N-Phenyl-Phthalamic Acid and Fertilization Effects on Flowering, Fruit Set and Fruit Quality of Apple (*Malus domestica* Borkh.)

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SUMMARY

On seven apple cultivars (Gala Must, Gloster, Granny Smith, Idared, Jonagold, Jonathan Csány 1, Mutsu), the authors studied the influence of N-phenyl-phthalamic (PPA) acid and fertilization on flowering, fruit set and fruit quality in the years 2003-2004. The research results showed that PPA application extended the flowering time of the most cultivars. Fruit set of apple cultivars increased in many cases when regulator was applied. The additional nutrient supply could increase the fruit set too. The increase of fruit set increased the number of fruit per tree. Quality parameters determined by fertilization and fruit number per tree. For example, when N-phenyl-phthalamic acid was applied without fertilization the fruit number per tree increased considerably however, it caused a considerable frittering away. The reason for this is that fruit set was high and fruit received not enough nutrition for growing up. The skin colour of fruits was decreased in several cases by the treatments. In one respect the enlarged fruit number was shaded the others and the fertilization increased the vegetative shading leaf area.

Keywords: *apple, N-phenyl-phthalamic acid (PPA), flowering time, fruit set, fruit drop, fruit quality*

INTRODUCTION

Ensuring yield-balance – although the applied technologies give a good possibility for this – in large-scale farming is a difficult and complicated task (Nyéki et al., 2002). Pollination of certain horticultural species – because of climatic and genetic influences – is not possible in many cases (Kozma et al., 2003; Nyéki and Soltész, 1996). For sufficient yield amount and required yield quality we have to interfere in pollination. With the help of N-phenyl-phthalamic acid (PPA) we can achieve this goal (Búza, 1986).

PPA is a regulator that increases the working life of stigma and supports the better pollination, which results in a higher yield (Nyéki, 2002). The acid is not auxin, but it has a synergistic effect with it in biological tests (Nyéki, 1980). It does not cause any phytotoxicity or parthenocarpia (Nyéki, 1980). Applying PPA, the possible unfavourable effects of the objective (agronomics, agrotechnics, species, weather) and subjective conditions of production can be reduced, and yield fluctuation can be levelled, thus crop safety can be considerably increased. The agent, like other regulators and all synthetic pesticides, is not approved in the organic production system (Holb, 2002). Its application is recommended for the flowering period in greenhouses, and foilhouses, as well as in field (orchard) cultivation for some crops (tomato, paprika, pea, bean, cucumber, grape, apple, sour cherry, lupin, soya) (Előri, 1984; Teleky, 1985; Teleky and Bésán, 1986; Teleky and Előri, 1984; Teleky and Horváth, 1987; Teleky and Veress, 1987; Racskó and Lakatos, 2003).

It is important to note that while a higher yield is aimed at through better fruit setting, a higher level of basic nutrition should be provided (Szirtes, 1984; Racskó and Lakatos, 2003).

MATERIALS AND METHODS

The research was conducted in the period of 2004-2005, in field experiments involving private growers at Kálmánháza and Nagylapos. The experimental apple plantation and the various characteristics of cultivars are presented in *Table 1*. We have chose seven apple cultivars for the research. Trees were planted in north-south row direction. In our research, the usual cultivation and integrated plant protection was applied.

Table 1

Characteristics of the experimental apple plantations and the chosen cultivars

Place of experiment	Cultivar	Rootstock	Date of plantation (year)	Size of area (ha)	Size of parcel (m^2)	In-row spacing (m x m)
Kálmánháza	Gala Must	MM106	1998	6.0	700	4.0 x 1.5
Kálmánháza	Gloster	MM106	1998	1.8	700	4.0 x 1.5
Kálmánháza	Granny Smith	M9	1999	0.8	700	3.5 x 0.7
Nagylapos	Idared	M4	1995	4.0	400	3.5 x 2.0
Kálmánháza	Jonagold	MM106	1998	3.2	700	3.5 x 1.5
Nagylapos	Jonathan Csány 1	M4	1989	2.5	400	4.0 x 2.0
Nagylapos	Mutsu	M4	1995	4.0	400	3.5 x 2.0

For better fruit setting, we applied N-phenyl-phthalamic acid (in 0.4 kg/ha Nevirol 60 WP doses). It was sprayed at full bloom. For the nutrition supply of the increased number of fruits, we used artificial fertilizer: N 75 kg/ha, P 30 kg/ha, K 32 kg/ha.

The observation and measurement were carried out on twenty trees per treatment. The total number of trees was 520. Tables contain the average of these data. Trees were assigned at the beginning of research. Each cultivar was represented by four blocks and each block by five trees. Five apple fruits were randomly sampled from each tree for this evaluation, so that the total number was 100 per cultivar.

In our investigations, we determined the following properties of apple fruits:

1) *Fruit fresh weight:* It was measured with a digital analytical scale with 0.1 g punctuality. Fruit weight is the weight of the washed fruit without fruit stalk.
2) *Skin colour:* When examining colouration three categories were set up to ease visual assessment: 1. ground colour, 2. transition between basic and over-colour and 3. over-colour. We have determined colour-coverage by the different colours using a transparent plastic sheet with millimeter scale. Cover by the different colours was expressed as a percentage of the total fruit surface.
3) *Flesh firmness:* It was measured with a Bishop handheld penetrometer on the sunny and dark side of the fruit along the greatest cross-sectional diameter. It was expressed as a mean of the two values with 0.1 N punctuality.
4) *Dry matter content:* It was measured with OG-101/A handheld refractometer from fruit juice. It was expressed with 0,1 °Brix punctuality.

RESULTS AND DISCUSSION

Flowering

PPA application extended the flowering time of the most cultivars. Because application was in full bloom, thus the agent could increase duration of the main bloom and the end of bloom. In 2004, the flowering time of main bloom was extended in cvs. Granny Smith, Idared and Jonathan Csány 1 compared to the control, the date of the end of flowering was increased in cvs. Gala Must, Granny Smith, Idared, Jonagold, Jonathan Csány 1 and Mutsu. In 2005, the duration of main bloom was increased by PPA application for 3 cvs.: Gala Must, Granny Smith and Idared. Regulator extended the end of bloom for all cvs, except Jonagold (*Figure 1*).

PPA application modified the descent of flowering course from full bloom (*Figure 2*). Differences are not considerable, but they can play an important role in the frost protection and simultaneous flowering of cultivars.

PPA application increased the stigma viability too in 2004-2005 (except cv. Mutsu). Significant changes were found by cvs. Gala Must, Idared and Jonathan Csány 1 (*Figure 3*).

Figure 1: **Effect of PPA treatments of flowering time of apple cultivars (2005)**

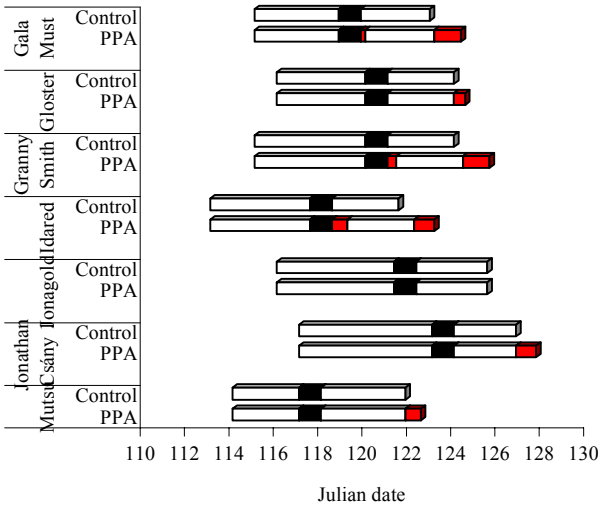


Figure 2: **Effect of PPA treatment on flowering phenogram for Granny Smith (2005)**

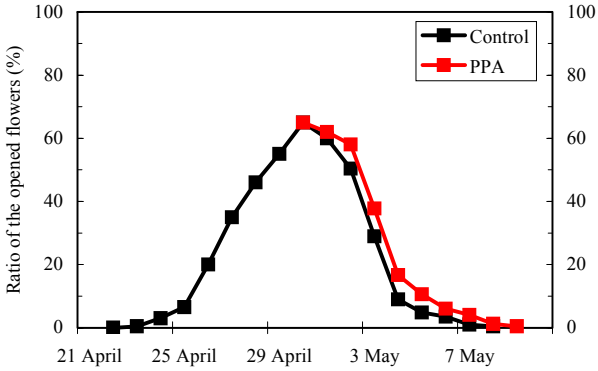
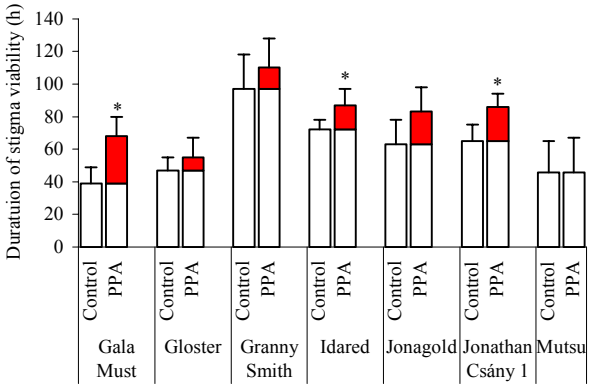


Figure 3: **Effect of PPA treatment on stigma viability of apple cultivars (avg. of 2004-2005)**



Fruit set, fruit drop

PPA application could increase fruit set in the cases of open- and self-pollination. The self-fertility was very low in both two years (In 2004 Gloster, Granny Smith, Idared and Jonagold, in 2005 Gloster, Granny Smith and Jonagold were not self-fertile). Also, treatment could increase fruit set for only cvs.

Gala Must, Jonathan Csány 1 and Mutsu (*Figure 4*). Ratio of open pollination was much higher. The highest increase was found for Jonathan Csány 1 in 2004 and 2005 (*Figure 5*).

Figure 4: **Effect of PPA treatment on self fertility (avg. 2004-2005)**

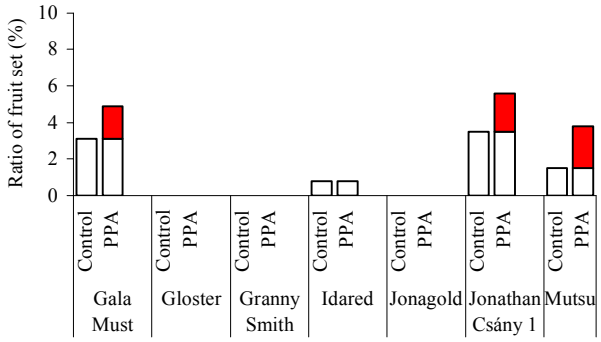
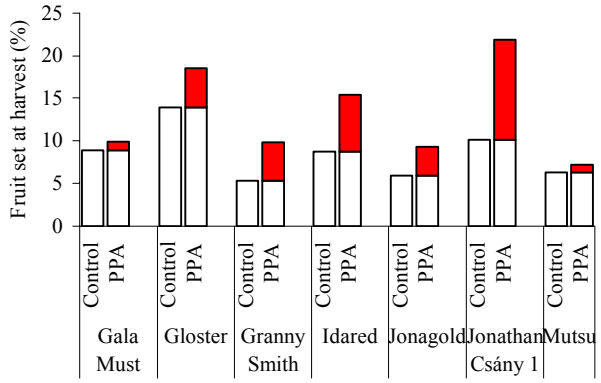


Figure 5: **Effect of PPA treatment on fruit set under open pollination conditions (avg. of 2004-2005)**



The seasonal changes of fruit set (fruit drop) can be seen on *Figure 6*. Several treatments had different effects: single PPA application resulted the highesta fruit drop. As a result of fruit drop occur the fruit number per tree at harvest. Its value was different depending on the cultivars, the following order was found in all cultivars: control<PPA<PPA+fertiliztion treatments (*Figure 7*).

Figure 6: **Effect of PPA treatments (single PPA, PPA+fertilization) on fruit number per tree (avg. of 2004-2005)**

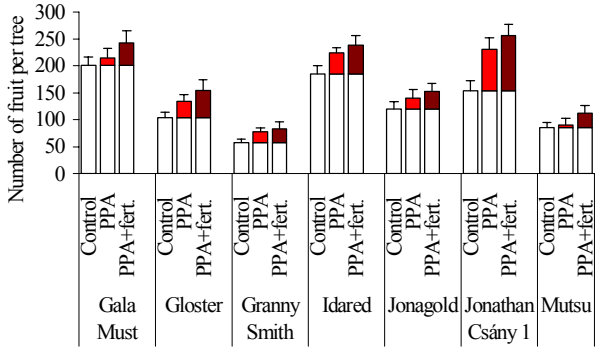
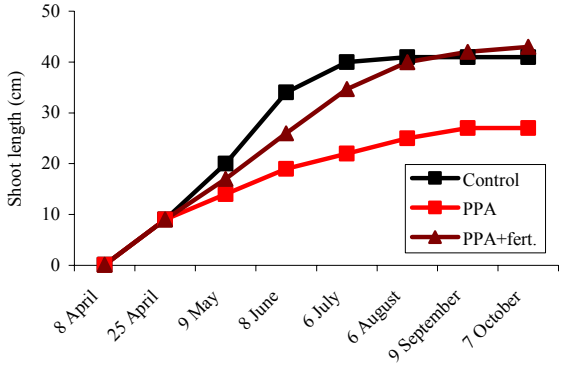


Figure 7: **Effect of PPA treatments on seasonal shoot growth development for Idared (avg. 2004-2005)**



There is a competition between young developing fruits and vegetative parts of the tree, thus heavy crop load kept back the shoot growth. There is a negative close correlation (R=-0,78) between fruit number per tree and shoot growth development. Additional nutrient-supply could compensate the generative predominance (*Figures 8-10*).

Figure 8: **Fruit set and viable seed content of fruits for Idared under control conditions (avg. of 2004-2005)**

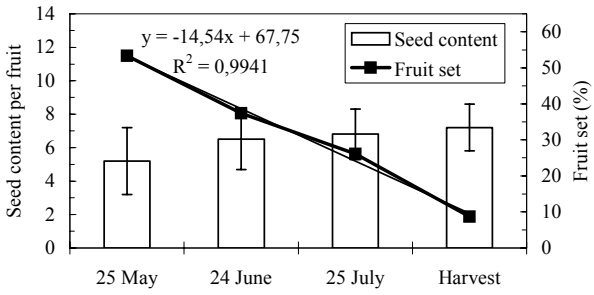


Figure 9: **Effect of single PPA treatment on fruit set and viable seed content of fruits for Idared (avg. of 2004-2005)**

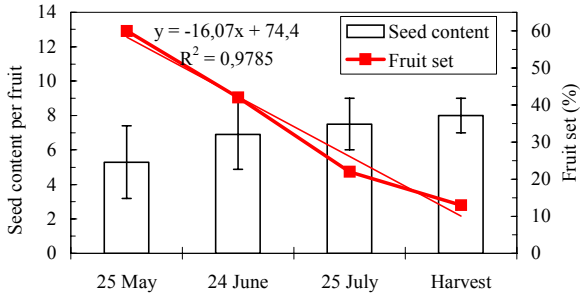
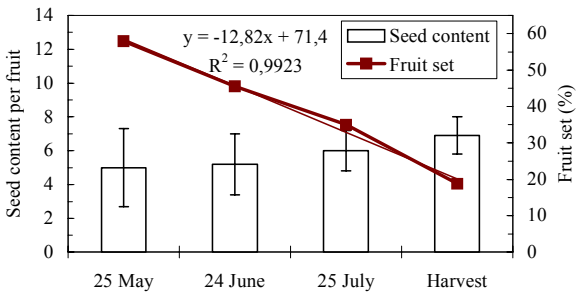


Figure 10: **Effect of PPA+fertilization treatment on fruit set and viable seed content of fruits for Idared (avg. of 2004-2005)**



Fruit quality

The single PPA treatment reduced fruit fresh weight in the most cases (*Figure 11*). It was the cause of heavier load, because the tree could not synthesize assimilates enough to develop optimal fruit weight. PPA+additional fertilization treatment provided nutrition supply, thus fruit weight correspondend to control, even it exceeded that. These effects can be seen on seasonal growth curves of fruit fresh weight. The risest curve was observed in the PPA+fertilization treatment (*Figure 12*).

Figure 11: **Effect of treatments on fruit weight for Idared (avg. of 2004-2005)**

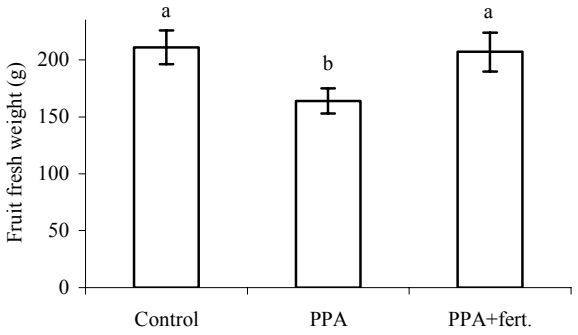
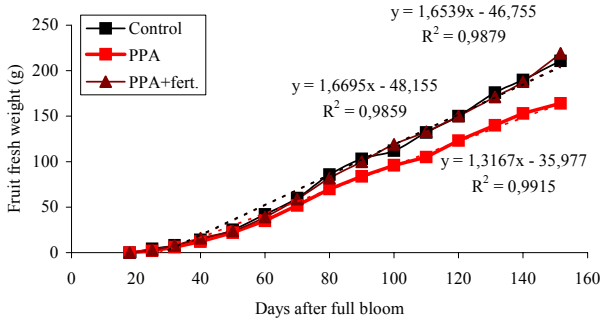


Figure 12: **Effect of treatments on fruit weight development for Idared under the vegetation period (avg. of 2004-2005)**



Treatments had effects on skin colour. Colour structure was changed unfavourably as a consequence of oversetting (under single PPA treatment). Generally, the red over-colour was decreased and ground colour or transition were increased. In the case of PPA+fertilization treatment the red over-colour was decreased too. The increased vegetative development because of additional nutrient supply contribute to these changes (*Figures 13-14*).

Figure 13: **Effect of PPA treatments on skin colour of fruit for Idared (avg. of 2004-2005)**

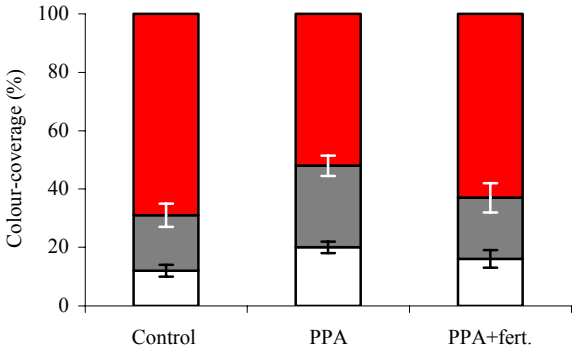
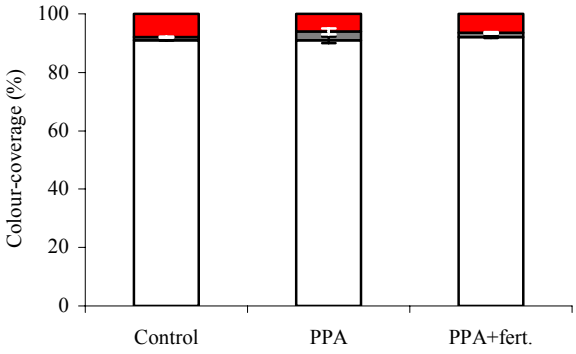
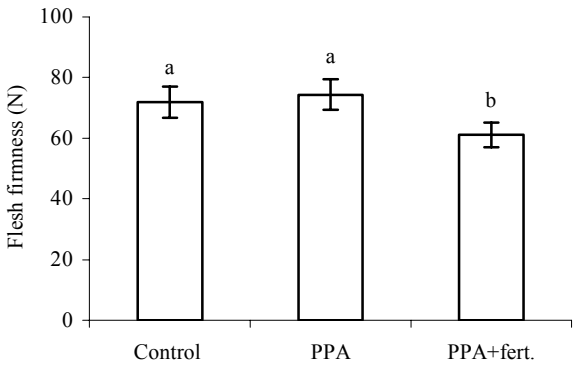


Figure 14: **Effect of PPA treatments on skin colour of fruit for Granny Smith (avg. of 2004-2005)**



Flesh firmness of fruits did not show clear reaction under single PPA application. Firmness was increased for Gloster and Jonagold. In other cultivars were not found any significant changes. In contrast, firmness was decreased in PPA+fertilization treatment. Negative correlation between firmness and fruit weight was responsible for the changes. Significant changes were not found for Gala Must and Granny Smith (*Figure 15*).

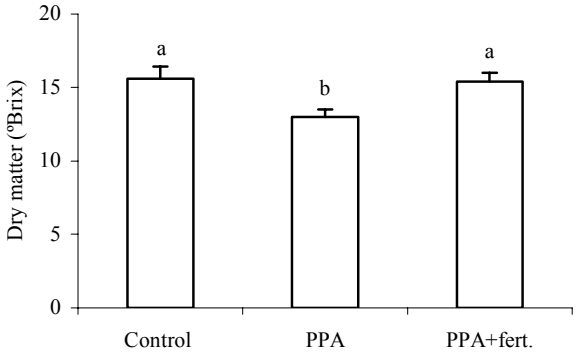
Figure 15: **Effect of PPA treatments on flesh firmness of fruit for Idared (avg. of 2004-2005)**



Cultivar	PPA	PPA+fert.
Gala Must	**ns.**	**ns.**
Gloster	✓	✓
Granny Smith	**ns.**	**ns.**
Idared	**ns.**	✓
Jonagold	✓	✓
Jonathan Cs.	**ns.**	✓
Mutsu	**ns.**	✓

Dry matter content of fruits was decreased under PPA application, because the assimilation green area was very small for the relative so many fruits. Under additional fertilization we did not observed any changes compared to the control (except Idared) (*Figure 16*).

Figure 16: **Effect of PPA treatments on dry matter content of fruit for Idared (avg. of 2004-2005)**



Cultivar	PPA	PPA+fert.
Gala Must	✓	**ns.**
Gloster	✓	**ns.**
Granny Smith	✓	**ns.**
Idared	✓	✓
Jonagold	✓	**ns.**
Jonathan Cs.	✓	**ns.**
Mutsu	**ns.**	**ns.**

CONCLUSIONS

Advantages of PPA application

- Flowering period of PPA-sensitive cultivars can extend so much, that more favourable cultivar-structure can build up in an orchard.
- The extended time of main bloom and the end of bloom can play an important role that time and site, where frost damage occurs often in spring.
- Fruit set can increased considerably for poorly setting cultivars.
- With additional nutrient supply, significant improve of fruit quality can be found with regard to increased fruit number per tree.

Disadvantages of PPA application

- In the case of oversetting, the optimal vegetative-generative ratio is shifted to the generative parts and will be any competition.
- Fruit drop is increased. It is undesirable, because the assimilates which are used up by young fruits until the abscission are wasted.
- Other negative effect of competition and using up the assimilates is increased frost sensitivity of trees during winter.
- The heavy crop load on young trees often cause branch breaking, especially in lateral ones.
- As a result of oversetting, alternate bearing can occur for susceptible cultivars.
- In fact, PPA application can decrease fruit quality inderctly through the effect of heavy crop load.

The consistent consideration of advantages or disadvantages and the expert cultivar specific application (doses, date of application etc.) of PPA can result in desired positive impacts.

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