

# Phytotoxic effects of fungicides, insecticides and nonpesticidal components on pepper depending on water quality

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## SUMMARY

Modern agriculture relies on simultaneous application of fungicides, insecticides, fertilizers and adjuvants. The selection of compounds for tank-mixes has been rarely studied and it presents a risk in the application of pesticides but the quality of water should also be considered. The aim of this study was to assess the phytotoxic effects of several fungicides, insecticides, a complex fertilizer, an adjuvant and their mixtures on pepper (*Capsicum annuum* L.) as a test plant, depending on water quality. The effects of the pesticides: azoxystrobin (Quadris, 0.75 l/ha), mancozeb (Dithane M-70, 2.5 kg/ha), thiamethoxam (Actara 25-WG, 0.07 kg/ha) and cypermethrin (Cipkord EC-20, 0.3 l/ha), a complex fertilizer (Mortonijc plus /hereinafter: M+ / 3kg/ha), an adjuvant (Sillwet 77-L, 0.1 l/ha) and their mixtures, were assessed depending on the quality of water (well water – slightly alkaline, very hard and with high nitrite content; tap water – neutral and slightly hard; surface water – alkaline, slightly hard and with high content of nitrite and ammonia) using a puncture method. The effects were assessed after seven days by measuring the diameter of chlorosis and/or necrosis around puncture sites, and were expressed in mm<sup>2</sup>. The significance of differences between treatments was analyzed using a one-way ANOVA (LSD 0.05 %). In the slightly alkaline and very hard well water, all spray liquids containing Dithane M-70 caused a significant increase in leaf chlorosis area (from 6.0 to 25.2 mm<sup>2</sup>), compared to the control and other treatments. In the neutral and slightly hard tap water, all spray liquids containing Dithane M-70 caused a significant increase in leaf chlorosis (5.3 to 7.9 mm<sup>2</sup>) compared to the control and the other spray liquids, although its phytotoxicity in that water was at a lower level than it was in well water. However, in the weakly alkaline and slightly hard surface water from the river Sava, Dithane M-70, Dithane M-70 + Actara WG-25, Dithane M-70 + Sillwet L-77, and Dithane M-70 + Actara 25-WG + M+ showed a significant increase in phytotoxicity, compared to the control.

**Keywords:** Pesticides; Water quality; Phytotoxicity

## INTRODUCTION

Phytotoxicity is the ability of pesticides to cause temporary or permanent damage to vegetative or generative organs, to reduce or totally inhibit germination, and to cause other physiological and morphological changes in sensitive plant species, and/or to certain varieties or genetic lines. Damage occurs in various ways, mostly as a chlorosis, i.e. partial or complete destruction of chloroplasts, when leaves become chlorotic. Necrosis (burn) is another manifestation of phytotoxicity, which can lead to complete leaf drying or defoliation (Stanković, 1972; Short, 1981; Vuković, 2011).

Toxic effects of pesticides may occur in response to the activity of certain components in a preparation, or a short interval between successive treatments. Also, weakened and undernourished plants, those exposed to excessive fertilization with nitrogen and plants damaged by parasites and pests are much more sensitive to the activity of pesticides. Conditions during application, such as high moisture and temperature in particular, may adversely affect the metabolism and activity of pesticides and result in an unwanted harm done to the plants. Phytotoxicity may depend on the sensitivity of plant species, its variety or growth stage, or the compatibility of components in pesticide mixtures. Plants have better tolerance of mixtures of two preparations formulated as suspension concentrates than of two emulsifiable concentrates or an emulsifiable concentrate and a suspension concentrate (Kišpatić & Maceljčki, 1989). According to Ostojić (1977), phytotoxicity can occur as a consequence of simultaneous application of two or more different products for different uses, because the amounts of substances in pesticide products (including solvents, diluents, emulsifiers, etc.) double.

The quality of water used to prepare spray liquids can also cause toxicity to cultivated plants. The hardness and pH of water affect the quality and performance of individual pesticides, as well as pesticide mixtures, thus adding to treatment risks. Water properties can either cause rapid decay of an active ingredient or its persistence, which may lead to changes in biological effects as well (Vuković et al., 2009a).

Well water (pH 8.2) used in the mixture of Mankogal-80 + Sucip 20-EC has been found to cause phytotoxicity to tomato plants, whereas no phytotoxic effect was observed with tap water (pH 7.4) (Klokočar-Šmit et al., 2001). Also, the mixtures of Pyrinex EC-48 + Folpan WP-50 and Sucip EC-20 + Folpan WP-50 in well water (pH 8.2) caused phytotoxicity to tomato plants

(Klokočar-Šmit et al., 2002). Perović et al. (2005) and Perović (2006) assessed the influence of spray liquids containing imidacloprid, pirimiphos-methyl, mancozeb, propioneb, a complex fertilizer and their mixtures in well and tap water using three varieties of pepper (Krušnica, Buketna and Vranje). The phytotoxic effects depended on water quality, mixture components and plant varieties. In our earlier study, chlorotic changes had been observed on pepper leaves after applying solutions containing Dithane M-70 in surface water, while phytotoxic area increased 1.5- to 1.2-fold after applying the mixtures of Dithane M-70 + Actara 25-WG and Dithane M-70 + Sillwet L-77 in the same water, respectively (Vuković et al., 2009b). The aim of this study was to assess the effects of different fungicides, insecticides, a complex fertilizer, an adjuvant and their mixtures depending on water quality (i.e. well, tap and surface water) using pepper as the test plant.

## MATERIAL AND METHODS

### Waters tested

Water quality was determined in the Laboratory for Food and Feed Testing, Faculty of Technology, Novi Sad. Three waters were chosen for the experiment: well water (site Adice, GPS N 45°13.868' Eo 19°46.870'), tap water (Novi Sad, GPS N 45°14.833' Eo 19°51.132') and surface water (river Sava, GPS N 44° 58 477' Eo 19°35.629').

### Water quality

The quality of the waters tested (i.e. their pH, hardness, conductivity, content of chlorides, nitrites, nitrates, ammonium, calcium and iron) was determined according to standard methods: APHA (1998) and Savezni zavod (1990) (Table 1).

### Pesticides, complex fertilizer, adjuvant and their mixtures

The effects of several fungicides, insecticides, a complex fertilizer and an adjuvant and their mixtures, depending on water quality, were assessed in the Laboratory for Biological Testing and Pesticides, Department for Plant and Environmental Protection, Faculty of Agriculture, University of Novi Sad. The fungicides, insecticides, complex fertilizer (M<sup>+</sup>), adjuvant, their binary and triple mixtures, and their applied quantities are presented in Table 2.

**Table 1.** The quality of water used in experiments

Sampling sites (GPS)	Concen. of ions H (pH)	Hardness (d° H)	Conductivity (μ S/cm)	Chlorides (Cl) (mg/l)	NO <sub>2</sub> <sup>-</sup> (mg/l)	NO <sub>3</sub> <sup>-</sup> (mg/l)	NH <sub>3</sub> (mg/l)	Ca <sup>2+</sup> (mg/l)	Fe <sup>2+3+</sup> (mg/l)
Adice (well water)	7.55	<b>34.7</b>	1470	61.2	<b>2.5</b>	36.0	0.0	74.8	<0.05
Novi Sad (tap water)	7.42	15.4	641	26.0	0.002	2.8	0.01	78.4	0.02
Sava (S. Mitrovica) (surface water)	8.15	11.7	415	7.4	<b>0.18</b>	15.6	<b>0.93</b>	67.3	<0.3
<i>II class</i> *	<b>6.8-8.5</b>	**	<b>2500</b>	<b>200</b>	<b>0.03</b>	<b>50</b>	<b>0.1</b>	<b>200</b>	<b>0.3</b>

\* - maximum allowable values for waters of II quality class (Pravilnik, 1998);

\*\* - scale of hardness (0-4 very soft; 4-8 slightly soft; 8-16 slightly hard; 16-30 hard; >30 very hard)

**Table 2.** Insecticides, fungicides, complex fertilizer, adjuvant, their mixtures and application rates

Pesticides and nonpesticidal components	Application rates (kg, l/ha)/300 l water
Quadris	0.75 l/ha
Dithane M-70	2.5 kg/ha
Actara 25-WG	0.07 kg/ha
Cipkord 20-EC	0.3 l/ha
Mortonijc plus (M <sup>+</sup> )	3 kg/ha
Sillwet L-77	0.1 l/ha
Quadris+Cipkord 20-EC	0.75 l/ha+0.3 l/ha
Quadris+Actara 25-WG	0.75 l/ha+ 0.07 kg/ha
Dithane M-70+Cipkord 20-EC	2.5 kg/ha+0.3 l/ha
Dithane M-70+Actara 25-WG	2.5 kg/ha+0.07 kg/ha
Cipkord 20-EC+M <sup>+</sup>	0.3 l/ha+3.0 kg/ha
Quadris+ M <sup>+</sup>	0.75 l/ha+3.0 kg/ha
Dithane M-70+M <sup>+</sup>	2.5 kg/ha+3.0 kg/ha
Actara 25-WG+M <sup>+</sup>	0.07 kg/ha+3.0 kg/ha
Quadris+ Silwett L-77	0.75 l/ha+0.1 l/ha
Dithane M-70+ Silwett L-77	2.5 kg/ha+0.1 l/ha
Cipkord 20-EC+Silwett L-70	0.3 l/ha+0.1 l/ha
Actara 25-WG+Silwett L-77	0.07 kg/ha+0.1 l/ha
Quadris+Cipkord 20-EC+M <sup>+</sup>	0.75 l/ha+0.3 l/ha+3.0 kg/ha
Quadris+ Actara 25-WG+M <sup>+</sup>	0.75 l/ha+0.07 kg/ha+3.0 kg/ha
Dithane M-70+ Cipkord 20-EC+M <sup>+</sup>	2.5 kg/ha+0.3 l/ha+3.0 kg/ha
Dithane M-70+ Actara 25-WG+M <sup>+</sup>	2.5 kg/ha+0.07 kg/ha+3.0 kg/ha
Quadris+Cipkord 20-EC+Silwett L-77	0.75 l/ha+0.3 l/ha+0.1 l/ha
Quadris+Actara 25 WG+Silwett L-77	0.75 l/ha+0.07 kg/ha+0.1 l/ha
Dithane M-70+Cipkord 20-EC+Silwett L-77	2.5 kg/ha+0.3 l/ha+0.1 l/ha
Dithane M-70+Actara 25-WG+Silwett L-77	2.5 kg/ha+0.07 kg/ha+0.1 l/ha

## Test organism

Pepper (*Capsicum annuum*), the cultivar Novosadanka selected in the Institute of Field and Vegetable Crops in Novi Sad, was used as the test organism. Plants were grown under controlled laboratory conditions in a sterile soil without pesticide or fertilization treatment until the sixth true leaf was formed (stage BBCH 15-19).

## Testing the effects on plants

The effects of individual pesticides and their mixtures with nonpesticidal components (complex fertilizer and adjuvant), depending on water quality (well, tap and surface water), were assessed in tests using the puncture method (Gard, 1963; Stanković, 1969 cited by Šovljanski & Klokočar-Šmit, 1976;

Indić & Vuković, 2012). Water free of pesticides, fertilizer and adjuvant was used as the control. The tests were carried out in six replicates, under 16/8 h light/dark regime,  $22 \pm 2$  °C temperature and 54-63 % relative humidity. The effects, i.e. the chlorosis and/or necrosis diameter on pepper leaves, were determined after 7 days by measuring the diameter around puncture sites. The average values were expressed in mm<sup>2</sup>.

**Data processing and statistical analysis**

The significance of differences between treatments, i.e. between changes on test plants after the application of pesticide spray liquids and their mixtures with non-pesticidal components, depending on water quality, was analyzed using One-way ANOVA (LSD 0.05 %) in the software Statistica (2008).

**RESULTS**

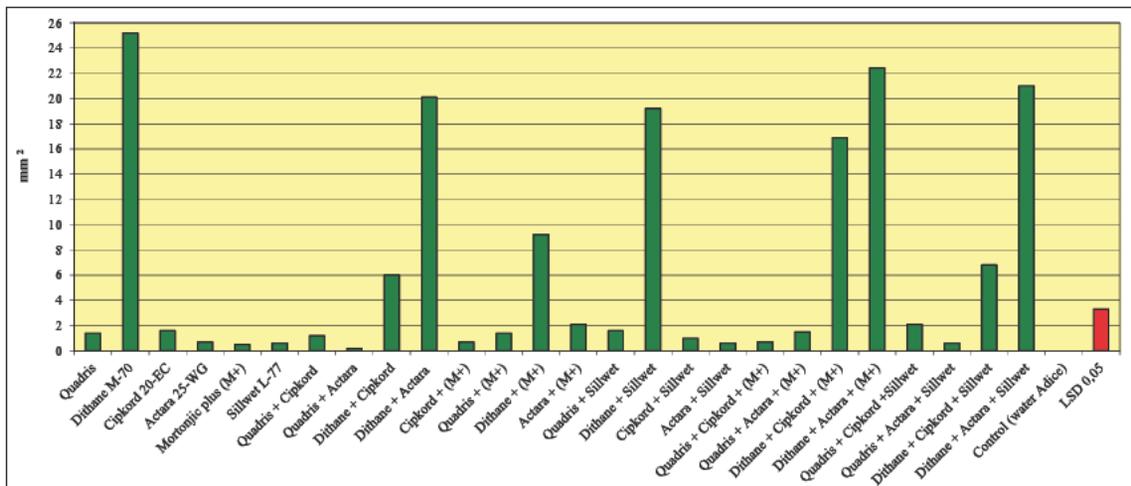
**Phytotoxic effects on test plants after application of fungicides, insecticides, nonpesticidal components and their mixtures in well water**

Toxic effects of the spray liquids of fungicides, insecticides, nonpesticidal components and their mixtures in well water (slightly alkaline /pH 7.55/, very hard /34.7 d°H/, with a high content of nitrite

/2.5 mg/l/) are presented in Figure 1. In the control with slightly alkaline and very hard water, no toxic changes around puncture sites were observed on pepper leaves. After applying the spray liquids of fungicides, insecticides, and nonpesticidal components, damage (0.5-1.6 mm<sup>2</sup>) was at the same level of significance with the control in all treatments except those containing Dithane M-70. Spray liquids that contained Dithane M-70 caused light to dark yellow chlorotic areas of average 25.2 mm<sup>2</sup> on leaves around puncture sites (Figure 2). The presence of Dithane M-70 in binary mixtures (Dithane M-70 + Cipekord 20- EC, Dithane M-70 + Actara 25-WG, Dithane M-70 + M<sup>+</sup> and Dithane M-70 + Sillwet L-77) caused changes around puncture sites with chlorotic surface of 6.0 to 20.1 mm<sup>2</sup> or reduced phytotoxic zones from 1.2- to 4.2-fold, compared to the damage caused by individual products. The changes caused by the triple mixtures of Dithane M-70 with other insecticides and the fertilizer or adjuvant (6.8 to 22.4 mm<sup>2</sup>) were reduced 1.1- to 4.2-fold, compared to the damage caused by that fungicide alone.

The data infer that all spray liquids containing Dithane M-70 in slightly alkaline, very hard water with a high content of nitrite caused chlorotic changes on test plants that were significantly greater than those in controls and variants that did not contain Dithane M-70, while all other mixtures caused minor changes which were at the same level of significance with the control.

**Figure 1.** Leaf area (mm<sup>2</sup>) damaged by the application of fungicides, insecticides, nonpesticidal components (complex fertilizer and adjuvant) and their mixtures in well water from Adice\*



\* slightly alkaline (pH 7.55); very hard (34.7 d°H) - nitrite content is increased 80-fold MAC (2.5 mg/l)



Figure 2. Phytotoxic effects on pepper leaves after application of Dithane M-70 in well water

### Phytotoxic effects on test plants after application of fungicides, insecticides, nonpesticidal components and their mixtures in tap water

The effects of spray liquids of fungicides, insecticides, nonpesticidal components and their mixtures in tap water (neutral /pH 7.4/, slightly hard /15.4 d°H/) on leaves of the test plant are shown in Figure 3. By applying only tap water in the control, no toxic changes were recorded around puncture sites on pepper leaves. After the application of spray liquids containing Quadris, Actara 25-WG, Cipkord 20-EC, M<sup>+</sup> and Sillwet L-77 and their binary and triple mixtures, toxic changes were at the same level of significance with the control. The spray

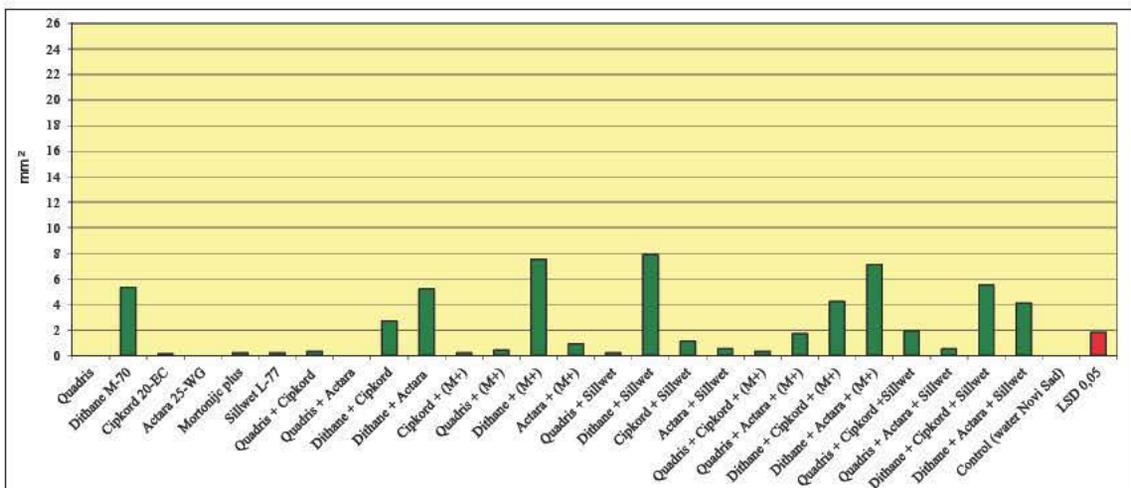
liquids containing Dithane M-70 caused significantly more leaf damages than the control. Concerning changes caused by Dithane M-70 (5.3 mm<sup>2</sup>), its phytotoxicity was significantly reduced (2.7 mm<sup>2</sup>) when Cipkord EC-20 was added. However, the mixtures of Dithane M-70 + M<sup>+</sup> and Dithane M-70 + Sillwet L-77 significantly increased (7.5 and 7.9 mm<sup>2</sup>, respectively) the chlorosis area around puncture sites. Triple mixtures (Dithane M-70 + Cipkord 20-EC + M<sup>+</sup>, Dithane M-70 + Actara 25-WG + M<sup>+</sup>, Dithane M-70 + Cipkord 20-EC + Sillwet L-77 and Dithane M-70 + Actara 25-WG + Sillwet L-77) caused chlorotic changes on leaves that ranged from 4.1 to 7.1 mm<sup>2</sup>. By adding M<sup>+</sup> fertilizer into the mixture of Dithane M-70 + Actara 25-WG, phytotoxicity was significantly increased (7.1 mm<sup>2</sup>) compared to the effect of the binary mixture (5.2 mm<sup>2</sup>).

The findings show that all spray liquids containing Dithane M-70 in slightly alkaline and slightly hard water caused phytotoxic changes to plants that were significantly higher than the control and all other liquids, while those other spray liquids caused changes that were at the same level of significance with the control.

### Phytotoxic effects on test plants after application of fungicides, insecticides, nonpesticidal components and their mixtures in surface water

The effects of spray liquids of fungicides, insecticides, nonpesticidal substances and their mixtures in surface water (slightly alkaline /pH 8.1/ slightly hard /11.7 d°H/

Figure 3. Leaf area (mm<sup>2</sup>) damaged by the application of fungicides, insecticides, nonpesticidal components (complex fertilizer and adjuvant) and their mixtures in tap water from Novi Sad\*



\* neutral (pH 7.4); slightly hard (12.9 d°H)

with increased nitrite /0.18 mg/l/ and ammonia /0.93 mg/l/ contents) on leaves of the test plant are presented in Figure 4. The application of surface water from the river Sava in the control did not cause any phytotoxic changes around puncture sites on pepper leaves. After application of the spray liquids of Quadris, Actara WG-25, Cipkord EC-20, M<sup>+</sup> and Sillwet L-77, as well as their mixtures, changes were recorded but they were at the same level of significance with the control. However, the application of Dithane M-70 and its mixtures (Dithane M-70 + Actara 25-WG, Dithane M-70 + Sillwet L-77, Dithane M-70 + Actara 25-WG + M<sup>+</sup>) caused significantly higher changes than the control liquid. The toxicity of Dithane M-70 was significantly reduced by an addition of Cipkord EC-20 and M<sup>+</sup>, and the triple mixture of Dithane M-70 + Cipkord-20 EC+ Sillwet L-77 also caused a significant reduction. However, the mixtures of Dithane M-70 + Actara 25-WG (21.7 mm<sup>2</sup>) and Dithane M-70 + Sillwet L-77 (17.0 mm<sup>2</sup>) increased the phytotoxicity zone (chlorotic area) 1.5-fold and 1.2-fold, respectively, compared to Dithane M-70, although they were at the same level of significance.

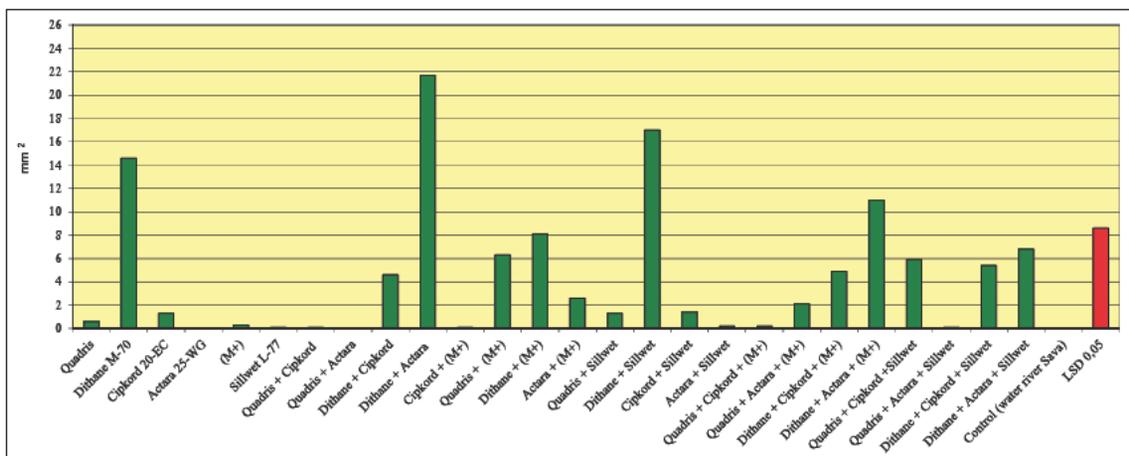
The findings show that the spray liquids Dithane M-70, Dithane M-70 + Actara 25-WG, Dithane M-70 + Sillwet L-77 and Dithane M-70 + Actara 25-WG + M<sup>+</sup> in slightly alkaline, slightly hard surface water caused chlorotic changes to test plants that were significantly higher than changes in the control and all other variants, while the other spray liquids caused changes of the same level of significance with the control.

## DISCUSSION

The requirements of modern agriculture are moving towards application of pesticide mixtures (fungicides, insecticides, acaricides) and their mixtures with nonpesticidal components (adjuvants, synergists, protectants, complex and/or mineral fertilizers) but literature data on such trends are scarce, although the practice is economically sound and already a part of strategic measures of plant protection. Data on the effects of water quality on such pesticide treatments are also sporadic (Indić et al., 1999). When mixtures are used without appropriate prior tests, their effects on harmful species may be reduced and the risk for treated plants (phytotoxicity) or the environment increased (Igrc, 1983). Changes in cultivated or test plants may be the result of an incompatibility of tested pesticides in different formulations (SC, WP, WG and EC) with nonpesticidal components (solvents, emulsifiers, etc.) or their mixtures, but the quality of water used for the application of plant protection products may also cause them.

There are ample data about the phytotoxicity of herbicides with different modes of action, while data referring to the phytotoxicity of fungicides and insecticides are insufficient. The professional community is aware, especially in direct communication with farmers, that cases of physical and chemical incompatibility during the mixing process of pesticides and the occurrence of phytotoxicity on crop plants are not rare, while published data on the phenomenon are scarce. Based on previously presented data (Vuković et al., 2008) and an analysis

Figure 4. Leaf area (mm<sup>2</sup>) damaged by the application of fungicides, insecticides, nonpesticidal components (complex fertilizer and adjuvant) and their mixtures in surface water from the river Sava\*



\* slightly alkaline (pH 8.15); slightly hard (11.7 d°H) with high content of nitrites 6-fold (0.18 mg / l) and ammonia 9-fold (0.93 mg / l)

of 36 samples of water from the territory of Vojvodina Province, out of which 30 were well waters, one tap and five surface river waters that are used for preparing pesticides in practice, it was noted that they differed in quality (30 water samples were classified as alkaline, six were neutral; 27 were hard, nine were soft; 24 water samples had nitrite contents above permissible limit, in two samples nitrate content was increased; 14 water samples had high content of ammonia).

In these tests, three types of waters were included: well, tap and surface waters that differ in quality and are used for preparing pesticide spray liquids in practice. No changes on test plants were registered after applying the waters in control variants. Phytotoxic changes on pepper leaves were found after application of spray liquid containing Dithane M-70 in slightly alkaline, very hard well water, as well as after using its mixtures, although the phytotoxic area was 4.2-fold smaller than the damage caused by the preparation alone, which makes the application of Dithane M-70 in tank mix an advantageous option. The smallest phytotoxic changes were caused by the spray liquids prepared in neutral, slightly hard tap water, compared to the other waters. After using the mixtures of Dithane M-70 + M<sup>+</sup> and Dithane M-70 + Sillwet L-77, the zone of phytotoxicity increased, compared to Dithane M-70 alone, which may be the consequence of an incompatibility between preparations based on mancozeb and a complex fertilizer containing boron (Mitić, 2004).

Slightly alkaline and slightly hard surface water supplemented with Dithane M-70 caused toxic changes on leaves, while the mixtures of Dithane M-70 + Cipkord 20 EC and Dithane M-70 + M<sup>+</sup>, reduced leaf damage. The mixtures of Dithane M-70 + Actara-25 WG and Dithane M-70 + Sillwet L-77 increased the damaged zones around puncture sites, compared to Dithane M-70 alone. The damage caused by triple mixtures with Dithane M-70, compared to the damage caused by its individual preparation, was reduced up to 3-fold.

This may be the consequence of applying higher rates of Dithane M-70 (the label rate is 2.5 kg/ha) than of the other products, which were used in much smaller amounts (0.07 to 0.75 kg, l/ha). One should have in mind that mixing different pesticides for different uses involves the application of recommended quantities of different products which, according to Ostojčić (1977), increases at the same time the amount of nonpesticidal components per unit area, and sometimes can cause the undesirable phenomenon of phytotoxicity.

Cattanach et al. (1997) presented data indicating that Dithane in tank mix with other pesticides and

nonpesticidal substances did not cause phytotoxic changes in plants, but water quality was not specified. Klokočar-Šmit et al. (2001, 2002) reported that the effects of pesticides, water quality and components included in their composition affected the phytotoxicity of spray liquids. The mixtures: Mankogal-80 + Sucip-20 EC, Pyrinex-48 EC + Folpan 50-WP, and Sucip 20-EC + Folpan 50-WP prepared in well water (pH 8.2) caused phytotoxicity to tomato plants, but the phenomenon was not observed when the pesticides were mixed in tap water (pH 7.4). Ables et al. (2013) assessed the phytotoxicity of a phosphonate-containing product (FNX-100) used for control of *Phytophthora capsici* on pepper in foliar application and in soil drench. Foliar applications, regardless of concentration, caused prominent phytotoxicity, compared to the soil drench application of FNX-100.

The findings inferred that spray liquid containing Dithane M-70 and its mixtures with other pesticides and nonpesticidal components caused phytotoxic changes on pepper leaves, primarily in the slightly alkaline and very hard well water (6.0 to 25.2 mm<sup>2</sup>), then in the slightly alkaline and slightly hard surface river water (4.6 to 21.7 mm<sup>2</sup>), while minimum damage was found after applying them in the neutral and slightly hard tap water (2.7 to 7.9 mm<sup>2</sup>). Changes caused by the other spray liquids were at the same level of significance with those of the control. The results confirmed that the effects of spray liquids on test plants depended not only on their composition but also on the quality of water.

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# Fitotoksični efekti na paprici posle primene fungicida, insekticida i nepesticidnih komponenti zavisno od kvaliteta vode

## REZIME

Savremena poljoprivreda teži istovremenoj primeni fungicida, insekticida, kompleksnih đubriva i ađuvanata. Izbor jedinjenja za tank-miks malo je proučen i predstavlja rizik u primeni pesticida, međutim treba imati u vidu i kvalitet vode. Cilj rada je bio da se ispituju efekti fungicida, insekticida, kompleksnog đubriva, ađuvanta i njihovih mešavina zavisno od kvaliteta vode. Kao test biljka poslužila je paprika (*Capsicum annuum* L). Metodom uboda ispitani su fitotoksični efekti pojedinačnih pesticida: azoksistrobin (Quadris, 0,75 l/ha), mankozeb (Dithane M-70, 2,5 kg/ha), tiametoksam (Actara 25-WG, 0,07 kg/ha) i cipermetrin (Cipkord 20-EC, 0,3 l/ha), zatim kompleksno đubrivo (Mortonijc plus /u daljem tekstu M<sup>+</sup>, 3 kg/ha) i ađuvant (Sillwet L-77, 0,1 l/ha), kao i njihovih mešavina, zavisno od kvaliteta vode (bunarska voda, slabo alkalna, jako tvrda, povećan sadržaj nitrita; česmenska, neutralna, slabo tvrda; površinska voda, alkalna, slabo tvrda, povećan sadržaj nitrita i amonijaka). Ocena je izvedena posle sedam dana, merenjem prečnika hloroze i/ili nekroze oko uboda na listu i izražena je u mm<sup>2</sup>. Analizom varijanse (ANOVA) određena je značajnost razlika (NZR 0,05%) između tretmana. U slabo alkalnoj, jako tvrdoj bunarskoj vodi, sve radne tečnosti koje su sadržale preparat Dithane M-70, prouzrokovale su značajno povećanje hloroze na listovima test biljaka (6,0-25,2 mm<sup>2</sup>) u odnosu na kontrolu i na druge varijante. U česmenkoj, neutralnoj i slabo tvrdoj vodi, takođe sve radne tečnosti sa preparatom Dithane M-70, prouzrokovale su značajno povećanje hloroze na listovima biljaka (5,3-7,9 mm<sup>2</sup>) kako u odnosu na kontrolu tako i u odnosu na druge radne tečnosti u kojima nije sadržan, iako je u ovoj vodi nivo fitotoksičnosti na nižem nivou u odnosu na one u bunarskoj vodi. Međutim u slabo alkalnoj, slabo tvrdoj površinskoj vodi iz reke Save značajno povećanje fitotoksičnosti u odnosu na kontrolu zabeleženo je samo primenom radnih tečnosti Dithane M-70, Dithane M-70+Actara 25-WG, Dithane M-70+Sillwet L-77 i Dithane M-70+Actara 25-WG+M<sup>+</sup>.

**Ključne reči:** Pesticidi; kvalitet vode; fitotoksičnost