Nutrient cycling from the *Musa* mother plant at various physiological stages to suckers as affected by spacing and sucker retention using tracer techniques

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Nutrient cycling from the *Musa* mother plant at various physiological stages to suckers as affected by spacing and sucker retention using tracer techniques.

Abstract — Introduction. A project was undertaken to study the nutrient cycling from *Musa* mother plants to daughter suckers based on the physiological stages of the mother plant. It also reports on the dependency or competition at critical stages of flowering and fruiting and the combinations of different densities and sucker retention at different physiological stages of the mother plant. **Materials and methods**. A combination of three spacings and five sucker retention phases formed 15 treatments. ^{32}P was given through injection into the mother plant pseudostem. The experiment was carried out over two years, the first being a rain-fed crop and the second being under irrigated conditions. **Results**. Differential aspects of nutrient cycling were observed between rain-fed and irrigated crops with regard to spacing. In the case of sucker retention phases, in the first year, it was retention at fruit maturity, shooting and flower bud differentiation stages which showed higher radioactivity recovery whereas, in the second year, it was the early phases of retention which showed significantly higher recovery. In the case of interaction effects, in the first year, the highest recovery was found in various combinations of spacing with the stages of bud initiation and shooting and, in the second year, the maximum recovery observed was in the combination of the closest spacing with the stage of flower bud initiation. In both years, recovery was observed in the border row plants. **Conclusion**. The study confirmed that activity extruded out from the treated plant and was absorbed by the border plants, revealing that nutrient sharing takes place in banana. This result opens up another concept that banana recommendation should not only be at an individual plant level but at block or plot level also. Hastening and improving the efficiency of nutrient cycling to the sucker is suggested as a future line of investigation.

India / *Musa* / tracer techniques / radioisotopes / spacing / nutrient transport

Transfert d'éléments nutritifs d'un plant mère de bananier à ses rejets, étudié par la technique des traceurs et en fonction de la densité de plantation et de la capacité de rétention des rejets.

Résumé — Introduction. Un projet a été entrepris pour étudier le transfert d'éléments nutritifs d'un plant mère de bananier à ses rejets fils en liaison avec le stade de développement physiologique du plant mère. Il a permis d'étudier également les relations de dépendance ou de concurrence existant aux stades critiques de la floraison et de la fructification et l'effet de combinaisons entre différentes densités de plantation et la rétention des rejets en fonction de différents stades physiologiques du plant mère. **Matériel et méthodes**. La combinaison de trois densités de plantation et de cinq stades de traitement reliés à la rétention des rejets a constitué les 15 traitements de l'expérimentation. Le ^{32}P a été injecté dans le pseudotronc d'un plant mère. L'expérimentation a duré deux ans ; la première année, la culture a été menée en saison des pluies et, la seconde année, elle a été effectuée en conditions irriguées. **Résultats**. Différents aspects du cycle de nutrition ont été observés selon que les cultures avaient été irriguées ou non et selon les densités de plantation. Pour la première année, le meilleur taux de récupération a été observé dans les rejets de plants traités lors des stades de maturité du fruit, de rejetonnage et de différenciation du bourgeon floral ; pour la deuxième année, ce sont les plants traités à des stades de développement précoces qui ont permis la meilleure récupération de la radioactivité dans leurs rejets. Par ailleurs, lors de la première année, la meilleure récupération a été trouvée dans diverses combinaisons de la densité de plantation et de plants traités lors des stades de l'initiation florale et du rejetonnage et, lors de la deuxième année, la récupération maximale a été observée pour la combinaison de la densité de plantation la plus forte et du plant traité au stade de l'initiation florale. Au cours des deux années, il y a eu une récupération de la radioactivité par les plants de bordure. **Conclusion**. L'étude a confirmé que l'activité était transférée hors du plant traité et était absorbée par les plants de bordure, ce qui indique qu'un partage des éléments nutritifs a lieu chez le bananier. Ce résultat introduit aussi un autre concept selon lequel les recommandations concernant la culture du bananier devraient non seulement concerner le plant individuel mais encore se situer à l'échelle du bloc ou de la parcelle. L'étude de l'activation et de l'amélioration de l'efficacité du cycle de nutrition du rejet est suggérée comme sujet de futures recherches.

Inde / *Musa* / technique des traceurs / isotope radioactif / espacement / transport des substances nutritives

1. Introduction

Musa culture in the warm humid southern part of most states of India is highly diversified. A pick of the 'Nendran' varieties is cultivated as a monocrop and receives the best of attention and care. However, most of the other varieties are confined to the homegardens. The shrinking land holding and the population explosion have made the homegardens the main cultivation system in the Kerala state (India) as it covers both as a food and security system. In the homegardens, the banana plant is observed to be a numerically dominant species due to its manifold uses. The male bud and green fingers are consumed as a cooked vegetable, the ripe fingers as a fruit and the pseudostem in the traditional healthcare system. Another speciality observed in the homegardens is that *Musa* is cultivated as ratoons. Desuckering and fresh planting are taken up only when reduced finger size and consequent reduction in yields are observed.

Clump management, thus, can assume significance and realisation of quality yields can be possible only if the mechanisms underlying the association or interactions between the mother plant and the follower or the daughter suckers are well understood. Initially, the daughter suckers are dependent on the mother plants and this nursing continues until a stage of physiological independence is reached. Transfer of nutrients from the mother plant to the followers and *vice versa* has been confirmed with experiments with ^{32}P [1]. Another similar work confirmed that suckers could contribute to the mineral nutrition of the mother plants [2]. Using tracer techniques, it has been clearly established that, in nature, this dependency and spacing of sucker production is timed in such a way that the first produced ones reach independence [3]. The concept of mattocking is based on the fact that there is translocation of nutrients from the portions of the mother plant after harvest to the suckers in the clump and has been a long-used practice. This has again been confirmed [4].

To date, no reports exist on the nutrient cycle or internal cycle from the *Musa* mother plant to the daughter sucker based on the physiological development of the mother plant. Further, the influences of the nutrient cycle based upon intermat competition at different spacings have never been attempted. Hence, this study gains all the more importance and was taken up as it can directly explain the nutrient cycle patterns at different physiological stages of the mother plant. This answers the question of the extent of the interplant dependency or competition at critical stages of flowering and fruiting and the combinations of different densities and sucker retention at different physiological stages of the mother plant.

2. Materials and methods

The 'Mysore', synonym 'Palayankodan', the most important clone of banana in India, was the material of the study and its manure practices were applied [5]. Suckers of uniform size and shape were selected from a large population. The planting was done such that each block consisted of nine plants with the central plant being considered as the experimental plant receiving the radioactivity.

The study was conducted as a fully funded *ad hoc* project of the Indian Council of Agricultural Research (ICAR), in the central orchard and the radiotracer laboratory in the main campus of Kerala Agricultural University (India) located at 12° 32' N and 74° 2' E, at an altitude of 22.52 m. The experiment was conducted over 2 years. The soil of the area belongs to the great group eutroothox order oxisol, Vellanikkara series with a pH of 5.3 soil–water (1:2.5), organic carbon content of 0.47%, CEC of 10.4 cmol (p+)·kg^{-1} and pore space of 42.83%.

A combination of three spacings (1.5 m × 1.5 m, 1.8 m × 1.8 m and 2.0 m × 2.0 m) with five stages of sucker retention (retention of a sucker at the early vegetative phase, vegetative phase, flower bud initiation phase, shooting phase and fruit maturity stage) formed the 15 treatments. For each of the 15 treatment plots, another similar plot was maintained without suckers. The stages studied were selected from a previous work [6] carried out with the same variety and reviewed by the ICAR technical committee. The two common major seasons of planting in the Kerala state formed the two separate experiments.

In the first experiment, planting was done on 15 April; that planting date coincided with the rain-fed banana crop of the state, which is nourished by the south-west monsoon from June to August and by the north-east monsoon from September to November.

The second experiment, done on 1 September, coincided with the most important planting time of banana in the state, which is the normal irrigated crop of the state; the crop received irrigation once every three days as per the package of practices recommendation.

Two holes were bored using iron nails on opposite sides of the mother plant pseudostem at a level (height) distance of 15 cm from each other. The height of the boring from the base was midway between 1/2 and 3/4 of the height of the mother plant which was selected for the experiment. The depth (1.5 inches) and inclination of the holes were prepared using distilled water [7]. The holes were pierced accordingly on the previous day of application and sealed using a tape. After all the retention phases were achieved, ^{32}P was procured from the Bhaba Atomic Research Centre, Bombay (India), and a dose of 1 mCi and 0.5 mCi per plant was given during the first and second year, respectively, through the two previously bored holes in the pseudostem. The dose was given using a micro pipette such that each hole and every experimental plant received an identical dose.

Sampling was done four times at ten day intervals beginning from the fifth day after application of the isotope. The mid-portion of the second full opened leaf was used for the analysis. The leaf samples from the suckers of the experimental plants and border plants on all the four sides were collected. The recovery of the radioactivity was measured using a liquid scintillation counter (Rack Beta of LKB Wallac OY, Finland) following a di-acid digestion. The activity was corrected for background radiation and radiation decay by giving it a common zero hour and it was expressed as counts per minute per gram of the dried leaf sample ($cpm \cdot g^{-1}$). To facilitate comparison between years, the recovery of activity was multiplied by a common factor of two.

The data in each experiment was logarithmically transformed and analysed using the analysis of variance technique [8].

3. Results

The recovery of radioactivity applied through pseudostem injection was monitored in the daughter suckers and border plants in all the 15 treatments on all the four sampling dates (i.e., 5, 15, 25 and 35 d after application) during the 2 years of study (*tables I, II*).

In both the years, the radiotracer applied to the pseudostem of the experimental mother plant could be retrieved not only in the daughter suckers but also in the border plants.

3.1. Effect of spacing

A comparison of the effect of spacing did not show any significant difference in the first year. However, in the first sampling (5 d after injection), the recovery of the radioactivity was highest in the suckers of the widest spacing (spacing 3); in the second samplings (15 d after injection), this effect was highest in the closest spacing (spacing 1); in the third and fourth samplings (25 d and 35 d after injection), all the spacings showed almost the same recovery of activity. In the border plants, the highest activity was observed in the closest spacing in the first sampling, but, in the later samplings, the widest spacing showed the highest activity.

During the second year, the effects of spacing were not significant, but a definite trend was observed. In the first two samplings, the suckers of the closest spacing showed the maximum activity, whereas it was just the reverse in the last two samplings. Almost an identical trend was observed in the border plants in the second year.

3.2. Effect on sucker retention

With regard to the sucker retention, it was observed that, in the first year, the retention at the fruit maturity, shooting and flower

Table I.
Recovery of activity (cpm·g^{-1} of dry matter) in *Musa* daughter suckers and border plants after the injection of the mother plant pseudostem with a dose of 1 mCi ^{32}P (1st year) (spacing 1: 2.0 m × 2.0 m; spacing 2: 1.8 m × 1.8 m; spacing 3: 1.5 m × 1.5 m).

Stage of ^{32}P injection	5 d after injection			15 d after injection			25 d after injection			35 d after injection		
	Spacing 1	Spacing 2	Spacing 3	Spacing 1	Spacing 2	Spacing 3	Spacing 1	Spacing 2	Spacing 3	Spacing 1	Spacing 2	Spacing 3
(a) Daughter suckers												
Early vegetative	100.45 (1.65)[1]	251.95 (2.15)	6909.69 (3.643)	180.44 (2.18)	1270.09 (2.84)	413.71 (2.55)	0.0 (0.0)	0.0 (0.0)	740.33 (2.37)	0.0 (0.0)	71.70 (1.53)	860.09 (1.62)
Vegetative	3141.69 (3.33)	145.07 (2.04)	279.11 (1.37)	1696.54 (3.20)	534.96 (1.52)	22.54 (0.83)	96.895 (1.98)	1020.87 (1.66)	46.71 (0.99)	45.36 (0.98)	1115.45 (1.67)	121.45 (2.04)
Flower bud initiation	2693.27 (3.41)	1212.62 (2.49)	205.92 (1.42)	495.50 (2.59)	75.79 (1.89)	1698.57 (3.20)	1205.25 (3.07)	1089.55 (2.78)	326.93 (2.45)	807.77 (2.91)	1165.20 (2.14)	113.04 (1.18)
Shooting phase	170.81 (1.27)	301.47 (1.39)	34.9 (2.07)	36.46 (1.57)	35.90 (1.35)	2949.13 (3.06)	729.84 (2.26)	35.895 (0.93)	0.0 (0.0)	713.39 (1.58)	128.40 (2.00)	264.14 (1.36)
Fruit maturity	16368.5 (3.31)	0.0 (0.0)	532.92 (1.93)	1272.97 (2.75)	75.735 (1.81)	367.565 (2.34)	25.45 (0.86)	14.29 (0.74)	571.61 (1.53)	847.88 (1.62)	14.99 (0.75)	610.95 (2.50)
(b) Border plants												
Early vegetative	532.92 (1.51)[1]	14.07 (1.34)	1505.92 (2.95)	3537.87 (3.51)	59.19 (1.73)	458.54 (2.45)	6297.40 (3.69)	35.89 (0.93)	330.42 (2.14)	5960.27 (3.67)	22.68 (1.35)	458.52 (2.22)
Vegetative	45.70 (0.98)	1585.11 (3.20)	621.48 (2.43)	105.01 (1.92)	49.33 (1.00)	105.01 (1.94)	1185.30 (2.91)	0.0 (0.0)	64.83 (1.06)	1245.32 (2.96)	34.39 (0.92)	45.36 (1.67)
Flower bud initiation	59.88 (1.75)	221.19 (1.32)	146.15 (1.23)	229.77 (2.14)	862.75 (1.62)	653.03 (2.32)	107.70 (1.17)	690.46 (2.17)	341.22 (1.42)	101.71 (1.96)	516.57 (1.51)	411.200 (2.33)
Shooting phase	727.72 (2.28)	450.18 (2.29)	243.12 (2.11)	2361.70 (3.37)	934.99 (2.79)	96.65 (1.99)	1031.67 (2.55)	43.22 (0.97)	1117.77 (2.52)	1219.71 (2.86)	37.68 (0.94)	1098.29 (2.66)
Fruit maturity	185.97 (1.20)	129.35 (1.99)	2140.93 (3.32)	171.55 (1.94)	1686.65 (3.18)	187.12 (2.27)	902.03 (2.83)	566.35 (2.66)	222.71 (2.35)	852.77 (2.84)	1474.33 (3.10)	256/45 (2.35)

[1] Figures in parenthesis show mean of log transformed values.
Critical difference (p = 5%) for comparison of suckers and border plants is not significant.
Critical difference (p = 5%) for comparison of spacing is not significant.
Critical difference (p = 5%) for comparison of sucker stage of injection is not significant.
Critical difference (p = 5%) for comparison of spacing × sucker retention is not significant.

bud initiation stages showed higher recovery in the later samplings. In the border rows, the same trend was observed in the first sampling, but in the second, third and fourth samplings, the earliest retention phase showed the maximum recovery of activity.

In the second year, the effects of sucker retention were significant. Early sucker retention phases showed higher recovery

Table II.
Recovery of activity (cpm·g^{-1} of dry matter) in *Musa* daughter suckers and border plants after the injection of the mother plant pseudostem with a dose of 0.5 mCi ^{32}P (2nd year) (spacing 1: 2.0 m × 2.0 m; spacing 2: 1.8 m × 1.8 m; spacing 3: 1.5 m × 1.5 m).

Stage of ^{32}P injection	5 d after injection			15 d after injection			25 d after injection			35 d after injection		
	Spacing 1	Spacing 2	Spacing 3	Spacing 1	Spacing 2	Spacing 3	Spacing 1	Spacing 2	Spacing 3	Spacing 1	Spacing 2	Spacing 3
(a) Daughter suckers												
Early vegetative	10689.03 (3.22)[1]	53.04 (1.72)	2257.48 (3.11)	20754.7 (3.51)	96.75 (1.99)	4616.38 (3.38)	2880.06 (3.25)	15.05 (0.98)	7012.53 (3.55)	3825.05 (3.04)	470.17 (0.99)	4773.71 (3.31)
Vegetative	1124.21 (2.86)	317.60 (2.16)	3630.20 (3.55)	2077.36 (3.08)	535.86 (2.35)	6862.63 (3.82)	2902.75 (3.24)	609.03 (2.40)	1029.9 (3.99)	1209.33 (2.99)	692.13 (1.57)	3323.07 (3.43)
Flower bud initiation	1460.89 (2.95)	440.15 (2.21)	10962.0 (2.95)	2596.75 (3.17)	702.59 (2.40)	22775.2 (2.82)	4160.75 (3.37)	864.03 (2.47)	2794.84 (2.83)	5061.34 (3.36)	947.96 (1.64)	575.97 (2.15)
Shooting phase	86.68 (1.91)	1438.41 (3.02)	1618.28 (1.76)	181.94 (2.26)	19577.6 (3.18)	2379.37 (2.83)	226.10 (2.35)	3043.43 (3.45)	3822.45 (2.67)	185.31 (2.66)	1746.21 (3.54)	2774.00 (1.87)
Fruit maturity	930.96 (2.94)	405.98 (2.61)	109.69 (1.17)	1637.64 (3.184)	681.62 (2.83)	180.40 (1.28)	2462.45 (3.33)	1056.55 (3.02)	264.78 (2.20)	2133.09 (3.29)	751.36 (2.74)	0 (0.0)
(b) Border plants												
Early vegetative	1263.44 (2.94)[1]	214.90 (2.09)	1681.46 (3.06)	2146.31 (3.16)	395.39 (2.36)	2749.80 (3.28)	4042.18 (3.45)	634.95 (2.49)	4478.23 (3.47)	6390.29 (3.61)	840.79 (1.61)	6975.23 (3.67)
Vegetative	126.52 (1.20)	660.59 (2.22)	2435.03 (3.18)	2115.11 (2.57)	1376.09 (2.57)	4116.96 (3.40)	2975.85 (1.89)	2229.55 (2.66)	1285.10 (3.11)	5111.10 (2.01)	2704.91 (1.87)	1174.00 (3.06)
Flower bud initiation	289.48 (2.39)	1234.33 (2.48)	180.31 (2.04)	478.21 (3.56)	2208.44 (2.92)	318.00 (2.39)	1059.95 (3.00)	3499.90 (2.90)	169.58 (1.27)	1313.04 (2.98)	5541.20 (2.65)	295.94 (2.29)
Shooting phase	2382.62 (2.94)	507.93 (2.32)	344.12 (2.18)	4230.00 (3.17)	876.40 (2.64)	612.93 (2.55)	7057.55 (3.42)	978.35 (1.27)	480.28 (2.46)	9872.38 (3.50)	1644.94 (3.02)	672.08 (1.56)
Fruit maturity	549.49 (2.55)	1158.65 (2.67)	1012.18 (2.74)	930.1 (2.78)	1712.96 (2.73)	1704.04 (2.96)	1558.90 (3.021)	2595.90 (2.83)	1920.58 (3.03)	2352.29 (3.18)	3997.91 (2.92)	2283.14 (3.12)

[1] Figures in parenthesis show mean of log transformed values.
Critical difference (p = 5%) for comparison of spacing is not significant.
Critical difference (p = 5%) for comparison of sucker stage of injection is not significant for the border plants and equal to –1.137 for the dauthter suckers.
Critical difference (p = 5%) for comparison of spacing × sucker retention is not significant.

Figure 1.
Mean recovery of phosphorus activity in *Musa* suckers of a treated plant (injection of ^{32}P) in rain-fed and irrigated conditions.

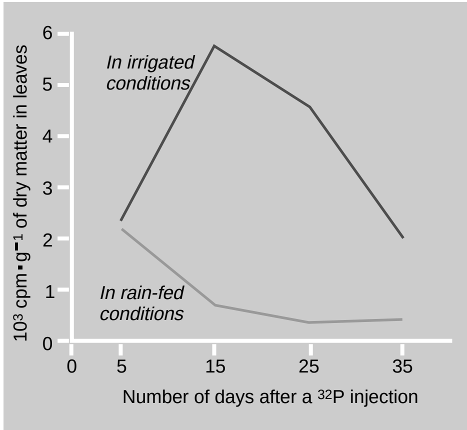
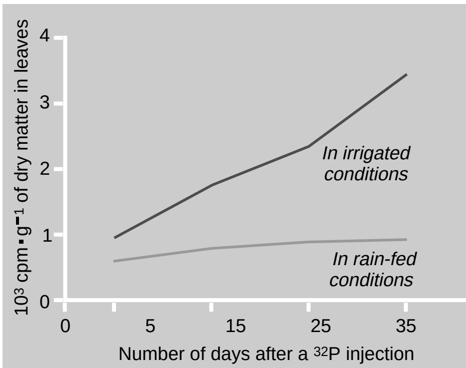


Figure 2.
Mean recovery of phosphorus activity in *Musa* border plants of a treated plant (injection of ^{32}P) in rain-fed and irrigated conditions.



of activity in the suckers. A similar trend was observed in the border plants but it was not significant.

3.3. Interaction effects of spacing and sucker retention

In the first year, the interaction effects revealed that the nutrient cycle was the best in the combination effects of spacing with that of various fruiting stages. At the first sampling, it was the combination of the widest spacing (spacing 1) with the treatment at the fruit maturity stage which showed the best nutrient cycle; at the second sampling, it was the closest spacing (spacing 3) with the shooting phase; at the third and fourth samplings, the combination of the widest and intermediate spacings (spacing 1 and 2) with the flower bud initiation stage showed the best interaction effects. On the contrary, in the border rows, the best interaction effect occurred in the last sampling with the combination of the closest spacing with the fruit maturity stage, followed by the widest spacing with the earliest vegetative stage of the plant.

In the second year, the interaction effects revealed a different trend. In the first and second samplings, the maximum recovery observed was in the combination of the closest spacing (spacing 3) with the flower bud initiation stage; in the third sampling, it was the closest spacing (spacing 3) combined with the earliest stage of plant development, whereas, in the last sampling, it was the widest spacing (spacing 1) with the flower bud initiation stage. In the case of the border rows, the highest recovery in the first sampling was observed when the closest spacing was combined with the second vegetative phase of plant development. In all other samplings, it was the widest spacing at the shooting phase which showed the highest recovery.

3.4. Recovery of activity at different sampling intervals

The mean percentage of the nutrient cycle to the sucker plants and the recovery observed in the border plants revealed an interesting trend (*figures 1, 2*).

The nutrient cycle to the daughter suckers in the rain-fed crop was found to reduce from the first sampling to the third. The mean values were very similar in the third and fourth sampling intervals. On the contrary, in the irrigated crop, the values were found to increase from the first to second and then gradually decrease to the fourth sampling. However, the differences between the second and third were not explicit.

In comparison, the activity in the border plants revealed an identical trend, whether it was rain-fed or irrigated. In both cases, the recovery of activity increased from the the first to fourth sampling. The increase observed from the first to the last sampling in the recovery in the rain-fed crop was only a half time more, whereas in the irrigated crop it was more than three and half times more.

The results of the study on the mat competitions revealed that, in all the

15 treatments, the border plants showed sizeable recovery of radioactivity. The studies involving the pseudostem injection and the retrieval of activity in the border row plants in all the 15 treatments revealed that the activity injected into the mother plants was extruded out from the roots of the treated plant and this activity was absorbed by the neighboring border plants, confirming that nutrient sharing takes place both between mats and within a mat.

4. Discussion

A critical analysis of the results reveals that, in the first year, the widest spacing (2.0 m × 2.0 m) in the first sampling (5 d after the ^{32}P treatment) and the closest spacing (1.5 m × 1.5 m) in the second sampling (15 d after the ^{32}P treatment) recorded the highest nutrient cycling. On the contrary, in the second year, the closest spacing recorded the maximum recovery. In the later samplings (35 d after the ^{32}P treatment), almost the same trend was observed in the first year but, in the second year, the widest spacing showed the best recovery. This result can be argued only on the basis of the management. Another reason could be mobility. The differential cycling in rain-fed and irrigated crops is a pointer in this direction, with its effect on the mobility. However, this is one aspect which requires further investigation. In the rain-fed crop, the results were not as explicit as those of the irrigated one. Results of the irrigated crop in the first two samplings are contrary to expectations and reveal that if the crop is nurtured and well managed, the closer spacing, instead of adversely affecting the cycling pattern, rather improves it. The yield and benefit cost ratio, which was separately worked out, confirms this point.

The effects of sucker retention at different physiological phases of the mother plant were revealed with more clarity. In the rain-fed crop, in gross contrast, the different stages from the flower bud initiation to the fruit maturity showed better cycling of nutrients, revealing that the developing acted as a good physiological sink and was not much influenced by the flowering or fruiting. The highest average yields of (6.17 and 5.92) kg fruits per plant obtained at fruiting and flowering phases support this finding. During the second year, the retention stages at the flower bud initiation and early vegetative phase in the two early and late samplings gave the highest recovery. As this was an irrigated crop and there were no limitations involved, it should be inferred that, under ideal conditions, the cycling of nutrients to the daughter sucker is not much influenced by the physiological phase of the mother plant.

Nutrients differ in their mobility. Phosphorous is highly mobile within the plant and is involved in reactions in which organic compounds are phosphorylated or dephosphorylated. As older tissues become less metabolically active, phosphorus is transported to sites where increasing activity creates a demand, thus paving the way for internal redistribution [9]. The results in our study of better cycling patterns in the late stages of retention in the rain-fed crop and those at flower bud differentiation in the irrigated crop can be explained by the lesser age of the sucker. They also opined that the net amount is some fraction of the total amount required to grow the leaf.

Withdrawal of P during leaf senescence is an established factor. The movement of P by internal distribution has been estimated to be 46% of the total annual cycle in *Eucalyptus* [10]. In in-depth studies in Australia [11] and in Scotland [12] on nutrient cycling and internal redistribution, the authors have proposed three definable and sequential stages of forest growth. The first stage of growth is the development of the photosynthetic and metabolic transport system, the second is the development of the support structure and third stage is one of maintenance. In the present study, the young developing suckers are in the first stage and are in the process of the development of the support structure whereas the mother plant stage is in the stage of maintenance. This, along with the withdrawal of P from the old mother plant, should be the reason for the cycling. The extent of cycling is one area which requires further attention. If this can be quantified in relation to the actual requirement of the plant, it would help in assessing the savings of costly fertilizer inputs. It will also open up another area of vital interest in improving the efficiency and in hastening the process of cycling. Monitoring the weekly loss of mineral nutrients from banana pseudostems after harvest, it was observed that nutrients were translocated to a young growing sucker, as is likely when mattocking is practiced, and this contributes to more than 40% of the requirement for all the elements, except Mg and Zn [13]. Though reports of the same are there in banana [4, 14], none of them have dwelt on the causes of this. On the other hand, it was reported that it is one of nature's mechanisms of perpetuation and this continues until the sucker reaches its physiological independence [3]. Same authors have also reported that this nurturing continues in such a way that the younger suckers in a clump receive more nutrients.

The differences observed in the sampling intervals in the first and second years can be explained only in terms of abiotic stress. In the rain-fed crop, the sucker should have been totally dependent on the mother plant and, hence, this led to a higher level of nutrient cycling in the early stage. In the second year, as water was not a limiting factor, the dependence of the sucker on the mother plant in the early stages should have been comparatively reduced and hence the nutrient cycling was spread over a longer period.

During both years, the recovery of activity in the border rows increased from the first to the fourth sampling. The isotope extruded out through the roots and nutrient sharing of the isotope was observed which was more explicit under irrigated conditions. Nutrient exudation through roots in banana has been previously reported [13] and a reduction in loss of nutrients by root exudation under increasing plant densities has also been reported [15].

Finally, it may be concluded that the study has generated results of immense practical relevance and that both the spacing and sucker development phases have a bearing on the nutrient cycling pattern. The mobility is affected by the irrigation. The nutrient cycling, if tapped efficiently, can result in reducing costly fertilizer inputs. Improving and hastening this process remain an area for future investigation. Most importantly, the amount of tracer recovered from the neighboring border plants confirms beyond doubt that the tracer is extruded out from the treated plant which is, in turn, absorbed by the neighboring plant. This proves that there is some form of nutrient sharing in operation both within a clump and between clumps, confirming that, in banana, the system of giving recommendation on an individual basis needs to be coupled with that at a block or plot level.

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Transferencia de elementos nutritivos de una planta madre de banano a los hijos en función de la densidad de siembra y de la capacidad de retención de los hijos, estudiada mediante la técnica de trazadores.

Resumen — **Introducción**. Se emprendió un proyecto para estudiar el ciclo de nutrición de una planta madre de banano a sus hijos en relación con el estado de desarrollo fisiológico de la planta madre. Ha permitido también estudiar las relaciones de dependencia o competencia existentes en las fases críticas de floración y fructificación y el efecto de combinaciones entre diferentes densidades de siembra y la retención de los retoños en función de los diferentes estadios fisiológicos de la planta madre. **Material y métodos**. La combinación de tres densidades de siembra y de cinco fases de tratamiento vinculadas a la retención de los hijos formaron los 15 tratamientos de la experimentación. El ^{32}P fue inyectado en el seudotallo de una planta madre. La experimentación duró dos años; el primer año, el cultivo se condujo en temporada de lluvias y, el segundo año, en condiciones de riego. **Resultados**. Se observaron diferentes aspectos del ciclo de nutrición dependiendo de que los cultivos hubieran sido o no regados, en función de las densidades de siembra. Durante el primer año, la mejor tasa de recuperación se observó en los hijos de plantas tratadas durante las fases de madurez del fruto, de retoñamiento y de diferenciación de la yema floral; en el segundo año, las plantas tratadas en fases de desarrollo precoces permitieron la mejor recuperación de la radioactividad en sus hijos. Por otra parte, durante el primer año, la mejor recuperación se encontró en diversas combinaciones de la densidad de siembra y de plantas tratadas en estadios de iniciación floral y de retoñamiento y, durante el segundo año, la recuperación máxima fue observada en la combinación de la densidad de siembra más alta y de la planta tratada en la fase de iniciación floral. Durante estos dos años, se produjo una recuperación de la radioactividad por las plantas colindantes. **Conclusión**. El estudio confirmó que la actividad se transfería fuera de la planta tratada y era absorbida por las plantas colindantes, lo que indica que se produce un reparto de los elementos nutritivos en el banano. Este resultado introduce también otro concepto según el cual las recomendaciones que conciernen el cultivo de banano no sólo deberían aplicarse a una planta individual sino que también deberían abarcar el bloque o la parcela. El estudio de activación y de mejora de la eficacia del ciclo de nutrición del hijo se sugiere como tema para futuras investigaciones.

India / *Musa* / técnicas de trazadores / radioisótopos / espaciamiento / transporte de nutrientes