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Impact of grafting and different levels of spacing and nitrogen fertilizers on non-marketable fruit yield in brinjal (*Solanum melongena* L.)

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Abstract
An experiment with double split design for analysing the non-marketable fruity yield in Brinjal was conducted in Bhubaneswar, Odisha over two years while taking grafting as main factor, spacing levels as sub factor and different nitrogen fertilizer doses as sub sub factor. From the experimental findings it was observed that grafting has no impact on non-marketable fruit yield in Brinjal, whereas higher non marketable fruit yield was observed under the closest spacing of 90 cm x 60 cm and higher doses of nitrogen fertilizers.

Keywords: Grafting, non marketable fruit yield, spacing, nitrogen fertilizer, fruit borer

Introduction
Vegetable grafting is a popular technology for vegetable growing especially in Solana coos and cucurbitaceous vegetable crops which depend upon the goodness of the rootstocks mostly through enhanced plant vigour and reduced soil borne disease incidence due to its efficient root system which not only avoids the entry of pathogens but also enhances nutrient and water use efficiency (Frank *et al*., 2010) [6]. Spacing between the plants is a very much important agronomic aspect because the light interception is affected due to this which ultimately affects photosynthesis. It also influences photosphere and rhizosphere exploitation by the plants. Optimum plant spacing gives the plants the proper space to grow and express its full potential (Ibeawuchi *et al*., 2008) [7]. Other than plant spacing, plant nutrition is also another agronomic aspect that plays very important role for enhancing yield and quality of Brinjal. However, the available information on nutrition for grafted plants is not sufficient for commercial cultivation (Ruiz *et al*., 1997, Colla *et al.*, 2006 and Arao *et al*., 2008) [10, 4, 1]. The balanced application of major nutrients especially nitrogen is very much important for maximization of yields in Brinjal. Grafted Brinjal produces fruits for longer duration thus need balanced and sufficient supply of nutrients for maintaining higher yield and better quality. Therefore, there is a need among the farming community for the standard production technologies and efficient management systems for optimizing productivity of grafted vegetables (Lee and Oda, 2003) [9]. Often in Brinjal cultivation the fruits harvested need proper grading before marketing due to the presence of significant amount of non-marketable fruits. The non-marketable fruits produced in Brinjal are mainly due to various factors such as fruit borer infestation, phomopsis fruit rot incidence, smaller fruits harvested from wilting affected plant and winter or pollination induced deformed fruits. In this experiment the impact of grafting along with different levels of spacing and nitrogen fertilizer levels are studied to observe their impact on non-marketable fruit yield.

Materials and Methods
The experiment was conducted for two years in which the whole plot was divided to two main strips with three replications of each. Grafted Brinjal hybrid VNR-212 on rootstock *Solanum torvum* was grown in one strips and on the other strip non grafted VNR-212 hybrid seedlings were grown. Again each strip was divided into the sub lots with different spacing's between plant to plant (*i.e.* 60 cm, 75 cm and 90 cm respectively) with row to row spacing remaining constant *i.e.* 90 cm. Again each subplot was divided into 4 sub sub plots based on applied Nitrogen fertilizers doses such as 50%, 75%, 100% and 125% of recommended nitrogen fertilizer doses. The recommended doses of farm yard manure, phosphorus and potassium were applied and other cultural practices were followed.

The experiment was conducted in Double split plot design. Three replications were used with twenty four treatment combinations. From the above factors, twenty four treatment combinations with three replications were obtained and adopted in the experiment at field level. The experiment was carried out in Split Plot Design. The gross plot size was 4 x 3 m^2. The plants were spaced at 90 cm between the rows and within plant to plant it differed according to the treatments. The total number of plants per plot for 90 x 60 cm, 90 x 75 cm and 90 x 90 cm were 20, 16 & 12 respectively.

The total non-marketable fruit yield per plant was recorded by weighing the unsellable fruits infested with diseases and pests produced in each plant at every harvest and was expressed in kilograms. Non marketable yield per hectare was estimated by multiplying nonmarketable yield per plot with total number of plots per hectare and was expressed in tons. The non-marketable portion involves deformed fruits, fruit borer infested fruits and phomopsis rot affected fruits.

Results

Data on non-marketable yield are illustrated in Table no.1. Differences in non-marketable yield (kg/plant) of Brinjal was found to be non-significant among different levels of grafting. among different levels of grafting, grafted Brinjal hybrid VNR 212 plants on rootstock *Solanum torvum* produced non-marketable yield (0.46 and 0.54 kg/plant) was observed by grafted Brinjal hybrid VNR 212 plants on rootstock *Solanum torvum* where as non-grafted Brinjal hybrid VNR 212 produced non- marketable yield (0.42 and 0.57 kg/plant) in both years of experiment, which were not statistically different from each other. Among different levels of spacing, 90 cm × 90 cm spacing produced the highest non-marketable yield (0.57 and 0.70 kg/plant) compared to 90 cm × 60 cm (0.33 and 0.42 kg/plant) and 90 cm × 75 cm (0.42 and 0.53 kg/plant) in both years of experiment respectively which were again not different statistically. Among nitrogen fertilizer doses, application of 180 kg N/ha produced the highest value (0.50 and 0.62 kg/plant) in both years of experiment, which was at par with 180 kg N/ha (0.50 and 0.60 kg/plant), respectively. Lowest value was obtained from application of 90 kg N/ha (0.35 and 0.45 kg/plant) for both the years of experiment respectively.

Table 1: Non-marketable yield per plant and Non-marketable yield per hectare of grafted and non-grafted Brinjal plants under different levels of spacing and N-fertilization

Treatments	Non-Marketable yield/plant (kg)		Non Marketable yield/ha (t)	
	2017-18	2018-19	2017-18	2018-19
G0-Non Grafted	0.46	0.54	4.26	5.33
G1-Grafted	0.42	0.57	4.76	5.67
S.Em±	0.01	0.02	0.04	0.13
CD (0.05)	NS	NS	0.26	NS
S1-90 X 60 cm	0.33	0.42	4.65	5.76
S2-90 x 75 cm	0.42	0.53	4.35	5.17
S3-90 x 90 cm	0.57	0.70	4.52	5.58
S.Em±	0.01	0.03	0.16	0.15
CD (0.05)	NS	NS	0.53	0.50
N1-90 N/ha	0.35	0.45	3.51	4.47
N2-135 N/ha	0.42	0.53	4.13	5.27
N3-180 N/ha	0.50	0.60	5.20	6.01
N4-225 N/ha	0.50	0.62	5.20	6.26
S.Em±	0.02	0.03	0.15	0.16
CD (0.05)	0.06	0.08	0.42	0.47

Data on non-marketable yield (t/ha) are mentioned in Table no.1. Among different levels of grafting, grafted Brinjal hybrid VNR 212 plants on rootstock *Solanum torvum* produced the highest non-marketable yield (4.76 t/ha) compared to non-grafted Brinjal hybrid VNR 212 (4.26 t/ha) in first year of experiment. Differences in non-marketable yield (t/ha) of Brinjal was found to be non-significant among different levels of grafting in second years of experiment. Among different levels of spacing, 90 cm × 90 cm spacing produced the highest non-marketable yield (4.52 and 5.58 t/ha) compared to 90 cm × 60 cm (4.65 and 5.76 t/ha) and 90 cm × 75 cm spacing (4.35 and 5.17 t/ha) in 2017-18 and 2018-19, respectively. Among nitrogen fertilizer doses, application of 225 kg N/ha produced the highest value (5.20 and 6.26 t/ha) in both years of experiment, being at par with 180 kg N/ha (5.20 and 6.01 t/ha), respectively. Lowest value was obtained from application of 90 kg N/ha (3.51, 4.47t/ha, respectively).

Discussions

As per the results observed, the highest nonmarketable yield per hectare was observed in case of grafted Brinjal plants compared to the non-grafted plants. But as the per plant non marketable yield in non-grafted plants was similar with that of the yield per plant in grafted plants, we can conclude that the higher non marketable yield in grafted plants being observed here is just because of higher yield observed in grafted plants per unit area. The lower non marketable yield per hectare observed among the non-grafted plants is only due to the death of non-grafted plants due to bacterial wilt over cropping duration.

In this experiment highest nonmarketable yield per hectare was observed in the closer spacing of 90cm x 60 cm as compared to the wider spacing options. This might be due to higher incidence of disease pest in the closer spaced plants. This higher crop pest incidence may be due to the fact that in closer spacing insects find better places to hide and escape from the pesticide spray and natural enemies. Again the closer spaced plants create a microclimate suitable enough for development of pathogens and insects. Similar results were observed by Assinapol *et al*. (2018) [2] in grafted Brinjal experiments. These findings also fall in line with the basis of recommendations by FAO (2003) [5] for controlling the fruit and shoot borer incidence in Brinjal.

Again the highest amount of nonmarketable yield was observed when both the grafted and non-grafted Brinjal plants were grown under higher nitrogen fertilizer doses. This again might be due to the higher incidence of disease pests in the crop. In this experiment higher number of phomopsis fruit rot infested fruits and borer damaged fruits were noticed in the treatments involving higher dose of nitrogenous fertilizers. This is in similar tunes with the findings of Batal *et al*. (1994) [3], who opined that excess nitrogen fertilization makes the crops more susceptible to disease pests along with decreasing the crop quality. Assinapol *et al*. (2018) [2] while working with grafted Brinjal observed that excess fertilizer application lead to higher fruit borer infestation due to more succulency observed in the plants. Again, the higher phomopsis fruit rot incidence in Brinjal was observed by Kumar and Sugha (2003) [8] with increased application of nitrogenous fertilizers, which supports the results observed here.

Conclusion

Hence it can be concluded from the experiment that grafting in Brinjal with rootstock *Solanum torvum* does not solve the problem of higher unmarketable yield caused due to phomopsis fruit rot or fruit borer attack. However to reduce the non-marketable yield in Brinjal optimum doses of nitrogenous fertilizers can be used in Brinjal avoiding closer spacing among the plants.

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