Plant Archives Vol. 25, No. 1, 2025 pp. 434-440 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.065

EFFECT OF DIFFERENT FRUIT PEEL POWDERS AS NATURAL MANURES ON GROWTH AND YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS* L.)

Pranjal Raikwar[1], Harpal Singh[1], Rashmi Nigam[2]* and Abhishek Kumar[1]

[1]Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.), India.
[2]Department of Plant Pathology, Janta Vedic College, Baraut, Baghpat (U.P.), India.
*Corresponding author E-mail : rashmipathologist1979@gmail.com
(Date of Receiving-08-12-2024; Date of Acceptance-10-02-2025)

ABSTRACT

Purpose: Fruit peels waste is one of the waste accumulate in huge quantity every day. It is a serious problem and need to be managed to make environment free from pollution. Fruit peels are very rich in macro and micro nutrients that are beneficial for plant growth. By using fruit peel as fertilizer we can reduce load of wastes and can get more benefits than inorganic fertilizer.

Research Method: The experiment was carried out in a Completely Randomized Design with eight treatments having twenty-four replicates. Treatments were, recommended fertilizer application at basal and topdressing (T_1, control), half dose of recommended fertilizer application at basal and topdressing times with 1g of banana peel powder (T_2), 1g of pomegranate peel powder (T_3), 0.5g each of banana and pomegranate peel powders (T_4), 1g of orange peel powder (T_5), 0.5g each of banana and orange peel powders (T_6), 1g coconut peel powders (T_7) and 0.5g each of banana, Pomegranate, orange and coconut peel powders (T_8) at both times. All agronomic practices were carried out at the organic research farm, Karguan ji, Institute of Agricultural Science, Bundelkhand University, Jhansi (U.P.).

Findings: The results reveals that application of fruit peel powder at basal and top dressing had significant differences on plant height, leaf area, root length, chlorophyll content, days to 50% and 100% flowering, no. of fruit per plant, fruit length and yield. At 1st, 2nd, 3rd and 4th picking, the highest value was obtained in T_8 and lowest value in T_1.

Originality/ Value: Application of fruit peel powder into the soil leads to improve growth and yield of okra. Present study suggested that, among the all tested treatments, half recommended fertilizer application at basal and topdressing times 0.5g each of banana, Pomegranate, orange and coconut peel powders (T_8) at both times would be the most suitable fruit peel powders to get higher growth and yield of okra.

Key words : Banana peel powder, Orange peel powder, Pomegranate peel powder, Coconut peel powder, Okra.

Introduction

Okra (*Abelmoschus esculentus* L.) is a vegetable plant belonging to the family Malvaceae, grown as an annual crop in tropical and subtropical regions of the world. The cultivation and consumption of okra are popular in India due to its rich nutritional composition and significant medicinal value. It contains considerable amounts of protein, carbohydrates, fiber, and vitamins A, B and C, as well as minerals such as calcium (Ca), phosphorus (P), and iron (Fe) (Sachan *et al.*, 2017). Okra is highly beneficial for human health, helping to prevent numerous diseases and aging, boost immunity, and improve overall well-being (Ibeawuchi *et al.*, 2005). It also helps control cholesterol levels, thereby reducing the risk of cardiovascular diseases (Dubey and Mishra, 2017). Its high fiber content stabilizes blood sugar by regulating the rate at which sugar is absorbed in the intestinal tract and reducing digestive issues. Additionally, it promotes heart health, regulates cholesterol levels, and supports a healthy pregnancy (Gemede *et al.*, 2015). Okra is a resilient crop that can tolerate a wide range of climatic conditions (Akanbi *et al.*, 2010). However, its growth and yield

depend on factors such as seed quality, soil nutrition, climatic conditions, cultural practices, and the use of plant growth regulators (Shahid *et al*., 2013). Low yield due to poor soil nutrient status has been identified as one of the major constraints limiting okra production (Ajayi *et al*., 2017).

Fruit peel waste accumulates in significant quantities daily at both domestic and industrial levels. Most people discard fruit peels as waste. This is a crucial issue, particularly at the industrial level, where proper waste management is necessary to reduce environmental pollution (Jariwala and Syed, 2016). Fruit peels are rich in macro- and micronutrients essential for plant growth (Ibrahim *et al*., 2016). They can be used as natural fertilizers to enhance soil fertility and enrich soil microbiota due to their high mineral content. Additionally, some active compounds in fruit peels and seeds possess insecticidal and antifungal properties against plant pathogens (Singh *et al*., 2017). Therefore, fruit peels can serve as natural fertilizers in crop production. Using fruit peels as fertilizer can help reduce waste accumulation while providing additional agricultural benefits. Fruit peel powders can also regulate soil pH, improve soil fertility and morphology, supply essential nutrients, and combat harmful insect pests and nematodes, particularly in citrus crops (Mercy *et al*., 2014). Furthermore, using fruit peels as fertilizers could help replace expensive and environmentally harmful inorganic fertilizers, promoting sustainable and high-quality crop production.

The peels of tropical fruits such as bananas, papayas, pineapples, mangoes, oranges and pomegranates are abundantly available in India and can be used as natural fertilizers. Bananas are widely consumed, and their peels constitute approximately 40% of the total fruit weight (Fatemeh *et al*., 2012). Banana peels are rich in potassium (K), calcium (Ca), sodium (Na), iron (Fe), manganese (Mn) and bromine (Br) (Anhwange *et al*., 2009). Similarly, a large quantity of orange (*Citrus sinensis*) peel is produced annually. Although often considered waste, orange peels are valuable sources of molasses, pectin, and limonene (Rafiq *et al*., 2018). Pomegranate fruit peels, which are discarded during juice processing, account for 26–30% of the total fruit weight. They contain significant amounts of phenolic compounds, including flavonoids and hydrolyzable tannins (Rowayshed *et al*., 2013) and possess 92% antioxidant activity (Ismail *et al*., 2012). Pomegranate peels also contain essential macronutrients such as potassium (K), nitrogen (N), calcium (Ca), phosphorus (P), magnesium (Mg) and sodium (Na), along with micronutrients such as boron (B), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) (Rowayshed *et al*., 2013). Therefore, the present study aims to investigate the effects of different fruit peel powders as natural fertilizers on the growth and yield of okra (*Abelmoschus esculentus* L.).

Materials and Methods

The experiment was conducted at the Organic Research Farm, Karguan Ji, Institute of Agricultural Science, Bundelkhand University, Jhansi (U.P.). The geographical coordinate of study site were Lat 25.450966^0, Long 78.616292^0, during the cropping period, the temperature varied between 11°C and 32°C. The soil at the experimental site is sandy clay. For this experiment, okra (*Abelmoschus esculentus*) variety Neelima F1 (Hybrid) seeds were used. The experiment followed a Randomized Block Design (RBD) with eight treatments and twenty-four replicates. The treatments were as follows:

- T_1 (Control): Recommended fertilizer application at basal and topdressing.
- T_2: Half-dose of the recommended fertilizer applied at basal and topdressing along with 1 g of banana peel powder.
- T_3: Half-dose of the recommended fertilizer applied at basal and topdressing along with 1 g of pomegranate peel powder.
- T_4: Half-dose of the recommended fertilizer applied at basal and topdressing along with 0.5 g each of banana and pomegranate peel powders.
- T_5: Half-dose of the recommended fertilizer applied at basal and topdressing along with 1 g of orange peel powder.
- T_6: Half-dose of the recommended fertilizer applied at basal and topdressing along with 0.5 g each of banana and orange peel powders.
- T_7: Half-dose of the recommended fertilizer applied at basal and topdressing along with 1 g of coconut peel powder.
- T_8: Half-dose of the recommended fertilizer applied at basal and topdressing along with 0.5 g each of banana, pomegranate, orange and coconut peel powders.

Fruit peels were collected separately from the Jhansi fruit market. The collected peels were cleaned, and foreign materials were removed. The peels were then cut into small pieces (1–5 cm) and air-dried under natural sunlight for 20–25 days. After drying, the fruit peels were ground separately using a grinder and sieved through a 2 mm sieve. The powders were then stored at room

temperature (Jariwala and Syed, 2016). For treatment application, 1 g each of banana, pomegranate, orange, and coconut peel powders were measured separately and stored in airtight containers. Additionally, mixtures containing 0.5 g of banana and 0.5 g of pomegranate peel powders, 0.5 g of banana and 0.5 g of orange peel powders, and 0.5 g each of banana, pomegranate, orange, and coconut peel powders were also prepared, sealed, and labelled for later use.

The experimental field was prepared by ploughing with a mouldboard plough, followed by crisscross cultivation. During the second ploughing, farmyard manure (FYM) at a rate of 15 t/ha was incorporated into the soil. After 11–13 days of ploughing, the field layout was prepared by dividing it into 24 plots, arranged in three replications of eight plots each, ensuring proper irrigation channels and pathways for differentiation between replications. When seedlings developed two to three leaves per plant, they were transplanted at a spacing of 45 × 60 cm, accommodating 16 plants per plot with a plot size of 4.32 m². Healthy seedlings with uniform growth were selected for transplanting and light watering was done immediately after transplantation. All agronomic practices were carried out as per the recommendations of the Department of Agriculture. An 80% water-holding capacity was maintained in all pots. Growth and yield parameters were measured using selected tagged plants and the destructive sampling method. The collected data were analysed using parametric and non-parametric statistical methods.

Results and Discussion

Plant height

Plant height significantly varied among the tested treatments at 4th, 6th and 8th WAP (Table 1). At 4th WAP maximum plant height (16.47cm) was recorded in T_2 which was found statistically at par with T_5 (15.84 cm), T_6 (15.80cm), T_7 (15.87cm) and T_8 (16.38cm) while minimum plant height (14.03cm) was recorded in the T_1. Banana fruit peel has more K and it may help to create new cells, which then organize into plant tissues may be the reason for tallest plant in T_2, T_6 and T_8. At 6th and 8th WAP, maximum plant height was measured in T_8 and minimum plant height was recorded in the T_1. Application of fruit peel powder into the soil leads to increase soil nutrients level and that may be the reason to increase plant height in fruit peel applied treatments compared with T_1. These results are in agreement with Mercy *et al*. (2014), who stated that height of the fenugreek plants were higher in fruit peel powder applied soil than the control. Kadir *et al.* (2016) reported that fruit peels significantly enhanced the shoot height of *Solanum scabrum* plants compared with untreated plants. Further, Tan and So (2018) stated that holy basil plant height was increased when banana peel based biochar prepared at different pyrolysis temperatures were applied.

Table 1 : Plant height (cm) of okra.

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T_1	6.70	**14.03**	**28.60**	**39.30**
T_2	6.77	**16.47**	31.13	59.87
T_3	6.83	15.16	32.17	54.40
T_4	**6.50**	14.99	32.92	57.32
T_5	6.70	15.84	32.98	57.22
T_6	**7.30**	15.80	38.40	55.88
T_7	7.17	15.87	39.53	59.23
T_8	6.97	16.38	**40.10**	**61.63**
SEM±	0.25	0.27	0.76	0.63
CD	0.78	0.82	2.33	1.94
	NS	SIG**	SIG**	SIG**

Table 2 : Leaf area (cm^2).

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T_1	35.17	**179.25**	**353.70**	**589.03**
T_2	**36.82**	217.44	**655.79**	**699.96**
T_3	35.43	193.56	492.25	601.82
T_4	34.40	227.80	541.93	620.48
T_5	35.51	213.60	541.12	632.51
T_6	**34.11**	244.66	643.44	644.86
T_7	34.24	**245.57**	625.46	634.91
T_8	35.57	243.68	648.99	656.28
SEm±	0.74	7.45	7.96	8.83
CD	2.28	22.97	24.51	27.22
	NS	SIG**	SIG**	SIG**

Leaf area

Plant grown with higher concentration of fertilizers produces larger leaf area (Kang and Iersel, 2004). Application of fruit peel powder significantly influenced the leaf area at 4th, 6th and 8th WAP (Table 2). At 4th WAP, the highest leaf area was recorded in T_7 (245.57 cm^2) followed by T_6 (244.66 cm^2), T_8 (243.68 cm^2 and T_4 (227.8 cm^2), while the lowest leaf area was recorded in T_1 (179.25 cm^2). At 6th and 8th WAP, the highest leaf area was recorded in T_2 (655.79 cm^2 and 699.96 cm^2, respectively) followed by T_6 (643.44 cm^2 and 644.86 cm^2, respectively) and T_8 (648.99 cm^2 and 656.28 cm^2, respectively) while the lowest leaf area was recorded in T_1 (353.70 cm^2 and 589.03 cm^2, respectively). These findings are agreeable with Mercy *et al*. (2014), who stated that leaf area of the rye plant was higher in fruit peel powder applied soil than control and Wazir *et al.*

(2018) noted that application of banana peel as an organic fertilizer into the soil increase leaf area of pea plant.

Root length

There were significant differences in root length which measured from collar region to tip of the root at 2nd, 4th, 6th and 8th WAP as shown in Table 3. T_6 recorded the maximum root length and T_1 recorded the lowest root length from 2nd WAP to 6th WAP. At 8th WAP, the highest root length was recorded in T_6 (49.07 cm), followed by T_6 (46.18 cm), while the lowest root length was recorded in T_1 (20.42 cm). However, there was no variation among T_4, T_7, T_2, T_5 and T_3 in root length at 8th WAP. Mineral nutrients are important for plant root growth (Fageria and Moreira, 2011). Amin *et al.* (2015) stated that Potassium supplement improves root and shoot growth and enhance plant nutrient uptake. Phosphorus and iron increase plant root length (Ding *et al*., 2018). The presence of Cytokinins in fruit peels could be another reason of increased root length (Singh and Prasad, 2014). Those may be the reasons for increase root length in fruit peel applied okra plants compared with control. It is in line with Sakpere *et al.* (2018), who noted that root length was enhanced by fruit peels treated *Solanum scabrum* plants than untreated plants.

Chlorophyll content

Chlorophyll content was measured with the help of SPAD meter. There was a significant change noted at 4th, 6th and 8th WAP as shown in Table 4 and Fig. 1. In 4th WAP, T_5 showed maximum chlorophyll content and T_1 recorded the lowest chlorophyll content. 6th and 8th WAP, the highest chlorophyll content was recorded in T_4 (45.92 and 84.07, respectively), followed by T_3 (44.16 and 78.12 respectively), T_5 (42.93 and 77.76, respectively) and T_8 (43.69 and 79.35, respectively) and while the minimum chlorophyll content was recorded in T_1 (38.33 and 39.98, respectively). The findings are agreeable with Bakry *et al.* (2016), who stated that banana peel extract significantly increased chlorophyll a, chlorophyll b, total carotenoids and consequently total pigments and maximum increase of the photosynthetic pigments. However, no difference was noted among T_7, T_6 and T_2 in 8th WAP.

Days for 50% and 100% flowering

Days for 50% and 100% flowering of okra varied significantly due to the fruit peel powder application at both stages shown in Table 5 and Fig. 2 and time period of 40.67 and 43.67 days were taken by T_1 for 50% and 100% flowering, respectively. Theoretically, additional need of potassium application for flowering and banana peel rich in potassium may be the reason for the shortest period for flowering on T_6 and T_2.

Table 3 : Root length.

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T_1	**7.90**	**13.20**	**15.37**	**20.42**
T_2	8.41	14.03	22.66	41.01
T_3	8.57	13.82	18.22	35.34
T_4	10.10	15.04	18.95	44.98
T_5	9.68	14.55	19.21	33.57
T_6	**11.07**	**16.83**	**23.34**	46.18
T_7	10.90	17.10	23.03	38.88
T_8	11.00	16.83	22.40	**49.07**
SEm±	0.29	0.25	0.54	1.31
CD	0.88	0.77	1.65	4.02
	SIG**	**SIG****	**SIG****	**SIG****

Table 4 : Chlorophyll content.

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T_1	38.04	**36.29**	**38.33**	**39.98**
T_2	38.35	42.08	45.81	66.41
T_3	37.51	41.66	44.16	78.12
T_4	38.77	42.14	**45.92**	**84.07**
T_5	**38.81**	**42.81**	42.93	77.76
T_6	**36.00**	41.76	40.58	70.74
T_7	37.64	40.79	42.09	72.92
T_8	38.24	40.24	43.69	79.35
SEm±	0.57	0.48	0.44	2.39
CD	1.76	1.48	1.35	7.37
	NS	**SIG****	**SIG****	**SIG****

Table 5 : Days for 50% and 100% flowering

Treatment	Days for 50% flowering	Days for 100% flowering
T_1	**40.67**	**43.67**
T_2	36.33	39.33
T_3	36.00	39.67
T_4	37.67	41.00
T_5	37.67	41.33
T_6	37.00	40.00
T_7	36.67	39.67
T_8	**35.33**	**37.33**
SEm±	0.39	0.33
CD	1.20	1.03
	SIG**	**SIG****

Number of fruits per plant

There was a significant change noted in number of fruits per plant at at 1st, 2nd, 3rd and 4th picking as shown in Table 6. The highest number of fruits per plant at 1st,

Table 6 : Number of fruits per plant at each picking.

Treatment	1nd Picking	2nd Picking	3rd Picking	4th Picking
T_1	**1.00**	**1.33**	**2.67**	**3.00**
T_2	2.00	3.00	3.33	4.33
T_3	2.00	2.33	3.00	4.67
T_4	2.00	2.33	4.00	4.33
T_5	2.33	3.00	3.33	4.33
T_6	2.00	3.67	4.00	5.00
T_7	2.67	3.67	4.67	5.00
T_8	**3.00**	**4.00**	**5.33**	**5.67**
SEM±	0.17	0.28	0.25	0.30
CD	0.53	0.85	0.77	0.93
	SIG**	SIG**	SIG**	SIG**

Table 7 : Fruit length.

Treatment	1nd Picking	2nd Picking	3rd Picking	4th Picking
T_1	**10.11**	**11.02**	**11.27**	**11.98**
T_2	15.09	14.67	15.47	15.87
T_3	13.44	14.37	14.03	15.41
T_4	13.84	14.50	14.17	15.62
T_5	14.17	14.40	13.88	13.91
T_6	12.61	14.37	14.95	15.79
T_7	14.44	**15.36**	14.32	15.49
T_8	**15.21**	15.16	**16.17**	**15.87**
SEm±	0.33	0.28	0.43	0.41
CD	1.02	0.85	1.33	1.27
	SIG**	SIG**	SIG**	SIG**

2nd, 3rd and 4th picking was recorded in T_4 (3.00, 4.00, 5.33 and 5.67, respectively), followed by T_7 (2.67, 3.67, 4.67 and 5.00, respectively), while the minimum chlorophyll content was recorded in T_1 (10.11, 11.02, 11.27 and 11.98, respectively). Contradictory findings were noted by Colpan *et al.* (2013), who stated that with an increase in potassium application, there was an increase and then a decrease in the fruit number of tomato plant and Mazed *et al.* (2015) stated that the highest number of pods per mung bean plant was recorded from potassium whereas, the lowest number of pods per plant was found from control treatment.

Fruit length

The data presented in Table 7 clearly indicated that the fruit peel application played a significant role in length of fruits. At 1st, 2nd 3rd and 4th picking there was a significant difference among treatments. At 1st, 3rd and 4th pickings, maximum length of fruits were observed in T_8 and minimum length of fruits were observed in T_1, while At 2nd pickings, maximum length of fruits were

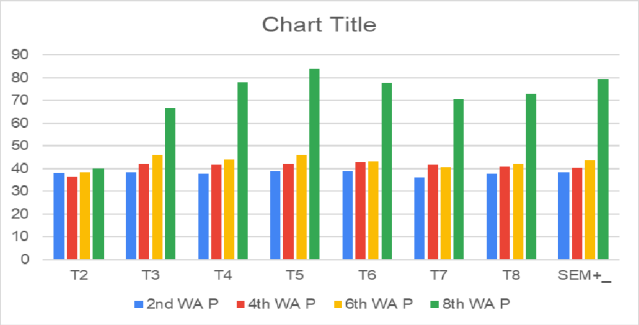

Fig. 1 : Effect on Chlorophyll content.

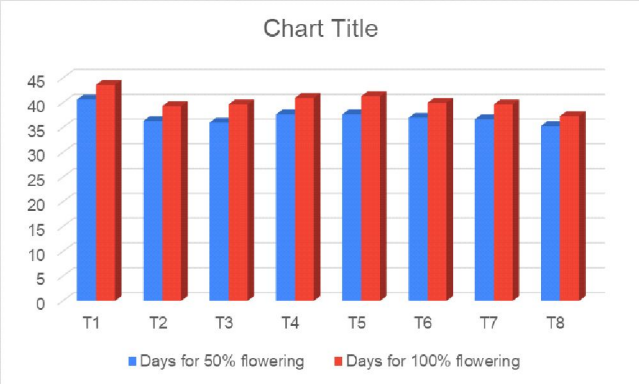

Fig. 2 : Effect of fruit peel powder 50% and 100% flowering.

Table 8 : Yield in kg/plot of okra.

Treatment	1nd Picking	2nd Picking	3rd Picking	4th Picking
T_1	**0.12**	**0.39**	**0.41**	**0.68**
T_2	0.52	0.85	0.99	1.26
T_3	0.38	0.67	0.70	0.90
T_4	0.47	0.76	0.79	1.00
T_5	0.39	0.67	0.70	0.89
T_6	**0.57**	**0.88**	1.03	1.21
T_7	0.39	0.70	0.71	0.95
T_8	0.65	1.04	**1.05**	**1.27**
SEm±	0.02	0.02	0.02	0.03
CD	0.05	0.07	0.07	0.09
	SIG**	SIG**	SIG**	SIG**

observed in T_7 and minimum length of fruits were observed in T_1. Colpan *et al.* (2013) stated that when potassium levels are low, fruits are small and when potassium levels are high, fruits are too large. It is agreed with the present study.

Total yield at each picking (kg/plot)

Application of different fruit peel powder significantly influenced total yield in 1st, 2nd, 3rd and 4th picking (Table 8). At 1st, 2nd, 3rd and 4th picking, the highest value was obtained in T_8 (56.41, 85.15, 89.42 and 110.73 q ha^{-1}) and the lowest value in T_1 (10.84, 33.62,35.36 and 59.42 q ha^{-1}). It is agreeable with Bakry *et al.* (2016), who stated

that effect of foliar application of banana peel extract significantly increased the yield of quinoa plants.

Conclusion

The results revealed that the application of fruit peel powder at basal and topdressing significantly affected ($P < 0.05$) plant height, number of leaves per plant, leaf area, chlorophyll content, days to 50% and 100% flowering, dry weights of leaves, stem, root and fruit, as well as fruit length and girth. Furthermore, across the 1st, 2nd, 3rd and 4th picking, the highest values were recorded in T_6, while the lowest values were observed in T_1. Based on the present study, it is suggested that among all the tested treatments, the most suitable approach for achieving optimum growth and yield of okra in sandy regosol is the application of half the recommended fertilizer at basal and topdressing stages, combined with 0.5 g each of orange and banana peel powders at both times (T_6).

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