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Respiration and Ethylene Production in Muskmelons in Relation to Nitrogen and Calcium Nutrition

M. Fazalur Rahman MALLICK, Masao MASUI,
Akira ISHIDA and Akira NUKAYA
Faculty of Agriculture, Shizuoka University, Ohya, Shizuoka 422

Summary

The physiology and biochemistry of muskmelon (*Cucumis melo* L.) fruit were studied in combination with nitrogen and calcium nutrition. Two forms of nitrogen ($(NH_4)_2SO_4$ and NH_4NO_3) and 2 sources of calcium ($CaCO_3$ and $CaCl_2$) were studied with particular reference to carbon dioxide and ethylene production. In addition, fruit ethanol, chlorine and sugar contents were also estimated. Calcium, when applied in the form of $CaCl_2$, was detrimental, in that, it produced more carbon dioxide and ethylene, decreased the mean fruit weight and also advanced the respiration peak by about 2 days to the ninth day after harvest compared with the 11 th day in $CaCO_3$. In this case, very high fruit ethanol and chlorine content seemed to affect the fruit quality. Such detrimental results were not observed in $CaCO_3$ treatments. Irrespective of the treatments, carbon dioxide and ethylene production curves followed a typical sigmoidal pattern, confirming the climacteric nature of the fruit. Carbon dioxide and ethylene production, total soluble solid and ethanol contents, and ethanol and chlorine contents were positively correlated. Carbon dioxide production and fruit weight, and fruit weight and chlorine content were negatively correlated.

Introduction

Muskmelon is an excellent dessert fruit grown throughout the world for its pleasant flavour and delicious taste. The physiology, biochemistry and genetics of this crop have been studied elaborately(7, 8, 13). However, reports on such studies in combination with nitrogen and calcium nutrition are very rare. Of all nutrient elements, nitrogen and calcium have been reported(3, 10) to influence the fruit quality, probably by controlling the physiology (enzymes) and anatomy (cell structure) of the fruit. When $CaCO_3$ was applied along with NH_4-N, melon growth and fruit quality improved, but, when $CaCl_2$ was applied instead of $CaCO_3$, the results were detrimental(9). Therefore, this study was undertaken to clarify the effect of nitrogen form and calcium source on the post-harvest fruit quality with particular reference to respiration and ethylene production.

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Materials and Methods

Uniform seedlings (2. 5 to 3. 0 leaves) of muskmelon cv. Earl's Favourtie Fall No. 1 were planted in wooden boxes filled with 20 liters of sand and placed in a greenhouse with a minimum temperature of 20°C, on September 20 th, 1982. Treatment details and composition of nutrient solution used are shown in Table 1. There were in all six treatments, of which, four were with NH_4-N (applied as $(NH_4)_2SO_4$) and two with NH_4NO_3. Calcium was applied at 2 levels as $CaCO_3$, equal to 10 and 40 g of CaO per plant, along with $(NH_4)_2SO_4$ and NH_4NO_3, separately. $CaCl_2$ was applied at similar rates with NH_4-N. The treatments were coded as A, B, C, D, E and F. Nitrogen concentration in the solution was 60 ppm. Nutrient solution was applied, instead of watering, throughout the growth phase till December 11 th, 1982. Fruits were harvested 51 days after pollination.

Freshly harvested fruits were incubated,

Table 1. Effect of nitrogen form and calcium source on the post-harvest fruit quality in muskmelons.

Treatment[z]		A	B	C	D	E	F
N-form		NH_4-N	NH_4-N	NH_4-N	NH_4-N	NH_4NO_3	NH_4NO_3
Ca-source		$CaCO_3$	$CaCO_3$	$CaCl_2$	$CaCl_2$	$CaCO_3$	$CaCO_3$
CaO - g/plant		10	40	10	40	10	40
Fresh weight	(g)	815b[y]	833ab	695c	690c	881ab	925a
CO_2 production[x]	(mg/kg/h)	36.84bc	35.89bc	38.05ab	39.50a	30.50d	34.81c
C_2H_4 production[x]	(μl/kg/h)	0.33c	0.34c	0.45a	0.39b	0.12e	0.26d
Ethanol	(mg/g)	0.96b	0.54cd	0.72bc	1.41a	0.25d	0.99b
Chlorine[w]	(%)	0.55b	0.56b	0.88a	1.02a	0.55b	0.41b
TSS	(% Brix)	14.3a	14.1a	13.0a	13.5a	12.8a	13.6a

[z] Composition of nutrient solution : N=60 ppm, $Na_2HPO_4 \cdot 12\,H_2O$=1 mM, $MgSO_4 \cdot 7\,H_2O$=2 mM, K_2SO_4=3 mM, Fe=1 ppm, Zn=0.05 ppm, Cu=0.02 ppm, Mo=0.05 ppm, B=0.5 ppm, Mn=0.5 ppm.

[y] Mean separation in rows by Duncan's multiple range test, 5% level.

[x] Mean of 11 days.

[w] Dry weight basis.

individually, in air-tight glass desiccators for 3 hours at 20°C. Gas samples were withdrawn from these desiccators, and carbon dioxide and ethylene content estimated by gas chromatography(4). Fruits were cut open 2 days after peak respiration and further analyses carried out.

Total soluble solid (TSS) content was recorded with a hand refractometer. For this, juice was taken from the flesh, adjoining the placenta in the equatorial region of the fruit. Chlorine content was estimated by the mercuric thiocyanate colorimetric method(11) with dried fruit samples. Ethanol content in the fruit juice was estimated by gas chromatography with gas samples drawn from the head space of sealed Erlenmeyer flask, in which a known volume of fruit juice was incubated at 40°C over a water bath for 10 min(2).

While growing the muskmelons, the vines were trained to a single stem and topped off at the 20 th node and one fruit was maintained per plant. Treatments were replicated 5 times. Uniform and healthy fruits were sampled from 3 replications only. All data were subjected to statistical analyses.

Results

Fruits weighed more than 880 g in treatments receiving $CaCO_3$. They were less than 700 g in $CaCl_2$ treatments. Among nitrogen forms, NH_4NO_3 proved to be better than $(NH_4)_2SO_4$. Fruit total soluble solid content was not affected much (Table 1).

Respiration in muskmelon fruit was affected significantly by various treatments. Calcium, when applied in the form of $CaCl_2$ (Table 1), produced more carbon dioxide and ethylene compared with the other treatments. In this case, mean weight of the fruit was very low. Peak respiration was on the ninth day after harvest. This indicates a poor storage life after harvest. Very high fruit ethanol and chlorine content affected the fruit quality. On the contrary, data from treatments receiving NH_4NO_3 and $CaCO_3$ showed significant favourable results with the peak respiration on the 11 th day after harvest. In addition to large sized fruits, carbon dioxide and ethylene production, and fruit ethanol and chlorine content were less compared with the other treatments.

Respiration in muskmelon fruit followed a typical sigmoidal pattern (Fig. 1). The trend of carbon dioxide and ethylene production was similar, even though the amount varied with treatments. The overall mean indicated that the maximum ethylene production was on the 10 th or 11 th day after harvest. It was also intresting to note that fruits developed flavour 1 or 2 days preceding peak carbon dioxide production. This development happens to coincide with the peak ethylene production.

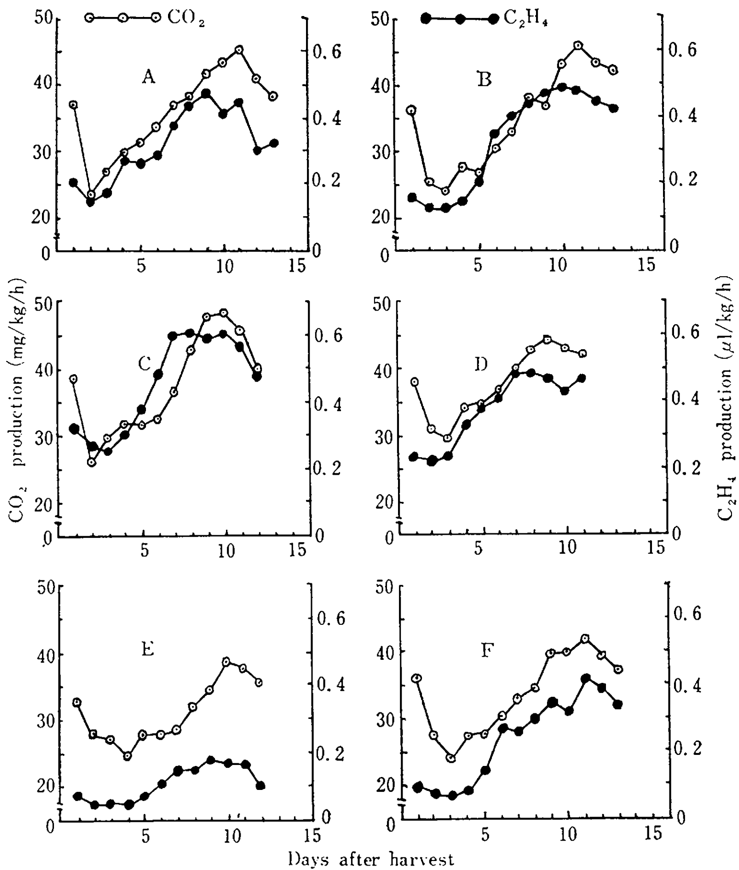

Fig. 1. Carbon dioxide and ethylene production in muskmelon fruits after harvest.
As to codes A~F, refer to Table 1.

There was a significant positive correlation between carbon dioxide and ethylene production (r=0.529**) and total soluble solid and ethanol content (r=0.511*). A negative relationship existed between carbon dioxide production and fruit weight (r=−0.363**) and fruit weight and chlorine content (r=−0.797**). However, such significant relationships were absent in other combinations.

Discussion

The climacteric nature of the muskmelon fruit after harvest has been confirmed. After numerous trials, it was found that a minimum of 3 hours of incubation was essential to permit the fruit to produce enough carbon dioxide and ethylene for reliable estimation. The final result was in agreement with those of earlier workers(5, 12).

The sudden drop in carbon dioxide and ethylene production immediately after harvest indicates the physiological shock of the fruit on detachment from the plant. Further development in the harvested fruit was in accordance with the normal climacteric (physiological) process of ripening. A more or less similar result has been reported in a study with ethylene application in muskmelons(1). This information is valuable to the grower, retailer and consumer, since muskmelon can be better handled based on its natural physiology.

Calcium is generally applied to muskmelon to improve the fruit texture. It is well known that calcium combines with pectin to form calcium pectate in the cell wall which results in a firm flesh(6). $CaCO_3$, $CaSO_4$, $Ca(OH)_2$ and $CaCl_2$ are different forms of calcium available in the market. Of these, $CaCl_2$ was found to be deleterious to both plant growth and fruit quality. The present investigation showed that chlorine ion in $CaCl_2$ was very harmful. Correlation analyses and other data further confirmed this trend.

Fruit weight and ethylene production increased with $CaCO_3$ level irrespective of the nitrogen form while chlorine and ethanol content was not affected much. The low fruit weight, high carbon dioxide and ethylene production, and high ethanol and chlorine content in $CaCl_2$ treatments conspicuously indicate the harmful nature of chlorine ion. Moreover, the close positive relationship between total soluble solid content and ethanol shows that the increase in fruit ethanol was due to the breakdown of polysaccharides to soluble sugars, thus indicating the shift from the TCA Cycle to the fermentation process after the climacteric peak. Hence, the lower the ethanol content the longer the shelf life of the fruit. Also, a positive, though non-significant, relationship ($r=0.364$) was observed between chlorine and ethanol contents. This shows the role of chlorine in affecting the fruit quality.

Thus, if $CaCl_2$ is chosen as the source of calcium for muskmelon production, the chlorine ion in it will affect the grower, by producing small sized fruits; the retailer, by reducing the storage life and the consumer, by imparting poor quality. On the other hand, application of NH_4NO_3 with $CaCO_3$ will yield high quality fruits.

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メロンの窒素，石灰栄養と果実の呼吸，エチレン生成との関係

M. F. R. マリック・増井正夫・石田　明・糠谷　明
静岡大学農学部　422 静岡市大谷

摘　要

メロンの窒素，石灰栄養と果実の生理化学，特に二酸化炭素とエチレン生成との関係を明らかにするため，窒素と石灰の形態それぞれ2種類 {$(NH_4)_2SO_4$ と NH_4NO_3, $CaCO_3$ と $CaCl_2$} の処理区を設けて実験を行った．また，果実のアルコール，塩素，糖含量も測定した．石灰を $CaCl_2$ で施用した場合，$CaCO_3$ に比べ，果実の二酸化炭素排出量，エチレン生成量は多く，果重は小となり，また，呼吸のピークは2日早まって9日目に現れた．この場合，果実のエタノール，塩素含量は高く，これが果実の品質に悪影響を及ぼすものと思われた．石灰を $CaCO_3$ で施用した場合，このような悪影響はみられなかった．処理のいかんにかかわらず，二酸化炭素とエチレン生成の経過は典型的なシグモイド曲線を示し，メロンはクリマクテリックを有する果実であることがわかった．二酸化炭素とエチレン，可溶性固形物とエタノール含量，エタノールと塩素含量との間には正の相関が，二酸化炭素と果重，果重と塩素含量との間には負の相関関係がみられた．