Effect of Plant Density and Nutrient Management on Plantain Yield

By Sylvio Belalcázar and José Espinosa

Plantain (*Musa paradisiaca* L.) is a staple and inexpensive food grown in the tropical and subtropical areas of Latin America. Plaintain consumption in the region has been increasing steadily in recent years, with Colombia having the highest consumption rate. Colombia cultivates more than 400,000 ha and has a total annual plantain production of around 1.7 million tonnes (M t). Inadequate inputs and low technology management practices combine to be the main causes for its poor average yield of 6 t/ha.

Population growth and the consequent demand for more food have encouraged the search for innovative methods of production that can obtain higher sustainable yields. High plant density can significantly increase yield per unit area. Successful examples include high-density coffee and cocoa production systems. Research work conducted in the last seven years has documented yield increases of up to 300 percent where plantain plant populations were increased from the traditional 1,000 plants/ha to 3,000 plants/ha.

Increasing plant density from 1,000 up to 3,000 plants/ha has resulted in higher yields in research.

An added benefit of high-density plantain cultivation is a lower incidence of yellow sigatoka (*Micosphaerella musicola*) and black sigatoka (*Micosphaerella fijiensis*), two of the most important diseases affecting the crop.

High plant population increases the length of the production cycle and reduces bunch weight, but the negative effect of these factors is outweighed by the higher number of bunches per unit area. These results have attracted the attention of plantain growers, extension personnel, and researchers in several countries of Latin America. Starting in 1992, the National Agricultural Research Institute of Colombia (CORPOICA) initiated a research program to investigate high-density plantain cultivation. Some of the results from this program are discussed here.

High-Density Plantain: A New Option

Traditionally, plantain has been treated as a semi-perennial crop grown with different plant arrangements in the field according to agro-

ecological zone and grower objective. Plant population varies from 1,400 to 1,600 plants/ha. The plantation is kept in the field for several ratoons using sucker plants that originate from the mother plant. Plant population and plant vigor decrease rapidly after the first harvesting cycle. Growers pay little attention to the crop and harvest every time bunches are ready. This small but continuous cash income has prevented any change in the approach to plantain cultivation.

The high population approach treats the plantation as an annual crop (i.e., one harvest only). This is an unorthodox way of handling plantain and differs radically from traditional cultivation. All plants are eliminated after harvest, and a new stand is planted using new corms. It has been demonstrated that keeping this type of plantation for more than one cycle is not economical. This new technology is normally quite difficult to introduce because of grower resistance to the elimination of an apparently good stand to establish a new one.

In high-density management, plantain is treated as an annual crop with one harvest.

Results from work conducted in several experimental sites indicate that an increment in the number of plants per hectare reduces the yield per plant and increases the total time to harvest. Growers typically wait an extra three to five months for harvest with plant densities of 3,300 to 5,000 plants/ha compared to using normal densities of 1,400 to 1,600 plants/ha (**Table 1**). However, data also indicate that these negative effects are completely offset by the higher yields obtained per unit area. Semi-commercial plots have confirmed these results, and growers are adopting this new technology faster than expected.

Data in **Table 1** also indicate that the number of harvested plants decreases as plant population increases. This is a direct effect of plant competition. In high population systems, it is important to eliminate all plants that have not developed normally during the first two to three months after planting. Plants that have fallen behind never recuperate and have to compete with the plants growing at the normal rate.

The usual plant arrangement in the field is laid out in patterns of

Table 1. Plant population effect on growth factors and plantain yield grown on an Andisol, Quindio, Colombia.

		Growth factors			Yield factors		
Plants per site	Plants per ha	Plant height, m	Pseudostem circumference, cm*	Cycle length, months	Mean bunch weight, kg	Total yield, t/ha	Number harvested plants, %
1	1,666	3.5	49	15.5	15.0	23.1	92.6
2	3,332	4.2	50	18.0	14.3	40.4	85.0
3	4,998	4.3	51	20.0	13.3	51.9	78.0

*One meter from soil surface.

2 x 3 m (i.e., plant spacing within and between rows, respectively). High population can be obtained by planting two or three corms in the same planting hole. This will result in approximate populations of either 3,332 or 4,998 plants/ha. Planting density of 3,332 plants/ha can also be obtained by planting one corm per hole at a spacing of 1.5 x 2 m.

Management of High-Density Plantain Crops

To be efficient and profitable with high-density plantain, it is necessary to consider the following management recommendations.

Seed Size

This factor is of particular importance since the success of the new plantation depends on the correct selection of the corms to be planted. A practical way of selecting corms is to organize them in homogeneous groups of the same size and weight. This selection of the seed allows uniform growth and development of the plantation. At the same time, a gradient of maturity develops in the field which allows harvesting to occur in order of the size of the corm from which plants developed. Lack of uniformity in the plantation reduces yields significantly.

Plant Uniformity

Even with the use of uniform corms, there are differences in the size of plants growing in the same planting hole due to a difference in the physiological age of the planted corms. In such cases, it is necessary to remove leaves from tall plants or by cutting the pseudostem. The best time for trimming plants is when the fifth leaf appears, which is approximately 30 to 45 days after the first leaf appears, depending on altitude.

Disease Control

Control of the two main plantain diseases, yellow sigatoka and black sigatoka, is indispensable. Good control has been obtained by monthly trimming of dead or broken green leaves hanging from the pseudostem and all leaves with necrotic spots covering more than one-third of the lamina. High population plantations have a lower incidence of these two diseases. This could be related to the increase in the length of the pathogen growth cycle induced by the modifications in light and temperature inside high-density plantations.

Nutrient Management

Fertilizer requirements for plantain in high-density arrangements are greater when compared to conventional planting. Higher yields remove more nutrients and even in soils with high natural fertility these nutrients must be replaced to sustain high yields. The effects of plant density and fertilizer application on plantain yield in two soils from

Colombia with different native fertility status are shown in **Table 2**.

Table 2. Effects of plant density and fertilizer application on plantain yield in two Colombian soils.

Treatments	Plants per ha	Yield, t/ha Quindio (Andisol)	Yield, t/ha Magdalena (Inceptosil)
Check	1,666	19.3	7.3
Check	3,332	28.5	15.6
NPK*	3,332	32.7	31.3

*N = 100; P_2O_5 = 20; K_2O = 210 kg/ha, respectively.

Conclusion

The advantages of high population density plantain include: the potential to increase yields significantly, synchronize the crop cycle and harvesting with best market conditions, and optimize land use. One hectare of high-density plantain can produce as much as three to five hectares of conventional planting. High-density planting also produces higher numbers of good quality corms that can be used as seed for the next cycle, lowering the incidence of pests, diseases and weeds. Farmers in the plantain producing areas of Ecuador, Colombia and Venezuela are benefiting from this technology. **BCI**

Dr. Belalcázar is a private consultant formerly with the Colombian Institute of Agricultural Research (CORPOICA), Colombia. Dr. Espinosa is Director, PPI-PPIC Northern Latin America (INPOFOS), Ecuador. E-mail: jespinosa@ppi-ppic.org.

References

Belalcázar, C.S., A.A. Baena, J.A. Valencia, G.A. Martínez. 1990. Estudios sobre densidades de población. p. 63-76. In: Belalcázar C.S. et al. Generación de tecnología para el cultivo y producción rentable de plátano en la zona cafetera central Colombiana. Creced Quindío, ICA Armenia, Regional Nueve. (Informe técnico).

Belalcázar, C.S., V.V.M. Merchán, A.M. Baena, M.J.A. Valencia. 1990. Efectos de la epoca y el grado de defoliación sobre la producción. p. 77-85. In: Belalcázar, C.S. et al. Generación de tecnología para el cultivo y producción rentable de plátano en la zona cafetera central colombiana. Creced Quindío, ICA Armenia, Regional Nueve. (Informe técnico).

Cardona, A.J.H., G. Franco, C.S. Belalcázar, C.A. Giraldo. 1991. Validación y ajuste de tecnología sobre prácticas de siembra y manejo de plantaciones. Instituto Colombiano Agropecuario, ICA, Creded Quindío, Regional Nueve. p. 28. (Mimeografiado).

Herrera, M.A., C.S. Belalcázar, M.J.A. Valencia, A.M. Baena. 1990. Evaluación de tamaños de semilla. p. 39-52. In: Belalcázar, C.S. et al. Generación de tecnología para el cultivo y producción rentable de plátano en la zona cafetera central Colombiana. Creced Quindío, ICA Armenia, Regional Nueve. (Informe técnico).

Merchán, V.V., C.S. Belalcázar. 1990. Evaluación y alternativas para el control de Sigatoka amarilla, p. 97-110. In: Belalcázar, C.S. et al. Generación de tecnología para el cultivo y producción rentable de plátano en la zona cafetera central Colombiana. Creced Quindío, ICA Armenia, Regional Nueve (Informe técnico).