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Effect of Large Applications of Gypsum and Fermentation Residues on the Growth of Tomato Plants[1]

H. C. De Roo
Department of Soil and Water, The Connecticut Agricultural Experiment Station, Valley Laboratory, Windsor, CT 06095

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Abstract. **Raw mycelial sludge produced by the pharmaceutical industry, containing 34% gypsum on a dry weight basis injured and suppressed early growth of tomato (*Lycopersicon esculentum* Mill. cv. Rutgers) when incorporated into a loamy sand at the rate of 27 or 242 ton (wet weight)/ha. Equivalent amounts of gypsum, 3 or 27 ton/ha added to soil in a greenhouse experiment produced no ill-effects indicating that the gypsum *per se,* contained in these fermentation wastes, was not responsible for injury and suppressed growth of tomato.**

Gypsum forms a substantial part of the fermentation residues resulting from the commercial production of various organic acids and antibiotics by microorganisms. Their potential usefulness as a N fertilizer or organic soil amendment in horticulture and agriculture has been evaluated (3). About half of the dry wt of the silty-textured combined wastes is organic, mainly spent fungal mycelial tissues. The high moisture content and relatively low concn of plant nutrients (about 2% N, 0.1% P and 0.06% K on a dry wt basis) are typical of any biological tissue. The main differences are that some of the wastes contain added Zn and/or large amounts of filter aids, such as perlite, and gypsum (about 34%, on a dry wt basis of the waste mixture).

The response of various crops to this raw mycelial waste has been reported (3). The early growth of tomato plants was damaged; the lower leaves showed a yellow mottled-leaf pattern, while the top growth was stunted or compacted. Toxic effects by the added amounts of zinc were not observed.

The purpose of the greenhouse experiment reported here is to determine whether gypsum was a limiting factor in the use of these mycelial wastes as an organic N fertilizer or soil amendment. Since tomato plants showed symptoms of mycelial waste-injury, the effects of gypsum applications equivalent to those added by the mycelial waste additions, were studied on the early growth, flowering and fruit setting. The experimental set-up and conditions were similar to those used previously (3).

The soil was a coarse-textured, well-aerated Windsor loamy sand; amendments, lime and fertilizer additions, based on soil tests (4), are shown in Table 1.

The soils and amendments for each of the 5 treatments were thoroughly mixed in a cement mixer. The mixed fermentation residues were air-dried and pulverized since raw waste has the consistency of a heavy sludge. Each treatment mixture supplied enough material to fill twelve 3.8 liter containers, which were subsequently placed in 4 randomized blocks on a greenhouse bench.

The following day (day 0) uniform 'Rutgers' tomato transplants were planted, each pot receiving one transplant. To check the fertility status, soil tests (4, 6) were made every 3 to 4 days for the first 2 weeks and later weekly. When required, 56 to 78 kg N/ha and 60 to 164 kg K/ha were top-dressed.

Treatment effects were evaluated by noting the quality and quantity of foliage, by plant ht and by number of inflorescences and their stage of development.

In agreement with previous observations (3), the early growth of plants treated with mycelial waste was less than that of plants not receiving mycelia (Fig. 1). The addition of gypsum resulted in growth rates similar to those of the control plants. The low rate of mycelial waste retarded tomatoes size for about 10 days, while the retarding effect of the high rate lasted about 3 weeks. Later, the growth rates increased, and 5 to 6 weeks after transplanting the mycelia treated plants were about as high as the other treatments.

The foliage of the plants also demonstrated the effect of the treatments. Three days after transplanting, the first signs of injury by the mycelial treatments were observed. On day 17 the injury varied from moderate to severe. In 1/3 of the plants receiving the low mycelial application older leaves were moderately yellowed with mottled-leaf pattern and some marginal browning; all plants receiving the high mycelial application showed these same symptoms, but more severely. Plant growth was normal in the other treatments.

Observations on the amount and earliness of flowering of the tomato plants showed the same trends (Table 2). The mycelial waste treatments retarded and suppressed the flowering and fruit setting, while the gypsum plants did as good or slightly better than the check plants.

The possibility that phytotoxicity is caused by the excess of certain specific ions was examined previously (3). Zn concn did not approach those known to be toxic (2). Total S concn did not clearly indicate that the high sulfate S concn of the gypsiferous mycelial waste were toxic. Thus, our previous investiga-

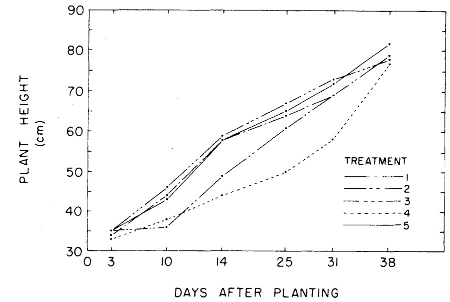

Fig. 1. Height of potted tomato plants in Windsor loamy sand as affected by gypsum and mycelial amendments. (Refer Table 1 for treatments.)

Table 1. Amendments and fertilization of Windsor loamy sand for growing tomatoes in pots in the greenhouse.

Additions	Treatment 1	2	3	4	5
Amendments			*tons/ha*		
Gypsum	3.0		27.2		
Mycelial residues		27		242	
Limestone, dolomitic	3.4	0	3.4	0	3.4
Hydrated lime	2.2	2.9	2.2	0	2.2
Preplanting fertilizer			*kg/ha*		
Organic N (mycelial)		179		1613	
Inorganic N	123	33	123	33	123
P	48	44	48	44	48
K	284	209	284	209	284

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Table 2. No. of inflorescences, with flowers and fruit, 25 and 42 days after transplanting (Refer Table 1 for treatments).

Treatment	No. of inflorescences		
	Day 25	Day 42	
	Total	Total	With fruit
1	3.0ab[z]	9.9ab	1.2ab
2	2.0b	7.1b	1.2ab
3	3.4a	11.8a	1.9a
4	0.1c	3.0c	0.0b
5	2.6ab	10.0ab	1.0ab

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

tions led to the conclusion that the salinity of the mycelial waste, although only moderate, was the principal cause of the injury and growth depression of plants.

In the present experiment, however, the regular soil testing of the various treatments showed only minor differences in the concn of soluble salts (Table 3). Furthermore, with the exception of the control, the salinity in all treatments did not change much with time, remaining slightly above 2 mmhos/cm. This is understandable, since the conductivity of a saturated solution of gypsum is 2.2 mmhos/cm (6), and treatments 1 to 4 contain large amounts of gypsum. The salinities at planting time were only modest, and probably not the cause of any damage to the tomato plants, which are considered to be moderately tolerant of salts (1). Others found that tomato yield was reduced by 10% for every 1.5 mmhos/cm increase in conductivity above 2.0 mmhos/cm; however, the yield of shoots was not affected (5). Thus, the assumption that the tomato plants were injured and stunted by the moderate concn of soluble salts is not warranted. Other possible causes for these detrimental effects on plant growth should be investigated, such as chemical compounds and transformations that are operative during and shortly after mycelial wastes are incorporated into soil. Although not yet known or understood, these factors could be related to the initial nitrate-N immobilization reaction in soil observed previously (3).

Table 3. Electrical conductivities in Windsor loamy sand in pots planted with tomatoes.

Days after transplanting	ECe in mmhos/cm				
	Treatment				
	1	2	3	4	5
0	3.2	2.7	2.7	3.0	2.5
3	3.2	2.0	2.6	2.6	2.2
10	2.4	2.6	2.2	2.2	1.2
17	2.4	2.5	2.2	2.8	0.8
25	2.1	2.3	2.2	2.7	1.6

In conclusion, tomato growth in loamy sand is not affected by large applications of gypsum, while additions of mixed fermentation residues caused depressed early growth and foliar injuries. Thus, it appears that the gypsum contained in the mycelial wastes is not the cause of these injuries and suppressed growth of the tomato.

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Cabbage Looper Oviposition and Survival of Progeny on Leafy Vegetables[1]

A. N. Kishaba[2], T. W. Whitaker[3], Wade Berry[4], and H. H. Toba[5]
Agricultural Research Service, U.S. Department of Agriculture, Riverside, CA 92502

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Abstract. **When given a choice, the cabbage looper, *Trichoplusia ni* (Hübner), preferred lettuce for oviposition over chard [*Beta vulgaris* L. (Cicla group)], cabbage [*Brassica oleracea* (Capitata group)], broccoli (*Brassica oleracea* L. [Italica group)], and spinach (*Spinacia oleracea* L.). Preference did not appear to be related to leaf area or to any factor that enhances the survival of progeny of a particular plant species. A 20- to 29-fold difference in oviposition was noted on lettuce grown under 2 environmental conditions.**

Although we reported differential oviposition of the cabbage looper, among and within *Lactuca sativa* L., *L. serriola* L., and *L. saligna* L. in the screenhouse (6), none was apparent among *L. sativa* cultivars grown in the field. These discrepant results probably reflect differences in plant age, available hosts, and environmental factors. Variable results such as these have been noted among cruciferous crops. For example, Harrison and Brubaker (3) compared looper populations on 8 crucifers over a 3-year period and found no outstanding resistance in any of the cultigens tested, though any one may be the most resistant in a given year. Radcliffe and Chapman in contrast reported (7, 8, 9, 10), that chinese cabbage 'Michihli' was resistant to oviposition compared with other crucifer cultigens. They reported that ovipositional preferences were modified by prior insect injury though plant size had no effect. They also found that egg and larval counts were usually, but not always, correlated; i.e., Brussel sprouts and collards had relatively fewer eggs than other plants but were susceptible to larval attack. Wolfenbarger (11) reported less damage to *Brassica oleracea viridis* L. (P.I. 236259) than to some commercial cabbages.

We noted fewer loopers (unpublished) on chard than on broccoli in small home gardens. The number of looper eggs in the field is affected by the physiological and chronological age of the plant and the cultivar. However, in screening breeding materials for differential oviposition of the cabbage looper on lettuce, we needed to know the extent of looper ovipositional preference for lettuce (*Lactuca sativa* vs. *L. serriola*) compared with the preference for other leafy vegetables.

Commercial seeds of the test plants were germinated in vermiculite and transplanted into 5.1-cm^2 peat pots containing peat, soil, plasters' sand, silt and vermiculite (1:4:5:5:5 by volume). The potted plants were placed in a screenhouse at La Jolla and watered with half strength Hoagland's solution (5) as needed. As the initial planting of 'Prizehead' lettuce germinated poorly, they were kept in a greenhouse equipped with smog filters, maintained at 20°C (night) and 30°C (day), at Riverside for 1 month before they were transferred to La Jolla. There they were held for 1 additional month before the

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[2]Research Entomologist, Boyden Entomology Laboratory, Agr. Res. Serv., USDA, P.O. Box 112, Riverside, CA 92502.

[3]Geneticist, Horticultural Field Sta., Agr. Res. Serv., USDA, La Jolla, CA 92037. (Retired).

[4]Laboratory of Nuclear Medicine and Radiation Biology, Univ. of California, Los Angeles, CA 90024.

[5]Research Entomologist, Yakima Agricultural Research Laboratory, Agr. Res. Serv., USDA, 3706 Nob Hill Blvd., Yakima, Washington 98902.