ha) which was statistically similar with 15t/ha vermicompost under plastic mulch (18.34t/ha) while significantly the least fruit yield was observed on control under non mulch (9.65t/ha).

Table 9. Interaction effect of vermicompost on number of fruits per plant, yield per plant and yield per hectare of okra (*Abelmoschus esculentus* L.) under different mulch condition at Chitwan, Nepal, 2023

Treatments	Number of Fruits per Plant ± SEM	Yield per Plant (g) ± SEM	Yield per Hectare (mt) ± SEM
Interaction (Vermicompost × Plastic mulch)			
Control × non-mulch	$16.52^{d} \pm 0.12$	$281.68^{e} \pm 4.57$	$9.65^{e} \pm 0.12$
Control × plastic mulch	$24.33^{c} \pm 0.15$	$416.80^{c} \pm 5.74$	$14.29^{c} \pm 0.13$
5t/ha × non-mulch	$17.19^{d} \pm 0.12$	$295.89^{de} \pm 4.65$	$10.14^{de} \pm 0.12$
5t/ha × plastic mulch	$26.80^{bc} \pm 0.16$	$455.11^{b} \pm 6.33$	$15.60^{b} \pm 0.15$
10t/ha × non-mulch	$17.54^{d} \pm 0.12$	$307.77^{de} \pm 4.75$	$10.55^{de} \pm 0.13$
10t/ha × plastic mulch	$27.89^{b} \pm 0.17$	$475.73^{b} \pm 6.75$	$16.31^{b} \pm 0.15$
15t/ha × non-mulch	$17.20^{d} \pm 0.12$	$315.55^{de} \pm 4.88$	$10.81^{d} \pm 0.13$
15t/ha × plastic mulch	$31.17^{a} \pm 0.18$	$515.59^{a} \pm 7.39$	$18.34^{a} \pm 0.17$
20t/ha × non-mulch	$17.84^{d} \pm 0.12$	$322.01^{d} \pm 4.94$	$11.04^{d} \pm 0.13$
20t/ha × plastic mulch	$33.45^{a} \pm 0.18$	$530.93^{a} \pm 7.56$	$18.62^{a} \pm 0.17$
LSD (0.05)	**2.54**	**35.44**	**1.07**
CV (%)	**6.44**	**5.27**	**4.61**
F-test	**	*	**
Grand Mean	**22.99 ± 0.13 ****	**391.71 ± 5.56 ***	**13.53 ± 0.09 ****

Treatments means followed by the common letter(s) within column are non- significantly different among each other based on DMRT at 5 % level of significance. DAS= Days after sowing, LSD=Least significant difference, CV= Coefficient of variation, SEM=Standard error of mean

DISCUSSION

Effect of vermicompost and mulching on growth parameters

Days to 50% germination

The plots mulched with plastic mulch showed early germination and higher germination percentage (Joshi et al., 2015). This might be because more soil moisture retention, improved physical, chemical, and biological soil properties, improved temperature regulation, and ultimately improved crop development and yield are all made possible by plastic mulching (Hossam et al., 2022). The use of vermicompost and the earthworms' breakdown of organic mulches would enhance the quantity of humus in the soil, which would assist improve the soil's physical, chemical, and biological characteristics as well as its ability to store water (Singh et al., 2011). This trend was also seen in the current study where the days to 50% germination in the mulched group was 2.00 days compared to 2.37 days in the non-mulched group.

Plant height

The lowest plant height in control was mainly due to unavailability of vermicompost and mulch. The data of present study clearly indicated that the plant height was maximum in plots that received 20t/ha vermicompost and plastic mulching. This might be due to the fact mulch materials ensured the uptake of essential nutrients through the holding of optimum

moisture. When applied to the soil surface, plastic mulching affects plant development and yield by lowering evaporation, raising water infiltration, preventing soil erosion, enhancing soil structure (Arun, 2016). Vermicompost can influence several physical, biological, and chemical processes of soil which have their bearings on plant's growth (Chanda et al., 2011). Furthermore, the altered nutritional status of soil was noticeably increased by the microbially enhanced vermicompost.

Number of leaves per plant

Rajablariani (2012) reported the maximum number of leaves per plant in the plots mulched with plastic mulch. Using plastic mulch to create a favorable root-zone temperature encourages the uptake of water and mineral nutrients, which in turn improves the foliage and plant growth (Bosland and Votava, 2000). Data of the present study clearly indicated that number of leaves per plant was higher in plots that received 20t/ha vermicompost and plastic mulching. This could be because the vermicompost application supplied enough N, which is linked to high photosynthetic activity and rapid vegetative development. (K.C. and Bhattarai, 2011).

Number of primary branches per plant

The application of varying levels of vermicompost resulted in a considerable increase in the number of primary branches when compared to the control (Dhayal et al., 2018). Mulching of plastic sheet resulted in significantly maximum number of branches per plant over rest of the all-mulching practices. This may be because plastic mulches absorb comparatively large amounts of the incoming radiation and transmit a considerable part of it to the soil (Parte et al., 2020). The number of branches and leaves were better for the plants grown over plastic mulch compared to bare soil (Rajablariani et al., 2012).

Stem diameter

Plastic mulches prevent evaporation and regulate soil temperature and moisture levels to promote healthier root development. The growth and uptake of nutrients by plants increases plant growth in the long run. The results of the current investigation consonance with Khan et al. (2015) where it is shown that plants growth exceeded control levels due to the prolonged moisture retention and availability, which also increased nutrient uptake necessary for healthy plant growth and development.

Leaf area

The other treatments with soil nutrient addition demonstrated an increase in leaf growth in comparison to the control, which had a decreasing tendency. By improving soil power stability and limiting soil water evaporation, plastic mulches affect the microenvironment of plants, which in turn affects plant growth (Mutetwa and Mtaita, 2014). Both macro- and micronutrients are present in vermicompost, and plant nutrition, growth, photosynthesis, and leaf chlorophyll content are all positively impacted by nutrient intake (Rekha et al., 2018).

Effect of vermicompost and mulching on fruit parameters

Fruit length, fruit weight and fruit diameter

One of the results inferred that vermicompost and mulching improves the partition of photo- assimilates from source to sink and thereby increases the fruit weight (Singh et al., 2013). Mulching is beneficial for preserving soil moisture, regulating temperature,

preserving soil health, controlling weeds, and ultimately boosting productivity (Pramanik et al., 2015). Vermicompost applications have been shown to improve fruit development and production (Javed and Panwar, 2013). Increased number of fruits per plant, average fruit weight, and fruit yield/ha were the results of the more favorable soil environment under the plastic mulching (Mamkagh, 2009).

Effect of vermicompost and mulching on yield parameters

Number of fruits per plant, yield per plant (g) and yield per ha (t/ha)

The increase in yield was attributable to adequate soil moisture near the roots, which reduced evaporation loss through mulching and increased nutrient intake for healthy growth. Higher growth was a result of plant development and less weed competition compared to control (Puri et al., 2022). Average yield of chilly was observed higher in plastic mulch (Dattatraya, 2014). Enhanced fruit yield and weight could be ascribed to the use of polythene mulch, which also helped to limit weed growth during key growth stages and maintain ideal soil moisture levels. These results are consistent with those mentioned by Kundu et al. (2018).

CONCLUSION

Based on the result of this research, it can be concluded that vermicompost had significant effect on most of the growth and yield parameters. The yield parameters were significantly the highest when 20t/ha or 15t/ha vermicompost was used. Plastic mulching also had significantly highest values of growth, yield parameters while decreasing trend was observed on non-mulch condition. The interaction effect showed that the number of fruits per plant (33.45), yield per plant (530.93g) and yield per hectare (18.62 t/ha) was found significantly highest when 20t/ha vermicompost and plastic mulch was used, which is statistically at par with 15t/ha vermicompost and plastic mulch was used simultaneously while the lowest number of fruits per plant (16.52), yield per plant (281.68g) and yield per hectare (9.65 t/ha) was under no vermicompost and non-mulch condition. Since, the yield per hectare under plastic mulched condition was statistically similar for both 20t/ha and 15t/ha vermicompost, application of 15 t/ha vermicompost is more appropriate compared to 20t/ha vermicompost to minimize the cost associated with fertilizer usage while maintaining comparable productivity.

ACKNOWLEDGEMENT

Authors like to extend sincere gratitude to Nepal Polytechnic Institute (NPI) for providing the opportunity for this study as part of academic requirement of the first author. Special thanks to Mr. Chandra Prasad Adhikari for providing necessary materials for research work and Dr. Biplov Sapkota for his continuous motivation, suggestions, supervision and full inspiration with patience and guidance which helped me in all the time of research and writing of the thesis.

REFERENCES

Amooaghaie, R. and Golmohammadi, S. (2017). Effect of vermicompost on growth, essential Oil, and health of *Thymus Vulgaris*. Compost science and utilization, 25(3), pp. 1-12.

Arun, T. (2016). Effect of different mulching practices on growth, yield and weed control in tomato (*Solanum Lycopersicon* L.). Doctoral Dissertation, College of Horticulture, Rajendranagar, Hyderabad500 030, Dr. Yrs. Horticultural University.

Adhikari, S., Poudel, P. and Adhikari, A. (2023). The Response of Okra (*Abelmoschus esculentus* L. Var Arka Namika) to Different Mulching Techniques Under the Organic Condition at Udayapur, Nepal. Acta Scientific Agriculture, 7(1), pp.70-79.

Ashrafuzzaman, M., Halim, M.A., Ismail, M.R., Shahidullah, S.M. and Hossain, M.A. (2011). Effect of plastic mulch on growth and yield of chilly (*Capsicum annuum* L.). Brazilian Archives of biology and technology, 54, pp.2.

Bhujbal, P.D., Tambe, T.B. and Ulemale, P.H. (2015). Effect of mulches on growth and yield of tomato (*Lycopersicon esculentum* Mill). A Quarterly Journal of Life Sciences, 12(2), pp. 464-466.

Bosland, P. W. and Votava, E. J. (2000). Peppers: Vegetables and spice capsicums. Wallingford, England, UK: CAB International Publishing.

Chanda, G., Bhunia, G. and Chakraborty, S. (2011). The effect of vermicompost and other fertilizers on cultivation of tomato plant. Journal of Horticulture and Forestry, 3(2), pp. 42-45.

Dattatraya, M Y. (2014). Studies on effect of different mulches on growth and yield of chilly (*Capsicum annuum* L.) cv. Phule Jyoti. M Sc thesis. Horticulture Section College of Agriculture, Kolhapur Mahatma Phule Krishi Vidyapeeth, Rahuri, (MS), India, pp.57.

Dhayal, M., Aravind S. K., Meena, M. K., Choudhary, A., and Choudhary, R. (2018). Response of okra (*Abelmoschus esculentus* L. Moench) to vermicompost, mycorrhiza and micronutrients mixture. Archives of Agriculture and Environmental Science, 3(2), pp.198-201.

Dutta, S., Kalita, N. and Maibangsa, S. (2020). Effect of organic source of nutrients in growth and yield parameters of okra in Karbi Anglong district of Assam. International journal of chemical studies, 8(5), pp. 910-913.

Gemede, H., Ratta, N., Haki, G. and Woldegiorgis, A. (2015). Nutritional quality and health benefits of okra. Journal of food processing and technology, 6(458), pp. 2.

Gupta, AK., Bishwas, R., Singh, MP., Vibha, U., Singh C. K. (2011). Effect of fertilizers and vermicompost on growth, yield and biochemical changes in (*Abelmoschus esculentus*) Plant. Plant Archives, 11, pp. 285–287.

Hossam, S., Beltagi, E.L., Basit, A., Mohamed, H.I., Ullah, S., Shalaby, T.A. (2022). Mulching as a sustainable water and soil saving practice in agriculture: a review, Agronomy, 12 (8), pp. 1–31.

Ijoyah, M. and Usman, U. (2013). Okra: A potential intercrop for farmers in Nigeria. Journal of Global Biosciences, 2(6), pp. 222-235.

Javed, S. and Panwar, A. (2013). Effect of biofertilizer, vermicompost and chemical fertilizer on different biochemical parameters of *Glycine max* and *Vigna mungo*. Recent Research in Science and Technology, 5, pp. 40-44.

Jha, RK., Neupane, RB., Khatiwada, A., Pandit, S., Dahal, BR. (2018). Effects of different spacing and mulching on growth and yield of okra (*Abelmoschus esculentus* L.) in Chitwan, Nepal 1(1).

Joshi, R., Singh, J. and Vig, A. P. (2015). Vermicompost as an effective organic fertilizer and biocontrol agent: Effect on growth, yield and quality of plants. Reviews in Environmental Science and Bio/Technology, 14(1), pp. 137-159.

KC, P. and Bhattarai, B. P. (2011). Effect of integrated nutrient management in growth, yield and soil nutrient status in Tomato. Nepal Journal of Science and Technology, 12, pp. 23-28.

Khan, S., Pal, M. and Kumar, V. (2015). Influence of different mulches on growth and yield of sponge gourd. Plant Archives, 15(1), pp. 393.395.

Kumar, D. and Sharma, R. (2018). Effect of Mulching on Growth, Yield and Quality in Different Summer Squash. International Journal of Current Microbiology and Applied Sciences, 7(6), pp. 113-119.

Kumar, V., Ramjan, Md. And Das, T. (2019). Cultivation practices of Okra. Biomolecule reports, pp. 1-5.

Kundu, P., Adhikary, N. K., Saha, M., Ghosal, A., and Sahu, N. C. (2019). The effects of mulches on tomato (*Lycopersicon esculentum* L.) in respect of yield attribute in ecosystem of coastal Bengal. Current Journal of Applied Science and Technology, 35(4), pp. 1-8.

Mamkagh, A.M.A. (2009). Effect of tillage time and plastic mulch on growth and yield of okra (*Abelmoschus esculentus*) grown under rainfed conditions. International Journal of Agriculture and Biology, 11, pp. 453–457.

Mishra, K. (2023). Impediments in the agricultural sector of Nepal. Nepal Economic Forum.

MoALD. (2022). Statical information on Nepalese Agriculture 2020/2021.

Murungu, F. S., Chiduza, C., Muchaonyerwa, P., and Mnkeni, P. N. S. (2011). Mulch effects on soil moisture and nitrogen, weed growth and irrigated maize productivity in a warm-temperate climate of South Africa. Soil and Tillage Research, 112(1), pp. 58-65.

Mehata, D.K., Kattel, I., Yadav, S.P.S., Bhujel, S., Bhattarai, S., Yadav, P. and Lahutiya, V. (2023). Varietal trial of okra (*Abelmoschus esculentus* L.) for evaluation of yield and yield parameters. Journal of Genetics, Genomics and Plant Breeding, 6(4), pp.111-116.

Selim, MM. (2020). Introduction to the integrated nutrient management strategies and their contribution to yield and soil properties, International Journal of Agronomy, pp.14.

Mutetwa, M. and Mtaita, T. (2014). Effects of mulching and fertilizer sources on growth and yield of onion. Journal of global innovation in Agricultural and Social science, 2(3), pp. 102-106.

Olabode, O.S., Ogunyemi, S. and Awodoyin, R.O. (2006). Response of Okra (*Abelmoschus esculentus* (L.) Moench) to control weed by mulching. Ghana Journal of Agricultural Science, 39(1), pp. 35- 40.

Parmar, H. N., Polara, N. D., Viradiya, R. R. (2013). Effect of mulching material on growth, yield and quality of watermelon (*Citrullus lanatus* Thunb Cv. Kiran). Universal Journal of Agricultural Research, 1 (2), pp. 30–37.

Parte, V., Dagore, P., Kujur, A. and Markam, U. (2020). Effect of mulching and methods of irrigation on okra (*Hibiscus esculentus* L. Moench). Department of Agronomy, International Journal of Current Microbiology and Applied Sciences, 9(2), pp. 759-765.

Pramanik, P., Bandyopadhyay, K. K., Bhaduri, D., Bhattacharyya, R. and Aggarwal, P. (2015). Effect of mulch on soil thermal regimes - A review. International Journal of Agriculture Environment and Biotechnology, 8, pp.645-58.

Puri, P., Dhungana, B., Adhikari, A., Chaulagain, M., Oli, D., Shrestha, B. (2022). Effect of mulching materials on the vegetative growth and yield of okra (*Abelmoschus esculentus* L. var. US 7109) in Bharatpur, Chitwan. Sustainability in Food and Agriculture, 3(1), pp.24-27.

Rajablariani, H., Hassan khan, F. and Rafezi, R. (2012). Effect of colored plastic mulches on yield of tomato and weed biomass. International Journal of environment science and development, 3(6), pp. 590– 593.

Rekha, G. S., Kaleena, P. K., Elumalai, D. and Srikumaran, M. P. (2018). Efects of vermicompost and plant growth enhancers on the exo- morphological features of *Capsicum annum* (Linn) Hepper. International Journal of Recycling of Organic Waste in Agriculture, 7, pp. 83-88.

Singh, B. K., Pathak, K. A., Ramakrishna. Y., Verma, V. K., Deka, B.C. (2013). Vermicompost, mulching and Irrigation level on growth, yield and TSS of tomato (*Solanum lycopersicum* L.). Indian Journal of Hill Farming, 26(2), pp. 105-110.

Sundari, U.S. and Gandhi, A. (2013). Effect of vermicompost prepared from different organic wastes on growth and yield of okra (*Abelmoschus esculentus* L. (Moench)). International Journal of Recent Scientific Research ,4(5), pp. 568 – 571.

Verma, B.C., Pramanik, P. and Bhaduri, D. (2020). Organic fertilizers for sustainable soil and environmental management. Nutrient dynamics for sustainable crop production, pp. 289-313.

Yaghi, T., Arslan, A. and Naoum., F. (2013). Cucumber (*Cucumis sativus*, L.) water use efficiency (WUE) under plastic mulch and drip irrigation. Agricultural Water Management, 128, pp. 149-157.