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PAPAYA (*CARICA PAPAYA*) RESPONSE TO FOLIAR TREATMENTS WITH ORGANIC COMPLEXES OF PEPTIDES AND AMINO ACIDS

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Abstract. **Selected application programs of two organic biostimulants were tested to determine their effects on papaya (*Carica papaya* L.) yield. Acetylthioproline (AP) (0 and 0.25 g·L^{-1}) and a commercial complex of peptides and free amino acids (APC) (0 and 3.0 g·L^{-1}) were sprayed on the papaya canopy at different frequencies and intervals: (1) one day after flowering (DAF), (2) 1, 90, and 180 DAF, (3) 1, 60, 120, and 180 DAF, (4) 1, 45, 90, 135, and 180 DAF, and (5) 1, 30, 60, 90, 120, 150, and 180 DAF. Papaya fruit yield tended to increase when biostimulants were applied more frequently. One application of AP or APC did not significantly increase papaya yield as compared to control plants. When AP and APC were sprayed at 1, 30, 60, 90, 120, 150, and 180 DAF, yield increased 18 and 22%, respectively, as compared to papaya without biostimulant application.**

Papaya (*Carica papaya* L.) production ranks 10th among all fruit species grown commercially in the world, following citrus (*Citrus* spp.), bananas (*Musa* spp.), grapes (*Vitis* spp.), apples (*Malus* spp.), mangoes (*Mangifera indica* L.), pine-

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apples (*Ananas comosus* Merr.), pears (*Pyrus* spp.), peaches and nectarines (*Prunus* spp.), and dates (*Phoenix* spp.). Global papaya production in 2002 was approximately six million metric tons (t). The same year, the main papaya producing countries in 2002 were Nigeria, India, Brazil, Indonesia, and Mexico, which generated approximately 70% of the world production (FAOSTAT, 2003).

In 2002, there were approximately 700 ha under commercial papaya production in the US, mainly in Hawaii, Texas, and Florida, producing about 20,640 ton in 2002 (USDA-NASS, 2003). The same year, the US imported 84,000 ton of papaya with a value >$50 million (FAO, 2002). With about 85% of the domestic demand for papaya being unsatisfied by local production, papaya may be an attractive alternative for growers in south Florida.

Plant growth regulators and stimulants (PGR) may be an important component in papaya production systems. PGR have been used in papaya to promote seed germination (Mederos-Olalde and Benítez, 1989), limit shoot height (Rodríguez and Galán, 1995), promote early growth (Morales-Payan et al., 1998), regeneration and multiplication in vitro (Chen and Chen, 1992; Teo and Chan, 1994), facilitate asexual propagation (Ramkhelawan et al., 1999), manipulate flowering (Jindal and Singh, 1976; Kumar and Jaiswal, 1985), increase latex yield (Liaquat and Mazumbar, 1994), improve fruit yield (Morales-Payan, 1996), and prolong post-harvest life (Ergun and Huber, 2001).

Organic amino acid and peptide complexes have been found to increase yield in various crops, and may enhance papaya yield in conventional and organic production systems. Acethylthioprodione (AP) has been found to have anti-oxidant activity in enzymatic systems, to increase mitochondrial activity, increase uptake nutrients, and enhance yield in corn (*Zea mays* L.) (Oeriu et al., 1969), lettuce (*Lactuca sativa* L.) (Morales-Payan and Santos, 1996a), spinach (*Spinacea oleracea* L.) (Paspatis, 1990), cilantro (*Coriandrum sativum* L.) (Morales-Payan and Santos, 1996b), pepper (*Capsicum annuum* L.) (Belakbir et al., 1996; Morales-Payan and Stall, 2002), and carrot (*Daucus carota* L.) (Sanders et al., 1990). A complex of free amino acids and short peptides (<5 amino acids) derived from hydrolyzed animal skin (APC) has been reported to increase tolerance to stress in corn (Mladenova et al., 1998), and fruit set in olive (*Olea europea* L.) (Viti et al., 1989) and almond (*Prunus amygdalus* L.) (Viti and Bartolini, 1998).

The documented effects of AP and APC on horticultural crops refers to responses to one or two applications, and little is known about the differential effects of AP and APC application programs on horticultural crops, including papaya. The objective of this study was to determine the effects of selected application programs of the organic biostimulants AP and APC on the yield of 'Sunrise' papaya.

Materials and Methods

The experiment was performed in La Altagracia, Dominican Republic, in 1994. 'Sunrise' papaya was grown from transplants and managed according to local practices (Morales-Payan et al., 1998).

The papaya canopy was sprayed at the beginning of the flowering stage (approximately 100 d after transplanting) with aqueous solutions of either AP (Ergostim®, 5.1% folcysteine. Isagro, Italy) (0 and 0.25 $mg \cdot L^{-1}$) or APC (Siapton®, 15% free amino acids, 85% peptides < five amino acids. Isagro, Italy) (0 and 3.0 $mg \cdot L^{-1}$). AP and APC were applied only once at flowering or several times within 180 d after flowering (DAF) (at intervals of 30, 45, 60, and 90 DAF).

The treatments were established in a randomized complete block design with four replications, where six papaya plants were the experimental unit. Fruit yield was determined by weekly harvesting fruit at the beginning of the fruit yellowing stage during 30 weeks. Fruit was classified as grade A (400 to 600 g, 10- to 15-cm long, without blemishes) and grade B (off sized and/or with blemishes). Analysis of variance and appropriate separation of means by the Least Significant Difference test (5% significance level) were conducted on the data (StatSoft, 1997).

Results and Discussion

The yields of grade A and grade B papayas were affected in the same way by AP and APC treatments (data not shown). Therefore, only the treatment effects on grade A papaya (referred to as papaya yield hereafter) will be discussed.

There were significant AP and APC effects on papaya yield. As AP and APC were applied at shorter intervals, papaya yield tended to increase (Table 1). One APC application (at flowering) did not affect papaya yield. When applied three times (1, 90, and 180 DAF), APC significantly increased papaya yield as compared to untreated papayas. Monthly applications of APC resulted in approximately 22% yield increase as compared to papaya without biostimulant treatment. Applying APC at 45-d intervals enhanced yield as compared to papaya without APC, but the yield increase was significantly lower than for papayas sprayed monthly (1, 30, 60, 90, 120, 150, and 180 DAF) with APC (Table 1).

In contrast, four AP applications were necessary (1, 60, 120, and 180 DAF) to significantly increase papaya yield compared to untreated papayas. In AP-treated papayas, the highest yield increase (18%) was found when that biostimulant was sprayed at the highest frequency (1, 30, 60, 90, 120, 150, and 180 DAF) (Table 1).

The physiological mechanism for yield improvement from amino acid and peptide-based biostimulants is complex and not well understood. Mladenova et al. (1998), Oeriu et al. (1969), Viti and Bartolini (1998) and Viti et al. (1989) associated the application of AP and APC with significant changes in the secondary metabolism and enzymatic systems of plants,

Table 1. Effect of selected application programs of a complex of amino acids and peptides (APC) and acethylthioproline (AP) on the yield of 'Sunrise' papaya.[z]

	Papaya yield (fruits per hectare)	
Biostimulant application program	AP[y]	APC
Not applied	39, 162.4 d	39, 162.4 e
1 DAF[x]	39, 234.5 d	39, 180.3 cde
1, 90, and 180 DAF	40, 728.0 cd	42, 273.5 bcd
1, 60, 120, and 180 DAF	41, 864.6 bc	44, 078.1 bc
1, 45, 90, 135, and 180 DAF	44, 466.7 ab	46, 020.7 b
1, 30, 60, 90, 120, 150, and 180 DAF	46, 410.0 a	47, 9970.8 a

[z]30 harvests.
[y]Within a column, values followed by the same letter are not significantly different, according to the Least Significant Difference test (5% significance level).
[x]DAF = days after flowering.

especially oxidation/reduction systems. In our experiment, papaya yield increase was due to increased fruit number in both A and B grades (data not shown). The biostimulants may have increased fruit set and/or contributed to increasing the size of small fruit that would normally be discarded as unmarketable. This speculation is supported by the fact that the proportion of unmarketable fruit in the total fruit number tended to decrease as the frequency of biostimulant application increased (data not shown). Our findings agree with other reports that APC improved flower and fruit set in other crops (Viti and Bartolini, 1998; Viti et al., 1989).

From the practical viewpoint, several of the AP and APC programs tested in this study increased papaya yield. Repeated applications of either biostimulant (1, 45, 90, 135, and 180, or 1, 30, 60, 90, 120, 150, and 180 DAF) seems necessary to stimulate substantial yield enhancement.

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