Canopy management in Valery and Grand Nain using leaf area index and photosynthetically active radiation measurements.

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CONDUITE DU COUVERT VEGETAL DE LA VALERY ET DE LA GRANDE NAINE A L'AIDE DE L'INDICE DE SURFACE FOLIAIRE ET DE MESURES DE RADIATIONS PHOTOSYNTHETIQUES ACTIVES.

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RESUME - Les densités de population recommandées (système conduit à un seul rejet successeur) en plantation permanente de bananiers doivent être basées sur des caractéristiques du couvert végétal comme l'indice de la surface foliaire (LAI) et la quantité de radiation photosynthétique (PAR) transmise à travers le feuillage. La PAR a été mesurée en Watts par mètre carré (W/m2) à partir d'un capteur d'énergie de type Licor LI - 191SB.
L'indice LAI a été variable suivant la variété, le type de sol et les conditions de croissance. La Grande Naine pour une même densité de population avait un LAI 20 p. 100 inférieur à celui de la Valery. Sur argile légère, Valery et Grande Naine avaient respectivement 15 et 23 p. 100 de feuillage en moins que sur sol plus lourd. Dans une zone très favorable à la Valery (régime de 43 kg, 15,5 feuilles par pied à la jetée) le LAI est de 5,1 pour une densité de 1700 plants/ha et de 6,1 pour une densité de 1900 plants/ha. Dans une zone moins favorable (régime de 37 kg, 12,5 feuilles à la jetée) le LAI est de 3,5 pour 1700 plants/ha et de 4,5 pour 2100 plants/ha. Dans la zone favorable, 2 à 3 p. 100 seulement de la PAR atteignent le sol alors qu'en conditions défavorables 20 p. 100 de la PAR arrivent au sol (1700 plants/ha) et 13 p. 100 (2100 plants/ha). En plein soleil (9 heures 30 à 12 heures) avec une PAR de 160 à 170 W/m2 au-dessous du feuillage, 14 à 18 p. 100 atteignent le sol en moyenne pour les plantations commerciales du Honduras.
Pour une même LAI, la proportion de PAR transmise au sol était plus élevée là où la population avait des pieds plus petits avec des feuilles plus petites et moins nombreuses que là où la population comprenait des pieds plus grands avec des feuilles plus grandes et plus nombreuses.

When conversion to Cavendish varieties began in Central America in the early 1960's plant spacing was about 2.9 meters apart in a hexagonal design giving populations of 1374 production units (mother plus one daughter) per ha. Later plantings were made at 2.74 meter spacings and 2.59 meters giving populations of 1534 and 1720 production units per ha, respectively. Present populations mostly range between 1500 and 2000 production units per ha depending on plant growth and size.

In the mid-1970's the shorter variety called 'Grand Nain' began to be planted and in some areas the taller varieties were replaced with Grand Nain because of the much fewer losses from strong winds. In general, Grand Nain was planted at the same spacing as the taller Cavendish varieties such as Valery. Following planting, populations tend to shift up and down over the years often reflecting different views of management as to the «optimum» population. However, plantations once established are permanent and there is no replanting at intervals as in the Caribbean and other areas.

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Previous studies (STOVER, 1981) showed the Grand Nain plant was much more compact than Valery occupying 35% less ground area and had 20% less foliage area. It was pointed out that in order to have the same leaf area index Grand Nain would have to be planted at a higher population than Valery.

Plant size, and hence leaf area index, vary not only between varieties but with soil type. In general, individual plant size and foliage are greater in loam than in light clay. Therefore, in order to have a uniform canopy that makes maximum utilization of radiation, populations have to vary with soil type. Two methods are available to measure canopy characteristics : leaf area index and radiation

transmission. Studies were carried out measuring the leaf area index and the amount of photosynthetically active radiation transmitted through the canopy of Valery and Grand Nain growing on different soils and at different populations.

METHODS

The leaf area index or LAI (square meters of foliage per square meter of plantation) was measured as previously described (STOVER, 1981). A Licor LI-191SB line quantum sensor was used to measure photosynthetically active radiation (PAR) transmitted through the canopy to the ground around recently shot plants. After various trials to determine variation and sample size, it was decided to take four measurements on the ground around each plant on a North, South, East, and West grid 1-meter from the base of each plant. After every two plant measurements PAR was measured above the canopy in Watts per m2. PAR was recorded as percentage transmission to the ground of the recorded PAR above the canopy. Readings were taken in full sun between 9:30 and noon. Four measurements from each of 25 plants at each location sampled were averaged (100 readings) for comparison with adjacent or near-by locations.

In addition to measuring PAR in old established commercial plantations, the LAI and PAR were measured in two planted population experiments prior to and following the harvest of the second crop.

RESULTS

Plant measurements on different soils and populations adjustment using the LAI.

Two sets of plant measurements were made on loam and light clay in 10-year old Caimito farm in Honduras (Table 1). Valery had 19% and Grand Nain 23% less foliage on light clay. The pseudostem circumference was 15-16% less on light clay. Grand Nain was 13% shorter on light clay whereas Valery was only 3% shorter. Apparently, the size of Grand Nain is reduced more on light clay than Valery.

In Santa Rosa farm, Honduras two areas were chosen with wide differences in Valery stem weight on loam and light clay, and 10 plants at shooting were measured (Table 2).

The difference in average leaf area per plant between loam and light clay was only 15 %. The actual populations carried were 1705 on loam and 2100 on light clay, a difference of 19%. If the foliage of the suckers are included this resulted in almost the same LAI of 5.33 and 5.36, respectively.

The lesser size and amount of foliage on the mother plant in light clay also applies to the suckers (Table 3). The suckers foliage at time of shooting, however, contributes less than 6% to the total LAI.

Photosynthetically active radiation transmitted through the canopies of Valery and Grand Nain on different soils.

PAR data from different areas are presented in Table 4. In Santa Rosa there was no significant difference in the amount of PAR transmitted at Valery population of 2100 on light clay and 1704 on loam. After a harvest on the light clay the amount of transmission almost doubled.

The second measurement was at an obviously overpopulated area in Breck farm in Honduras. Although the Valery population was only slightly higher than on Santa Rosa loam, plants were much larger with a more dense canopy. In this case, PAR transmission was only about 50% of that in Santa Rosa.

In the third area Grand Nain and Valery were compared at two different populations on loam. There was slightly more transmission in the Grand Nain at the higher population but the difference was not statistically different. Apparently, a Grand Nain population even higher than 10% over Valery could be carried in this area and maintain similar canopy transmission.

Percentage PAR transmitted through canopies of adjacent Grand Nain and Valery at three different locations in Caimito were studied (Table 5). Locations studied were selected to indicate differences in vigor of growth as measured by pseudostem circumference 1-meter above the ground.

In the first location the Grand Nain population was only 9% higher than Valery and the pseudostem circumference was 13% smaller indicating poorer growth than Valery. This was reflected in slightly more PAR transmission in Grand Nain. In the second location, there was little difference in PAR between Grand Nain populations of 1951 and 2087. Transmission at 2087 was similar to Grand Nain at 1749 in the first location and both were greater than Valery. In the third location a population of Grand Nain 22% greater than Valery transmitted only slightly less PAR. These data tend to support leaf measurements (Table 1) showing that Grand Nain has less foliage than Valery and that a population 20% higher than Valery does not reduce PAR transmission through the Grand Nain canopy.

Leaf area index and PAR transmitted at different planted populations.

Valery populations planted at 1500, 1700, and 1900 production units per ha in Changuinola, Panama,and 1300, 1700 and 2100 in Palmar,Costa Rica, were studied when most of the second crop of fruit was present. Plant growth

TABLE 1 - Plant measurement differences at shooting in loam and light clay areas in Ciamito Farm, Honduras.

	Valery		Grand Nain	
	Loam	Light clay	Loam	Light clay
No. leaves	16.5	15.2	16.4	14.9
Av. area leaf M^2	2.08	1.83	1.64	1.43
Av. area foliage per plant M^2	34.8	28.3	27.9	21.6
Height in M	4.2	3.9	3.2	2.8
Pseudostem circumference Cm	83.2	70.6	73.9	61.8
LAI at 1730 plants ha	6.0	4.9	4.8	3.7

TABLE 2 - Growth characteristics at shooting of Valery growing in loam and light clay in Santa Rosa Farm, Honduras

	Loam	Light clay	Significantly different at
Fruit weight (Kg)	41.6	30.7	.01
Height (Cm)	404.3 ± 7.6	366.7 ± 8.5	.01
Pseudostem circumference (Cm)	78.3 ± 1.7	65.0 ± 1.3	.01
Leaf area per plant (M^2)	29.6	25.1	01
Land area in M^2 occupied by plant	16.9	15.6	-
Average No. leaves per plant	13.7	13.8	-
Length of leaves (Cm)	281.7 ± 3.8	265.5 ± 3.1	.01
Width of leaves (Cm)	97.7 ± 1.5	90.6 ± 1.0	.01
Area of leaves (M^2)	2.22 ± 0.06	1.95 ± 0.04	.01
* LAI (1730 plants/ha)	5.10	4.34	-
* LAI (1705 plants/ha)	5.04	-	-
* LAI (2100 plants/ha)	-	5.26	-
* LAI mother and sucker 1705 (loam) and 2100 (light clay) plants/ha	5.33	5.36	-

* - Not including furled heart leaf or bract leaf.

TABLE 3 - Growth characteristics of suckers at shooting of mother plant for Valery growing in loam and light clay in Santa Rosa Farm, Honduras.

	Loam	Light clay
Height (Cm)	224.0 ± 13.1	161.5 ± 16.7
Circumference (Cm)	31.2 ± 2.8	21.2 ± 3.5
Av. no leaves	7.1 ± 0.45	5.6 ± 0.61
Length leaves (Cm)	105.0 ± 10.0	71.2 ± 9.5
Width leaves (Cm)	23.3 ± 3.0	12.6 ± 2.5
Area leaves (M^2)	0.25 ± 0.05	0.10 ± 0.03
LAI (1705 plants/ha)	0.32	-
LAI (2100 plants/ha)	-	0.13

and foliage were much greater in Changuinola than in Palmar (Table 6). This is also reflected in average stem weights which were 42.8 kg in Changuinola and 36.7 kg in Palmar. The LAI in Palmar at a population of 2100 was comparable to that in Changuinola at a population of 1500 (Table 6). At the same population of 1700 production units per ha Changuinola had a LAI of 5.1 compared with 3.5 for Palmar (Table 7).

The pronounced differences in amount of foliage between the two locations are reflected in the radiation date (Table 8). The canopy in Changuinola is so dense that there was no difference in the PAR transmitted to the ground at 1500, 1700, and 1900 populations. This canopy density was related to the fact that most of the second crop of fruit was still present.

TABLE 4 - Percent photosynthetically active radiation transmitted through different canopies, Honduras.

Valery Santa Rosa light clay	
Population 2100 ha	16.1 a*
After harvest	30.1 b
Valery Santa Rosa loam	
Population 1704 ha	18.6 a
Valery Breck loam	
Population 1778 ha	9.8 c
Valery Caimito loam	
Population 1600 ha	14.0 a
Grand Nain Caimito loam	
Population 1750 ha	17.8 a

* - Figures followed by the same letter are not statistically different.

DISCUSSION

An even spacing of plants that results in a uniform canopy depends upon the skill of the pruner. Usually, the overall husbandry of a banana plantation can be judged by the spacing and quality of the pruning. Proper spacing results in a full, even canopy that will intercept a maximum of the PAR and not cause excessive interplant competition (overpopulation).

Following planting at a uniform spacing, population adjustments are gradually made in permanent plantations. These population changes take into consideration soil characteristics that determine the size and amount of foliage of individual banana plants. Population adjustments are made by the visual and subjective assessment of experienced pruners.

TABLE 5 - Photosynthetically active radiation (PAR) transmitted through the canopy og Grand Nain and Valery at different populations in Caimito Farm, Honduras.

Location variety	Population per ha	Pseudostem circumference (cm)	Percent PAR transmission
1. Grand Nain	1749	72.3	17.8
Valery	1598	83.4	13.9
2. Grand Nain	2087	73.2	19.7
Grand Nain	1951	64.4	17.9
3. Grand Nain	1889	76.8	14.8
Valery	1482	81.1	16.7

TABLE 6 - Plant and foliage characteristics in Palmar, Costa Rica and Changuinola, Panama, at 2100 and 1500 production units per hectare, respectively.

	Palmar (2100)	Changuinola (1500)	Percent increase
Plant height M	3.70	4.02	8.6
Circumference Cm	63.8	72.6	13.8
Leaf area/plant M^2	22.0	30.2	37.3
Leaves/plant	12.5	15.5	24.0
Individual leaf area M^2	1.8	2.0	11.0
Leaf area index	4.49	4.4	-

TABLE 7 - Plant and foliage characteristics in Palmar, Costa Rica and Changuinola, Panama, at 1700 production units per hectare.

	Palmar	Changuinola	Percent increase
Height M	3.65	4.20	15.1
Circumference Cm	63.7	77.8	22.1
Leaf area/plant M^2	21.4	31.0	44.8
Leaves/plant	12.5	15.5	24.0
Individual leaf area M^2	1.8	2.1	16.6
Leaf area index	3.5	5.1	44.7

TABLE 8 - Photosynthetically active radiation (PAR) transmitted through canopy with different populations in Changuinola, Panama and Palmar, Costa Rica.

Populations/ha	Av. W/M^2 below canopy *	Av. W/M^2 above canopy	Percent transmission PAR
Changuinola			
1500	6.1	166.8	3.7
1700	4.8	160.3	3.0
1900	3.0	147.7	2.0
Palmar			
1300	52.5	160.9	32.6
1700	32.3	160.0	20.2
2100	21.1	162.9	13.0

* - Watts per square meter.

Using the LAI and PAR measurements it is now possible to make an objective evaluation of population needs and canopy quality. It appears that a LAI of between four and five encompasses most populations in permanent plantations five years or older in Central America. With respect to PAR, 14-18% transmission includes most older populations of Valery and Grand Nain in Honduras. Readings considerably above or below these would indicate overpopulation and underpopulation. When 32% of the PAR was transmitted to the ground in Costa Rica, grass growth became abundant.

Studies of LAI and PAR in recently planted different populations are strongly influenced by harvest timing. During the first three to four crops most fruit within a population treatments is harvested within a short time span. This results in the canopy being very closed when fruit is developing and then very open when most of the fruit is harvested. Also, fruiting is faster at the lower than at the higher populations. Therefore, readings in recently planted populations must be interpreted with caution in relation to old permanent plantations.

LITERATURE CITED

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