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EVALUATION OF STICKINESS OF PLANTS PROTECTION PRODUCTS IN THE LABORATORY CONDITIONS

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Abstract

The stickiness of the plant protection products, means their ability to sustain washing out from sprayed plant surfaces from rain, is one of the most critical and important attributes, especially for protective action non-systemic pesticides. Lack or insufficient stickiness will cause a greatly dropping in effectiveness, especially during rainy weather (seasons), which on the other side, will prove favourable conditions for spreading pests on plants. Therefore, selecting plant protection products with good rain retention ability is critical for achieving a satisfactory level of effectiveness in the case of treatments in such weather conditions. This of course, invokes the need to evaluate of this property, which is the object of the given research. Plant protection products were tested alone and in combinations with sticky and wetness agents for evaluation their stickiness ability. The results shows that stickiness ability can vary greatly for different plant protection products, but addition of sticky agent to the pesticide solution can improve it significantly in most of the cases. Hoverer there was some exceptions.

Key words*: pesticides, stickiness, rain resistance, effectiveness.*

INTRODUCTION

Stickiness of the plant protection products which means their ability to sustain of washing out from sprayed plant surfaces from rain is one of most critical and important attribute especially for protective action plant protection products. Lack or insufficient stickiness cause greatly dropping of the effectiveness especially during rainy weather (seasons) which from the other side will prove favourable conditions for spreading pests on plants. Therefore, selecting the plant protection product with the good rain retention ability. This of course invoke the need of evaluation of this property which is the object of the given research and paper respectively (Trevisan et al., 1993; Gossen et al., 2008). The washing out of the pesticides from treated plant surfaces not only decrease their effectiveness but can also cause significant pollution of the environment, especially soils, underground and surface waters (Hüskes & Levsen, 1997; Bruce et al., 1975; Ahmed et al., 1998).

Using the pesticides with goods stickiness to the plant surfaces or adding the sticker adjuvant onto spayed solutions is also recommended as a strategy for combating the resistance towards the pesticides (Beresford et al., 2005). The stickiness of the pesticides also is affected from addition of different adjuvant especially wetting and sticking agents to the spaying solutions. Typically rain retention of the pesticides is evaluated with spectrophotometry which provide from one side very credible results but from the other - is completely impossible to be used from the regular agronomists and farmers, plus the price and time for conducting suck king of evaluations (Decaro et al., 2016). Especially that there is a differences in retention and rainfastening properties between commercial stickers of the same chemical type (Taylor & Matthews, 1986; Gaskin & Steele, 2009). Large differences in roughness, in the amount and composition of surface waxes and in the retention and rain fastness of mancozeb were found among species in the study was made of the influence of the upper leaf surface characteristics on the retention and rain fastness of the contact fungicide mancozeb with and without tank-mix adjuvant (RSO 5 and RSO 60) on apple seedlings, bean seedlings and kohlrabi plants. Rain fastness correlated strongly or very strongly with the amount of C28 alcohol and C33 alkane. The addition of a more hydrophobic (RSO 5) or a more hydrophilic (RSO 60) adjuvant to the spray solution influenced retention and rain fastness, and also altered the correlation coefficients (Hunsche et al., 2006).

The formulation of the plant protection products i.e. addition of the adjuvant into them actually greatly affect rain retention of the pesticides (Lopez & Hua, 1970). Was established that pesticides formulated as wettable powders were retained by a greater amount than those formulated as emulsifiable concentrates (Cooper & Hall, 1993), but the increase of surfactants in the pesticide sprays (decreasing the surface tension) lead to the reduction of the rain retention (Prado et al., 2016). However, this statement is controversial because other studies reveal the opposite (Basu et al., 2002). However, the structure of the leaf surface also can affect the stickiness of the pesticides. Plant species with crystalline epicuticular waxes like pea or wheat retained much less spray solution than the other species, which are characterized by a smooth cuticular surface (De Ruiter et al., 1990). In the similar study, the adhesion of the spreader-Sticker adjuvants was evaluated by using PARAFILM M, Bemis NA, Neenah, WI pieces weighed before and after the test i.e. dropping onto them the pesticide solution. The pieces were dipped into a beaker containing 500 ml de-ionized (DI) water either 100 times, 200 times, or 300 times at an approximate dipping rate of two dips/s (Meredith et al., 2014)

MATERIALS AND METHODS

A standard glass slides for microscope observations were used for the trials. Tested plant protection product solutions were dropped onto slides (0.5 ml per slide). After drying of the solutions, slides were placed into 400 ml plastic cups filled with water, at 45° angle. The cups were covered with scratch transparent kitchen folio and were placed on shelf at 24-25°C temperature and no direct sunshine for 14 days. After this period, the slides were pulled out from the cups and visual observations and measurement for degree of retention were conducted with millimetre paper. This is a typical method for evaluation of the sticky abilities of the plant protection products by using so called "tracers" (Allagui et al., 2018). Were conducted tests with several plant protection products:

1. **Delaro 325 SC** - fungicide on the base of prothioconazole - 175 g/L and trifloxystrobin - 150 g/L at 0.08% concentration;
2. **Forester EW** - insecticide on the base of cypermethrin - 100 g/l at 0.2% concentration;
3. **Indaziflam 500 SC** - herbicide on the base of Indaziflam - 450 g/l at 0.02% concentration;
4. **Qilt Excel SE** - fungicide on the base of azoxystrobin - 135 g/l and propiconazole - 117 g/l at 0.1% concentration;
5. **Capito SC** - insecticide on the base of indoxacarb - 75g/l and abamectin - 18 g/l at 0.1% concentration;
6. **Daxur SC** - fungicide on the base of mefentrifluconazole - 100 g/l and kresoxim methyl - 150 g /l at 0.1% concentration;
7. **Fluxapiprolin 20 SC** - fungicide on the base of fluxapiprolin - 200 g/l at 0.1% concentration;
8. **Traciafin Plus EC** - fungicide on the base of prothioconazole - 250 g/l at 0.08% concentration;
9. **Enevrvin SC** - fungicide on the base of ametoctradin - 200 g/l at 0.15% concentration;
10. **Mikal Flash WG** - fungicide on the base of fosetyl aluminium - 500 g/kg and folpet 250 g/kg at 0.3% concentration;
11. **Cabrio Top WG** - fungicide on the base of methiram - 550 g/kg and pyraclostrobin - 50 g/kg at 0.2% concentration;
12. **Delan Pro SC** - fungicide on the base of dithianon - 125 g/l at 0.05% concentration;
13. **Dithane M-45 WP** - fungicide on the base of mancozeb - 750 g/kg at 0.25% concentration;
14. **Funguran OH 50 WP** - fungicide on the base of Copper (II) hydroxide - 770 g/kg at 0.3% concentration;
15. **Triomax WP** - fungicide on the base of cymoxanil - 40 g/kg, copper oxychloride - 290 g/kg and mancozeb - 120 g/kg at 0.25% concentration;
16. **Manex C-8 WP** - fungicide on the base of cymoxanil - 80 g/kg and mancozeb - 600 g/kg at 0.15% concentration;
17. **Medody Compact 49 WG** - fungicide on the base of iprovalicarb - 84 g/kg and copper oxychloride - 406 g/kg at 0.15% concentration;
18. **Bordomix 20 WP** - fungicide on the base of bordeaux mix - 200 g/kg at 0.5% concentration;
19. **Kumulus DF WG** - fungicide on the base of sulfur - 800 g/kg at 0.3% concentration;
20. **Thiozole 80 WP** - fungicide on the base of sulfur - 800 g/kg at 0.3% concentration;
21. **Thiovit Jet 80 WG** - fungicide on the base of sulfur - 800 g/kg at 0.3% concentration;
22. **Curzate 60 WG** - fungicide on the base of cymoxanil - 600 g/kg at 0.25% concentration;

23. **Cuprozin Super M WP** - fungicide on the base of mancozeb - 200 g/kg and copper oxy-chloride -500 g/kg at 0.4% and 0.2% concentrations;
24. **Champion WP** - fungicide on the base of Copper (II) hydroxide - 770 g/kg at 0.3%.
The stickiness of the plant protection products were evaluated alone and with addition of sticky agents to the solutions: Elect 90 EC© on the base of paraffin oil at 0.2 % concentration and Strong Oil© on the base of plant triglyceride oil at 0.5% concentration, and with addition of wetting agents to the solutions: Silwet L-77© on the base of organosilicone surfactant at 0.1% concentration and 2.Spur© on the base of organosilicone surfactant at 0.1% concentration.

RESULTS AND DISCUSSIONS

In the Table 1 are presented results from conducted test for stickiness of plant protection products applied alone without adjuvants.

Table.1 Stickiness of tested plant protection products used without adjuvants

Plant Protection Product	Percent Retention
Mikal Flash - 0.3%	0
Cabrio Top - 0.2%	100
Delan Pro - 0.05%	100
Dithane M-45 - 0.25%	85
Funguran OH 50 WP - 0.3%	100
Triomax - 0.25%	100
Manex C-8 - 0.15%	60
Medody Compact 49 WG - 0.15%	80
Bordomix 20 WP - 0.5%	100
Kumulus DF - 0.3%	100
Thiozole 80 WP- 0.3%	15
Thiovit Jet 80 WG - 0.3%	90
Curzate 60 WG - 0.25%	95
Cuprozin Super M - 0.4%	98
Cuprozin Super M - 0.2%	100
Champion - 0.3%	100
Delaro 325 SC - 0.08%	2
Forester - 0.2%	10
Indaziflam 500 SC - 0.02%	10
Qilt Excel - 0.1%	0
Kapito - 0.1%	0
Daxur - 0.1%	100
Fluxapiprolin 20 SC - 0.1%	0
Traciafin Plus - 0.08%	2
Enevrvin - 0.15%	90
Pasta Caffaro - 0.03%	60
Electis Cobre - 0.3%	95
Micrithiol Dispers Sulfur - 0.6%	95
Arrone - 0.73%	0

From table above is clear that some of the plant protection products as: Cabrio Top, Delan Pro, Funguran OH 50 WP, Triomax and others have a 100% retention (stickiness) and their application do not require any addition of sticky agents. However other plant protection products as: Mikal Flash, Delaro 325 SC, Qilt Excel, Arrone and others actually were completely washed out in the conducted trials**.**
Addition of sticky agents to the pesticide solutions improve significantly their retention ability (Figures 1 and 2).

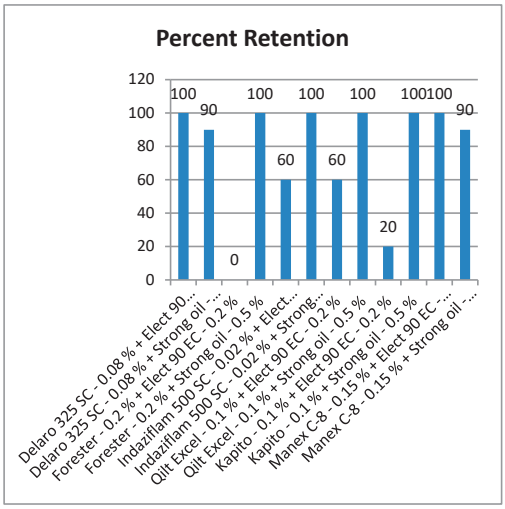

Figure 1. Stickiness of tested plant protection products with addition of sticky agents

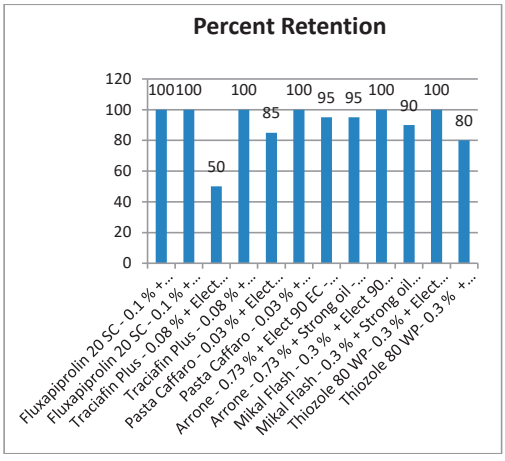

Figure 2. Stickiness of tested plant protection products with addition of sticky agents

However, in some products were received differences according used two different sticky agents: Elect 90 EC on the base of mineral oil and Strong Oil on the base of plant derived oil. Forester mixed with Elect 90 EC was completely washed out while with Strong Oil has 100% retention. Similar results were received and with Indaziflam 500 SC, Qilt Excel, Kapito and Traciafin Plus. Tests with Thiozole 80 WP shows the opposite – stickiness with Strong Oil was better than with Elect 90 EC. Tests with Delan Pro shows that addition of sticky agents actually decrease the retention of the product. Delan Pro used alone have 100% retention, while with addition of Elect 90 EC, only 10% and with addition of Strong Oil - 60%. Similar results was received with Triomax which alone also have 100 % stickiness. With addition of Strong oil, this property drop to 60%. However addition of Elect 90 EC maintain 100% stickiness. The same situation was received with other products on the base sulphur Kumulus DF and Thiozole 80 WP where the addition of Strong Oil drop the retention with 20%.

In the Table 2 are presented results from conducted test for stickiness of plant protection products applied together with organosilicone surfactant (Silwet L-77 and Spur) in 0.1% (v/v) concentration for the surfactant:

Table 2. Stickiness of tested plant protection products with adding organosilicone sufactant to the solutions

Plant Protection Product	Percent Retention
Delaro 325 SC - 0.08% +surfactant- 0.1%	1
Forester - 0.2% + surfactant - 0.1%	0
Indaziflam 500 SC - 0.02% + surfactant - 0.1%	0
Qilt Excel - 0.1% + surfactant- 0.1%	0
Kapito - 0.1% + surfactant - 0.1%	0
Daxur - 0.1% + surfactant - 0.1%	0
Fluxapiprolin 20 SC - 0.1% + surfactant- 0.1%	0
Traciafin Plus - 0.08%+ surfactant - 0.1%	0
Enevrvin - 0.15% + surfactant - 0.1%	10
Pasta Caffaro - 0.03 % + surfactant - 0.1%	60
Electis Cobre - 0.3 % +surfactant - 0.1%	75
Micrithiol Dispers Sulfur - 0.6% + surfactant - 0.1%	55
Arrone - 0.73% + surfactant - 0.1%	0
Mikal Flash - 0.3% + surfactant- 0.1%	0
Cabrio Top - 0.2% + surfactant- 0.1%	40
Delan Pro - 0.05% + surfactant - 0.1%	0
Dithane M-45 - 0.25% + surfactant- 0.1%	100
Funguran OH 50 WP - 0.3% + surfactant - 0.1%	100
Triomax - 0.25% + surfactant - 0.1%	100
Manex C-8 - 0.15% + surfactant - 0.1%	100
Medody Compact 49 WG - 0.15% + surfactant - 0.1%	100
Bordomix 20 WP - 0.5% + surfactant - 0.1%	100
Kumulus DF - 0.3% +surfactant - 0.1%	20
Thiozole 80 WP- 0.3% + surfactant - 0.1%	3
Thiovit Jet 80 WG - 0.3% +surfactant - 0.1%	80
Curzate 60 WG - 0.25% + surfactant - 0.1%	100
Cuprozin Super M - 0.4% + surfactant - 0.1%	90
Cuprozin Super M - 0.2% + surfactant - 0.1%	100
Champion - 0.3% + surfactant - 0.1%	100

From the table above is can be see that addition of surfactant to the pesticides solutions in the most cases decrease the stickiness to the 0%. However, in some of the products as: Champion, Cuprozin Super M, Dithane, Manex C-8 and others, the retention is not affected. From the three sulfur based plant protection products: Kumulus DF, Thiozole 80 WP and Thiovit Jet 80 WG, in the last one addition of surfactant drop the retention only with 20 %. Solutions of Kumulus DF and Thiozole 80 WP with surfactant shows stickiness 20 and 3%.

Addition of sticky agents (Elect 90 EC and Strong Oil) to the solutions of plant protection products combined with surfactant restore their retention to 90-100%, however only towards some of products as: Enevrvin, Pasta Caffaro and Micrithiol Dispers Sulfur. Towards other products as: Forester, Indaziflam 500 SC, Daxur, Fluxapiprolin 20 SC, Electis Cobre and Cabrio Top such action was observed towards Strong Oil but not towards Elect 90 EC. In the solutions of Thiovit Jet 80 WG was the opposite. Towards other plant protection products as: Delaro 325 SC, Qilt Excel, Kapito, Traciafin Plus, Arrone, Mikal Flash, Delan Pro, Kumulus DF and Thiozole 80 WP addition of both sticky agents (Elect 90 EC and Strong Oil) to the solutions of plant protection products combined with surfactant do not improve their retention ability.

CONCLUSIONS

From conducted trials can be concluded that stickiness of the plant protection products greatly variable and addition of sticky agents do not improve it in the all cases. Different products can express different sticky ability when they are mixed with different sticky agents or combination of sticky agents and surfactants. However, there were no differences in the action between two organosilicone surfactants used in the tests. Some of tested plant protection products as: Dithane M-45, Funguran OH 50 WP, Medody Compact 49 WG, Cuprozin Super M shows good levels of retention alone and no matter with what kind adjuvant are mixed. In some products as Champion, Cuprozin Super M, Curzate 60 WG and Bordomix 20 WP, this retention percent was 100%. The tests reveal that always the good stickiness of the plant protection products had to be tested alone and with combinations of selected adjuvants for best effectiveness and performance before use.

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