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Effects of various fertilizer combinations on Okra (*Abelmoschus esculentus* L.) varieties for dietary fiber content and vegetative characteristics

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Abstract

A Field experiment using two determinate hybrid varieties of okra (Venus and Nitya) was conducted at Agriculture and Forestry University, Rampur, Chitwan during summer of 2021 to examine the impact of different fertilizer combinations on the dietary fiber content and vegetative characteristics of okra. This study was laid out in a split-plot design and comprised three replications; there were two main plots of Okra varieties, and each main plot contained four sub-plots of fertilizer combinations (Inorganic fertilizer + Poultry manure, Inorganic fertilizer + Vermicompost, Inorganic fertilizer + FYM, and Inorganic fertilizer alone). The experimental results revealed that the Venus variety had a higher dietary fiber content (3.52%) than the Nitya variety (2.98 %). Venus variety (6.6 t/ha) had a higher yield as compared to the Nitya variety (5.3 t/ha). It was observed that Inorganic fertilizer + Poultry manure (3.80%) followed by Inorganic fertilizer + Vermicompost (3.46 %) had a superior effect on the dietary fiber content of fruit. Inorganic fertilizer + Poultry manure produced the highest plant height (1.13 m), average canopy diameter (1.10 m), and yield (6.8 t/ha), while Inorganic fertilizer + FYM produced the highest pod length (11.81 cm). The results suggest that combined application of a recommended dose of inorganic fertilizer with organic fertilizer (Poultry manure) improves dietary fiber content and vegetative characteristics of the Okra plant.

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1. Introduction

Okra, "Lady's finger," is one of the vegetables that is produced and consumed the most all over the world (Diizyaman, 2010). It is a C4 plant having efficient photosynthesis (Mncube & HRM Banda, 2017) and grows well in tropical and sub-tropical regions (Singh et al., 2018).It is a tall annual dicotyledonous whose capsule and stem are used for the extraction of crude fibers that have a paramount use in paper industries (Kumar et al., 2013). Various parts of the Okra plant carry a specific significance of their own; hence, its fruit and other plant parts are used for special purposes (Martin, 1982).

Okra fruit possesses great nutritional importance and is proven to contain an excellent number of antioxidants, essential fatty acids, dietary fibers, folate, proteins, and several minerals like Calcium, Magnesium, Potassium, and Sodium (Bawa & Badrie, 2016). Dietary fiber encompasses all the polysaccharides, lignin, pectin, some oligosaccharides, and other associated substances such as cutin, gums, waxes, and suberin that are undigested by human indigenous secretions (Kay, 1982; Trowell et al., 1976). The relatively high content of dietary fibers in Okra makes it effective for preventing cardiovascular diseases, controlling diabetes, and strengthening the digestive system (Elkhalifa et al., 2021).

In addition, the yield and quality of Okra depend on the types and amount of nutrients present in the soil (Tiamiyu et al., 2013). It has been found that the maintenance of organic manure in the soil also ensures the optimum and sustainable production of Okra in the field (Adekiya et al., 2020). Research by Bhandari et al. (2019) showed that total yield and vegetative characteristics depend on the types of fertilizer applied

in the field. Similarly, different varieties of the same plant species might have marked differences in vegetative attributes and total yield (Ghimire et al., 2015). Study conducted by Adekiya et al. (2020) using different fertilizer sources concluded that poultry manure results in greater plant growth, yield, mineral content, and proximate composition of Okra fruit. According to them, such differences were due to the application of diverse sources of fertilizers resulting in differing consequences in soil chemical properties. Thus, different genotypes and growing conditions might play a principal role in determining the yield and total dietary fiber amount of Okra. Shewry et al. (2010) and Thomas et al. (2015) in a similar study reported varied dietary fiber levels of rye grain and rice respectively.

Though organic fertilizers release important micronutrients in the field, the sole application of organic fertilizer would not replenish the required amount of nutrients (Gutser et al., 2005). On the other hand, if inorganic fertilizers are applied exclusively in the field, they may enhance productivity but gradually degrade soil health and imparts serious environmental problems (Pahalvi et al., 2021). As evident from multiple experiments, combining organic and inorganic fertilizer sources has contributed to sustainable, eco-friendly, and efficient production through synergetic effect in improving multiple dynamics of soil, microbes, and plant growth and health. Thus, the balanced combination of organic and inorganic fertilizers could provide optimum results as crops can harness the beneficial attributes of both types (Islam et al., 2017). So, the objective for conducting this study was to appraise the optimal combination of inorganic and organic fertilizer by analyzing their effect on vegetative properties, yield, and fiber content of two commonly grown Okra cultivars (Venus and Nitya).

Farmers of Chitwan are unaware of appropriate combination of fertilizer which limit the performance and yield of Okra. Very few researches has been conducted regarding the appropriate combination of fertilizer on different varieties of okra in Nepal. Thus, this research was carried out to determine the best combination of fertilizer on yield and dietary fiber content of Nitya and Venus varieties.

2. Materials and Method

2.1. Site description

The experiment was conducted at the horticulture farm of the Agriculture and Forestry University, Rampur, Chitwan, Nepal during March to May 2021. The experimental site is 228 meters above sea level and situated at latitude 27°38'50.92" North and longitude 84°20'49.43" East. The site was chosen purposively emphasizing the existing soil conditions, with special importance being given to the ease of field irrigation. The soil had a sandy loam texture with slightly acidic - with PH value of 6.6.

2.2. Experimental design

The experiment was laid out in Split-plot design - Split-plot design was chosen as this involves the combination of two factors by allowing different variations among them (Altman & Krzywinski, 2015).Two commonly available determinate hybrid varieties of Okra, namely Venus and Nitya as main plot factors while the sub-plot factors were four fertilizers treatments consisting of the combinations of inorganic fertilizer and organic manures namely, Inorganic fertilizer + Poultry manure, Inorganic fertilizer + Vermicompost, Inorganic fertilizer + FYM, and Inorganic fertilizer only. The treatments were replicated three times in different blocks. An individual plot was of dimension 160cm × 200 cm ($3.2m^2$) with 4 rows and each row having 5 plants. The plant-to-plant and row-to-row spacing were both kept at 45 cm (Paththinige et al., 2008)

Every plot was provided with the inorganic fertilizer (120 kg N, 80 kg P, 60 kg K per ha) in the form of Urea, Diammonium phosphate, and Muriate of potash respectively. All the fertilizer doses were used as basal application during field preparation. Similarly, the plots with different types of organic fertilizers were applied with 2.5 kilograms of that particular fertilizer. Irrigation was done regularly till all the seeds were germinated and after then the field was provided with water at a regular interval of 3 days. The whole field was mulched with silver mulch plastic to reduce weed interference.

2.3. Measurements and calculations

Each plot had five plants that were marked and data on the following parameters were taken.

2.3.1 Plant Height:

The height of five tagged plants from each plot was taken at 30, 45, 60, and 75 DAS (days after sowing).

2.3.2 Plant Canopy:

Diameters along two axes were taken using a meter scale and the mean value of two diameters proceeded

for the analysis of data. This data was also recorded at 70 days of sowing.

2.3.3 Pod length:

Five Okra flowers from each plot were tagged at 65 days of sowing and 10 days later their respective lengths were measured.

2.3.4 Fruit Yield:

Okra pods were harvested from each tagged plant after 50 days of sowing and were continued till 75 days at 5 days intervals. The obtained data was transformed into production per unit hectare using the unitary method for ease of analysis and interpretation.

2.3.5 Fiber Content:.

5 flowers from each plot were marked with tags, and 10 days later fruits from those flowers were collected for dietary fiber analysis. Two Okra fruits per plot were randomly selected for fiber content analysis. Thus, selected fruits were dried and ground to obtain a sample size of 1mm (Soest & McQueen, 1973). Fiber content was evaluated at the Laboratory of Animal Nutrition and Fodder Production Department of Agriculture and Forestry University, Rampur, Chitwan, Nepal.

For the accurate estimation of Dietary fiber, the Enzymatic gravimetric method namely AOAC 2009.01 given by the Association of Official Agricultural Chemists (AOAC) was used for the determination of dietary fiber.

The dried sample was treated with enzymes (Pancreatic α amylase and Amylo glucosidase) and then it was incubated in a shaking water bath at 37° C for 16 hrs. The incubated mixture was precipitated with ethanol and subsequently filtered. High molecular weight dietary fiber (HMWDF) content was obtained by correcting the total dry residue weight with protein and ash content.

Similarly, the filtrate was subjected to high-performance liquid chromatography to obtain soluble dietary fiber (SDF) content. Eventually, Total dietary fiber was obtained as:

HMWDF = Total dry residue weight – (Protein content + Mineral Content)

Total Dietary fiber = HMWDF + SDF

This method of dietary fiber analysis gives the estimate of dietary fiber per the definition of Codex Alimentarius (McCleary et al., 2013).

2.4 Data Analysis

R-Studio (R version 4.1.3) was used to statistically analyze the data. Analysis of variance (ANOVA) was used to analyze the difference between means and Duncan's Multiple Range Test (DMRT) was used as post hoc test to statistically compare the means of the parameters. The interpretation of the significant differences between the means was done using the least significant differences (LSD) at the 5% level. (Gomez & Gomez, 1984). The correlation coefficient between dietary fiber and yield was calculated using Excel.

3. Result and discussion

3.1 Plant height

Plant height also has a marked positive association with the Okra fruit yield (Mishra et al., 2015). So, for the proper assessment, the observation of plant height was also done. Data on height was taken on four different days (30,45,60 and 75 DAS). The treatment's effect on the height of the Okra plant is presented in Table 1.

The difference in plant height due to different varieties was found to be statistically significant at 45 and 75 DAS but not at 30 DAS and 60 DAS. Venus variety was found to have a taller average height (37.86 cm) as compared to that of the Nitya variety (31.69 cm) at 45 DAS. Similarly, at 75 DAS, the average height of Venus (112.25 cm) was found to be statistically greater than Nitya variety (93.66 cm).

The effect of different fertilizer combinations on plant height taken at 45, 60, and 75 DAS was found to be statistically significant whereas non-significant results were obtained for plant height at 30 DAS (Table 1). Inorganic manure + poultry manure had statistically superior plant height, whereas, Inorganic fertilizer only had least plant height taken recorded at three days (45, 60, and 70 DAS). At 45 and 75 DAS, two treatments (Inorganic fertilizer + Vermicompost and Inorganic fertilizer + FYM) were statistically similar to Inorganic fertilizer + Poultry manure. Likewise, at 75 DAS Inorganic fertilizer + Vermicompost was statistically on par with Inorganic manure + Poultry manure; The third treatment - Inorganic fertilizer + FYM- was statistically lesser than Inorganic fertilizer and greater than Inorganic fertilizer only. Interaction of two treatments (Variety + Fertilizer Combinations) did not produce statistical variation on plant height recorded at all 4 DAS.

Fagwalawa & Yahaya(2016) also had similar findings as the height of the Okra plant grown by providing the field with poultry manure was reported to be better when compared to that provided with cow dung and poultry manure. An experimental study performed by Ajari et al. (2004) to assess the effect of

fertilizers on plant height came out with a finding that fertilizers have a consequential effect in increasing the height of the plant which is similar to the findings of the study.

Table 1. Effect of different varieties and fertilizer combinations on plant height of Okra

Treatment	**Plant height (cm)**			
	30 DAS	45DAS	60DAS	75 DAS
Variety				
Venus variety	14.47	36.58[a]	85.95	112.25[a]
Nitya variety	13.79	32.14[b]	83.72	93.66[b]
SEm (±)	1.47	0.69	2.56	3.29
LSD (0.05)	6.31	2.97	11.04	14.76
T test	NS	*	NS	*
Fertilizer				
Inorganic fertilizer + Poultry manure	15.50	38.49[a]	89.59[a]	113.67[a]
Inorganic fertilizer + Vermicompost	14.23	34.79[ab]	89.49[a]	105.33[ab]
Inorganic fertilizer + FYM	13.83	33.59[ab]	83.20[ab]	102.33[b]
Inorganic fertilizer	12.95	30.58[b]	77.03[b]	90.5[c]
SEm (±)	1.22	2.29	4.99	4.86
LSD (0.05)	2.67	3.79	7.61	10.6
F test	NS	*	*	**
Variety× Fertilizer				
F test	NS	NS	NS	NS
Grand mean	14.13	34.36	84.84	102.95

(Value of the parameter is the average of 5 plants each from 24 plots distributed between 3 replications)

The identical letter(s) between the means in a column do not significantly vary by DMRT at the 5% level of significance. NS indicates "Not Significant", * indicates significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.

3.2 Plant canopy

Plant canopy is also one of the important yield parameters and thus determines the quality and quantity of yield (Rhodes, 1971). Higher the plant canopy, the higher the light interception, thus greater the yield. According to Yang et al. (2014), plant canopy is primarily determined by plant density. However, varietal differences and fertilizer disparity could also have a pronounced effect on the plant canopy and leaf area of a plant (Sasaki et al., 2005; Subedi et al., 2006). The data on the plant canopy was also taken at 70 DAS. The difference observed between the two varieties on average canopy diameter was not found to be statistically significant. Though not significant, the Venus variety had a greater plant canopy of 103.85 cm when compared to the Nitya variety whose average canopy diameter was observed to be 101.24 cm. Inorganic fertilizer supplemented with Poultry manure, Vermicompost, and FYM were on par regarding average canopy diameter. However, the sole application of Inorganic fertilizer showed a significantly lowest canopy diameter of 91.38 cm when

compared to the other three treatments (Inorganic fertilizer + Organic manures). There was no significant difference in the result for average canopy diameter due to the interaction between variety and fertilizer combinations.

Table 2. Effect of different varieties and different fertilizer combinations on Canopy diameter of Okra

Treatment	Average Canopy diameter (cm)
Variety	
Venus variety	103.85
Nitya variety	101.24
SEm (±)	3.43
LSD (0.05)	14.76
T test	NS
Fertilizer	
Inorganic fertilizer + Poultry manure	110.88[a]
Inorganic fertilizer+ Vermicompost	104.82[a]
Inorganic fertilizer + FYM	103.10[a]
Inorganic fertilizer	91.38[b]
SEm (±)	4.99
LSD (0.05)	10.87
F test	*
Variety× Fertilizer	
F test	NS
Grand Mean	102.54

(Value of parameter is the average of 5 plants each from 24 plots distributed between 3 replications)

The identical letter(s) between the means in a column do not significantly vary by DMRT at the 5% level of significance. NS indicates "Not Significant", * indicates significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.

3.3 Pod Length

The result of the pod length as influenced by different treatments is shown in Table 3. The length of the tagged pod was measured at 75 DAS. Ozer et al. (1999) found the pod length of rape seed to be directly correlated with the total yield of a crop, so we also observed the data on pod length to assess the effect of different treatments on the pod length of Okra. The difference in the pod length between the two varieties was found to be statistically significant. The pod length of the Venus variety (11.56 cm) was found to be greater than that of the Nitya variety (9.62 cm). Different fertilizer combinations exerted no significant variation in the pod length of Okra. Similarly, no significant difference was observed in the pod length of Okra due to the interactive effect of different varieties and fertilizer combinations. Analogous to the nature of our finding, Aminu et al. (2016) also found a significant difference in pod length in different varieties of Okra. Similarly, Tiamiyu et al. (2013) in their experimental study also obtained a non-significant difference in the pod length of Okra attributable to different fertilizer combinations.

3.4 Fruit yield

Total fruit yield is the cumulative effect of different

environmental and genotypic components (Kaya et al., 2009). Through this study, the effect of different varieties and fertilizer combinations on the yield of Okra was also figured out and shown in Table 4. The difference in mean yield of the two different varieties was found to be statistically significant with the Venus variety resulting in a remarkably higher yield (6.592 t/ha) than that of the Nitya variety (5.320 t/ha).

Similarly, the difference in mean yield due to variation in the combination of fertilizers was also proven to be statistically significant. Poultry manure, when applied along with Inorganic fertilizer, was found to have a superior effect on yield among other combinations i.e. the mean yield being 6.818 t/ha of treatment Inorganic fertilizer + Poultry manure. This was followed by two other different combinations viz Inorganic fertilizer + FYM (6.320 t/ha) and Inorganic fertilizer + Vermicompost (5.690 t/ha). The mean yield of the plot with the sole application of Inorganic fertilizer was found the least (4. 995t/ha).

The research performed by Fagwalawa & Yahaya (2016) involved the application of sheep manure, poultry manure, and cow manure, and among these combinations, poultry manure was recorded to be the best organic fertilizer among others. Their study also came up with the finding that Poultry manure is superior to other organic fertilizers when its effect on fruit yield was analyzed.

Table 3. Effect of different variety and fertilizer combinations on fruit yield of Okra

Treatment	**Fruit yield (t/ha)**
Variety	
Venus variety	6.592[a]
Nitya variety	5.320[b]
SEm (±)	234.75
LSD (0.05)	1.237
T test	**
Fertilizer	
Inorganic fertilizer + Poultry manure	6.818[a]
Inorganic fertilizer+ Vermicompost	5.690[b]
Inorganic fertilizer + FYM	6.320[ab]
Inorganic fertilizer	4.995[c]
SEm (±)	176.29
LSD (0.05)	0.665
F test	***
Grand mean	5.956

(Value of parameter is the average of 5 plants each from 24 plots distributed between 3 replications)

*The identical letter(s) between the means in a column do not significantly vary by DMRT at the 5% level of significance. NS indicates "Not Significant", * indicates significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.*

Similarly, the interaction between varieties and different fertilizer combinations was also found to cause statistical differences in the mean yield (Table 4). Venus variety when applied with Inorganic fertilizer + Poultry manure resulted in the highest yield (8.032 t/ha) followed by Venus variety with Inorganic

fertilizer + FYM whereas the Nitya variety when applied with Inorganic fertilizer, had the lowest yield (4.187 t/ha).

Table 4. Effect of interaction between Varieties and Different fertilizer combinations on fruit yield of Okra

Variety × Fertilizer	Yield (t/ha)
Venus × Inorganic fertilizer + Poultry manure	8.032[a]
Venus × Inorganic fertilizer + FYM	6.880[b]
Venus × Inorganic fertilizer only	5.804[c]
Nitya × Inorganic fertilizer + FYM	5.760[c]
Nitya × Inorganic fertilizer + Vermicompost	5.727[c]
Venus × Inorganic fertilizer + Vermicompost	5.653[c]
Nitya × Inorganic fertilizer + Poultry manure	5.605[c]
Nitya × Inorganic fertilizer only	4.187[d]
F test	*
Grand mean	5.956

(Value of parameter is the average of 24 plots distributed between 3 replications)

*The identical letter(s) between the means in a column do not significantly vary by DMRT at the 5% level of significance. NS indicates "Not Significant", * indicates significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.*

3.5 Dietary fiber content

As shown in Table no.5, the differences in fiber content were found significant between the two varieties. The average fiber content of the Venus variety was found to be 3.52 % whereas that of the Nitya variety was found to be 2.98 %. Similarly, the difference in fiber content due to different fertilizer combinations was also found to be significant. Inorganic fertilizer + Poultry manure resulted in superior fiber content with an average of 3.80 % followed by Inorganic fertilizer + Vermicompost with a fiber content of 3.46 %. The Okra supplemented with Inorganic fertilizer had the least fiber content (2.75 %) among all combinations; however, it was at par with Inorganic fertilizer + FYM (3.00 %). A study by Adekiya et al. (2020) had similar findings as Okra grown with supplementing poultry manure contained a comparatively better amount of nutrients than that grown with other organic fertilizers. Due to different interactions between the variety and fertilizer combinations, there was no statistically significant variation in the fiber content. The nutritional value of any crop production could be affected by the variation in the availability of organic and mineral fertilizers (Marzouk & Kassem, 2011). On the other hand, Oyelade et al. (2003) also reported that the variation in nutritional value might result due to the difference in genotypes of the crop varieties. Therefore, the significant difference in our study between different fertilizer combinations and varieties is not fortuitous but might be due to the above causes.

The study performed to evaluate the chemical properties of Tunisian pods by Romdhane et al. (2020) resulted in dietary fiber content of 8.16 % of Okra. The difference between this finding and our estimation could be attributed to the differences in varieties or to the different methods employed for dietary fiber determination (Wolters et al., 1992). The statistical analysis report of our experimental study recommends that for good dietary fiber content, the Venus variety could be preferred to the Nitya variety and poultry manure and vermicompost could be used along with Inorganic fertilizer for the higher fiber content in fruit.

Table 5. Effect of variety and fertilizer combinations on Dietary fiber content of Okra Fruit

Treatment	Dietary fiber content (%)
Variety	
Venus variety	3.52[a]
Nitya variety	2.98[b]
SEm (±)	0.11
LSD (0.05)	0.48
CV	8.43
T test	*
Fertilizer	
Inorganic fertilizer + Poultry manure	3.80[a]
Inorganic fertilizer + Vermicompost	3.46[ab]
Inorganic fertilizer + FYM	3.0[bc]
Inorganic fertilizer	2.75[c]
SEm (±)	0.25
LSD (0.05)	0.54
F test	**
Variety × Fertilizer	
F test	NS
Grand mean	3.26

(Value of parameter is the average of 24 plots distributed between 3 replications)

*The identical letter(s) between the means in a column do not significantly vary by DMRT at the 5% level of significance. NS indicates "Not Significant", * indicates significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.*

3.6 Correlation between dietary fiber content and yield

The correlation coefficient was calculated between dietary fiber content and yield of the Okra plant and they were found to co-relate with each other with the value of 0.459 ; likewise, the p value was obtained as p-value = 0.01525 which indicates there lies significant positive relation (At 5% significance level) between the variables (Taylor, 1990).

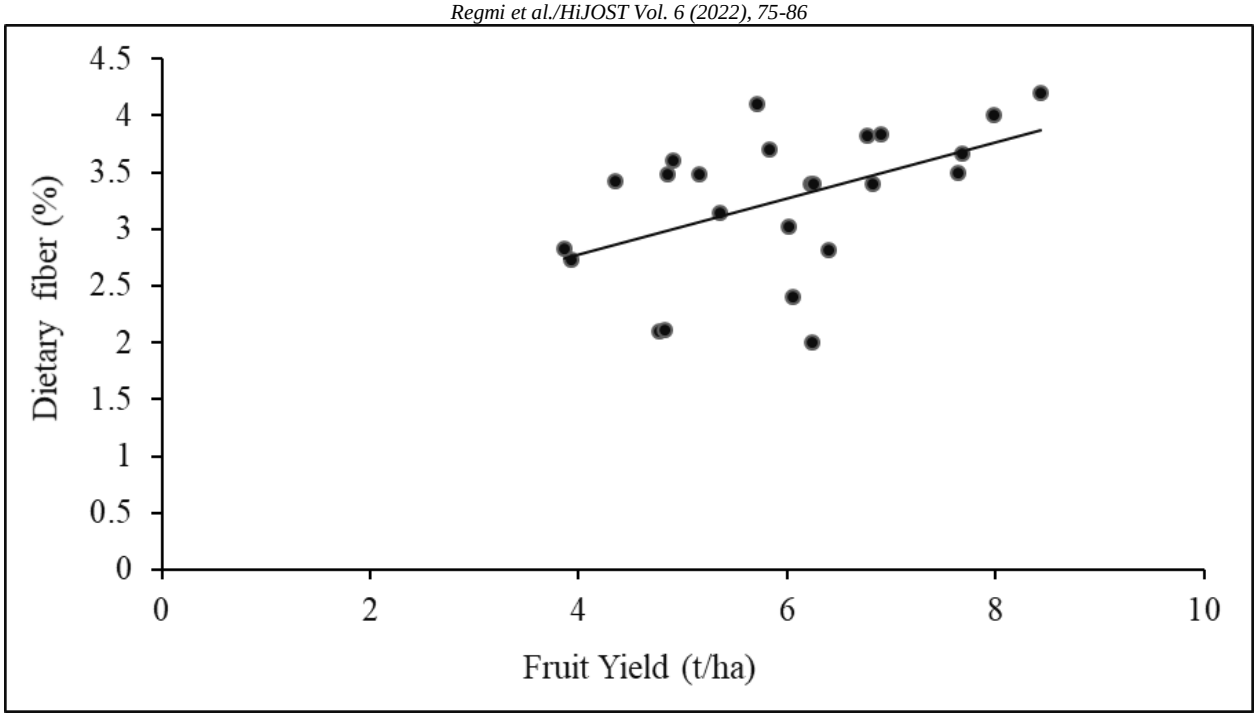

Figure 1. Correlation between dietary fiber content and fruit yield

4. Conclusions

This study was carried out to evaluate the Okra varieties (Venus and Nitya) as well as varying combinations of fertilizer sources on the fruit's dietary fiber content and yield attributes. From the experimental results obtained from all the parameters, we can conclude that the use of the Venus variety along with the application of Inorganic fertilizer + Poultry manure yielded superior fruit dietary fiber content and fruit yield as compared to the Nitya variety and other fertilizer combinations.

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Competing interests

The authors declare no competing interests.

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