Some factors affecting the yield and quality of sweet pepper (*Capsicum annuum* L.) cv. Domino

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Abstract

A series of studies were undertaken to examine some of the factors which influence yield and quality in sweet pepper. In the first study the influence of soil moisture status (stress and control) and harvesting regime (Green, Green-Red and Red) on growth, yield and Blossom-End Rot (BER) incidence on sweet pepper (*Capsicum annuum* L.) cv. Domino was carried out alongside a second experiment which examined the effect of water stress on fruit growth, and dry matter production and partitioning of destructively harvested sweet pepper plants.

These studies revealed that water stress reduced fruit number, and fresh and dry weights, increased fruit dry matter and hastened fruit maturity, but the stage of harvesting had no effect on both vegetative and reproductive yields. Water stress and harvesting stage had also little effect on the incidence of BER. An analysis showed that water stressed plants had a slightly higher incidence of BER than control plants. Water stress reduced the Ca concentration of fruit and leaves (which had a higher Ca concentration than fruit).

Sweet pepper fruit were the major assimilate sinks 60 days after transplanting and as plants became generative, there was a steady decline in leaf dry weights. RGR and NAR progressively increased while SLA and LAR decreased with plant ontogeny. At the final harvest control plants had accumulated 58% of the dry matter accumulated in their fruit against 49% for the stressed plants.

Fruit Ca, Mg and K increased throughout fruit development although most of the Ca accumulated during the early fruit growth period. The concentration of all these elements declined during the rapid fruit growth period 2-4 weeks after anthesis. A gradient in accumulation of Ca, Mg and K in the fruit was found with the stem-end of the fruit having more nutrients than the blossom-end. Both waxing and KOH treatments had little effect in the accumulation of nutrients in the fruit. Treatment with KOH however, slightly increased the concentration and contents of the mineral nutrients studied.

Sweet pepper plants were grown under Nutrient Film Technique (NFT) system using a nutrient solution of EC 2 $mS.cm^{-1}$. Higher nutrient conductivity levels of 4, 6, 8 and 10 $mS.cm^{-1}$ were achieved by adding concentrated KCl solution to the basic nutrient, and a high Ca solution with an EC of 10 $mS.cm^{-1}$ was developed with a mixture of KCl and $CaCl_2$ at a ratio of 3:1 (w/w).

Higher nutrient conductivity induced higher BER incidence which was related to the suppression of Ca uptake and accumulation in the fruit. This was accompanied by an increase in the accumulation of Mg and particularly K. Extra Ca at higher EC level promoted the accumulation of Ca by the fruit and reduced the incidence of BER. The reduction in Ca uptake in the fruit at higher EC was more pronounced at the blossom end of the fruit. Fractionation of Ca compounds revealed that high EC levels reduced the physiologically active acetic acid soluble Ca compound, particularly during the rapid fruit growth stage when BER was likely to appear. Higher solution conductivity further reduced the accumulation of Ca in the roots and leaves while increasing those of Mg and K.

Higher conductivity of the nutrient solution resulted in small sized fruit, reduced fruit dry weights, decreased vegetative yields in terms of lower leaf area, SLA, diversion of more assimilates to shoots than fruit, decreased water consumption, decreased leaf ψ, decreased fruit firmness, increased leaf stomatal resistance, fruit dry matter content, fruit respiration and ethylene production and advancing fruit colour change.

Enclosing sweet pepper fruit with hygroscopic materials such as $CaCl_2$ and NaCl reduced the RH around the fruit and promoted Ca accumulation by the fruit. Fruit enclosed in polyethylene bags without the hygroscopic materials however, had higher RH and this suppressed Ca accumulation by the fruit. The use of an air flow system to regulate the RH around the fruit had a similar effect.

High RH treatment particularly reduced the Ca concentration in the distal part of the fruit which resulted in more BER. This incidence was related to fruit Ca concentration and content as well as the ratio of Ca to Mg and K. Humidity however, had little effect on sweet pepper fruit growth and the accumulation of Mg and K.

Sweet pepper is considered to be a non climacteric fruit which is independent of ethylene for ripening. Characterization of the changes in $P^iC_2H_4$, P^iCO_2, P^iO_2 as well as colour change in mature green fruit at 20°C showed that $P^iC_2H_4$ significantly increased in both attached and detached fruit coincident with colour change. Detached fruit showed a steady decline in P^iCO_2 while attached fruit showed an increase in P^iCO_2 during ripening with out the climacteric. It is speculated that the decline in P^iCO_2 and the lower magnitude of $P^iC_2H_4$ in detached fruit was a result of egress of these gases through the pedicel rather than apparent difference in ripening physiology of attached and detached fruit. It was also suggested that the lack of climacteric respiration in attached fruit could be due to the overlapping of a CO_2 dependent photosynthesis by the fruit which declines with fruit age and fruit respiration which obscured the rise in P^iCO_2. The association between sweet pepper cv. Domino fruit ripening and the significant increase in $P^iC_2H_4$ may indicate that ethylene may be responsible for ripening of sweet pepper fruit.

The maturity of sweet pepper fruit cv Domino was studied to determine objective maturity indices which correlate with physiological maturity. The attributes evaluated were fruit fresh weight, diameter, length, volume, pericarp thickness, firmness. Changes in surface colour change, TSS, P^iCO_2, $P^iC_2H_4$, fruit respiration as well as ethylene production.

Fruit size and weight increased slowly during the early growth period and increased rapidly towards maturity. From 8 weeks after anthesis (WAA) until the final harvest there was no a significant change in fruit size although it increased until 9 WAA. Starting from 8 WAA the hue angle values started to decline accompanied by an increase in chroma. Fruit surface colour change also coincided with a significant increase in $P^iC_2H_4$ and a slight increase in P^iCO_2, respiration and ethylene production. The change in hue angle values was found to be an effective maturity index due to its correlation with most of the attributes evaluated. This coupled with WAA, TSS and fruit firmness appeared to be good indicators of fruit maturity.

On the other hand, treatment of mature green sweet pepper fruit cv. Domino with 1000 $\mu l.l^{-1}$ ethylene promoted ripening by advancing colour change, TSS and acidity of treated fruit as compared with control. The treatment also increased fruit respiration and P^iCO_2. However, treatment of half ripe fruit of the same cv. had less marked effect than mature green fruit. Treating sweet pepper fruit of the cv Evidence with ethylene at different maturity stage however, had no effect on colour change.

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List of Abbreviations

BER	Blossom end rot
DM	Dry matter
AASP	Atomic absorption spectrophotometer
LAR	Leaf area ratio
NAR	Net assimilation rate
RGR	Relative growth rate
SLA	Specific leaf area
LWR	Leaf weight ratio
FWR	Fruit weight ratio
SWR	Stem weight ratio
RWR	Root weight ratio
HI	Harvest index
C	Cytoplasm
V	Vacuole
ER	Endoplasmic reticulum
CS	Casparian strip
ANOVA	Analysis of variance
a.i.	Active ingredient
kg	kilogram
g	gram
P	Probability
SE	Standard error
SEM	Standard error of means
t	time
Ln	natural logarithm
DAA	Days after anthesis
WAA	Weeks after anthesis
C_2H_4	Ethylene
CO_2	Carbon dioxide
O_2	Oxygen
STD	Standard
TSS	Total soluble solids
$P^iC_2H_4$	Internal C_2H_4 concentration
P^iCO_2	Internal CO_2 concentration
mm	millimetre
cm	Centimetre
cc^3	Cubic centimetre
Pa	Pascal
kPa	Kilo pascal
Ca	Calcium
Mg	Magnesium
K	Potassium

°C	Degree celsius
EC	Electrical conductivity
pH	Measure of acidity or alkalinity of a solution
ψ	Leaf water potential
NFT	Nutrient film technique
RH	Relative humidity
VPD	Vapour pressure deficit
RCBD	Randomized complete block design
GLM	General linear model
SAS	Statistical analysis system
°	Degree angle
r	Partial correlation
R^2	Coefficient of determination
v/v	volume ratio
w/w	weight ratio
N.D.	no date given