MODELING OF ACID RAIN CONTENT AND ITS EFFECT ON THE BEARING CAPACITY OF PEACH TREES

M.I. Klymenko, O.E. Klymenko

Nikita botanical gardens UAAS, Steppe Department,
v. Novy sad, 11, Gvardeyskoye, 97513 Simferopol, Ukraine.
Telephone: 38 0652 325390, e-mail: olga.gnbs@mail.ru

Acid precipitation (AP) is one of environmental contamination components. Chronic effect of them with definite chemical composition and concentration during the vegetation can decrease the yield of peach (Persica vulgaris Mill.) to 30-50 % (1). The aim of our experiments was to establish a period when reproduction organs are more damaged by AP, estimate the effect of AP with sulfate chemical content and pH values on ones and indicate the sensitivity of peach tree to AP. Our investigations are made on the models because the AP is an incidental phenomenon in nature. We have investigated influence of simulated acid rain (SAR) of sulphate content with pH equal 2, 3, 4 and 5 units on peach 'Favorita Morettiny' on the almond stock. As control trees was taken no sprayed trees. Content and degree of SAR acidity didn't significantly effect on the fruit bud formation and infructescense. SAR of sulphate composition with pH=3 and =2 decreased significantly the quantity of pistils especially in the condition of self-pollination. The amounts of formatted fruits depend on the SAR pH and breading property. The correlate analysis and equal of regressions allow predicting the capacity of peach yield. More danger for peach tree which effected by AR are the periods of blossoming, growing and ripening of fruit.

Introduction

Acid precipitations (AP) are a powerful factor of negative anthropogenic influence on natural environment, including on agricultural plants. Damage of the foliar apparatus, oppression of growth, the infringement of physiological processes in organism results in reduction or complete loss of a crop – the basic parameter of their efficiency. There is the information about the influence of AP on the productivity fruit plants in the literature (2, 3, 4, 5), but basically they only deal with the apple tree. Our peach researches show for the first time reduction of its crop till 30-50 % under the influence simulated acid rain (SAR) with pH = 2 and 3 (1). However, it is not clear, at what stage of reproductive organ growing and developing in fruit cultures they are most vulnerable for AP. Not numerous works are devoted to the study of AP influence and the air pollution by sulfur and nitrogen oxides, those are the basic suppliers of the acid to the atmosphere, on the pollen viability in fruit plants (6, 7). In the literature we have not met the researches on AP influence on this parameter in peach trees. AP, dropped out during flowering trees, can cause irreparable harm to the crop. In this connection there are carried out the field and laboratory experiments on SAR of sulfuric content influence on the condition of blossom elements, pollen viability of peach on the quantity and formation degree of flower buds, infructescense

of fruits and peach bearing of variety ‘Favorita Morettiny’ in the conditions of chronic and sharp damage. The purpose of the researches was also to establish quantitative dependences of various parameters in fruit bearing and growth of peach on pH SAR size.

Methods

Objects of the research were fruit-bearing peach trees variety ‘Favorita Morettiny’ on almond rootstock. In the field experiment there were studied chronic SAR influence of sulfuric content with various pH size on the characteristics of bearing and growth in peach trees this variety during 2 vegetation periods in 1997 and 1998 on the standard techniques (8). The technique of foundation and realization of field experiment is described in detail by us (1) earlier. Reiteration of the experiment is five-multiple.

Viability of pollen was defined in two experiments. In the first case pollen from bearing trees were collected from non-revealed button, dried on the air and let germinate in the thermostat at 25^{o}C on the environment consisting of 1 % agar-agar, 10 % sucrose and solutions of a sulfuric acid with pH = 2, 3, 4 and 5. The control was the environment prepared on distilled water with pH = 5.6. Environment in a hot condition was placed onto the subject glass; pollen was placed and then located into Petri dish, on which bottom there was put damp and filtered paper. In a day there was observed the degree of the pollen germination under the microscope (300 pollen grains on a variant), which was accepted for its viability (9).

In the second experiment pollen of ‘Favorita Morettiny’ variety, which trees during two vegetation periods were applied with the same sizes pH in SAR, let germinate in the same conditions on the substrate, prepared on the distilled water to define chronic SAR influence, influencing in the previous years on the pollen viability of the current year. The data are processed statistically; as authentic there is accepted their 5 % significance value. Reiteration of the experiments is five-multiple.

Modeling experiment on SAR influence on the pistils condition of ‘Favorita Morettiny’ species was carried out after button castration Saks method, expendable blossom processing by the solutions of the acid with various pH sizes and their isolation for 7 days. After that the isolators were removed and the percent of alive pistils was counted up. Study of fruit infructescense degree in the condition of self-pollinated peach ‘Favorita Morettiny’ was carried out on a technique (9) on the fruit-bearing trees on almond rootstock, by expendable blossom processing by the solutions of the acid with various pH sizes and their further isolation for self-pollination.

Results

The chronic SAR influence with various pH size, influencing in the period of foundation and formation of blossom buds in ‘Favorita Morettiny’ (a) is established to cause some reduction of pollen viability, which at pH = 2 – 4 differs from the control on 9 – 15 %, at pH = 5 is close to the control, the differences with it on all variants are doubtful (tab. 1). The acid influence direct on the process of pollen germination in the peach (b) factually reduced almost twice the pollen viability at pH = 2 and 3 in comparison with the control. SAR with pH = 4 on the influence on this parameter is close to the control, with pH = 5 it stimulated a little pollen germination of the peach tree (tab.1).

Table 1. SAR influence on pollen viability of peach tree 'Favorita Morettiny', %; a – chronic influence; b – sharp influence, 1998.

pH SAR	a	b
2,0	39,0	13,7
3,0	39,5	18,3
4,0	34,0	24,2
5,0	44,8	26,8
Control (pH=5,6)	48,5	25,6
HCP_{05}	$F_{\Phi} < F_{05}$	3,9

Researches of blossom bud foundation, flowering, infructescense and formation of peach fruit of 'Favorita Morettiny' have shown that on the average for two years of the experiment the quantity of blossom bud on the control plant was rather high (tab. 2). SAR with pH = 2 has lowered this size considerably. While SAR applying with pH = 3 and 4 about identical quantity of blossom buds was founded, which was a little lower, than on the control. SAR with pH = 5 has not almost affected their number, and the differences are authentic for all variants of experiment in comparison with the control. SAR influences a little the degree of blossom bud formation, which in the control achieves 85.1 %, on the variants of experiment the differences with the control are insignificant and are doubtful (tab. 2).

The realization of modeling field experiment on SAR influence of various structures on the condition of blossom elements of the variety 'Favorita Morettiny' has shown, that the spraying of blossoming trees had not caused seen damages of petals. SAR sulphate content with pH = 2 and 3 damaged pistils, from which 67 and 52 %, accordingly, were lost as a result of drying by the acid.

Table 2. SAR influence on formation and quantity of blossom buds, blossoms and fruits of 'Favorita Morettiny' peach trees, 1997-1998.

pH SAR	Blossom buds, pieces	Formed from them, %	Blossoms, pieces	Ovaries, %	Fruit bearing, %
2.0	259	85.4	56	63	13.5
3.0	297	85.0	71	72	13.4
4.0	294	85.1	68	79	29.9
5.0	327	86.2	70	72	26.8
Control (pH=5.6)	319	85.1	78	86	36.3
HCP_{05}	$F_{\Phi} < F_{05}$	$F_{\Phi} < F_{05}$	$F_{\Phi} < F_{05}$	$F_{\Phi} < F_{05}$	2.6

SAR influenced considerably the process of infructescense of fruits in self-pollinated peach. The isolation of blossoms, processed by the sulfuric acid, has shown, that at pH = 2 infructescense of fruits made up only 15%, at pH = 3 – 68.6 % and at pH = 4 – 84.4 % from the blossom quantity. At the cross-pollination the decrease of infructescense at pH = 2 was not so significant for the account of pollen bringing

from the neighbour trees without SAR applying and made up 39 % from the blossom quantity.

Quantity account of the formed fruits from the blossom number has shown reduction of their quantity under SAR influence in all variants of the experiment, and at pH = 2 and 3 it was almost three times less than in the control (tab. 2).

Table 3. Dependences between SAR pH value (x) and parameters of pollen viability, fruit bearing and growth (y) of 'Favorita Morettiny' peach tree.

Parameter of fruit bearing and growth (y)	Factor of correlation	Mistake of correlation factor	Factor of determinatio n, %	Equation of line regression
Pollen viability, %	0.91	0.21	83	$У_1 = 4.7 x + 3.1$
Quantity of blossom buds, pieces	0.82	0.29	67	–
Quantity of blossom, pieces	0.85	0.26	72	$У_2 = 4.3 x + 51.4$
Infructescense, %	0.86	0.26	74	$У_3 = 4.5 x + 60.0$
Fruit bearing, %	0.91	0.21	83	$У_4 = 5.9 x + 0.38$
Length of one-year gain, m	0.68	0.37	46	–
Area of a leaf plate, cm^2	0.63	0.39	40	–
Gain of trunk diameter	0.94	0.17	88	$Y_5 = 0.095 x + 1.076$

Especially close connection is stated with the size of fruit infructescense. From the parameters of the growth, only a gain of a trunk diameter of a tree authentically depended on size of pH as an integrated parameter for all synthetic processes of the fruit tree (tab. 3). The percentage of fruit infructescense was closer connected with percentage of ovary from the blossom quantity and the gain of the trunk diameter at all sizes of SAR pH, the factors of correlation are accordingly equal to 0.88 and 0.83.

For those cases, when the correlation connection was authentic, expected the equation of rectilinear regress between the specified parameters (tab. 3), on the basis of which, knowing pH size of the dropped out rains, is possible to predict the decrease of parameters of pollen viability and peach bearing. The factors of determination, expressing a share (percent) of changes in the investigated factor caused by SAR pH size (tab. 3), show the greatest share of influence its on pollen viability, and also percent of fruit infructescense and make up 83 and 88 %.

Discussion

Quantity of outbuded blossom (after pruning) and percent of ovary from the quantity of blossom were lower in all variants of our experiment in comparison with the control, especially much more at pH = 2 (statistically difference is not large), however such degree of fruit infructescense is capable to supply a high crop (10).The chronic SAR influence of the previous year on the foundation and formation of peach was

insignificant, the total SAR influence effect last and current years (on blossom and ovary) was appreciable only at pH = 2 and 3, but doubtful.

The process of fruit formation did not depend so much from the ovary, but it depended more on a general condition of a tree and physiological processes in the organism, occurring under SAR influence. It proves to be true by the results of the correlation analysis of fruit bearing parameters, pH growth and size. Thus, losses in the peach crop are connected most closely with an oppression of growth and other physiological processes of an organism and inability of a plant to found the ovary and to generate fruits. Close direct authentic correlation dependences for all investigated parameters of fruit bearing and pollen viability are found out, except for quantity of blossom buds, from size of SAR pH.

Conclusion

1. The simulated acid rain of sulfate structure reduced pollen viability in peach, apricot and myrobalan plum. The levels of pH = 2 and 3 are most toxic for peach and apricot. For myrobalan plum, as steadier fruit species, critical is pH = 2 at sharp damage. SAR influence during flowering oppressed pollen viability in peach more strongly, than its chronic influence in previous vegetation.

2. SAR did not render significant influence on the foundation of blossom buds, their formation and quantity of blossom. SAR influence with pH = 2 and 3 during flowering, growth and maturing of fruits has resulted in authentic reduction of the number of ovary and fruits in peach tree at the expense of pistil destruction, infringement of pollination process and fertilization and, probably, insufficient supply of fruits by nutritious substances because of the damage of the leaf apparatus by the acid. It is not established the adverse SAR influence with pH = 5 on process fruit bearing in peach.

3. There are established the close authentic correlation dependences between SAR pH size and parameters of pollen viability, quantity of blossom, ovaries and fruits in peach. Designed equations of regress allow to predict the size of the peach crop in conditions of the acid rain of sulfate structure with various pH sizes.

References

1. O.E. Klymenko, M.I. Klymenko, The acid precipitations and growth of peach tree, Subjects of Bioindication and Ecology, Zaporigga, 55-60, (1999) (in Russian).
2. D.A. Kolesova, P.G. Chmir, Influence of acid rains on apple orchards and way of its reduction, Horticulture and viticulture, **1**, 5-7, (1996). (in Russian).
3. D. P. Ormrod, Gaseous air pollution and horticultural crop production, Hortic. Reviews, **8**, 1-42 (1986).
4. J. T. A. Proctor. Effect of simulated sulfuric acid rain on apple tree foliage, nutrient content, and yield and fruit quality. Environ. Exp. Bot. **23**. 167-174 (1983).
5. C. Rinallo, Comparative effect the salt components of acid rain, acidified water and simulated acid rain on *Malus communis L.* and *Pirus Communis L,.* Advances in horticultural Science, **3**, # 3, 126-132, (1989).

6. V.P. Bessonova, I.I. Ligenko, Influence of environmental pollution on germination and physiological pollen status of some wood plants, Botanical journal, **76**, № 3, 422-426, (1991) (in Russian).
7. P.L. Forsline, R. C. Musselman, R.J. Dee and W. J. Kender, Effect of acid rain on grapevines. Am. J. Enol. Vitic. **34**. 17-22 (1983).
8. Program and technique of strain investigation fruit, berry and nut cultures, Ed. G.A. Lobanova, All-Union institute named by Michurin, Michurinsk, (1973). (in Russian).
9. Z. P. Pausheva. Practical works in plant physiology. 3th. Kolos, Moskow (1980). (in Russian).
10. I.M. Shajtan, L.M. Chuprina, V.A. Anpilogova, Biological features and planting of peach, apricot and myrobalan plum trees, Ed. B.K. Gaponenko, Naukova dumka, Kijiv, (1989). (in Russian).