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Sucker Selection on Banana (*Musa* AAA cv Valery) Root Content, Nematode Populations, and Yield

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A B S T R A C T

A field experiment was carried out in El Guabo, Ecuador, to study how sucker selection affect root content, nematode numbers, and yield variables on banana (*Musa* AAA cv. Valery) plants. The two treatments evaluated were sword sucker selection at plant flowering and early sword sucker selection of 60 cm height on un-shooting plants. The two treatments were laid out in RCD with ten replicates and in each replicated, 10 of each sucker were evaluated across five ratoon crop cycles. With few exceptions, no differences were found in root contents between the two types of sword sucker selected. No differences in the number of *Pratylenchus* spp. (P> 0.0911), *Meloidogyne* spp.(P> 0.1011), *Helicotylenches* spp., (P> 0.1189), *Radopholus similis*(P> 0.2657), and total nematodes (P> 0.0557) were found in none of the ratoons between the two types of suckers selected. The number of total nematodes varied across the five ratoon crop cycles between 6021 and 22327 per 100 g of roots by sucker. In none of the yield variables (bunch weight P> 0.1528, ratio P> 0.1527, rationing P> 0.1261, and number of boxes per hectare by year P> 0.1447) differences were found between the selected suckers at the parent plant and the subsequent four ratoon crop cycles. Across the five harvests, the number of boxes oscillated between 2971 and 4072 per hectare per year. Although, no differences in yield were found, in the last three ratoon crop cycles consistently more than 100 (106 to 133) boxes per hectare per year were got when sucker selection was done on un-shooting plants. Considering the actual market price of a box of 18.14 kg of bananas of US $6.25, the additional net income from the increase in yield, deducted the cost of labour of $0.75 of packing for each additional box would varies between 580 to 732 US$ per hectare per year.

Introduction

Bananas (*Musa* AAA cv. Grande Naine, Valery, and Williams) are cultivated in Ecuador for export markets. It is the most important crop, accounting for almost 25% of the agricultural gross national product. In 2020, 380.4 million boxes of 18,14 kg were exported (ACORBANEC, 2021), produced on 176000 (El Universo, 2021a), which gave a total income of US $3669 million FOB (Moreno *et al.,* 2021).

Although banana is an annual crop, it is produced in a perennial monoculture. To keep the long-term banana ratoon plantation with high productivity, each stool must consist of the mother plant, the follower sucker and when possible, a small peeper. However, in each stool several suckers (usually three) from the underground stem are produced during the banana life cycle which, if allowed to grow freely, can result in intra-mat competition through creation of multiple sinks and intensification of root and corm-rhizome competition for space, water, and nutrients. Even, the follower sucker reduces the bunch weight of the parent plant (Araya and Vargas, 2002). Therefore, growth of excess suckers must be discouraged before they become too large and unmanageable to interfere with growth of the parent plant and the follower sucker, which otherwise will result in extended crop cycle (loss ratooning) and reduced ratoon crop yield (Robinson, 2003; Robinson and Galán, 2010). Ratooning, which is the number of bunches harvested by each banana stool by year influence yield greatly as has been shown by Jaramillo *et al.,* (2019) and Chávez *et al.,* (2020).

Sucker trimming or sucker pruning (removing unwanted or surplus suckers) is one of the most critical operations and controversial issue in banana production and plantation management among growers. When and how to do the sucker selection it is always a question with uncertain answered among growers and technicians. In Ecuadorian banana conditions, some growers do the follower sucker selection, at flower emergence of the parent plant, more likely, following Stover and Simmonds (1987) recommendation. Other growers, remove the surplus suckers on un-shooting plants selecting sword suckers with a range of height usually 60-100 cm and eliminating the rest.

For the decision on what plant stage to do the sucker selection it is necessary to consider that between the mother plant and its suckers exists translocation of nutrients (Wamsley and Twyford, 1968, Teisson, 1970, Kurien *et al.*, 1999, Kurien *et al.*, 2002, 2006). For Martín-Prevel (1964) and Lahav and Turner (1989), this movement of nutrients is important in the nutrition of the follower sucker. In Australia, unwanted suckers must be cut off at an early stage with less of 30 cm high, otherwise if removal it is carried out late, bunch weight in the parent crop can be reduced by up to 18% (Tropical banana information kit, 1998).

Robinson and Nel (1990) found a reduction in yield as the height of the unwanted suckers increases in the cv. Williams. According to Kurien *et al.,* (1999) the decrease is a consequence of the continuous transfer of nutrients from the parent plant to the suckers, a process that, although it ceases in the follower sucker with its independence from the mother plant, continues again in the remaining suckers not eliminated.

Independently at which plant stage is done the sucker selection, removing of unwanted suckers, in Ecuadorian conditions, is carried out every 6 to 8 weeks throughout the year, in long-term commercial banana plantations, due to the continuous soil humidity since irrigation is applied during the dry season and semi-warm or warm conditions all the year around.

With the actual increment in production costs, there is a great need to keep the banana ratoon productivity through improvement of the present standards of husbandry practices since many growers lack the correct scientific bases of de-suckering. The present study was carried out to compare root content, nematode numbers, and yield variables (bunch weight, ratio, ratooning, follower sucker height, boxes per hectare per year) on sucker selection at plant flowering vs early de-suckering, doing the sword follower sucker selection at 60 cm height in un-shooting plants.

Materials and Methods

The field experiment was carried out for the parent plant and four consecutive ratoon crop cycles within a long-term (26 years) commercial banana (*Musa* AAA cv. Valery) plantation located in El Guabo county, province of El Oro, Ecuador. The soil was alluvial, taxonomically classified as an Inceptisol and it had a clay texture (20 % sand, 20 % silt and 60 % clay) with a pH of 6.7 and 1.58 % organic matter. The following concentrations of extractable bases were found, using Modified Olsen as the extractant: Ca 15.4, Mg 4.7, and K 0.85 cmol L^{-1}, and P 33, Zn 17.2, Cu 4.8, Fe 61.0, and Mn 18.9 µg ml^{-1}. The block where the experiment was established had an average production in 2016 of 3200 boxes of 18.14 kg per hectare per year with a plant density of about 1450 plants by hectare.

Before, set up the experiment, de-suckering was carried out every 6-8 weeks in recently flowered plants, leaving the production unit with a bearing mother plant, a large daughter sucker (follower) and a small peeper when possible. Bunching plants were propped with double polypropylene twine to the bottom of two well-developed adjacent plants. The follower sucker of each production unit was fertilized every 28 days at the rate of 80 kg ha^{-1} with a formula adapted to the soil and crop requirements, consisting of urea (46 % N). Generally, during the rainy season, from January to May each year, water requirements was supplied by rainfall, where the annual precipitation was of 637, 771, 504, and 597 mm per year, for 2016, 2017, 2018, and 2019, respectively. A complex system of primary, secondary, and tertiary drains was provided to disperse excess rainfall and prevent water logging during heavy rains. From June to December each year, water was supplied by sprinkling irrigation. Mean daily average, maximum, and minimum temperatures were 24.8-29.6-22.3 /25.1-30.1-22.5 / 24.9-30-22.5 and 24.7-29.7-22.3^{o}C, at the year 2016, 2017, 2018, and 2019, respectively.

Cultural practices in the experimental site: Leaf fungi, especially black Sigatoka (*Pseudocercospora fijiensis*), was managed by deleafing weekly to reduce the pressure of black Sigatoka inoculum and by aerial spraying of alternate fungicides which resulted in 31 sprayings each year at 11 to 13 days intervals. The sequencing of the fungicides applied were: 2-3 cycles with Thalonex® 720SC (chloratalonyl-Crystal Chemical) 3 L ha^{-1} in water, and then one cycle of Mancozin® 430SC (mancozeb-Crystal Chemical) 2.4 L ha^{-1} in combination with Acord® 250EC (difeconazole-Crystal Chemical) 0.7 L ha^{-1} in emulsion with miscible oil (Banole®-Total) and water, both cases in a spray solution of 23 L ha^{-1}. Weeds were controlled spraying every 5-8 weeks a Glifonox® 480CS (glyphosate-Crystal Chemical) solution of 2 L in 200 L of water. Nematodes were controlled every year by 1.5-1.8 nematicide cycles (Counter® 15GR-AMVAC, Rugby® 10GR-FMC, Vydate® 24SL-DuPont) per year, based on the nematode economic threshold.

Two treatments were evaluated: treatment 1, where the follower sucker (sword sucker) selection was done at plant flowering, and treatment 2, where in un-shooting parent plants, the follower sucker was selected at 60 cm height. In both treatments the selected sucker was on the most open side of the parent to keep the distance among stools as equal as possible, to maintain the symmetry arrangement for the plantation. The two treatments were applied randomly to 10 plants each, in 10 contiguous terraces-repetitions (rectangular plots with 150 to 175 stools) within the block. Surplus suckers were removed by cutting off at ground level with a sharp knife. Plots were arranged in a randomized complete design. So, each de-suckering type was applied to 100 plants. In each terrace, plants from plot edges, edge drains, cable edges, dompings, replanting plants or from stools with double ratoon suckers, were excluded from treatment.

Just after sucker selection, a root sample for nematode extraction was taken from each sucker. In front of each selected follower sucker, a hole of 20 cm length, 20 cm wide and 30 cm depth (soil volume of 12 L) was dug at the plant base using a shovel. All the roots found were collected and placed in labeled plastic bags and delivered to NEMALAB laboratory in coolers for nematode extraction. In the laboratory, the root samples were registered and processed as soon as possible, and when it was necessary, stored in a refrigerator Indurama serie RS-10989-593 adjusted to 6-8^{o}C until being processed. The roots were rinsed free of soil, separated in living roots (white or cream-colored roots), dead roots by nematodes (with symptoms of nematode damage, with light necrosis, but without root decay) and dead roots by other causes (rotten roots by excess water, snapping), left to dry off the surface moisture and weighed (Fisher Scientific serie 10309201 scale precision 710 g ± 1 g). During the root separation process, in some roots, it was necessary to cut some damaged parts, which were classified accordingly. The total root weight corresponds to the sum of living roots, dead roots by nematodes and roots dead by other causes.

The three types of roots were cut into 1-2 cm long pieces separately and after homogenization, 25 g were randomly selected following the found proportion of each type of root. For example, in a sample of 43 g of total roots, with 31 g of living roots, 8 g of dead roots by nematodes, and 4 g of dead roots by other causes, there would be 72.1 % of living roots, 18.6% of dead roots by nematodes, and 9.3 % of dead roots by other causes that multiplied by the used sample size of 25 g, would have 18 g of living roots, 4.6 g of dead roots by nematodes and 2.4 g of dead roots by others causes in the 25 g sample. These roots were macerated (Araya, 2002) in a kitchen blender (Osterizer; Sunbeam-Oster) for two periods of 10 seconds, at low and then at high speed, and nematode recovered in 0.025 mm (No 500) sieve. The nematodes were identified at the genus and species level, when possible, based on the morphological characteristics under a light microscope, following the key of Siddiqi (2000). The population densities of all plant-parasitic root nematodes present were recorded, and the values were converted to numbers per 100 g of roots.

Harvesting of the parent plant and the selected suckers was done by calibration starting when bunches reached 10 weeks of age. When in the second hand, the central fruit of the outer whorl had a diameter of at least a grade of 45 (35.5 mm-diameter) the bunch was harvested. If in week 13, it did not reach the required minimum grade of 45, they were harvested with the grade they had. Bunch weight (Tru-Test electronic scale XR3000 kg ± 1g), follower sucker height (m) measured from the sucker base to the point of junction of the upper two youngest leaves, were recorder. The ratio, which is the number of boxes of 18.14 kg given by each bunch, was calculated considering a reduction of 20%, because was the average of the farm during the experimental time, which includes 11 % of bunch stalk and 9 % of non-marketable fruit. With the data of the number of bunches harvested in 2016 in the block where the experiment was located, and the number of plants per hectare, the initial ratoon was calculated in 1.63. Since the date of bunch harvest was registered for the 5 ratoon crop cycles in each stool, the ratooning in each ratoon crop cycle was calculated dividing the 365 days of the year by the number of days between bunch harvest in each stool for each of the following crop cycles. The first harvest corresponds to the mother-parent of the selected follower suckers and the others are from the treatment effect.

The composition of the nematode population was determined for each ratoon crop cycle. Data of root weights were averaged for the10 suckers in each repetition (terrace) and subjected to ANOVA by Proc GLM of SAS. The number of nematodes were averaged for the 10 suckers in each repetition (terrace) and were analyzed with generalized linear models, using the log transformation as link function and negative binomial distribution of the errors. Bunch weight, follower sucker height, ratio, ratooning, and number of boxes of 18.14 kg per hectare per year (97% bunch recovery; 1, 406 bunches * ratio * ratooning) were averaged for each repetition (terrace) and ratoon crop and subjected to ANOVA in PC-SAS® version 9.4.

Results and Discussion

With exception of the first ratoon crop cycle, where suckers selected in un-shooting plants, with 60 cm height had 65% more (P= 0.0013) living roots than the suckers selected at plant flowering, no differences(P> 0.1862) in living root content were found in the subsequent 4 ratoon crop cycles (Figure 1A). Across the five ratoon crop cycles, living roots in suckers selected at plant flowering varied between 14.8 and 38.7 g by sucker and in the suckers selected at 60 cm height it oscillated between 16.2 and 46.9 g by sucker.

Dead roots by nematodes fluctuated between 2.2 and 8.6 g by sucker, when it was selected at plant flowering, and between 3.7 and 9.6 g by sucker when selected at 60 cm height in un-shooting plants through the five ratoon crop cycles (Figure 1B). Difference (P= 0.0089) in dead root by nematodes was only found at the four-ratoon crop cycle, where suckers selected at 60 cm height, had 68% (1.5 g) more damaged roots by nematodes.

Dead roots by other causes were very small in both treatments, varying between 0.1 and 1.2 g by sucker when selected at plant flowering and between 0.3 to 1.5 g by sucker selected at 60 cm height (Figure 1C). With exception of the first ratoon crop cycle, where suckers selected at 60 cm height in un-shooting plants, had 1.2 g (500%) more (P= 0.0008) dead roots by other causes than those suckers selected at plant flowering, in the subsequent four ratoon crop cycles no differences (P> 0.0767) were observed.

The total root weight by sucker (sum of living roots + dead roots by nematodes + dead roots by other causes) across the five ratoon crop cycles oscillated between 21 and 44 g and between 21 and 58 g by sucker when selected at plant shooting or at 60 cm sucker height in un-shooting plants, respectively (Figure 1D). Difference in total root weight was observed only in the first ratoon crop cycle, where suckers selected at 60 cm height in un-shooting plants had 21 g (56%) more (P= 0.0028) than those selected at plant flowering. Percentage of living roots by sucker varied across the five ratoon crop cycles between 72 to 89% in suckers selected at plant flowering and between 74 to 86% in suckers selected at

60 cm height in un-shooting plants (Figure 1E). With exception of the four-ratoon crop cycle, where suckers selected at plant flowering had 7% more (P= 0.0003) living roots than the suckers selected at 60 cm height in un-shooting plants, in the others ratoon crop cycles no differences (P> 0.1740) were found.

The composition of the plant-parasitic nematode population varies slightly across the five ratoon crop cycles (Figure 2A-E). The most abundant nematode was *Radopholus similis* which varies between 39.9 to 51.5%, followed closely by *Helicotylenchus* spp. that oscillated between 39.9 and 50.4%, thereafter *Meloidogyne* spp. which fluctuated between 4.8 and 15.5% and finally *Pratylenchus* spp. with a negligible amount between 1.8 and 3% of the nematode population.

The number of *Pratylenchus* spp. was small in both type of selected suckers across the five ratoon crop cycles without differences (P> 0.0911) in none of the ratoons. In suckers selected at flowering the population varied between 73 and 424 and in suckers selected at 60 cm height in un-shooting plants between 167 and 448 per 100 g of roots per sucker (Figure 3A). The population of *Meloidogyne* spp. was similar (P> 0.1011) in both types of suckers across the five ratoon crop cycles (Figure 3B). It varied in suckers selected at plant flowering between 388 and 1145 and in suckers selected at 60 cm height in un-shooting plants, between 456 and 988 per 100 g of roots per sucker.

Helicotylenchus spp. per 100 g of roots per sucker was similar (P> 0.1189) for both type of suckers, across the five ratoon crop cycles (Figure 3C). The number fluctuated between 2410 and 9491 and between 2733 and 12401 per 100 g of roots for suckers selected at plant flowering and suckers selected at 60 cm height in un-shooting plants, respectively. For *R. similis*, the population for both type of suckers, was similar (P> 0.2657) across the five ratoon crop cycles (Figure 3D). The number varied between 2698 and 10067 and between 2280 and 8538 per 100 g of roots in suckers selected at plant flowering and in suckers of 60 cm height in un-shooting plants, respectively. Also, no differences (P> 0.0557) between the two kinds of suckers selected were found across the five ratoon crop cycles for total nematodes (Figure 3E). The population in the suckers selected at plant flowering varied between 6021 and 21127 and in the suckers selected at 60 cm height in un-shooting plants, oscillated between 6206 and 22327 individuals per 100 g of roots per sucker, respectively.

In bunch weight, no differences (P> 0.1528) were found for the two suckers selected for the parent plant and across the fourth subsequent ratoon crop cycles (Figure 4A). For the suckers selected at plant flowering, bunch weight varied between 31.7 and 36.6 kg, and for those selected at 60 cm height in un-shooting plants, it fluctuated between 34.9 and 36.4 kg per bunch. With exception of the second ratoon crop cycle, where the follower sucker height at harvest of the parent plant from those de-suckered when the follower sucker reached 60 cm height in un-shooting plants, which were 21 cm (7.8%) taller, in the others ratoon crops, no differences (P> 0.1981) were found (Figure 4B). The follower sucker height varied between 262 and 290 cm, and between 254 and 296 cm in those selected at plant flowering and those selected at 60 cm height in un-shooting plants.

Ratio, which is the number of banana fruit boxes (18.14 kg) obtained from each bunch, was similar (P> 0.1527) between the two selected suckers for the parent plant and across the four ratoon crop cycles (Figure 4C). In suckers selected at plant flowering it varied between 1.40 and 1.63 and for those selected at 60 cm height in un-shooting plants it fluctuated between 1.41 and 1.77 boxes per bunch. Ratooning, which is the number of bunches harvested per year in each banana stool was similar (P> 0.1261) for both types of selected suckers across the four ratoon crop cycles (Figure 4D). In stool de-suckered at plant flowering, the ratooning varied between 1.51 and 1.79 and in those where the sucker was selected at 60 cm height in un-shooting plants, it fluctuated between 1.60 and 1.85 bunches per stool per year. No differences (P> 0.1447) in the number of boxes of 18.14 kg per hectare per year (1450 plant density * 97% bunch recovery= 1406 bunches * ratio * ratooning) between the two kinds of selected suckers was found for the parent plant and across the subsequent four ratoon crop cycles (Figure 4E). For suckers selected at plant flowering, it varied between 2971 and 3752 and for suckers selected at 60 cm height in un-shooting plants, it oscillated between 3104 and 4072 boxes per hectare per year.

In root variables (living roots, root dead by other causes, total root weight) most of the differences found where in the first ratoon crop cycle, which it is reasonable, because the suckers evaluated at that time did not have the treatment effect. That evaluation was done when the experiment starts, on a commercial banana plantation where de-suckering was carried out at plant flowering. Therefore, the differences found on root variables are obvious, since de-suckering on un-shooting plants was done at specific sucker height of 60 cm, while in the sucker trimming at plant flowering, the sucker selected was the sword sucker regardless of its height, which means that those suckers were old, taller and had more roots.

The abundance of *R. similis* (between 39.9 and 51.5%) and *Helicotylenchus* spp. (between 39.9 and 50.4%) agreed with Jaramillo *et al.*, (2019) who reported 31.5 and 68.2% and Chávez *et al.*, (2020) who found 44.6 and 42.1% of *R. similis* and *Helicotylenchus* spp., respectively, in Ecuadorian conditions. High proportion of *Helicotylenchus* spp. have been reported in Ecuador in banana plantations with insufficient nematode control (Jaramillo *et al.*, 2019). A similar behaved have been found in Costa Rica (Araya and Moens, 2005), and Belize (Salguero *et al.*, 2016), where high proportions of *Helicotylenchus* spp. was found in areas with insufficient nematode control. However, the farm where the experiment was run, managed nematode with almost two nematicide cycles per year for the last 10 years. Then, more likely, the saline soil conditions present, favored *Helicotylenchus* abundances since this nematode was found associated with the decline of banana plantations in Israel (Minz *et al.*, 1960) where soils are also saline.

The population of the four nematode genera found were similar in both types of suckers selected across the five ratoon crop cycles. This was expected and it is reasonable since the suckers selected where in the same terrace, with equal soil and weather conditions, and with exception of sucker selection, the same farm management practices. The experimental area was within a long-term commercial banana plantation that have been infected with nematodes for long time.

In the follower sucker height, only in the second ratoon crop cycle, suckers selected at 60 cm height on un-shooting plants were taller than those selected at plant flowering. This faster growth should be related with the time of the year on which the selection was done. It is known that from December to May, temperatures and radiation are close to the optimum and frequent in the zone where the experiment was run.

Fig.1A-E Fresh root weight (g) of living roots (A), dead roots by nematodes (B), dead roots by other causes (C), total roots (D), and percentage of living roots in banana (*Musa* AAA cv. Valery) suckers selected at plant flowering or at 60 cm height in un-shooting plants across five ratoon crop cycles. Each bar is the average of ten repetitions. In each repetition, 10 follower suckers were evaluated, and a hole of 20 cm long, 20 cm wide, and 30 cm dept was dug at the base and in front of the follower suckers.

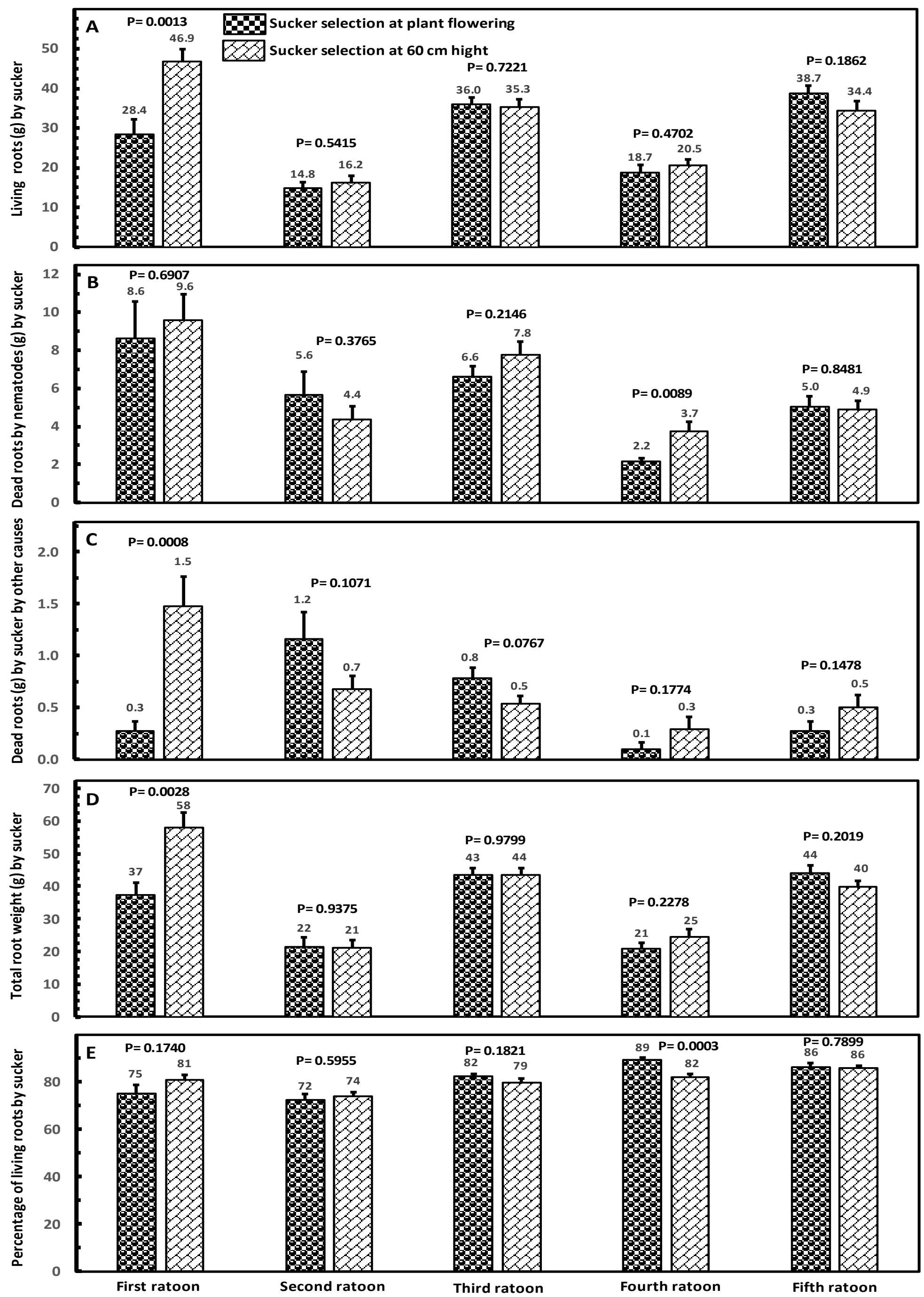


Fig.2 Proportion from the nematode population of each plant parasitic nematode genus in banana (*Musa* AAA cv. Valery) sucker roots by ratoon crop cycle. Each slide is the average of ten repetitions. In each repetition, 10 follower suckers selected at plant flowering and at 60 cm height in un-shooting plants, were sampled digging a hole of 20 cm long 20, cm wide, and 30 cm dept at the base and in front of them, and all roots were collected for nematode extraction.

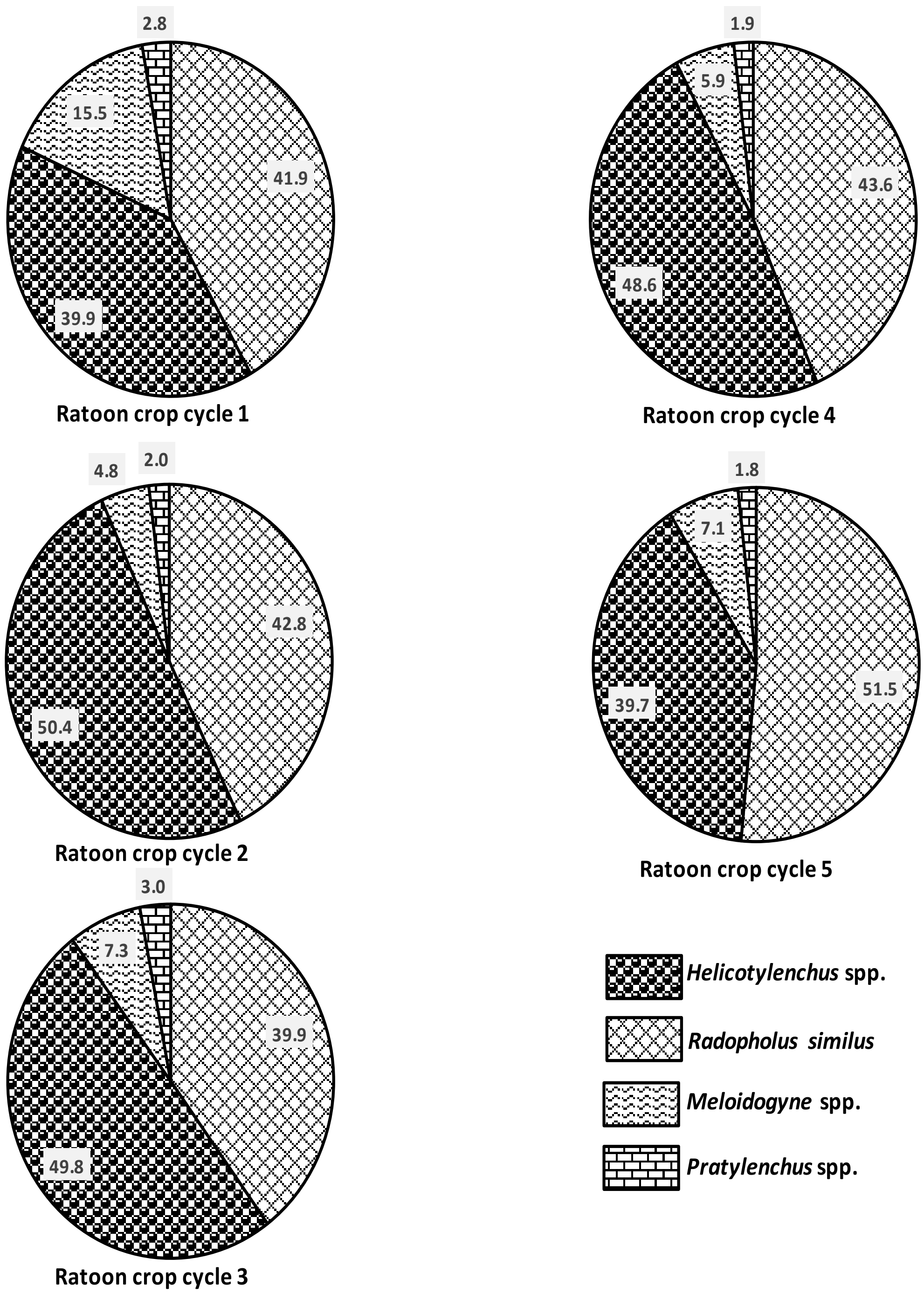


Fig.3A-D Number of *Pratylenchus* spp. (A), *Meloidogyne* spp. (B), *Helicotylenchus* spp., *Radopholus similis* (D), and total nematodes (E) per 100 g of banana (*Musa* AAA cv. Valery) roots by sucker selected at plant flowering or at 60 cm height in un-shooting plants across five ratoon crop cycles. Each bar is the average of ten repetitions. In each repetition, 10 follower suckers were sampled digging a hole of 20 cm long, 20 cm wide, and 30 cm dept at the base and in front of them, and all roots were collected for nematode extraction.

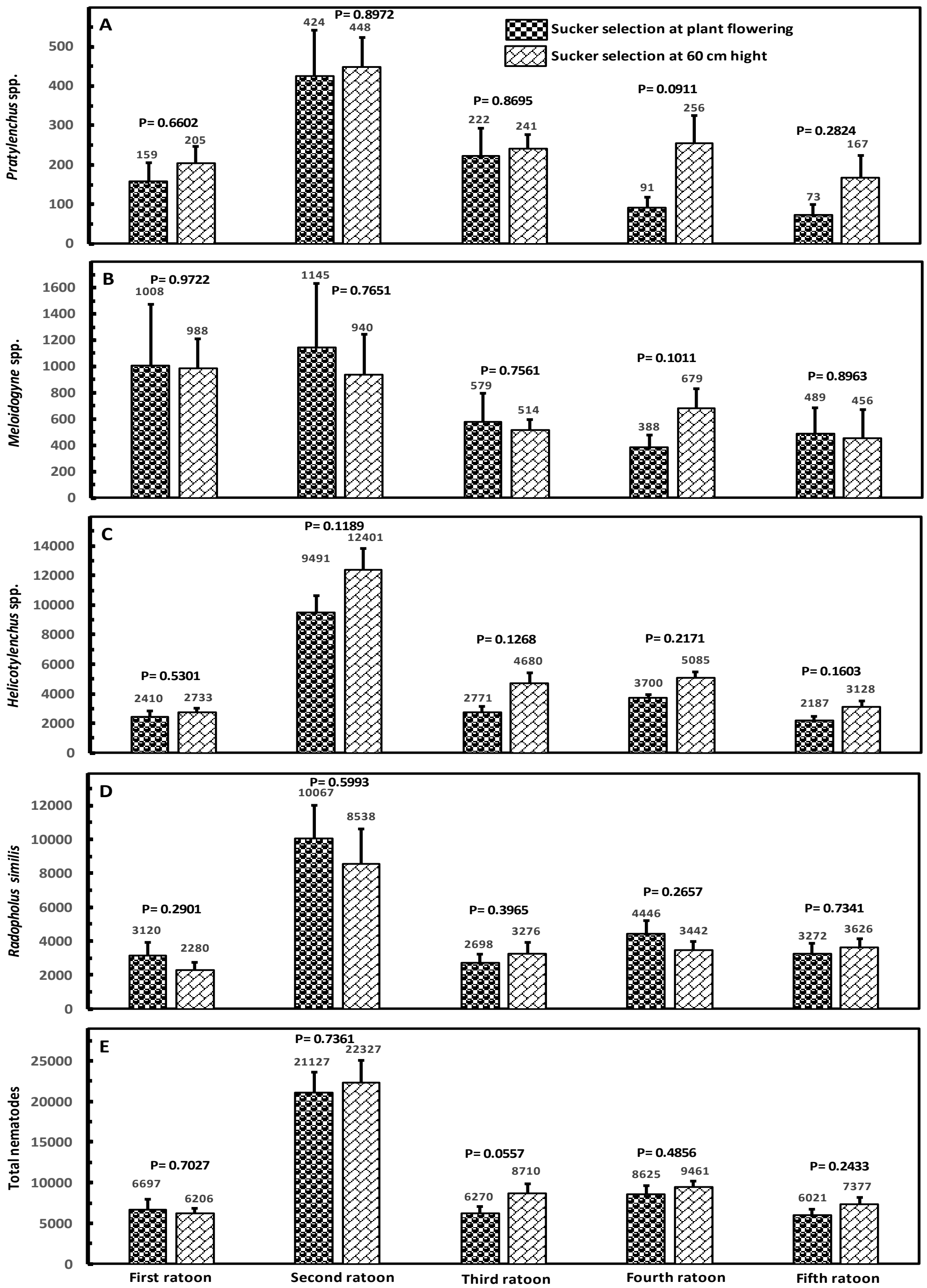
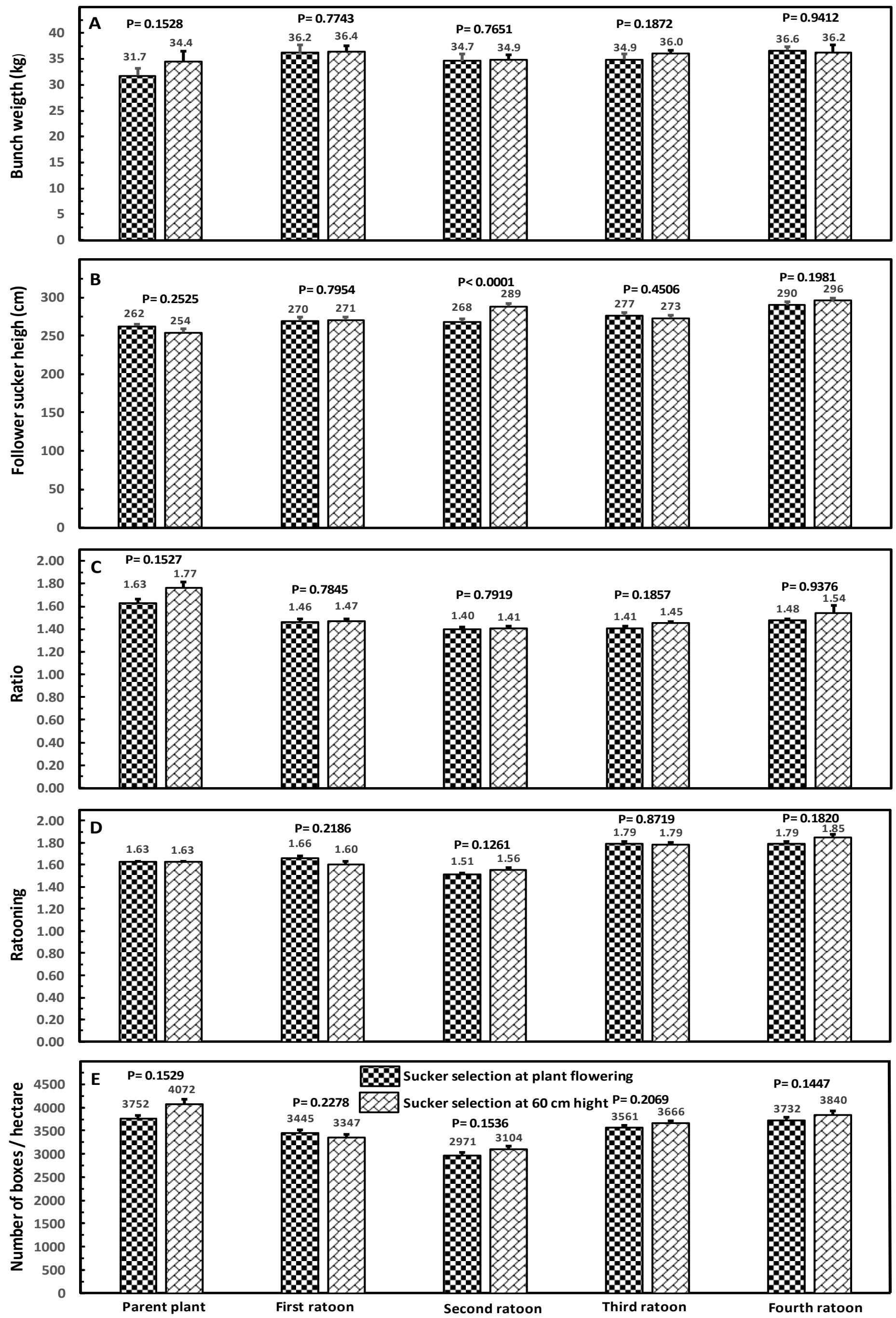


Fig.4A-E A) Bunch weight (kg), B) follower sucker height (cm), C) ratio (number of banana boxes of 18.14 kg per bunch), D) ratooning (number of bunches harvested by stool by year), E) number of boxes per hectare per year by sucker selected at plant flowering or at 60 cm height in un-shooting plants in the parent plant and across fourth ratoon crop cycles. Each bar is the average of ten repetitions and in each repetition 10 follower suckers were evaluated.



None of the yield variables (bunch weight, ratio, ratooning or number of boxes per hectare per year) evaluated was affected by the type of sucker selected at the parent plant and across the four ratoon crop cycles. Our results contrast with those of Raouf (2008) who reported increased vegetative growth, yield, shortest growth cycles and time to harvest, when unwanted suckers were removed at 15 and 20 cm height compared with suckers of 30, 40 and 100 cm height in the hot arid climate of Sudan. Also disagreed with Gasim *et al.,* (2014), who found as well in Sudam, that early de-suckering (15 cm and 20 cm) gave better plant height, pseudostem girth and total number of functional leaves than delayed de-suckering (30, 40 and 100 cm height). In South Africa, Robinson and Nel (1990) determined experimentally, that by allowing all excess suckers in a Williams plantation to reach a height of 50 or 80 cm before removal, average yield per annum after three cycles was decreased by 7.6 and 15.6% respectively, compared with the recommended 30 cm for de-suckering. However, it is necessary to keep in mind, that those differences were found within farm production systems developed in subtropical conditions.

In Costa Rica, tropical conditions, Soto *et al.,* (1992), Soto (2015) considered that unwanted suckers should be eliminated after they reach at least 60 cm height, while Stover and Simmonds (1987) recommended, also in tropical conditions to do the sucker selection at plant shooting, removing those with at least 1 m tall. Suckers with this height still have the leaves in the thin, bract like stage which does not compete with the selected follower sucker, while suckers with broad leaves, rapidly become competitive with the selected follower sucker. In tropical conditions, removing of undesired suckers must be done frequently between 4 and 8 weeks, not allowing them to become excessively large and unmanageable. For example, in Jamaica (Dadzie, 1999), in fields over 3 years old, recommend setting of followers during the routine pruning operation which it is carried out every 6-8 weeks. However, the frequency of de-suckering varies with the climate and labour costs. For example, In South Africa, monthly de-suckering it is recommended in summer, but it is unnecessary in winter (Robinson 2003). In Puerto Rico, de-suckering is carried out when labour it is available and at high cost.

Unwanted large suckers deplete the nutrient reserves of the stool, reduce transmission of radiation, cause a drain of assimilates from the parent plant, compete directly with follower sucker, extending the crop cycle and reducing the yield (Robinson and Galán, 2010, Robinson, 2003). Borah *et al.,* (2018) found on banana cv. Malbhog (AAB) in the state of Assam India, that mother plants + 1 sucker/plant recorded higher yield (19.73 t/ha), shorter period from harvesting of first crop to harvesting of first ratoon crop (72.92 days) compared with 2, 3 and 4 suckers per plant.

Even though, in both treatments, the unwanted young suckers were cut off at ground level leaving the meristem undamaged, the sucker regrows was so small (< 15 cm) that did not need cutting again in none of the ratoon crop cycles. One advantage of this way of de-suckering, is the prevention of spreading soil-borne diseases and nematodes since the tool did not get in contact with the soil. In addition, they give anchorage to the stool without drain assimilates from the parent plant.

The results obtained suggest that in tropical conditions, the selection of suckers must be made considering additional attributes of the de-suckering method because no differences in yield were found. Nevertheless, in the last three ratoon crop cycles consistently more than 100 (106 to 133) boxes per hectare per year were got when sucker selection was done on un-shooting plants. Considering the actual market price of a box of 18.14 kg of bananas of US $6.25 (El Universo, 2021b), the additional net income from the increase in yield, deducted the cost of labour of $0.75 of packing for each additional box would varies between US$ 580 to 732 per hectare per year, since all the other cultural practices were the same for both types of sucker selection. For those who prefer to do the sucker selection at plant flowering in Ecuadorian conditions, the unwanted suckers to be removed still have the leaves in the thin, bract like stage. Then, in parallel with Soto *et al.*, (1992), and Soto (2015) thought, we also believe that this surplus suckers in such stage give vitality and support to the mat due to sucker prolific root system that provides anchorage to the stool. However, we disagreed with them in the contribution of nutrients from the sucker to the mother plant. In contrast, our results are consistent with research that indicates a transfer of nutrients from the mother towards the sucker (Martín-Prevel, 1964; Wamsley and Twyford, 1968; Teisson, 1970; Lahav and Turner, 1992; Kurien *et al.*, 1999, 2002, 2006). In Costa Rica, (Araya and Vargas, 2002) comparing the bunch weight of parent plants with and without the follower sucker, found a higher bunch weight when follower sucker was eliminated at plant shooting, which support the translocation of assimilates from the parent to the follower. Along with the de-suckering, it is done the stem desheathing, it is removes the rotten standing pseudostem and the soil surface around the selected sucker it is cleaned.

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