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Original Article

Selected Preharvest Treatments on Subsequent Seed Quality of Okra (*Abelmoschus esculentus L.*)

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ABSTRACT

Preharvest treatments affect the quality seeds, which has great importance on crop productivity. This study aims to determine the effects of selected preharvest treatment, including the application of muriate of potash, gibberellic acid (GA3) and Paclobutrazol (PBZ) on the quality of okra seed. The experiment was carried out in Randomized Complete Block Design with four treatments replicated three times. Okra flower was sprayed with 100 ppm of GA3 and PBZ at seven days after anthesis and muriate of potash was applied directly to the soil. The weight of pods, length and width of pods, number of seeds, the weight of seeds/pod, polar and equatorial size of seeds, dry matter of seeds and pods, and internal structure of seeds were gathered. Application of GA3, PBZ, and muriate of potash increased the weight of pods, dry matter of seed and dry matter of pods from 2 to 2.83 grams, 0.15 to 0.57 grams and 0.15 to 0.53 grams, respectively. These weights were higher than the control at day 28. Okra had wider pods than the control when applied with Paclobutrazol (mean of 16.27 at day 7 and 17.19 mm at 21 days after anthesis). Application of Paclobutrazol enhanced the equatorial of seeds at 7, 21, and 28 days although it showed a comparable result to the control treatment. Application of muriate of potash increased the number of seeds per pod compared to all other treatments at 21 days (53.67 seeds/pod) and 28 days (58.84 seeds/pod) after anthesis. Thus, the application of GA3, PBZ, and muriate of potash can be beneficial because most of the quality parameters of the okra seeds improved as compared to the control treatment.

KEYWORDS: *gibberellic acid, muriate of potash, Paclobutrazol, preharvest seed treatment, seed quality*

1 INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an annual vegetable crop, which can develop well in most hot and humid and subtropical areas where the young flower buds of pods are normally vegetable crop (FAO, 1988). It is a money-based vegetable crop while its edible pods provide humans with nutritional benefits, including vitamin C, A, B complex, iron, calcium and proteins. The fresh pod is a source of gum and pectin which possess medicinal properties, including the formation of vigorous blood tubes in the body and the avoidance of high blood pressure (Adebooye and Opunta, 1996). On the other hand, the pod mucilage is used as a skin softener, laxative, and expectorant (Muresan and Popescu, 1993).

Growth and yield of okra rely on many elements including seed quality, nutrition, climatic conditions and cultural practices (Kusvuran, 2012). Potassium (K) is an extremely important plant nutrient that assumes an important role in plant growth and development. Some important functions of potassium in the plant are osmoregulation, internal cation/anion balance, enzyme activation, proper water relations, photosynthate translocation, and protein synthesis. Tolerance to external stress, including frost, drought, heat, and high light intensity, is enhanced with appropriate potassium nourishment (Mehdi *et al.*, 2007).

Paclobutrazol (PBZ) as a growth regulator can reduce the synthesis of gibberellin (GA) in the plant tissues which can delay the growth of okra. GA participates in the cell division in the sub-apical meristem of the shoot, and its reduction can decrease of stem elongation (Gianfagna, 1995; Chutichudet *et al.*, 2006). PBZ can control GA biosynthesis, especially in the pathway at the ent-kaureno oxidation stage (Rademacher, 1995).

Gibberellins (Gas) mediate numerous reactions in plants from seed germination to the senescence (Davies, 1995). Gibberellic acid (GA3) or gibberellins include a group of naturally occurring plant hormones which assume a central role in the early germination processes of seeds by activating enzyme production and mobilizing storage reserves (Bewley and Black, 1983). Furthermore, foliar application of gibberellins stimulates and synchronizes flowering and fruit set (Briant, 1974), and additionally improving the

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photosynthesis and growth (Yuan and Xu, 2001), or invigorating growth however not the rate of photosynthesis (Dijkstra and Kuiper, 1989). The present study aimed to evaluate the effect of selected preharvest treatment on the seed quality of okra.

2 MATERIALS AND METHODS

Fully grown three-month-old okras were ratooned. The plants were grownat the experimental area of FarmResource and Management Institute, Visayas State University, Visca, Baybay City, Leyte. The experiment was arranged in Randomized Complete Block Design with four treatments and three replications. Ten sample pods per replication was used. Treatment tested includes control (ordinary tap water), 100 ppm of GA3 and PBZ solution and muriate of potash. Ordinary water, PBZ, and GA3 were applied through spraying while muriate of potash was applied by side dressing. A total of 24 flowering okra plants were used in this study, and there were six designated randomly selected sample plants for each replication. Seven days after flower anthesis, GA_3 and PBZ were applied at 100 ppm, while muriate of potash was applied at approximately 7days before anthesis at 10 grams per plant. The fruits of okra were harvested at 7days after flower opening at 7days intervals. The harvested fruits were subjected to quality and internal structure evaluation. The following parameters were gathered: the weight of pods, length and width of pods, number of seeds, the weight of seeds/pods, polar and equatorial size of seeds, dry matter of seeds and pods and internal structure of seeds. The data was analyzed using analysis of variance, while post-hoc analysis utilized the Least Significant Difference test. All analysis was performed in Statistical Tool for Agricultural Research (STAR) software.

3 RESULTS AND DISCUSSION

Fresh weight of pods

PBZ application at 7days after anthesis obtained the heaviest weight as compared to other treatments with a mean of 22 g (Table 1). However, at 14 days, the heaviest weight was observed with the plant applied with GA3 and a control with a mean ranging from 25.33-24.33 g. On the other hand, during day 28, it was clearly observed that pods coming from plants applied with GA3, Paclobutrazol, and muriate of potash were not significantly different from each other and were heaviest compared to the control treatment.

The result is supported by the study of Whiley (1993), Katz *et al.* (2003), and Chutichudet *et al.* (2006) as cited by Benjawan *et al.* (2007) who supported that chemical PBZ has its essential property on the accumulation of carbohydrates in this manner it hastens a rapid development of sinks or pods where it significantly increased crop yields per ha.

Moreover, the increase in fresh weight of pods applied with plant growth regulator (IAA and GA3) was supported by Ayyub *et al.* (2013) and Pilot and Saugy (2007). Foliar application of GA3 has been shown to influence the number of pods per plant, the number of seed pods and yield per plant per area in several crop**s** (Alkaff and Hassan, 2003). The increment in pod yield and contributing components in response to growth regulators (IAA and GA3) was also observed Fatima and Bano (2000) in okra and Lee *et al.* (2001) in chickpea.

Length of pods

Results show that Paclobutrazol reduces the length of pods of okra at 7days after anthesis having a mean of 109.5 mm (Table 1). Whereas, control treatment and GA3 application significantly increased the length of pods with a mean ranging from 151.6-137.8 mm. On another hand, at 28 days after anthesis control treatment and Paclobutrazol application increased the length of pods of okra having a mean of 139.8 mm and 144.2 mm respectively. However, GA3 and muriate of potash application reduced the length of pods with a mean ranging from 132.8-131.7 mm.

The significant effect of Paclobutrazol at 28 days after anthesis was supported by Benjawan*et al.* (2007) who reported that chemical PBZ had highly influenced both pod length and edible fresh weight/pod. This might be attributable to the rapid rate of carbohydrate production demanded a larger size of sinks for a rapid unloaded translocation of assimilates. On the contrary, Emongor (2007) reported that GA3application to cowpea plants significantly ($p \leq 0.01$) increased pod length. However, Dhankhar and Singh (2009) reported that GA3 application expanded okra pod length and diameter.

Width of pods

Application of PBZ significantly enhanced the width of pods as compared to other treatments on 7 and 21 days after anthesis having a mean of 16.3 mm and 17.2 mm respectively (Table 2). However, the result did not agree with the result of Benjawan (2007) stated that Paclobutrazol had no significant effect on stem diameter and diameter of pods of okra plants.

Number of seeds

The number of seeds was increased with the application of Paclobutrazol on 7 and 14 days after anthesis with a mean 55.5 and 47.8 (Table 2). However, on the 21 and 28 days significant increase in a number of seeds was observed on plant applied with muriate of potash having a mean ranging from 53.7-58.8. There was no definite pattern of effect on the number of seeds, however, if we will try to focus on the harvesting time or on days 21 and 28, it can be observed that pods coming from plants applied with muriate of potash got the highest number of seedscompared to other treatments and the control treatment got the lowest number of seeds. The lower number of seeds treated

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Table 1. Fresh weight (g) and length of pods (mm) of okra as influenced by some preharvest treatments from 7-28 days after anthesis.

Treatment	**Fresh weight of pods (g)**				**Length of pods (mm)**			
	7	**14**	**21**	**28**	**7**	**14**	**21**	**28**
T1- Control	12.17b	24.33a	19.53	17b	110.21a	151.62a	147.67	139.83a
T2- GA3	8.83c	25.33a	22.3	19.33a	109.02a	137.79ab	152.67	132.83b
T3-Paclubutrazol	22a	15.5b	20.68	19a	103.09b	109.51c	152.33	144.17a
T4-Muriate of potash	9.67bc	17.5b	21.02	19.83a	106.53a	128.13b	141.17	131.67b
Standard error	1.63	1.59	1.13	0.86	8.11	6.85	5.47	2.86
CV (%)	15.19	9.42	6.62	5.59	9.73	6.37	4.52	2.55

Mean of the same letter are not significantly different at 5% level of significant using LSD test.

with GA3 coincide with the study Emongor (2002) where it was reported that GA3 and GA4+7 significantly decreased the seed yield and had no impact on seed number/pod and the number of pods/plant of common beans (*Phaseolus vulgaris*).

Weight of seeds/pods

Weights of seeds/pods were not affected by the application of different treatments (Table 3). The results of this study were in agreement with the study of Sarnaik*et al.* (1986) who indicated that there were no significant differences in 100 seeds weight for various nitrogen and potassium levels. On the other hand, Pal and Hossain (2001) found no effect of GA3 on okra seed germination and seed weight, but a significant effect of this hormone on plant height and the number of pods per plant. Another study suggests that Paclobutrazol treatment decreased seed weight in maize (Bayat and Sepehri, 2012).

Table 2. The width of Pod (mm) and the number of seeds per pods of okra as influenced by some preharvest treatments from 7-28 days after anthesis.

Treatment	**Width of pods (mm)**				**Number of seeds**			
	7	**14**	**21**	**28**	**7**	**14**	**21**	**28**
T1- Control	13.35d	17.05	16.18b	15.48	50.33b	45.00ab	48.33b	40.67d
T2- GA3	14.54c	16.37	16.18b	15.82	46.33c	35.50c	44.83c	48.00c
T3-Paclubutrazol	16.27a	17.54	17.19a	16.35	55.50a	47.83a	48.00b	56.83b
T4-Muriate of potash	15.21b	16.19	15.69b	15.19	52.00b	42.00b	53.67a	58.84a
Standard error	0.28	0.52	0.38	0.39	1.24	2.11	1.29	0.76
CV (%)	2.3	3.82	2.84	3.08	2.98	6.08	3.25	1.83

Mean of the same letter are not significantly different at 5% level of significant using LSD test.

Table 3. The weight of seed (g) of okra as influenced by some preharvest treatments from 7-28 days after anthesis.

Treatment	**Weight of seeds (g)**			
	7	**14**	**21**	**28**
T1- Control	2.17	3.83	4.62	5.34
T2- GA3	1.83	3.50	5.08	5.50
T3-Paclubutrazol	1.67	3.67	4.78	5.43
T4-Muriate of potash	2.00	2.50	5.27	5.48
Standard error	0.50	0.49	0.26	1.34
CV (%)	31.95	17.63	6.39	3.08

Mean of the same letter are not significantly different at 5% level of significant using LSD test.

Equatorial measurement of seeds

PBZ application increased significantly the equatorial measurement of the seed of okra from 7, 21, and 28 days after anthesis with a mean of 5.0, 5.1, and 5.8 mm, respectively (Table 4). An almost similar pattern of effects was observed on the different days of data gathering. Okra plant applied with Paclobutrazol was consistent for having a significant highest value among treatments and plant applied with muriate of potash got the lowest value on equatorial measurement of seeds. The result coincides with the study of Setia *et al.* (1996) that reported that at maturity, the seeds harvested from Paclobutrazol-treated plants had a greater diameter (by about 5%) than controls.

Polar measurement of seeds

PBZ application significantly increased the polar measurement of seeds at seven days after anthesis with a mean of 5.05 mm as compared to other treatments (Table 4). On another hand, application of PBZ and muriate of potash significantly reduced the polar measurement of seeds at day 14 and day 21 with a

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mean ranging from 5.07-5.04 mm and 5.62-5.51 mm, respectively.

Table 4. Equatorial (mm) and polar (mm) measurement of a seed of okra as influenced by some preharvest treatments at 7-28 days after anthesis.

Treatment	**Equatorial of seeds (mm)**				**Polar of seeds (mm)**			
	7	**14**	**21**	**28**	**7**	**14**	**21**	**28**
T1- Control	4.03b	5.13	5.19a	5.96a	4.55b	6.19a	6.73a	5.52
T2- GA3	4.05b	5.01	5.03a	5.15b	4.37b	5.45b	6.04b	5.53
T3-Paclubutrazol	5.04a	5.21	5.05a	5.83a	5.05a	5.07c	5.62c	5.39
T4-Muriate of potash	3.46c	5.15	4.66b	5.07b	4.57b	5.04c	5.51c	5.56
Standard error	0.04	0.23	0.10	0.12	0.14	0.14	0.08	0.13
CV (%)	1.22	5.60	2.35	2.70	3.62	3.10	1.73	2.92

Mean of the same letter are not significantly different at 5% level of significant using LSD test.

Dry matter of seeds

PBZ application significantly increased the dry matter of seeds at day 7 with a mean of 0.53 g as compared to other treatments (Table 5). On another hand, GA3 application enhanced significantly at day 14 and had a comparable result with the control with a mean of 1.40 g and 1.37 g, respectively. However, at 28 days of anthesis, Paclobutrazol, and muriate of potash application showed increased in the dry matter of seeds as compared to control treatment having a mean of 1.62 g and 1.57 g, respectively.

A similar result also was reported by Setia *et al.* (1996) who found significant increments in the dry matter of siliqua wall and seed at all the phases of development because of Paclobutrazol treatments. An increase of dry matter of seeds at day 28 in this study was supported by the previous studies of Anac *et al.* (1993) who stated that muriate of potash (K) has a vital contribution to fruit weight, color, dry matter content and the final yield of tomatoes.

Dry matter of pods

Muriate of potash significantly reduced the dry matter content of pods of okra from day 7 to day 28 with a mean ranging from 0.88-1.52 g per pods, respectively (Table 5). On the other hand, Paclobutrazol application increased the dry matter at day 7 with amean of 1.68 g but on day 14-28, an increased in the dry matter of pods was observed with the plant applied with GA3 with a mean ranging from 1.73-2.08 g at day 14-28. A similar result also noted by Emongor (2007) who stated that cowpea plants applied with GA3 had significantly higher dry matter contents in the whole plant, shoot and root than control plants. Increase dry matter accumulation was also reported by Hore *et al.* (1988) by the GA3 application. The increase in plant dry matter in GA3-treated plants was credited to the expansion of leaf area and leaf number/plant. Bigger amounts of dry matter are developed when cowpea plants of determinate cultivars keep up generally large and healthy leaf areas for prolonged periods (Summerfield *et al.*, 1985; Littleton *et al.*, 1979).

Dry matter is a positive sign indicating high solid mass or the dry weight of seeds. Plant growth regulator assumes a critical part in enhancing photosynthetic activity and subsequently the accumulation of photosynthesis in plant organs to account for more fresh weight and dry weight. Gibberellins activate the growth mechanism, by effective photosynthetic action in this way expanding carbohydrates accumulation and subsequently dry matter contents (Letham, 2002; Khan, 2006).

Table 5. Dry matter of seed (g) and dry matter of pods (g) of okra as influenced by some preharvest treatments at 7-28 days after anthesis.

Treatment	**Dry matter of seeds (g)**				**Dry matter of pods (g)**			
	7	**14**	**21**	**28**	**7**	**14**	**21**	**28**
T1- Control	0.17b	1.37a	1.27	1.05c	1.10b	1.60b	1.70b	1.30d
T2- GA3	0.23b	1.40a	1.08	1.20b	0.85b	2.08a	1.90a	1.73a
T3-Paclubutrazol	0.53a	0.42c	1.17	1.62a	1.68a	1.73b	1.77b	1.58b
T4-Muriate of potash	0.28b	0.67b	1.38	1.57a	0.88b	1.17c	1.52c	1.45c
Standard error	0.05	0.06	0.09	0.05	0.13	0.06	0.05	0.04
CV (%)	22.26	7.79	9.43	4.39	14.12	4.80	3.75	3.56

Mean of the same letter are not significantly different at 5% level of significant using LSD test.

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Internal Structure of the Seeds

There are noticeable changes in the internal structure of okra seeds as influenced by some preharvest treatments at 7-28 days after anthesis (Figure 1). Embryo development was visible under 1000× magnification microscope at a weekly interval and changes over time.

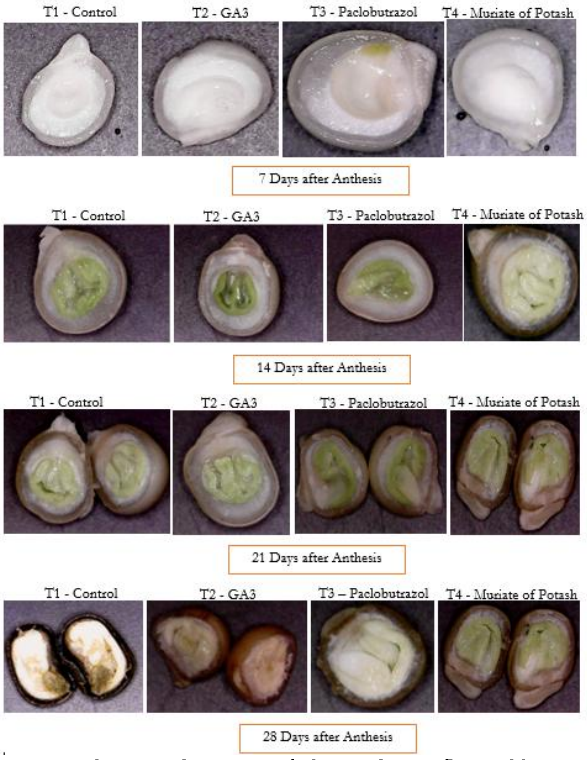

Figure 1. The internal structure of okra seeds as influenced by some preharvest treatments from 7-28 days after anthesis.

4 CONCLUSION

Application of GA3, PBZ, and muriate of potash increase the weight of pods, dry matter of seed, and dry matter of pods at day 28. Okra had a wider pod when applied with Paclobutrazol at 7 and 21 days after anthesis. The Paclobutrazol application also increased the equatorial of seeds at 7, 21, and 28 days. Application of muriate of potash increased the number of seeds per pods at 21 (53.67 seeds/pods) and 28 days (58.84 seeds/pods) after anthesis.

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