Effect of Chitosan on Growth Parameters of Rootstock and Grafting Success of Jack Fruit (*Artocarpus heterophyllus*) Variety Father Long

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Abstract - A study was conducted to investigate the effect of Chitosan on seedling growth and grafting success of Jack Fruit (*Artocarpus heterophyllus*) variety Father Long. Chitosan was applied as a seed treatment and seedling spray to root stock before grafting. It was used alone or combines with fungicide (Mancozeb 70 WP) and Albert's solution i.e. commercial formulation of macro and micro nutrient mixture. Results indicated that spraying of Albert's solution (2g l^{-1}) was the best treatment for higher growth of seedlings. Seed treatment with chitosan (20 g l^{-1} for 90 min.) or Mancozeb (2 g l^{-1} for 90 min.) and foliar spraying of Albert's solution showed higher dry matter accumulation of seedling compared to other treatments. Tap root length of the seedlings was higher in all treatments compared to control. Seed treatment by chitosan solution for 90 minutes and spraying of chitosan solution at 10 days after germination of seeds in two weeks intervals was showed early seed germination, higher stem thickness of rootstock and increase grafting success of jack variety Father Long over 80% compared to 40% in control.

Key words - *Chitosan, Artocarpus heterophyllus, grafting success*

I. INTRODUCTION

Jack fruit *Artocarpus heterophyllus* Lam.is an extensively grown tree in Sri Lanka. Although it has very high timber value, it is mainly grown in homesteads due to its food value. Fruitlets or bulbs of jack fruit are used as a vegetable, ripe fruit as well as processed products. Recently Department of Agriculture was released five high yielding, good quality varieties of Jack Fruits. These varieties have a high demand from consumers as well as growers especially due to their excellent quality as a fresh fruit. Among these, Father Long variety is the best variety as a ripe fruit variety. Higher demand is exist for planting materials (grafted plants) of this variety however; production of grafted plants of the variety is very difficult due to lower success rate of grafting. Poor growth of the root stock, larger size of the scion wood of the variety and fungal infection around the graft are the main reasons for lower success rate.

Chitosan, a given name to a de-acetylated form of chitin, is a natural biodegradable compound derived from crustaceous shells such as crabs and shrimps (Sandford 1989). Chitosan has been proven to control numerous pre and post-harvest disease on various horticultural commodities (Bautista-Banos*et al., 2006*). It has been reported that both soil and foliar plant pathogens fungal, bacterial and viral may be controlled by chitosan application (Bautista-Banos *et al., 2006*). In addition to its direct microbial activity, other studies strongly suggest that chitosan induces a series of defence reactions correlated with enzymatic activities (Ben-Shalom *et al., 2003*). Chitosan has been shown to increase the production of glucanohydrolases, phenolic

compounds and synthesis of specific photoalexins with antifungal activity, and also reduces macerating enzymes such as polygalacturonases, pectin metal esterase etc (Awadalla and Mohmond, 2005). In addition, chitosan induces structural barriers for example inducing the synthesis of lignin- like material (*Bautista-Banos et al., 2005*). Gornik*et al,* in 2008 reviled that application of chitosan increased key enzymes activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and improved the transportation of nitrogen (N) in the functional leaves which enhanced plant growth and development.Therefore, the objective of the studies was to investigate the effect of chitosan on the growth of the seedlings and success of grafting rate of Jack fruit variety Father Long.

II. MATERIALS AND METHODS

Pot experiment was carried out at the Fruit Crop Research and Development Institute Gannoruwa (7° 15' 47N, 80° 36' 10E). Seeds were collected from fully matured jack fruits of variety Hirosa i.e. one of the commonly grown jack variety, located in the fruit research orchard Gannoruwa. Gauge 300, black colour and 20 x 30 cm size polythene bags were used as nursery pots. Compost, top soil and sand ratio of 1:1:1 mixture was used as potting mixture.One seed per bag was established and applied treatments accordingly. Chitosan compounds having different molecular weights were prepared by Atomic Energy Board, Colombo, Sri Lanka by Gamma radiation base technology. Efficacy of the different chitosan compounds on seed germination and growth inhibition of fungal pathogen was identified by in vitro test (Rajapakse *et al*., 2014). One chitosan compound having good fungicidal ability and other having stimulatory ability of seed germination was mixed and used for the study.

Table 1. The treatment combination

Treatments	Treatment Combination Levels
T1	Seed treatment by dipping seeds in chitosan solution at the rate of 20 g l^{-1} for 90 minutes and spraying of chitosan solution at the rate of 20 g l^{-1} at 10 days after germination of seeds in two weeks intervals and spraying was continued 2 times.
T2	Seed treatment by dipping seeds in chitosan solution at the rate of 20 g l^{-1} for 90 minutes and spraying of both chitosan solution at the rate of 20 g l^{-1} and Albert's solution at the rate of 2g l^{-1} at 10 days after germination of seeds in two weeks intervals and spraying was continued 2 times
T3	Seed treatment by dipping seeds in fungicide solution-Mancozeb 70 WP at the rate of 2g l^{-1} for 90 minutes and spraying of fungicide solution at the rate of 2g l^{-1} at 10 days after germination of seeds in two weeks intervals and spraying was continued 2 times
T4	Seed treatment by dipping seeds in fungicide solution-Mancozeb 70 WP at the rate of 2g l^{-1} for 90 minutes and spraying of Albert's solution at the rate of 2g l^{-1} at 10 days after germination of seeds in two weeks intervals and spraying was continued 2 times
T5	Spraying of fungicide solution at the rate of 2g l^{-1} at 10 days after germination of seeds in two weeks intervals and spraying was continued 2 times
T6	Spraying of Albert's solution at the rate of 2g l^{-1} at 10 days after germination of seeds in two weeks intervals and spraying was continued 2 times
T7	Control

Treatments were arranged in Randomized Complete Block Design with five replications. Each treatment consisted with twenty plants and data were taken from randomly selected ten plants and mean were calculated. Watering was done every other day. No serious pest damages were observed on seedlings.Days to 50% seedling emergence and percentage seed germination of root stock was recorded by observing the emergence of seedlings. Vegetative growth of plants was recorded since the time of grafting. Plant height was taken from the soil surface to epical bud of plant. Stem thickness of seedlings was measured by using a venire calliper in three and six week after seed germination. Fresh weight, dry weight and length of tap root of seedlings were recorded randomly uprooting two plants and drying in an oven at 105 ^{0}C inthree and six week after seed germination. Ten seedlings in each treatment

of each replicate were grafted with scion of jack fruit variety Farther Long 45 days after seedling emergence. Percentage of graft success was recorded by observing viability of scion 3 weeks after grafting.

III. RESULTS AND DISCUSSION

Most of the seeds were germinated and all treatments were showed more than 90% seed germination and seedling survival during study period (Table 2). It was similar to the study by Khan (2004) which showed that fresh jack fruit seeds have more than 85% seed germination. Jackfruit seeds are recalcitrant in nature. Furthermore Jalli*et al.*, (2012) reported thatmost of the recalcitrant seeds germinated easily, due to low seed dormancy in recalcitrant seeds. This was the reason for high germination percentage of jackfruit in almost all treatments.

Table 2: Effect of different treatments on percentage seed germination and days to 50% seed germination

Treatment	Seed Germination %	Days to 50% seedGermination
T1	100	23.2[d]
T2	100	23.0 [d]
T3	98	25.0 [c]
T4	100	25.8[bc]
T5	98	27.5 [a]
T6	98	27.0 [ab]
T7	100	27.0[ab]
	ns	
CV%	4.1	4.7

However, days taken to 50 % germination were significantly different among the treatments. Seeds treated with chitosan germinated quickly compared to other treatments. Defang et al, 2012 reported that chitosan can apply to plants as seed coat, or spray on foliageand improved the germination of several types of seeds.Chitosan has excellent film-forming property, making it easy to form a semipermeable film on the seed surface which can maintain the seed moisture and absorb the soil moisture, and thus it can promote seed germination. Further, it can cut off excessive soil moisture to prevent the seed from corrupting (Furbank*et al.*, 2004).

Table 3: Mean seedling height, root length and stem thickness of Jak Fruit seedlings of root stock at 3 weeks and 6 weeks after seedling emergence

Treatment	Seedling height (cm)		Root length (cm)		Stem thickness (mm)	
	3 weeks	6 weeks	3 weeks	6 weeks	3 weeks	6 weeks

T1	10.3	32.3^{bc}	11.7	14.7^{a}	5.4^{a}	6.9^{a}
T2	11.7	34.8^{a}	10.9	15.0^{a}	4.8^{b}	6.0^{b}
T3	10.4	30.8^{cd}	9.9	14.8^{a}	4.3^{c}	5.6^{bc}
T4	11.2	34.8^{a}	11.0	15.4^{a}	4.6^{b}	5.4^{cd}
T5	9.9	29.5^{de}	10.1	14.3^{ab}	4.2^{c}	4.9^{d}
T6	11.2	33.8^{ab}	10.8	15.2^{a}	4.5^{b}	5.3^{cd}
T7	9.9	29.0^{e}	9.8	13.5^{b}	4.1^{c}	5.4^{cd}
	ns		ns			
CV%	6.3	4.5	4.5	5.1	3.4	6.7

Note: Means with the same letter(s) on the column are not significantly different at P≤0.05.

Mean seedling heights of the different treatments were ranged 9.9 cm – 11.7 cm. However, values werewas not significantly different. Similarly, root length was not significantly different among treatments.Stem circumference were different among treatments and it was highest in the treatment 1 which is seed treatment with chitosan and spraying ofchitosan to growing seedlings in two weeks intervals (Table 3).

Seedling heights of the different treatments are ranged from 29.0-34.8 cm and values are significantly different among treatments. Highest seedling height was recorded the treatments which applied Albert solution in two weeks interval. Root length was significantly different among the control and other treatments. Stem thickness was also significantly different among the treatments. The highest value was observed in treatment 1 and treatment 2 and 3 followed by it. Ranasinghe and Weerakkody (2006) reviled that application of Albert's solution to green plants resulted, greater shoot length increase while reducing stem thickness. The results are similar in this study. Treatment 2, 4 and 6 showed higher seedling length while stem thickness is lower in these treatments. Highest stem thickness was recorded from sole Chitosan (T1) treated plants (Table 3). This indicated that application of chitosan have the ability to increase growth of jackfruit seedlings. This performance shows chitosan, because Chitosan also can increase soluble sugar content in the green tissues of plants. To transport these sugars, phloem tissues eventually become larger as a result stem thickness become larger on sole chitosan treatments in jackfruit.

Table 4: Total dry weight on shoot and root and rate of dry matter accumulation on shoot and root of the rootstock.

Treatment	Dry weight 24 DAP (g/plant)	Dry weight 42 DAP (g/plant)	Rate of dry matter accumulation (g/week)
T1	0.81	5.84	1.67^{b}
T2	0.92	6.20	1.76^{a}
T3	0.81	5.48	1.58^{c}
T4	0.88	6.07	1.73^{a}

T5	0.79	4.68	1.39[d]
T6	0.82	5.62	1.64[b]
T7	0.73	4.98	1.42[d]
CV%			4.2

Note: Means with the same letter(s) on the column are not significantly different at P≤0.05.

Higher rate of dry matter accumulation was recorded from T2 and T4. These were followed by T1. Lowest value of dry matter accumulation on shoots and roots were recorded from control and T5 treatments. Albert's solution treated plants showed high rate of dry matter accumulation at the time of grafting and highest shoot height. This was happened due to foliage of plants can absorb nutrients much as roots can. Elements such as phosphorus nitrogen and potassium move up and down from the point of application at rates similar to that of roots. Also in many cases, 95% of the mineral sprayed to the leaves are use immediately by plants, compared to roots in same conditions (Osborne, 1998).

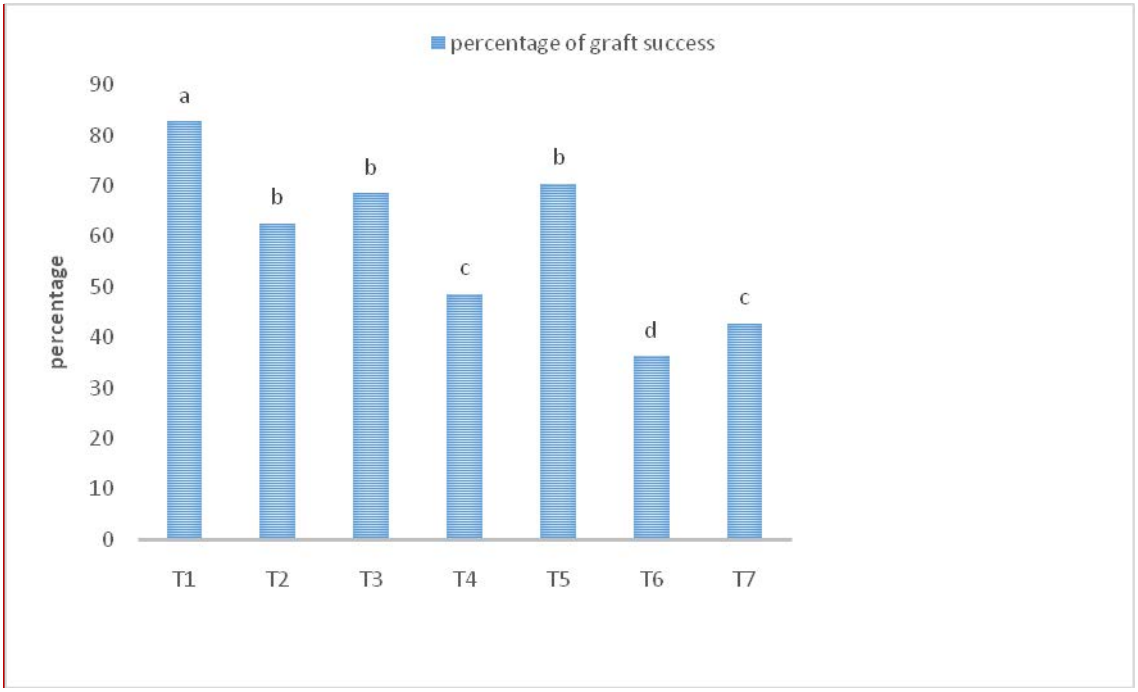

Figure 1. Effect of treatments on grafting success of Jack Fruit variety Father Long

Grafting success was significantly higher in treatment 1 which applied only chitosan compared to the other treatments. Application of chitosan with Albert's solution showed lower grafting success compared to sole chitosan treatment. Fungicide applied treatments also showed higher grafting success compared to control and Albert's solution applied treatments. Several studies showed that chitosan has an ability to accelerate wound healing, delay and inhibit common pathogens in plants and increase vegetative growth of seedlings (Defang *et al.*, 2012, Mondal*et al.*, 2012, Badawy and Rabea, 2011). Further, Chitosan inherently show anti-fungal properties because chitosan also can increase soluble sugar content and enhance the activity of protease conversion to protein and increasing free amino acid content, which has obvious inhibiting effect for many plant pathogenic fungi. (Chen and Xu, 2005). As a result of this action graft union was not infected by fungi. In this study highest grafting success was observed in chitosan treated plants (T1) compare to other treatments. This may be due to both inhibitions of fungi pathogens as well as wound healing ability of chitosan in stock- scion union of grafted plants.

Furthermore, seedling was grafted; root stock utilizes the stored carbohydrates for survival or growth. Immediate after grafting, shoot does not provide food for survival of root stock until graft union combine. Therefore, seed still intact act as sink for the root stock. chitosan film is also considered to have a good selective permeability, which can prevent oxygen from entering the film, restrict loss of CO2, and maintain a high concentration of CO2 in the film, so as to restrain the seed respiration and thus to make the internal nutrient consumption of seeds fall to the lowest possible level. As a result of this, sole chitosan treated seeds provide more food for survival of root stock until graft union combine compare to other treatments.

IV. CONCLUSION

Lower grafting successes of Jack fruit variety Father Long become a problem to expand the cultivation of improved high quality varieties. In present condition grafting success of the variety is below 40%. Seed dipping treatment in chitosan solution (20 gl^{-1}) for 90 minutes and spraying of chitosan solution (20 gl^{-1}) at 10 days after germination of seeds in two weeks intervals was showed early seed germination, higher stem thickness of rootstock and increase grafting success of Jack variety Father Long over 80%.

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