EFFECT OF SOME CHEMICAL TREATMENTS ON GERMINATIVE CHARACTERISTICS OF SUNFLOWER SEEDS

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SUMMARY

Sunflower seed treatments to ensure protection against fungi is now improving more and more. The trial, made on ten sunflower cultivars, had the aim to verify the effects of some chemical products (metalaxyl and iprodione) used at different doses on the germinative characteristics of the seeds. The doses, applied on seed samples according to the "slurry method", were, in the case of metalaxyl (35% of a.p.), 2, 3, 4, 6, 12 g of c.p./kg of seed; in the case of iprodione (50% of a.p.) 2, 4, 8, 16, 32 g of c.p./kg of seed. The research showed that even high doses of chemicals don't decrease the seed viability significatively: on the contrary seed treatment sometimes increases the viability because it fights effectively seed-borne fungi that injure the germinative characteristics of the seeds. Negative effects of the chemicals were found on the mean germination times that increase significatively when the doses grow. This is a very important aspect to be considered to avoid damaging the germinative characteristics of the seed and to allow the trade of seed with high vigour.

INTRODUCTION

A wide range of specific action and wide spectrum products is available today for seed treatment. The question of the effect of these chemical agents on seed viability was examined by Mariani Tosatti et al. in 1978. They showed that seed dressing and fumigation, when used correctly, had no notable adverse effect on germination or germination energy either in laboratory or in the soil. The only data of any statistical significance were for beet which showed lowered germination after treatment with benomyl, captafol,and copper oxychloride. By contrast, germination increased in maize and beet after treatment with aluminium phosphide. Tests carried out by Ponti et al. (1982), in greenhouse, laboratory and field, measured the action of fungicides, insecticides and fumigants on viability of several breeds of seed. Results indicate that neither seed dressing nor application to soil in contact with seed of these products frequently modify plant growth. Some negative effects on germination energy and seedlings length were noted but greenhouse and field tests revealed these effects to be of a transitory nature. The effect of a systemic fungicide dressing was tried for Fusarium oxysporum contamined peaseeds (Lorenzini et al 1975). Results indicated that treatment had no negative effect on germination which if anything was enhanced with respect to the untreated control. Montanari et al.(1980) showed that Triticum durum or other wheat seeds dressed with chlormequat or a mixture of chlormequat and mancozeb were not adversely affected. Work from Masoni et al.(1983) showed that the fungicides tested, if applied in doses slightly higher than those recommended had no effect on germination in healthy seeds while germination in infected seed increased, probably as a consequence of the elimination of the fungus infection which evidently depresses germination. At doses much higher than the recommended almost all fungicides tested were found to be toxic for healthy seed but infected seed showed little

reduction in germination. Research until the present has been chiefly directed towards the investigation of relationships between pathogens and the substances used for their control. Little research has been done into the effect, agronomically speaking, of chemical treatment on seed viability and the early stages of development in particular - during germination in other words, the first stage in plant life. If conditions are not the best at this point a whole crop may be affected - in growth uniformity, for example, or in crop density. The central theme in the present work was the effect of chemical dressings, applied in several different doses, on seed germination.
It is commonly noted during germination analyses for official seed certification that dressed samples have lowered germinabilities. Affected in particular are cariopses of autumn-winter species, known to be widely treated with dressings. Dressed seeds on inspection reveal a particular coloration due to the pigmentation used by manifacturers in the commercially-available chemical products used for dressing. In many cases this colour is particularly intense, suggesting that doses much higher than the recommended have been applied. For this reason our research aimed to investigate whether depressed or altered germination were to be attribute to excessive applications of fungicides to the seed.

MATERIALS AND METHODS

Trials were carried out in 1986 and 1987 on ten cultivars of Helianthus annuus L. . Samples of germinable seed were obtained from varietal trials carried out on the Pisa University Experimental Station. Seed was stored after harvest in refrigerated climatised cells at +5°C and 50% RH. Seed were dressed by spraying with a slurry of chemical product. This method avoids the spreading of dust and enables the chemical treatment to adhere well to the seed. A miniature compressed air spray gun with a reservoir, the sort used for painting pictures, was used. A carefully weighed quantity of chemical product was placed in the paint tank with a sufficient quantity of water (roughly 1l/q seed). The seed to be treated was placed in a plastic bag and sprayed with a mist of the aqueous suspension of fungicide. The fungicides used were as follows:
APRON 35 SD (the brand name for 35% metalaxyl). This systemic fungicide is particularly indicated in control against Plasmopara sp. The product was chosen as a preventive measure as this fungus is frequently found in the soil as oospores. Although it was not present on our sample seeds, they could be contamined in this way (Monotti et al., 1974; D'Armini et al., 1975; Zazzerini, 1980. Moreover, by Italian law all imported seed must be dressed to avoid diffusion of new infections (Zazzerini et al., 1975);
ROVRAL (the brand name for 50% iprodione). This is a versatile, essentially contact fungicide which acts on spores and mycelia from parasites. It was decided to use this product on six samples infected with Alternaria tenuis Nees;
APRON 35 SD + ROVRAL, on two sampes infected with A. tenuis. The chosen samples were treated with a mix of the two previous products to measure the effect on germination and to investigate the advisability of their practical use in association to combat Plasmopara spp. and Alternaria spp.. We report in Tab. 1 the cultivars, fungicides and doses used in the trial. On completion of dressing germination tests were carried out in three replications for each treatment combination. Each replication consisted in placing 50 seeds in a 15 cm sterilised glass Petri dish, between two layers of uniformly moist blotting paper. These were then incubated

in germination cabinets at 25°C under 2000 lux illumination. Seeds and seedlings were examinated using I.S.T.A. standards when the essential hypogeal and epigeal stuctures were sufficiently well-developed to enable precise measurements (Bekendam and Grob, 1979). The characteristics of the controls were checked at the same time as each replication of each test to avoid differences due merely to time lapse. The following measurements were made : - percentage germination; - % abnormal seedlings; - % dead seeds; - mean germination time. This last was calculate by the following formula:

$$M.G.T. = \Sigma (n \times d) / \Sigma n$$

where n = number of seeds germinating each day and d = ordinal number of day.
Data regarding germination characteristics and mean germination time were expressed in angular values, then submitted for variance and analysis so that the reaction of each single variety to each treatment could be calculated.

Tab.1 - Cultivars and treatments in trial.

CULTIVAR	FUNGICIDE	DOSES (g of c.f./q of seed)					
Stromboli Florum 305 Solaris Argentario Romsun HS 90 Romsun HS 52 Ala Giorlasol Tuscania Rustiflor	APRON 35 SD (35% metalaxyl)	0	200	300	400	600	1200
Stromboli Florum 305 Solaris Argentario Romsun HS 90 Romsun HS 52	ROVRAL (50% iprodione)	0	200	400	800	1600	3200
Florum 305 Argentario	APRON 35 SD + ROVRAL	0	200 + 200	400 + 400	800 + 800	1600 + 1600	

RESULTS

Results concerning germination characteristics and M.G.T. are reported in Tabs. 2-13. We have not reported results concerning the percentage of dead seeds, suggesting to consider it as the complement to one hundred.

DISCUSSION

Treatment with APRON 35 SD: - treatment with the fungicide metalaxyl has a different effect on percentage germination depending on plant variety (Tab. 2). Some varieties (Stromboli and Rustiflor) suffer from a considerable lowering of germination at the highest dosages whereas others show increased germination at the same doses. Dormancy percentage is low and, although significant in the tests, is of no practical value. Notably cv. Stromboli, which manifested a marked negative reaction to the products in germination trials, also gave dormancy values significantly higher than those for the other cvs. (Tab. 3). In general an increase in dose of fungicide determined a fall in the percentage of abnormal seedlings, varying

according to the cv. (Tab. 4). Mean germination time (M.G.T.) was clearly and significantly increased by increasing doses (Tab. 5). In this case the control gave briefest M.G.T., therefore greatest germination energy. Highest M.G.T. values correspond to highest doses of chemical.

Treatment with ROVRAL: - percentage germination was affected most in Stromboli and Romsun HS 52 by increasing doses of fungicide (Tab. 6). By contrast the other cvs. did not seem to be adversely affected - in some cases the opposite occurred, with highest percentages at highest doses. A secondary dormancy, on the other hand, was clearly induced in all varieties by increasing doses (Tab. 7) with marked sensitivity in the cvs. Florum 305, Stromboli and Romsun HS 90. The percentages of abnormal seedlings should be considered with care (Tab. 8): in general values are significantly lower with higher doses. Significant differences can be observed between one variety and another but there is an overall decrease in % abnormal seedlings when doses are strengthened. This could be explained by the fact that the abnormalities observed were caused by A. tenuis which is found in the pericarp, endosperm and the embryo (Singh, 1977) and which during germination forms a wad of mycelia around the rootlets. Treatment at high dosage probably controls this fungus whereas lower doses are insufficient. M.G.T. increased progressively as doses were increased. Certain varieties were more sensitive, e.g. Florum 305, which in the control gave an M.G.T. of 3,5 days and at the highest dose gave over 5 days (Tab. 9).

Treatment with APRON 35 SD + ROVRAL: - when the dose was increased percentage germination decreased progressively in both cvs. tested although interaction analysis shows the data not to be significant (Tab. 10). On the other hand, dormancy percentage (Tab. 11) increases significantly under the same circumstances. Florum 305 seems to be particularly sensitive to treatment in this respect showing over 20% fresh ungerminated seeds at the highest doses. Abnormal seedlings decrease significantly (Tab. 12) going from the control through the increasing doses. M.G.T. increases considerably, passing from 3,6 days in the untreated control to almost 6 days for samples at highest doses (Tab. 13).

At this point a rather unusual occurrence should be noted: certain varieties (Florum 305, Argentario and Romsun HS 52) showed variations in germination percentage with time (measured over 12 months). Germination in untreated seeds increased considerably with time and the percentage of abnormal seedlings fell. This perplexing result could perhaps be explained by the fact that seeds were stored at +5°C and 50% R.H.. It seems that abnormalities caused by fungus attacks, are less frequent after prolonged exposure to these conditions.

CONCLUSIONS

Today, seeds are widely treated, often for pathogens which are not present, since it is an accepted opinion that in so doing seeds are protected during dormancy and germination while no damage is caused to their germinative characteristics. It is claimed by many that germination is even improved by treatment with a mix of products against parasites. We do not agree that this is a sensible or valid means for obtaining first quality seed, especially if it is considered that indiscriminate use of such chemicals has an adverse effect on soil microflora and, what is even more important, on higher forms of animal life which come into contact with, or feed on, seeds treated in this way. Nonetheless such treatment is to be recommended for certain species after a pathogen count has been made

Table 1. Percentage germination

CULTIVAR	APRON 35 SD (35% metalaxyl) g/q seed T 0	T 200	T 300	T 400	T 600	T 1200	MEAN VALUE
Stromboli	74,33	69,00	64,33	71,67	70,67	33,67	63,94 C b c
Florum 305	60,33	63,00	58,67	62,33	64,33	87,67	68,05 B b
Solaris	72,67	53,00	61,00	68,00	57,67	73,00	65,85 B b c
Argentario	69,67	64,67	60,00	64,00	61,00	51,67	63,50 B C c
Romsun HS 90	76,00	72,33	77,00	44,33	68,67	75,00	68,89 A B a b
Romsun HS 52	36,67	36,33	37,33	51,67	50,67	69,33	47,33 E a
Ala	38,33	43,33	53,67	53,67	59,33	70,33	53,11 D d
Gloriasol	45,67	54,00	54,00	69,33	70,00	75,00	61,33 C c
Tuscania	66,00	53,00	73,67	76,33	77,00	31,00	71,17 A a
Rustiflor	61,00	66,00	54,00	27,67	36,33	25,33	45,22 E e
MEAN VALUE	60,07 B C c	57,57 C c	59,17 C c	58,90 C c	62,57 B b	65,10 A a	

NSD interaction { P 0,05 - 4,32 ; P 0,01 - 5,72 (Angular values)

Table 2. Fresh ungerminated seeds (%)

APRON 35 SD (35% metalaxyl) g/q seed T 0	T 200	T 300	T 400	T 600	T 1200	MEAN VALUE
0,00	0,00	0,00	5,00	0,00	33,00	6,33 A a
0,00	0,00	0,00	0,00	0,00	0,00	0,00 - -
0,00	0,00	0,00	0,00	0,00	0,00	0,00 - -
0,33	0,00	0,33	0,00	0,00	1,00	0,25 C c
0,00	0,00	0,00	1,33	1,00	0,00	0,39 C c
0,00	0,00	0,00	0,00	0,00	0,00	0,00 - -
0,00	0,00	0,00	0,00	0,00	2,67	0,44 C c
0,33	0,33	1,00	0,00	1,00	0,33	0,50 C c
0,00	0,00	0,33	0,67	0,00	1,33	0,39 C c
0,00	0,33	2,33	3,33	2,67	8,00	2,78 B b
0,07 C c	0,07 C c	0,40 B C b	1,03 B b	0,47 B C b	4,63 A a	

NSD interaction { P 0,05 - 4,02 ; P 0,01 - 5,33 (Angular values)

Table 3. Abnormal seedlings (%)

CULTIVAR	APRON 35 SD (35% metalaxyl) g/q seed T 0	T 200	T 300	T 400	T 600	T 1200	MEAN VALUE
Stromboli	24,67	28,67	34,67	17,33	42,67	13,33	26,89 E e
Florum 305	38,67	33,00	37,67	31,67	29,67	8,00	29,78 D E d e
Solaris	24,67	44,67	35,67	29,00	30,67	21,33	31,00 D d
Argentario	23,67	34,00	37,00	32,33	32,67	25,00	30,78 D d
Romsun HS 90	22,67	26,00	21,33	26,67	21,67	21,67	23,33 E f
Romsun HS 52	61,67	60,33	60,67	44,33	45,33	30,67	50,50 A a
Ala	38,67	49,33	38,67	37,33	36,67	22,33	40,50 B b
Gloriasol	48,67	44,33	43,33	30,00	25,67	26,67	36,44 C c
Tuscania	33,67	45,33	23,67	19,33	22,33	16,00	26,72 E e
Rustiflor	38,00	30,33	38,00	49,00	49,00	53,00	42,89 B b
MEAN VALUE	37,50 A a b	39,60 A a	37,07 A b	31,70 C D	33,63 B c	23,80 C e	

NSD interaction { P 0,05 - 4,34 ; P 0,01 - 5,75 (Angular values)

Table 4. Abnormal seedlings (%)

CULTIVAR	APRON 35 SD (35% metalaxyl) g/q seed T 0	T 200	T 300	T 400	T 600	T 1200	MEAN VALUE
Stromboli	24,67	28,67	34,67	17,33	42,67	13,33	26,89 E e
Florum 305	38,67	33,00	37,67	31,67	29,67	8,00	29,78 D E d e
Solaris	24,67	44,67	35,67	29,00	30,67	21,33	31,00 D d
Argentario	23,67	34,00	37,00	32,33	32,67	25,00	30,78 D d
Romsun HS 90	22,67	26,00	21,33	26,67	21,67	21,67	23,33 E f
Romsun HS 52	61,67	60,33	60,67	44,33	45,33	30,67	50,50 A a
Ala	38,67	49,33	38,67	37,33	36,67	22,33	40,50 B b
Gloriasol	48,67	44,33	43,33	30,00	25,67	26,67	36,44 C c
Tuscania	33,67	45,33	23,67	19,33	22,33	16,00	26,72 E e
Rustiflor	38,00	30,33	38,00	49,00	49,00	53,00	42,89 B b
MEAN VALUE	37,50 A a b	39,60 A a	37,07 A b	31,70 C D	33,63 B c	23,80 C e	

NSD interaction { P 0,05 - 4,34 ; P 0,01 - 5,75 (Angular values)

Table 5. M.G.T. (days)

APRON 35 SD (35% metalaxyl) g/q seed T 0	T 200	T 300	T 400	T 600	T 1200	MEAN VALUE
4,41	4,43	4,81	5,47	4,91	7,92	5,33 A a
4,15	4,22	4,19	4,17	4,20	4,32	4,21 D d
4,10	4,52	4,42	4,25	4,29	4,96	4,42 C c d
4,30	4,29	4,26	4,50	4,41	4,78	4,42 C c d
4,05	4,46	4,39	5,09	4,65	4,63	4,54 B C b c
4,13	4,23	4,13	4,35	4,32	4,59	4,29 C D d
4,56	4,87	4,74	4,01	4,96	4,93	4,66 B b
4,44	4,50	4,63	4,44	4,37	4,33	4,45 C c
4,32	4,41	4,27	4,30	4,22	4,18	4,28 C D d
4,35 n	4,44	4,52	5,12	4,55	4,71	4,61 B C b
4,28 C d	4,44 B c	4,44 B c	4,57 B b	4,49 B b c	4,93 A a	

NSD interaction { P 0,05 - 1,48 ; P 0,01 - 1,73 (Angular values)

Table 6. Percentage germination

CULTIVAR	ROVRAL (50% iprodione) g/q seed T 0	T 200	T 400	T 800	T 1600	T 3200	MEAN VALUE
Stromboli	90,67	82,67	82,00	78,67	76,00	76,67	81,11 A a
Florum 305	66,00	66,00	71,33	73,33	68,67	67,33	68,78 C c
Solaris	73,33	71,33	76,00	73,33	76,67	84,67	75,89 B b
Argentario	59,33	55,33	69,33	60,67	74,67	74,67	65,67 C c
Romsun HS 90	79,33	77,33	84,00	64,67	69,00	77,33	75,28 B b
Romsun HS 52	81,33	88,00	79,33	74,00	77,33	69,33	78,22 A B a b
MEAN VALUE	75,00 a	73,44 a b	77,00 a	70,78 b	73,72 a b	75,00 a	

NSD interaction { P 0,05 - 1,75 ; P 0,01 - 2,20 (Angular values)

Table 7. Fresh ungerminated seeds (%)

ROVRAL (50% iprodione) g/q seed T 0	T 200	T 400	T 800	T 1600	T 3200	MEAN VALUE
0,00	0,67	1,33	5,33	7,33	9,33	4,00 A B b
0,00	0,67	2,67	9,33	14,67	17,33	7,44 A a
0,00	0,00	2,00	2,00	4,00	3,33	1,89 B c
0,00	0,00	0,00	0,00	8,00	12,00	3,33 B b c
0,00	2,67	2,00	2,67	8,00	9,33	4,11 A B a b
0,00	0,00	1,33	2,67	1,33	6,00	1,89 B c
0,00 C d	0,67 C d	1,72 B C d	3,67 B c	7,22 A b	9,55 A a	

NSD interaction { P 0,05 - 7,11 ; P 0,01 - n.s. (Angular values)

Table 8. Abnormal seedlings (%)

CULTIVAR	ROVRAL (50% iprodione) g/q seed T 0	T 200	T 400	T 800	T 1600	T 3200	MEAN VALUE
Stromboli	8,00	9,33	9,00	15,33	13,33	13,33	11,22 C c
Florum 305	30,67	26,67	22,67	14,00	13,33	12,67	20,00 B b
Solaris	20,00	23,33	18,00	22,67	17,33	12,00	18,89 B b
Argentario	37,33	35,33	26,67	33,33	15,33	10,67	26,44 A a
Romsun HS 90	18,00	12,00	11,33	32,00	22,00	12,67	18,00 B b
Romsun HS 52	14,67	8,67	18,67	22,67	21,33	24,67	18,45 B b
MEAN VALUE	21,44 A B a b	19,22 A B b	17,56 B b c	23,33 A a	17,11 B b c	14,33 B c	

NSD interaction { P 0,05 - 7,87 ; P 0,01 - 10,45 (Angular values)

Table 9. M.G.T. (days)

ROVRAL (50% iprodione) g/q seed T 0	T 200	T 400	T 800	T 1600	T 3200	MEAN VALUE
3,57	3,75	3,54	3,93	4,55	4,99	4,11 A B b
3,50	3,73	3,93	3,93	4,64	5,05	4,13 A B a b
3,53	3,63	3,52	3,50	3,94	4,01	3,67 C d
3,72	3,65	3,84	3,77	3,98	4,23	3,87 B C c
3,70	4,10	4,16	4,68	4,55	4,62	4,30 A a
3,98	3,09	3,53	4,04	4,24	4,21	4,01 B b c
3,67 C d	3,79 B C d	3,85 B C c d	3,98 B c	4,30 A b	4,52 A a	

NSD interaction { P 0,05 - 0,45 ; P 0,01 - n.s. (Angular values)

Table 10. Percentage germination

CULTIVAR	APRON 35 SD + ROVRAL (50% + 50%) g/q seed T 0	T 400	T 800	T 1600	T 3200	MEAN VALUE
Florum 305	82,00	82,67	79,33	80,67	84,67	77,87 n.s.
Argentario	86,00	88,67	81,33	76,00	81,33	82,67
MEAN VALUE	84,00	85,67	80,33	78,33	73,00	n.s.

NSD interaction { P 0,05 - n.s. ; P 0,01 - n.s.

Table 11. Fresh ungerminated seeds (%)

APRON 35 SD + ROVRAL (50% + 50%) g/q seed T 0	T 400	T 800	T 1600	T 3200	MEAN VALUE
0,00	6,00	5,33	5,67	22,00	8,20 A a
0,00	0,67	1,33	5,33	3,33	2,13 B b
0,00 B c	3,33 B b	3,33 B b	7,00 A B a	12,67 A a	

NSD interaction { P 0,05 - 8,81 ; P 0,01 - n.s. (Angular values)

Table 12. Abnormal seedlings (%)

CULTIVAR	APRON 35 SD + ROVRAL (50% + 50%) g/q seed T 0	T 400	T 800	T 1600	T 3200	MEAN VALUE
Florum 305	14,00	5,33	5,33	2,00	9,33	5,33 n.s.
Argentario	10,00	5,33	9,33	6,00	6,67	6,13
MEAN VALUE	12,00 A a	5,33 A B b	7,33 A B a b	4,00 B b	8,00 A a b	

NSD interaction { P 0,05 - n.s. ; P 0,01 - n.s.

Table 13. M.G.T. (days)

APRON 35 SD + ROVRAL (50% + 50%) g/q seed T 0	T 400	T 800	T 1600	T 3200	MEAN VALUE
3,66	4,51	4,57	5,27	6,50	4,91 A a
3,65	4,25	4,29	4,74	5,23	4,43 B b
3,65 D d	4,39 C c	4,43 C c	5,01 B b	5,86 A a	

NSD interaction { P 0,05 - 0,35 ; P 0,01 - 0,48 (Angular values)

Means followed by the same letter are not significantly different at P= 0,05 (small letter) and P= 0,01 (capital letter)

on seeds to be planted. In this way many cases of superfluous treatments,which could damage the seed germination characteristics, could be avoided. It is probable that unnecessarily high doses are often applied to seed with no thought given to the consequences. For this reason the phytopathologist, who is in charge of seed health, and the agronomist, who must check on seed germinability and purity, must work together in a way that is not always seen.

REFERENCES

Bekendam J., Grob R., 1979, Handbook for Seedling Evaluation, I.S.T.A..

D'Armini M., Monotti M., Zazzerini A., 1975, Interventi agronomici e lotta chimica nel controllo della peronospora del girasole (Plasmopara helianthi Novot. f. helianthi), Atti Giornate Fitopatologiche 659-666

Lorenzini G., Favilli Mannerucci G., Triolo E., Gambogi P., 1975, Alcuni aspetti patogenetici di Fusarium oxysporum f.sp. pisi isolato da semi di pisello ed efficacia della concia con fungicidi sistemici, Rivista di Patologia Vegetale 11: 25-50.

Mariani Tosatti E., Pancaldi D., Flori P., Ponti I., 1978, Effetti di trattamenti chimici sulle sementi, Atti Giornate Fitopatologiche 125-132.

Masoni A., Macchia M., Mannerucci G., Ercoli L., 1983, Effetto di alcuni fungicidi sulle caratteristiche germinative di Hordeum vulgare L., Daucus carota L. e Allium cepa L., Informatore Fitopatologico 4: 41-47.

Monotti M., Zazzerini A., 1974, La peronospora del girasole. 1° contributo: risultati di osservazioni eseguite in Umbria nel 1973 e valutazione della resistenza delle varietà di girasole attualmente coltivate in Italia, Informatore Fitopatologico 3: 5-14.

Montanari N., Lovato A., 1980, Influenza della concia con chlormequat sulla vitalità del seme di frumento duro, frumento tenero e orzo, Sementi Elette 1: 5-12.

Ponti I., Flori P., Roberti R., 1982, Influenza della "concia" sulla vitalità delle sementi, Informatore Fitopatologico 1: 51-56.

Singh D., Mathur S.B., Neergaard P., 1977, Histopathology of sunflower seeds infected by Alternaria tenuis ,Seed Science and Technology 5: 579-586.

Zazzerini A., Buonaurio R., Amaducci M.T., 1975, Ulteriori osservazioni sull'impiego di fungicidi sistemici nella lotta alla peronospora del girasole (Plasmopara helianthi Novot.), Atti Giornate Fitopatologiche 377-384.

Zazzerini A., 1980, Impiego di fungicidi sistemici nella lotta contro la peronospora del girasole (Plasmopara helianthi Novot.) 255-261.