Agricultural Journal 2 (1): 55-59, 2007

Intercropping Citrus Rootstock Seedlings with Watermelon in the Nursery

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Abstract: The benefit of intercropping in the nursery is yet to receive the necessary research attention. Three experiments were conducted to determine the effect of intercropping watermelon at various spacings with citrus rootstock seedlings in the nursery. The yields of watermelon grown in mixture with the citrus seedlings, where significantly different. Watermelon suppressed the growth of weeds under all the cropping systems involving watermelon and the development of the companion citrus seedlings at very narrow spacing of 1×0.5 m and 1×1 m. The girth of citrus rootstock grown in such narrow spacings, were reduced significantly by about 24%. The intercrop of watermelon at 2 m×1 m consistently produced the best yields in the three trials, followed by 2×2 m and was followed by 4×2 m. Generally, these spacings did not affect the growth of the companion citrus seedlings. The study showed that intercrop at the spacings of 2×1, 2×2 and 4×2 m are beneficial and tolerable range of growing watermelon in association with citrus rootstock seedlings before budding.

Key words: Watermelon, intercropping, citrus seedlings, rootstock

INTRODUCTION

In Nigeria, there is a renewed awareness of the importance of fruits in up-grading the nutrition of the greater people that feed mainly on starchy food. As a result, the production of citrus seedlings is intensified to meet the national target of fruit production. Consequently, many citrus nursery farms are springing up to complement the efforts of government agencies, such as National Horticultural Research Institute. However, the present sole cropping system of raising citrus seedlings in the nursery before field transplanting takes about 18 months. This is a fairly long period and as a result would-be nurserymen will not afford to tie up their land to one crop. Under such conditions the soil is exposed to the hazards of erosion and fast regeneration of weeds. To forestall these agronomic setbacks, the cropping systems of the humid tropics are usually characterized by the use of cover crops or livemulch such as melons and legumes. *Citrullus lanatus* (watermelon) belongs to the family, *Curcurbitaceae*. The sweet juicy pulp of the mature watermelon fruit is eaten fresh. It is a valuable alternative to drinking water in the desert area and during dry seasons of wetter areas[1]. Rehm and Espig[2] reported that watermelon is of great economic importance, even as export fruit and that 100 g of fresh watermelon fruit contained 100 kj Energy, 93 g Water, 0.5 g Crude Protein, 6 g Carbohydrate, 0.1 g Fat, 0.2 Crude Fibre, 6 mg Ca, 9 mg P, 0.2 mg Fe as well as a wide range of vitamins. Although, the primary objective of growing economic livemulch, may be to earn extra income or get varieties of food, to meet family requirements, the carpets of vegetative material formed by the livemulch, enable the protection of the soil from erosion and control weeds reasonably[3-6]. Biological weed control in crop production includes the use of low-growing crops such as melons, to protect the soil from erosion and to smoother weeds[7]. Weed control using water-melon in tomato plot[8] seed melon (egusi-melon) in maize plot[9], seed melon in okra plot[10], cowpea in maize plot and *Psophocarpus palustris* in maize[11] have been grown successfully. Also, seed melon grown with pepper or okra as livemulch at various densities of sowing, were found to be compatible and beneficial[12,13]. A lot more benefits than the foregoing do accrue to the farmer when crops grown together are compatible. For example, Pino and Labrada (2000) reported that the yields of tomato produced under the maize shade increased by 5-6t ha^{-1} with better fruit quality in comparism with tomato grown in monoculture. These advantages were attributed to modifications in the environment, such as reduction in radiation intensity of about 25% and the reduction of white fly by 24%. The

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objective of this study is to assess the compatibility of various densities of growing watermelon in established citrus rootstock seedlings nursery.

MATERIALS AND METHODS

The study involved three trials which were carried out at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria (7° 24N, 3° 48E). The physico-chemical properties of the soil at the experimental site were as follows; pH, 7.5; Organic matter, 0.73%; Total N, 0.06%; and Available P, 7.84 (ppm). The exchangeable cations (mg 100 kg^{-1} soil) were as follows: Ca, 541; Mg, 112; Na, 66.7 and K, 82. The sand, silt and clay fractions were 89.8, 5.4 and 4.8%, respectively. The three trials were conducted during the dry seasons, each time on newly established citrus nursery. On each occasion, six-month old citrus seedling rootstocks (*Cleopatra mandarin*) were transplanted to a field nursery at a standard spacing of 40×30 cm. The treatments involved cropping patterns of citrus seedlings or watermelon in pure stands and their combinations with watermelon, having a varying range of spacings, commonly used under tropical production systems. The treatments were replicated four times in a randomized complete block design. Each plot measured 10×5 m. The 1st and 2nd trials had similar treatments while the 3rd trial had more enteries of watermelon at closer spacings of cropping (1×0.5 m and 1×1 m). In all the experiments, the watermelon treatment were superimposed on the established citrus rootstock seedlings, a week after transplanting the citrus seedlings into the field. The seed of watermelon variety used was Sugar-baby. At planting, four seeds of watermelon per stand were sown and later thinned to 2 plants per stand a week after seedling emergence. Each stand of watermelon received 40g of N.P.K. 15:15:15 at two weeks after seedling emergence. Fertilizer was applied to citrus seedling at 4 weeks after planting at the rate of 200 kgN, 100 kg P_2O_5, 100 kg K_2O ha^{-1}. There were two regimes of weeds management. The first was carried out using hoe at 2 weeks after watermelon seedling emergence and the second was by roguing when the melon vines had covered the ground reasonably. Insect pests were controlled with cypermetrine (Cymbush™) sprayed at the rate of 0.5 mL^{-1} per litre of water.

At the maturity of the component watermelon, the data taken of citrus seedlings were number of leaves, which were counted and plant height measured with meter ruler. The girth was measured with veneer callipers at 10 cm from the base of the plant while suppression was assessed with rating in the 3rd trial. Two representative quadrats measuring 2 m by 2 m were taken per plot to determine the yield and yield components of watermelon. Weed data were also taken using the quadrat method. Data analysis was by a two-way analysis of variance and means were separated with least significant difference (LSD) at p = 0.05.

RESULTS

Citrus seedling: This study showed that intercropping of watermelon and their densities of sowing did not affect the growth and development of citrus seedlings at higher spacing of watermelon with respect to number of leaves, plant height and plant girth in the first and second trials Table 1. However, when watermelon was grown at close spacings of 1×0.5 m and 1m and 1m in the third trial, it significantly suppressed the growth of the companion citrus crop. Specifically, the girth of citrus seedling grown under the two closest spacings of melon, were significantly reduced by 24%. Also the suppression rating of citrus under wider spacing of melon were low and compared to the value of the sole crop situation while those of the closest spacings were high Table 1.

Watermelon: The yield and yield components of watermelon intercropped with citrus seedlings or grown alone is shown in Table 2. In the first trial, the fruit of watermelon ranged between 1 and 2 fruits per m^2. Significant differences in number of fruit, fruit weight and fruit yield were observed in all the trials. Watermelon intercropped at 2 m×1 m and 2 m×2 m compared favourably and out-yielded watermelon intercropped at 4 m×2 m with respect to yield m^{-2}. In the 2nd trial, watermelon grown at the spacing of 2 m×1 m in mixture with citrus seedlings produced the highest number of fruits and however, the least fruit weight. Similar trend was observed in the 3rd trial where the closest spacings of watermelon produced the highest number of fruits with corresponding lower fruit weights. The reverse trend was true for watermelon grown at a spacing of 4×2m in companion with citrus seedlings in the 1st and 2nd trials. With regards to intercropping, watermelon grown with citrus at a spacing of 2×1 m consistently produced the highest yields and were closely followed by watermelon intercropped at 2×2 m. The least watermelon yields were obtained from watermelon grown at highest spacings of 4×2 m and least spacing of 1×1 m and 1×0.5 m Table 2. The yields of watermelon in the 3rd trial were generally low because of weed interference and the consequent damage of fruit by rodents.

Table 1: Growth and development of sole and intercropped citrus rootstock seedlings after watermelon harvest at 14 weeks after planting citrus

Cropping pattern	1st trial					2nd trial		3rd trial			
	No. of Leaves	Plant. ht.	Plant girth.	Plant. ht.	Plant girth.	No. of Leaves	No. of branches	Plant. ht.	Plant girth.	No. of leaves	Suppression rating?
Citrus alone	51	52	0.55	55	0.57	108	3	52	0.42	47	1
Citrus + Watermelon (2m×1m)	56	53	0.53	49	0.51	80	3	62	0.41	52	1.5
Citrus + Watermelon (2m×2m)	56	59	0.59	48	0.55	94	4	59	0.41	52	1
Citrus + Watermelon (4m×2m)	56	58	0.56	51	0.53	84	3	59	0.40	47	1
Citrus + Watermelon (1m×1m)								47	0.31	39	3
Citrus + Watermelon (1m×0.5m)								39	0.31	37	5
Mean	55	55	0.55	51	0.54	92	3	53	0.38	46	2.1
LSD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	*	*	*	*

? Suppression rating of 1 – 5 where 1 = No suppression of citrus seedlings and 5 = high suppression of citrus by melon NS and * = Means not significantly different and significantly different respectively

Table 2: Yield and yield components of watermelon grown alone and intercropped with citrus rootstock seedlings in the nursery at 13 weeks after sowing watermelon

Cropping pattern	1st trial			2nd trial			3rd trial		
	No of fruits No m^{-2}	Fruit wt kg	Fruit wt kg m^{-2}	No of fruits No m^{-2}	Fruit wt kg	Fruit wt kg m^{-2}	No of fruits No m^{-2}	Fruit wt kg	Fruit wt kg m^{-2}
Watermelon alone (2m×2m)	2	1.63	3.25	1.3	3.76	4.9	1.0	2.6	2.6
Citrus + Watermelon (2m×1m)	2	1.70	3.40	1.8	2.51	4.5	1.3	2.7	3.4
Citrus + Watermelon (2m×2m)	1	3.16	3.16	1.1	3.90	4.3	1.3	2.4	3.1
Citrus + Watermelon (4m×2m)	1	2.18	2.18	0.9	4.26	3.8	1.0	2.8	2.8
Citrus + Watermelon (1m×1m)							1.3	1.8	2.3
Citrus + Watermelon (1m×0.5m)							2.7	1.0	2.7
Mean	1.5	2.17	3.0	1.3	3.61	4.4	1.5	2.2	2.9
LSD (p = 0.05)	*	*	*	*	*	*	*	*	*

* = Means are significantly different

Table 3: Rating, spectrum and yield of weed at maturity of watermelon grown with citrus rootstock seedlings and their sole crops for the second trial at 14 weeks after sowing pattern

Cropping pattern	Weed rating+	Weed Spectrum?	Weed wt gm^{-2} Fresh	Dry
Citrus alone	4.9	7	2910	807
Watermelon alone (2m×2m)	2.5	4	565	178
Citrus + Watermelon (2m×1m)	2.1	4	365	97
Citrus + Watermelon (2m×2m)	2.7	5	472	144
Citrus + Watermelon (4m×2m)	4.1	5	967	335
Mean	3.2	5	1056	312
LSD (p = 0.05)	*	*	*	*

+ Weed rating of 1 – 5; 1 = low density of weeds; 5 = high density of weeds ? Weed spectrum indicates the number of dominant weeds in plot. * Means are significantly different

Weed interference: The range of weed on the experimental site included *Acalipha ciliata, Ageratum consizoides, Amaranthus spinosus, Euphorbia heterophylla* and *Tridax procumbens*. Others were *Panicum maximum, Bracharia lata, Oryza longisteminata* and *Maricus alternifolius*. Sole crop of citrus seedlings had significantly the highest weed spectrum and weed rating when compared to plot sown to melon Table 3. Similarly, fresh and dry weight of weed per unit area in sole crop of citrus more than doubled those plots intercropped with melon and plot which had closer spacing of melon (2×1 m) depressed weed significantly Table 3.

Table 4: Income, relative yields, land equivalent ratio (LER) of intercropping citrus rootstock and watermelon

Cropping pattern	Income[a] (N/m^2) of trials			Relative yields[b]			LER[c]		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Watermelon alone (2m×2m)	488	735	390	1	1	1	1	1	1
Citrus + Watermelon (2m×1m)	510	675	510	1.05	0.94	1.29	2.05	1.94	2.29
Citrus + Watermelon (2m×2m)	474	645	420	0.97	0.93	1.20	1.97	1.92	2.20
Citrus + Watermelon (4m×2m)	327	570	420	0.67	0.80	1.07	1.67	1.80	2.07
Citrus + Watermelon (1m×1m)			345			0.92			1.92
Citrus + Watermelon (1m×0.5m)			405			1.08			1.08

a. Price of watermelon is based on N150/kg (N130 = US$1) b. Relative yields are based on those of sole crops c. Land equivalent ratio assumes that the relative yields contributed by citrus is 1, if its growth was not suppressed by watermelon intercrop, otherwise it is scored zero

Economic returns and mixture productivity: The income/m^2 obtained as a result of intercropping watermelon with citrus seedlings followed the same trend of watermelon as described earlier for Table 2. The relative yields of melon component in the intercrop were higher than those of sole crop situation in the 1st and 3rd trials, while they were lower in 2nd trial Table 4.

DISCUSSION

This study has shown that watermelon grown at the wider spacings of 2×1, 2×2 and 4 m×2 m, which are the conventional or recommended spacing of growing melon, are compatible with citrus in intercrop, while closer spacings of 1×1 and 1 m×0.5 m are not compatible, because they suppressed the growth of citrus rootstock seedlings. This study has also shown that watermelon can control weeds to a reasonable level in citrus nursery. Similar observations have been made with other crops[10,12-14]. The ground cover created by watermelon deprives weeds of the much needed sunlight and therefore etiolates. Weed suppression and possibly soil moisture conservation, provided by creeping watermelon is desirable agronomic need for tropical environment. In all the studies, it is possible that additional returns obtained from watermelon can partly offset the running costs of raising citrus seedlings in the nursery. Such innovation can expand the area that can be used for raising citrus seedlings to meet national targets.

The major advantage derived from the intercrop is most probably due to the different architectures and growth patterns of the component crops. The citrus seedling is upright and less vigorous in growth, while the watermelon forms a carpet of vigorous vegetative growth. The latter imposes high growth requirement while the former is probably lower in growth requirement because of slow growth rate. This is therefore a complimentary combination. Another plausible reason for the successful intercrop may be due to limited competition for environmental growth resources. Competition for growth resources in intercrop is synonymous with competition of crop with weed. Such competition may either be for light, nutrient or water. Water was not limiting during the growing seasons because there was supplemental irrigation. Both crops derived their photosynthetic active radiation from different zones. The citrus seedlings have minimal shade. In this study, the only likely competition was for nutrient, since the roots of both crops grow very long to forage for nutrients, which again, were adequately applied.

Since watermelon gave a high economic return, the nursery stage of citrus seedling could fall within the dry season, if irrigation facility is available. Watermelon spaced at 1m×0.5m and 1m×1m significantly depressed the growth of the companion citrus crop even though they had potentials of controlling weeds effectively. Their depressive growth characteristic on citrus seedling does not recommend them for intercropping with citrus seedling at transplanting of the latter. It is probable that citrus may overcome this depressive effect when melon is sown long after the establishment of the citrus seedling. In that case, it may not be possible to complete the growth cycle of melon before the citrus are due for budding.

This study has shown that intercrop of watermelon at the spacings of 2×1, 2×2 and 4m×2m are economic and tolerable ranges of sowing watermelon when in association with citrus seedlings before buddable stage.

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