Research Paper

Seed Quality Improvement of Eggplant (*Solanum melongena* L.) through Canopy and Nutrient Management Package

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Abstract

Brinjal or eggplant (*Solanum melongena* L.) is a perennial Solanaceous crop which is cultivated in Sri Lanka with an average yield of 11.9 t ha^{-1}. Absence of quality seeds is a limiting factor to achieve potential yield of eggplant. Although the effects of plant canopy management on seed quality had been reported, very scanty information is available on the combined effects of canopy management and agronomic practices on the seed yield and seed quality of eggplant. This study was carried out to evaluate the effect of canopy management including fruit thinning, plant spacing and fertilizer application on the yield and quality of eggplant seed. The field experiment was conducted during 2015/ 16 *Maha* season, at the government seed farm, Kundasale, using the variety SM 164. Eight treatment combinations; two levels of canopy management with fruit thinning two levels of spacing and two fertilizer levels (recommended amount of fertilizer by the Department of Agriculture (DOA) and 1.5 times of the DOA recommendation were arranged in Randomized Complete Block Design with three replicates. Results of the study revealed that, canopy management with three shoots and seven fruits, at reduced spacing (60 cm × 60 cm) and increased fertilizer application was the best factor combination to achieve higher seed yield and enhanced seed quality attributes such as thousand seed weight, seedling vigor index etc., than the recommended crop management practice. This finding will help to fill the gaps of knowledge while providing valuable information to formulate recommendations for the development of a suitable agronomic package for quality seed production in eggplant.

Keywords: Brinjal, Canopy management, Fertilizer application, Fruit thinning, Plant spacing, Seed yield

Introduction

Eggplant or brinjal (*Solanum melongena* L.) is a perennial solanaceous crop which is economically grown in Sri Lanka. The land area under brinjal in Sri Lanka is 10,834 ha and annual production is 129,212 t with an average yield of 11.93 t ha^{-1} (Agstat, 2019). Seed quality is one of the prime factors to obtain high productivity in eggplant cultivation and the availability of good quality seeds often becomes a limiting factor to obtain successful yield (Patil, 2005). Maintenance of high degree of physiological and genetic qualities is crucial for the achievement of optimum stand establishment which in turn leads to a higher fruit yield (Deshi and Patil, 2016).

Although the cost of seed is usually less than 5-10% of total production costs, seed can affect the yield of crop more than any other input factor (Erker, 2008). Quality seed is defined as genetically pure with a high germination percentage, free from disease and disease organisms and with a proper moisture content and weight (Mirza, 2015).

Seed requirement for cultivation of eggplant is 350-375 g ha^{-1}. The actual yield of eggplant (7-10 t ha^{-1}) is always lower than the potential yield of 25-30 t ha^{-1} (Fonseka, 1999). Therefore, seed quality parameters should be enhanced to increase the availability of good quality seeds for farmers and thereby to increase the actual yield of eggplant. Seed germination percentage and the vigor index provide a good indication on seed quality and the suitability for long term storage (Das *et al*., 2017).

Although information available on the effect of canopy management on seed quality (Fonseka *et al*., 2013), there is little information on the combine effect of agronomic practices such as canopy management, fruit thinning, plant spacing and fertilizer application on the seed yield and seed quality of eggplant. Therefore, the study was carried out to evaluate the effect of crop management, plant spacing, and fertilizer application on the seed quality of eggplant. The finding of this study will help to fill the gaps of knowledge on this area while providing valuable information to the seed producers to achieve an enhanced seed yield of good quality to support for a profitable seed production program.

Materials and Methods

A field trial was conducted during 2015/2016 *Maha* season at the government seed farm, Kundasale and laboratory testing were done at the Seed conservation laboratory, Plant Genetic Resources Center (PGRC), Gannoruwa. The experiment was conducted according to the three factor factorial randomized block design (RCBD) with 3 replications. Breeder seeds of DOA recommended egg plant variety SM 164 was used for the experiment.

Description of treatments

Canopy management with fruit thinning, plant spacing and the fertilizer application level are the three factors for the factorial randomized complete block design. Eight treatment combinations were evaluated as illustrated in Table 1. Canopy management with fruit thinning was not practiced in first four treatment combinations and it was practiced in the rest of the treatments.

Only three shoots and seven fruits were maintained per plant in the treatments five to eight. Only three shoots per plant were maintained and remaining shoots were removed from the shoots below and above the first flower. Rest of the shoots were removed at their initial stage. Fruit thinning was done by removing the first fruit and maintaining seven fruits per plant and excess flower buds were thinned out after formation of required number of fruits in each treatment. Shoot or fruit removal was not practiced in treatment one to four. Healthy well grown four weeks old plants were transplanted on raised ridge with two different spacing (90 cm × 60 cm and 60 cm × 60 cm) accommodating 40 plants per plot and 50 plants per plot respectively. Two fertilizer applications were done as recommended fertilizer dosage and increased fertilizer, 1.5 of the DOA recommended fertilizer as practiced by Fonseka *et al*. (2013). Nursery management and crop establishment was done according to the recommendations of the Department of Agriculture. Drip irrigation was practiced according to the requirement. Weeds were controlled manually at two weeks interval up to twelve weeks.

Table 1. Treatment combinations of the experiment

Treatment code	Treatment description	Factor 01 Canopy management with fruit thinning	Factor 02 Spacing (cm)	Factor 03 Fertilizer level
T_1	C0T0FR S R	Without canopy management and fruit thinning	60 × 90	DOA recommendation
T_2	C0T0 F 1.5 S R	Without canopy management and fruit thinning	60 × 90	1.5 × DOA recommendation
T_3	C0T0 FR S 60	Without canopy management and fruit thinning	60 × 60	DOA recommendation
T_4	C0T0 F 1.5 S 60	Without canopy management and fruit thinning	60 × 60	1.5 × DOA recommendation
T_5	C3T7 FR S R	3 shoots and 7 fruits were maintained	60 × 90	DOA recommendation
T_6	C3T7 F 1.5 S R	3 shoots and 7 fruits were maintained	60 × 90	1.5 × DOA recommendation
T_7	C3T7 FR S 60	3 shoots and 7 fruits were maintained	60 × 60	DOA recommendation
T_8	C3T7 F 1.5 S 60	3 shoots and 7 fruits were maintained	60 × 60	1.5 × DOA recommendation

Data collection

Number of days to first flowering was counted by visual observation. Plant height was measured from every plant in each plot just after canopy management was done and expressed as an average value. Full ripen fruits at physiological maturity stage were harvested from experimental field. Standard size fruits were selected for seed extraction purpose. The selected fruits were kept under ambient condition for post harvest ripening to have softened fruits and seeds to become fully matured. The seeds were separated by washing under running tap water and air dried. Then they were kept in a dry air cabinet to have about 6% moisture content.

Dried seeds were analyzed for seed yield per fruit, seedling vigor (seedling shoot length, seedling root length and seedling fresh weight), germination percentage, seed viability and thousand seed weight. Seed viability of 400 seeds per treatment was measured using the tetrazolium test at four weeks after harvest. Germination percentage (400 seeds per treatment) was measured at two weeks after harvesting using standard method (ISTA protocol) practiced at seed conservation laboratory, Plant Genetic Resources Center, Gannoruwa and number of normal seedlings was counted at seventh and fourteenth day after seeding. Seedling shoot length, seedling root length and seedling fresh weights were measured using 20 randomly selected normal seedlings at seventh day after seeding. Seedling length was measured from the shoot tip to base of the root using a ruler and seedling fresh weight was measured using a three decimal top loading balance. Thousand seeds was counted using a seed counter and weight was measured using a three decimal top loading electronic balance

Data analysis

Analysis of variance was done using the statistical analytical package "SAS 9.2 for Windows". The Duncan's Multiple Range Test (DMRT) was used for mean separation.

Results and Discussion

The combined effect of canopy management with fruit thinning, spacing and fertilizer application was significant on average seed yield per fruit. Fertilizer application had a highly significant effect, canopy management with fruit thinning has a significant effect and spacing was not significant on average seed yield per fruit (Table 2).

Out of the tested ten parameters, much emphasize was given to last five parameters, Average seed yield per fruit, Seed germination % , Length of seedlings, Seedling vigor Index and thousand seed weight

Effect of treatment factors on average seed yield per fruit

The highest average seed yield per fruit was resulted in T_8 (5.5 g), which canopy was managed and increased fertilizer was applied and the lowest value was recorded in T_3 (3.1 g) in which canopy was not managed and DOA recommended fertilizer was applied (Figure 1). Similar results were observed by Genard *et al.* (2009) and reported that canopy management with fruit thinning reducing number of fruits. Therefore, these results confirmed that the average seed yield per fruit can be increased by canopy management with fruit thinning and increased fertilizer application.

Table 2. Analysis of variance results of probability values of tested parameters

	Parameter	Canopy management with fruit thinning (C)	Spacing (S)	Fertilizer application (F)	(C) X (S) X(F)
01	Time taken for first flowering	0.0271	0.0084	<0.0001	<0.0001
02	Plant height	0.0012	0.0747	<0.0001	0.0275
03	Single fruit weight	0.0004	0.1921	<0.0001	0.2272
04	Fruit length	0.0064	0.5676	<0.0001	0.5673
05	Fruit circumference	0.0068	0.5253	<0.0001	0.8042
06	Average seed yield per fruit	0.0005	0.1600	<0.0001	0.0260
07	Seed germination %	0.0005	0.6815	<0.0001	0.5281
08	Length of seedlings	<0.0001	0.2150	<0.0001	<0.0001
09	Seedling vigor Index	<0.0001	0.4070	<0.0001	<0.0001
10	Thousand seed weight	<0.0001	0.0003	<0.0001	0.0012

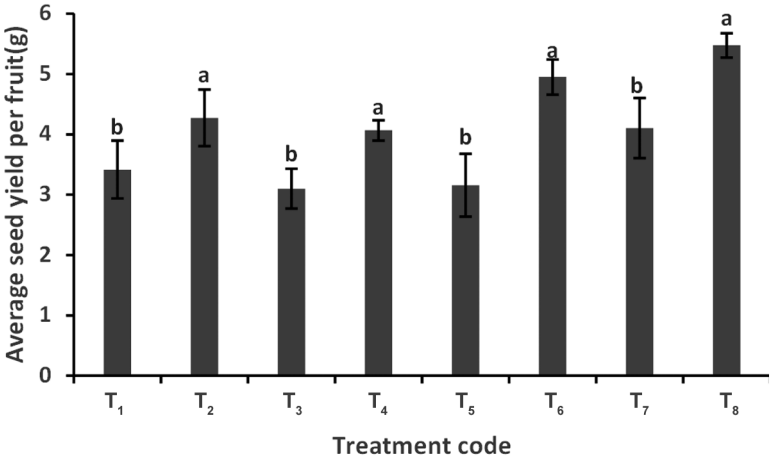

Figure 1. Effect of eight treatment combinations on average seed yield per fruit

Note: T_1 to T_8 treatment codes are described in table 01
Means followed by the same letter are not significantly different at 5% probability level

Effect of treatment factors on seed germination

Fertilizer application has high significant effect, canopy management with fruit thinning has a significant effect and spacing was not significant on seed germination (Table 2). The highest germination percentage was resulted in T_8 (94.3%) where crop was managed, reduced spacing (60 × 60 cm) and increased fertilizer. The lowest value was observed in T_3 (80.66%) where without canopy management with fruit thinning, reduced spacing (60 × 60 cm) with DOA recommended fertilizer

application (Figure 2). Therefore these results confirmed that seed germination percentage can be increased by canopy management with fruit thinning and increased fertilizer application. Similar results were obtained by Fonseka *et al*. (2013) from the study of effect of fruit thinning, canopy management and number of harvest on seed quality of eggplant. Their results revealed that the fruit number per plant affect germination percentage. The germination percentage increases with the decreasing fruit number. These results were similar to Patil (2005) for hybrid eggplant.

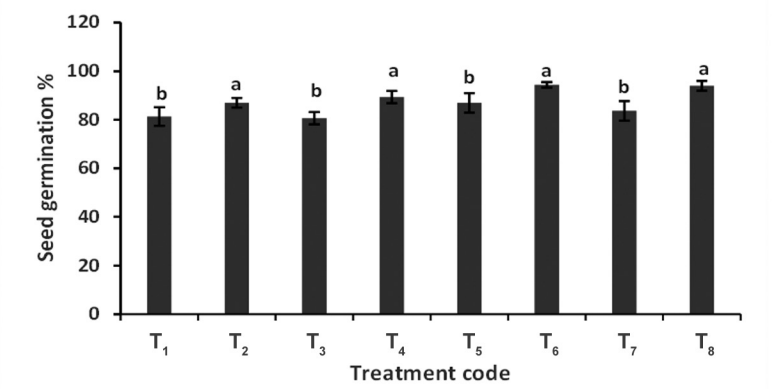

Figure 2. Effect of eight treatment combinations on seed germination percentage

Note: T_1 to T_8 treatment codes are described in Table 1
Means followed by the same letter are not significantly different at 5% probability level

Effect of treatment factors on thousand seed weight

The highest thousand seed weight (5.133 g) was observed in T_8 where canopy management with fruit thinning, reduced spacing and increased fertilizer were applied. The lowest value (4.128 g) was observed in T_3 where without canopy management, reduced spacing and recommended fertilizer were used (Figure 3). These results were confirmed by the findings of Genard *et al*. (2009) and Fonseka *et al*. (2013). According to them pruning of plants increase the photosynthetic efficiency and fruit thinning resulted in reducing number of fruits allowing development of large seeds, which gives high weight of 1000 seeds. Agrawal, 1995 proved that seeds lot having smaller seeds, lower specific gravity or thousand seed weight may perform poorly when compared to seeds having higher specific gravity and thousand seed weight.

Effect of treatment factors on length of seedling

The effect of canopy management with fruit thinning and fertilizer had a significant effect and spacing was not significant on length of seedlings on seventh day after seeding (Table 2). The highest seedling length was resulted in T_8 where canopy was managed with fruit thinning, reduced spacing (60 ×60 cm) and increased fertilizer.

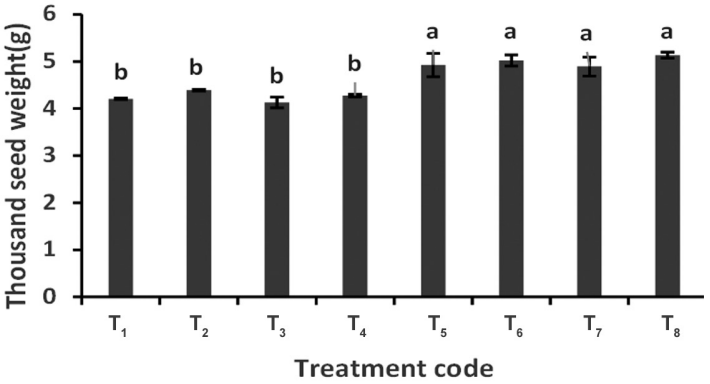

Figure 3. Effect of eight treatment combinations on thousand seed weight

Note: T_1 to T_8 treatment codes are described in Table 01
Means followed by the same letter are not significantly different at 5% probability level

It confirms that the increased fertilizer formulation had effect to increase the length of seedlings than the recommended fertilizer. According to the results, canopy management with fruit thinning leads to production of larger fruits and seeds, which producing seedlings with high seedling length. Fonseka *et al*. (2013) reported that numerically highest shoot length was observed in treatment where three shoots with four fruits were maintained.

Effect of treatment factors on seedling vigor index

Canopy management with fruit thinning and fertilizer application had a significant effect and spacing was not significant on seedling vigor index (Table 2). The mean value of crop managed treatments (7005.0) was higher than the treatments with canopy not managed (4940.3). The mean value of 1.5 × DOA recommendation, increased fertilizer application treatments (6873.3) was higher than the treatments with DOA recommended fertilizer application (5072.0). The highest seedling vigor index (8840) observed in T_8 where canopy was managed with less spacing and increased fertilizer, the lowest was observed in T_3 (4192) where without canopy management and fruit thinning, less spacing and DOA recommended fertilizer was applied (Figure 4) . The results confirm that the increased fertilizer formulation, less spacing and canopy management enhanced the seeding vigor.

Dry matter partitioning is changed dramatically making high quality seeds in brinjal fruits of canopy managed plants. The reason behind is the capability of leaves to produce more assimilates. According to the study conducted by Rahman *et al*. (2017), fruit thinning at the initial stage can improve the size of remaining fruits. Better seed quality attributes with proper spacing might be due to better plants nourishment resulting in proper development of seed, which reflected in higher thousand seed weight and other seed quality parameters. Salaudeen (2019) has proved in his study on effect of plant spacing on eggplant, the spacing improve the quality of yield and minimize disease infestation, which affect yield and fruit quality.

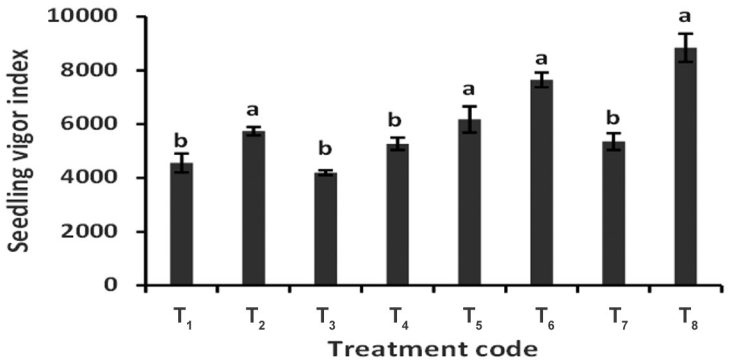

Figure 4. Effect of eight treatment combinations on seedling vigor index

Note: T_1 to T_8 treatment codes are described in Table 01
Means followed by the same letter are not significantly different at 5% probability level

Cultivable land extent is decreasing day by day due to many reasons and the recommended plant spacing of eggplant is 90 cm × 60 cm. This space is needed for eggplant, when it is grown as a well branched bush under the normal conditions. But eggplant can be managed as a low spreader plant through canopy management. According to Fonseka *et al*., 2013, the canopy and fruit managed plant recorded the highest seed quality parameters. Therefore, fruit thinning and canopy management can be used for seed production program to improve the seed quality parameters. Reduced plant spacing of 60 cm × 60 cm, can increase the number of plants per unit area, which would provide growers with more accurate spacing of canopy managed eggplants and would allow them to use their limited lands efficiently. Therefore, this research is important to determine appropriate spacing for eggplant and to determine the best economic returns.

The Department of Agriculture fertilizer recommendation for eggplant is given only considering the eggplant grown for consumption. But, for seed production, fruits are allowed to ripen fully to achieve physiological maturity of seeds. Therefore, fruits are harvested after the consumable stage. To supply the nutrients for this extra growing period a specific fertilizer application is required.

According to Chen *et al*. (2002), plant pruning is an essential procedure to reduce the number of shoots, leaves and fruit set in eggplant due to its intense vegetative growth. Amiard *et al*. (2005) emphasized that plant adjust their capacity to carry out photosynthesis in response to the demand for photosynthetic products. The balance between source and sinks is continuously adjusted in response to environmental and developmental conditions such as shoot or fruit thinning.

Based on the findings of this study few suggestions can be presented for future studies. Further studies needed for different levels of canopy management with fruit thinning, spacing and fertilizer would be suggested for different crops belong to family *Solanaceae* such as tomato and chilli. These findings could be repeated few seasons as well as at various climatic conditions to validate their success and if it will be succeed, these findings could be communicated to commercial farmers to improve seed yield and seed quality of eggplant.

conclusion

According to the results of this study, canopy management and fruit thinning with three shoots and seven fruits, less spacing (60 × 60 cm) and increased fertilizer of 1.5 × of the DOA recommendation (T_8) was the best factor combination to achieve better seed quality than the recommended cultural and agronomic practices under Sri Lankan condition.

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