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NAA-induced ethylene evolution by plum flowers and fruitlets

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ABSTRACT

Six-year-old plum trees 'Stanley' were sprayed with a solution of NAA potassium salt. The treatments were conducted at two dates on two groups of trees. The first treatment was carried out by the end of the blooming period after flower fertilization. An additional indicator of the treatment at that time was the falling off petals and a distinctly visible abscission zone between the floral tube and the pedicle. The applied NAA concentrations varied from 30 to 80 mg l^{-1}. The second treatment was conducted about 10 days later. In all treatments of the experiment an increase in the evolution of ethylene by flowers and plum fruitlets was recorded already on the second day after spraying. In the three years of the investigation the most intense and prolonged ethylene evolution was noted after the first NAA treatment. A significant effect of weather conditions and years on the intensity of ethylene evolution by plum flowers and fruitlets was noticed.

Abbreviations:
BA – 6-benzylaminopurine
NAA – potassium salt of alpha-naphtaleneacetic acid
ACC – 1-aminocyclopropane-1-carboxylic acid
AVG – aminoethoxyvinylglycine
term I – the first date of spraying at the end of blooming
term II – the second date of spraying about 10 days after the first treatment

INTRODUCTION

For the last 30-40 years NAA has been used in the regulation of fruiting. However, the mechanism of its effect is not quite clear yet (Williams and Fallahi 1999). Several theories concerning the mechanism of NAA effect have been described in the literature. One of them is based on the action of ethylene synthesis which is stimulated by exogenous auxin (Curry 1991 a).

MATERIAL AND METHODS

The investigation was carried out in a six-year-old trees of 'Stanley' plums. The treatment was conducted with the use of knapsack-spraying machine, at 6 p.m. in rainless weather conditions. NAA potassium salt was applied twice on two groups of trees. The first treatment (term I) was carried out by the end of flowering, however the main cause of this term was a distinctly visible abscission layer between the floral tube and the style indicating fertilization (Lott and Simons 1966). The second treatment (term II) followed 10 days later. In the first year of the investigation the concentrations of 30 and 40 mg NAA l^{-1} and in the second of 40 mg NAA l^{-1} were used. In the second and third year of the experiment 50 mg NAA l^{-1} dose was added at the first date of treatment and 80 mg NAA l^{-1} at the second. Flowers and fruit sets were sampled every day at the same time and closed in airtight vials for two hours. Twelve vials of 10 flowers each were prepared from each treatment of the experiment. After 2 hours 1 ml of gas was sampled and analysed using gas chromatography. In statistical calculations 10 replications were used, the highest and the lowest results being rejected.

RESULTS

In the first year of the investigation differences in the intensity of ethylene evolution by fruit sets of 'Stanley' plums treated with solution of NAA, were noted already on the next day after the first treatment (term I) (Fig. 1A). The greatest differences were found between the third and seventh day in comparison with the control. On the sixth day after the treatment with 40 mg l^{-1} the concentration of ethylene was five times higher than in the control. The distinctly more intensive ethylene evolution was maintained for about eight days after the treatment.

After the second treatment (term II) (Fig. 1B) the measurements conducted next day also showed a distinct increase in ethylene evolution. On that day flowers and fruit primordia liberated more than twice as much ethylene in comparison with the control trees. The greatest difference in the quantity of the exuded ethylene was recorded on the fourth day after application of 40 mg NAA l^{-1}. The evolution of ethylene by fruitlets from the treated trees was three times greater than that noted in control trees. The intensified evolution of ethylene was maintained during about 5 days after spraying.

In the second year of the experiment the distinct differences in the amount of exuded ethylene were observed on the third day after the treatment only (Fig. 2A). During 13 days of the investigation the quantities of the released ethylene varied to a great degree in the control plot. Hence in comparison with the control a distinctly greater amount of ethylene was only found in the treated plots between the third and fifth day and between the ninth and twelfth day after the treatment.

The second application (term II) of auxin induced an increase in the amount of ethylene evolution during 3 days after the treatment (Fig. 2B). The greatest amount of ethylene was recorded on the second day. On the fourth day the auxin-induced ethylene evolution by the treated trees did not differ from that in the control plot.

In the third year of the investigation the evolution of ethylene was only noted on the first and second day after the treatment of trees with an auxin solution (Fig. 3A). After the second treatment (term II) greater amounts of liberated ethylene were only found during four days after spraying (Fig. 3B).

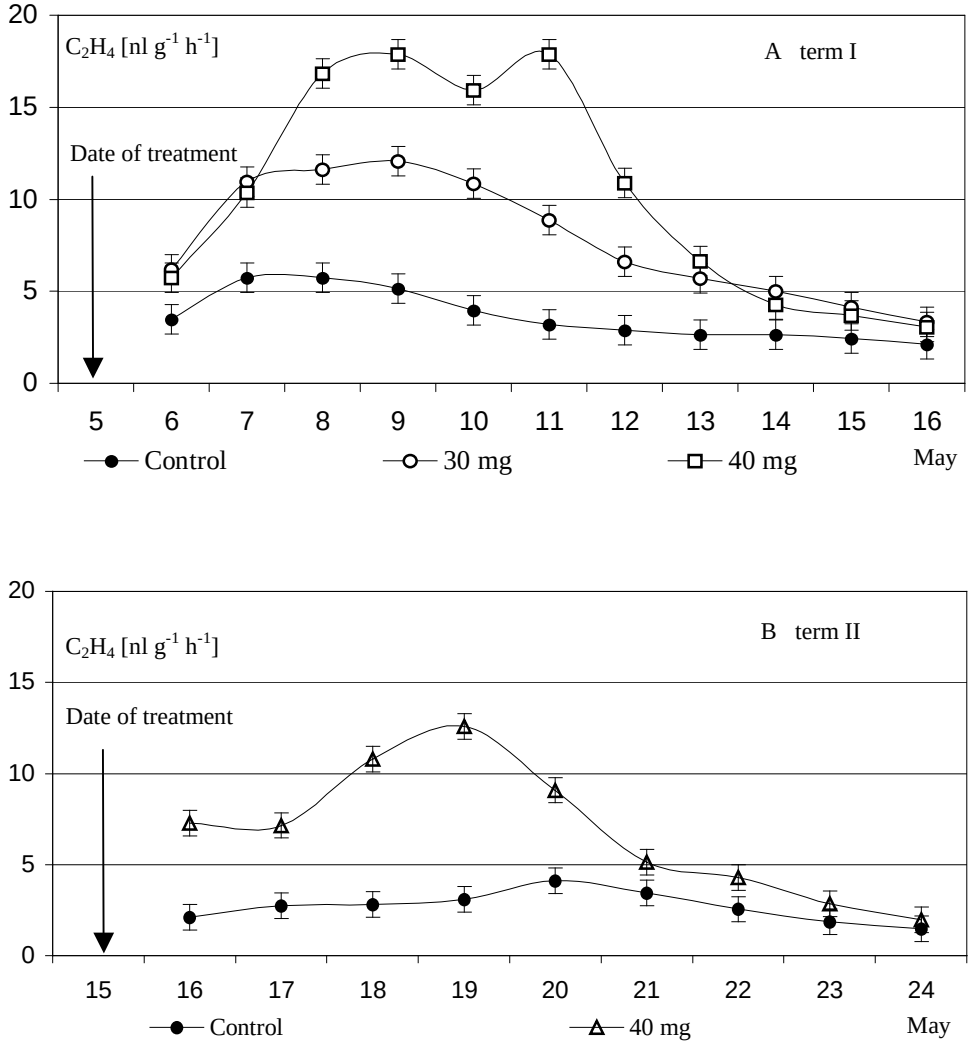

Figure 1. Quantity of ethylene emitted by flowers and fruitlets of 'Stanley' plums as depending on the concentration of auxin (mg NAA l^{-1}) applied at the first treatment (A: term I – May 5.) and at the second treatment (B: term II – May 15.) in 1999. Significance interval marked with vertical bars ±.

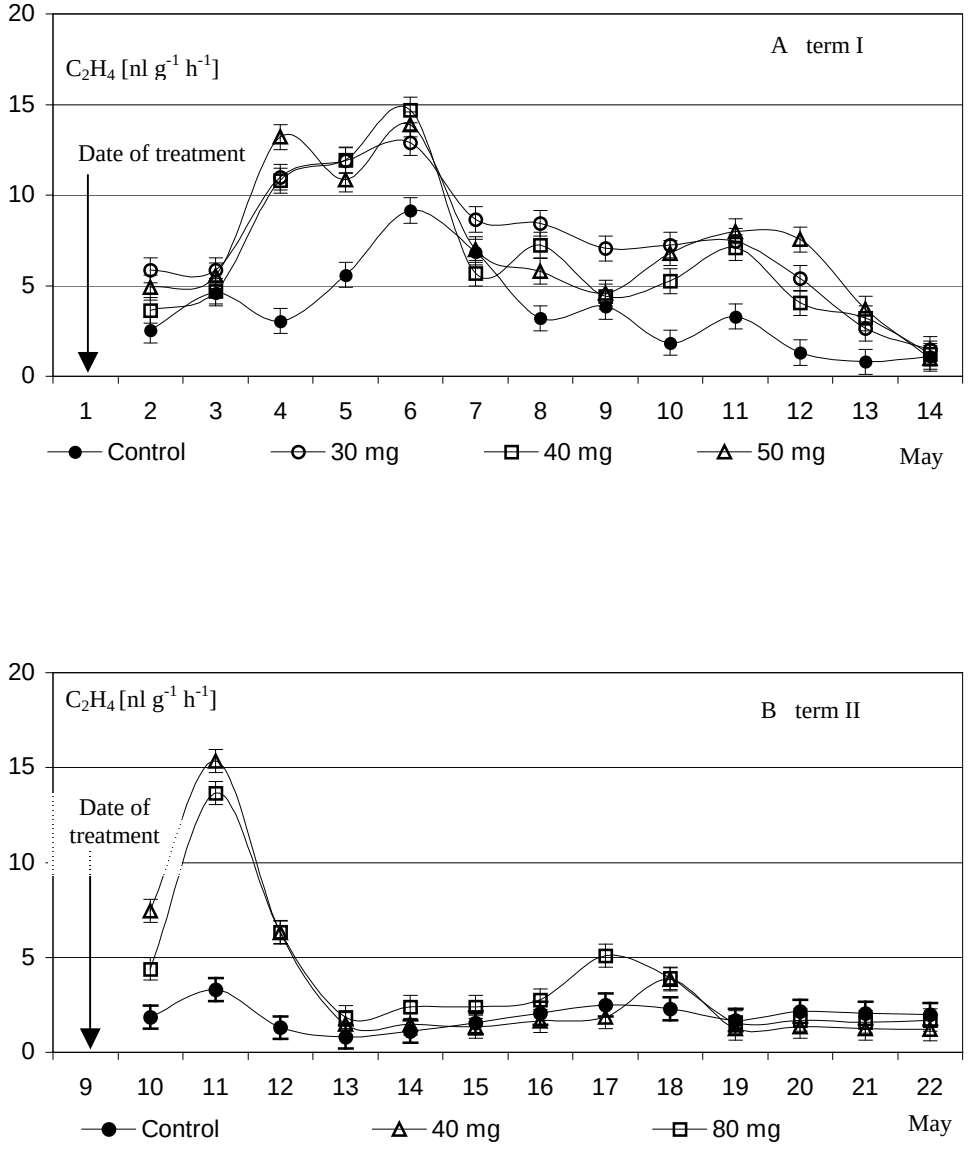

Figure 2. Quantity of ethylene emitted by flowers and fruitlets of 'Stanley' plums as depending on the concentration of auxin (mg NAA l^{-1}) applied at the first treatment (A:term I – May 1.) and at the second treatment (B: term II – May 9.) in 2000. Significance interval marked with vertical bars ±.

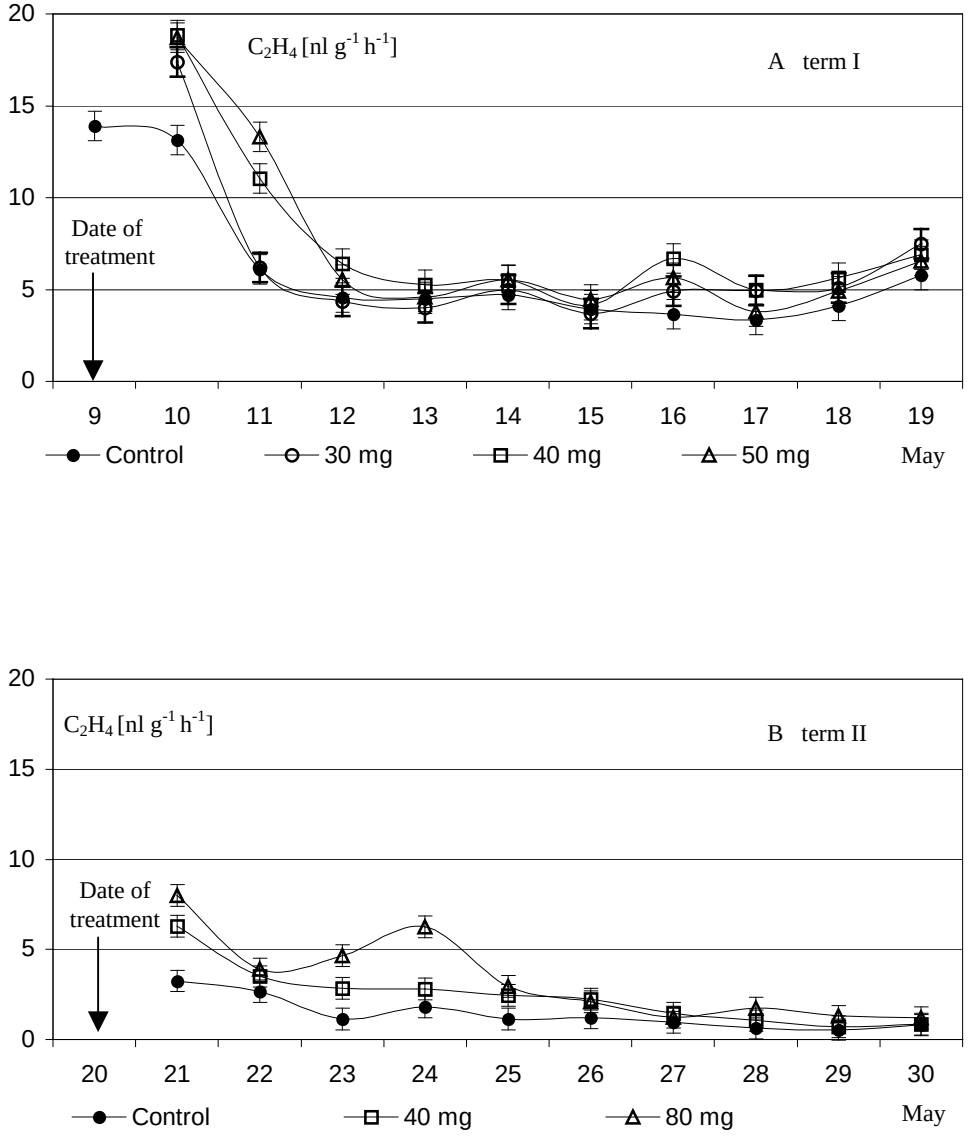

Figure 3. Quantity of ethylene emitted by flowers and fruitlets of 'Stanley' plums as depending on the concentration of auxin (mg NAA l^{-1}) applied at the first treatment (A: term I – May 9.) and at the second treatment (B: term II – May 20.) in 2001. Significance interval marked by vertical bars ±.

DISCUSSION

In all three years of the experiment an increase in the intensity of ethylene evolution by plum flowers and fruitlets was observed after NAA application. The intensified evolution of this gas appeared already on the day following the treatment. The obtained results agree with these reported by Curry (1991 a). In the experiment conducted by this author the application of 10 mg NAA l^{-1} to apple trees caused a more intensive evolution of ethylene already after 24 h, the greatest quantity (about 20 nl ethylene g^{-1} h^{-1}) being noted after 48 h. In another experiment Curry (1993 a) used three forms of NAA (ammonium, sodium and potassium forms) and recorded the most intensive ethylene evolution after the NAA treatment in the form of potassium salt. Ortola et al. (1998) also observed greater quantities of exuded ethylene in the case of mandarin trees treated with an NAA solution. Not only the exogenous NAA but also BA (Greene et al. 1992) and many other factors stimulate the production of ethylene. One of them is the plum-pox virus (Zhang et al. 2000) which induces conversion ACC to ethylene. In the present experiment the greatest quantities of liberated ethylene were recorded between the 2nd and 5th day after the application of auxin. These results agree with those reported by other authors (Iwahori 1976, Hirose 1981, Wheaton 1981, Ortola et al. 1997) who recorded the greatest amounts of this gas between the 2nd and 4th day after the treatment.

The comparison of three-year records of the intensity of ethylene evolution during some days after NAA application shows distinct differences between treatments. In general, the evolution of ethylene was more intensive after the first treatment (term I) than 10 days later (term II). This is corroborated by the results reported by Curry (1991 a) who recorded decrease in ethylene evolution with delayed periods of NAA application. It was also found that the fastest response of plant tissues to exogenous NAA, manifested by ACC synthesis and ethylene evolution occurs just after the period of full blooming. Distinct differences were also observed between the years. In the first year of the experiment the intense evolution of this gas was maintained during seven days following the treatment, the greatest amounts of ethylene being noted on the 4th and 5th day. In the third year of the investigation a distinctly greater quantity of the gas was only noted during two days after the application of NAA. Analyses of diagrams illustrating the amounts of ethylene evolution in that year of the experiment (2001) show a distinctly falling tendency in the evolution of this gas, which appeared already on the second day after the treatment. This finding suggests that in 2001 the greatest amounts of ethylene were exuded during the first 16 h after the application of NAA (the treatment at 6 p.m., the first measurement on the next day at 10 a.m.). Curry (1991 a) showed that the intensity of ethylene evolution depended on the

temperature. The sampling of gas from containers with the plant material kept at different temperatures showed a close dependence between the amount of released ethylene and the temperature. However, it is difficult to state definitely whether the differences between the treatments (also the variation within one treatment was observed) in the amount of liberated ethylene were connected with temperature variation. In the present experiment the accumulation always occurred at the same temperature (about 20^{o}C) while in the investigation by the above-quoted author at different temperatures. The comparison of the amounts of ethylene evolution with the average daily temperature (unpublished data) on the days following the NAA treatment in 1999 shows an increase in ethylene evolution on the successive days with increases in the temperature. In the second year of the experiment on days when the evolution of ethylene was reduced (or there was no increase), the temperatures were lower. In the third year of the experiment the daily temperatures below 15^{o}C followed both NAA treatments (term I and term II). In that year the intensive ethylene evolution was only recorded during two days after the spraying.

It can be definitely postulated that ethylene plays a significant role in the physiological processes in plants and its high concentration can induce fruitlets drop. The thesis that ethylene plays the basic role in the process of fruit thinning is corroborated by the investigation on the use of ethylene inhibitors AVG (Curry 1991 b, 1993 b) and silver salt (Yuan et al. 1989). In these experiments the application of a silver salt solution or AVG to the trees delayed or even prevented the June drop, inducing an increase in the final percentage of fruit setting. The treatment of trees with a mixture of AVG and NAA did not induce the effect of thinning contrary to the treatment with an NAA solution only.

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WYDZIELANIE ETYLENU PRZEZ KWIATY I ZAWIĄZKI OWOCOWE ŚLIW PO ZASTOSOWANIU AUKSYNY NAA

Streszczenie: Sześcioletnie drzewa odmiany ‘Stanley’ opryskano roztworem soli potasowej NAA. Zabieg wykonano w dwóch terminach na dwóch grupach drzew. Zabieg w terminie I wykonano pod koniec kwitnienia, po zapłodnieniu kwiatów. Dodatkowym wskaźnikiem dla wykonania zabiegu w pierwszym terminie był początek opadania płatków korony oraz wyraźnie widoczna warstwa odcinająca między okwiatem a szypułką. Zastosowano stężenia od 30 do 80 mg NAA l^{-1}. Zabieg w drugim terminie wykonano około 10 dni później. W każdej kombinacji, począwszy już od następnego dnia po zabiegu, stwierdzono wzrost wydzielania etylenu przez kwiaty i zawiązki owocowe śliw. We wszystkich trzech latach badań najintensywniejsze i trwające najdłużej wydzielanie etylenu zanotowano po zabiegu wykonanym w terminie pierwszym. Pomiar ilości wydzielanego etylenu trwał przez około dziesięć dni po traktowaniu NAA. Zaobserwowano duży wpływ pogody oraz lat na intensywność wydzielania etylenu przez kwiaty i zawiązki owocowe śliw.

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