The Journal of Agricultural Sciences - Sri Lanka
Vol 16, No. 1, January, 2021. Pp 67-79
http://doi.org/10.4038/jas.v16i1.9184

Effect of Different Fruit Peel Powders as Natural Fertilizers on Growth of Okra (*Abelmoschus esculentus* L.)

S.G.A.R.M. Dayarathna[1] and Brintha Karunarathna[1*]

Date Received: 30th November 2019 / Date Accepted: 3rd January 2020

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 six treatments having twenty replicates. Treatments were, recommended fertilizer application at basal and topdressing (T1, control), half dose of recommended fertilizer application at basal and topdressing times with 1g of banana peel powder (T2), 1g of pomegranate peel powder (T3), 1g of orange peel powder (T4), 0.5g each of banana and pomegranate peel powders (T5) and 0.5g each of orange and banana peel powders (T6) at both times. All agronomic practices were followed as per Department of Agriculture, Sri Lanka except fertilizers.*

Findings : *The results reveals that application of fruit peel powder at basal and top dressing had significant differences ($P<0.05$) on 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, fruit length and girth. At 1st, 2nd, 3rd and 4th picking, and the highest value was obtained in T6 and lowest value in T1.*

Originality/ Value : *Application of fruit peel powder into the soil leads to improve growth and yield of okra in sandy regosol compared to recommended inorganic fertilizer and present study suggested that, among the all tested treatments, half recommended fertilizer application at basal and topdressing times with 0.5g each of orange and banana peel powders at both times would be the most suitable fruit peel powders to get higher growth and yield of okra in sandy regosol.*

Keywords: *Banana peel powder, okra, orange peel powder, pomegranate peel powder*

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a vegetable plant of the family Malvaceae growing as an annual crop in tropical and sub-tropical areas of the world. Cultivation and consumption of okra are popular in Sri Lanka due to its nutritional composition and elevated medicinal value. It contains considerable amounts of protein, carbohydrate, fiber, vitamin A, B, C, Ca, P and Fe (Sachan *et al*., 2017). Okra is much useful for human to prevent numerous diseases and ageing, promote immunity, and improve health care (Ibeawuchi *et al.,* 2005), control cholesterol thereby reduce cardiovascular diseases (Dubey and Mishra, 2017). The high fiber content helps to stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract, and to reduce digestive issues. Besides, it improves heart health, control body cholesterol level and promote healthiness during pregnancy (Gemede *et al*., 2015). Okra is a tolerant crop to a wide range of climatic conditions (Akanbi *et al*., 2010). However, growth and yield of okra depend

[1] *Department of Crop Science, Faculty of Agriculture, Eastern University, Sri Lanka*

brinthak@esn.ac.lk

http://orcid.org/0000-0002-3773-9402

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

Fruit peel waste accumulates in considerable quantities daily, at domestic and industrial levels. Most frequently, people remove fruit skin and throw away as a waste. It is a vital issue, especially at industrial level that needs to be appropriately managed (Jariwala and Syed, 2016) to make the environment free from pollutants. Fruit peels are very rich in macro and micro nutrients that are indispensable for plant growth (Ibrahim *et al*., 2016). Fruit scraps are utilized as fertilizers to enhance soil fertility and enrich soil micro biota due to their mineral contents essential for plant growth. Besides, some active compounds from fruit peels seeds have insecticidal and antifungal properties against some plant pathogens (Singh *et al*., 2017). Therefore, fruit peels can be used as a natural fertilizer in crop production. By using fruit peel as a fertilizer we can reduce the loads of wastes lying around receiving further benefits. Fruit peel powders can also be used to regulate pH in soil, increase and improve soil fertility and morphology, fulfill requirements of nutrients, kill harmful insect pests and nematodes, especially in citrus varieties (Mercy *et al*., 2014). Furthermore, it would help to substitute costly an environmentally unfriendly inorganic fertilizers directing towards sustainable and quality crop production.

Peels of tropical fruits such as banana, papaya, pineapple, mango, orange, and pomegranate are the frequently available materials in large quantities in Sri Lanka. Such, can be used as natural fertilizer for the plants. Banana is consumed in a large quantity in Sri Lanka. Peel represents about 40% of total weight of fresh fruit (Fatemeh *et al*., 2012). Banana fruit peels are rich in K, Ca, Na, Fe, Mn and Br (Anhwange *et al*., 2009). From orange (*Citrus sinensis*) a large amount of peel is produced annually. It is primarily a waste, but it is a good source for molasses, pectin and limonene (Rafiq *et al*., 2018). Pomegranate fruit peel is an inedible part during processing of pomegranate juice. Peel represents 26-30% of total fruit weight and it has notable amounts of phenolic compounds, including flavonoids and hydrolysable tannins (Rowayshed *et al*., 2013) and 92% of antioxidant activity (Ismail *et al*., 2012). Pomegranate fruit peel has K, N, Ca, P, Mg, Na and it has micronutrients like B, Fe, Zn, Cu, Mn (Rowayshed *et al*., 2013). Therefore, the present study was aimed to study the effect of application of banana, orange and pomegranate fruit peel powders on growth and yield of okra.

MATERIALS AND METHODS

A pot experiment was carried out at the open field at Crop Farm of Eastern University, Sri Lanka located in the Eastern Province of Sri Lanka which falls under low country dry zone. Annual temperature varies from 28˚C to 32˚C and annual rainfall varies from 1400 mm to 1680 mm. The soil of experimental site is a sandy regosol. For this experiment, Okra variety *Haritha* seeds were used. Experiment was carried out in a Completely Randomized Design (CRD) with six treatments having twenty replicates. Treatments are recommended fertilizer application at basal and topdressing (Control T1), half recommended fertilizer application at basal and topdressing times with 1 g of banana peel powder (T2), 1 g of pomegranate peel powder (T3), 1 g of orange peel powder (T4), 0.5 g each of banana and pomegranate peel powders (T5) and 0.5 g each of orange and banana peel powders (T6) at both times. Fruit peels were collected separately from the market, Batticaloa.

Collected fruit peels were cleaned and foreign materials were removed. Then the peels were cut in to small pieces of 1-5 cm and air dried under natural sunlight for 20 – 25 days. Thereafter, the dried fruit peels were powdered using a grinder separately. Subsequently those were sieved separately using sieve of 2 mm in size and stored at room temperature (Jariwala and Syed, 2016). After that 1 g of banana, pomegranate and orange peel powder each were measured separately and filled into pots and sealed air tightly. Also mixtures of 0.5 g of banana and 0.5 g pomegranate peel powders and 0.5 g of banana and 0.5 g orange peel powders were sealed

separately in the similar manner and labeled for later identification.

Pots with 45 cm height and 30 cm diameter were used in this experiment. Pots were prepared by adding equal volume of soil and inorganic and fruit peel powders were applied as per the treatments. Two days after scarified okra seeds were sown at two seeds per bag with 1-2 cm depth. All agronomic practices were followed as per recommendations of the Department of Agriculture, Sri Lanka except fertilizers. 80% water holding capacity was maintained in all pots. Growth and yield parameters were measured using destructive sampling method. Collected data was analyzed using parametric and non-parametric statistics.

RESULTS AND DISCUSSION

Plant height

Plant height significantly varied ($P<0.05$) among the tested treatments at 2nd, 6th and 8th WAP (Table 01). At 2 WAP tallest plant was recorded in T2 (17 cm), followed by T6 (16 cm) and T5 (15.83 cm) while the lowest plant height was recorded in T1 (13.5 cm). 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 T2, T6 and T5. At 6th and 8th WAP, plant height did not show a significant difference among tested treatments except T1. 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 T1. 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.

Leaf area

Plant grown with higher concentration of fertilizers produces larger leaf area (Kang and Iersel, 2004). Application of fruit peel powder significantly influenced ($P<0.05$) the leaf area at 6th and 8th WAP. At 6th and 8th WAP, the highest leaf area was recorded in T2 (667.17 cm^2 and 741.90 cm^2 respectively) followed by T6 (642.88 cm^2 and 658.08 cm^2 respectively) while the lowest leaf area was recorded in T1 (333.59 cm^2 and 566.40 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. However, there was no variation in leaf area between T2 and T6 at 6th WAP.

Table 01: Plant height (cm) of okra with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	13.50±0.54c	25.00±0.24	26.27±2.32b	35.67±0.47b
T2	17.00±0.35a	29.33±0.85	33.00±0.91a	60.00±2.27a
T3	15.17±0.43bac	29.30±0.94	32.00±0.81a	53.00±1.47a
T4	14.67±0.12bc	30.33±2.04	32.67±2.49a	57.67±2.95a
T5	15.83±0.43ba	28.00±0.23	31.33±0.94a	56.67±1.17a
T6	16.00±0.41ba	31.33±2.01	39.00±0.85a	56.33±2.01a
F test	*	ns	**	**

*Values represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 02: Leaf area (cm^2) with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	34.52±2.92	147.3±5.32	333.59±4.04c	566.40±10.91b
T2	38.03±3.17	215.0±4.43	667.17±9.56a	741.90±10.00a
T3	37.41±3.26	172.7±3.30	480.96±7.94b	598.96±9.28b
T4	37.30±1.96	234.7±4.28	537.69±9.79ba	622.18±9.14b
T5	33.31±3.01	214.3±6.63	526.43±9.40ba	612.01±9.16b
T6	31.54±5.82	243.7±5.39	642.88±9.03a	658.08±9.95ba
F test	ns	ns	**	*

*Values represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Root length

There were significant differences (P<0.01) 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. T6 recorded the maximum root length and T1 recorded the lowest root length from 2nd WAP to 8th WAP. At 8th WAP, the highest root length was recorded in T6 (49.33 cm), followed by T4 (46.33 cm), T2 (43 cm) and while the lowest root length was recorded in T1 (16.67 cm). However, there was no variation among T6, T4 and T2 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.

Table 03: Root length (cm) with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	7.00±0.20d	12.00± 0.20d	14.67±0.23c	16.67±0.77c
T2	8.33±0.23dc	14.17±0.31cb	23.00±1.08a	43.00±2.94a
T3	8.00±0.20dc	13.17±0.31cd	18.00±0.40cb	29.83±0.11b
T4	10.0±0.20ba	15.33±0.23b	19.33±0.62b	46.33±1.31a
T5	9.17±0.58bc	14.17±0.42cb	17.00±0.40cb	31.83±1.85b
T6	11.2±0.11a	17.00±0.40a	23.33±1.24a	49.33±1.84a
F test	**	**	**	**

*Values represent mean ∓ standard error of four replicates. F test: - **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Chlorophyll content

Chlorophyll content was measured with the help of SPAD meter. There was a significant change (P<0.05) noted at 4th, 6th and 8th WAP as shown in table 4. From 4th to 8th week, T2 showed maximum chlorophyll content and T1 recorded the lowest chlorophyll content. At 8th WAP, the highest chlorophyll content was recorded in T2 (89.00), followed by T5 (80.20), T3 (80.03), T6 (69.90) and while the chlorophyll content was recorded in T1 (32.73). 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 T2, T5, T3 and T6 in 8th WAP.

Days for 50% and 100% flowering

Days for 50% and 100% flowering of okra varied significantly (P<0.05) due to the fruit peel powder application as confirmed by *P* value of 0.027 and chi square value of 12.67 at both stages shown in table 5. Minimum duration of 35 and 37 days were taken by T6 to attain the 50% and 100 % flowering respectively. Longer time period of 40 and 44 days were taken by T1 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 T6 and T2.

Table 04: Chlorophyll content with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	38.17±1.74	36.63±0.87b	38.37±0.35c	32.73±2.30b
T2	39.70±0.74	43.33±0.72a	47.10±0.54a	89.00±3.85a
T3	37.87±0.67	41.80±0.49a	45.77±0.43ba	80.03±5.42a
T4	40.90±1.52	42.83±0.58a	46.90±1.12a	63.67±2.47ba
T5	39.77±2.12	43.30±1.74a	43.63±1.10b	80.20±3.74a
T6	38.38±1.19	40.13±1.16ba	44.77±0.20ba	69.90±2.46a
F test	ns	*	**	*

*Values represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 05: Days for 50% and 100% flowering with respect to treatment during the experiment period

Treatment	Days for 50% flowering	Days for 100% flowering
T1	40	44
T2	36	39
T3	38	40
T4	39	41
T5	39	42
T6	35	37
P value	0.027	0.027
Chi – square	12.67	12.67

These results are in agreement with Shah *et al*. (2014) who stated that more days to flowering were recorded in control plots, while fewer days to flowering were observed in plots received potassium. According to Larik *et al*. (1999) potassium is required to increase carbon exchange, enhance carbohydrate movements, stimulates early growth and decreases the translocation of photosynthates into storage organs/sinks and consequently leads to the early initiation of flowers.

Dry weight of leaves

Dry weight of leaves was significantly influenced (P<0.05) with the application of different fruit peel powder at 4th, 6th and 8th WAP as shown in table 6. At 2nd WAP, there was no significant difference (P>0.05) among treatments. However, at 4th and 6th WAP, the maximum dry weight of leaves were recorded in T2, followed by T6 while the lowest fresh weight of okra leaves were recorded in T1. At 8th WAP, the maximum dry weight of leaves were recorded in T2 (4.23 g) and while the lowest fresh weight of okra roots were recorded in T1 (2.12 g). But at 8th WAP, dry weight of leaves were not significantly (P>0.05) different among treatments except T1.

Dry weight of stem

At 6th WAP, the maximum dry weight of stems were recorded as T2 (8.06 g), followed by T6 (6.67 g), T5 (6.71 g) and while the minimum fresh weight of okra stems were recorded as T1 (2.90 g). At 8th WAP, okra stems did not show a significant difference among treatments except T1. Fruit peel contains substantial amounts of macronutrients which are essential for plant growth (Anhwange *et al.,* 2009). It helps to increase the plant growth such as plant height, the number of branches that help to increase dry weight of stems. Bakry *et al*. (2016) found that foliar application of banana peel extract increased shoot dry weight of quinoa plants compared to the untreated plants.

Dry weight of root

There were significant differences (P<0.05) at 2nd, 4th and 6th WAP. All four stages, T6 recorded the maximum dry weight of roots and T1 recorded the lowest dry weight of roots (Table 8). Phosphorus promotes rooting, flowering, and fruit set and K is essential for stem and root growth and protein analysis (Wazir *et al*., 2018). Presence of growth promoting factors and macro and micronutrients in the fruit peel powder may have enhanced the growth of the plants. This may be the reason for high dry weight of roots in T6. Bakry *et al*. (2016) noted that foliar application of banana peel extract helps to increased root dry weight of quinoa plants compared to the untreated plants. Sakpere *et al*. (2018) noted that root length of *Solanum scabrum* plants were enhanced by fruit peel treated plants than untreated plants.

Table 06: Dry weight (g) of leaves with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.33±0.16	0.96±0.06c	2.44±0.10d	2.12±0.21b
T2	0.21±0.01	2.36±0.15a	4.14±0.15a	4.23±0.32a
T3	0.44±0.19	1.26±0.37bc	3.16±0.25c	3.96±0.29a
T4	0.12±0.01	1.45±0.08bac	3.46±0.17bc	3.72±0.26a
T5	0.49±0.21	1.09±0.18c	3.57±0.06cb	3.83±0.44a
T6	0.21±0.01	2.17±0.30ba	3.90±0.10b	3.99±0.29a
F test	ns	*	**	*

*Value represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 07: Dry weight (g) of stems with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.04±0.01	0.57±0.10	2.90±0.29c	4.49±0.12b
T2	0.06±0.01	0.99±0.02	8.06±0.07a	11.90±0.32a
T3	0.03±0.01	0.76±0.22	6.07±0.20b	10.10±0.52a
T4	0.04±0.01	0.68±0.02	6.32±0.27b	8.49±1.49a
T5	0.04±0.01	0.69±0.11	6.71±0.36ba	9.89±1.37a
T6	0.05±0.01	0.99±0.08	6.67±0.49ba	10.5±0.68a
F test	ns	ns	**	*

*Values represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 08: Dry weight (g) of roots with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.01±0.01b	0.17±0.01d	0.83±0.06b	1.66±0.20
T2	0.02±0.01b	0.39±0.07b	2.01±0.34a	4.13±0.37
T3	0.02±0.01b	0.21±0.01cd	1.63±0.17ba	2.45±0.19
T4	0.01±0.01b	0.31±0.04cbd	1.87±0.29ba	3.72±0.76
T5	0.02±0.01b	0.36±0.01cb	1.50±0.33ba	3.33±0.50
T6	0.03±0.01a	0.56±0.01a	2.63±0.10a	4.37±0.45
F test	*	**	*	ns

*Values represent mean ∓ standard error of four replicates. F test: - *: P<0.05; ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Number of fruits per plant

Application of fruit peel powder did not influence (P>0.05) the number of fruits per plant as confirmed with *P* values of 0.109, 0.078, 0.075, 0.197 and chi square values of 9.00, 9.90, 10.00, 7.33 at 1st, 2nd, 3rd and 4th picking respectively (Table 9). 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 and girth

The data presented in table 10 clearly indicated that the fruit peel application played a significant role in length of fruits. At 1st, 3rd and 4th picking there was a significant difference (P<0.01) among treatments. At 1st , 2nd , 3rd and 4th pickings, maximum length of fruits were observed in T6 while minimum length of fruits were observed in T1. 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.

Table 09: Number of fruits per plant at each picking with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	1	1	3	3
T2	2	3	4	5
T3	2	2	3	4
T4	2	2	5	4
T5	2	3	4	5
T6	3	4	5	5
P value	0.109	0.078	0.075	0.197
Chi – square	9.00	9.90	10.00	7.33

Table 10: Fruit length (cm) with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	9.82±0.24c	12.50±0.20	10.10±0.24d	11.33±0.62b
T2	15.33±1.00a	15.33±0.23	15.67±0.77ba	16.00±0.20a
T3	13.33±0.42ba	15.17±0.51	13.60±0.34bc	15.17±0.51a
T4	14.00±0.73ba	14.50±1.27	14.20±0.66bac	15.50±0.20a
T5	12.17±0.23bc	13.83±0.31	13.17±0.23c	12.83±0.51b
T6	15.83±0.11a	16.00±0.20	16.00±0.20a	16.17±0.42a
F test	**	ns	**	**

*Value represent mean ∓ standard error of four replicates. F test: - ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

At 1st, 2nd and 4th picking, maximum average girth of fruit was obtained in T6. At 4th picking, girth of fruits did not significantly differ among treatments except T1. In line with present study, Colpan *et al*. (2013) reported that the lowest fruit diameter was obtained by the control dose and the highest fruit diameter was obtained by the potassium treated tomato plants. Further, they found that when potassium levels are low, fruits are small and when potassium is high, fruits are too large.

Fresh and dry weights per fruit

Fresh weight of okra fruit was significantly influenced (P<0.01) by the fruit peel powder application (Table 12). At 1st, 2nd and 3rd pickings, and maximum fresh weight of fruit was observed in T6 while the lowest fresh weight of fruit was observed in T1. At 4th picking, maximum fresh weight of fruit was observed in T2 while the lowest fresh weight of fruit was observed in T1. Colpan *et al*. (2013) stated that the lowest fruit fresh weight was obtained by the control dose and the highest fruit fresh weight was obtained by the potassium treated tomato plants. This is in line with present study.

At all the picking stages, maximum dry weight of fruit was observed in T6 and minimum fresh weight of fruit was observed in T1 (Table 13). At 3rd and 4th picking, maximum dry weight of fruit was observed in T6 (4.23 g and 4.59 g) followed by T2 (3.13 g and 3.71 g) while the lowest fresh weight of fruit was observed in T1 (1.62 g and 2.43 g). Islam *et al*. (2004) noted that the highest value of the pod dry weight was observed in the bush-bean plant that received potassium under control condition, while the lowest value dry weight of pod was recorded in untreated plants.

Number of seeds per fruit

There was a significant difference (P<0.05) at 2nd, 3rd and 4th picking were confirmed with *P* value of 0.027 and chi square value of 12.67 is shown

in table 14. The highest number of seeds of 55, 54 and 59 were observed in T6 and the lowest number of seeds of 24, 20 and 20 were observed in T1 at 2nd, 6th and 4th picking respectively. These results are in agreement with Bakry *et al.*(2016) who stated that the effect of foliar application of banana peel extract (500 and 1000 mg/l) significantly increased seed weight per plant and 1000 seed weight of quinoa plants compared to the untreated plants.

Table 11: Fruit girth (cm) with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	1.32±0.11b	5.00±0.01d	4.67±0.11	4.67±0.23b
T2	2.83±0.64ba	6.67±0.11ba	6.17±0.11	6.33±0.11a
T3	2.05±0.24b	6.17±0.11bc	5.83±0.31	6.17±0.11a
T4	1.94±0.27b	6.33±0.11bac	6.00±0.35	6.17±0.11a
T5	2.64±0.09ba	5.83±0.11c	6.00±0.01	6.00±0.01a
T6	4.07±0.49a	7.00±0.35a	6.33±0.47	6.67±0.31a
F test	**	**	ns	**

*Value represent mean ∓ standard error of four replicates. F test: - ns: not significant; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 12: Fresh weight (g) of fruit with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	12.82±0.50c	15.60±0.19d	14.72±0.42b	14.83±0.26c
T2	19.11±0.36b	20.52±0.58b	20.01±0.36a	21.02±0.58a
T3	17.24±0.03b	19.54±0.34bac	18.14±0.03a	20.04±0.34ba
T4	17.17±0.42b	18.73±1.06bc	18.07±0.42a	19.23±1.06ba
T5	17.76±1.11b	17.87±0.32dc	18.66±1.11a	18.37±0.32b
T6	22.26±1.11a	21.46±0.38a	20.50±0.33a	20.63±0.32ba
F test	**	**	**	**

*Value represent mean ∓ standard error of four replicates. F test: - **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 13: Dry weight (g) of fruit with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	1.31±0.11b	1.93±0.03d	1.62±0.11b	2.43±0.03d
T2	2.83±0.64ba	3.21±0.19b	3.13±0.64ba	3.71±0.19b
T3	2.05±0.24b	2.27±0.05cd	2.35±0.24b	2.77±0.05cd
T4	1.94±0.27b	2.46±0.31cd	2.26±0.27b	2.63±0.31d
T5	2.64±0.09ba	2.92±0.09cb	2.94±0.09ba	3.42±0.09cb
T6	4.07±0.49a	4.08±0.07a	4.23±0.45a	4.59±0.07a
F test	*	**	*	**

*Value represent mean ∓ standard error of four replicates. F test: - *: P<0.05; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Table 14: Number of seeds per fruit with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	13	24	20	20
T2	44	50	51	54
T3	39	40	38	44
T4	40	30	31	46
T5	40	28	28	36
T6	53	55	54	59
P value	0.206	0.027	0.027	0.027
Chi – square	7.20	12.67	12.67	12.67

Table 15: Total yield (tons/ha) at each picking with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking	4th picking
T1	0.23±0.01c	0.37±0.06c	0.61±0.11	0.81±0.12
T2	0.69±0.01ba	0.97±0.07b	1.31±0.22	1.77±0.13
T3	0.52±0.07bc	0.82±0.08b	0.87±0.08	1.44±0.14
T4	0.52±0.07bc	0.78±0.07b	1.44±0.30	1.30±0.28
T5	0.64±0.04ba	0.96±0.02b	1.36±0.18	1.44±0.17
T6	0.90±0.16a	1.41±0.08a	1.84±0.03	1.99±0.12
F test	*	**	ns	Ns

Value represent mean ∓ standard error of four replicates. F test: -: P<0.05; **: P<0.01; Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.*

Total yield at each picking (tons/ha)

Application of different fruit peel powder significantly influenced (P<0.05) total yield in 1st and 2nd picking (Table 15). There was no significant difference (P>0.05) at 3rd and 4th picking. At 1st and 2nd picking, the highest value was obtained in T6 and the lowest value in T1. 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.

CONCLUSIONS

The results reveal that application of fruit peel powder at basal and top dressing had significant differences (P<0.05) on 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, fruit length and girth. Further at 1st, 2nd, 3rd and 4th picking, the highest value was obtained in T6 and the lowest value in T1. Present study can be suggested that among the all tested treatments, half recommended fertilizer application at basal and topdressing times with 0.5 g each of orange and banana peel powders at both times (T6) would be the most suitable to get optimum growth and yield of okra in sandy regosol.

REFERENCES

Ajayi, E.O., Adeoye, I.B. and Shittu, O.A. (2017). Economic analysis of intercropping okra with legumes. *Journal of Agricultural Sciences*. 62(2): 193-202. https://doi.org/10.2298/jas1702193a

Akanbi, W.B., Togun, A.O., Rewatkar, S.S., Anjali, M. and Shelke, T.S. (2010). Growth and dry matter and fruit yields components in okra under organic and inorganic sources of nutrients. *American Eurasian Journal Sustainable Agriculture.* 4(1): 1-13. https://doi.org/10.4314/njhs.v14i1.62155

Amin, M.R., Karim, M.A., Khaliq, Q.A., Islam, M.R. and Aktar, S. (2015). Effect of nitrogen and potassium on the root growth, nutrient content and yield of mungbeans under waterlogged condition. *A Scientific Journal of krishi Foundation.* 13(1): 67-78. https://doi.org/10.3329/agric.v13i1.26549

Anhwange, B.A., Ugye, B.A. and Nyiaatagher, T.D. (2009). Chemical composition of *Musa sapientum* (banana) peels. *Electronic Journal of Environmental.* 8(6): 437-442.

Bakry, A.B., Ibrahim, F.M., Abdallah, M.M.S. and Bassiouny, H.M.S. (2016). Effect of banana peel extract or tryptophan on growth, yield and some biochemical aspects of quinoa plants under water deficit. *International Journal of Pharm Tech Research*.9(8): 276-287.

Colpan, E., Zengin, M. and Ozbahce, A. (2013). The effects of potassium on the yield and fruit quality components of stick tomato. *Horticulture Environment Biotechnology*. 54(1): 20-28. https://doi.org/10.1007/s13580-013-0080-4

Ding, Y., Wang, Z., Ren, M., Zhang, P., Li, Z., Chen, S., Ge, C., and Wang, Y. (2018). Iron and callose homeostatic regulation in rice roots under low phosphorous. *Plant Biology*. 18: 1-5. https://doi.org/10.1186/s12870-018-1486-z

Dubey, P. and Mishra, S. (2017). Effect of okra seed in reduction of cholesterol. *Journal of Entomology and Zoology Studies*. 5(4): 94-97.

Fageria, N.K. and Moreira, A. (2011). The role of mineral nutrition on root growth of crop plants. *Advances in Agronomy.* 110: 251-255. https://doi.org/10.1016/b978-0-12-385531-2.00004-9

Fatemeh, S.R., Saifullah, R., Abbas, F.M.A. and Azhar, M.E. (2012). Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: influence of variety and stage of ripeness. *International Food Research Journal*. 19(3): 1041-1046.

Gemede, H.F., Ratta, N., Haki, G.D., Beyene, F. and Woldegiorgis, A.Z. (2015). Nutritional quality and health benefits of okra (*Abelmoschusesculentus*): a review. *American Journal of Food Science and Nutrition.* 2(1): 1-8.

Ibeawuchi, I.I., Obiefuna, J.C. and Ofoh, M.C. (2005). Effects of row spacing on yield and yield components of okra (*Abelmoschusesculentus*) and mixture groundnut (*Archishypogaea*). *Journal of Agronomy*. 4(4): 304-307. https://doi.org/10.3923/ja.2005.304.307

Ibrahim, U.K., Kamarrudin, N., Suzihaque, M.U.H. and Hashib, S.A. (2016). Local fruit wastes as a potential source of natural antioxidant: an overview. *IOP Conference Series: Materials Science and Engineering*. 206: 1-3. https://doi.org/10.1088/1757-899x/206/1/012040

Islam, M.S., Haque, M.M., Khan, M.M., Hidaka, T. and Karimi, M.A. (2004). Effect of fertilizer potassium on growth, yield and water relations of bushbean (*Phaseolus vulgaris* L.) under water stress conditions. *Japanese Journal of Tropical Agriculture*. 48(1): 1-9.

Ismail, T., Sestili, P. and Akhtar, S. (2012). Pomegranate peel and fruit extracts: a review of potential anti-inflammatory and anti-infective effects. *Journal of Ethnopharmacology.* 143: 397-405. https://doi.org/10.1016/j.jep.2012.07.004

Jariwala, H.J. and Syed, H.S. (2016). Study on use of fruit peels powder as a fertilizer. *National Conference on Recent Advances in Environmental Science and Engineering Technologies*. 1-3.

Javid, Q.A., Abbasi, N.A., Hafiz, I.A. and Mughal, A.L. (2005). Performance of Zinnia (*Zinnia elegans*) dahlia flowered crimson shade by application of NPK fertilizer. *International Journal of Agriculture and Biotechnology*. 7(3): 474–476.

Joiner, J.N. and Gruis, J.T. (1961). Effect of nitrogen and potassium levels on growth, flowering and chemical composition of zinnia and marigold. *Florida State Horticulture Science*. 8: 445-448.

Kadir, A.A., Rahman, N.A. and Azhari, N.W. (2016). The utilization of banana peel in the fermentation liquid in food waste composting. *IOP Conference Series: Materials Science and Engineering*. 136: 1-8. https://doi.org/10.1088/1757-899x/136/1/012055

Kang, J. and Iersel, M.W. (2004). Nutrients solution concentration affects shoot: root ratio, leaf area ratio, and growth of sub irrigated salvia. *Horticulture Science.* 39(1): 49-54. https://doi.org/10.21273/hortsci.39.1.49

Larik, K.K., Shafkh, M.A., Kakar, A.A. and Shaikh, M.A. (1999). Effect of nitrogen and potassium fertilization on morphological traits on *Zinnia elegans*. *Pakistan Journal of Agricultural Science*. 36 (1-2): 20-22.

Mazed, H.E.M.K., Moonmoon, J.F., Haque, N., Pulok, A.I. and Rahman, H. (2015). growth and yield of mungbean as influenced by potassium and sulphur. *Annals of Biological Research*. 6(1): 6-10.

Mercy, S., Mubsira, B.S. and Jenifer, I. (2014). Application of different fruit peels formulations as a natural fertilizer for plant growth. *International Journal of Scientific & Technology Research.* 3(1): 300-307.

Rafiq, S., Kaul, R., Sofi, S.A., Bashir, N., Nazir, F. and Nayik, G.A. (2018). Citrus peel as a source of functional ingredient: a review. *Journal of the Saudi Society of Agriculture Sciences.* 17: 351-358. https://doi.org/10.1016/j.jssas.2016.07.006

Rowayshed, G., Salama, A., Abul-Fadl, M., Akila-Hamza, S. and Emad, A.M. (2013). Nutritional and chemical evaluation for pomegranate (*Punicagranatum L.*) fruit peel and seeds powders by products. *Middle East Journal of Applied Sciences.* 3(4): 169-179.

Sachan, S., Sing, D., Kasera, S., Mishra, S.K., Tripathi, Y., Mishra, V. and Singh, R.K. (2017). Intergrated nutrient management (INM) in okra (*Abelmoschusesculentus* (L.) Monech) for better growth and high yield. *Journal of Pharmacognosy and Phytochemistry.* 6(5): 1854-1856.

Sakpere, A.M.A., Bankole, M., Oyekola, O.B., Akinyemi, O.S., Akosile, O.R., Adegboye, O.A., Akinropo, M.S. and Obisesan, I.A. (2018). Effect of different *Moringaoleifera* extracts and fruit peels on the growth of *Solanumscabrum.International journal of Biological Science*. 12(4): 1543-1549. https://doi.org/10.4314/ijbcs.v12i4.2

Shah, S.N.M., Ali, A., Amin, N., Shah, M. and Khan, A. (2014). Potassium influence on flowering and morphology of *Zinnia elegans*. *International Journal of Farming and Allied Sciences.* 3(4): 377-381.

Shahid, M.R., Amjad, M., Ziaf, K., Jahangir, M.M., Ahmad, S., Iqbal, Q. and Nawaz, A. (2013). Growth, yield and seed production of okra as influenced by different growth regulators. *Pakistan Journal of Agriculture Science.* 50(3): 387-392.

Singh, M.D., Chirag, G., Prakash, P.O., Mohan, M.H., Prakash, G. And Vishwajith. (2017). Nano fertilizers is a new way to increase nutrients use efficiency in crop production. *International Journal of Agriculture Sciences.* 9(7): 3831-3833.

Singh, S. and Prasad, S.M. (2014). Growth, photosynthesis and oxidative responses of *Solanummelongena* L. seedlings to cadmium stress: Mechanism of toxicity amelioration by kinetin. *ScientiaHorticulturae*. 176: 1–10. https://doi.org/10.1016/j.scienta.2014.06.022

Tan, N. and So, R.C. (2018). Biochar from waste banana peels as growth promoter for holy basil (*Ocimumtenuiflorum*) and chili pepper (*Capsicum annum*). Available online: https://briefs.techconnect.org (accessed on 4.12.2019).

Wazir, A., Gul, Z. and Hussain, M. (2018). Comparative study of various organic fertilizers effect on growth and yield of two economically important crops, potato and pea. *Agricultural Science.* 9: 703-717. https://doi.org/10.4236/as.2018.96049