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EFFECT OF ORGANIC MANURE APPLICATION ON YIELD DISTRIBUTION OVER TIME AND IN TRUSS POSITION ON THE MAIN STEM IN EGGPLANTS

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ABSTRACT

Temporal distribution of yield over harvests and yield in various truss positions on the main stem in three West African eggplants were studied in the field under five poultry manure rates.

Fruit yields were spread over 12-15 weeks, unless where the life of the crop was cut short due to insect pest or disease attack. Two peaks, the first major and a second minor one, were evident in the temporal fruit yield distribution, apparently arising from inherent flowering and fruiting periodicities of the eggplants and influenced by weather factors, especially rainfall. Multiple harvests were necessary as fruits were always at different stages of development, reaching maturity at different times. On the basis of time to first harvest, Marvelum was classified as early maturing, Roundgreen intermediate and Sweet Samaru late maturing.

Flower abortion was generally high and increased with higher truss positions. Fruit set was higher with the lower trusses and decreased with higher truss positions. Although manuring benefited yields generally, it did not help much in enhancing assimilate distribution among truss positions or in stabilizing fruit yield values during different harvest periods.

INTRODUCTION

The start and time span of fruit-set and its harvest in West African eggplant may vary depending on the variety grown. In the eggplant, as the green-mature fruits are harvested, there is usually more fruit induction as has been demonstrated for okra (Asiegbu, 1987). This necessitates many fruit harvests in the life of the crop. However, the extent of continued production of harvestable fruits will depend on the variety and environmental conditions of plant growth such as nutrient supply and climatological factors, especially rainfall, under rain-fed conditions. Continued photosynthate formation and existence of a strong fruit sink capacity are essential.

In two of the experiments being reported in this paper, it was aimed to study temporal yield distribution of fruit yield by recording fruit yields at different times of harvest. In another experiment, flower and fruit induction and harvestable yields at different trusses on the main stem were studied to help account for yield distribution in truss positions. It was also hypothesized that a good manuring programme could help stabilize yield at different periods of harvest or at different truss positions on the main stem. It was felt that the results could aid in programming such agronomic management practices as manuring and harvesting to gain yield advantage.

MATERIALS AND METHODS

Three field experiments were conducted at Nsukka, Nigeria, in a derived savanna located at latitude 06° 52'N and longitude 07° 24' E, and at 447 m above sea level. The soil is a highly leached sandy clay loam tropical ultisol of the Nkpologwu series. According to the criteria for soil fertility classification by Ibedu *et al* (1988), the soil was acidic at the soil pH of 4.9 (water), and low in soil fertility at 0.07% total N, 15.0 ppm, 0.03 and 0.15 exchangeable K and Mg (meq/100 g soil), respectively.

Experiment 1: Treatment comprised five poultry manure rates – 0, 5, 10, 15, and 20 t ha^{-1}, laid out in a randomized complete block design, and there were eight replications. Only one eggplant genotype, *Solanum incanum* cv. Marvelum was used. The

Table 1. Weather records for the site of the experiments.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990												
Total rainfall (mm)	4.6	0.0	3.0	173.3	96.6	206.4	264.8	185.5	235.6	210.6	6.1	36.1
Total radiation (cal/cm^{-2}/day^{-1})	918.2	930.8	962.1	868.3	818.7	745.7	560.7	544.2	676.2	760.9	849.0	746.9
Mean soil temperature (°C)	29.2	30.4	32.6	31.0	29.7	28.2	26.4	25.8	26.8	27.6	29.2	28.6
Wind speed (km hr^{-1})	124.0	151.9	163.3	167.6	124.2	93.0	80.9	72.3	57.5	53.9	50.7	65.9
1991												
Total rainfall (mm)	0.0	45.0	168.2	164.7	341.9	196.0	321.4	345.6	200.6	227.0	9.9	0.0
Total radiation (cal/cm^{-2}/day^{-1})	949.9	849.4	919.9	811.8	843.1	717.7	574.8	481.3	633.8	669.6	926.2	1018.1
Mean soil temperature (°C)	28.1	31.3	30.4	29.6	28.3	27.8	26.4	25.7	26.5	26.4	28.9	28.2
Wind speed (km hr^{-1})	56.5	109.5	119.4	75.1	50.2	51.5	36.5	35.4	27.7	20.9	22.3	64.8

plots measured 3.6 m x 12.0 m each. On June 1990, five-and-half-week old seedlings were transplanted into the field plots, in which the appropriate manure treatments had been incorporated, at a spacing of 60 cm x 45 cm. Temporal distribution of fruit yield was studied by recording yield at different harvest dates. Table mature fruits, which were judged about fully grown and with no ripening colour changes, were harvested from the middle row plants at one weekly interval.

Experiment 2: All possible combinations of three eggplant genotypes and five manure rates were laid out in field plots in a randomized complete block design, and there were three replications. The eggplant genotypes were *Solanum gilo* cv. Roundgreen (medium sized fruits), *Solanum incanum* cv. Marvelum (big fruited) and *Solanum gilo* cv. Sweet Samaru (small sized fruits), while the five manuring regimes were 0, 5, 10, 15, and 20 t ha^{-1} of poultry manure. Each plot measured 1.8 x 3.6 m. The requisite poultry manure rates were applied broadcast and worked into the appropriate plots one week before the seedlings were transplanted into the field plots on July 15, 1990 at a spacing of 0.6 x 0.45 m. Hoe weeding was done twice while insect pest control was by spraying with Vetox 85 (carbaryl 85%) dissolved in water at the rate of 32g per 8 litres of water at anthesis. Fruit harvests commenced at first table maturity and subsequently at one weekly interval. At each harvest, those fruits judged to be fully developed, and in any case likely to be over-mature in the following harvest, were harvested from the middle row plants.

Experiment 3: The manure and eggplant treatments and the experimental layout were as in experiment 2. However, each plot measured 4 m x 3.8 m. Five-week old seedlings were transplanted into the field one week after manuring on March 14, 1991. Other cultural operations carried out included weeding three times and insect pest control by spraying with Nuvan 1000 EC at the rate of 5 ml per litre of water. Temporal yield distribution was studied as in experiment 2. In addition, truss studies on two of the eggplant genotypes, viz.; Roundgreen and Marvelum, were conducted. Four plants were randomly selected per plot and in each plant, the first six consecutive trusses on the main stem were tagged and numbered 1, 2, 3, 4, 5 and 6 from the ground towards the stem apex. They were used for records on number of flowers per truss, flower abortion, fruit-set per truss and fruit yield per truss.

All statistical analyses were according to the procedure for a randomized complete block design as outlined by Gomez and Gomez (1986).

RESULTS

The meteorological data for the period of the experiment are summarized in Table 1. While rainfall was late in coming and stabilizing in 1990, it was early in 1991. The bimodal peaks of rainfall characteristic of the area were evident in July and September for 1990 and in July and October for 1991. Radiation and soil temperatures were lowest during the period from June to September, evidently coinciding with periods of high and more frequent rainfall.

Temporal Yield Distribution in Eggplant Genotypes

Temporal yield distribution data from experiment 2 showed that the first harvestable yields were obtained from Marvelum, Roundgreen and Sweet Samaru at 82, 95 and 103 days after planting (DAP), respectively, indicating that Marvelum was very early maturing (Table 2). For each genotype, yield was low initially and increased subsequently, reaching a peak in the third or fourth harvest from the time of the first harvestable yield of the individual genotype. In the 4th and 5th harvest dates, Roundgreen gave the highest yield followed by Marvelum in the 4th harvest date only, while during the 6th to 8th harvest dates, Sweet Samaru yielded highest followed by Roundgreen. There was generally an alternation of low yield followed by higher yield with consecutive harvests, evidently from a flush of fruits that did not mature in the previous harvest reaching maturity at the following harvest.

From the 9th to 11th harvest date, yields were depressed in all the genotypes and there were no significant differences among genotypes. Subsequently, yields picked up again in all the genotypes and finally dropped at the 14th and 15th harvests. Generally, overall yield was similar for Sweet Samaru and Roundgreen and lower for Marvelum.

Although harvesting was initially delayed in the third experiment, Marvelum had significantly the highest yield in the first and second harvest dates, still

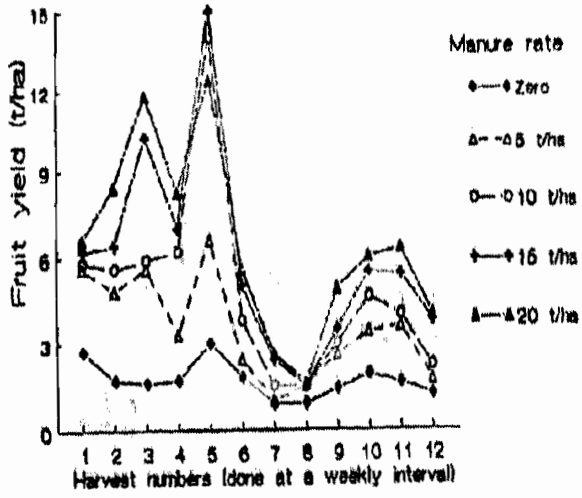

Fig 1. Temporal yield distribution (mean of 3 eggplant genotypes) as influenced by manure rates (experiment 1).

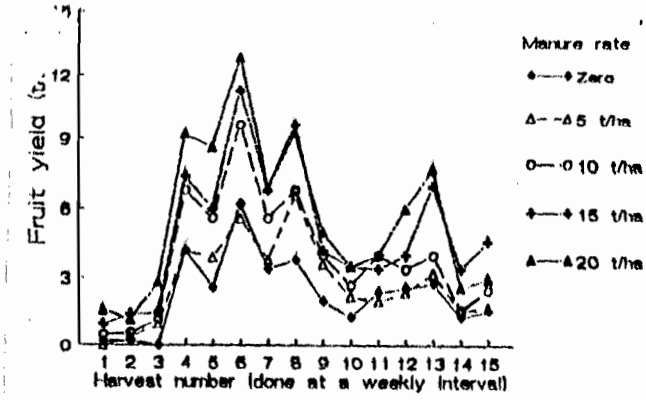

Fig 2. Temporal yield distribution (mean of 3 eggplant genotypes) as influenced by manure application (experiment 2).

Table 2: Fruit yield (t ha^{-1})[1] at different harvest dates in three eggplant genotypes.

		Eggplant genotype			
Harv. Date (DAP)[2]	Harv. No.	Roundgreen	Marvelum	Sweet Samaru	$LSD_{0.05}$
Experiment 2					
7/9/90 (82)	1	0.0	1.7	0.0	0.8
14/9/90 (89)	2	0.0	2.1	0.0	0.4
20/9/90 (95)	3	0.9	2.7	0.0	1.1
27/9/90 (102)	4	8.4	7.6	3.5	2.3
3/10/90 (108)	5	6.6	4.5	4.9	1.4
12/10/90 (116)	6	10.4	6.0	11.0	2.1
18/10/90 (122)	7	5.6	2.3	7.9	1.3
27/10/90 (131)	8	6.1	4.9	10.6	2.2
3/11/90 (139)	9	4.1	3.3	3.6	N.S
10/11/90 (146)	10	2.9	2.7	2.0	N.S
17/11/90 (153)	11	3.6	2.6	3.4	N.S
23/11/90 (159)	12	4.8	2.4	4.0	1.5
2/12/90(168)	13	4.5	3.7	6.5	1.8
8/12/90 (174)	14	1.5	1.7	3.1	1.1
21/12/90 (137)	15	2.0	2.3	3.7	1.2
	Total	61.4	50.5	64.2	6.7
Experiment 3					
2/5/91 (83)	1	1.4	4.0	0.3	0.6
8/5/91 (89)	2	2.9	4.9	1.8	0.7
15/5/91 (96)	3	5.7	5.0	3.9	0.7
22/5/91 (103)	4	4.5	3.2	4.7	0.3
29/5/91 (110)	5	2.1	1.2	3.1	N.S
6/6/91 (118)	6	0.7	0.4	1.0	0.3
12/6/91 (124)	7	0.1	0.1	0.3	0.1
	Total	17.4	18.8	15.1	2.6

[1]Data are mean of five manure rates.
[2]DAP = Days after planting; 5-week old seedlings were transplanted on July 15 in 1990, and on March 14 in 1991

Table 3 Flower and fruit inductions in truss positions on the main stem in two eggplant genotypes (experiment 3.)

Eggplant genotype	Truss position on the main stem[1]						
	1	2	3	4	5	6	Mean
Number of flowers per truss							
Roundgreen	6.3	6.4	5.6	5.3	5.1	4.9	5.6
Marvelum	1.4	1.7	2.0	1.5	1.7	1.4	1.6
Mean	3.8	4.0	3.8	3.4	3.4	3.1	3.8
Number of fruits set per truss							
Roundgreen	3.2	2.7	1.9	1.3	0.6	0.2	1.6
Marvelum	1.2	1.2	1.2	0.6	0.3	0.2	0.8
Mean	2.2	2.0	1.5	0.9	0.5	0.2	1.2
Percentage flower abortion							
Roundgreen	49.9	57.5	66.4	75.4	88.8	96.8	72.5
Marvelum	10.3	24.4	36.6	59.3	78.9	87.3	49.6
Mean	30.1	40.9	51.5	67.4	83.9	92.3	61.0
Yield per truss (g)							
Roundgreen	121.1	83.8	50.8	28.1	12.3	2.7	49.8
Marvelum	104.7	75.1	61.4	23.4	8.1	4.0	46.1
Mean	112.9	79.4	56.1	25.7	10.2	3.4	48.0

	Flower/ Truss	Fruits/ truss	Flower abortion	Fruit yld/truss
$LSD_{0.05}$ for 2 position (T) means	0.3	0.1	6.0	8.2
$LSD_{0.05}$ for 2 genotype (V) means	0.2	0.1	3.5	N.S
$LSD_{0.05}$ for2 T x V means	0.5	0.2	8.6	11.7

[1]Truss position is numbered from the stem base to the apex

showing evidence of its earliness in fruit induction compared with others. During the third harvest, Roundgreen followed by Marvelum gave significantly the highest yield; in the 4th, yield was significantly lowest in Marvelum while in the 5th yield was significantly highest in Sweet Samaru and lowest in Marvelum. During the 5th, 6th and 7th harvests yields were particularly depressed in all the genotypes. The experiment was then terminated essentially because of the insect pest and disease incidents. The plants were infested by the leaf-hopper, *Zonocerus variegatus*, and some other sap-sucking insects which brought with them virus infection.

Initially, yields were low especially where manure was not applied (Figs. 1 and 2). Subsequently, higher manure rates (15 and 20 t ha-1) gave higher yields than the lower manure rate of zero or 5 t ha-1, until the 7th and 8th (experiment 1) and 10th and 11th (experiment 2) harvest dates when yields were lowest. The characteristic peaks in yield were evident, irrespective of the manuring treatment, and there could be identified the first major peak at the 5th (expt.1) or 6th (expt. 2) harvest date and the second peak, after the low values at the 11th or 13th harvest for experiment 1 or 2. Rainfall (Table 1) was adequate in the first modal phase but seemed inadequate in the second.

The temporal yield distribution trends with varying manure rates for experiment 3 were essentially similar as for experiments 1 and 2 and, therefore, the figure has not been presented.

Flower and Fruit Induction at Different Trusses

On average, Marvelum had only 1-2 flowers per truss compared to an average of 5.6 for Roundgreen (Table 3). The number of flowers produced and fruit set per truss decreased with higher positions on the main stem, being significantly lower at the 4th-5th truss positions compared to the case at the 1st to the 3rd truss position. The percentage of flowers that aborted, on the other hand, increased with higher truss positions, being about 30% in the 1st truss compared to about 92% in the 6th truss on average. Fruit yield (g) was significantly highest with the 1st truss, while yields were particularly low with the 4th-6th truss positions, irrespective of the eggplant genotype.

Higher number of flowers and fruits tended to be produced when poultry manure was applied, especially at higher rates than when not (Table 4). The number of flowers produced per truss was significantly lower with zero manure rate at the 6th truss compared with the 1st, while the number of fruits produced per truss decreased with higher truss positions, irrespective of the manure rate. The influence of high poultry manure rates on flower abortion in each truss position did not show any remarkable trend, although it appeared to ameliorate abortion at the 6th truss position. However, no matter the manure rate used, fruit yields were low as from the 4th truss and above.

DISCUSSION

On the basis of the time to first harvest, Marvelum would be classified as early maturing, Roundgreen as intermediate and Sweet Samaru as late maturing. Singh *et al* (1985) also identified early maturing cultivars of *S. melongena* in terms of time of first harvest.

The bimodal peaks in the pattern of temporal yield distribution of the eggplants could be attributed to two flowering and fruiting periodicities whereby the first major flush of flowers, evidently supported by adequate soil moisture and early availability of soil nutrients, produced the greater bulk of the total yields. During the second minor flush or modal phase, rainfall was inadequate (November to December, Table 1) while soil nutrients will also have been depleted from leaching that must have occurred through the major rainy season. Davy and Taylor (1974) recognized a striking seasonal pattern in soil N mineralisation, while Asiegbu (1985) attributed poor performance of late planted crops, in part, to loss in soil fertility from leaching caused by earlier rains. Timely fertilization and supplementary irrigation during this second flush of flowering will undoubtedly benefit yields.

Fruit yield in a truss is dependent on the number of flowers produced, the proportion of the flowers produced which set fruit and on weight per fruit in the truss. The lower trusses, 1-3, which were produced earlier, had more flowers and bore more fruits, and eventually gave higher fruit yields (weight basis) than the upper, 4 – 6, trusses. For example, the 2nd truss gave about twice the yield by the 4th, 5th and 6th trusses put together. Adcock and Lawes (1976) had similarly reported that *Vicia faba* L. produced

Table 4 Influence of poultry manure rates on flower and fruit induction at different truss positions on the main stem of two eggplants (experiment 3).

	Truss position on the main stem[1]						
Manure rate (t ha^{-1})	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**
Number of flowers per truss							
0	3.8	3.5	3.5	3.1	3.5	2.3	3.4
5	3.5	4.5	4.0	3.6	3.3	3.0	3.7
10	4.0	3.9	3.7	3.5	3.5	3.4	3.7
15	3.8	4.1	3.8	3.3	3.0	3.0	3.5
20	4.0	4.2	4.1	3.7	3.7	3.4	3.8
Mean	3.8	4.0	3.8	3.4	3.4	3.1	3.6
Number of fruits per truss							
0	1.8	1.6	1.3	1.0	0.4	0.4	1.0
5	2.3	2.0	1.0	0.8	0.5	0.1	1.1
10	2.3	2.1	1.8	1.1	0.5	0.2	1.3
15	2.3	2.2	1.7	0.9	0.3	0.2	1.3
20	2.2	1.9	1.7	1.0	0.6	0.4	1.3
Mean	2.2	2.0	1.5	0.9	0.5	0.2	1.2
Percentage flower abortion (%)							
0	31.4	43.2	55.0	63.4	85.1	96.7	62.5
5	24.4	47.2	66.1	74.4	80.8	94.7	64.4
10	30.7	31.5	46.3	64.1	84.1	91.0	58.0
15	30.5	37.0	39.2	63.2	86.9	90.8	57.9
20	33.4	45.7	50.8	71.7	82.5	88.1	62.0
Mean	30.1	40.9	51.5	67.4	83.9	92.3	61.0
Fruit yield (g) per truss							
0	74.6	50.3	40.0	21.6	6.9	0.5	32.3
5	114.0	76.6	47.8	28.4	12.3	2.8	47.0
10	136.0	92.7	72.8	25.7	11.8	2.0	56.8
15	118.1	80.7	55.0	27.1	8.6	4.3	49.0
20	121.6	96.8	65.1	25.9	11.5	7.2	54.7
Mean	112.9	79.4	56.1	25.7	10.2	3.4	48.0

	Flower/ Truss	**Fruits/ truss**	**Flower/ abortion**	**Fruit yid/truss**
$LSD_{0.05}$ for 2manure (M) means	0.3	0.1	5.5	7.52
$LSD_{0.05}$ for 2 position (T) means	0.3	0.1	6.0	8.2
$LSD_{0.05}$ for 2 M x T means	0.8	0.3	13.5	18.4

[1]Truss position is numbered from the stem base to the apex

a larger proportion of the seed yields in the lower nodes. Evidently, the earlier formed fruit-sinks in the lower eggplant trusses were preferentially supplied with assimilates than the upper ones. Fisher (1969) obtained large fruit size (by weight) in the first tomato truss with a progressive decrease in size with the upper trusses, and attributed that to diversion of increased amount of carbohydrates to the earlier trusses at the expense of later trusses. Presumably, with less assimilates to support and supply new fruit sinks, increased flower abortion became more in the higher trusses which apparently had reduced sink strength. Fisher (1977) also recognized competition effects amongst tomato fruit trusses and noted that a lack of sink strength reduced fruit yields, while assimilate partitioning among different fruit sinks were known to be determined by the strength of the different sinks (Stenvers and Staden, 1976; Walker and Ho, 1977).

In the present experiment, high manure rates did not help considerably to effect even distribution of assimilates among the truss positions. Improvements can be achieved through progressive and timely harvests of the table-mature older fruits, as demonstrated for okra (Asiegbu, 1987) where successive harvests resulted in continued production of more harvestable pods. One weekly interval of harvest seemed satisfactory in the present case of West African eggplants. Multiple harvests are undoubtedly necessary, as yields were spread over 12-15 harvests or over 12-15 weeks, and since the fruits in a plant were always at different stages of maturity.

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