CHEMICAL CONTROL OF SOYBEAN DAMPING-OFF FUNGI

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المقاومة الكيماوية لفطريات النبول الطرى لبادرات فول الصويا

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ملخص البحث

قللت المبيدات الفطرية المستخدمة فى معاملة بذور فول الصويا موت البادرات معنويا تحت ظروف الصوبة ، وكان المبيد بنليت (بنوميل) أكثرها كفاءة فى حين كان المبيدين تكتو وداكونيل أقلها كفاءة . أدت المبيدات المختبرة الى تقليل معدل تكوين العقد الجذرية لفول الصويا تحت ظروف الصوبة ، وكان المبيد بنليت ، روفرال / ثيرام ، فيتافاكس / كابتان أقل المبيدات المختبرة خطرا على تكوين العقد الجذرية . أدت معاملة البذور بالمبيد بنليت سواء التى خزنت أو التى لم تخزن بعد المعاملة الى تحسين الانبات فى المعمل بالمقارنة بالبذور التى لم يتم معاملتها ، ولم تؤثر فترة تخزين البذور بعد معاملتها بالبنليت تأثيرا معنويا على الانبات . هذا ولم يلاحظ فروقا معنوية بين فترات التخزين المختلفة فى تأثيرها على موت البادرات تحت ظروف الصوبة وذلك لكلا الصنفين المختبرين (وليامز وكالاند) . أدت كل المبيدات الفطرية المستخدمة فى معاملة البذور الى زيادة معدل ظهور البادرات فوق سطح التربة ، وكان أفضلها روفرال / ثيرام فيتافاكس وتوبسن و فيتافاكس/ كابتان وبنليت ، بينما نتج عن تكتو أقل عدد من البادرات فوق سطح التربة . هذا وقد أدت المبيدات الفطرية المستخدمة الى تقليل معدل تكوين العقد الجذرية تحت ظروف الحقل ، وكانت المبيدات روفرال / ثيرام ، فيتافاكس/ كابتان ، فيتافاكس ، بنليت أقلها تأثيرا على تكوين العقد الجذرية .

ABSTRACT

All fungicides tested as seed dressing controlled soybean damping-off significantly under greenhouse conditions. Benlate was the most effective fungicide, while Tecto and Daconil were the least effective ones. Also the tested fungicides reduced soybean root nodulation. Benlate, Rovral/Thiram and Vitavax/Captan were the least damaging inhibitors of nodulation. All Benlate treated seeds and either stored or not stored after treatment in laboratory experiment germinated somewhat better than untreated seeds. Seed storage after Benlate treatment did not affect seed germination. After Benlate treatment, there were no significant differences in damping-off incidence in greenhouse after different periods of seed storage. Under field conditions, all tested fungicides improved the stand of soybean seedlings, Rovral/Thiram Vitavax/Captan Vitavax, Topsin and Benlate being best, whereas Tecto gave the lowest number of soybean seedlings per plot. Moreover, the fungicides inhibited soybean nodulation significantly. Rovral/Thiram, Vitavax/Captan, Vitavax and Benlate were the least damaging inhibitors.

INTRODUCTION

Soybean (Glycine max (L.). Merill.) suffers considerably from soil-borne pathogens which cause severe losses in most growing areas in Egypt. Sclerotium rolfsii, Rhizoctonia solani and Macrophomina phaseolina are wide spread and destructive soil-borne fungi. They have been reported on soybean throughout the world as well as in Egypt.

Shanmugam and Govindaswamy (1973) tested some seed dressing fungicides for controlling pre-emergence rot of peanut caused by M. phaseolina. They found that the best fungicide tested was Difolatan (captafol), followed by Thiram (TMTD), Vitavax (carboxin) and Orthocide (captan). In soil treatment studies 0.1% Benlate (benomyl) drench gave the best control of root rot followed by 0.5% Brassicol drench.

Ellis *et al*. (1975) reported that Orthocid (captan), Thiram (TMTD) and Benlate (benomyl) at 0.016, 0.033, and 0.033 a.i./20 g seed, respectively, were used to treat three lots of soybean seeds with high levels of internally seed-borne fungi and low percentage germination. They observed that seed treatment with fungicides caused a higher germination *in vitro*, and more emergence in vermiculite and field soil than nontreated controls.

Ellis *et al*. (1976) revealed that soybean seed treatment with methyl 2-benzimidazolecarbamate (MCB) in dichloromethane (methylene chloride) resulted in higher germination *in vitro*, and emergence in vermiculite and soil than control seeds treated with dichloromethane alone.

Maggione and Lam-Sanchez (1976) demonstrated that soybean seed germination was improved significantly by seed treatment with fungicides. Thiabendazole, when combined with captan, presented better results than when used in single formulation.

Caravalho and Jacinto (1979) studied the effect of soybean seed storage after treatment with Thiram on seed germination. Soybean seeds (cv. Santa Rosa) were kept during 12 months under two storage conditions. They found that only seeds treated before seeding germinated as well as those treated before storage.

Ganacharya (1979) noted that Captan, Thiram (TMTD) and Derosal (carbendazim) at 3, 4.5 and 2 g/kg seed significantly increased soybean emergence to 99.7, 98.3 and 96.6%, respectively.

Wu (1980) found that 1 ppm of Benlate 50% (benomyl), Benlate C 60% (benomyl 10% + captan 50%), Benlate T 40 (benomyl 20% + thiram 20%), Terrachlor 75% (PCNB) and 5 ppm of Ronilan 50% (vinciozolin) was fungistatic to *R. solani in vitro*, whereas 100 ppm of the first four fungicides were fungicidal to R. solani. Dusting soybean seeds with Benlate C and soaking seeds with 500 ppm Terraclor in acetone provided significantly better disease control caused by R. solani as compared with seeds treated with other fungicides in glass tube tests. These fungicides did not provide disease control or better germination in either greenhouse or field tests.

Caravalho et al. (1981) tested the effect of some seed dressing systemic fungicides on soybean seedling emergence. They revealed that soybean seelding emergence was highest after treatment with mixtures containing Chloroneb or with Benomyl + Thiram at 200 g/ 100 kg seeds.

Elazegui and Mew (1983) studied the comparative effects of fungicides on pre-emergence damping-off of grain legumes caused by R. solani and S. rolfsii. They found that the most effective seed treatment against R. solani on cowpea, mungbean (Vigna radiata) and soybean was with PCNB (quintozene) + Thiadiazole. Mancozeb and Thiram gave significant protection. Against S. rolfsii, Carboxin + captan was the best, but Carboxin + Thiram, Iprodione and Orthocide (captan) were not significantly different.

Te Krony et al. (1985) evaluated the effect of benomyl treatment in the field during reproductive growth of soybean on fungal seed infection for 2 years. There was a tendency for improved seed germination and lower levels of seed infection by Phomopsis sp. and Cercospora kikuchii by all benomyl treatments except a single application (1.12 kg/ha) near the R 7 growth stage (first yellow pod) only. However, there was little yield response to benomyl treatment except for a significant increase occurring in one variant (June 1978) out of nine planting dates after split application.

Effect of chemical control of soybean damping-off on nodulation and nitrogen fixation was also studied.

Hamdi et al. (1974) reported that results from tests on the effect of seed treatment with fungicides on nitrogen fixation indicated that Orthocide treatment can be used safely with soybean.

Curley and Burton (1975) studied the effect of four seed protectant chemicals on the survivial of R. japonicum on soybean seeds in the laboratory. The chemicals tested were Thiram, Captan, PCNB and Carboxin at the rates of 0.6, 0.8, 0.9 and 1.1 g/kg seed, respectively. They revealed that PCNB reduced Rhizobium survival on seed and decreased taproot nodulation. Captan was less toxic to rhizobia than was PCNB, but taproot nodulation of plants was greatly reduced by captan. Carboxin had little effect on viable rhizobia or taproot nodulation when seeds were planted whithin 24 hours after inoculation. Thiram had no adverse effect on viable rhizobia or taproot nodulation even when seeds were treated 24 hours before planting.

Ganacharya (1979) pointed out that soybean nodulation was not adversely affected by Captan, Thiram and Derosal (carbendazim) applied to the seeds 3, 4.5 and 2 g/kg respectively.

Caravalho et al. (1981) studied the effect of soybean seed dressing with some fungicides on nodulation. They revealed that Benlate + Thiram at 200 g/100 kg seeds gave the maximum dry weight of nodules.

Marzocca (1983) studied the effect of seed treatment with fungicides on soybean nodulation. He reported that, in pot trials in the glasshouse, no harmful effects were found when using

Thiabendazole at 200 g/100 kg seed simultaneously with inoculation with R. japonicum, while other treatments (400 g Thiabendazole and PCNB at 40 and 80 g) effected nodulation.

Abd El-Monem and El-Sawah (1984 a) studied the effect of certain seed-dressing fungicides on bacterial nodulation of soybean. Results from greenhouse and field tests indicate that Benlate T (benomyl + thiram) and Orthocide 83 (captan) partially inhibited root nodulation due to the toxicity of Thiram and Captan. Granosan (benomyl + maneb), Quinolate 15 M (copper oxyquinolate + imazalil), Quinolate CT S (copper oxyquinolate + carbendazim), Quinolate V 4 X (copper oxyquinolate + carboxin), RH 50-50 (quintozene + maneb), Tecto 20/60 (thiabendazole + mancozeb), Vitavax SP (carboxin) and Vitavax 300 (carboxin + captan) did not inhibit root nodulation.

Abd El-Monem and El-Sawah (1984 b) demonstrated that Captan and Thiram inhibited the growth of R. japonicum and nodulation on the roots of soybean plants. Brassicol 75 (quintozene), Dithane M-45 (mancozeb), Vitavax (carboxin), Topsin 70-M (thiophanate-methyl) and RH 50-50 (maneb + quintozene) were not inhibitory at 1.2 g/kg seeds. The benzimidazol derivates Benlate (benomyl), Bavistin (carbendazim) and Topsin M (thiophanate-methyl) increased nodulation. They mentioned that the inhibitory effect could be eliminated or reduced by treating the seeds before Rhizobium inoculation.

Jauhri and Agarwal (1984) studied the effect of seed dressing fungicides, Thiram, Captan, PCNB (quintozene) and Dithane M-45 (mancozeb), on soybean seeds inoculated with R. japonicum in charcoal rot infested soil. They found that Dithane M-45 alone or with Thiram gave the best yield and seed emergence in Macrophomina phaseolina-infested soil when the seeds were also inoculated with R. japonicum. No adverse effects of the fungicides on the inoculation were observed.

Rennie et al. (1985) pointed out that captan, applied to the seeds of pea, lentil and broad bean reduced nodulation and nitrogenase activity. Some captan-containing mixtures (B-3 with 33.5% and Evershield with 29.5%) also reduced nodulation and nitrogenase activity, but DL-PLUS (15% captan) was not harmful. This suggests that fungicides containing less than 29.5% captan may not be compatible with seed-applied Rhizobium leguminosarum.

This work was carried out to study the effect of certain fungicides on the control of damping-off fungi and on soybean seed germination as well as on the root-nodulation of soybean plants.

MATERIALS AND METHODS

Ten fungicides, namely Benlate (50 WP benomyl), Daconil (chlorothalonil), Orthocide (captan), Quinolate C-T-S (copperoxyquinolate + carbendazim), Quinolate V-4-X (copperoxyquinolate + carboxin), Rovral/Thiram (iprodione + TMTD), Tecto (60% thiabendazol), Topsin (thiphanate methyl), Vitavax (carboxin) and Vitavax/captan (carboxin + captan) were tested for their seed-dressing potential to control soybean damping-off caused by S. rolfsii, R. solani and M. phaseolina under greenhouse and field conditions. The effect of these fungicides on soybean nodulation in the greenhouse, as well as in the field was also studied.

1. Greenhouse experiments:

a) Effect of seed dressing on damping-off of soybeans incited by S. rolfsii, R. solani and M. phaseolina:

The inocula of S. rolfsii, R. solani and M. phaseolina were prepared by growing them on barley grain medium. The soil was infested with each fungus at the rate of 2% of soil weight 7 days before sowing. Soybean seeds (cv. Calland) were treated with each fungicides. Benlate, Daconil, Orthocide, Quinolate C-T-S, Quinolate V-4-X, Rovral/Thiram, Tecto 60%, Topsin, Vitavax and Vitavax/captan were applied at the rates of 1, 2.5, 2, 3, 3, 2, 1, 1, and 3 g/kg of seeds, respectively. Fifteen soybean seeds were planted in each pot (20 cm in diameter). Pots of control were sown with untreated seeds. Each treatment was replicated four times. Pre-emergence damping-off was recorded 2 weeks after sowing, whereas post-emergence damping-off and the number of survived plants were recorded 4-weeks after sowing.

b) Effect of seed dressing on soybean root nodulation:

Soybean seeds (cv. Calland) were treated with each tested fungicide at the recommended rate of use as mentioned in the last experiment. The pots were treated with nitragin granule inoculum (*Rhizobium japonicum*) on the day of planting. Fifteen treated soybean seeds were sown in each pot and replicated 4 times for each particular fungicide treatment. Untreated seeds were sown in pots inoculated with nitragin as control. Number and size of nodules per plant were recorded 5 weeks after sowing.

c) Effect of storage period of soybean seeds after Benlate treatment on:

- Germination of soybean seeds in the laboratory:

Soybean seeds (cvs. Calland and Williams) were treated with Benlate (the best tested fungicide for the control of *S. rolfsii*, *R. solani* and *M. phaseolina*) at the recommended rate of use (1 g/kg seeds). Fifty gram of seeds were mixed with 5 ml of 5% methyl cellulose containing 50 mg of Benlate. Coated seeds were air dried over night at 20 ± 2°C, and then stored in the dark at room temperature until planting. The first treatment was carried out on 15 October, 1985, and similar applications were carried out every 2 weeks until the beginning of April, 1986. The seeds treated on 1st April were stored only for one week. The last treatment was on

8 April, 1986 when the seeds were not stored and tested at the same day. Untreated seeds were used as control. Sixty seeds from each treatment were transferred to Petri plates (10 seeds/plate containing pieces of moistened filter paper and incubated at room temperature (25 ± 2°C). Germination data were recorded after 4 days.

- Control of soybean damping-off caused by *S. rolfsii*, *R. solani* and *M. phaseolina*:

The tested fungi inocula were prepared and the soil was infested with each fungus alone. Seeds were treated with Benlate at the recommended rate and stored as described in the last experiment. Twenty seeds were sown in each pot (20 cm in diameter) and replicated 4 times for each particular treatment. Pots of both controls were sown with untreated seeds. Pre- and post-emergence damping-off, as well as the number of survived plants were recorded.

2. Field experiment:

The effect of 10 soybean seed dressing fungicides on damping-off and yield of soybean under field conditions were tested. The effect of these fungicides on soybean root nodulation were also studied.

a) Effect of seed-dressing on stand and yield of soybean:

Soybean seeds (cv. Calland) were treated with each fungicides as described in the greenhouse experiment. Plots (10.5 m^2) were used as experimental units. The experiment was designed as randomized block. Sixty seeds were sown in each row (360 seeds/plot). Non-treated seeds were sown as control. Each treatment was replicated 4 times. The number of soybean seedlings per plot was recorded 3 and 4 weeks after sowing. Grain yield per plot was also detemined after harvest.

b) Effect of seed dressing fungicides on soybean root nodulation:

For this purpose, the last mentioned experiment was carried out in the same way but nitragin granule inoculum (*Rhizobium japonicum*) was added into the furrows at the day of planting. Four weeks after emergence, 10 plants from 2 rows were removed carefully from the soil after irrigation, and the number and size of nodules per plant were recorded.

All data were subjected to statistical analysis using L.S.D. test.

RESULTS

1. Greenhouse experiments:

a) Effect of seed dressing on soybean damping-off caused by *S. rolfsii*, *R. solani* and *M. phaseolina*:

Data presented in Tables (1), (2) and (3) indicate that all fungicides tested as seed dressing were able to control damping-off significantly. Benlate was the most effective fungicide tested in controlling damping-off caused by *S. rolfsii*, *R. solani* and *M. phaseolina* and resulted in the lowest percentage of damping-off and the highest percentage of survived plants, followed by Rovral/Thiram and Vitavax/Captan. On the other hand, Tecto and Daconil were least effective. The other fungicides tested fell in between the two categories.

Table (1): Effect of seed dressing on soybean damping-off incited by *S. rolfsii* under greenhouse conditions.

Fungicide	Pre-emergence damping-off %	Post-emergence damping-off %	Survived plants %
1. Benlate	17.6	2.3	80.1
2. Daconil	49.6	7.3	43.1
3. Orthocide	35.9	9.4	54.7
4. Quinolate C-T-S	40.9	9.1	50.0
5. Quinolate V-4-X	45.5	6.6	47.9
6. Rovral/Thiram	17.4	4.8	77.8
7. Tecto	53.9	4.8	41.3
8. Topsin	31.7	4.6	63.7
9. Vitavax	22.2	4.8	73.0
10. Vitavax/Captan	18.0	4.6	77.4
11. Control	68.1	9.1	22.8
L.S.D. 5%	4.2	0.6	4.3
1%	5.7	0.9	5.7

Table (2): Effect of seed dressing on soybean damping-off incited by *R. solani* under greenhouse conditions.

Fungicide	Pre-emergence damping-off %	Post-emergence damping-off %	Survived plants %
1. Benlate	8.9	4.4	86.7
2. Daconil	40.5	4.8	54.7
3. Orthocide	31.5	4.4	64.1
4. Quinolate C-T-S	36.3	2.3	61.4
5. Quinolate V-4-X	36.3	6.4	57.3
6. Rovral/Thiram	18.3	4.4	77.3
7. Tecto	43.1	2.5	54.4
8. Tospin	27.4	4.4	68.2
9. Vitavax	20.3	4.4	75.3
10. Vitavax/Captan	18.0	4.4	77.6
11. Control	58.7	9.3	32.0
L.S.D. 5%	4.0	1.2	4.1
1%	5.4	1.7	5.7

Table (3): Effect of seed dressing on soybean damping-off incited by M. phaseolina under greenhouse conditions.

Fungicide	Pre-emergence damping-off %	Post-emergence damping-off %	Survived plants %
1. Benlate	4.2	0	95.8
2. Daconil	15.8	0	84.2
3. Orthocide	17.8	0	82.2
4. Quinolate C-T-S	18.3	0	81.7
5. Quinolate V-4-X	15.5	0	84.5
6. Rovral/Thiram	6.4	0	93.6
7. Tecto	18.3	0	81.7
8. Topsin	17.8	0	82.2
9. Vitavax	13.5	0	86.5
10. Vitavax/Captan	9.1	0	90.9
11. Control	27.2	4.6	68.2
L.S.D. 5%	2.2	2.3	2.8
1%	3.0	3.5	3.8

b) Effect of seed dressing on soybean root nodulation:

All fungicides tested seemed to be toxic to soybean root-nodule bacteria (Rhizobium japonicum) and reduced the total number of nodules per plant significantly compared to the non-treated control. Benlate, Rovral/Thiram and Vitavax/Captan were the least damaging inhibitors of nodulation among the fungicides tested (Table 4).

Table (4): Effect of seed dressing on soybean root nodulation under greenhouse conditions.

Treatment		Average No. of nodules/plant main	Lateral	Size of nodules large	small	Total No. of nodules/plant
1. Benlate	+ R. japonicum	5.0	6.5	6.1	5.4	11.5
2. Daconil	+ R. japonicum	3.0	4.1	3.5	3.6	7.1
3. Orthocide	+ R. japonicum	3.0	4.9	3.9	4.0	7.9
4. Quinolate C-T-S	+ R. japonicum	3.1	3.7	2.9	3.9	6.8
5. Quinolate V-4-X	+ R. japonicum	2.9	4.1	3.0	4.0	7.0
6. Rovral/Thiram	+ R. japonicum	4.1	7.1	5.3	5.9	11.2
7. Tecto 60%	+ R. japonicum	2.9	4.1	3.0	4.0	7.0
8. Topsin	+ R. japonicum	3.6	4.5	4.0	4.1	8.1
9. Vitavax	+ R. japonicum	3.9	4.7	3.6	5.0	8.6
10. Vitavax/Captan	+ R. japonicum	4.7	6.3	5.1	5.9	11.0
11. Control*		7.3	7.7	7.0	8.0	15.0
L.S.D. 5%						2.5
1%						3.2

* R. japonicum only.

c) Effect of the length of storage period of soybean seeds after Benlate-treatment on:

Germination of soybean seeds in the laboratory:

Data presented in Table (5) reveal that all Benlate-treated seeds in both cultivars, Williams and Calland germinated somewhat better than untreated seeds. The length of seed storage after Benlate treatment did not significantly affect germination. Seeds treated only at seeding time germinated as well as those treated before being stored.

Table (5): Effect of storage period of soybean seeds after Benlate-treatment on the germination of soybean seeds in the laboratory.

Storage periods of Benlate treated seeds in weeks	Percentage of seed germination	
	cv. Williams	cv. Calland
0	98.3	88.3
1	95.0	86.7
2	96.7	85.0
4	98.3	86.7
6	95.0	88.3
8	95.0	86.7
10	98.3	85.0
12	95.0	85.0
14	96.7	86.7
16	96.7	85.0
18	95.0	85.0
20	96.7	86.7
22	95.0	85.0
24	95.0	85.0
Control	88.3	71.7
L.S.D.	5%	1%
for storage periods	4.3	5.4
for cultivars	3.5	4.4

Control of damping-off caused by S. rolfsii, R. solani and M. phaseolina:

Results in Tables (6), (7) and (8) show that all Benlate-treatments significantly reduced soybean damping-off caused by S.rolfsii, R. solani and M. phaseolina in both cultivars tested compared with the non-treated controls. Benlate-treatments completely controlled damping-off caused by M. phaseolina for cv. Williams, and all plants survived. There were no significant differences in damping-off or in the number of survived plants after different periods of seed storage after Benlate-treatment for all the three tested fungi in both cultivars.

Table (6): Effect of storage period of soybean seeds after Benlate treatment on damping-off caused by S. rolfsii under greenhouse conditions.

Storage periods of Benlate treated seeds in weeks	Pre-emergence damping-off %		Post-emergence damping-off %		Surviving plants %	
	Williams	Calland	Williams	Calland	Williams	Calland
0	13.8	17.9	6.4	7.3	80.3	74.8
1	11.0	15.8	4.8	6.1	84.2	78.1
2	10.6	15.8	4.8	6.1	84.6	78.1
4	12.7	17.9	6.4	7.3	80.9	74.8
6	13.3	16.4	6.4	7.3	80.3	76.3
8	11.0	17.9	7.3	8.5	81.7	73.6
10	10.6	16.4	6.4	6.1	83.0	77.5
12	12.7	16.4	6.4	8.5	80.9	75.1
16	15.2	17.9	7.3	7.3	77.5	74.8
18	13.3	20.0	7.3	7.3	79.4	72.7
20	13.3	20.7	6.4	9.0	80.3	71.0
22	15.2	17.9	7.3	9.0	77.5	73.1
24	13.3	20.0	7.3	9.0	79.4	71.0
Control	45.0	68.7	10.0	13.3	45.0	18.0
L.S.D.	5%	1%	5%	1%	5%	1%
for storage periods	5.1	6.0	3.1	4.2	7.5	8.9
for cultivars	3.1	4.1	1.8	2.6	4.2	5.1

Table (7): Effect of storage period of soybean seeds after Benlate-treatment on damping-off caused by R. solani under greenhouse conditions.

Storage periods of Benlate treated seeds in weeks.	Pre-emergence damping-off %		Post-emergence damping-off %		Surviving plants %	
	Williams	Calland	Williams	Calland	Williams	Calland
0	9.8	12.7	4.4	6.4	85.8	80.9
1	8.5	10.3	4.4	6.4	87.1	83.3
2	9.8	10.3	4.4	6.4	85.8	83.3
4	8.5	14.1	6.1	8.5	85.4	77.4
6	9.8	10.3	4.4	7.3	85.8	82.4
8	8.5	14.1	4.4	7.3	87.1	78.6
10	10.3	13.5	6.1	8.5	83.6	78.0
12	10.3	13.5	7.3	7.3	82.4	79.2
14	12.7	14.1	4.4	9.8	82.9	76.1
16	13.5	15.8	4.4	8.5	82.1	75.7
18	12.7	15.8	6.1	9.8	81.2	74.4
20	12.7	13.5	6.1	8.5	81.2	78.0
22	13.5	14.1	6.1	10.3	80.4	75.6
24	13.5	15.8	7.3	10.3	79.2	73.9
Control	37.5	58.7	13.7	16.7	48.8	24.6
L.S.D.	5%	1%	5%	1%	5%	1%
for storage periods	6.8	4.1	5.0	5.0	8.2	9.8
for cultivars	4.0	4.9	1.7	2.6	4.1	5.1

Table (8): Effect of storage period of soybean seeds after Benlate-treatment on damping-off caused by M. phaseolina under greenhouse conditions.

Storage periods of Benlate treated seeds in weeks.	Pre-emergence damping-off %		Post-emergence damping-off %		Surviving plants %	
	Williams	Calland	Williams	Calland	Williams	Calland
0	0	6.4	0	0	100.0	93.6
1	0	6.4	0	0	100.0	93.6
2	0	6.4	0	0	100.0	93.6
4	0	7.3	0	0	100.0	92.7
6	0	7.3	0	0	100.0	92.7
8	0	6.4	0	0	100.0	93.6
10	0	7.3	0	0	100.0	92.7
12	0	7.3	0	0	100.0	92.7
14	0	7.3	0	0	100.0	92.7
16	0	9.0	0	0	100.0	91.0
18	0	8.5	0	0	100.0	91.5
20	0	8.5	0	0	100.0	91.5
22	0	9.0	0	0	100.0	91.0
24	0	9.0	0	0	100.0	91.0
Control	13.5	20.0	0	6.4	86.5	73.6
L.S.D.	5%	1%	5%	1%	5%	1%
for storage periods	3.1	4.3	2.1	2.9	3.3	4.2
for cultivars	2.2	3.1	1.8	2.6	2.4	3.4

2. **Field experiments:**

a) **Effect of seed dressing on stand and yield of soybean:**

Data in Table (9) reveal that all fungicides tested significantly increased the number of soybean seedlings per plot, Rovral/ Thiram and Vitavax/Captan being best, followed by Benlate, Topsin and Vitavax, whereas Tecto gave the lowest number of soybean seedlings per plot.

All fungicides except Tecto and Daconil also increased soybean grain yield significantly, Benlate, Vitavax and Vitavax/Captan being on top, followed by Topsin.

Table (9): Effect of seed dressing on stand and yield of soybean under field conditions.

Treatment	number of plants/plot after sowing		average yield/plot (kg)
	3 weeks	4 weeks	
1. Benlate	260.0	249.0	4.5
2. Daconil	225.5	212.3	3.7
3. Orthocide	251.3	235.5	4.1
4. Quinolate C-T-S	246.3	239.8	4.0
5. Quinolate V-4-X	240.0	231.0	4.0
6. Rovral/Thiram	290.3	281.0	4.8
7. Tecto	209.0	189.0	3.5
8. Topsin	258.0	249.0	4.3
9. Vitavax	265.3	245.0	4.5
10. Vitavax/Captan	285.5	270.8	4.7
11. Control	184.0	175.8	3.5
L.S.D. 5%	12.9	13.4	0.3
1%	17.3	18.1	0.4

b) Effect of seed dressing on soybean root nodulation:

All fungicides tested reduced the number of nodules per plant significantly, Rovral/Thiram, Vitavax/Captan, Vitavax and Benlate, gave the highest number of nodules per plant, followed by other tested fungicides.

Table (10): Effect of seed dressing on soybean root-nodulation under field conditions.

Treatment		Average No. of nodules/plant		Size of nodules		Total No. of nodu-les/plant
		main root	lateral roots	large	small	
1. Benlate	+ R. japonicum	6.7	10.3	9.2	7.8	17.0
2. Daconil	+ R. japonicum	6.4	7.1	8.3	5.2	13.5
3. Orthocide	+ R. japonicum	6.8	8.2	9.1	5.9	15.0
4. Quinolate C-T-S	+ R. japonicum	6.1	7.4	8.3	5.2	13.5
5. Quinolate V-4-X	+ R. japonicum	6.0	7.0	6.9	6.1	13.0
6. Rovral/Thiram	+ R. japonicum	8.2	13.0	12.0	9.2	21.2
7. Tecto	+ R. japonicum	5.8	7.2	6.6	6.4	13.0
8. Topsin	+ R. japonicum	7.1	8.1	8.0	7.2	15.2
9. Vitavax	+ R. japonicum	7.5	10.2	10.4	7.3	18.7
10. Vitavax/Captan	+ R. japonicum	8.7	11.3	12.2	7.8	20.0
11. Control*		15.7	16.5	18.0	14.2	32.2
L.S.D. 5%						4.4
1%						5.2

* R. japonicum only.

DISCUSSION

Under greenhouse conditions, all tested fungicides controled damping-off caused by S. rolfsii, R. solani and M. phaseolina. Benlate was the most effective fungicide, whereas Tecto and Daconil were the least effective ones. Such results are in accordance with that reported by chemically controlled with fungicides by many investigators, Shanmugam and Govindaswamy (1973), Wu (1980) and Elazegui and Mew (1983).

Also, all tested fungicides significantly reduced the total number of nodules per plant. Benlate, Rovral/Thiram and Vitavax/ Captan were less inhibitory than the other chemicals. The toxicity of the chemicals to the root-nodule bacteria, Rhizobium japonicum may account for the decrease of nodulation after seed treatment with the fungicides. Similar results were reported by Curley and Burton (1975), Maggione and Lam-Sanchez (1976), Ganacharya (1979), Caravalho et al. (1981), Marzocca (1983), Abd El-Monem and El-Sawah (1984 a,b), Jauhri and Agarwal (1984), and Rennie et al. (1985).

Under laboratory conditions, soybean seeds treated with Benlate yielded a higher percentage of germination than nontreated seeds for all lengths of seed storage periods after Benlate treatment. There were no significant differences among the varients with different lengths of seed storage periods after Benlate treatment. Seeds treated just before seeding germinated as well as those treated before storage. The improvement of seed germination in the laboratory by Benlate treatment may be due to the effect of this fungicide on seed-borne fungi, which reduced the germination of the seeds (Ellis et al., 1975). Similar results have been reported by Maggione and Lam-Sanchez (1976) and Caravalho and Jacinto (1979).

Under greenhouse conditions, seed treatment with Benlate reduced seedling damping-off all seed storage periods after Benlate treatment. There were no significant differences among the lengths of seed storage periods after Benlate treatment.

Under field conditions, all fungicides tested as seed-dreesing significantly increased the stand of soybean seedlings when evaluated three or four weeks after sowing. Rovral/Thiram and Vitavax/Captan gave the best results, followed by Topsin, Vitavax and Benlate, whereas Tecto was the least effective one, reflecting the toxic effect of these fungicides to the soil-borne fungi causing damping-off. Similar results have been reported by Ellis et al. (1975), Ganacharya (1979), Caravalho et al. (1981) and Te Krony et al. (1985).

All fungicides tested by seed treatment except Tecto and Daconil, significantly increased soybean yield under field conditions. Rovral/Thiram, Vitavax/Captan and Benlate, gave the highest grain yield. Increase in soybean yield using seed treatment fungicides was reported by Chamber and Montes (1982 a,b) and Te Krony et al. (1985).

Under field conditions, all tested fungicides significantly reduced soybean nodulation, which was less affected by Rovral/Thiram, Vitavax/Captan, Vitavax and Benlate, compared with the other tested fungicides. Similar trend was observed when the experiment was done under greenhouse conditions.

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