THE USE OF COADJUTANTS IN TANK MIX WITH FUNGICIDES IN ORDER TO IMPROVE THEIR EFFECTIVENESS EVEN AT LOW DOSAGES

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ABSTRACT

One of the most important items of modern agriculture is the reduction of environmental impact thanks to the integration of new cultivation and protection techniques. Therefore it is important to optimise the use of chemicals and pesticides.

We found that some coadjutants applied in tank mix with fungicides on sugar beet protection improve the effectiveness of active principles in cercospora leafspot (Cercospora bieticola sacc.) control.

KEYWORDS: coadjutant; fungicide; environment; biological promoter; aminoacids; fulvic acids

INTRODUCTION

In literature coadjutants are reported to have an important influence on the action of fungicides: they can improve the effectiveness of active principles allowing better coverage of the product and reducing losses due to drift or leaching. Coadjutants can improve the wettability rate and retention of drops, and, if applied in tank mix with systemic fungicides, they enhance the absorbtion of the active principle from the foliar cuticle even under unfavourable weather conditions [17].

As already reported in weed killers [20, 25], we could expect to optimise and reduce the application dosages of fungicides by addition of coadjutants.

On the base of their composition and their mode of action coadjutants can be classified into: surfactants, stabilizers, solvents, acidifiers etc. Sometimes also organic fertilisers and biological promoters [32] are used together with pesticides. Several experiences were conducted about the application of coadjutants, foliar nutrients and biological promoters in order to optimize pesticides performance, improve metabolism of plants and quality of crops, and reduce weakness of plants [7, 16, 19, 28, 10]. Some experiments about the use of coadjutants in cercospora (Cercospora bieticola sacc.) control were recently carried out [4, 5, 36] .

To check the real action of coadjutants in improving fungicides performance at low dosages was the goal of this experiment.

MATERIALS AND METHODS

Tests were conducted on fields cultivated with sugar beet during the years 2000, 2001, 2002 and 2003, in medium textured soils (sand 22 %; silt 47 %; clay 31 %; organic substance 2,04 %; pH 8,09) and clay soils (sand 11 %; silt 42 %; clay 47 %; organic substance 1,87 %; pH 7,66). The products (described in Tab. 1), were applied with a towed spraying bar on 20 sq.mt. trial plots with 4 replications. Dilution of the products was 80 ml of water per plot. Chemical analyses of the water were: pH 7,66; Ca 106 mg/L; Na 26,2 mg/L; Mg 22,2 mg/L; K 2,09 mg/L; Fe 0,047 mg/L.

All plots were periodically controlled checking the intensity of cercospora leafspot attacks on leaves. (% AFA = diseased foliar area). The central area of each plot was harvested at the end of crop cycle, the weight and qualitative parameters of the pulp were checked. We measured also sucrose content and the GROSS SALEABLE PRODUCTION (GSP). Data were turned into indexes (index 100 = non treated area) for a better and more rapid interpretation of the results and were statistically processed.

Statistical data were processed with PSW – Plabstat, a programme utilized in the whole sugar beet sector. This programme carries out analyses of variance (ANOVA), Scott-Knotts test and Duncan test with Standard deviation score P=0.05, P=0.01, etc. In this specific case we reported SDS P=0.05 that are the most widely used in sugar beet sector.

We tested seven kinds of coadjutants: their features are described in table 1. We chose products that were considered good carriers and promoters, on the base of what reported in scientific literature and of our practical experiences.

Coadjutants were tested in tank mix with the following fungicides:

EMINENT 40 EW - Tetraconazole. Concentration of pure active principle: 38,5 g/litre.

SPYRALE - Difenoconazole100 g/litre + Fenpropidin 375 g/litre.

SCORE 25EC – Difenoconazole 239 g/litre.

GRANIT – Bromuconazole 191 g/litre.

SPHERE – Cyproconazole 80 g/litre + Trifloxystrobin 187,5 g/litre

RESULTS AND DISCUSSION

Year 2000 – Medium textured soil (Tab. 2)

The test carried out in the year 2000 on a medium textured soil (sand 22 %; silt 47 %; clay 31 %; organic substance 2,04 %; pH 8,09) showed a sharp improvement of cercospora leafspot control in the plots treated with coadjutant A and a low dosage of tetraconazole. Improved polarization and pureness of juices were also observed. Poor results were obtained with other testing products, that were then abandoned during the following tests.

Year 2001 – Clay soil (Tab. 3)

In the year 2001 tests were carried out on clay soils (sand 11 %; silt 42 %; clay 47 %; organic substance 1,87 %; pH 7,66) with two anti-cercospora fungicides. Because of climatic conditions during that year few attacks from cercospora leafspot occurred. We could not notice big differences between the plots treated with a full dosage of tetraconazole and the plots treated with a 30% reduced dosage. However, the plots where coadjutant A and F were applied together with fungicide showed a higher production than the plot treated with a full dosage of tetraconazole. We got similar, even if not so evident, results with the use of "difenoconazole + fenpropidin", applied together with coadjutant A. The results obtained with coadjutant A in tank mix with a 30% reduced dosage of fungicide were the same of those obtained with a full dosage of fungicide.

Tab. 1 - Table of fungicides and coadiuvants used during the tests.

Products	Active principle	conc. g/L	Commercial name (f.c.)
Fungicides			
TETRA	tetraconazole	38,5	Eminent 40EW
(DIFENO + FEN)	(difenoconazole + fenpropidin)	100+375	Spyrale
DIFENO	difenoconazole	239	Score 25EC
BROMU	bromuconazole	191	Granit
(CIPRO + TRI)	(ciproconazole + trifloxistrobin)	80+187,5	Sphere
Coadiuvants			
A	balanced compound of aminoacids and oligopeptides with fulvic acids and biological promoters. Organic Nitrogen 6% - Organic Carbon 20% - Average molecular wheigt: 800-900 Dalton		Amminostim Bio
B	complexed phosphorus with sugars+aminoacids - Total Nitrogen 4% (0,7% ammoniacal; 0,6% organic; 2,7% ureic) - Organic Carbon 12% - Phosphorus 8%		Glucos-P
C	Fluid organic nitrogen fertilizer - compounds of amino acids and peptides - Total Nitrogen 7% Organic Nitrogen 7% - Organic Carbon 20%		Splinter
D	organic nitrogenous fertiliser with aminoacids and peptides- Organic Nitrogen 8% - organic Carbon 23,5% - aminoacids 50% p/p		Nutrigreen
E	mineral oil + wetting coadiuvant		Turbocharge
F	mineral fertiliser NP + Fe, B, Mg, Mn, Zn + humic fulvic acids		Betafort
G	mineral fertilizers with phosetyl-Al		testing sample

Year 2002 – Clay soil (Tab. 4)

During the testing period in the year 2002 the weather was anomalous, it was very hot at Summer beginning while there were frequent rainfalls from the end of July until the harvest of beets. Under these conditions the yield of the plots treated with coadjutants together with a 30% reduced tetraconazole was inferior to the one obtained with a full dosage of tetraconazole. However, the integration of tetraconazole with coadjutants improved biological activity in the control of cercospora leafspot. On the contrary, we did not get any result with the use of "ciproconazole + trifloxistrobin" applied together with tested coadjutants.

Year 2003 – Clay soil (Tab. 5)

During the tests we carried out in the year 2003 the temperatures were higher than usual from May to September, and we could see that tetraconazole together with coadjutants improved its biological activity, even if this result could not be statistically proven. We obtained similar results after a second test with other active principles (difenoconazole, bromuconazole, difenoconazole+fenpropidin, ciproconazole+trifloxistrobin) used alone or together with coadjutant A. There was an interesting increase of biological activity and production, even if not statistically demonstrable.

The above written results can be explained considering that , as reported in literature, amino acid compounds with a low average molecular weight and a balanced composition have a good penetrating and carrier action inside the plant and in particular to the growing parts [9, 27].

They are reported to improve the following metabolic processes:

- Nutritional action with formation of proteins, amid and sugars [18];
- Hormonal function with effects on cellular extension and root induction [30, 31];
- Multi polar action with formation of biologically useful substances such as chlorophyll [8];
- Better transportation and assimilation of oligoelements [34];
- Biological promotion through the action on

Tab. 2 - Year 2000 - Medium textured soil - Cultivar Duetto - Seeding date: 29-02-2000

Trial	Products (litres/ha) x 2 treatment: 30-06 + 25-07	*AFA % 28-aug	Production indexes - Harvesting date: 21-09-2000 Weight	Pol	Sucrose	GSP	PSD
1	-	96	100	100	100	100	100
2	TETRA (1,25)	75,5	105,39	105,85	111,68	115,26	100,31
3	TETRA (1,25) + A (3)	30,5	111,58	114,35	127,59	135,96	101,55
4	TETRA (1,25) + B (2)	79	105,65	106,51	112,43	116,29	101,03
5	TETRA (1,25) + C (1,5)	80,2	107,04	108,24	115,82	120,66	101,29
6	TETRA (2,5)	51,7	107,04	110,83	118,64	124,93	101,05
	Avge treated	63,38	107,34	109,16	117,23	122,62	101,05
	Standard deviation P=0,05		6,94	3,32	7,98	8,01	0,76

Tab. 3 - Year 2001 - Clay soil - Cultivar Duetto - Seeding date: 12-03-2001

Trial	Products(litres/ha) x 2 treatment: 02-07 + 23-07	*AFA % 21-aug	Production indexes - Harvesting date: 19-09-2001 Weight	Pol	Sucrose	GSP	PSD
1	-	74,8	100	100	100	100	100
2	TETRA (1,75)	51	102,71	103,89	107,12	108,95	100,13
3	TETRA (1,75) + A (2)	44,8	110,11	105,62	116,32	119,04	100,2
4	TETRA (1,75) + F (4)	49,2	114,80	102,59	118,20	119,66	99,76
5	TETRA (2,5)	42,5	106,44	103,77	110,48	112,2	100
	Avge treated	46,8	108,21	104,20	113,00	115,05	100,08
	Standard deviation P=0,05		18,01	4,01	15,91	15,1	1,01

Trial	Products (litres/ha) x 2 treatment: 02-07 + 23-07	*AFA % 21-aug	Production indexes - Harvesting date: 19-09-2001 Weight	Pol	Sucrose	GSP	PSD
1	-	73,2	100	100	100	100	100
2	(DIFENO + FEN) 0,5	39,5	110,38	106,21	116,96	119,89	100,53
3	(DIFENO + FEN) 0,5 + A (2)	33,8	107,74	111,86	120,99	126,77	101,62
4	(DIFENO + FEN) 0,7	28,2	109,71	110,36	121,72	126,94	101,51
	Avge treated	34,2	109,11	109,15	119,34	123,87	101,04
	Standard deviation P=0,05		11,07	3,57	13,12	12,22	1,18

enzymatic systems of the plants [21, 33];

- Amino acids in L- isomeric form are used by the plants for protein synthesis [2, 35, 32], i.e. to build new vital tissues.

Also humic and fulvic compounds have an important action as carriers and biological promoters. In particular fulvic acids have the following properties:

- form Complexes with Trace Elements [22]
- aid the actual movement of metal ions that are normally difficult to mobilize or transport. They help transportation of minerals through plant structures [24, 29];
- enhance the availability of nutrients and make them more readily absorbable [6];
- dissolve and transpose vitamins, coenzymes, auxins, hormones [38];
- increase activity of enzymes [13, 23];
- increase assimilation [3];
- form organic metal complexes with a high penetration degree into cells. This is probably due to their low molecular weight [1];
- form complexes and chelates that are able to readily pass through semi-permeable membranes such as cell walls. Fulvic acids can transport nutrients through cell membranes, and also act as specific cell sensitizing agents to enhance the permeability of the cell membrane [26, 6, 24];
- stimulate Metabolism [26];
- appear to enhance the genetic mechanism of plants. It has been concluded that when plant cells are exposed to fulvic acid they can improve their growth [11]. Oxygen is absorbed more intensely in presence of

Tab. 4 - Year 2002 - clay soil - Cultivar Gea - Seeding date: 04-03-2002

Trial	Products (litres/ha) x 2 treatment: 27-06 + 22-07	*AFA % 24-aug	Production indexes - Harvesting date: 10-09-2002 Weight	Pol	Sucrose	GSP	PSD
1	-	87,8	100	100	100	100	100
2	TETRA (1,75)	59,6	119,15	110,24	130,61	135,33	102,34
3	TETRA (1,75) + A (2)	50,8	122,59	113,82	138,64	146,15	103,25
4	TETRA (1,75) + E (2)	52,7	117,26	113,48	132,50	140,12	102,74
5	TETRA (1,75) + D (1)	51,5	129,91	112,63	145,29	151,99	103,4
6	TETRA (2,5)	50,8	133,27	115,87	153,58	164,26	103,39
	Avge treated	52,95	123,51	113,71	139,65	147,50	103,15
	Standard deviation P=0,05		15,53	4,26	20,32	23,51	1,45

Trial	Products (litres/ha) x 2 treatment: 27-06 + 22-07	*AFA % 24-aug	Production indexes - Harvesting date: 10-09-2002 Weight	Pol	Sucrose	GSP	PSD
1	-	86,6	100	100	100	100	100
2	(CIPRO + TRI) 0,5	45,3	113,82	114,10	130,17	140,05	102,27
3	(CIPRO + TRI) 0,5 + A (2)	48,3	110,45	112,70	124,57	132,66	102,56
4	(CIPRO + TRI) 0,5 + F (6)	48,7	110,17	115,25	126,97	137,5	103,01
5	(CIPRO + TRI) 0,7	43	116,30	117,21	136,80	150,09	103,09
	Avge treated	46,35	112,28	114,57	128,87	139,00	102,75
	Standard deviation P=0,05		17,72	4,09	20,57	23,28	1,04

Tab. 5 - Year 2003 - Clay soil - Cultivar Gea - Seeding date: 27-02-2003

Trial	Products (litres/ha) x 2 treatment: 27-06 + 17-07	*AFA % 22-aug	Production indexes - Harvesting date: 05-09-2003 Weight	Pol	Sucrose	GSP	PSD
1	-	70,5	100	100	100	100,00	100
2	TETRA (2,5)	20	110,28	107,89	119,20	127,29	100,35
3	TETRA (2,5) + A (2)	14	114,03	107,89	124,00	131,62	100,35
4	TETRA (2,5) + A (3)	11,5	115,60	107,89	125,60	133,43	100,46
5	TETRA (2,5) + E (2)	14,5	110,88	109,21	121,60	130,84	100,93
6	TETRA (2,5) + F (6)	15,5	122,37	103,95	128,00	131,81	99,82
7	TETRA (2,5) + G (4)	16	115,60	107,24	124,80	131,94	100,46
	Avge treated	15,29	114,70	107,42	123,77	131,24	100,38
	Standard deviation P=0,05		8,41	3,53	12,15	15,31	0,97

Trial	Products (litres/ha) x 2 treatment: 27-06 + 17-07	*AFA % 22-aug	Production indexes - Harvesting date: 05-09-2003 Weight	Pol	Sucrose	GSP	PSD
1	-	70,5	100	100	100	100	100
2	DIFENO (0,3)	16,5	117,65	108,55	128,80	132,28	100,69
3	DIFENO (0,3) + A (3)	13	119,47	108,55	130,40	134,32	100,58
4	BROMU (1)	34	119,23	107,24	128,80	131,77	100,23
5	BROMU (1) + A (3)	25,5	120,68	107,89	130,40	134,53	100,46
6	(DIFENO + FEN) 0,7	16	119,47	107,89	129,60	133,18	100,81
7	(DIFENO + FEN) 0,7 + A (3)	13	117,17	111,84	132,00	137,34	101,97
8	(CIPRO + TRI) 0,8	9,5	112,33	111,18	125,60	130,6	101,39
9	(CIPRO + TRI) 0,8 + A (3)	8,5	113,18	115,13	131,20	138,08	102,78
	Avge treated	17	117,40	109,79	129,60	134,01	101,11
	Standard deviation P=0,05		9,23	3,62	13,76	16,72	0,99

N.B.
AFA = diseased foliar area
GSP= Gross Saleable Production
PSD: pureness of dense juice

fulvic acids [15];

- increase and intensify the metabolism of proteins [6, 14];
- increase and enhance the rate of RNA synthesis. [12]
- catalyze Vitamins within the Cell [37];

Tested coadjutants are supposed to enhance the absorbtion of active principles from the foliar cuticle and to grant a carrier action inside the plant and in particular to the growing parts. Moreover they may improve coverage of the product enhancing wettability rate and retention of drops.

CONCLUSION

On the basis of investigation conducted during the years 2000-2003 about cercospora leafspot control, we can confirm that the use of specific coadjutants together with the tested fungicides can improve the biological efficacy in cercospora control, grant a better production of sugar beet and lead to better quality of juices. The activity of all tested fungicides was enhanced, even if we reached the best improvement with tetraconazole. The best productive results and best prevention of cercospora leafspot were obtained using a coadjutant based on amino acids and biological promoters (coadjutant A). Goods results, even if at higher dosages, were also obtained using mineral foliar nutrients containing humic-fulvic acids.

We should further deepen this item with an interdisciplinary research in order to clarify the mechanisms and synergic actions that occur among coadjutants and active principles for the improvement of biological activity towards disease control.

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