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Influence of Seedling Age at Infection and Watering Frequency on Growth and Yield Responses of Eggplant to Cucumber Mosaic Virus

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ABSTRACT: Eggplant, (*Solanum melongena* L), cv. golden beauty obtained from the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria was used in greenhouse experiments aimed at evaluating the interactive effect of infection of *cucumber mosaic virus* (CMV, genus Cucumovirus; Family-Bromoviridae) at different ages of direct-seeded eggplant and varying watering frequency. Infected plants generally manifested mosaic symptoms and stunting, with the growth and yield responses varying with the inoculation and watering regimes. Plants inoculated earliest, i.e., at 1 week after germination, manifested the most severe symptoms while those inoculated latest at 3 weeks after germination manifested the least severity. Regardless of the inoculation regime, plants that were watered once or thrice a week with 500ml of water each time performed poorer than those that received twice. On the whole, plants that were inoculated at a relatively older age of 3 weeks after germination and received water twice a week performed better under infection than other treatment combinations in term of growth and yield values. The results suggest that careful manipulation of planting and watering may be an effective cultural disease management strategy in CMV infected eggplant.

Keywords: Cucumovirus; Cucumber Mosaic Virus; Watering frequency; Inoculation regime, *Solanum melongena.*

Introduction

Egg plant, *Solanum melongena* L. *is* of the night shade family Solanaceae. Along with tomato and pepper, it is a vegetable grown mainly for its fruit that is utilized in various ways around the world. All crops in this group are grown as annuals, and have much in common with regards to nutrient requirements (Hedge, 1997).

Eggplant is a much branched, erect plant with varieties grouped according to the similarities of use, appearance, morphology and environmental sensitivity among other criteria. It can be planted by direct field seeding or as transplant. Early variety of eggplant matures in 75-110 days while the late takes over 100-200 days. A well-drained sandy loam of pH 5.5 to 6.5 with high organic matter content is ideal for growing eggplant. Several side dressings are however, usually recommended because of the long growing season (Peet, 2003).

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According to the USDA (2006), production of eggplant is highly concentrated, with 93 percent of output coming from seven countries. China is the top producer (55% of world output), with India (28%) with the United States though producing significant crops coming a distant 20th position. Egypt, Turkey, and Japan round out the top five producing nations. More than 4 million acres (16,000 km²) are devoted to the cultivation of eggplant in the world.

The average yield of eggplant in some developing countries may be considerably low compared to the value obtained in advanced economies. This low yield may be attributed to some limiting factors, prominent among which are climatic factors and occurrence of pest and diseases. Among the most serious diseases, which threaten the stability of yield, are anthracnose, bacterial wilt, *Verticillium* wilt and a complex of viruses. *Alternaria tenuissima* causing leaf spot and fruit rot on eggplant (*Solanum melongena*) had recently been reported in India (Raja *et al*, 2006).

A disease of eggplant (*Solanum melongena*) associated with a mycoplasma-like organism (MLO) has been found in the Federal District, Brazil (Boiteux *et al.*, 1994). Symptoms were characterized by teratological changes in the flowering structure, reduction and malformation of leaves, proliferation of lateral buds, and an overall plant stunting. Evidence for the association between MLO infection and disease symptoms was obtained through graft-transmission experiments and electron microscopy.

The importance of viruses attacking solanaceous crops of which eggplant is one, can be realized from the fact that, viral diseases are prominent and capable of inflicting serious losses in crop production. The most obvious symptoms of virus infected plants are usually those appearing on the foliage such as chlorosis, yellowing, mosaics, vein clearing resulting in reduced growth rate of the plant, stunting of the entire plant and dwarfing. These usually result in reduction in total yield and the length of lives of virus infected plants (Mattews, 1991). Severe losses have been reported in tomato infected singly or doubly with Potato virus X (PVX, genus Potexvirus) and tomato mosaic virus (ToMV, genus Tobamovirus) (Balogun, 2003; Balogun *et al.* 2005). CMV is also capable of inflicting serious losses in some tomato cultivars (Balogun and Daudu, 2007).

There is growing importance of eggplants in the economy of the rural farmers in Nigeria who increasingly grow them under some form of irrigation or the other, especially during the dry season, when water supply could be especially limiting. In many areas there is scarcely sufficient water for domestic use let alone for agricultural production today. In view also of the fact that no resistance against CMV is yet to be reported in eggplant in this clime, study of the disease problems of the crop especially under the different cropping systems becomes justified. This study therefore was carried out not only to evaluate the pathogenic effect of cucumber mosaic virus (CMV) on egg plant but to also evaluate the effect of age of eggplant at infection and the effect of watering regime on the performance of infected plants.

Materials and Methods

Sourcing of seeds and propagation of eggplant seedlings and watering regime

The seeds of cv black beauty eggplant (*Solanum melongena*) used in the experiments were collected from the National Institute of Horticultural Research (NIHORT) Ibadan, Nigeria. The seeds were pre - soaked in warm water (50°C) for about 1hr and later left in the cool water overnight. The seeds were air-dried before sowing directly in 2.5 litre plastic buckets filled with steam-sterilized sandy loam soil augmented with 5g NPK 15:15:15 fertilizer per liter soil at seeding.

The pots were arranged in the screenhouse (to prevent insect attack) under ambient tropical temperature, lighting and humidity regimes between the months of January and June 2006. Watering followed a regime such that some plants received 500 ml water once, twice or thrice a week.

Sourcing and preparation of inoculum and inoculation procedure

The inoculum used was obtained from the stock of the Plant Pathology laboratory at the International Institute of Tropical Agricultural (IITA), Ibadan, Nigeria. Infected leaf sample was macerated in phosphate buffer (pH 7.2) at the rate of 1g/5 ml of buffer in pre-cooled mortar and pestle. The homogenate was applied immediately on the two lower leaves of the plants that had been previously sprinkled with carborundum using cotton wool. Inoculated plants were rinsed thereafter with water. Plants that were

mock-inoculated with buffer only served as control. Plants were inoculated following a regime such that sets of plants were mock- or viral inoculated at 1 week after germination, 2 weeks after germination or three weeks after germination respectively.

Data collection and analysis

Data were collected at the time of inoculation as well as on weekly basis thereafter on plant height, number of leaves per plant and stem girth. The number of days to flowering, including the number of flowers and yield parameters such as shoot and root weights, number of fruits and weights were recorded.

Data were collected from two separate but simultaneous experiments and the data were pooled together. In each case, the treatment design was a factorial fitted into a completely randomized experimental design (CRD). All collected data were statistically subjected to analysis of variance having regard for the factorial nature of the treatment design. Where significant differences existed, treatment means were partitioned using the new Duncan's multiple range test at $P \leq 0.05$.

Results

Symptom manifestation

The early symptoms manifested by viral inoculated eggplant (*Solanum melongena*) included mild mosaic, which became more pronounced with age. Regardless of the watering regime general stunting of the plant was more pronounced in viral inoculated plants than in mock- inoculated plants (Plate 1A).

Generally, the extent of the symptoms manifested depended on the age of plants at inoculation. Plants inoculated at 1 week after germination manifested mosaic symptoms earliest (about 9 days after inoculation) and had the most severe disease symptom while those inoculated at 21 days after germination manifested mosaic symptoms relatively late (about 16 days after germination). The severity of symptoms in those plants was generally less than in other categories of inoculation regime (Plate 1B).

Watering frequency had effect on the symptom manifestation. Plants that received extremes of water frequency i.e. 500ml once a week and 500ml thrice a week had more severe symptoms than those plants that received 500ml of water twice a week (Plate 1C). All mock inoculated control plants were free of mosaic but those that received low dosage of water were more stunted than other categories of plants. The comparative appearance of mock inoculated plants under different watering regime is shown in Plate 1D.

The main effect of inoculation, watering frequency and age of plant at inoculation on growth parameters as at 12 weeks after planting are as shown (Table 1). Viral inoculated plants generally had shorter plants than mock inoculated ones while plants that were inoculated at 1 week after germination generally had shorter heights than plants inoculated at 2 weeks and 3 weeks after germination respectively.

Critical evaluation of the general effect of watering frequency showed that significant differences exist between plants watered once a week, twice a week and thrice a week. Those watered twice a week had taller plants compared to those watered thrice a week, and they were both taller than those watered once a week.

The same trend as was observed for plant height was recorded for number of leaves, number of branches and leaf size. Viral inoculated plants generally had lesser values than mock inoculated ones while those with watering frequency of two times a week were better than those of other watering regimes.

Effect on yield parameters

Table 2 shows the main effect of water frequency, inoculation type and seedling age at inoculation on the number of flowers, number of fruits, average weight of fruit, total weight of fruit and percentage fruit set at harvest. As with growth parameters, analysis of variance shows that the yield parameters in mock inoculated plants significantly differed from those in viral inoculated ones with mock inoculated plants having higher values compared to the viral inoculated ones. In the same vein, watering frequency and seedling age at inoculation had significant effect on most yield parameters.

Effect on plant growth

Plate 1: Comparative growth response demonstrating the respective effects of viral inoculation, age of seedling at inoculation and watering frequency in viral inoculated and control *Solanum melongena* plants at 7 weeks after final inoculation regime with cucumber mosaic virus.

A: Plants were inoculated at 1 week after germination and watered Once weekly with 300ml water. Left Plants were mock –inoculated; Right Plants were Viral inoculated.

B: From Left: Plants were viral inoculated at 3 wks after germination; 2 wks after germination; and 1 wk after germination with CMV respectively..

All plants were watered once in a week.

C: All Plants were viral inoculated at 1 week after germination.

From Left: Plants were watered Once; Twice; and Thrice weekly with 300ml water respectively.

D: Plants were mock inoculated at 1 week after germination.

From Left: Plants were Watered Once; Twice; and thrice weekly with 300ml water respectively

Table 1: Main Effect of inoculation type, water frequency and age of plant at inoculation on some plant growth parameters.

Inoculation type	Final height of plant (cm)	Final No. of leaves at 12 wk a i	Mean area of a leaf at 12wai (cm^2)	Final mean number of branches
Mock	39.1a	16.5a	25.3a	3.9a
Viral (CMV)	30.6b	12.7b	19.3b	2.5b
SEM	0.112	0.101	0.161	0.107
Age at inoculation				
1 wag	34.0b	13.8b	20.4b	3.1
2 wag	39.6a	16.7a	22.7a	3.0
3 wag	37.0a	16.6a	21.2a	2.8
SEM	0.137	0.124	0.198	0.132
				NS
Watering frequency per week				
Once	32.8c	15.3c	18.5c	2.5b
Twice	40.4a	18.0a	23.0a	3.9a
Thrice	37.9b	16.3b	20.8b	2.7b
SEM	0.137	0.124	0.198	0.132

Wag: Week after germination
WAI: week after inoculation
Means followed by the same letter in a section of a given column are not significantly different at P< 0.05 using the new Duncan's multiple range test.

Table 2: Main Effect of inoculation type, water frequency and age of plant at inoculation on some yield parameters in *Solanum melongena.*

Inoculation Type	**Final number of flowers**	**Number of fruits**	**Average weight of fruit (g)**	**Total weight of fruit (g)**	**Percentage fruit set**
mock	16.5a	4.4a	18.5a	80.6a	41.7a
viral (CMV)	12.6b	3.8b	15.7b	60.5b	30.6b
SEM	0.81	0.120	0.365	1.412	1.087
Age at Inoculation					
1 wag	11.5b	3.7b	17.8b	66.3b	32.3b
2 wag	11.6b	4.0b	15.9b	64.7b	35.3b
3 wag	11.4a	4.6a	17.6a	80.6a	40.8a
SEM	0.099	0.147	0.447	1.730	1.332
Watering frequency per week					
Once	11.5a	3.6b	13.7c	49.2c	31.8b
Twice	11.6a	4.8a	19.5a	90.8a	41.6a
Thrice	11.5a	4.0b	18.2b	71.6b	35.0b
SEM	0.099	0.147	0.447	1.730	1.332

Wag: Week after germination
WAI: week after inoculation
Means followed by the same letter in a section of a given column are not significantly different at P< 0.05 using the new Duncan's multiple range test.

Late infection as well as watering with 500 ml water twice a week resulted in higher yield values than other treatments. Plate 2 shows fruiting in mock inoculated plants watered twice a week and lack of it in a plant inoculated a week after planting and watered only once weekly.

Plate 2: Effect of treatment variation on fruit yield in egg plant with and without viral infection.
Left: Plants inoculated with CMV at 1 wk after germination and watered once weekly with 500 ml water (Not fruiting yet).
Right: Plants mock-inoculated at 1 wk after germination and watered twice weekly (Fruiting).

Discussion

The results of this study have shown that the egg plant variety cv black beauty used in this experiment was susceptible to infection by cucumber mosaic virus. The most common and conspicuous symptom infection on the plant foliage was yellow mosaic and leaf distortion and reduced leaf size. The rate of flower abortion was also higher in viral inoculated plants thus leading to poor yield (Compare plates 1A and 2). Similar observation had been made (Balogun and Daudu, 2007) on tomato plants infected by CMV. Symptoms of viruses, which include those appearing on the foliage such as chlorosis, yellowing, mosaics and vein clearing usually result in reduced growth rate of the plant, stunting of the entire plant and dwarfing. These usually result in reduction in total yield and the length of lives of virus infected plants (Mattews, 1991; Agrios, 2005).

Excessive watering of eggplants as well as under watering, as seen in this study resulted in poor growth of viral inoculated plants. Poorly drained soils has been said to result in slow plant growth, reduced root systems and low yields. According to Peet (2003) a well drained sandy loam of pH 5.5 to 6.5 with high organic matter content is ideal for growing eggplant.

Considering the effect of age of plant at infection on plant response, it is observed that plants inoculated earliest (1 wk after germination) were more susceptible to infection than those inoculated lately (2weeks and 3 weeks after germination), regardless of the watering frequencies. This suggests that avoiding infection during the nursery period before subsequent transplanting to the field may considerably mitigate disease effect. Furthermore, considering the fact that moderate watering led to improved tolerance even in plants that were infected at an early age, while extremes of moisture aggravated the pathogenic response, it

is also advisable for growers to avoid drought and over flooding conditions so as to ensure some measure of good growth and yield even in virus infected eggplants.

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