Recent Advances in Plant Nutrition Management of Banana

Bülent Topcuoğlu

Abstract— **There have been significant differences from past to present in the cultivated varieties of the Banana plant, which is widely produced in tropical and semi-tropical regions of the world. It is seen that the varieties that are widely cultivated today have higher values than the varieties cultured in the past 60 years in terms of total biomass, fruit weight and fruit productivity per unit area and total nutrient uptake. In regions with climate limitations for banana culture, greehouse cultivation has also been commonly used in recent years due to the developments in agricultural technologies, and it has become possible to obtain high quality and abundant Banana products with advanced irrigation and plant feeding techniques and effective pest control methods. Fertigation and foliar fertilizer applications in fertilization are used more effectively in the banana plant nutrition compared to the usual base and top fertilizer dressing methods. The amount of plant nutrients removed from the soil with the harvested banana fruit is one of the important criteria for fertilizer recommendations. Since Banana varieties cultivated today show a wide variation in terms of total biomass values and nutritional requirements. It is evaluated that arrangement of variety-specific nutrition programs in fertilization management, application of fertilizer doses and forms in accordance with phenological periods which determined according to soil and leaf analysis report and effective communication between the farmers and the analysis laboratory that suply fertilization recommendation should be provided for an effective nutrition manegement.**

***Keywords*—Banana, Nutrient Requirement, Fertilization.**

I. Biomass And Nutrient Consumption Of Banana Plant

Banana plant can grow well in different geographies of the world by adapting to a wide variety of soils. Generally, uncompacted soils with high water holding capacity, well-drained texture and pH of 5 to 7.5 provide ideal growing environments in many climatic conditions. Banana plant is a large perennial plant with a pseudostem structure and leaf covers. The plant height can vary up to 270 cm in length and 60 cm in width in many varieties and can form 8-12 leaves. In light textured soils, root development can be intense, in some cases it can extend laterally up to 9 m. Plant height, bunch size and other characteristics vary widely depending on the varieties. With these features, there is a special nutritional requirement due to the fact that it creates a significant amount of biomass per unit area during a growing period.

According to the Banana varieties cultivated in the world and the production techniques and methods applied over time, the biomass values obtained from the unit area of the Banana plant have increased significantly since the last 60 years (Table 1). Due to the fact that the banana plant needs more nutrients than the fruit plants taken in many other cultures; Considering the plant density growing in a unit area in a plantation, it causes the consumption of very high amounts of nutrients per unit area in a production season and the necessity of fertilizing to meet this requirement arises.

TABLE I. CHANGES RECORDED IN THE BIOMASS OF THE BANANA PLANT CULTIVATED SINCE THE 1960s. [I, 2]

	1960's	**1990's**	**Current values**
Average plant height (cm)	150	270	300-500
Average bunch weight (kg)	18	28	45-60
Bunch number (adet/ha)	1700	2100	-
Average yield (ton/ha)	30	60	60-100

TABLE II. AMOUNT OF NUTRIENTS REMOVED FROM SOIL BY DIFFERENT CROPS DURING FRUIT HARVEST. [3]

Fruit Species	Average yield (ton/ha)	Plant nutrients removed by plants (kg/ha)		
		N	P_2O_5	K_2O
Banana	40	250	60	1000
Citrus	30	270	60	350
Grape	20	170	60	220
Apple	25	100	45	180

The food consumption of the banana plant is in a wide range among the varieties that have adapted to very different regions in the world geography. Table 3 compares the average food consumption of the Cavendish variety which is widely cultivated in the world and other varieties. According to these data, there are differences among the varieties especially in the consumption of N, P and K nutrients.

TABLE III .AVERAGE NUTRIENT CONSUMPTION OF CAVENDISH BANANA VARIETY AND OTHER BANANA VARIETIES. [4]

Varieties	Plant nutrients (kg/ton Biomass)					
	N	P_2O_5	K_2O	MgO	CaO	S
Cavendish	4-7	0,9-1,6	18-30	1,2-3,6	3-7,5	0,4-0,8
Others	→10	→ 3,5	→ 60	1,2-3,6	→ 12	0,4-0,8

Banana plant generally takes macronutrients from the soil in the order K> N> Ca> Mg> P; and micronutrients in the order Mn> Fe> B> Zn> Cu during the vegetation [5]. Although there are differences in the proportional distribution of nutrients in leaves and fruits, K and N nutrients are dominant in both plant tissues (Figure 1 and Figure 2). In all nutrients, the nutrient accumulation rate of the fruit in the total biomass is nearly half with the exception and almost half of the fertilizer nutrients applied in plant nutrition practice are removed by the fruit product (Table 4).

Manuscript received April. 9, 2021.

Bülent Topcuoğlu is with the Akdeniz University Vocational School of Tech. Sciences, 07058, Antalya, TURKEY.

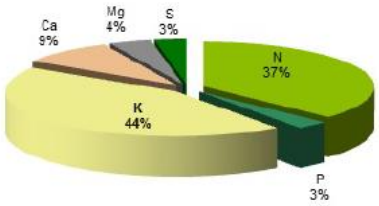

Fig. 1. Proportional content of plant nutrients in banana leaves.

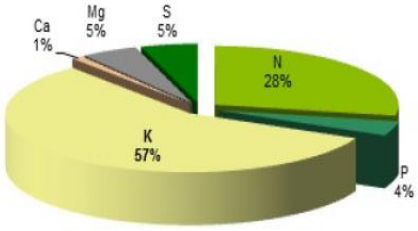

Fig. 2. Proportional content of plant nutrients in banana fruit

TABLE IV. NUTRIENT REMOVAL BY BANANA PLANT (50 TONS / HA; 200 PLANTS/HA; CAVENDISH VAR.) BY THEIR FRUIT AND PSEUDO-STEM FROM SOIL. [6]

Nutrient	Total uptake (kg/ha)	Removal in fruit (kg/ha)	Removal in pseudo-stem (kg/ha)	Nutrient absorption rate of fruit, %
N	388	189	199	49
P	52	29	23	56
K	1438	778	660	54
Ca	227	101	126	45
Mg	125	49	76	39

II. Soil And Nutrient Requirements Of Banana Plant

By adapting to various climatic and soil conditions around the world, it has provided a wide variation in Banana production. The optimum soil requirements of the various varieties of the Banana plant in cultural conditions have also varied in this context. In various countries, the ideal soil criteria adopted in production in accordance with the Banana varieties compatible with the climate and soil conditions of the regions where the banana plant is cultivated have been established. There are quite a wide range of differences in some of these soil criteria proposed in the previous years for Banana varieties cultivated in various geographical conditions. (Table 5). The minimum soil requirements of Banana varieties that are widely cultivated today and their soil and nutrient requirements are presented in Table 6.

TABLE V. SUGGESTED SOIL NUTRIENT LEVELS FOR BANANA PLANT GROWTH IN DIFFERENT COUNTRIES. [7]

	P, mg/kg	K, meq/100 g	Ca, meq/100 g	Mg, meq/100 g
Carribbeans	40	0,4		
Martinique	25	0,5	3	1
Costa Rica	5-10	0,5-0,6	15-20	1,5-1,9
Australia		1,4	15	5

TABLE VI. IDEAL SOIL CHARACTERISTICS AND MINIMUM SOIL NUTRIENT LEVELS RECOMMENDED FOR BANANA PLANT GROWTH. [8]

Nutrient	Unit	Ideal ranges
P	ppm	50-75
K	meq/100 g	0,4-0,5
Ca	meq/100 g	4-10
Mg	meq/100 g	1-3
pH (1:5 water suspention)		5-6,5
EC	dS/m	< 0,15

In the mineral nutrient contents of the banana plant, leaf nutrient values were lower than today due to the cultivated varieties and the fertilization practices applied before the last 30-50 years. (Figure 3).

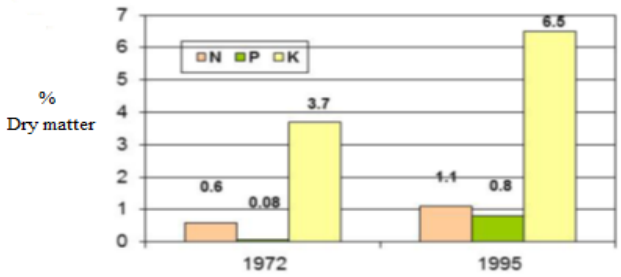

Fig. 3. Proportional levels of N, P and K nutrients determined in leaves of banana plant in the past years. [1]

During these years, there was almost no change in the adopted nutritional adequacy levels of the leaf blade, but over the years the predicted N, P and K levels in the petiole and leaf blade were rearranged (Table 7), and variety-specific sufficiency levels were proposed for different varieties (Table 8). The high genetic yield capacity and high plant nutrient consumption of the varieties newly cultured were determinant in this. n the nutrition program of the banana plant, the nutritional adequacy levels can be determined by leaf analysis during the growing period and the feeding program can be arranged when necessary.

TABLE VII. AVERAGE NUTRIENT CONTENTS IN THE TISSUES OF THE BANANA PLANT AND THE RECOMMENDED CRITICAL LEVELS OF NUTRIENTS IN THE LEAF BLADE (UPPER THIRD LEAF). [6]

Nutrient	Leaf blade (Leaf 3)	Midrib (Leaf 3)	Petiole (Leaf 7)	Leaf blade sufficiency ranges (in past)	Leaf blade sufficiency ranges (current)
N, %	2,6	0,65	0,4	2,4-3	2,5-3
P, %	2,2	0,08	0,07	0,15-0,25	0,17-0,4
K, %	3	3	2,1	2,7-3,5	2,3-4
Ca, %	0,5	0,5	0,5	0,4-1	0,7-1,4
Mg, %	0,3	0,3	0,3	0,2-0,36	0,24-0,4
Fe, ppm	80	50	30	60-80	100-300
Mn, ppm	25	80	70	25-150	200-2000
Zn, ppm	18	12	8	15-18	12-50
Cu, ppm	9	7	5	5-9	5-30
B, ppm	11	10	8	11	15-50
Mo, ppm	1,5-3,2	-	-		0,25-1
S, %	0,23	-	0,35		0,25-0,5

TABLE VIII. OPTIMAL NUTRITIONAL STANDARDS IN LEAVES OF CAVENDISH AND LADYFINGER BANANA VARIETIES. [4,8,9]

Nutrient	Cavendish var. leaf blade optimum sufficiency ranges	Ladyfinger var. leaf blade optimum sufficiency ranges
N, %	2,8-4	2,4-3,2
P, %	0,19-0,25	0,15-0,2
K, %	3-4	2,4-3,2
Ca, %	0,74-0,125	0,74-0,125
Mg, %	0,3-0,46	0,3-0,46
B, ppm	10-20	10-20
Zn, ppm	20-35	20-35

Achieving efficiency and quality in banana production depends on sufficient and balanced fertilization to a great extent. On the other hand, it is seen that in regions where large-scale banana fruit trade is carried out, it is also important to improve the storage characteristics of banana fruit with appropriate feeding management and to improve the quality of fruit storage.

The root system of the banana plant generally spreads in a limited volume of 60 cm deep in the topsoil and makes use of plant nutrients in this volume during the growing period. In order to obtain high yield from the banana plant, which is difficult to produce, an appropriate fertilization planning should be made, taking into account the soil conditions, the variety selected and other cultural practices to be applied. Selection of fertilizers, nutrient level, application form and time, etc. considerations can vary greatly according to the agricultural climatic regions and the varieties taken in culture and cultural practices.

The following benefits are provided by the effective fertilization of the Banana plant, which provides high incoms to growers under good care and application conditions:

- Increasing product yield by improving the bunch weight,
- The shortening of the time required for the banana bunch to mature,
- Increasing the number of quality clusters with high marketing value per unit area,
- Improving the storage properties,
- Improvement of marketable banana quality in terms of physical and chemical properties.

The banana plant needs fertile soil and plenty of soil moisture for optimum growth and yield. The growth rate in the first 3-4 months of plant development determines the weight of the cluster and the number of bunches, so it is of great importance to provide the best care and feeding conditions during this period. The development of the banana plant in various nutritional deficiencies is given in Table 9.

TABLE IX. THE TOTAL NUMBER OF LEAVES PRODUCED IN 158 DAYS IN NUTRIENT DEFICIENCIES AND THE TIME BETWEEN LEAF EMERGENCEUNDER NUTRIENT DEFICIENCIES (CAVENDISH VARIETY). [10]

Nutrient deficiency	Number of leaves	Days between leaf
Control, no deficiency	16,6	9,5
- N	7	22,6
- P	13	12,1
- K	11,5	13,8
- Ca	13,5	11,7
- Mg	14,5	10,9

III. Specific Functions Of Nutrients İn Banana Plant

Although the effects of all the essential nutrients on the plant growth in terms of plant nutrition principles are indisputable; according to the findings obtained from experimental studies, it has been shown that the effects of some nutrients on many products and quality parameters of the Banana plant are determinative. Among these plant nutrients, it is seen that N, K, Ca, B, Cu and Zn are dominant in terms of their total and special effects (Table 10).

TABLE X: SPECIFIC FUNCTIONS OF PHYTONUTRIENTS IN BANANA PLANT. [11]

	N	P	K	Mg	Ca	S	B	Cu	Fe	Mn	Zn
Yield parameters											
Yield	+	+	+	+	+	+	+	+	+	+	+
Bunch weight	+	+	+	+	+		+	+			
Hands/Bunch	+		+					+			
Fruit/Hand			+								
Fruit number			+								
Fruit weight			+				+	+			+
Fruit diameter			+				+	+			+
Fruit lenght			+								
Quality parameters											
Starch	+	+	+								
Sugars			+				+				+
Acid	+										+
Sugar/Acid ratio			+				+				+
Toal soluble solids	+		+				+	+			+
Askorbic acit (Vitamin C)			+				+	+			+
Peel disorders					-						

IV. Mineral And Organic Nutrition Of Banana Plant

The plant nutrients required to meet the high nutritional requirement of the Banana plant, which is fed in a narrow soil volume with a limited root structure, should be presented to the plant in sufficient and available forms after planting in accordance with the phenological stages of the plant.

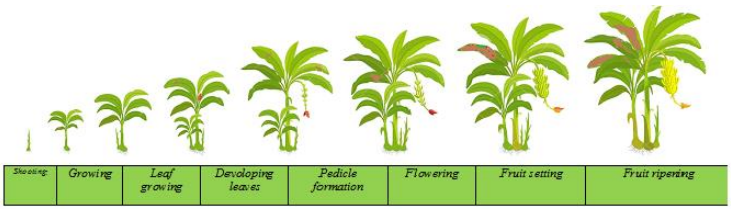

Fig. 4. Phenological periods of the banana plan

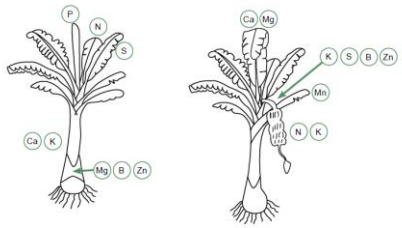

Fig. 5. Places with the highest concentrations of elements in different parts of the banana plant. [6]

In the nutrition of the banana plant, fertilizers and their amounts determined according to soil characteristics, cultivation form and conditions and fertilization method can be applied in various ways.

1) Fertilizers can be applied in certain growth periods with base and top dressing. In base dressing, fertilizers are concentrated at a suitable distance from the pseudostem to reduce possible fixation losses, to the band under the soil, and in top dressing, the fertilizers are divided into phenological periods, spreaded by sprinkling and applied to the surface in the projection of the crown.
2) Fertilizers can also be applied by fertigation method. In fertigation applications, nutrients are applied directly to the root area in the form of salts dissolved with irrigation water in the appropriate nutrient amounts for the relevant phenological period and provide an effective feeding.
3) Fertilizers can also be applied by spraying the leaves as a solution. In the application, which is mostly used for micronutrients taken from the soil in less amounts by plants during critical periods, macronutrients can also be applied.

Care should be taken to ensure that the timing of fertilizer applications in open field cultivation in banana production is compatible with the climatic conditions and the phenological stages of the plant. In open field production, in light textured soils and in areas where precipitation is intense, frequent applications of nitrogenous fertilizers by dividing are especially important in plant nutrition. Fertilizers containing phosphorus nutrients with relatively limited mobility in the soil are applied once or twice a year in semi-tropical regions; fertilizers of nitrogen and potassium nutrients with faster mobility are applied at short intervals in accordance with the phenological periods. The frequency of application can be significantly reduced by the use of slow release fertilizer forms if the soil properties are suitable.

Fertigation is a continuous feeding process within a specified time period. In the application made with the pressurized irrigation system, it is based on the principle of giving the determined amount of fertilizer through the irrigation system each time the system is started. In the Fertigation method, which is accepted as the method of applying the nutrients, soil arrangement material and other water-soluble products that the plant needs during the growth stages, through irrigation, technically high operating needs are eliminated and fertilizer application costs are reduced. In addition, by applying plant nutrients when the plant needs it, nutrient utilization efficiency is ensured, nutrient losses in the form of fixation, leakage or gas in the soil and consumption of luxury nutrients by plants are reduced. Traditionally, fertigation provides nutrients in the form of fertilizers, but can also be used for soil conditioners, including agrochemicals to combat plant diseases and pests.

In the selection of the fertilizing material, the soil and climate characteristics and the fertilization method to be applied (base/top dressing, fertigation and foliar application), the phenological periods of the plant and the nutritional state during the vegetation period are determinants in the open field and/or greenhouse production pattern. Base fertilizers are used in solid form and slow-acting, while top fertilizers are easily dissolved and used quick-acting.Water soluble forms of solid fertilizers and liquid fertilizer preparations, which are widely used today, are successfully used in fertigation applications. Solid fertilizers with water soluble macro and micronutrients and liquid fertilizers with suitable composition can be used in foliar fertilization.

In the presence of problems restricting the availability of nutrients according to the specific characteristics of the soil (high/low pH, high lime/active lime, high nutrient buffering capacity, etc.), the application of soil improvement methods to bring the existing problems to an acceptable level and the application of chelated preparations when necessary in nutrition provides success in plant production.

While the roots of plants can easily absorb most mineral nutrients, leaves and other plant tissues can also absorb ionic nutrients. The large area of the banana leaves and the large number of pores (stomata cells) on them are suitable for the intake of plant nutrients and allow them to be used as a supportive nutrition channel.

Foliar application of nutrients provides fast and effective intake of nutrients and, when timed correctly, can prevent the hidden hunger that occurs in plants and especially severe deficiencies in micronutrients. However, due to the high consumption of primary macronutrients by the plant compared to other nutrients and the low absorption rate, it is not sufficient to meet the macro nutrient requirement of the plant through foliar fertilization in a production period. Secondary macronutrients and micronutrients are more suitable for foliar feeding due to the lower requirement of plants for these elements. However, it is also known that the N, P and K spraying solutions applied to the banana plant during the fruit formation phase increase the amount of product observably.

High nutrient availability is important to support the plant's requirements until harvest, as photosynthesis products begin to move from the plant body to fruit bunches in large amounts, especially during the fruit formation phase of banana production. Hidden hunger syndrome can occur even in fertile soils when plant roots cannot provide certain nutrients in sufficient proportions during these critical stages of growth. Foliar fertilization may be necessary as any limitation in the feeding of the banana plant during critical periods of development that adversely affects the cluster size and quality.

Foliar fertilizers under the following conditions provide a high level of nutrient availability to target organs, reducing stress conditions and providing significant advantages for banana growers as a supportive practice in plant nutrition:

- When the banana plant needs nutrient deficiencies in the soil, reduced availability of nutrients by fixing in the soil and/or limited availability due to ion interaction,
- When nutrient deficiencies are detected in the plant in the advanced stages of plant growth and a rapid correction is required,
- In case root activity is hampered by external pressures such as low soil temperature, insufficient aeration, parasitic organisms or damage by cultivation machinery,
- If the effectiveness of soil fertilization is limited due to weed infestation.

V. Nutrient Requirements Of Banana Plant

In the past years, it has been evaluated that the banana plant needs 150-200 g N, 40-60 g P2O5 and 200-300 g K2O / plant nutrients based on the pure plant nutrient requirement, depending on the soil conditions and the cultivar. The past range values given regarding the nutrient requirement may be higher for the high yield varieties used today, due to the new production patterns. Table 11.

TABLE XI. AVERAGE FOOD CONSUMPTION OF BANANA PLANT AND RECOMMENDED APPLICATION RATES (g/PLANT) (EXPECTED YIELD 30-60 TONS / ha). [11]

Plant nutrients	Nutrient uptake by whole plant	Nutrients removal by fruits	Available nutrients from recycled	Recommended application rates
N	198-339	57-114	48	190-359
P_2O_5	68-114	15-30	12	91-146
K_2O	734-1268	240-480	280	454-988
MgO	165-273	24-48	16	67-121
CaO	92-155	21-42	16	76-139

In the conventional base/top dressing applications, all of the phosphorus (P_2O_5) fertilizers are applied in the final soil cultivation or in the seedling planting time; nitrogen and potassium top dressing fertilizers are divided and applied 45, 90, 135 and 180 days after planting time. The fertilizer material of other necessary nutrients can be applied as base dressing. In the fertilization, applying 1/4 of the total nitrogen and 1/3 of the total potassium (K_2O) during the fruiting phase is beneficial in terms of fruit quality; nitrogenous fertilizer application at this stage delays the aging of the leaves and improves the cluster weight; it is stated that the application of potassium fertilizers increases the finger filling.

Fertilizers planned to be given in fertigation applications are applied in different proportions of each nutrient in accordance with the plant growth periods. Base fertilization can also be recommended before planting, taking into account the soil characteristics in terms of supporting the development period in practice. In this application, fertilization is made according to the plant nutrients that the plant needs the most during the relevant phenological development stages.

VI. Nutrition Management Based On Soil And Leaf Analysis

Determining the availability of soil and water production tools and climate suitability before the open field or greenhouse banana plantation facility is very important in production. The availability of the soil and water resources quality of the production site and the elimination of the identified problems affect the success, sustainability and production costs of the production. If the conditions are favorable, fertilizer expenditures become an important factor in total costs in plant nutrition practices and the importance of fertilizer use efficiency comes to the fore. Soil analysis is an important implementation requirement that reflects the current inherent and dynamic properties of the soil and guides fertilization recommendations. The main focus in analysis-based fertilization is to maximize the efficiency of nutrient use without compromising environmental values, to increase crop production and quality, to protect soil quality and to ensure soil use sustainability.

Leaf analysis in the plant gives very useful results in the control of the healthy nutrition of the plant by determining the sufficiency ranges of the mineral nutrients and especially in the plant nutrition by helping the fertilization program based on soil analysis. The symptoms that cannot be often observed in the leaves (visible nutrient deficiency) remain as a hidden deficiency in the plant leaves (the plant looks like a healthy plant although there is a deficiency) and negatively affects the subsequent development and product performance of the plant at that time. In this, the predominance of the parameters that affect the nutrient availability in the soil (high/low pH, excess lime, structural disorders, low organic matter, lack of chelation, etc.), the quality of the irrigation water, ion interactions in the soil and special soil problems (salinity, ion toxicity, etc.) can be effective. In this respect, leaf analysis gives very useful results in a complementary nature to the plant nutrition program based on soil.

For the optimum development of the plant, each nutrient must be in a sufficient and reliable concentration range. Values outside the sufficiency range (very low or very high nutrient contents) cause unhealthy growth in the plant, cost increases and product losses with effects such as deficiency, ion antagonism, luxury consumption, toxicity. If the required elements are not sufficient during critical periods (rapid vegetative development, fruit set, fruit growth, etc.) of plant physiology, stress factors increase, growth disorders and product losses are inevitable.

One of the important parameters affecting the productivity and quality of the banana plant is the N/K nutrient ratio in the leaves. The critical leaf N: K ratio for optimum yield has been stated to be between 1: 1 and 1: 1.6 depending on the leaf analysis method [6, 12]. When the N/K ratio increases in the banana leaf, the following problems are observed:

- Finger drop occurs on ripe banana bunches after harvest; Spills occur in tropical regions during hot and humid periods when there is insufficient K in the soil or due to NH_4 accumulation in the plant.
- There are delays in bunch output.
- Bundles are widely spread and can be easily damaged in transport.
- Fruit stalks become brittle and fruits can fall from the bunch when ripe.
- The wind resistance of the body is reduced.

Leaf sampling from the banana plant has been taken from the 7 th petiole and the leaf blade of the 3rd leaf for many years. Today, the blade of the third leaf on the pseudostem is used as a standard sampling method in determining the nutritional status of the banana plant.

Leaf samples in the banana plant can be taken before flowering or following flower emergence, at the stage when all female fingers appear. For the control of the fertilization program, samples are generally taken after bunch formation and up to 1 month before the harvest. Leaf samples are taken from the last opened leaf, from the middle part of the third leaf that has completed its backward development, with 10-15 cm wide incisions made on both sides of the midrib (Figure 6).

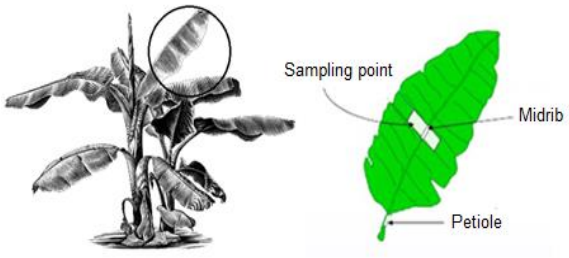

Fig. 6. Leaf sampling in a banana plant

VII. Salt Sensitivity Of Banana Plant In Plant Nutrition

Banana plant, which has a limited root area with its shallow and spreading feature, is a fast growing plant with high water consumption, weak penetration power and ability to draw water from the soil, low drought resistance and rapid physiological response to water deficiency in the soil. Salinity stress can cause leaf edges chlorosis, stunted growth, thin and deformed fruits.

For the banana plant, 100-500 ppm total soluble salts concentration in the soil is generally acceptable levels. However, when the salt concentration exceeds 1000 ppm (~ 1.56 dS / m), there may be visible symptoms in plants and fruits at the salinity levels of 500-1000 ppm, the growth of the plants is restricted or they die.

Due to the high total nutrient consumption and high fertilization requirement of the Banana plant, which grows in a limited root area and creates a high biomass; It is important to apply the fertilizers with the right dose and timing and to plan the irrigation management correctly in a way that the temporary salt rises occurring in the root zone with fertilizer applications will not limit the growth of the plant.

VIII. General Recommendations In Plant Nutrition Management Of Banana Plant

The amount of plant nutrients removed from the soil with the harvested banana fruit is one of the important criteria for fertilizer recommendations. The nutrient content of the plant's biomass and the amount of plant nutrients in the fruit are the basis for the planning of the fertilization program. In addition to these, the following issues are also required in the preparation of an effective fertilization program:

- Taking into account the genetic yield potential, average height and total biomass of the cultivated variety, a fertilization program as required should be arranged.
- Criteria such as production type (open/under cover), irrigation method, planting sizes to be used in practice should be taken into account in fertilization planning.
- The fertilization dose foreseen for the plant requirement should be arranged in accordance with the inherent and dynamic characteristics of the soil determined by current soil analyzes.
- Possible leaching, gaseous removal and fixation losses of the nutrients in the soil should be taken into consideration, and fertilization options that will minimize nutrient losses should be adopted in the application planning.
- Fertilizer material should be selected in accordance with the adopted fertilization method and soil properties, and the distribution and timing of the relevant total amounts of the determined fertilizers should be planned in accordance with the phenological stages of the plant.
- Nutritional control should be done according to the results of the leaf analysis made in the prescribed time during the vegetation period and the arrangements should be implemented on time by making revisions with appropriate options in the fertilization planning when necessary.
- The communication between the banana producer and the expert institution/organization that provides analysis and fertilization advice services should be kept open and the success criteria should be evaluated by receiving the feedbacks of the application.

References

[1] Lahav, E., and A. Lowengart. "Water and nutrient efficiency in growing bananas in subtropics." *II International Symposium on Banana: I International Symposium on Banana in the Subtropics 490*. 1997. https://doi.org/10.17660/ActaHortic.1998.490.10

[2]FAO, 2018. Banana Statistical Compendium 2017. www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/ Bananas/Documents/Banana_Statistical_Compendium_2017.pdf

[3] Ganeshamurthy, A. N., G. C. Satisha, and Prakash Patil. "Potassium nutrition on yield and quality of fruit crops with special emphasis on banana and grapes." *Karnataka Journal of Agricultural Sciences* 24.1 (2011).

[4] Halliday, Denis J. IFA world fertilizer use manual. Ed. Martin E. Trenkel. Paris: International fertilizer industry association, 1992.

[5] Moreira, A., and N. K. Fageria. "Yield, uptake, and retranslocation of nutrients in banana plants cultivated in upland soil of Central Amazonian." *Journal of Plant Nutrition* 32.3 (2009): 443-457. https://doi.org/10.1080/01904160802660750

[6] Lahav, E., and Turner, D. W. Fertilising for high yield: Banana. International Potash Institute, IPI-Bulletin No. 7, 2nd edition, Berne/Switzerland (1989).

[7] Turner, D. W., Chai Korawis, and A. D. Robson. "Soil analysis and its relationship with leaf analysis and banana yield with special reference to a study at Carnarvon, Western Australia." (1989).

[8] Broadley, R., Rigden, P., Chay-Prove, P., & Daniells, J. Subtropical banana grower's handbook. *Queensland Government Printers, Brisbane, Australia(2004)*.

[9] Reuter, D., and Robinson, J. B. (Eds.). *Plant analysis: an interpretation manual*. CSIRO publishing (1997). https://doi.org/10.1071/9780643101265

[10] *Murray, D. B.:* The effect of deficiencies of the major nutrients on growth and leaf analysis of the banana. Trop. Agric. Trin. ***37*** 97-106 (1960)

[11] Anonymous (Haifa), Nutritional recommendations for Banana. https://www.haifa-group.com/files/Guides/Banana.pdf

[12] Irizarry, Héber, Edmundo Rivera, and José Rodríguez. "Nutrient uptake and dry matter composition in the plant crop and first ratoon of the Grand Nain banana grown on an Ultisol." *The Journal of Agriculture of the University of Puerto Rico* 72.3 (1988): 337-351. https://doi.org/10.46429/jaupr.v72i3.6862

Bülent TOPCUOĞLU has born in Turkey, 1966; obtained PhD degree in 1993 from the Ankara University, Turkey in Soil Science and Plant Nutrition department.

He is currently working as a Professor on Soil Science and Plant Nutrition, Soil Pollution and Environmental Sciences topics, at the Akdeniz University Vocational school of Tecnical Sciences, Antalya TURKEY. Author has done more than one hundred research publication to his credit.

Prof. Topcuoğlu has a scientific member of many organizations and chaire of many conferences organized by IAAST, IAE, CBMSR, IICBEE, IIENG and PSRC in İstanbul and Antalya, TURKEY.