Effect of soil moisture stress on fruit growth and nutrient accumulation in banana cultivar 'Robusta'

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EFFECT OF SOIL MOISTURE STRESS ON FRUIT GROWTH AND NUTRIENT ACCUMULATION IN BANANA CULTIVAR 'ROBUSTA'
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ABSTRACT - Studies on pattern of growth and nutrient accumulation in banana fruits in relation to stress revealed that fresh and dry weights, length and girth of fruits were conspicuously reduced by the stress of -85 kPa as compared to those not subjected to stress. Concentration of all the nutrients declined with maturity in both stressed and unstressed fruits. Stress reduced N, K and Mg concentrations and increased P and Ca concentration in fruits as compared to those not subjected to stress.Stress slightly increased TSS but reduced pulp-to-peel ratio. There was fruit cracking and peel splitting in ripened fruits harvested after 22nd week in both stressed and unstressed fruits. Based on the changes in growth and quality parameters, it is suggested to harvest 'Robusta' banana after 20 to 21 weeks from bunch emergence in both stress and unstress situations.

CONSEQUENCE DU STRESS HYDRIQUE DANS LE SOL SUR LA CROISSANCE DU FRUIT ET SUR L'ACCUMULATION DES ELEMENTS NUTRITIFS CHEZ LE BANANIER 'ROBUSTA'.
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RESUME - Des études sur le modèle de croissance et d'accumulation d'éléments nutritifs dans la banane de plants soumis à un stress ont montré que poids des matières fraîche et sèche, longueur et circonférence des fruits étaient manifestement réduits par rapport à ceux qui n'avaient pas connu de stress. Les concentrations pour tous les éléments diminuent, dans les deux cas, avec la maturité. Le stress abaisse N, K et Mg et augmente P et Ca dans les fruits touchés si on les compare avec ceux non «stressés». Le choc accroît légèrement l'extrait sec mais réduit le rapport pulpe/peau. On note un fendillement du fruit et une déchirure de la peau sur bananes mûres récoltées après la 22e semaine, pour les deux catégories de fruit. En s'appuyant sur la croissance et sur les paramètres de qualité, on suggère de récolter la 'Robusta' 20 à 21 semaines après l'émergence de l'inflorescence qu'il y ait eu ou non stress hydrique.

INTRODUCTION

The fruit weight and quality in banana are greatly influenced by the stage of maturity at harvest (TROCHOULIAS, 1973). Harvesting banana at optimum stage of maturity is an important operation to derive maximum benefit as early harvesting may reduce the yield by lower fruit weight and late harvesting may increase the losses by peel-splitting and fruit cracking besides reducing the productivity/unit time by prolonging the crop span. Farmers usually decide the suitability of harvesting time for fruits by observing the degree of roundness of fruits which is subject to an error of judgement. Soil moisture is an important input affecting the fruit growth and development in banana (KE, 1979, HOLDER and GUMBS, 1983). However, no systematic work has been carried out to find out the effect of moisture stress on the pattern of fruit growth and nutrient accumulation in banana which may help to decide optimum maturity standards. The present studies were carried out to determine the time course of growth and nutrient accumulation in banana fruits as influenced by moisture stress.

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MATERIALS AND METHODS

The investigations were carried out at the Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, during 1985-1986. The Station is located at an altitude of 890 m above Mean Sea level with mean maximum temperatures of 29.5°C and minimum temperature of 19.1°C and an average annual rainfall of 825 mm. The crop was planted with a spacing of 1.8 m x 1.8 m and recommended cultural practices were followed. Normal irrigations followed until the beginning of bunch emergence. Later, half of the plants received irrigation at a soil matric potential of -25 kPa (no stress) and the other half received irrigation at -85 kPa (stress). Soil matric potential was monitored by Jet-fill tensiometers which were installed at a depth of 15 cm and 30 cm away from the plants. From the day bunches fully

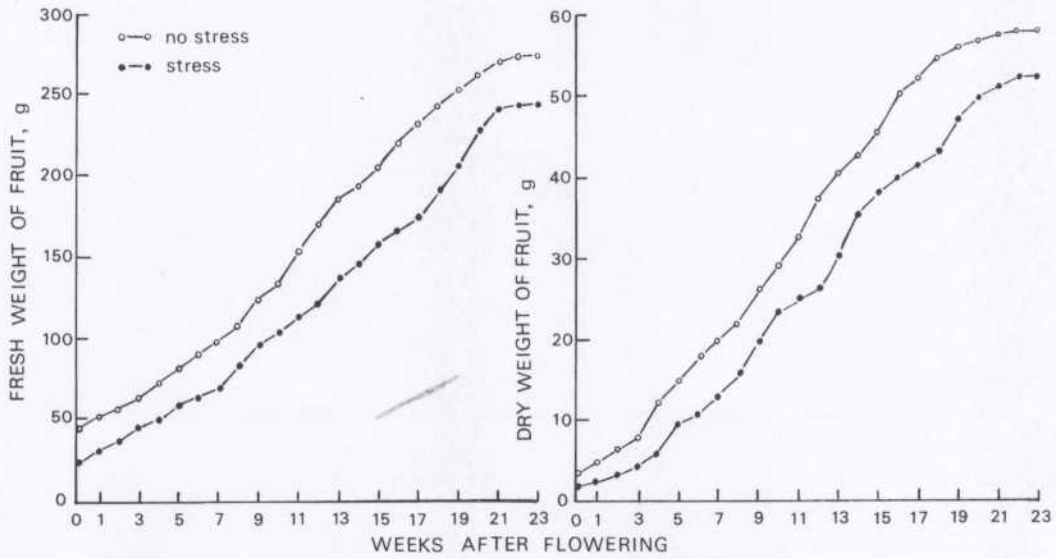

FIGURE 1 - Changes in fresh and dry weight of banana fruit with maturity in relation to soil moisture stress.

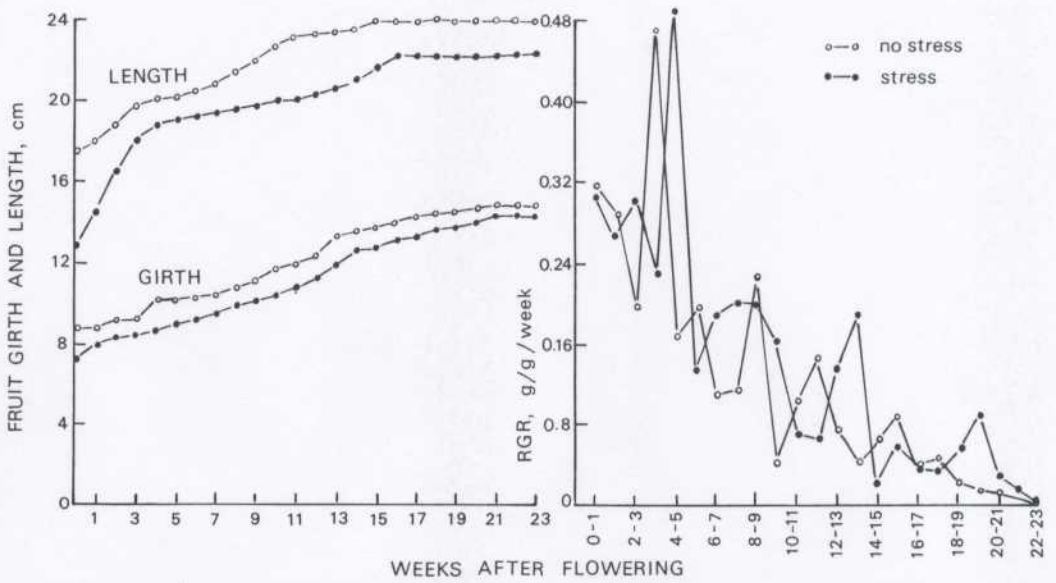

FIGURE 2 - Changes in girth, length and relative growth rate of banana fruit with maturity in relation to soil moisture stress.

emerged, 10 fruits were cut in duplicate starting from the base of the bunch at weekly intervals until complete maturity (145 days from flowering). Care was taken to see that some border fruits were left before taking the next sample. Since the sampling procedure was common for both stress and non stressed bunches, the finger growth was uniformly affected.

RESULTS AND DISCUSSION

The fresh and dry weight of fruit increased continuously upto 21 weeks after flowering and later levelled off (Fig. 1). Soil moisture stress had deleterious effect on both fresh and dry weight of fruits in banana. There was more than 50% reduction in the fresh and dry weight of fruits under stress as compared to those which were not subjected to stress in initial stages but this narrowed down with the advance in the maturity of the fruits. At 23 weeks from flowering, fresh and dry weights were less by 13 and 10%, respectively, under stress. Adverse effect of soil moisture stress on fruit

growth in banana was also reported earlier by KE (1979) and HOLDER and GUMBS (1983). Fruit length increased progressively upto 16 weeks from flowering and later remained almost unchanged. Fruits were considerably shorter under stress as compared to those which were not subjected to stress. The differences in fruit length between stress and unstressed situation persisted upto maturity and at harvest fruits under stress were about 2 cm shorter. Fruit girth gradually increased with maturity upto 21 weeks and later remained almost constant (Fig. 2). The rate of increase in fruit girth was higher upto 16 weeks and later slowed down. There was marked decrease in fruit girth under stress in initial stages which was gradually made up with advance in maturity and at 23 weeks, fruits subjected to stress were just 0.5 cm less in girth as compared to those under no stress.

The RGR of fruit, in general, declined continuously from flowering to maturity although there were occasional increases in between (Fig. 2). Maximum RGR was observed between 3rd and 4th week in unstressed fruits while in stressed fruits, it was between 4th and 5th week. Moisture stress had no definite impact on RGR of banana fruits.

The changes in nutrient concentrations in banana fruit (both peel and pulp) indicated their continuous decline with maturity (Table 1). N and P concentrations declined sharply during the first 5 to 6 weeks from flowering, while those of K, Ca and Mg declined rapidly during the first 10 weeks and later there was gradual decline. The decline in nutrient concentration was probably due to dilution effect as the rate of dry matter accumulation overtook the rate of nutrient accumulation. There was practically no change in fruit composition after 19 weeks. Moisture stress increased the concentration of P and Ca and decreased the concentrations of N, K and Mg. These changes in nutrient concentration in response to moisture stress are as expected (BEGG and TURNER, 1976). The concentrations of all the nutrients in fruit were significantly and negatively correlated with maturity.

The quality of fruits harvested and ripened during the last five weeks of these studies did not reveal large variations (Table 2). However, fruit cracking and peel splitting were noticed only in fruits harvested after 22nd week from flowering. Moisture stress had conspicuous effect on several of these quality parameters. TSS increased and pulp-to-peel ratio reduced under stress as compared to those fruits not under stress. Stress reduced N and K concentrations in both pulp and peel while P concentration in pulp and peel were increased. Ca and Mg concentrations were not affected by soil moisture stress except that in peel which was slightly more in the fruits subjected to stress.

From the changes in growth and quality parameters, harvesting banana fruits about 20 to 21 weeks after bunch emergence seems to be quite optimum both under stress and unstress conditions. Harvesting earlier than this period results in considerable loss in fruit weight while retaining fruits beyond this period results in fruit cracking and peel splitting during ripening and prolongs crop span resulting in reduced productivity/unit time.

TABLE 1 - Changes in nutrient composition (%) of whole banana fruit with maturity in relation to soil moisture stress.

Week after flowering	N		P		K		Ca		Mg	
	No stress	Stress	No stress	Stress	No stress	Stress	No stress	Stress	No stress	Stress
0	1.95	1.96	0.27	0.33	5.60	5.10	0.61	0.74	0.46	0.36
1	1.68	1.49	0.22	0.24	5.40	4.90	0.50	0.60	0.34	0.31
2	1.49	1.35	0.17	0.18	4.80	4.40	0.44	0.56	0.28	0.26
3	1.40	1.26	0.15	0.16	4.15	3.90	0.31	0.44	0.26	0.23
4	1.17	1.10	0.15	0.15	3.95	3.65	0.26	0.42	0.22	0.17
5	1.09	1.05	0.13	0.13	3.60	3.20	0.24	0.30	0.19	0.15
6	1.05	1.01	0.12	0.12	3.30	3.10	0.18	0.25	0.16	0.14
7	1.04	1.00	0.12	0.12	3.30	3.05	0.16	0.20	0.15	0.12
8	1.03	0.98	0.11	0.12	3.20	2.90	0.15	0.18	0.14	0.12
9	0.98	0.93	0.11	0.12	3.10	2.90	0.13	0.17	0.12	0.11
10	0.97	0.86	0.11	0.11	3.00	2.70	0.12	0.12	0.11	0.10
11	0.96	0.84	0.10	0.11	2.70	2.50	0.11	0.12	0.11	0.10
12	0.93	0.81	0.11	0.11	2.60	2.50	0.11	0.11	0.10	0.09
13	0.89	0.81	0.10	0.12	2.50	2.40	0.10	0.11	0.10	0.09
14	0.89	0.80	0.09	0.11	2.40	2.30	0.10	0.11	0.10	0.09
15	0.89	0.80	0.10	0.11	2.30	2.30	0.09	0.10	0.09	0.09
16	0.87	0.79	0.10	0.10	2.30	2.20	0.09	0.10	0.09	0.08
17	0.87	0.79	0.10	0.11	2.30	2.20	0.08	0.10	0.09	0.08
18	0.86	0.78	0.10	0.11	2.30	2.20	0.08	0.09	0.08	0.08
19	0.85	0.73	0.09	0.10	2.30	2.20	0.08	0.09	0.08	0.08
20	0.85	0.74	0.09	0.11	2.20	2.10	0.08	0.09	0.08	0.08
21	0.85	0.74	0.09	0.11	2.20	2.10	0.08	0.09	0.08	0.08
22	0.85	0.75	0.09	0.11	2.20	2.10	0.09	0.09	0.08	0.08
23	0.85	0.73	0.09	0.11	2.20	2.10	0.09	0.09	0.08	0.08
Correlation coefficient	-0.8389*	-0.8944*	-0.9226**	-0.7178**	-0.9068**	-0.8899**	-0.8246**	-0.8420**	-0.8124**	-0.8223**

** - significant at P = 0.01.

TABLE 2 - Changes in fruit quality and nutrient composition in banana with maturity in relation to soil moisture stress.

	No stress Weeks after flowering					Stress Weeks after flowering				
	19	20	21	22	23	19	20	21	22	23
Total soluble, solids %	22.7	22.7	23.0	23.1	23.0	23.4	23.5	23.6	23.5	23.6
Pulp-peel ratio	3.72	3.78	3.80	3.77	3.82	3.18	3.21	3.22	3.21	3.21
Fruit cracking, %	-	-	-	5.00	10.0	-	-	-	-	10.0
Peel splitting, %	-	-	5.00	20.0	40.0	-	-	-	15.0	40.0
N concentration, % :										
pulp	0.77	0.76	0.76	0.76	0.76	0.72	0.71	0.71	0.70	0.70
peel	0.90	0.89	0.88	0.89	0.89	0.87	0.86	0.86	0.85	0.86
P concrntration, % :										
pulp	0.08	0.08	0.08	0.08	0.08	0.10	0.11	0.10	0.10	0.10
peel	0.13	0.12	0.12	0.12	0.12	0.13	0.13	0.14	0.13	0.13
K concentration, %										
pulp	1.83	1.81	1.80	1.80	1.80	1.84	1.80	1.76	1.75	1.75
peel	5.35	5.30	5.30	5.29	5.30	4.83	4.81	4.80	4.80	4.80
Ca concentration, % :										
pulp	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
peel	0.24	0.24	0.24	0.23	0.24	0.29	0.28	0.28	0.28	0.28
Mg concentration, % :										
pulp	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
peel	0.12	0.11	0.11	0.11	0.11	0.11	0.12	0.11	0.11	0.11

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FOLGEN DER WASSERSPANNUNG IM BODEN FÜR DAS WACHSTUM DER FRUCHT UND DIE ANREICHERUNG MIT NÄHRSTOFFEN BEI DER BANANENPFLANZE 'ROBUSTA'.

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KURZFASSUNG - Wachstum und Nährstoffanreicherung in Bananen aus Pflanzen, die einer Belastung durch Wasserdruck ausgesetzt gewesen sind, wurden analysiert mit dem Ergebnis, dass das Gewicht der Frisch- und der Trockensubstanz, sowie Länge und Umfang der Früchte im Vergleich zu jenen ohne Druckbelastung ganz offensichtlich geringer ausfallen. Die Konzentrationswerte aller Elemente regredieren in beiden Fällen im Zuge des Reifeprozesses. Der Wasserstress reduziert die Werte für N, K und Mg, und steigert jene für P und Ca im Vergleich zu den nicht «gestressten» Früchten. Der Druckstoss erhöht etwas die Menge an Trockenextrakt, mindert jedoch das Verhältnis zwischen Fruchtfleisch und Schale. In der Frucht entstehen Risse und bei beiden Bananensorten reisst die Schale der reifen, nach der 22. Woche geernteten Früchte. Aufgrund der Wachstumsverhältnisse und der Qualitätsparameter wird angeregt, die 'Robusta' ungeachtet einer Belastung durch Wasserdruck 20 bis 21 Wochen nach der Blütenbildung abzuernten.

CONSECUANCIA DEL ESTRES HIDRICO EN EL SUELO SOBRE EL CRECIMIENTO DEL FRUTO Y SOBRE LA ACUMULACION DE LOS ELEMENTOS NUTRITIVOS EN EL BANANO 'ROBUSTA'.

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RESUMEN - Los estudios sobre el modelo de crecimiento y de acumulación de elementos nutritivos en el plátano de plantas sometidas a un estrés, han mostrado que peso de las materias fresca y seca, longitud y circunferencia de los frutos se reducían manifiestamente con relación a los que no habían conocido estrés. Las concentraciones para todos los elementos disminuyen, en los dos casos, con la madurez. El estrés reduce el N, K y Mg y aumenta el P y Ca en los frutos afectados, si se les compara con aquéllos no «sometidos a estrés». El choque accrecienta ligeramente el extracto seco pero reduce la relación pulpa/piel, Se observa una resquebrajadura del fruto y un desgarramiento de la piel sobre plátanos maduros, recogidos después de la 22 semana, para las dos categorías de fruto. Apoyándose sobre el crecimiento y sobre los parámetros de calidad se sugiere cosechar la 'Robusta' 20 a 21 semanas después de la emergencia de la inflorescencia, que haya o no estrés hídrico.