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Potassium Uptake from the Subsoil by Green Manure Crops

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ABSTRACT

The aim of this experiment was to compare crops commonly used as green manure or forage crops in temperate climatic regions in terms of their total K uptake and the proportion of K taken up from the subsoil. Two techniques were used to determine K uptake from the subsoil: The 'open-ended pot' technique based on a decrease in the K-to-Rb ratio of plants grown in Rb-enriched topsoil compared with plants grown in pots without access to the subsoil, and a technique based on injection of Rb, as tracer for K, at different soil depths. The green manure crops tested were chicory (*Cichorium intybus* L.), red clover (*Trifolium pretense* L.), perennial ryegrass (*Lolium perenne* L.), lucerne (*Medicago sativa* L.), barley (*Hordeum vulgare L.*), birds-foot trefoil (*Lotus corniculatus* L.), yellow sweetclover (*Melilotus officinalis* L.) and lupine (*Lupinus angustifolius* L.). The latter four crops were grown for one season, the others two seasons. In the first year of establishment, all green manure crops, except chicory, took up K from the subsoil and topsoil in much the same proportion as the cash crop barley, with 41–67% of the K taken up originating from the subsoil. K uptake from the subsoil was mainly determined by differences in the crop's total K uptake. Chicory had the highest total uptake amounting to 124 kg ha^{-1} in the first year and twice that in the second year. A period of drought in the second year reduced growth of most crops, except chicory and lucerne. This did not result in a higher uptake of Rb injected at 60 and 90 cm relative to uptake at 10 cm, but it is possible that chicory and lucerne took up substantial amounts of K from depths greater than 1 m, not accessible to the other crops.

INTRODUCTION

Crop rotations in low-input agricultural systems often include non-cash crops with the aim to improve or maintain the productivity of the cash crops. These non-cash crops, such as green manure crops, often comprise nitrogen-fixing species to provide net N input or to improve the N-supplying capacity of the soil. To maintain or improve the supply of other nutrients to the cash crops, green manure crops may be grown that are able to extract nutrients from the soil

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not available to the cash crops. These nutrients are released when the green manure crop is incorporated into the soil.

The stock of plant nutrients, such as potassium, in soils is often very large relative to annual crop uptake. Nevertheless, deficiency may occur either because the nutrient is present in chemical forms unavailable to the crop, or because part of the pool of plant-available K is located beyond the crop rooting zone. Plants differ in their ability to utilize different chemical forms of K in soils (Memon *et al.*, 1988) and this difference can sometimes be related to their ability to take up initially non-exchangeable K (Fergus & Martin, 1974), such as shown for ryegrass (Steffens & Mengel, 1979; Tributh *et al.*, 1987; Hinsinger & Jaillard, 1993). Under most conditions diffusion is the process limiting K supply to the plant root so that the plant's ability to use soil K will to a large extent be influenced by its root length and density. A crop with a higher root density may, therefore, be able to take up more K from the same soil volume than a crop with a lower density, but this does not mean that the crops are not utilizing the same resource. A deep-rooting green manure crop, in contrast, may extract K from deeper soil layers not accessible to a more shallow-rooting cash crop. Such an idea is by no means new: Lady Eve Balfour was perhaps one of the first to suggest this opportunity in relation to organic farming in the 1940's (Balfour, 1975). Even though much of the agroforestry work, especially in developing countries, relies heavily on this principle (Cannell *et al.*, 1996), there appear to have been no studies in the literature that have tried to quantify differences in subsoil K, or any other nutrient for that matter, uptake between agricultural crops grown in temperate regions.

Plants with a strong primary rooting system generally have the greatest rooting depths, although even plants with a weak primary rooting system, such as grasses, may reach depths of up to 2 m (Kutschera, 1960). There is little information available on the amount of subsoil K taken up by deep-rooting plants. Studies in Sweden (Haak, 1978) and Germany (Kuhlmann, 1990) have shown that spring-sown cereals, with an average rooting-depth of up to 1 m, may obtain on average 30–40% of their K from the subsoil. Some plant species, such as lucerne, can have an effective rooting depth exceeding 2 m (Evans, 1978), which, combined with its large capacity for K uptake of up to 200 kg ha^{-1} yr^{-1} (Lee & Metson, 1977), means that lucerne may have a considerable potential for K uptake from the subsoil.

The aim of this experiment was to compare crops commonly used as green manure or forage crops in temperate climatic regions in terms of their total K uptake and the proportion of K taken up from the subsoil. Two techniques were used to determine K uptake from the subsoil: The 'open-ended pot' technique developed independently by Haak (1978) and by Kuhlmann *et al.* (1985), and a technique based on injection of Rb, as tracer for K, at different soil depths.

MATERIALS AND METHODS

Experimental site

The study was carried out during 1998 and 1999 on a field 10 km south of Uppsala in central Sweden (60°N 17°E). The soil is a loam, with a clay content of 21% in the topsoil (0–30 cm) and 53% in the subsoil (60–90 cm). Soil pH increased with depth, and concentrations of ammonium lactate extractable P and K were lowest at a depth of 30–60 cm and then increased with depth (Table 1).

Choice of crop crops and layout of field experiment

The experimental design was a completely randomized block replicated four times with different crops as treatments. The crops chicory (*Cichorium intybus* L. cv. Grasslands Puna), red clover (*Trifolium pretense* L. cv. Rajah), perennial ryegrass (*Lolium perenne* L. cvs. Condesa (25%), Trani (21%), Parcour (20%), Fennema (17%) and Meltra (17%)), red clover and ryegrass in mixture (50/50 w/w), lucerne (*Medicago sativa* L. cv. Vela), barley (*Hordeum vulgare* L. cv. Filippa) and birds-foot trefoil (*Lotus corniculatus* L. cv. Dawn) were sown in plots of 4 × 15 m in May 1998. A cold and rainy spring resulted in a weak stand of birds-foot trefoil. Yellow sweetclover (*Melilotus officinalis* L.) and lupine (*Lupinus angustifolius* L. cv. Azuro) were sown in May 1999 on the plots sown to barley and birds-foot trefoil, respectively, in 1998. Legume seeds were inoculated with the appropriate bacterial symbiont immediately before sowing. In 1998, the whole experimental area was fertilized with 80 kg P ha^{-1}. Chicory, ryegrass and barley received one application of 80 kg N ha^{-1} in 1998 after germination, and chicory and ryegrass a further two applications at the same rate in 1999; in the beginning of May and after the first harvest at the end of June. The plots were manually kept free of weeds. The perennial crops sown in 1998 were harvested on 11 August 1998, 21–22 June 1999 (harvest I) and 8–9 September 1999 (harvest II), using a hand-operated motorized mower with a 78 cm wide cutter bar. Lupine and yellow sweetclover sown in 1999 were harvested once in September 1999. Total dry matter yield and K uptake were determined on 3–4 m long strips cut with the cutter bar. After harvest of the sub-plots the whole experimental area was harvested and all plant material removed. Clover and grass were separated in the red clover/ryegrass treatment. Weeds were separated from the crop plants in all harvested samples. The samples were dried in a forced-air oven at 60°C, weighed and ground for chemical analysis.

Determination of Rb uptake from different depths by Rb injection

method based on injection of a tracer at different depths in the soil is
~~The method based on injection~~

TABLE 1

Soil properties at the site of the field experiment. Mean values of seven samples taken across the site with the standard error given in brackets.

Soil depth (cm)	pH (H_2O)	Exchangeable P* (mg 100 g^{-1})	Exchangeable K* (mg 100 g^{-1})	Particle size (mm) distribution (%)				Total C (%)
				< 0.002	0.002–.02	0.02–0.2	0.2–2	
0–30	6.2 (0.2)	1.9 (0.8)	9.4 (1.8)	21	14	58	3	1.80
30–60	6.5 (0.3)	1.1 (0.3)	5.4 (1.8)	19	14	63	2	0.52
60–90	6.9 (0.2)	0.8 (0.1)	12.4 (2.4)	53	28	15	1	0.17
90–120	7.4 (0.2)	2.3 (0.7)	20.6 (2.4)					
120–150	7.6 (0.2)	4.3 (1.3)	25.2 (2.3)					
150–180	7.7 (0.1)	3.0 (0.5)	25.5 (1.4)					

*Determined by extraction with 0.1 M ammonium lactate (pH 3.75) at a 20:1 (v:w) extractant-to-soil ratio.

similar to that described by Ozanne *et al.* (1965) who, however, used the radioactive isotope ^{42}K rather than Rb as tracer to measure short-term K uptake. Rb was injected on 6–13 May 1999. In each experimental plot, injection was carried out in one subplot (1.25 × 0.5 in) at each of the depths 20, 60 and 90 cm. Holes for injection (18 in each subplot) were made by nine steel rods (1 cm diameter), evenly arranged on a specially designed metal frame fitted to a hydraulic lift on a tractor, which could be raised and lowered hydraulically. Immediately after withdrawal of the rods, 8 ml of a RbCl solution (15 mg Rb ml^{-1}) was injected in each hole through a plastic tube introduced in the holes by means of a 0.5 cm diameter metal rod. A steel ball of 1 cm diameter was fitted to the lower end of the rod to ensure free passage for the plastic tube and to reduce the risk of contamination of the upper soil layers. The thin rod was inserted until the ball reached the bottom of the injection holes and then raised 10 cm, to create a space for the solution, before injection. The holes were filled with sand to prevent preferential root growth.

The whole area of the Rb-injected subplots was harvested. Control samples of herbage, to determine dry matter yield, K uptake and uptake of native soil Rb, were taken from an area 1–2 m away from the subplots. Uptake of Rb injected at the different depths was calculated from the difference in Rb concentration of the herbage in the subplots with that of the control samples.

Determination of K-uptake from subsoil by a K:Rb dilution technique

The technique developed by Haak (1978) and Kuhlmann *et al.* (1985), which is based on growing two sets of plants, was used to differentiate K uptake from the subsoil from K uptake from the topsoil. Both sets are grown in pots containing Rb-enriched topsoil. One set is grown in pots dug into the topsoil at the experimental site. These pots are open-ended to allow root penetration into the subsoil. The other set is grown in regular pots. Uptake of K from the subsoil will decrease the K-to-Rb concentration ratio of the plants grown in the open-ended pots. The difference in the K-to-Rb ratio between these sets is used to calculate K uptake from the subsoil (see below).

Topsoil (5.5 kg air-dry) from the experimental site was used to fill the pots (4712 cm^3 volume and 314 cm^2 surface area) after mixing with 23 mg P kg^{-1} soil as superphosphate and 6.2 mg Rb kg^{-1} soil as RbCl. Pots sown to non-leguminous crops were fertilized with 57 mg N kg^{-1} soil as $Ca(NO_3)_2$.

Two sets of pots were sown in May 1998 with the following crops: barley, chicory, birds-foot trefoil, red clover, lucerne, ryegrass, red clover/ryegrass in mixture, yellow sweetclover and lupine. One set of pots was kept without contact to the subsoil and with manual irrigation in a pot garden. The other set was dug into the topsoil (25 cm) in the plots of the field experiment after

removing the bottom of the pots. After germination, chicory and red clover were thinned to 35 plants pot^{-1}, birds-foot trefoil to 48 plants and lucerne, yellow sweetclover and lupine to 30 plants. Pots with barley had 11 plants pot^{-1} and ryegrass 64 plants.

The pots were harvested in August 1998 by clipping the shoots 2–3 cm above the soil surface. Red clover and ryegrass grown in mixture were separated in the laboratory. All samples were dried in a forced-air oven at 60°C. K uptake from the subsoil expressed as a percentage of total K uptake was calculated from the K-to-Rb ratio of the above ground plant biomass from pots with and without contact to subsoil (Kuhlmann *et al.*, 1985):

$$\% \text{ of K uptake derived from subsoil} = 100 \times \frac{\text{K/Rb (with contact)} - \text{K/Rb (without contact)}}{\text{K/Rb (with contact)}}$$

Analyses

Total K and Rb in plant material were determined after digestion by inductively coupled plasma atomic emission spectrometry (ICP-AES). The results were analysed by analysis of variance for a completely randomized block design using a General Linear Model procedure. Fisher's LSD test was used as *post-hoc* test in the comparison of means (StatSoft, 2000).

RESULTS

Climatic conditions

The first year (1998) was characterized by a wet, cool summer (mean temperature 13°C, precipitation 285 mm, Penman evapotranspiration 305 mm over the period May-August), whereas 1999 was unusually dry (mean temperature 13°C, precipitation 48 mm, Penman evapotranspiration 201 mm over the period May–June (harvest I) and 17°C, 45 mm and 200 mm, respectively over the period July–August (harvest II)).

Total K uptake

Ryegrass and chicory had the highest K uptake in shoots (122–124 kg K ha^{-1}) in the year of establishment (Table 2). This was partly due to a higher K concentration in their tissues, 4.1% compared with 2.7–3.3% for the other perennial crops, and partly to a higher dry matter yield (data not shown). Also in the following year total uptake was higher for chicory and ryegrass (248 and 230 kg K ha^{-1}, respectively) than for the other perennial crops. K uptake by lupine and yellow sweetclover sown in 1999 was very low (47–56 kg ha^{-1}). The dry weather during the second half of the summer in 1999 resulted in strongly reduced dry matter production in most crops, with yields at harvest II for most crops only 21–37% of those at harvest I (data not shown). There was no reduction in yields of chicory and lucerne, and K uptakes at harvest I and II were similar (Table 2). At harvest I in 1999 ryegrass showed the highest K uptake (180 kg ha^{-1}) and chicory at harvest II (129 kg ha^{-1}). K concentrations in the shoots were lower in 1999 than in 1998 in all crops (Table 2).

Uptake of Rb injected at different depths

Rb uptake from the injection depths 10–20 cm, 50–60 cm and 80–90 cm, determined at harvests I and II in 1999, is expressed as a percentage of total uptake of injected Rb (Table 3). The crops showed only small differences in relative uptake from the three depths. At harvest I, uptake from 10–20 cm represented 75–90% of total uptake. Relative Rb uptake by ryegrass from 10–20 cm was significantly lower (75% of total uptake), and from 50–60 cm (17%) significantly higher than in red clover and chicory. Relative Rb uptake from 80–90 cm was less than 10% of total uptake for all crops. Relative Rb uptake from the three depths by ryegrass and red clover was similar in pure stands and in the mixed sward. At harvest II, relative Rb uptake from 10–20 cm was 57–78% of total uptake, with no significant differences among crops in relative Rb uptake from any of the three depths.

K uptake from subsoil in pots with and without contact to subsoil

Based on a decrease in the Rb-to-K ratio due to uptake of K from the subsoil by the plants grown in the open-ended pots, it was calculated that among the crops in 1998 between 42 and 67% of total K uptake originated from the subsoil (Figure 1). It was significantly larger for chicory (67%) than for barley, ryegrass and the ryegrass—red clover mixture ($p < 0.05$; Fisher LSD test). Differences among the other crops were not significant. In 1999, about 68% of K taken up by both lupine and yellow sweetclover originated from the subsoil (data not shown). Total K uptake from the subsoil was calculated from % uptake from the subsoil calculated from the pots and total K uptake determined in strips cut with the cutter bar (Table 2). This suggested that total K uptake from the subsoil was about 80 kg ha^{-1} for chicory, but only about half that (35–51 kg ha^{-1}) for the other crops. Uptake from the subsoil in 1999 by the crops sown in 1998 could, unfortunately, not be determined because a large number of the plants in the pots in the field had not survived winter

TABLE 2.

Potassium content and uptake by the crops in 1998 and 1999. Mean values of four blocks with the standard error given in brackets.

Crop	1998			1999				
		Total uptake	From subsoil*	Harvest I		Harvest II		Harvest I+II
	(%K)	(kg K ha^{-1})	(kg K ha^{-1})	(%K)	(kg K ha^{-1})	(%K)	(kg K ha^{-1})	(kg K ha^{-1})
Chicory	4.1 (0.3)	124 (12)	83	2.6 (0.3)	119 (19)	3.4 (0.3)	129 (11)	248 (15)
Red clover	3.3 (0.3)	64 (8)	36	2.1 (0.1)	107 (15)	2.1 (0.1)	30 (3)	138 (15)
Red clover in mixture				1.9 (0.1)	56 (7)	2.0 (0.1)	23 (6)	79 (11)
Ryegrass	4.1 (0.1)	122 (13)	51	2.5 (0.1)	180 (13)	2.9 (0.1)	50 (5)	230 (13)
Ryegrass in mixture				2.6 (0.1)	76 (7)	2.6 (0.3)	15 (2)	91 (9)
Ryegrass/clover mix	3.3 (0.1)	88 (6)	42		132		38	170 (5)
Lucerne	2.7 (0.1)	77 (13)	43	1.8 (0.2)	53 (11)	2.3 (0.4)	42 (8)	96 (15)
Lupine						1.4 (0.1)	59 (4)	59 (4)
Yellow sweetclover						1.6 (0.1)	42 (2)	42 (2)
Birds-foot trefoil	3.1 (0.1)	67 (5)	35					
Barley	1.3 (0.1)	77 (13)	35					
LSD (0.05)	0.5	32		0.4	30	0.6	17	29

*Calculated from the percentage of K uptake derived from the subsoil shown in Figure 1.

TABLE 3

Uptake of Rb injected at different depths expressed as percentage of the sum of uptake from all three depths at harvests I and II in 1999. Mean values of four blocks with standard error in brackets. ns = not significant

Crop	Harvest I			Harvest II		
	Depth of injection (cm)			Depth of injection (cm)		
	10–20	50–60	80–90	10–20	50–60	80–90
Chicory	86 (6)	8 (2)	6 (2)	78 (3)	10 (3)	12 (2)
Red clover	90 (4)	8 (2)	2 (1)	69 (2)	13 (2)	19 (2)
Red clover in mixture	90 (3)	8 (2)	2 (1)	64 (5)	15 (4)	20 (6)
Ryegrass in mixture	76 (3)	18 (2)	6 (1)	64 (5)	18 (1)	18 (5)
Ryegrass	75 (3)	16 (3)	9 (1)	72 (5)	15 (4)	13 (2)
Lucerne	82 (4)	10 (2)	8 (3)	57 (5)	15 (3)	29 (3)
Mean (above crops)	83 (2)	11 (1)	5 (1)	67 (2)	14 (1)	18 (2)
Lupine				67 (4)	19 (4)	14 (4)
Yellow sweetclover				62 (4)	18 (2)	20 (3)
LSD (0.05)	8	5	5	ns	ns	ns

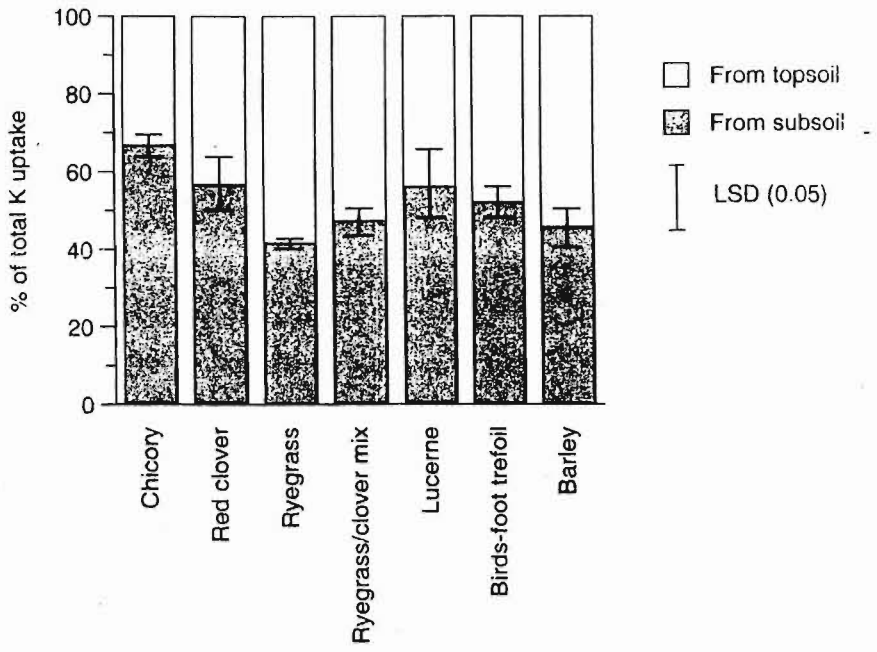

FIGURE 1. Relative uptake of potassium from the top- and subsoil in the year of establishment (1998) as determined by the 'open-ended pot' technique. Mean values from four blocks with the error bars indicating the standard error. The effect of crop is significant at $p < 0.1$.

DISCUSSION

Methodological aspects

There are few studies on nutrient uptake from the subsoil by crop plants. No doubt, this is partly due to lack of suitable, simple methods for determination of nutrient uptake from different soil depths. The 'open-ended pot technique' offers a relatively easy technique to separate nutrient uptake from the topsoil from that from the subsoil. Nevertheless, the method appears to have been used by few other than the original developers (Haak, 1978; Kuhlmann *et al.*, 1985). An important assumption in the method is that differences in total nutrient uptake, root density and other factors that may vary between the plants grown in open-ended and those in closed pots do not affect the ratio of K-to-Rb uptake from the topsoil. The validity of this assumption appears not to have been tested directly (Kuhlmann *et al.*, 1985).

The ratio of K-to-Rb uptake appears independent of root density (Baligar, 1985) but may be affected by the level of K depletion of the soil. In a preliminary experiment with ryegrass grown in Mitscherlich pots, the K-to-Rb ratio decreased as available K became depleted through successive harvests, as indicated by decreasing K concentrations in the shoots (data not shown). This may seem to contradict the observation by Baligar (1985) that the K-to-Rb ratio remained constant over growth periods of up to 30 days. In the latter experiment, however, most uptake was from K in the soil solution, rather than from exchangeable K, as is likely under the conditions of K-deficiency in our experiment with ryegrass. The assumption in the 'open-ended pot technique' of an equal ratio of K-to-Rb uptake from the topsoil in the closed and open-ended pots may, therefore, need to be further scrutinized. Our results from the pot experiment with ryegrass suggest that depletion of K in the topsoil of the closed pot could lead to a lower K-to-Rb ratio in the plant, which would result in overestimation of K uptake from the subsoil. Our estimates of 46 ± 5% of total K uptake by barley originating from the subsoil were similar to those, on average 30–40%, obtained by Haak (1978) and Kuhlmann (1990) using the same technique in studies of spring-sown cereals.

Results from injection of Rb at the three depths in the profile suggest that Rb uptake at 10–20 cm contributed more than 70% of the total uptake from the three depths. Studies on a range of forage crops (including deep-rooting species) with placement of either Rb or K at different depths confirm that (potential) K uptake from the topsoil often accounts for more than half the total uptake (Ozanne *et al.*, 1965; Peterson & Smith, 1973; Peterson *et al.*, 1983). Our results from the Rb-injection technique cannot directly be compared with those from the 'open-ended pot technique' as it does not reflect uptake from the entire topsoil or subsoil layer and the measured uptake is that of added Rb rather than native K. This technique, therefore, measures potential K uptake from different soil layers rather than actual K uptake from the subsoil.

The ratio of K-to-Rb uptake will depend on the relative concentrations of Rb and K at the root surface. In all crops, uptake of Rb injected at 10–20 cm represented a smaller percentage of the total uptake from all three injection depths at the second (67%) than at the first (83%) harvest in 1999 (Table 3). This could be the result of a proportionally higher root activity at the greater depths in the second half of 1999. It can, however, not be excluded that this result is an artefact caused by a proportionally greater depletion of Rb at 10–20 cm during the first half. Concentrations of exchangeable K ranged from 5 to 12 mg 100 g^{-1} soil at a depth of 0–90 cm, with the highest concentration at 60–90 cm, and further increasing below this depth. The ratio of the concentrations of plant-available K and Rb may, therefore, not have been the same at the three injection depths. Higher K concentration at 80–90 cm, for example, would have resulted in underestimation of Rb uptake at that depth, relative to that from the other two depths. Differences in adsorption of the added Rb at the different depths may also have affected the results. The injection technique can, therefore, not be directly used to estimate Rb (or K) uptake from soil layers with different physico-chemical properties, but it does allow a comparison of the ability of

different crops to take up Rb injected in different soil layers, which is not affected by differences in soil properties, and was the main objective of this study.

Both techniques used rely on the use of Rb as an analogue for K. Recent studies have shown that some uptake transport systems in roots discriminate between Rb and K, contradicting earlier studies suggesting no discrimination (for details see Rodríguez-Navarro, 2000). It is important to bear in mind that neither technique requires that there is no discrimination, or that it is the same among the plant species, but only that any discrimination is the same along any part of the root.

Differences between crops in K uptake from the subsoil

The crops in this study included some with a strong primary root system (chicory and lucerne) and some with a weaker primary root system (ryegrass). Nevertheless, both the direct injection and the 'open-ended pot' technique suggest only small differences in the relative uptake from different soil depths. During the period of low precipitation in the second half of 1999, growth of ryegrass and red clover was particularly reduced, whereas growth of chicory and lucerne was only slightly affected. This suggests that chicory and luceme were able to exploit water reserves, presumably at greater depth, not available to the other crops. Nevertheless, the pattern of Rb uptake to a depth of 1 m during the dry period was similar among all crops, and the pattern of Rb uptake with depth in all crops did not markedly differ in the dry period compared with that in the wet period (Table 3). These results suggest that a root system able to explore deep-lying water reserves does not necessarily result in enhanced actual or potential uptake of K from the deeper soil layers down to 1 m. It may, however, be possible that there was substantial K uptake by lucerne and chicory from depths greater than 1 m, which would not have been recorded with our Rb-injection technique. The difference in K uptake by chicory and lucerne and that of the other crops may partly or entirely have come from a depth greater than 1 m. Comparing K uptake at harvest II by chicory (129 kg ha^{-1}) with that by ryegrass (50 kg ha^{-1}), for example, would then suggest that up to 79 kg ha^{-1} of K taken up by chicory may have originated from depths not accessible to ryegrass.

We hypothesized that competition for K in the topsoil by red clover and ryegrass grown in mixture would result in increased uptake from the subsoil by the species with a deeper rooting system. Separation in time or space of use of a limiting resource is an important mechanism that allows different species to co-exist in the same ecosystem (Fitter, 1986). Nevertheless, growing ryegrass and red clover in mixture did not change the relative uptake of injected Rb from different soil depths (Table 3). As the concentration of K in the shoots was not affected by growth in the mixture (Table 2), it is possible that concentrations of available K in the topsoil were too high to stimulate competition and thus increased uptake from the subsoil.

The potential for using deep-rooting crops to enrich the topsoil with nutrients extracted from the subsoil

The value of a green manure crop in enriching the topsoil with nutrients from the subsoil is determined by its total nutrient uptake, the percentage derived from the subsoil and its ability to take up K from sources not available to a cash crop. Obviously, the performance of a crop in these respects is highly dependent on local climatic and soil conditions. The soil in this study was, on the whole, favourable for deep root penetration into the subsoil, and especially favourable for K uptake from the subsoil with a high exchangeable-K content. Deep root penetration was further favoured by dry conditions in the second half of 1999. In the year of establishment (1998), chicory, compared with the other crops, obtained only a slightly larger percentage of its K uptake from the subsoil, but it had the highest K yield largely due to its high K content. As a result, total K uptake from the subsoil by chicory (80 kg ha^{-1}) was about twice that by the other crops. For 1999, it was not possible to quantify uptake from the subsoil, but results from the Rb-injection experiment suggests only small differences among crops in their ability to extract K from depths up to 1 m. It is therefore likely that differences in K uptake from the subsoil also in 1999 would have been largely determined by differences in K uptake among the crops. Highest K uptake at the first harvest in 1999 was obtained for ryegrass followed by chicory and red clover. During the dry conditions, prior to the second harvest in 1999, yield and total K uptake were reduced in all crops, except chicory and lucerne. Under the conditions of our two-year experiment, chicory, therefore, outperformed other crops in terms of K uptake from the subsoil. Lucerne probably performed below its potential in our experiment in terms of total yield and K-uptake which were less than half those reported from New Zealand (Lee & Metson, 1977). Studies in New Zealand suggest that lucerne can easily outperform ryegrass under dry conditions (Evans, 1978) and has been found to be able to exploit water and nutrient resources at depths up to 3 m (Fox & Lipps, 1960, 1964).

All potential green manure crops tested, except chicory, took up K from the subsoil and topsoil in 1998 in much the same proportion as the cash crop barley. The percentage uptake from the subsoil by barley was similar to that measured by Haak (1978) and Kuhlmann, (1990) in spring cereals. Use of these green manure crops would, therefore, not increase soil K availability to such cereal crops. They may, however, do so to more shallow rooted cash crops such as radish, lettuce and other short-season crops that have been shown to meet nearly their entire K demand by uptake from the topsoil only (Kuhlmann, 1990).

CONCLUSIONS

There are no easy shortcuts to determine nutrient uptake from the subsoil. Neither the 'open-ended pot technique' nor the Rb-injection technique was found to be wholly satisfactorily to assess nutrient uptake from the subsoil. The former is simple and easy to carry out, but the assumptions inherent in the method need to be further investigated. The latter is more cumbersome, especially if uptake from great depths is to be investigated. The method measures potential, rather than actual K uptake from the depths of injection and has fewer assumptions.

Green manure crops with a potentially deep root system that explores soil layers not accessible to the cash crops in the rotation can increase the amount of K circulating in the cropping system. In the year of establishment there were, however, only small differences in the % of K taken up from the subsoil among the crops. This could be because the root system of the perennial crops had not yet fully developed in the first year, but also to the wet conditions that year. Our results show that even deep-rooting crops extract most of their K demand from the upper soil layers, unless conditions, of drought for example, force the crop to penetrate deeper into the soil profile.

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The priming effect of organic matter: a question of microbial competition?

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Abstract

It is generally accepted that the low quality of soil carbon limits the amount of energy available for soil microorganisms, and in turn the rate of soil carbon mineralization. The priming effect, i.e. the increase in soil organic matter (SOM) decomposition rate after fresh organic matter input to soil, is often supposed to result from a global increase in microbial activity due to the higher availability of energy released from the decomposition of fresh organic matter. Work to date, however, suggests that supply of available energy induces no effect on SOM mineralization. The mechanisms of the priming effect are much more complex than commonly believed. The objective of this review was to build a conceptual model of the priming effect based on the contradictory results available in the literature adopting the concept of nutritional competition. After fresh organic matter input to soils, many specialized microorganisms grow quickly and only decompose the fresh organic matter. We postulated that the priming effect results from the competition for energy and nutrient acquisition between the microorganisms specialized in the decomposition of fresh organic matter and those feeding on polymerised SOM.

Keywords: Enzyme regulation; r/K strategy; Nutritional competition; Energy limitation; Carbon storage

1. Introduction

Soil organic matter (SOM) is a major determinant of carbon and nutrient cycling in the biosphere: it is the main nutrient source for plant growth (after microbial decomposition) and contributes to soil quality (soil structure, resistance to erosion) (Herrick and Wander, 1997); it also represents the major carbon reservoir of the biosphere-atmosphere system (Falkowski et al., 2000). Given the current concerns over global warming, it is important to understand when soils serve either as a source or sink for atmospheric CO_2 (Lal et al., 1995; Smith et al., 2000). The accumulation of organic matter in soil results from the activity of the soil biota: plants ensure the supply of organic matter while soil fauna and microorganisms transform it. In soil, most organic compounds are processed by heterotrophic microorganisms that use organic carbon as nutrient and energy sources. Predicting and modelling SOM dynamics therefore requires the identification of the physiological and environmental constraints driving microbial activities. Soil carbon is the driving force of most microbially mediated processes, particularly soil respiration and nitrogen mineralization. The quality of carbon is particularly important because it constrains the supply of energy for enzyme production and growth. The decomposition of the humified carbon is commonly slow because the acquisition of energy from such substrate is slow.

Logically, maintaining or enhancing carbon storage requires consistent input of carbon, for example from crop residues, compost, cattle slurry or sewage sludge in cultivated soils. However, in cultivated soils where crop residues are incorporated in large quantities, SOM content varies slowly (Campbell et al., 1991; Nyborg et al., 1995; Soon, 1998). In the same way, the removal of crop residues does not necessarily induce a rapid decrease of SOM content. For instance, Campbell et al. (1991) showed that the removal of straw over a period of 30 years did not significantly affect the SOM content of an old wheat–wheat-fallow rotation system. This is surprising since it is unlikely that all the carbon supplied in the form of straw during this experiment had been mineralized because straw contains many recalcitrant components such as lignin. Indeed, other experiments have shown that the remaining straw may account for 50–60% of the applied dry matter

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after 1 year of decomposition (Cheshire et al., 1999) and 20% of the applied carbon after 4 years (Shields and Paul, 1973). The stability of SOM content despite the regular supply of crop residues suggests an equivalent output of ancient organic compounds.

It has been shown that the incorporation of fresh organic matter (FOM) such as green manure or straw in a soil may intensify SOM mineralization (Löhnis, 1926; Broadbent, 1947; Broadbent and Bartholomew, 1948; Bingeman et al., 1953; Broadbent and Nakashima, 1974; Sørensen, 1974; Wu et al., 1993). The stimulation of SOM mineralization, named the 'priming effect' by Bingeman et al. (1953) has been clearly observed at the rhizosphere scale. For example, Liljeroth et al. (1994) showed in laboratory conditions without mineral nutrient supply, that the rhizodeposition by wheat and maize induced a two-fold increase in the mineralization rate of pre-existing soil carbon.

The mechanisms leading to the priming effect remain poorly understood (Kuzyakov et al., 2000). It is commonly believed that the low quality of SOM limits the amount of available energy for soil microorganisms, and in turn the rate of SOM mineralization. Thus, the priming effect is often supposed to result from an increase in overall microbial activity due to the higher availability of energy and nutrients released from FOM (Löhnis, 1926; Broadbent, 1947; Bingeman et al., 1953; Sørensen, 1974). However, the supply of easily assimilable compounds to soils, such as glucose, fructose and mineral nutrients induces no or little effect on SOM mineralization, compared to the effect of ryegrass, cellulose or wheat straw (Bingeman et al., 1953; Dalenberg and Jager, 1989; Wu et al., 1993; Shen and Bartha, 1997). Such materials contain less readily available energy than glucose and fructose because of their polymerised structure, and one might have expected a weaker priming effect with the former than with the latter. The mechanisms of the priming effects are thus much more complex than commonly believed.

The aim of this paper is to propose a conceptual model of the priming effect by the reassessment of data available in the literature. Our approach is based on the specificity of microbial enzymes for the degradation of substrate. We tackle our analysis at individual and community level, focusing on possible interactions for energy and nutrient acquisition between FOM and SOM specialized microorganisms.

2. The microbe–substrate relationship

It is conceivable that SOM feeding microorganisms could increase their enzyme production when growth conditions become limiting, or decrease it when the soil solution is concentrated in energetic compounds and mineral nutrients (Henkinet et al., 1989). Indeed, studies in axenic conditions have shown that several microbial species are able to increase their production of extracellular enzymes when the growth medium is deficient in nitrogen (Bumpus et al., 1985; Haider and Martin, 1988). But, this phenomenon has not been observed in soil to date suggesting that soil microorganisms do not adjust their enzyme production according to metabolizable substrate. In contrast, most studies have shown, in controlled conditions, that the supply of nutrients and quickly assimilable carbon such as soluble sugars, amino acids, root mucilage or rhizosphere extract did not alter decomposition rates (Dalenberg and Jager, 1989; Mary et al., 1992, 1993; Wu et al., 1993; Sikora and Yakovchenko, 1996; Jans-Hammermeister et al., 1997; Shen and Bartha, 1997; De Nobili et al., 2001). Thus, the rate of SOM mineralization does not seem to be influenced by individual response to the change in the amount of available energy. This suggests that the priming effect depends mostly on the dynamics of SOM degrading populations. Any increase in these populations due to a greater availability of energy originating from input of FOM to soil, should accelerate SOM mineralization leading to the priming effect.

A major characteristic of soil microbial populations is their enzymatic specificity for substrate degradation. For example, a succession of microbial types (Garrett, 1951; Lemoigne et al., 1951; Kendrick and Burges, 1962; Zvyagintsev, 1994) and depolymerising enzymes (Kshattriya et al., 1991; Joshi et al., 1993) is observed throughout the decomposition of plant litter because the relative proportions of the different chemical compounds change with time due to different degradation rates. The rates of population growth and extracellular enzyme production are linked by positive feedback as long as fresh substrate is not limiting (Kshattriya et al., 1991; Joshi et al., 1993). The late stages of the decomposition process are marked by the colonisation of plant residues by particular populations, continuously active, that slowly degrade the most recalcitrant SOM.

Even if a huge range of microbial types are present in soil, only few of them are adapted to the dominant soil organic resource (Swift et al., 1979), the others being dormant. After FOM input to soils, many dormant microorganisms are triggered into activity (De Nobili et al., 2001). The supply of FOM allows enhanced activity and growth of previously starving microbial populations, now able to specifically use this new substrate. This leads to dramatic changes in the structure of the microbial community as soon as sufficient FOM is added (Winogradzky, 1924; Lemoigne et al., 1951; Holding, 1960; Behera and Wagner, 1974; Griffiths et al., 1998). Subsequently, the rate of energy and nutrient release by the decaying FOM, the microbial population size (Mary et al., 1992; Wu et al., 1993; Jans-Hammermeister et al., 1997) and the rate of enzyme production decrease as the substrate is exhausted (Kshattriya et al., 1991; Joshi et al., 1993). Thus, an increase then a decrease in enzymatic activity occurs at each FOM inputs that follows the growth and decline of the microbial populations decomposing FOM.

These FOM specialized microorganisms, commonly classified as r-strategists, are adapted to intervals of rapid growth, depending on availability of their substrate (Paul and Clark, 1989). After substrate exhaustion, r-strategists die or become dormant because they are unable to use SOM. In contrast, SOM feeding microorganisms are classified as K-strategists. They are continuously active because they use the almost inexhaustible SOM. They grow slowly and dominate only in the last stages of FOM decomposition (Kendrick and Burges, 1962; Zvyagintsev, 1994; Paul and Clark, 1989). The slow growth rate of K-strategists results from the pattern of energy allocation (Tate, 1995). Indeed, K-populations are expected to allocate more energy to extracellular enzyme production and defence from predation (SOM decomposing microorganisms often show defence structures such as cysts (Winogradzky, 1924)) than to growth.

We suggest that most energetic compounds of FOM are used by r-strategist microorganisms that only decompose FOM. K-strategists arise only in the last stage of FOM decomposition process when energy-rich compounds have been exhausted and that only polymerised compounds remain. It is clear that many soluble compounds released by FOM may be metabolised by SOM feeding microorganisms because these are found in SOM (Tate, 1995; Saiz-Jimenez, 1996). However, the real availability of FOM for K-strategists relies on their ability to compete with r-strategists. Even if large amount of energy and nutrients are supplied, K-strategists may not have enough time to assimilate these because they grow too slowly compared to r-strategists. This could be the reason why the supply of soluble and quickly assimilable carbon has no effect on SOM mineralization while the supply of carbon in the form of complex and insoluble compounds may induce a priming effect.

3. Which mechanisms could induce a priming effect?

The decomposition of insoluble organic matter requires a depolymerisation step. Microorganisms carry out organic matter depolymerisation in order to produce soluble components available for microbial absorption and metabolism. This depolymerisation implies the production of extracellular enzymes that are released into the soil. Because these enzymes are extracellular, we hypothesize that the enzymes produced in order to decompose FOM by r-strategists maybe partly efficient for degrading SOM (Fig. 1, Mechanism 1). The intensity of this mechanism depends on biochemical similarities between FOM and SOM. The higher is chemical diversity of FOM, the higher will be the diversity of the produced enzymes and the probability of occurrence of the priming effect. Wu et al. (1993) has suggested this mechanism in order to explain why a ryegrass input lead to a priming effect when glucose had no effect.

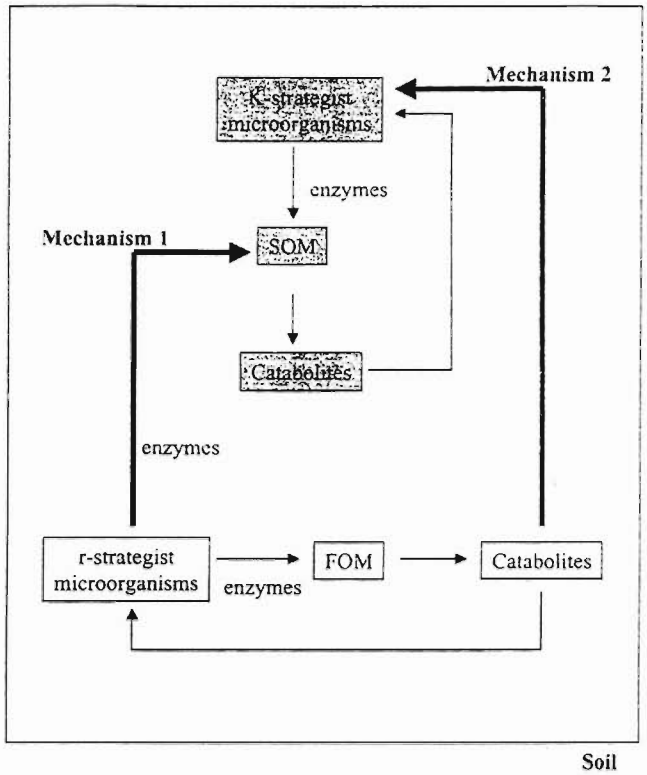

Fig. 1. Potential mechanisms leading to the priming effect. *Mechanism 1*: extracellular enzymes produced in order to decompose FOM by r-strategists may also be efficient for degrading SOM. *Mechanism 2*: a proportion of the FOM may be taken up by K-strategists according to the growth rate of r-strategists. This increases the K-strategist populations, the production of SOM decomposing enzymes and hence the rate of SOM decomposition.

The second mechanism deals with the FOM availability for r-strategists. A striking feature of microbial succession following the incorporation of fresh plant litter is the dominance of sugar-feeding populations during the first stages of litter decomposition (Winogradzky, 1924; Garrett, 1951, 1963; Alexander, 1964). These types of r-strategist grow very quickly on simple and soluble substrates, which are exhausted in some hours (Voroney and Paul, 1983; Bremer and Kuikman, 1993). In these conditions, it is unsurprising to observe no effect of soluble and quickly assimilable carbon supplies on the activities of K-strategists. Indeed, most available substrates are taken up by r-strategists before the slow K-strategists can increase their populations. In contrast, polymerised compounds of plant litter persist in soils longer than simple substrates. For example, cellulose decomposition takes several weeks. We therefore postulate that K-strategists mineralizing SOM, with slow growth rates, may benefit from polymerised substrates which have a long residence time in soil. In these conditions, K-strategists populations increase increasing the amount of SOM decomposing enzymes released in soil, since these microorganisms apparently do not adjust their enzyme production according to exogenous substrate at

individual level. The sur-production of SOM decomposing enzymes leads to the priming effect (Mechanism 2). The intensity of this mechanism relies on the competition for FOM between r and K strategists (Fig. 1, Mechanism 2). As claimed by Bingeman et al. (1953), the intensity of priming effect should depend on the type of populations that are stimulated by the added FOM.

4. The priming effect as an expression of the intensity of r–K competition

Any soil environment and FOM characteristic delaying the growth of r-strategists should be positive for K-strategists and, consequently, for the magnitude of a priming effect. Based on this concept of nutritional competition between FOM and SOM feeding, we can predict the impact of FOM and soil mineral nutrient on the intensity of the priming effect.

The regular and slow exudation of organic compounds by roots could be a means by which the plant stimulates SOM mineralization whilst at the same time minimising the cost in energy. Indeed, plants could avoid a rapid growth of r-strategists by maintaining moderate levels of energy and nutrients in the rhizosphere. Consequently, a maximum of energy could be allocated to SOM decomposing K-strategists (Mechanism 2). An increase of K-strategist microorganisms is of great importance for plant fertility because K-strategists make SOM nitrogen assimilable. Another effect of the slow energy release by roots could be to curtail microbial growth and therefore, the immobilisation of released nitrogen from SOM decomposition. This latter effect have been reported by Merckx et al. (1984); Martens (1990) who observed that the available carbon in the rhizosphere was quickly taken up and metabolised though the increase of microbial biomass was generally moderate. Grazers also exert an important role in plant fertility because they feed on microbes making microbial biomass *N* available for plant uptake (Clarholm, 1984). The role of grazers on soil processes, however, could be more profound. Selective feeding of grazers may alter the structure of microbial communities (Paul and Clark, 1989). Consequently, they could indirectly control the magnitude of a priming effect by influencing the balance between r-strategists and K-strategists that are much resistant from predation (Winogradzky, 1924; Tate, 1995). More generally, many experiments show an overall positive effect of the presence of roots on the mineralization of native soil nitrogen and carbon (Jansson and Persson, 1982; Clarholm, 1984; Robinson et al., 1989; Billes et al., 1993; Liljeroth et al., 1994; Bottner et al., 1999). However, depressive effects have also been observed when the effect of living roots on soil carbon metabolism was studied by following the decomposition of labelled FOM that was applied before planting (Sparling et al., 1982; Bottner et al., 1999). This effect was likely due to competition between microorganisms and plants for inorganic nutrients (Jingguo and Bakken, 1996) and occurred only during the fast initial decomposition stage of FOM (Bottner et al., 1999). As soon as the labile fraction of labelled FOM was exhausted, the presence of living roots stimulated SOM decomposition (Bottner et al., 1999).

The growth rate of microbes is controlled by the availability of nutrients, which can be found in the organic matter and soil solution. Consequently, the decomposition of nutrient-poor residues, such as straw, is commonly N-limited in field conditions (Mary et al., 1996; Henriksen and Breland, 1999; Sakala et al., 2000) and both microbial growth and carbon respiration rates of associated populations are low (Tenney and Wakman, 1929; Azam et al., 1988; Recous et al., 1995; Henriksen and Breland, 1999). Our model predicts that when soil mineral nutrients are abundant, r-strategists may grow quickly and consume most FOM. When soil mineral nutrients are scarce, r-strategists grow more slowly and thereby, K-strategists become more competitive for FOM. Furthermore, SOM feeding microorganisms may use the nutrients in SOM that strengthens their trophic competitivity under low nutrient conditions. Thus, we predict that nutrient-limited decomposition of FOM promotes the priming effect. It is very likely that nutrient-poor soils are more often subject to the priming effect than nutrient-rich soils. This prediction is supported by Asmar et al. (1992) who showed that glucose might induce a priming effect on SOM if no nutrients are supplied.

Interactions between the nature of added carbon and soil nutrient status are also to occur. The decomposition of polymerised carbon such as cellulose is delayed more by low nutrient availability than the decomposition of simple ones (Stewart et al., 1966a; Azam et al., 1988; Williamson and Johnson, 1994; Chapman, 1996). It is clear that the low rate of FOM decomposition, typical of polymerised FOM in nutrient poor soil, should be favourable to a priming effect.

Most trials have shown positive effects of nutrient addition in the form of fertilization in crop systems on SOM content (Christensen, 1988; Gregorich et al., 1996; N'Dayegamiye et al., 1997; Salinas Garcia et al., 1997). The extent of this effect is weak, suggesting that the increase in plant productivity, i.e. input of fresh dead plant matter to soil (Gregorich et al., 1996), could be balanced by the priming effect on SOM degradation. Indeed, in these experiments, fertilisers were applied during the plant growth period. A proportion of nutrients could have been leached, or taken up by the plant, before crop residue incorporation. This loss of nutrients induces a relative lack of, nutrients during FOM decomposition that should be favourable to priming effect. Clearly, our understanding of the effect of nutrients on the long term SOM dynamics will require experiments in controlled conditions in the absence of living plants.

5. Conclusions

As claimed by Kuzyakov et al. (2000), no studies to date 'explain causes, mechanisms and sources of the extra C and N mobilisation in priming effects in a satisfactory manner'. The aim of this paper was to contribute to a more heuristic view of the priming effect through a comprehensive reassessment of the contradictory results available in literature. We think that the hypothetical view of the priming effect that we propose here could help to build a better research strategy susceptible to leading to a predictive understanding of the priming effect. Indeed, the maintenance or restoration of soil fertility on the one hand, and the need for soil carbon sequestration in the context of global warming on the other, demand an efficient management of the interactions between fresh and stabilised organic matter.

To achieve this goal, much more attention should be paid to:

1. the enzymatic activities of SOM feeding microorganisms in relation to nutrient availability and energetic status;
2. the inability of microorganisms to control the dynamics of the extracellular enzymes they produce;
3. the environmental control (biotic and abiotic) of the intensity of the competition for FOM between r-strategists with rapid growth rates and K-strategists with slow growth rates;
4. the mechanisms of the impact of the chemical characteristics of FOM (C/N ratio, polymerisation) and soil nutrient content on the intensity of priming effect; and
5. the impact of the temporal course of FOM incorporation to soil on the intensity of priming effect.

Due to the diversity of factors involved in the priming effect, one may expect it to be a much more common phenomenon in cultivated and natural soils than predicted by laboratory experiments. Indeed, in most laboratory experiments, the priming effect has been investigated with a single incorporation of a very energy rich substrate to a nutrient amended soil. In nature, dead plant matter is incorporated more or less continuously to soils and sometimes these soils are very poor in mineral nutrients.

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Investigation of the Fertiliser and Nematicidal Properties of Two Local Plants for Organic Bean Production

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Key words: *Azadirachta indica, Melia azederach*, soil chemical and biological properties, soil nematodes

Introduction

Crop agriculture in the small island state of Mauritius is at the heavy expense of synthetic chemical fertilisers with 65,000 tonnes fertiliser and 1180 tonnes pesticide formulations annually applied to sugarcane alone (Ng Kee Kwong et al, 1998). Vegetable planters even use 2 or 4 -times the recommended rate of fertilisers and pesticides (Facknath and Lalljee, 2001). This fragile island ecosystem is hence under intensive pressure due to agrochemicals. The investigation reported in this paper aims at developing eco-friendly soil fertility improvement measures and the use of botanical pesticides to control pests in organic as well as conventional agriculture. Two local plants, namely, *Azadirachta indica* and *Melia azederach,* were investigated for their fertiliser and nematicidal potential.

Materials and methods

Chopped, fresh leaves of the 2 tests plants were mixed with 2 kg of a Tropeptic Haplustox soil in pots to give rates of 90, 180, and 270 tonnes /ha., sown with bean seeds and watered with distilled water to field capacity. The pots were laid out in a randomised block design in a greenhouse in 3 replicates, each consisting of 3 pots. Soil parameters, such as pH, CEC, organic matter, N, P, K, Cu, Zn, Fe, Mn, B and nematode populations, and macro- and micro- element content in whole bean plants (N, P, K, dry matter yield, Zn, Cu, Fe, Mn, B) were determined by methods described by Sillannpaa (1990) and Anon (1997), before, and 60 days after, addition of the treatments.

Results and discussion

The soil content of available Zn, Cu, Fe, Mn increased significantly as compared to untreated control (Table 1), whereas pH, CEC, N,P,K, organic matter and B did not shown any significant difference. Similar trends were observed for trace element content in the bean plants. The two green manures did not differ significantly from each other in their effect on soil levels of Zn, Cu, Fe and Mn, whereas the reduction of nematode numbers was significantly higher at 5% level in the *M. azederach* treatment, while increase in dry matter yields (DMY) was higher in the *A. indica* treatment.

Table 1 : Effect of *Azadirachta indica* and *Melia azederach* on some soil chemical and biological properties

Treatment (270 tonnes/ha)	**% increase compared to untreated control in values of soil parameters**					**% decrease in numbers**
	Zn	**Cu**	**Fe**	**Mn**	**DMY**	**Nematodes**
A. indica	31.2	23.8	15.2	30.7	890	63.7
M. azederach	30.5	27.5	18.7	32.5	383	87.2

Conclusion

Both *A. indica* and *M. azederach* significantly improved soil and plant properties, and decreased soil nematode populations. *M. azederach* had better nematicidal property than *A. indica.* The experiment showed that these two plants could effectively be used in the organic production of beans, for improving soil fertility in terms iof micronutrients and for the control of nematodes. Work is ongoing to determine the appropriate formulation and application rate under field conditions.

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Effects of Medicinal Herbs Incorporated into Soil on Late Blight of Potatoes

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Keywords: medicinal plants, late blight, potatoes, *Phytophthora infestans*

Introduction

Late blight of potatoes, caused by *Phytophthora infestans*, is one of the most damaging diseases affecting potato production world-wide. It can cause total crop losses. Copper fungicides are the main method of control in organic potato production. However, copper is a heavy metal, it is ecotoxicologically critical and its use is forbidden in some countries and will be restricted in other countries in the future. By this organic potato production will be threatened because until now no alternatives of control are available.

Materials and methods

In an outdoor pot experiment with a completely randomized block design (4 repetitions) 25 different medicinal herbs with antifungal or allelopathical properties (15 g dried material per kg soil) were incorporated into the soil before planting the potatoes. Into each pot (volume 13 litres) one seed-potato (variety Désirée) was planted on 16.05.01. Two months after planting the foliage of the potato plants was inoculated with a *Phytophthora* sporangia suspension and 9 days later the first late blight occurrence on leaves was estimated. Plant development, density of weeds and potato tuber yield were recorded.

Results

During early plant development most of the medicinal herbs inhibited the growth of the potato plants. This growth inhibition disappeared as time passed by in most treatments. Some herb species increased development of potato foliage and prolonged the vegetation period compared to the untreated control.

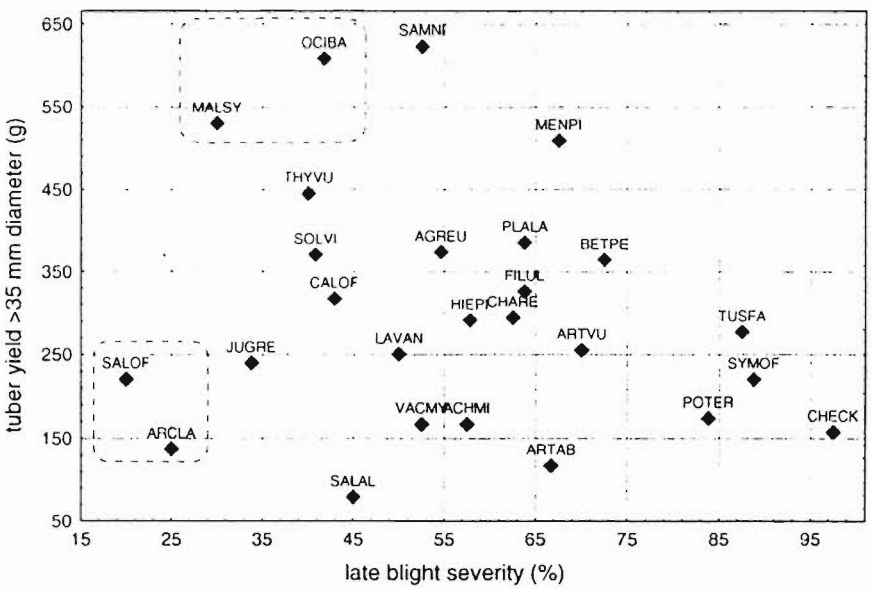

Figure 1: The late blight severity of the foliage on 10.08.01 was significantly reduced in 18 of 25 treatments with herbs in comparison with the untreated control. *Salvia officinalis* (drug term: *Salviae folium*) and *Arctium lappa* (drug term: *Bardanae radix*) were most effective on late blight. Additionally some herbs enhanced potato tuber yield. However, this yield response was correlated with nitrogen content of herbs. Moreover, about two thirds of the herbs used in this trial suppressed weed growth in the pots.

Summary and conclusion

Some of the medicinal herbs incorporated into soil reduced late blight severity on the foliage and increased the tuber yield of potatoes. Additionally, some herbs reduced the occurrence and growth of weeds. However, for practical applications and recommendations more field experiments are necessary. The most promising approach could be the cultivation of selected medicinal herbs as a pre-crop to the potato crop.

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The Long-term Vegetable Production Experiment: Plant Growth and Soil Fertility Comparisons between Fertilizer and Compost-amended Soils

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Keywords: compost, soil fertility, plant tissue, vegetables

Introduction

Numerous authors have examined different characteristics of vegetable crops whose soils were amended with compost and/or fertilizer. However, most studies were flawed since they were short-term and did not compare identical cultivars grown in the same soil type with similar soil and crop management practices. A paired comparative study of compost versus conventionally-fertilized vegetable plots has been conducted for 12 years; likely the longest study of its kind in Canada.

Materials and methods

In 1990, a fertilizer and pesticide-free site (Pugwash sandy loam [Humo-Ferric Podzol]) in Lower Onslow, N.S. was selected for the study. Fertility treatments have been applied annually to 6 rotation plots planted with 6-8 crops. Compost was made the year prior to its application using the aerated static pile method with a combination of manure, food and yardwaste. Marketable fresh weight yields were taken annually, leaf samples were taken at flowering or fruit-set, and soil samples were taken post-harvest. Plant and vegetable tissue was digested in nitric acid and analysed by ICP for 15 elements, C & N was examined using a CNS analyzer. The soil was extracted with Mehlich-3 solution and analysed by ICP for the same 15 elements. Treatment results were compared using a paired, two-tailed t-test or ANOVA at $p<0.05$.

Results and discussion

Crop yield response was inconsistent between the two amendments; yields of tomatoes and broccoli varied from 1999-2001. The fertilized plots produced higher bean yields and numerically higher carrot and pepper yields, while the compost-amended plots produced higher onion yields in 1999 & 2000. In 2001, compost-amended plots produced higher yields of all crops except for the two Brassica species. There were few effects of treatments on plant tissue content; only Fe and B in organically-amended leaves in 1999, and P and K in fertilized-amended leaves in 2001 were significantly different. Of 19 soil parameters evaluated, the cation exchange capacity and the Mehlich-3 extractable Ca, Mn and Pb content of compost-amended soils were higher following the harvest in 1999-2000. In 2001 the following soil parameters were higher in the compost-amended plots: pH, EC, CEC, C, N, P, Ca, Mg, Mn, Zn, and B. This six crop rotation study ended in 2001; emphasis is now directed to evaluating soil biochemical changes that may have occurred from the continuous agronomic applications of the compost or fertilizer.

Conclusion

Seasonal variation in soil moisture and temperature seem to have a greater influence on plant production, through mineralization, than the source and amount of mature compost applied. Continuous compost application is providing a higher level of available nutrients than the literature would predict, probably because the soil environment has more biological activity and is more conducive to mineralization from these long-term organic applications. It took 6-8 years before the compost-amended plots produced the same quantity and quality of vegetables as the commercially-fertilized plots.

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Microbial Community Analyses in Organically and Conventionally Managed Soil Ecosystems

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Keywords: farming systems, soil tillage, soil microbial communities

Introduction

Soil microbial communities are responsible for productivity and stability of agricultural landuse systems and have, moreover, important functions in global nutrient cycling. To understand these processes in detail analyses of the structure of soil microbial communities are essential.

Materials and methods

Soil samples from two different long-term field trials were investigated to study influences of farming systems and different tillage techniques on soil microbial communities. 1) The DOC long-term field trial in Switzerland consists of plots managed bio-dynamically (D), bio-organically (O), conventionally (C) and of those which are managed conventionally but only receive mineral fertiliser (M). 2) In the field trial of the "Project Ecological Soil Management" (PÖB) in Germany, three different tillage techniques were compared consisting of conventional ploughing (CP), two-layer ploughing (TP) and conservation tillage (CT). In the DOC trial samples were taken from 0-10 cm soil depth, and in the PÖB plots sampling depths were 0-15 cm and 15-30 cm, respectively. Analyses of phospholipid fatty acids (PLFA) and phospholipid etherlipids (PLEL) were carried out to determine bacterial, eukaryotic and archaeal microorganisms (Gattinger, 2001).

Results and discussion

DOC trial: Influence of farming system

Total microbial biomass which is the sum af all identified PLFA and PLEL was highest in samples of soil D followed by O, C, and M. The observed differences were statistically significant at the 0.05 level. Apart from bacteria, fungi and protozoa, members of the archaeal domain were also present in the DOC soils. Archaeal biomass expressed as total PLEL concentration was highest in the conventional plot C followed by O and D with no statistical difference to the PLEL concentration estimated in plot C. For the comparison of whole community profiles, the log-transformed data of the identified phospholipid biomarker were subjected to principal component analysis (PCA). The largest difference in terms of the microbial community structure was between plot M and all other plots. Among the three organically fertilized plots the phospholipid profiles from O and C were closest related to each other indicating an outstanding microbial community in the plot D, as might be affected by the bio-dynamic preparations.

PÖB trial: Influence of soil tillage

In all samples microbial biomass decreased with increasing soil depth. The highest values for the top soil samples were found in CT followed by CP and TP, where the latter ones were not statistically significant. PCA of the phospholipid data revealed that microbial community structure was different between the three tillage systems. The greatest similarity of microbial communities was detected between plot CT and CP. In contrast to CT and CP, a differentiation in microbial community structure according to soil depth could be obtained in plot TP, indicating the specific effects of two-layer ploughing. While in 0-15 cm the ranking of the fungi-to-bacteria ratio followed the order CT > CP ≥ TP, in 15-30 cm soil depth the ranking order was CP ≥ CT ≥ TP.

Conclusions

Phospholipid analyses revealed that both, farming system as well as soil tillage had an effect on size and structure of soil microbial communities. These may result in differences in nutrient fluxes (eg. trace gases) and in the overall soil fertility.

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Arbuscular Mycorrhizal Fungi and Sustainable Availability of Nutrients for Field-grown Maize

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Introduction

Arbuscular mycorrhizal fungi have symbiotic association with many crops. Arbuscular mycorrhizae improve the health and growth of plant by increasing nutrients uptake, especially immobile nutrients such as phosphorus.

Materials and methods

Effects of arbuscular mycorrhizal fungi on uptake of nutrients were evaluated on two years experiments with two factors and three replications Phosphorus levels included: P0=0, P1=50, P2= 100 and P3= 150 kg P2O5 per hectare. Inoculums levels included: I1=*Glomus mosseae*, I2= *Glomus caledonium*, I3= *Glomus intraradices* and I4= sterile plots.

Results and discussion

In the first year results of this study, application of phosphorus levels had significant effects on N and Mg percent and also Mg and Cu content in plant. Similarly, the application of fungi inoculums on Na percent was statistically significant. For second year trail, the results showed significant effects of P treatments on Cu concentration. P, K percent and Fe, Mn concentration and also Fe, Mn content were significantly affected by inoculums treatments. Combined results of two years experiments showed the effects of phosphorus levels on Na percent and also Na content were significant. Combined results of two years experiments showed Na percent, Ca, Fe and Mn content and also Fe , Mn concentration were significantly affected by inoculums treatments. The effects of phosphorus treatments on P and Ca percent and also Ca content were significant. Similarly P, N, K, Na, Mg and Cu content were statistically affected by inoculums treatments.

Conclusions

The results of this study revealed that application of arbuscular mycorrhizal fungi can help agronomic plants to effectively absorb nutrients. The large amounts of chemical fertilizers or pesticides such as fungicide can inhibited this association. The difference observed in this study between two years also due from application of different amount of methyl bromide.

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Impact of Microbial Inoculation on Composting in Organic Systems

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Keywords: compost, microbial inoculation, nutrient release, crop growth

Introduction

Many factors affect the process of composting, among which temperature (Hood 2001) and microbial inoculation play pivotal roles. Effective Microorganisms (EM) influences the productivity of organic systems and also composting (e.g. Senanayake and Sangakkara 2001). However, the efficiency of EM in composting has not been clearly defined in relation to other common inoculates.

Materials and Methods

15N labelled corn residues (2.01% enrichment) and tree legume leaves were mixed to a ratio of 1:1, with chicken manure (1 Kg manure per 10Kg of plant material). The inoculates were a slurry of fresh cattle manure **CM** (2Kg in 5 l water), Bakers yeast (10 g and 5 g sugar in 5 l water) or EM (made from Lactic acid bacteria, Yeast and Phototropic bacteria in a sugar medium at pH 3.5, dilution 50ml in 5 l water). Water was used as a control. The inoculates or water were added to prepared heaps of organic matter (each 10Kg) until moistened, mixed and covered with black polythene. The rise in temperature of heaps were determined daily at 1000 Hrs. When temperatures of heaps exceeded 60oC, they were turned and covered. The quality of compost was determined visually, and on maturity sub samples were analysed for available 15N. The composts were incorporated into prepared seedbeds and Cowpea (Vigna unguiculata L Walp) was planted and managed as per an organic system. At flowering (R1), plants were sampled, washed, dry weights determined and 15N enrichment measured by Emission Spectrometry.

Results and discussion

Application of EM increased temperatures of compost heaps rapidly and attained 60oC in 3 – 4 days thus increasing the frequency of turning and mixing to make good compost. The use of cattle manure and yeast increased temperatures to 60oC in 8 and 14 days respectively, while the application of water enhanced temperatures only to 54oC. The microbial inoculates had a significant effect on time to compost maturity. The heap with EM was matured in 44 days + 1.4, while the application of CM and yeast produced quality compost in 96 + 3.5 and 121 + 15.1days respectively. The heap to which water was added was composted in 185 + 3.6 days

Table 1. Impact of inoculates on 15N-release and plant uptake from compost

Treatment	%15N in compost (enrichment)	%15N derived from compost
Compost + water	0.024	0.48
Compost + Yeast	0.041	2.45
Compost + CM	0.076	3.96
Compost + EM	0.094	5.21
LSD (P=0.05)	0.004	1.052

The release of 15N was highest in the heap with EM (Table 1) followed by heaps inoculated with CM or Yeast. More importantly, Cowpea plants grown on compost with EM had the highest level of 15N enrichment (Table 1), thus providing N, a nutrient usually deficient in the tropics (Rigby and Caceres, 2001). The use of cattle manure also increased 15N uptake when compared to yeast or water.

Conclusions

Microbial mixes enhanced the process of composting when compared to yeast or water. However the usefulness of EM as an inoculate over that of CM was clearly evident by the temperature build up, time taken and release of 15N. Tropical farmers thus could use EM, for better composting in organic systems.

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Soil Nitrogen in an Organic Apple Orchard

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Keywords: apple, nitrate, nitrogen fertilisation, rosy aphid

Introduction

The lack of vigour of an organic apple orchard (*Smoothee* cultivar) planted in 1994 pointed out the management of tree nitrogen supply in this orchard. Serious damages due to *Dysaphis plantaginea*, the rosy aphid, were also noted on trees. As tree vigour and therefore aphid population levels are related to nitrogen nutrition, the monitoring of soil nitrogen availability was necessary to analyse the causes of these problems. Besides, the aim was to optimise the orchard organic nitrogen fertilisation.

Materials and methods

From 1994 to 1998, the fertilisation management mainly consisted in compost supply (10 $t.ha^{-1}$). From 1999 to 2001, autumn compost supply was reduced to 5 $t.ha^{-1}$, complemented with organic quickly mineralised fertilisers in spring (2 x 20 $kg.ha^{-1}$ N). Lysimeters have been installed (density of 32 lysimeters per ha) in the orchard at 80 cm from trees in the areas under irrigation emitters; at 35 cm depth in 1999, at 35 cm and 50 cm depth in 2000 and 2001. These lysimeters allowed to sample the soil solution and to measure its nitrate content each week along the vegetative period. Growth of the trees, yield, fruit quality and pests were monitored. Soil and leaf analyses were performed in order to evaluate their nitrogen status.

Results

During the first year of the experiment (1999), nitrate content in soil solution was low and slightly varied among the tested places. In 2000 and 2001, the orchard homogeneity and the very low risk for nitrate leaching were assessed, as nitrate content in soil solution was comprised between 5 and 15 ppm, and remained lower at 50 cm than at 35 cm depth. Analyses of soil samples before and after the vegetative period led to the same conclusions: soil nitrate content varied between 20 and 30 $kg.ha^{-1}$ at the end of winter, 15 and 25 $kg.ha^{-1}$ in autumn. These results suggested that soil nitrate content was low enough to limit nitrate leaching, but sufficient to ensure an appropriated nitrate availability for the apple trees (Bussi and Gojon, 1997). The soil C/N ratio increased (from 8.6 in 1998 to 9.8 in 2001), as a result of the soil organic matter increase due to compost supplies. In our soil conditions, a close to 10 C/N ratio, as measured in 2001, appears to be an adequate level (Delas and Molot, 1983). Leaf nitrogen content decreased from 23.7 $g.kg^{-1}$ in 1999 to 20.4 $g.kg^{-1}$ in 2001, and fruit nitrogen content from 2.45 $g.kg^{-1}$ in 1999 to 1.69 $g.kg^{-1}$ in 2001; nevertheless these N content remained quite suitable for apple production (Sharples, 1980). Yield varied from 15 to 23 $t.ha^{-1}$ according to the year, and first choice fruit represented 51 to 75 % of the total harvest. These yield fluctuations were mostly a consequence of the serious damages caused by the rosy aphid. Damages by rosy aphid were serious in 1998 and 2000. In 1998, damages might have been favoured by high soil nitrate content, as a consequence of the 10 $t.ha^{-1}$ compost yearly applied. In 2000, results showed that trees were not overfertilised, which excluded a stimulation effect of nitrogen. Weather in spring 2000 was wet and hot, which was likely to favour the increase of aphid populations, despite pest management before blooming.

Conclusion

Soil solution and soil nitrate content are useful tools to check the adequacy of organic fertilisation. They may allow to quickly detect excess or lack of nitrogen fertilisation, in order to correct it. Leaf and fruit nitrogen contents are diagnostic elements to evaluate the nitrogen fertilisation effectiveness in organic apple orchard. In our conditions, the optimisation of nitrogen fertilisation was simultaneous of an effective control of the rosy aphid in 1999 and 2001. However, rosy aphid damages in 2000 were serious, suggesting that this problem is most probably related to multi-factorial causes.

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The Effect of Vermicompost on Tomato Yield

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Key words: vermicompost, tomato yield

Introduction

Sustaining soil productivity has a high priority in any developed country. In order to maintain fertility and productivity of soils, several kinds of wastes can be added to the soils as a source of organic matter without any risk. This report describes what effects vermicompost has on the growth characteristics of the tomato.

Materials and methods

Vermicompost was made by introducing 500 earthworms (Eisenia foetida) to one cubic meter of cow manure and after a six months period; the vermicompost was prepared for the experiment (Kaplan et al., 1980). Three levels of chemical fertilizer and five levels of vermicompost (Control, 25%, 50%, 75% and 100%) were treated to soil (Xeric haplargids). A completely randomized design in factorial arrangement with three replications was used. Tomato plants were grown in pots at 25OC and 50% relative humidity under greenhouse condition. Root, shoot, fruit weight and the number of tomatoes were measured at the end of the experiment.

Results and discussion

The effects of different levels of vermicompost on tomato yield were highly significant. At the highest level of vermicompost treatment, the fruit number was four folds more than the control treatment. Fruit weight of tomato was increased at all vermicompost treatments compared to control. However, there was no significant difference among them. Vermicompost treatment also had a significant effect on root and shoot weight of tomato plants. The relationship between root weight and vermicompost was almost linear and the root weight was increased nine fold at the highest level of vermicompost treatment. Vermicompost also had a significant effect on the shoot weight of the tomato plant. At the 75% and 100% of vermicompost treatments, the shoot weight increased four and five times more than the control group, respectively. The interaction between chemical fertilizer and vermicompost treatment was only significant for shoot, root and fruit weight. The result also showed that at all levels of chemical fertilizer changes in fruit weight was significant only at 25% of vermicompost. It seems that root weight showed a better response to vermicompost compared to shoot weight (Fig 1). Vermicompost not only provided essential element for plant growth (Kale et al., 1992), it also improved the soil physical condition (Masciandaro et al., 2000).

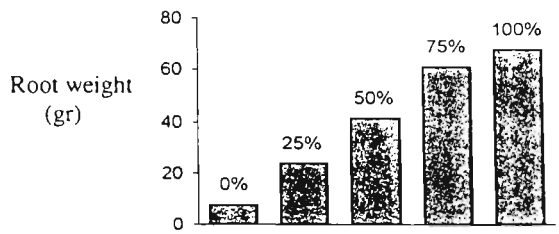

Fig. 1. The effect of different levels of vermicompost on the root weight

Conclusions

It can be concluded that for organic growers under green house condition, vermicompost can be efficiently used as an environmentally safe and economically sound cultural medium.

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Vegetable Production Comparisons between Conventional, Organic, and Natural Agriculture Systems

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Keywords: vegetable systems, biological control, soil chemistry

Introduction

In 1999, a five-year comparative study began comparing conventional, organic, and natural agricultural systems grown under similar environmental conditions. The site is located at the Cal Poly Pomona research farm in southern California. The goal of this project is to identify differences between systems and changes over time within each system. During this time the project will track trends in production, soil chemical, physical, and biological changes, and insect predation.

Materials and methods

Each system is treated as an independent ecosystem receiving appropriate cultural practices for fertilizer and pesticide treatments. The field site consists of four treatment areas, one each for the conventional and organic systems and two areas for the natural agriculture systems. Each system is divided into five cropping areas with four replications. Five winter and five summer crops are grown each year and rotated into different subsections annually. Chemical system (C) uses BMP for fertilizer, insecticide, and herbicide uses; organic system (O) uses CCOF standards with applications of composted manure and biological insecticides; the natural agriculture system (N) is based on a Japanese method developed by Mokichi Okada reflecting growing patterns and practices in natural ecosystems and is considered the control system. Data is analyzed via ANOVA with significance at the 0.05 level.

Results and discussion

Depending on the year, either the C or O systems for total field production produce greater yields than the N system. All systems have generally increased in production over time. Each year, the yield and vegetative production of a specific crop within a given system could increase or decrease. C tomatoes, as an example, had the greatest yield the first year, declined to similar yield of NA the second year, and increased the third year comparable to O yields and significantly higher than the N system. Average combined production shows no significant difference between the C and O systems in tomato and soybean crops. Corn produced significantly better in the C system; eggplant significantly greater in the O system. N system grows more slowly throughout the season. If given time to reach maturity, yield is lower than C and O, but by the third year not significantly less. Organic matter levels have remained relatively constant over time in the O system. The C and NA levels decreased the first two years, but are beginning to increase. pH has remained stable over time, while bulk density has increased slightly for all systems. Nitrate N has remained unchanged over time and similar in all systems in the summer, but increasing in all systems during the winter season. Phosphorus levels increased significantly in the O system compared to the C and N systems by the third year. Potassium levels show no clear trend at this time. Insect levels varied depending on the specific crop. N system had the highest diversity in 2000 and C least diversity. The O system had the highest number of beneficials.

Conclusions

The results show that conventional and organic systems can produce at a similar level depending on the crop and the year. Changes in soil characteristics take many years to show differences between systems. Insect species are more diverse in the organic and natural systems which can potentially lead to changes in cultural practices over time. Natural systems, even though less productive than the C or O systems, can be used at an intensive small-scale level.

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The Relation between the Use of External Inputs by Organic Farmers and the Criteria and Standards Laid Down in Formal Legislation: Are Organic Farming Really Producing According the Principles behind Organic Agriculture?

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Keywords: certification, regulations, external inputs

Introduction

Organic agriculture does not mean simply a shift towards ecologically safe technologies; socio-economic dimensions are involved too. In view with this reality, it is of interest to analyse how organic farmers work and in how far their way of production is in line with the principles of organic agriculture. In different scientific papers, organic farming is considered as a holistic non-input based agricultural production system or a production method that minimises the number of external inputs. This reality has been accepted in different research publications, but there are not too many publications analysing whether this situation could is or not.

Materials and methods

This research was based on interviews with 41 farmers, 3 traders and 3 certification bodies as well as on analysis of organic standards and regulations. The farmer interviews were done in three different countries: Chile, Spain and England. Some criteria applied for farmers were to be properly certified, not self-subsistence agriculture and to be connected with formal markets, it means, non-direct selling in the farm.
The study of the organic regulations did not consider all the aspects of them. The analysis was concentrated in the technical requirements in order to be certified as organic farmer, main principles and the list of products for technical management (fertilisers, soil conditioners, plant protection products, etc). It was also considered the standards: ISO 14001 Environmental Management Systems and ISO 9001 Quality Management Systems.

Results and discussion

The main reason to become organic farmer is economical with 33%. The main source of technical advice comes from themselves (45%). On other hand, despite that 84 % of farmers think that organic agriculture use less input than mainstream agriculture, it is remarkable the high percentage (41%) of farmers who perceive a problem the lack of ecological inputs in the market. In relation with the standards, more than 50% of farmers consider that the standards are suitable for them, but the high percentage of farmers with different levels of disagreement about the organic standards is surprised. The answers show that soil fertility and pest and disease strategies are more concentrated on the use of products or inputs than in the use of agricultural practices. The relation between external and internal inputs for soil fertility is 67% against 33% and 73% against 27% for pest and disease management.

Conclusions

Despite that there are many organic farmers with environmental commitment, there are also many producers considering organic agriculture as an economic alternative to mainstream agriculture. 2) A group of farmers put more attention in replacing inputs than the application of practices in order to prevent some problems. This tendency shows very well the actual reality of organic agriculture between two extremes, an industrialised organic agriculture sector with high use of external inputs and an organic agriculture sector putting more attention in the practices and own resources. 3) Environmental management standards and systems must redesign farm systems, in order not to burden farms carrying capacity and achieve an overall environmental performance improvement.4) It is necessary to improve organic regulations incorporating more clear requirements in the standards about the use of inputs. The organic standards should be more precise.5) There are many interesting aspects in the norms ISO 14001 and ISO 9001 that could be implemented as a part of organic standards and certification requirements.

Biodynamic Agriculture in Poland: Past, Contemporary State and the Future

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Keywords: biodynamic agriculture, history, Poland

In the Pałace of von Keyserlingk in Kobierzyce (Koberwitz) near Wrocław (Breslau), 7-16 VI 1924, dr Rudolf Steiner gave 8 lectures during Agricultural Course. He presented possibilities of using Anthroposophy in agricultural practices for the members of Anthroposophical Society. One of the participants of the course dr Gunter Wachsmuth explained principles of the agriculture to earl Stanisław Karłowski – senator of II Republic of Poland during accidental meeting in a train. Stanisław Karłowski, interested in antrophosophic ideas in agriculture and converted his 1760 hectare farm in Szelejowo near Gostyń into biodynamic, the first farm in Poland of the type (1930). He very actively popularised this new way of farming, publishing a few teaching brochures and organising courses and meetings with farmers on his farm. Karłowski was killed during World War II, and his farm was confiscated. There were hard times for Polish agriculture after the war with obligatory collectivisation and contingents of grain and meat. Then in 1960, ing. Julian Osetek (died 7 Feb. 1998 at the age of 90) established 3-hectare biodynamic farm in Nakło near Noteć river. However there were not happy days for this method of farming in Poland, due to political, economic and other obstacles. Just after political changes in 1980, organic methods of farming gained more attention. Julian Osetek was announced as a pioneer of biodynamic practices in crop production and animal husbandry. He and his son started to popularise the method in Poland and in 1982/83 Prof. Mieczysław Górny from SGGW joined them, publishing a book entitled "Biodynamic plant cultivation in the garden". In January 1984 a biodynamic agricultural course was held with participation of dr Christian von Wistinghausen from "DEMETER", and the second course was performed in February 1985 also with participation of Maria Thun. Next important courses were conducted in February 1987, June 1988 and in February 1989. They became a basis for establishing Association of Organic Producers "EKOLAND" the first organisation in Poland, that was registered on 1st September 1989. Organic agriculture developed slowly in Poland during 1989-98 because of different reasons: lack of law regulations (absence of "Organic Agriculture Act"), political, economic (lack of subsidies for organic farms) and others (small number of consumers). There were 27 certified organic farms in 1990 and 182 in 1998. There was an increase in the number of the farms from 231 up to 640 in 2001 after introduction direct subsidies for organic farms, first time in Poland. Among them there are few biodynamic farms with certificate of Polish control unit in compliance with organic method of production. According to "Demeter-International" data they are under transformation process in compliance with "DEMETER" rules. On 16th March 2001 Seym of the Republic of Poland ratified "Organic Agriculture Act" that came into force on 3rd November 2001. Appearance of the act, subsidies for organic farming, interest of consumers in organic farming products and approaching date of joining European Union by Poland, create opportunity for development of organic agriculture in the country, and (with collaboration with Stanisław Karłowski Foundation in Juchowo, since 2001) for biodynamic farming.

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Farmer-Centered Training: To Change Farmers' Sense of Organic Agriculture Step by Step

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Keywords: farmer-centered training, conversion of farmers' sense, organic farming

Abstract
Based on the 5-year experience with an organic advisory service, the authors found that the key factor for successful organic conversion lay in the conversion of farmers' sense of organic agriculture, which can be achieved through farmer-centered training, step by step.

The paper indicated that farmer-centered training should take varied ways with participatory approaches, such as theoretical education on the concept, principle, basic techniques, marketing strategies of organic farming and organic food, on-the-spot demonstration, field experiment, farm tour, exhibition attending etc. The conversion of farmers' sense included the change of farming habit, the attitude to nature (soil, plants, insects and the whole environment), the understanding of organic farming and sustainable development, the relationship of organic food to human health, the sense of product marketing, and so on.

The experience summed up in this paper is useful for others to advise farmers to convert to organic production successfully.

There are lots of factors that can affect farmers to convert to organic farming successfully such as production techniques, funds, market, governmental policy and so on. But what is the key factor? Through several years' experiences with an organic farming consulting service, we get a conclusion that it is the farmers' sense of organic farming that is the key factor to decide whether their conversion is successful or not.

Farmers' general understanding of organic farming

For farmers who hear about organic farming for the first time, the possible initial understandings are as follows:

- To do organic farming is to forbidden manufactured agro-chemicals, which makes them much wondering since they are used to using fertilizer, pesticides and herbicides. Without agro-chemicals, they don't even know how to start crop growing. They often ask a question about where they can buy bio-pesticides and organic fertilizers which have the same effect as agro-chemicals.
- Organic farming is allowed to develop only in very clean areas since organic food is no pollution, zero chemical residue. So, they are always not convinced if their fields are suitable for organic production.
- To do organic farming is very difficult and strict, which leads to several results: one is that farmers give up the effort to convert; the second is that farmers invest huge money to "protect" and "separate" their fields in case of pollution from outside; the third is that farmers try to start conversion but become very prudent and scared of making mistakes which makes them abide by organic standards awkwardly and limits their creativity.
- They are just aware that organic products will have a promising market and higher price, but they generally have no clear idea what the concrete requirements for organic production are and where their products' market is and how much higher the price will be. So, when they decide to do conversion, their object is not so explicit. They usually expect that after their farms are certified the businessman will rush into their farms to order their products.

Through farmer-centered training to promote their sense of organic farming

The understanding of organic farming decides farmers' activities to develop organic production. In accordance with above farmers' initial understandings or imaginings, the training directly to farmers that promotes their sense of organic farming appears very important.

In the light of our experiences, during our advisory service, the first thing we do is hold an one-hour face-to-face training course for farmers, to help them get a correct understanding of organic farming. The essential contents related to organic farming involved in the first training include:

- the concept and basic principles;
- the aim and significance;
- the developing history and present situation;
- the general production techniques.

Through this training course, farmers can obtain a basic knowledge of organic farming, but it's still far from accepting and deep understanding. The next step is to adopt the method of "learning by doing." We invite farmers to design and do field experiments together. The usual experiments are: soil investigation; green manure growing; compost making; and bio-control. Soil quality and health is the core of organic production. Through spade soil analysis, farmers can judge soil quality through smell, color, clot size, root density and color, soil animals and so on. Some farmers don't even know that soil has smell. In the early stage of conversion, farmers often place hopes on some one method to settle their difficulties. For example, in organic farming, green manure plays an important role in soil fertilization, which has been much strengthened in organic field, but sometimes, farmers can have a kind of feeling or expectation that if they grow green manure then it is all for soil fertilization and it can supply enough nutrients to crops. In order to help farmers to know green manure, we lead farmers to do field trials, have them observe the whole process of green manure's germination, growing, flowering, weigh bio-masses of roots and plants, measure soil temperature and investigate the impact of green manuring to crops growing. Through these activities, farmers can obtain very good understanding of green manure, and the knowledge from practice is their own "knowledge."

It's the same for other organic production techniques. In the course of farmers' experiment and practice, their sense has a changing process. Generally, farmers like to judge a new technique and get conclusion by the first image. For example, we have farmers compare several different green manures. After some time, farmers tell us that some kind of green manure is the best one since it germinates very quickly and grows well, looks very nice and the other ones haven't come out. But through a longer time observation, maybe they will find the first thought best one has some defect and other one becomes the best. Only when they experience the whole stages of green manure growing can they realize that different green manures have different growing habits and different advantages. Besides field trials, we still organize farmers to visit demonstration farms or fields and exchange ideas and experiences, which can promote their cognition of organic agriculture.

After one to two years' education and practice, farmers' sense of organic farming can become clearer and clearer. Their understanding and sense improvement can be summed up as follows:

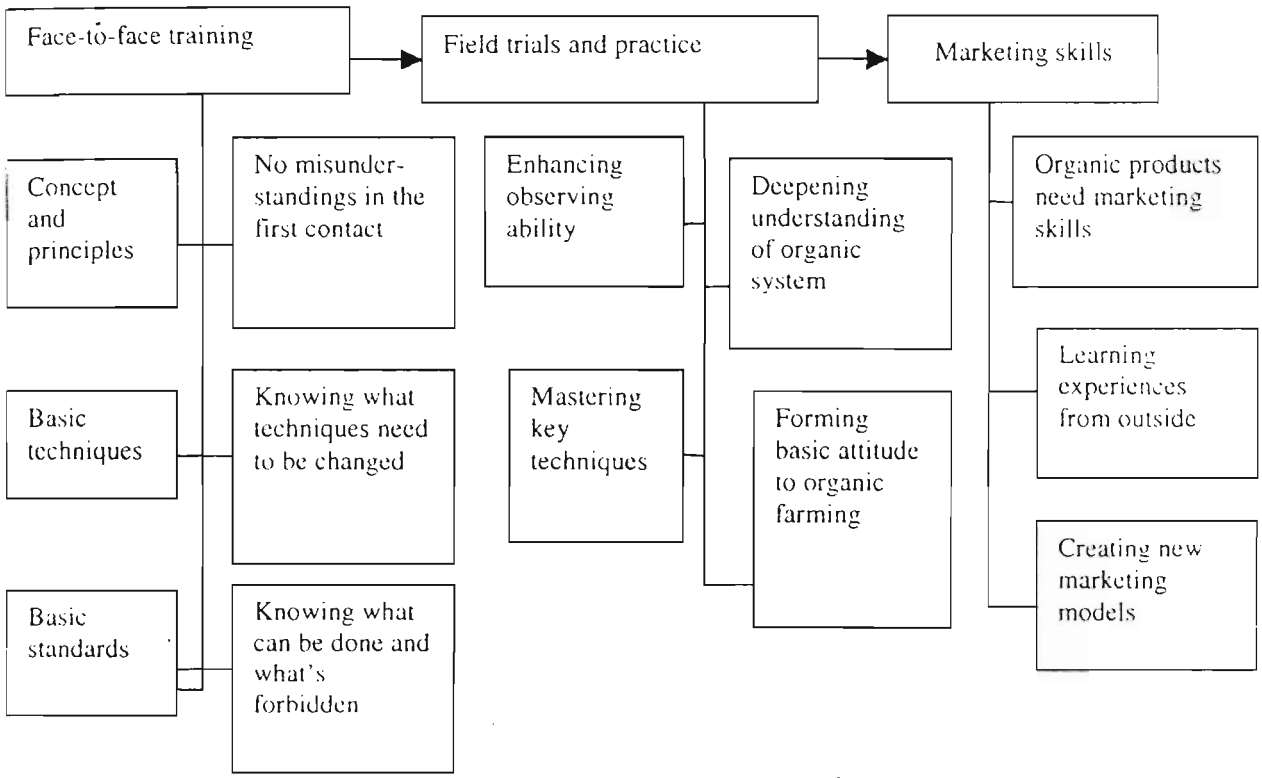
- Organic farming is not mysterious and it is a kind of agricultural model too that requires cycling the nutrients of the system and growing crops abiding by natural laws.
- Organic farming is not totally separated from other agriculture models. A lot of techniques from traditional and conventional agriculture can succeed.
- Farmers' attitude to insects, diseases and weeds changes hugely. In conventional farming, farmers are afraid of pests so that they spray pesticide at once while they find any pest or even use pesticide as prevention measure. After knowing the principles of organic farming and the relationship of all kinds of life, and through their own observation, they become calm facing pests, disease, and weeds. Their fields are no longer as clean as before. In a farm we consulted, the farmer needed to spray eight times pesticides a year to control pests of his fruit tree before, but after organic conversion, his attitude has been changed and he found that all the sprays were really not necessary because he didn't use any pesticide, even bio-pesticide, and his fruit tree grew well too. The pest problem is slight not to influence fruit trees and their yield, so there is no need for man-made controls.
- The investment of organic farming can be lower than conventional. Said in farmers' words is that the funds put in organic production are decreased but the labor is more. As to input, theoretically, to do organic farming should be lower than conventional, but in reality to realize the lower input in organic system is not so easy. Only when farmers have a right sense of organic farming can they have correct activities and correct input and avoid unnecessary investment such as building walls around the fields, constructing cement loads in fields, spraying bio-control materials lots of times, keeping clean weeding and so on.
- To do organic farming is a contribution to mankind's health and sustainable development. Organic farmers feel proud of their selection, but it needs love of fields, love of nature, otherwise it's difficult to do successful organic agriculture.

Pay attention to promoting farmers' product marketing skills

Product marketing is a key problem farmers meet after they finish organic conversion. They always cherish the idea that their organic products will be sought very easily. But the reality is not like this. Good quality, environment

friendly is a prerequisite for good market and good price, but it needs marketing skills too, specially in the early stage of organic movement in one area. There are a lot good ways for organic products marketing worldwide, so we introduce them to farmers, such as alternative marketing models in Japan, special shops, on-farm shops and supermarket selling in Europe and so on. We still encourage farmers to create their own marketing ways according to local conditions. In China at present, trade company combining together with small householders is a very popular marketing model, and organic farmers are trying to combine themselves together in the way of farmers' associations, companies or cooperatives to advertise and market their products together. Farmers like to attend exhibitions too: on the one hand they can advertise their products and obtain information, on the other hand they can make friends and exchange experiences. In a word, marketing is an important part of organic farming. For farmers, not waiting but taking action to explore markets is what they need to consider after they start organic conversion.

The following figure expresses the process to promote farmers' sense of organic farming through farmer-centered training.



Organic Farming Needs Organic Plant Breeding: A Network for Independent Seed Production and Plant Breeding

Christina Henatsch

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Keywords: organic seeds, network propagating and plant breeding activities, participative breeding

Motivation
Developments in conventional breeding (its multinational structure, use of biotechnology, gene technology and the disappearance of open pollinated varieties) and the current discussion about organic breeding standards show, that the organic movement must go its own way and face up to the challenge of developing its own methods and strategies.

The Initiative Group for Bio-Dynamic Vegetable Seeds in Germany and the Association for Bio-Dynamic Vegetable Plant Breeding, "Kultursaat", have built up a network for developing bio-dynamic plant breeding and seed production through the close cooperation of farmers/gardeners, breeders and the association. An organic seed company (partly owned by the propagators) is looking after cleaning, testing and draw off.

Gardeners	Breeders (mostly gardeners themselves)	Association "Kultursaat"
-Propagation - Testing of new varieties - Ideas/feed back	- Breeding in association with the gardeners - Research into: - new breeding methods - nutritional quality	-Coordination of plant breeding - Financial support - Payment of registration and testing fees - Owner of new varieties

The idea is for plant breeding to be returned to the gardeners/farmers themselves. The practical agricultural/horticultural experience and care of crops and the relationship between human being (breeder/gardener) and plant are the main prerequisites for successful plant breeding.
The following breeding and selection methods used and worked with by "Kultursaat"- breeders, are effective and simple enough to be applied directly at farm level:

Breeding methods are:

- Consistent and rigorous selection from a large stock base.
- Single plant selection.
- Cross fertilisation.
- Creating variation and developing special characteristics through:
  - Geology, geography and mineral provision
  - Effects of planetary influences and the bio-dynamic preparations.
- Influence of human and cultural conditions....more to develop

Breeding aims are:

- Good development and root growth
- Growth through organic fertilisers
- Ability to interact with the environment
- Tolerance and resistance to adversities
- Develop species-typical growth patterns and maturation processes
- Good, species-typical taste and nutritional qualities

During regularly held meetings (3/year) and more frequent regional ones, we train ourselves through studying background information, practical aspects and methods of breeding and comparing each others work and procedures. Together we then develop our skills and evolve new ideas and methods.
In the course of the last 15 years, Kultursaat has bred more than 20 new (registered) varieties. The first qualitative results we have had include better taste and higher nutritional quality of our own carrot, cabbage and spinach varieties.

Outlook

A further step will be to share ideas and experiences on an international level along with the varieties and breeding lines in order to provide a widely available open pollinated assortment of vegetable seeds and hence food of high nutritional quality and flavour.

In Europe we are actively building up such a network. For more information, seminars about breeding and selection contact: Christina-Henatsch@gmx.de.

The Concept of Integrity of Plants as a Leading Principle for Organic Plant Breeding

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Keywords: plant breeding, integrity, concept, traits.

Introduction

Currently the organic sector largely depends on modern varieties bred by conventional breeding companies for conventional farming systems including mineral fertilizers and chemical pest and disease management. More and more the organic sector is focussing on the possibilities to optimize cultivars for organic farming systems with breeding techniques and cultivar characteristics that suit the organic principles and farming conditions. Many discussions on breeding techniques have taken place in the Netherlands and other European countries in the last few years to define organic plant breeding. Judging the suitability of breeding techniques is based on the general principles for organic farming as a natural way of farming respecting integrity and intrinsic value of living entities like the soil, plants, animals and human beings. There is a need to transform such principles into terms for organic breeding.

Material and methods

An international workshop on organic breeding techniques was organized in Driebergen/Netherlands by the Louis Bolk Institute and Platform Biologica in cooperation with the European Consortium for Organic Plant Breeding (Eco-pb) in autumn 2001. As a basis the LBI-report on judging different breeding techniques for organic farming was used in the discussion (Lammerts et al., 1999). Parallel the Louis Bolk Institute conducted a project clarifying the content and use of the concept of nature and naturalness in organic farming. Both projects give input to develop a concept of integrity of plants as a leading principle for organic plant breeding.

Results and discussion

Based on the result of the research in the project on defining 'naturalness' in organic farming we distinguish three main approaches within the field of organic agriculture: the no chemicals approach, the agro-ecological approach and the integrity approach. It is stated that the concept of naturalness can be used to characterize organic agriculture and to distinguish it from conventional agriculture, but only if naturalness not only refers to not using chemicals but also to agro-ecological principles and respect for integrity of plants. The no chemical approach demands no use of chemicals and no gmo's in the breeding process. The agro-ecological approach implicates adaptation of cultivars to organic farming with ecological traits like: energy and nutrient efficient, deep rooting system capable of relating to beneficial soil organisms, weed suppressive, disease resistant or tolerant. It also includes strategies like using functional genetic diversity and in situ conservation of varieties. The integrity approach implicates a plant worthy and sustainable development of crops out of respect for the meaningful context of plants, including the socio-economic environment. From this point of view breeding is focussed on the optimal of expression of the species specific traits of the crops. It also implies development of participatory plant breeding strategies.
In the Driebergen-workshop on breeding techniques the concept of organic plant breeding with respect to integrity of plants was defined as: "The aim of organic plant breeding is to develop plants which enhance the potential of organic plant farming and biodiversity. Organic plant breeding is a holistic approach that respects natural crossing barriers and is based on fertile plants that can establish a viable relationship with the living soil".

Conclusions

The concept of integrity of plants, including the no chemical and agro-ecological approach, can be a leading principle to give clear direction for future organic breeding programs.

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FiBL

Zugelassene und empfohlene Hilfsstoffe für den biologischen Landbau

Hilfsstoffliste

Pflanzenbehandlungsmittel

Dünger und Handelssubstrate

Stallfliegenmittel

Ektoparasitenmittel

Siliermittel

Reinigungs- und Desinfektionsmittel

Reinigungs- und Entkeimungsmittel für Milchproduktionsbetriebe

Produkte gegen Bienenkrankheiten

2003

Hinweis für Firmen:
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Impressum

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Über wichtige Änderungen, welche nach der Drucklegung der Hilfsstoffliste eintreten, informieren wir auf unserer Homepage (www.fibl.ch).

Liste der zugelassenen und empfohlenen Hilfsstoffe für den biologischen Landbau in der Schweiz

Die Liste der Hilfsstoffe für den biologischen Landbau 2003 beinhaltet alle Pflanzenschutzmittel, Dünger und Handelssubstrate, Stallfliegenmittel, Siliermittel und Produkte zur Bekämpfung von Bienenkrankheiten, die im Handel erhältlich und für den biologischen Landbau in der Schweiz zugelassen sind. Sie enthält zudem eine Liste der vorzugsweise einzusetzenden Ektoparasiten-, Reinigungs- und Desinfektionsmittel, sowie der Reinigungs- und Entkeimungsmittel für Milchproduktionsbetriebe. Die Aufnahme eines Produktes in die Hilfsstoffliste ist nicht mit einer Anwendungsempfehlung gleichzusetzen.

Die Liste wird von Experten und Expertinnen des Forschungsinstituts für biologischen Landbau (FiBL) vorbereitet und nach Vernehmlassung bei den Behörden, BIO SUISSE und Migros-Bio-Production erstellt. Grundlage für die Beurteilung der Zulassung von Wirkstoffen und Formulierungshilfsstoffen ist die Verordnung des EVD über die biologische Landwirtschaft. Ergänzend werden Kriterien der nationalen und internationalen Richtlinien (BIO SUISSE, Migros-Bio, EU, IFOAM und Codex Alimentarius) herangezogen. Die Liste wird jährlich aktualisiert.

Die wichtigsten Änderungen gegenüber dem Vorjahr sind:

- Aufnahme von Mitteln zum Abhalten von Ameisen
- Aufnahme von Frischhaltemitteln für Schnittblumen
- Aufnahme von Düngern aus hydrolysierten Tierhäuten
- Nur noch die in der Hilfsstoffliste aufgeführten Blatt- und Spurenelementdünger sind zugelassen (verbindliche Positivliste).

Einige Handelsprodukte sind nicht mehr in der Liste aufgeführt. Für diese Produkte gilt: Bei Produzenten lagernde, im letzten Jahr eingekaufte Vorräte solcher Produkte dürfen im laufenden Jahr noch aufgebraucht werden (siehe Anhang).

Die Hilfsstoffliste wurde in der vorliegenden Form von der BIO SUISSE (Vereinigung Schweizer Biolandbau-Organisationen), der Migros-Bio-Production und der Zertifizierungsstelle bio.inspecta anerkannt und ist für die Produzenten von BIO SUISSE und Migros-Bio-Production verbindlich.

Inhaltsverzeichnis

		Seite
1	**Zugelassene Pflanzenschutzmittel**	5
	Beistoffe	5
	Biotechnische Verfahren	6
	Fungizide	7
	Insektizide und Akarizide	11
	Mikroorganismen	13
	Mittel zur Keimhemmung	14
	Mittel zum Schutz von Erntegütern	15
	Natürliche Feinde	15
	Saatgutbehandlungsmittel	19
	Wundverschlussmitttel für Gehölze	19
	Frischhaltemittel für Schnittblumen	19
2	**Zugelassene Dünger und Handelssubstrate**	20
	N-reiche Dünger	20
	P-reiche Dünger	21
	K-reiche Dünger	21
	Mehrnährstoffdünger	22
	Flüssige Dünger	24
	Kalkdünger	25
	Bodenverbesserer	25
	Gesteinsmehle	27
	Mikroorganismenpräparate	28
	Algenprodukte	28
	Abdeckmulch	29
	Düngerzusätze	29
	Pflanzenstärkungsmittel	31
	Blatt- und Spurenelementdünger	32
	Handelssubstrate: Presstopferden	34
	Handelssubstrate: Anzucht-, Topf- und Universalerden	34
3	**Zugelassene Stallfliegenmittel**	37
4	**Empfohlene Ektoparasitenmittel**	38
5	**Zugelassene Siliermittel**	39
6	**Empfohlene Reinigungs- und Desinfektionsmittel**	41
7	**Empfohlene Reinigungs- und Entkeimungsmittel für Milchproduktionsbetriebe**	43
8	**Zugelassene Produkte zur Bekämpfung von Bienenkrankheiten**	45
9	**Index der Produkte**	46
10	**Adressen der Firmen**	49
	Anhang 1: Liste „Nicht mehr aufgeführte" Produkte	53
	Anhang 2: Literatur	54

1 Zugelassene Pflanzenschutzmittel

Die Liste der Pflanzenschutzmittel ist gegliedert nach Beistoffen, biotechnischen Verfahren, Fungiziden, Insektiziden und Akariziden, Mikroorganismen, Mitteln zur Keimhemmung, Mitteln zum Schutz von Erntegütern, natürlichen Feinden, Saatbehandlungsmitteln, Wundverschlussmitteln und Frischhaltemitteln für Schnittblumen. Die Liste ist alphabetisch nach Hauptwirkstoffen gruppiert. Pro Produkt sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Wirkstoffe und das bewilligte Anwendungsgebiet angegeben (die Kategorie «Obst allg.» schliesst das Beerenobst ein). Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt. Anwendungsempfehlungen entnehmen Sie den im Anhang aufgeführten Merkblättern des FiBL. Diese Liste beinhaltet keine Pflanzenschutzmittel mit gentechnisch hergestellten Wirkstoffen.

Die in dieser Liste aufgeführten Mittel für den Pflanzenschutz dürfen ausschliesslich in den bezeichneten Kulturen eingesetzt werden. Die Liste enthält Pflanzenschutzmittel (welche generell vom Bundesamt für Landwirtschaft zugelassen sein müssen) sowie einige verwandte, jedoch nicht zulassungspflichtige Produkte. Ebenfalls für den biologischen Landbau zugelassen sind:

- Pheromonfallen (sofern vom BLW zugelassen) und Leimfallen zur Flugüberwachung von Insekten
- Kulturschutznetze, Schneckenzäune und ähnliches
- Selbst hergestellte pflanzliche Extrakte und Präparate wie Aufgüsse, Auszüge und Tee
- Hummelvölker zur Bestäubung
- Wildabhaltemittel, sofern sie weder mit Kulturpflanzen noch mit dem Boden in Kontakt kommen.

Verwendete Abkürzungen:
Fg = Fischgift
Tw = Teilwirkung
Nw = Nebenwirkung
Zv = Zulassung des BLW vorbehalten (definitiver Entscheid lag bei Redaktionsschluss nicht vor)

Beistoffe

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Huminsäuren				
Humin Vital WDG 70	Andermatt	frei	96 % Huminsäuren	*Obst allg.*: zur Wirkungsverbesserung von Madex, Capex
Pinolene				
Heliosol	Omya	5	70 % Pinolene	*Reben allg.*: zur Wirkungsverbesserung von Netzschwefel
Nu-Film-17	Andermatt	frei	96 % Pinolene	*Obst allg.*: zur Wirkungsverbesserung von Madex, Capex und Tonerdeprodukten *Reben allg.*: zur Wirkungsverbesserung von Tonerdeprodukten

Biotechnische Verfahren

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Alkoholfallen (Aethylalkohol; Insektenleim)				
Rebell Holzbohrerfalle	Andermatt	frei		*Kern-, Stein-, Beerenobst*: Befallsreduktion des Holzbohrers
Farbfallen (Leim)				
Kirschenfliegen-Falle	Neogard	frei		*Steinobst*: Befallsreduktion der Kirschenfliege
Rebell Fruchtfliegenfalle	Andermatt	frei		
Leim für Leimfallen				
Tangle-Trap	Andermatt	frei		Leim für Leimfallen
Leimringe (Fettsäuren, Naturharze)				
Raupenleimring	Andermatt, Neogard	frei	100 % Naturharze	*Kern-, Steinobst*: Frostspanner
Raupenleimring LG	Leu	frei	76 % Fettsäuren, 20 % Naturharze	
Repellents				
Ameisenstreumittel	Andermatt	frei		*Hausgarten*: Ameisen
Coop Oecoplan Biocontrol Ameisenstreupulver	Coop	frei		
Verwirrungstechnik mit Dispensern (Pheromone)				
Bocep Viti	Andermatt	frei	Sexualhormon	*Reben*: Einbindiger Traubenwickler (1. Generation = Heuwurm (Tw), 2. Generation = Sauerwurm)
Bocep Viti 230	Andermatt	frei	Sexualhormon	*Reben*: Einbindiger Traubenwickler
Isomate-C Plus	Andermatt	frei	Sexualhormon	*Kernobst*: Apfelwickler
Isomate-CLR	Andermatt	frei	Sexualhormon	*Kernobst*: Apfelwickler, Schalenwickler
Isomate-CTT	Andermatt	frei	Sexualhormon	*Kernobst*: Apfelwickler
Isomate-OFM Rosso	Andermatt	frei	Sexualhormon	*Kernobst*: Kleiner Fruchtwickler *Steinobst*: Pflaumenwickler
RAK 1+2	Andermatt	frei	Sexualhormon	*Reben*: Bekreuzter Traubenwickler, Einbindiger Traubenwickler
RAK 2	Andermatt	frei	Sexualhormon	*Reben*: Bekreuzter Traubenwickler

Fungizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Fenchelöl (Oleum foeniculi)				
Fenicur	Andermatt	frei	23 % Fenchelöl	*Beerenobst*: Echter Mehltau (Tw), Rostpilze (Tw) *Reben*: Echter Mehltau (Tw) *Kürbisgewächse*: Echter Mehltau (Tw) *Zierpflanzen allg.*: Echter Mehltau (Tw), Rostpilze (Tw) Wartefrist: Beeren 3 Wochen, Kürbisgewächse 3 Tage
Kupferhydroxid *				
Kupferhydroxid 50 Hoko	Hoko	4, Fg	50 % Reinkupfer	*Kernobst*: Schorf *Steinobst*: Schrotschuss, Kräuselkrankheit des Pfirsichs, Bakterienbrand der Kirsche, Narren- oder Taschenkrankheit der Zwetschge *Beerenobst*: Rutenkrankheit der Himbeere und Brombeere, Blattfleckenkrankheit der Erdbeere, Blattfallkrankheit der Johannisbeeren *Reben*: Falscher Mehltau, Rotbrenner (Nw) *Auberginen, Tomaten*: Alternaria-Dürrfleckenkrankheit, Kraut- und Fruchtfäule, Septoria-Blattfleckenkrankheit, bakterielle Fleckenkrankheit (Tw), bakterielle Tomatenwelke (Tw) *Karotten*: Alternaria-Möhrenschwärze *Sellerie*: Septoria-Blattfleckenkrankheit *Schwarzwurzeln*: Weisser Rost *Randen*: Cercospora- und Ramularia-Blattfleckenkrankheit *Kohlarten*: Adernschwärze (Tw) *Bohnen*: Bohnenbrand (Tw), Fettfleckenkrankheit *Gurken*: Eckige Blattfleckenkrankheit (Tw), Falscher Mehltau (Tw) *Kartoffeln*: Kraut- und Knollenfäule

Fortsetzung auf der nächsten Seite

ff. Fungizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Kupferhydroxid 50 Hoko, Fortsetzung				*Zierpflanzen allg.*: Blattflecken-pilze, Falscher Mehltau (Peronospora, Albugo, Bremia) *Rhododendron, Blautanne*: Knospensterben *Begonia, Pelargonien*: Bakteriosen *Rosen*: Rindenbrandkrankheit *Kirschlorbeer*: Schrotschuss **Mengenbeschränkung:** siehe auf Seite 9 Wartefrist: Obst, Gemüse und Kartoffeln 3 Wochen (Ausnahme: Tomaten und Auberginen 3 Tage)
Cupravit blau	Bayer	4, Fg	35 % Reinkupfer	Anwendungsgebiete wie Kupferhydroxid 50 Hoko; jedoch ohne Zierpflanzen
Kocide DF	Bayer	4, Fg	40 % Reinkupfer	
Microperl	Andermatt, Burri	4, Fg	40 % Reinkupfer	
Champion flow	Méoc	4	24 % Reinkupfer	Anwendungsgebiete wie Kupferhydroxid 50 Hoko; jedoch ohne Zierpflanzen, Kraut- und Knollenfäule
Kocide 2000	Bayer	4	35 % Reinkupfer	Anwendungsgebiete wie Kupferhydroxid 50 Hoko; jedoch ohne Zierpflanzen; zusätzlich: *Reben*: Echter Mehltau (Tw), Graufäule (Tw)
Kupferkalkbrühe = Bordeaux Brühe *				
Bouillie bordelaise Disperss	Landi/ fenaco	4, Fg	20 % Reinkupfer	wie Kupferhydroxid 50 Hoko, jedoch ohne Zierpflanzen **Mengenbeschränkung:** siehe auf Seite 9
Kupferoctanat *				
Cueva	Andermatt, Neogard	frei, Fg	10 % Kupfersalze (17.5 g/l)	*Kartoffeln*: Kraut- und Knollenfäule (Tw) **Mengenbeschränkung:** siehe auf Seite 9

ff. Fungizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Kupferoxychlorid *				
Cuprofix	Maag	4, Fg	50 % Reinkupfer	wie Kupferhydroxid 50 Hoko **Mengenbeschränkung:** siehe unten
Kupfer 50/Cuivre 50	Intertoresa	4, Fg	50 % Reinkupfer	
Kupfer 50/Cuivre 50	Leu	4, Fg	50 % Reinkupfer	
Kupfer 50/Cuivre 50 Hoko	Hoko	4, Fg	50 % Reinkupfer	
Kupfer 50 S	Schneiter	4, Fg	50 % Reinkupfer	
Oxychlorure de cuivre	Méoc	4, Fg	50 % Reinkupfer	
Oxykupfer 50	Siegfried	4, Fg	50 % Reinkupfer	
Vitigran 50	Omya	4, Fg	50 % Reinkupfer	
Kupferoxysulfat *				
Cuproxat flüssig/liquide LG	Leu	4, Fg	15 % Reinkupfer (190 g/l)	wie Kupferhydroxid 50 Hoko, jedoch ohne Kraut- und Knollenfäule **Mengenbeschränkung:** siehe unten

*** Mengenbeschränkung für kupferhaltige Produkte:**
Von allen kupferhaltigen Produkten dürfen höchstens die folgenden Mengen Reinkupfer in kg pro ha und Jahr eingesetzt werden: **Kernobst** 1.5; **Steinobst** 4; **Beerenobst** 2; **Gemüse, Kartoffeln und Zierpflanzen** 4. **Reben** 4 im Durchschnitt über 5 Jahre (gerechnet ab 2002), jedoch nicht über 6 pro Jahr.

Lecithin				
Bio-Blatt Mehltaumittel	Andermatt, Neogard	frei	50 % Lecithin	*Reben*: Echter Mehltau (Tw) *Gurken*: Echter Mehltau (Tw) *Zierpflanzen allg.*: Echter Mehltau (Tw)
Pflanzliche Seife				
Biofa Cocana RF	Andermatt	frei	29.7 % Kaliseife	*Kernobst*: Regenfleckenkrankheiten Wartefrist: 3 Wochen

ff. Fungizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Schwefel				
Elosal Supra	Omya	5S	80 % Schwefel	*Kernobst*: Schorf (Tw), Echter Mehltau *Steinobst*: Echter Mehltau und Schorf des Pfirsichs, Schrotschuss *Beerenobst*: Echter Mehltau der Erdbeere *Reben*: Echter Mehltau *Kürbisgewächse*: Echter Mehltau *Hopfen*: Echter Mehltau *Zierpflanzen allg.*: Echter Mehltau *Kirschlorbeer*: Schrotschuss Wartefrist: Obst und Reben 3 Wochen, Gemüse 3 Tage Bemerkung: Nicht alle Produkte sind für sämtliche Indikationen zugelassen. Die genaue Indikation kann der Produkteetikette entnommen werden. Siehe auch Angaben zu Schwefel unter «Insektizide und Akarizide»
Microthiol Spécial Disperss	Landi/ fenaco	5S	80 % Schwefel	
Netzschwefel 80 Spezial	Intertoresa	5S	80 % Schwefel	
Netzschwefel LG	Leu	5S	80 % Schwefel	
Schwefel 80 S	Schneiter	5S	80 % Schwefel	
Solfo fluid	Burri	5S	52 % Schwefel	
Solfovit WG	Bayer	5S	80 % Schwefel	
Soufre mouillable	Méoc	5S	80 % Schwefel	
Sufralo	Siegfried	5S	80 % Schwefel	
Thiovit Jet	Syngenta	5S	80 % Schwefel	
Schwefel + Pinienöl				
Heliosoufre S	Omya	5S	(700 g/l) Schwefel, (117 g/l) Pinienöl	wie Schwefel, jedoch ohne Zierpflanzen und Hopfen, aber einschliesslich Stachelbeermehltau und Schwarzfleckenkrankheit der Rebe
Schwefel-Stäubemittel				
Elosal Schwefel Stäubemittel	Omya	5S	99 % Schwefel	*Kernobst*: Echter Mehltau *Reben*: Echter Mehltau *Kürbisgewächse*: Echter Mehltau Wartefrist: 3 Wochen
Florfluid	Méoc	5S	98 % Schwefel	
Fluidosoufre	Landi/ fenaco	5S	99 % Schwefel	
Tonerde				
Myco-Sin	Andermatt	frei	65 % schwefelsaure Tonerde, 0.2 % Schachtelhalmextrakt	*Kernobst*: Birnenblütenbrand (Tw), Echter Mehltau (Tw), Feuerbrand (Tw), Schorf (Tw) *Steinobst*: Schrotschuss *Reben*: Falscher und Echter Mehltau (Tw), Rotbrenner (Tw) Bemerkung: in Kombination mit 0.3 % Netzschwefel
Ulmasud B	Andermatt	frei	96.9 % Gesteinsmehle (darin enthalten: 24 % Aluminiumoxid, 20 % Siliciumoxid, 13 % Schwefel)	*Kernobst*: Echter Mehltau, Schorf *Reben*: Falscher und Echter Mehltau Bemerkung: in Kombination mit 0.3-0.5 % Netzschwefel

ff. Fungizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Tonerde + Schwefel				
Myco-San	Andermatt	frei	50 % schwefelsaure Tonerde, 41 % Schwefel, 1 % Schachtelhalmextrakt	*Kernobst*: Echter Mehltau, Schorf (Tw) *Reben*: Falscher und Echter Mehltau (Tw), Rotbrenner (Tw) Wartefrist: Kernobst 3 Wochen

Insektizide und Akarizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Azadirachtin				
NeemAzal-T/S	Andermatt	5	Azadirachtin A (10 g/l)	*Kernobst*: Mehlige Apfelblattlaus, Faltenläuse *Zierpflanzen allg.*: Blattläuse, Thrips, Spinnmilben, weisse Fliegen Bemerkung: Abdrift führt bei einigen Birnensorten zu starken Blattverbrennungen (siehe Packungsbeilage)
Fettsäuren (Kaliseifen)				
Natural	Andermatt	frei	50 % Fettsäuren	*Obst allg.*: Spinnmilben, Blattläuse *Gemüse allg.*: Spinnmilben, Blattläuse *Zierpflanzen allg.*: Spinnmilben, Blattläuse, Weisse Fliegen Wartefrist: Obst 3 Wochen, Gemüse 7 Tage
Neudosan Neu	Neogard	frei	50 % Fettsäuren	
Siva 50	Omya	frei	50 % Fettsäuren	
Coop Oecoplan Biocontrol Insektizid	Coop	frei	1 % Fettsäuren	*Hausgarten:* gleiche Anwendungen wie Natural
Mineralöl				
Mineralöl Omya	Omya	frei	99 % Mineralöl	*Obst allg.*: Austernschildläuse, Birnenpockenmilbe, Grosse Obstbaumschildlaus, Frostspanner, Spinnmilben
Spray Oil 7-E	Leu	frei	99 % Mineralöl	
Sunspray 7-E	Blaser	frei	99 % Mineralöl	
Weissöl S	Schneiter	frei	99 % Mineralöl	
Zofal D	Siegfried	frei	99 % Mineralöl	
Neemextrakt				
siehe Azadirachtin				
Paraffinöl				
Promanal Neu	Andermatt, Neogard	frei	Paraffinöl (546 g/l)	*Zierpflanzen im Gewächshaus*: Palmenthrips, Schildläuse, Spinnmilben

ff. Insektizide und Akarizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Pyrethrin + Sesamöl				
Parexan N	Omya	frei, Fg	5 % Pyrethrin, 20 % Sesamöl	*Obst allg. (Zv)*: Blattläuse (Röhrenläuse), Blattwespen (Larven), Frostspanner *Gemüse allg. (Zv)*: Blattläuse, Weisse Fliegen, Kartoffelkäfer, Thripse, Spinnmilben, Kohlweisslinge *Zierpflanzen allg.*: Blattläuse, Spinnmilben, Thripse, Weisse Fliegen
Pyrethrum FS	Andermatt	frei	8.0 % Pyrethrin, 35.7 % Sesamöl	Anwendungsgebiete wie Parexan N, jedoch ohne Kartoffelkäfer und Kohlweisslinge; zusätzlich blattfressende Raupen bei Zierpflanzen
Quassiaextrakt				
Quassan	Andermatt	frei	30 % Quassiaextrakt	*Kernobst, Steinobst*: Sägewespen, Blattläuse (Tw) *Gemüse allg.*: Blattläuse *Zierpflanzen allg.*: Blattläuse Wartefrist: Gemüse 7 Tage
Rapsöl				
Genol Plant	Andermatt, Syngenta	frei	94.6 % Rapsöl	*Obst allg.*: Grosse Obstbaumschildlaus, Blattläuse (Tw), Birnenpockenmilbe (Tw), Frostspanner (Tw), Rote Spinne (Tw) *Zierpflanzen allg.*: Napfschildläuse, Blattläuse (Tw), Frostspanner (Tw), Spinnmilben (Tw)
Telmion	Omya	frei	85 % Rapsöl	
Rotenon				
Sicid	Siegfried	5, Fg	1.25 % Rotenon	*Obst allg.*: Blattläuse, Blattsauger, Frostspanner, Spinnmilben *Gemüse allg.*: Blattläuse, Spinnmilben, Thripse, Weissen Fliegen *Zierpflanzen allg.*: Blattläuse, Spinnmilben, Thripse, Weisse Fliegen Wartefrist: Obst 3 Wochen, Gemüse 7 Tage
Schwefel				
Produkte siehe Fungizide				*Beerenobst*: Brombeermilbe *Reben*: Kräusel- und Pockenmilbe

ff. Insektizide und Akarizide

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Spinosad (Fermentationsprodukt von Bodenmikroorganismen)				
Audienz	Omya	5	44.2 % Spinosad	*Kohlarten*: Grosser und Kleiner Kohlweissling, Kohldrehherzgallmücke, Kohleule, Kohlschabe, Weisse Fliegen *Gurken, Paprika, Tomaten*: Eulenraupen, Thripse, Weisse Fliegen, Minierfliegen *Zierpflanzen allg.*: Falter, Minierfliegen, Schmetterlingsraupen, Thripse, Weisse Fliegen *Reben*: Erdraupen, Springwurm, Thripse (Nw), Traubenwickler

Mikroorganismen

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Ampelomyces quisqualis				
Aq10	Andermatt	frei	Ampelomyces quisqualis	*Reben*: Echter Mehltau (Tw)
Bacillus subtilis				
Biopro	Andermatt	frei	Bacillus subtilis	*Kernobst*: Feuerbrand (Tw)
FZB24 WG	Bayer	frei	Bacillus subtilis	*Kartoffeln (Zv)*: Rhizoctonia (Tw), zur Optimierung der Sortierung
Bacillus thuringiensis var. israeliensis				
Skeetal	Omya	frei	Bacillus thuringiensis var. israeliensis	*Zierpflanzen gedeckt*: Trauermücken
Solbac	Andermatt	frei	Bacillus thuringiensis var. israeliensis	*Zierpflanzen allg.*: Trauermücken
Solbac Tabs	Andermatt	frei	Bacillus thuringiensis var. israeliensis	
Bacillus thuringiensis var. kurstaki				
Delfin	Syngenta	frei	Bacillus thuringiensis var. kurstaki	*Obst allg.*: Frostspanner, Gespinstmotten *Reben*: Traubenwickler *Kohlarten*: Kohlweisslinge, Kohleule, Kohlschabe *Gehölze ausserhalb Forst*: Gespinstmotten, Spanner, Trägspinner Wartefrist: Reben 3 Wochen, Gemüse 7 Tage
Baktur	Omya	frei	Bacillus thuringiensis var. kurstaki	Anwendung wie oben, jedoch ohne Kohleule und Gehölze

ff. Mikroorganismen

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Bacillus thuringiensis var. tenebrionis				
Novodor	Andermatt, Leu	frei	Bacillus thuringiensis var. tenebrionis	*Kartoffeln, Auberginen*: Kartoffelkäfer Wartefrist: Kartoffeln 3 Wochen, Auberginen im Freiland 7 Tage, im Gewächshaus 3 Tage
Beauveria bassiana				
Naturalis-L	Andermatt	frei	Beauveria bassiana	*Zierpflanzen gedeckt*: Weisse Fliegen
Beauveria brongniartii				
Beauveria-Schweizer	Schweizer	frei	Beauveria brongniartii	*Obst allg.*: Maikäfer
Engerlingspilz	Andermatt	frei		*Feldkulturen allg.*: Maikäfer
Coniothyrium minitans				
Contans	Omya	frei	Coniothyrium minitans	*Gemüse allg.*: Sclerotinia sp. *Tabak*: Sclerotinia sclerotiorum *Chrysantheme, Gerbera*: Sclerotinia sp.
Koni WP	Andermatt		Coniothyrium minitans	*Gemüse allg.*: Sclerotinia
Granulose-Viren				
Capex 2	Andermatt	frei		*Obst allg.*: Schalenwickler Wartefrist: 3 Wochen
Carpovirusine	Siegfried, Méoc	frei		*Apfel und Birne*: Apfelwickler
Granupom Neu	Omya	frei		*Obst allg.*: Apfelwickler
Madex 2	Andermatt	frei		Wartefrist: 3 Wochen
Madex 3	Andermatt	frei		

Mittel zur Keimhemmung

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Kümmelöl				
Talent	Omya	4	95 % D-Carvon	*Kartoffeln*: Keimhemmung Bemerkung: Wirkt nur in geschlossenen Räumen

Mittel zum Schutz von Erntegütern

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Siliziumoxid				
Silico-Sec	Andermatt	frei	96.5 % Siliziumoxid	*Getreide, Futtergetreide*: Getreideplattkäfer, Leistenkopfplattkäfer, Reiskäfer, Staubläuse *Lagerhallen, Mühlen, Silogebäude*: wie oben

Natürliche Feinde

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Gallmücken, Aphidoletes aphidimyza				
Aphidoletes aphidimyza	Andermatt, Omya		Aphidoletes aphidimyza	*Auberginen, Gurken, Tomaten, Peperoni im Gewächshaus*: Blattläuse (Tw)
Aphi-Pack Aa	Welte			*Zierpflanzen im Gewächshaus*: Blattläuse (Tw)
Aphidend	Leu, Welte			wie oben, jedoch ohne Zierpflanzen
Marienkäfer, Adalia bipunctata				
Adalia Marienkäferlarven	Andermatt		Adalia bipunctata	*Zierpflanzen im Gewächshaus*: Blattläuse
Marienkäfer, Cryptolaemus montrouzieri				
Cryptobug	Welte		Cryptolaemus montrouzieri	*Zierpflanzen im Gewächshaus*: Wolläuse (Schmierläuse)
Cryptolaemus montrouzieri	Andermatt, Omya			
Cryptopack	Welte			
Nematoden, Heterorhabditis sp.				
Dickmaulrüssler-Nematoden	Andermatt		Heterorhabditis sp.	*Obstbau allg.*: Gefurchter und Schwarzer Dickmaulrüssler
Larvanem	Welte			*Jungreben*: wie oben
Nematop	Landi Reba			*Zierpflanzen allg.*: wie oben
				Bemerkung: Nicht alle Produkte sind für sämtliche Indikationen zugelassen. Die genaue Indikation kann der Produkteetikette entnommen werden.
Nematoden, Phasmarhabditis hermaphrodita				
Bioslug-Schneckennematoden	Andermatt		Phasmarhabditis hermaphrodita	*Erdbeeren*: Ackerschnecken *Gemüse allg.*: Ackerschnecken *Zierpflanzen allg.*: Ackerschnecken
Nematoden, Steinernema carpocapsae				
Carponem	Andermatt		Steinernema carpocapsae	*Obstbau allg.*: Gefurchter und Schwarzer Dickmaulrüssler *Jungreben*: wie oben *Gemüse allg.*: Erdraupen, Maulwurfsgrille *Zierpflanzen allg.*: Gefurchter und Schwarzer Dickmaulrüssler, Erdraupen, Maulwurfsgrille

ff. Natürliche Feinde

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Nematoden, Steinernema feltiae				
Entonem	Welte		Steinernema feltiae	*Zierpflanzen (Dauerkulturen)*: Trauermücken
Nemaplus	Landi Reba			
Traunem	Andermatt		Steinernema feltiae	*Zierpflanzen (Dauerkulturen, Stecklinge)*: Trauermücken
Raubmilben, Amblyseius cucumeris				
Amblyseius cucumeris	Andermatt, Leu, Omya		Amblyseius cucumeris	*Auberginen, Gurken, Peperoni und Tomaten im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips
Amblyseius cucumeris SR	Omya			*Zierpflanzen im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips
Ambly-Pack	Welte		Amblyseius cucumeris	*Gurken und Tomaten gedeckt*: Spinnmilben, Thripse *Zierpflanzen gedeckt*: Spinnmilben, Thripse
Raubmilben, Amblyseius cucumeris & Amblyseius barkeri				
Thripex/Thripex-plus	Welte		Amblyseius cucumeris, Amblyseius barkeri	*Auberginen, Gurken, Peperoni und Tomaten im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips *Zierpflanzen gedeckt*: Kalifornischer Blütenthrips, Zwiebelthrips
Raubmilben, Hypoaspis aculeifer				
Entomite	Leu		Hypoaspis aculeifer	*Gemüse im Gewächshaus*: Trauermücken
Raubmilben, Hypoaspis miles				
Hypoaspis	Andermatt, Omya		Hypoaspis miles	*Gemüse im Gewächshaus*: Trauermücken (ausser Produkt von Omya) *Zierpflanzen im Gewächshaus*: Trauermücken
Raubmilben, Phytoseiulus persimilis				
Phytoseiulus persimilis	Andermatt, Leu		Phytoseiulus persimilis	*Gemüse im Gewächshaus*: Gemeine Spinnmilbe
Phytoseiulus persimilis Biopax	Omya			*Zierpflanzen im Gewächshaus*: Gemeine Spinnmilbe (ausser Produkt von Leu)
Phyto-Pack	Welte			
Spidex/Spidex-Plus	Welte			

ff. Natürliche Feinde

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Raubwanzen, Macrolophus caliginosus				
Macrolophus	Andermatt, Welte		Macrolophus caliginosus	*Gemüse im Gewächshaus*: Blattläuse (Nw), Spinnmilben (Nw), Weisse Fliegen
Mirical	Leu, Welte			*Zierpflanzen*: wie oben (ausser Produkt von Leu) Nicht alle Produkte sind für sämtliche Indiktationen zugelassen. Die genaue Indikation kann der Produkteetikette entnommen werden.
Raubwanzen, Orius insidiosus				
Orius insidiosus	Andermatt, Omya		Orius insidiosus	*Peperoni im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips *Zierpflanzen im Gewächshaus*: wie oben
Raubwanzen, Orius laevigatus				
Orius laevigatus Biopax	Omya		Orius laevigatus	*Gemüse im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips (Orius laevigatus Biopax nur für Gemüsepaprika zugelassen)
Thripor L	Leu			*Zierpflanzen im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips
Raubwanzen, Orius majusculus				
Orius majusculus	Andermatt		Orius majusculus	*Peperoni im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips *Zierpflanzen im Gewächshaus*: wie oben, sowie Gemeine Spinnmilbe
Ori-Pack	Welte		Orius majusculus	*Peperoni im Gewächshaus*: Kalifornischer Blütenthrips, Zwiebelthrips
Thripor	Leu, Welte			
Schlupfwespen, Aphelinus abdominalis				
Aphelinus abdominalis	Andermatt, Omya		Aphelinus abdominalis	*Gemüse im Gewächshaus*: Grüne Pfirsichblattlaus, Grünstreifige Kartoffelblattlaus
Aphi-Pack A abd	Welte			*Zierpflanzen im Gewächshaus*: wie oben
Schlupfwespen, Aphidius colemani				
Aphidius colemani	Andermatt, Omya		Aphidius colemani	*Gemüse im Gewächshaus*: Grüne Pfirsichblattlaus, Grüne Gurkenblattlaus *Zierpflanzen im Gewächshaus*: wie oben
Aphipar	Leu, Welte			
Aphi-Pack Am	Welte			

ff. Natürliche Feinde

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Schlupfwespen, Aphidius ervi				
Aphidius ervi	Andermatt, Leu		Aphidius ervi	*Gemüse im Gewächshaus*: Grünfleckige und Grünstreifige Kartoffelblattlaus *Zierpflanzen im Gewächshaus*: wie oben (ausser Produkt von Leu)
Schlupfwespen, Dacnusa sibirica				
Dacnusa sibirica	Omya		Dacnusa sibirica	*Gemüse im Gewächshaus*: Minierfliegen *Zierpflanzen im Gewächshaus*: Minierfliegen
Schlupfwespen, Diglyphus isaea				
Diglyphus isaea	Andermatt, Leu, Omya		Diglyphus isaea	*Gemüse im Gewächshaus*: Minierfliegen
Miglyphus	Welte			*Zierpflanzen im Gewächshaus*: Minierfliegen
Schlupfwespen, Diglyphus isaea/Dacnusa sibirica (Kombination)				
Dacnusa/Diglyphus	Omya		10 % Diglyphus isaea 90 % Dacnusa sibirica	*Gemüse im Gewächshaus*: Minierfliegen *Zierpflanzen im Gewächshaus*: Minierfliegen
Dacnusa sibirica/ Diglyphus isaea (Mischung)	Andermatt			
Minex	Leu, Welte			
Minierpack	Welte			
Schlupfwespen, Encarsia formosa				
Encarsia formosa	Andermatt, Leu, Omya		Encarsia formosa	*Gemüse im Gewächshaus*: Weisse Fliegen
En-Pack	Welte			*Zierpflanzen im Gewächshaus*: Weisse Fliegen (ausser Produkt von Leu)
En-Strip	Welte			
Schlupfwespen, Leptomastidea abnormis				
Leptomastidea abnormis	Andermatt		Leptomastidea abnormis	*Zierpflanzen im Gewächshaus*: Zitrusschmierlaus
Schlupfwespen, Leptomastix dactylopii				
Leptomastix dactylopii	Andermatt		Leptomastix dactylopii	*Zierpflanzen im Gewächshaus*: Zitrusschmierlaus
Schlupfwespen, Metaphycus helvolus				
Metaphycus helvolus	Andermatt		Metaphycus helvolus	*Zierpflanzen*: Kaffeeschildlaus

ff. Natürliche Feinde

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendung
Schlupfwespen, Microterys flavus				
Microterys flavus	Andermatt		Microterys flavus	*Zierpflanzen*: Napfschildläuse
Schlupfwespen, Pseudaphycus maculipennis				
Pseudaphycus maculipennis	Andermatt		Pseudaphycus maculipennis	*Zierpflanzen (öffentliche Tropenhäuser)*: Schmierläuse
Schlupfwespen, Trichogramma brassicae Bezdenko				
Trichobox	Landi Reba		Trichogramma brassicae	*Mais*: Maiszünsler
Trichocap-Kapseln zum Werfen	Landi Reba			
Tricho-Fix	Andermatt			
Trichogramma (Trichokarte)	Omya			
Trichosafe	Andermatt			
Trichosafe TS	Andermatt			

Saatgutbehandlungsmittel

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Gelbsenfmehl				
Tillecur	Andermatt	5	84.8 % Gelbsenfmehl	*Weizen*: Stinkbrand

Wundverschlussmittel für Gehölze

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Baumwachs (fest oder flüssig)				
Baumpflaster/Arbal	Andermatt	frei		*Obst allg.*: zur Wundbehandlung
Baumwachs kaltfl. Galopp	Bitex	frei		*Obst allg.*: für Veredelungsstellen, zur Wundbehandlung
Gaschell-Baumwachs	Radix	frei		
Lac Balsam	Scheidler	frei		
Kieselsäure, Tonmineralien, Haftmittel				
Stammanstrich	Andermatt	frei		*Kernobst, Steinobst*: zur Reduzierung von Frostschäden *Ziergehölze*: wie oben

Frischhaltemittel für Schnittblumen

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe/Konzentration	Anwendungsgebiet/Bemerkungen
Tonerde				
Chrysal RVB	Floristen	frei		Frischhalten von Schnittblumen nach der Ernte und beim Transport
Tonerde, Glucose				
Chrysal R01	Floristen	frei		Frischhalten von Schnittblumen in der Vase

2 Zugelassene Dünger und Handelssubstrate

Die Liste der Dünger und Handelssubstrate ist nach N-reichen, P-reichen und K-reichen Düngern, Mehrnährstoffdüngern, flüssigen Düngern, Kalkdüngern, Bodenverbesserern, Gesteinsmehlen, Mikroorganismenpräparaten, Algenprodukten, Abdeckmulch, Düngerzusätzen, Pflanzenstärkungsmitteln, Blatt- und Spurenelementdüngern und Handelssubstraten gegliedert. Mulchfolien sind nicht in der Hilfsstoffliste aufgeführt. Innerhalb jeder Kategorie sind die Produkte alphabetisch geordnet. Die aufgelisteten Produkte erfüllen die Anforderungen des Biolandbaus. Ein Wirkungsnachweis wird für die Aufnahme jedoch nicht vorausgesetzt (z.B. für Bodenverbesserer, Düngerzusätze oder Pflanzenstärkungsmittel). Die Aufnahme auf diese Liste stellt somit keine Anwendungsempfehlung dar. Für jedes Produkt sind Verkaufsfirma, Zusammensetzung, Gehaltsangaben und Bemerkungen angegeben. Adressen und Telefonnummern der Firmen sind am Schluss der Hilfsstoffliste aufgeführt. Die Einteilung der Düngertypen stimmt nicht mit der Einteilung in der Eidg. Düngerverordnung (DüV) und der Düngerbuch-Verordnung (DüBV) überein.
Futtermittel wie zum Beispiel Kartoffelprotein oder Ölpresskuchen sind als Dünger erlaubt, sofern sie den Richtlinien Art. 3.1.7-3.1.9 der BIO SUISSE entsprechen. Ihre Verwendung ist auf ein Minimum zu begrenzen.
Beim Ausbringen von staubigen Düngern wird zum Schutz der Anwender das Tragen von Staubschutzmasken empfohlen.

Verwendete Abkürzungen und Zeichen:

Ca	Kalzium	OS	organische Substanz
H_2O	Wasser	P_2O_5	Phosphat
K_2O	Kaliumoxid	SiO_2	Siliziumoxid
Mg	Magnesium		
mS	Millisiemens	*)	provisorisch zugelassen
N	Stickstoff	•	von BIO SUISSE lizenzierte Produkte

N-reiche Dünger

	Handelsname	Firma		OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Verfügbarkeit
	Azocor 8 *)	Méoc	Getrockneter Mist, Hornmehl, Wollreste	60	9	1	0.5	1	0.5	
•	Azor Bio-Stickstoffdünger	Hauert	Malz, Maisprotein	75	8					
	Bio 9-1-0.5 *)	Agribort Riddes	Presskuchen, Wollreste, Hühnermist, Hühnerfedern	66	9	1	0.5			
•	Biorga Stickstoffdünger gekrümelt	Hauert	Kompost/Traubentrester, Hornmehl, Malz, Vinasse	80	10-11		1			
•	Biorga Stickstoffdünger pelletiert	Hauert	Kompost/Traubentrester, Hornmehl, Malz, Vinasse	80	10-11		1			
•	Biorga Stickstoffdünger Pulver	Hauert	Kompost/Traubentrester, Hornmehl, Malz, Vinasse	80	10-11		1			

ff. N-reiche Dünger

	Handelsname	Firma		OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Verfügbarkeit
	Haarmehl Pellets 4 mm	Landor	Schweineborsten		13	1.4	0.2			
•	Hornmehl	Hauert	Tierhörner	80	14					mittel (2-3 Monate)
	Hornspäne	Renovita	Tierhörner	85	14					langsam (6-8 Monate)
•	Hornspäne fein	Hauert	Tierhörner	85	14					langsam (3-6 Monate)
•	Hornspäne mittel	Hauert	Tierhörner	85	14					langsam (5-8 Monate)
	Hornspäne SI fein, 1-4 mm	Landor	Tierhörner		14					
	Hornspäne SII fein, 4-7 mm	Landor	Tierhörner		14					
	Humosan-Horngriess/Hornspäne	Humosan	Tierhörner	85	14					mittel bis langsam

P-reiche Dünger

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Agri P15	Agribort Fully	Rohphosphat, Meeresalgen			15		36		
ASP 60	Feuerstein	Thomasmehl			6		32	2.4	
Biophos	Agroline	Rohphosphat			33		39		
Dolophos	Reichmuth	Weicherdiges Rohphosphat, kohlensaurer Magnesiumkalk			15		29	4	
Granuphos 18	Landor	Rohphosphat, Dolomit			18		22	4.8	
Litho Physalg 18	Timac	Rohphosphat, Dolomit, Meeresalgen			18		31	1.8	
Maxiflor P7	Landor	Rohphosphat, Magnesiumkalk			7		22	2.9	

K-reiche Dünger

weitere K-Quellen: siehe unter «Gesteinsmehle»

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Hapa Kali	Hauert	Kaliumsulfat				50			nur bei nachgewiesenem Kalimangel (Bodenproben)
Kalimagnesia (Patentkali)	Landor, Hauert	Kaliumsulfat, Magnesiumsulfat				30		6	dito
Kalin	Hauert	Kaliumsulfat				50			dito
Kalisulfat 50 %	Landor, Kali	Kaliumsulfat				50			dito
Magnesia-Kainit	Kali	Kalirohsalz (Kainit)				11		3	dito
Patentkali (Kalimagnesia)	Kali	Kaliumsulfat, Magnesiumsulfat				30		6	dito
Solupotasse	Kali, Landor	Kaliumsulfat				50			dito

Mehrnährstoffdünger

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Agrifum *)	Landi/ fenaco	Rindermist, Grünkompost	70	2.2	2	2.2		1	
	Agro Biosol	Isely	Fermentierte Pilzbiomasse	80	5	0.5	0.5			
	Angibio 6	Agribort Fully	Kompostierte Fischabfälle	55	7	5			2	
•	Biorga Natur Volldünger	Hauert	Kompost/Traubentrester, Malz, Vinasse, Tonmehl, Vinassekali	60	4	1	5		0.7	
	Biorga Rasendünger	Hauert	Kartoffelprotein, Malz, Vinasse	60	6	1	4		0.7	
•	Biorga Vegi	Hauert	Malz	70	5	1	5			
	Biovin	Enpro	Traubentrester	65	2	0.7	2.5	1	0.3	
	Collit-Standard *)	Omya	Hühnermist (gekörnt)		5	2	2			
	Foodgreen	Agrano	Hefe	85	7.2	1.5	1.6	1.5		
	Fumor grün *)	Bachmann	Hühnermist	65	2.7	2.7	2.7		0.4	
	Gallina Swiss *)	Jud	Hühnermist	65	3	3	3		0.4	
	Gallitos *)	Bernasconi	Malz, Hühnermist, Kartoffelprotein	65	4.5	2	3		0.5	
	Guanumus	Agribort Fully	Fischabfälle (kompostiert)	45	3	0.9	2		4	
	Herbaguano	Agribort Fully	Fischabfälle (kompostiert) Federmehl, Rohphosphat, Vinasse, Dolomit	33	3	3	15		3	
	Hexabio	Landor	Fermentierte Pilzbiomasse		6	2	2	18	0.6	
	Hühnermist gewürfelt *)	Hauert	Hühnermist	65	3	3	1.5			
	Humixa-B	Farmtech	Wurmhumus, Enzyme		3.5					
	Humotin *)	Hauert	Malz, Vinasse, Hühnermist	60-70	4	2-2.5	3-3.5			pelletiert
	Italpollina *)	Reichmuth	Hühnermist	70	4	4	3		0.5	
	Kompostierter Mist *)	Hauert	Stallmist, Gartenkompost	25-30	8.0-1	0.6-0.8	0.8-1			
	Kuhmist gewürfelt *)	Hauert	Kuhmist	65	1.7	1	2			
	Kuhmist pelletiert *)	Méoc	Kompostierter Rindermist	65	3	3	4			
	Maltaflor	Landor	Malz		5	1	5			
	Natura Rindermist *)	Optisol	Rindermist, Dolomit, Traubenhäute	60	1.5	0.8	1.2		2.4	
	Ökohum Bio-Langzeitdünger	Ökohum	Pilzbiomasse, Vinassekali, Rohphosphat, Tonmehl		7	4	7			
	Optisol Universel *)	Optisol	Huhnermist	65	3	3	3		0.4	
•	Organische Pflanzennahrung Belflor Bio	Bachmann	Kompost, Horn, Malz, Algenprodukte	25-35	3	3	3			
	Oscorna Floracorn	Humosan	Rizinus-, Raps-, Sojaschrot, Trebermehl	90	5.5	4.6	1.4			
	Phytoperls	Landor	Maisprotein		7.5	5.5	1			
•	Reinor *)	Hauert	Malz, Vinasse, Hühnermist, Kartoffelprotein	60	5	1.5	4		0.7	

ff. Mehrnährstoffdünger

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Rizinusschrot	Humosan	Rizinusschrot	75-80	5	2	1.5			
•	Rizinusschrot	Thurella	Rizinusschrot	75	6	2	1			
	Rizinusschrot	Méoc	Rizinusschrot	75	6	2	1			
	Rizinusschrot	Landor	Rizinusschrot	75	5	2	1			
	Valorga *)	Agribort Fully	Rindermist, Nadelholzrinden (kompostiert)	43	0.6	0.3	1.2	0.9	0.3	
	Vivasol *)	Vivasol, Landor	Hühnermist getrocknet, pelletiert	85	4.6	3.3	2.5	3.5	0.6	

Mehrnährstoffdünger (mit Patentkali und/oder Kalisulfat)

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Agri PK 0.8.20	Agribort Fully	Rohphosphat, Kalkalgen			8	20	17		nur bei nachgewiesenem Kalimangel (Bodenproben)
Biosol	Isely	Fermentierte Pilzbiomasse, Patentkali	70	5	0.5	1			dito
Oenutri	Isely	Fermentierte Pilzbiomasse, Patentkali	70	5	0.5	1			dito
Optisol K+ *)	Optisol	Hühnermist, Kalisulfat	60	1.5	2	10		0.3	dito
Organos *)	Hauert	Malz, Vinasse, Hornmehl, Rohphosphat, Hühnermist, Patentkali	60	9	3	6		1	dito

Flüssige Dünger

Bei der Anwendung von Flüssigdüngern ist darauf zu achten, dass sie nicht auf erntereife Produkte gelangen.

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Bioalgi Vegetali	Bioline	Vinasse, Algenextrakte		2.2		8			
	Biocorrettore Vegetale	Bioline	Vinasse, Torfextrakte		2.2		9			
	Biodite Vegetale	Bioline	Vinasse, Torfextrakte		2.2		9			
	Bioequi Vegetale	Bioline	Vinasse, Schachtelhalm-, Thymianextrakte		2.2		4			
	Bioorti vegetale	Bioline	Vinasse, Brennessel-, Wermuth- und Rainfarnextrakt		1.9		13.2			
	Biopropol Vegetale	Bioline	Vinasse, Propolis, Thymian-extrakt		2.1		7.6			
•	Biorga N flüssig	Hauert	N-reiche Vinasse		7					
	Biorga NK flüssig	Hauert	K-reiche Vinasse		2.5		7			
	Biovin (flüssig)	Enpro	Traubenkerne	65	2.7	2.7	2.7		0.4	
	Delfan	Optisol	hydrolisierte Tierhäute	20	10					
	Humixa-R	Farmtech	Wurmhumus, Enzyme		3.5					
	Liquazor	Landor	Hydrolisierte Tierhäute		9					
	Presswasser aus Kompogasanlage	Kompogas	Flüssigfraktion von Gärgut	6	0.4	0.2	0.5	0.5	0.1	in % Frisch-substanz
	Trapper	Omya	Hydrolisierte Tierhäute		14					für Flüssiganwen-dung
	Trapper flüssig	Omya	Hydrolisierte Tierhäute		9					
	Universaldünger Or Brun	Andermatt	Fischgräte, Hefe, Vinasse, Meeresalgen	38	3	1	4.5	1	3	
•	Vegesan Bio	Hauert	Vinasse		3.3		2.5			
	Vinasse	Landor	Vinasse		5	0.3	6			

Kalkdünger

siehe auch unter: «P-reiche Dünger», «Algenprodukte», «Gesteinsmehle»

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Agro-Düngkalk	Landi/ fenaco	Kohlensaurer Kalk					38	0.6	
	Calcisol/Calcosol	Feuerstein	Kohlensaurer Kalk					38		
	Calcodol 10	Feuerstein	Kohlensaurer Kalk, Dolomit					28	6	
	Chaux à semer I	Holcim	Kohlensaurer Kalk					39	0.1	
	Chaux à semer III	Holcim	Kohlensaurer Kalk					30	0.1	
	Dolokorn	Reichmuth	Kohlensaurer Magnesiumkalk					26	8	
	Dolomit	Agroline	Kohlensaurer Magnesiumkalk					22	13	
	Dolosul	Reichmuth	Dolomit, Gips					22	4.8	S 7 %
	Hasler Düngkalk	Landor	Kohlensaurer Kalk					37	1.5	
	Kalk-Steinmehl	Ulrich	Kohlensaurer Kalk					20-25		
	Kohlensaurer Kalk	Reichmuth	Kohlensaurer Kalk					38	1.5	
	Magnesiumkalk Dolomit	Landor	Kohlensaurer Magnesiumkalk					21	11	
	Naturrein Magnesiumkalk	Flora Geissler	Dolomit					22	12	
	Naturrein Rasengrün	Flora Geissler	Dolomit, Basalt, Tonmehl, Kartoffelrestwasser, Bakterien	7.5	0.3	0.2	0.3	16	8	
	Ovo Grit 12	Holcim	Kohlensaurer Kalk					39	0.1	
•	Ricokalk	Ricoter	Kohlensaurer Kalk aus der Zuckerfabrikation	10		1		22	0.6	
	Vitalsel AM.C.	Hedel	Meeresalgen, Tonmineral, Meersalz					30	2.1	Na 3.6 %

Bodenverbesserer

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Belflor Gartenkompost	Bachmann	Grünabfälle (kompostiert)	37	1.3	0.7	0.9	5	0.8	Transportdistanz max. 80 km ab Werk
	Belflor Rindenhumus	Bachmann	Baumrinde (kompostiert), Meeresalgen, Urgesteinsmehl							Zuschlagsstoff für Substrate
	Bihutherm (lose und pelletiert)	Renovita	Gehäckseltes Stroh	75	0.5	0.4	2	0.6		
	Biodenit	Rolusa	Zuckerrübenschnitzel, Luzerne-strohwürfel, Kenaf, Getreide-abgang, Mikroorganismen		1.5	0.4	1.6		0.3	Bodenverbesserer, Torfersatz
	Biohumin	Pareno	Sägemehl, Gesteinsmehle, Xylite, Treber, Vinasse	55	0.3	1.1	0.2			
	Biplantol agrar	Plantosan	Lavagranulat, Opticulit, Biplantol, Horngriess, Hafer-strohmehl, Urgesteinsmehl							Bodenverbesserer für die Landwirt-schaft
	Biplantol terra	Plantosan	Lavagranulat, Opticulit, Biplantol, Horngriess, Hafer-strohmehl, Urgesteinsmehl							Bodenverbesserer für den Gartenbau
	Casibac CP10	Casanova	Zeolith, Mikroorganismen							
	Champi-Hum	Kuhn	Champignonmist	58	0.5	0.7	1	3	0.6	Transportdistanz max. 80 km ab Werk
•	Compost Elite	Germanier	Rasenschnitt, Grünabfall	36	1.5	0.7	1.2	6.2	0.5	Transportdistanz max. 80 km ab Werk

ff. Bodenverbesserer

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
•	Compost Junior	Germanier	Rasenschnitt, Grünabfall							Transportdistanz max. 80 km ab Werk
•	Dünge-Kompost	Weiherhus	Grünabfall, Chinaschilf	60	0.5	0.8	1.2			Transportdistanz max. 80 km ab Werk
	E-2001	Andermatt	Ahornblattersirup, Melasse, Bierhefe, Mikroorganismen							
	Elementarer Schwefel	Schweizer-hall								S-Gehalt 99.9 %, Verwendung nur bei nachgewiesenem Bedarf
	Frischkompost	Kym	Grün-, Gemüseabfälle	22	1	0.4	0.7	2.7	0.3	Transportdistanz max. 80 km ab Werk
•	Frischkompost	Weiherhus	Grünabfall, Pferdemist		1.8	0.7	0.7			Transportdistanz max. 80 km ab Werk
	Fumor blau *)	Bachmann	Champignonmist, Traubentrester, Rindermist, Kaffeesatz	47	1.3	0.7	1.3		0.3	
	Gärgut aus Kompogasanlagen	Kompogas	Gärgut aus Vergärung	30-50	0.6	0.2	0.5	3.5	0.4	in % Frischsubstanz; Transportdistanz max. 80 km ab Werk
	Gartenhumus	Ricoter	Landerde, Gartenkompost	16	1	0.6	1.1			Transportdistanz max. 80 km ab Werk
•	Gartenkompost Bio-Line	Ricoter	Grünabfälle	40	1.3	0.2	1.5	3.3	0.6	Transportdistanz max. 80 km ab Werk
	Geolife	Bioma	Milchpulver, Pflanzenextrakt, Vitamine, Mikroorganismen, Gesteinsmehle, Vinasse							diverse Zusatznamen für verschiedene Anwendungsbereiche
	Gerber Champignonerde	Gerber	Pferdemist, Hühnermist, Torf, Gips	20	0.6	0.5	0.8	0.6	0.2	
	Humaform (10 mm)	Coulette	Kompostierte Grünabfuhr und Gartenabfälle	40	1.3	0.6	1	6.5	0.7	Transportdistanz max. 80 km ab Werk
	Humosan Bodenaktivator	Humosan	Rizinusschrot, Rapsschrot, Steinmehl, Bentonit, Algenkalk, Melasse	45	2	1	0.5			
•	Knospen Kompost	StGBS	Grüngut, Enzymix, Urgesteinsmehl, Hornmehl							Transportdistanz max. 80 km ab Werk
•	Komposterde	Komposta	Torferde, Holz, Grünabfall, Schilf, Hornspäne, Hühnerfedern	40						Transportdistanz max. 80 km ab Werk
•	Komposterde	Vollenweider	Kompost, Landerde	40	1.5	1.8	1.2	6	0.5	Transportdistanz max. 80 km ab Werk
	Mator	Méoc	Traubenkernentrester (pelletiert)	75	0.5	0.5	0.5		0.2	
	Naturrein Bodengranulat	Flora Geissler	Dolomit, Basalt, Tonmehl, Dextrin, Bakterien	3.5			1.7	10	10	
	Optisol Organo *)	Optisol	Traubentrester, Kaffeesatz, Tannenrinde, Hühnermist	80	1.2	0.7	1.2			
	PRP Bodenmineral	PRP	Meeralgenkalk, Meersalz, Spurenelemente, Lignosulfonate					24	1.5	
	Rasenerde	Vollenweider	Kompost, Sand	25	0.8	0.9	0.6	3	0.3	Pasenunterhalt
	Reifekompost	Kym	Grün-, Gemüseabfälle	48	0.9	0.3	0.7	2.3	0.2	Transportdistanz max. 80 km ab Werk
•	Reifekompost	Weiherhus	Grünabfälle		1.8	0.7	2			Transportdistanz max. 80 km ab Werk

ff. Bodenverbesserer

	Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Sferosol	Schweizer-hall	Schwefel, Bentonit							zirka 87 % S, nur bei nachgewiesenem Bedarf
	Soil Tonic	Ledona	Kalisulfat, Wasserauszug von Kräutermischung, Spurenelemente				2.1			
	Terraform (25 mm)	Coulette	Kompostierte Grünabfuhr und Gartenabfälle	40	1.3	0.6	1	6.5	0.7	Transportdistanz max. 80 km ab Werk
	TMS-B mineralischer Bodenverbesserer	TMCE	Meeresalgenkalk, Dolomit, Kieserit, Lignosulfonate	15				20	6.7	5 4 %
•	Torfersatz Belflor Bio	Bachmann	Kompost, Holzfasern, Horn, Malz, Rohphosphat							Bodenverbesserer, Zuschlagsstoff für Substrate, Torfersatz
•	Torfersatz Bio-Line	Ricoter	Kompost, Holzhackschnitzel, Vinasse	94	0.5	0.1	0.1	0.5	0.1	zur Bodenlockerung, Bestandteil von Erdenmischungen, Abdeckmulch
	Vegethumus *)	Méoc	Schafmist, Kaffeesatz	61	2	0.5	1		1.5	
	Vermi	Andermatt	Wurmhumus	17	0.7	0.5	0.6			
	Wauwiler Champignon-Kompost	Gassmann	Pferde-, Hühnermist, Gips, Soja	28	0.9	0.7	1.4		0.3	

Gesteinsmehle

	Handelsname	Firma	Zusammensetzung	SiO_2 %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
	Biolit	Landor	Urgesteinsmehl aus Diabas	50		0.4	2.2	1.2	2.4	
	Clinosoil	Eco	Aluminiumsilikat	64			1.2	3.5	0.7	
	Edasil G	Renovita	Bentonitmehl	56			2	3	2.5	
	Europerl	Schweizer-hall	Perlit				5			
	Fitoclin	Eco	Microlit	64			1.2	3.5	0.7	
	Hersbrucker Gesteinsmehl	Reichmuth	Gesteinsmehl	28		0.2	2.5	12	4	
	Klinofeed	Unipoint	Zeolith, Klinoptilolith, Tonminerale, Feldspat	70			2.8	2.5	0.6	
	Napf-Steinmehl	Ulrich, Andermatt	Gesteinsmehl	58				12	0.3	
	Perlit	Bernasconi	Vulkangestein	75			2.5	0.9	0.4	
	Pflanze 2000	Holistic	Urgesteinsmehl aus Diabas	50		0.4	2.2	1.7	4	
	Ringolit	Reichmuth	Urgesteinsmehl aus Diabas	42		0.3	0.7	7	4	
•	Steinmehl mit Magnesium	Bernasconi	Gesteinsmehl	20				5	19	
•	Steinmehl siliziumreich	Bernasconi	Gesteinsmehl	58				8	1.2	
	Steinmehl siliziumreich	Landor	Gesteinsmehl	58				8	1.2	
•	Urgesteinsmehl	Hauert	Urgesteinsmehl vom Gotthard	56			2.9		2.4	
	Vulkamin (Urgesteinsmehl)	Landor, Rem	Vulkanisches Urgesteinsmehl	48			5.1	5.7	0.6	

Mikroorganismenpräparate

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Biofitac PF1	Biophyt	Pseudomonas fluorescens							
EM1	Bionova	Bakterien, Hefen, Pilze							
MBI 600	Andermatt	Bacillus subtilis							
Polyversum	Andermatt	Pythium oligandrum							
Tri 002/003	Andermatt	Montmorillonit, Sand, Mikroorganismen (Trichoderma harzianum)	2						
Tri-Ton	Triton	Blähton, Mykorrhizakulturen							
Vaminoa	Andermatt	VA-Mykorrhiza	2						

Algenprodukte

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Agricol	Renovita	Meeresalgen							
Algada	Künzle	Meeresalgen	50	1.5	3	20	0.1	0.3	
Algamer compact	Agribort Fully	Meeresalgen					32	1.8	
Algamer poudre	Agribort Fully	Meeresalgen					32	1.8	
Algan	Omya	Braunalgenextrakt		1		4.2	1.5		
Algifol	Andermatt	Meeresalgen							
Algobrun Nr. 1	Landor	Braunalgen		0.2	0.3	1.3	0.6	0.1	
Algobrun Nr. 2	Landor	Braunalgen		0.7		2.5	0.9	0.2	
• Biorga Meeresalgenkalk gekörnt	Hauert	Meeresalgen					30	2.8	
Coralite Kk+ Pulver	Wytor	Meeresalgen					11	1.2	
Glenactin 290B	Landor	Meeralgenkalk, Braunalgen					28	2.5	
Goemar GA 14	Siegfried	Braunalgenextrakt							
Granukal	Omya, Renovita	Calcium- und Magnesiumcarbonat aus Algenablagerungen					32	1.5	
Granulit KR+	Wytor	Meeresalgen					30	3	
Hasolit Kombi granuliert	Landor	Meeresalgenkalk, Dolomit					35	3.8	
Litho KR+	Wytor	Meeresalgen					30	3	
Lithomagnesium	Timac	Meeresalgenkalk, Dolomit					25	6.6	
Lithothamne Granulit	Wytor	Meeresalgen					30	3	
Lithothamne T400	Timac	Meeresalgen					29	1.8	

Abdeckmulch

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Abdeckmaterial Ricoter	Ricoter	Koniferenrinde		0.2	0.1	0.1	0.3		
Belflor Abdeckmaterial	Bachmann	Koniferenrinde	67	0.3					C/N-Verhältnis: 92
Cartalit	Bernasconi	Schilfhäcksel und aromatische Pflanzen							
Decover Pinienrinde	Bachmann	Borke der Meerespinie	77	0.2					C/N-Verhältnis: 215
• Biorga Terravital Abdeckmulch	Hauert	Chinaschilf							
Oecoplan Abdeckmatérial	Coop	Nadelholzrinde							C/N-Verhältnis: 130
Rindenmulch	Renovita	Rinden							
Terra fit	Ökohum	Holzfaser, Stroh, Kartoffelstärke, Hornspäne	90	3 a)					a) in kg/m³

Düngerzusätze

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Actilith	Timac	Algenkalk, Bentonit, Hefen							für Gülle
Algalise L	Agribort Fully	Algenkalk, Bentonit, Hefen							für Harngülle
Algalise P	Agribort Fully	Algenkalk, Bentonit, Hefen							für Vollgülle
Amalgerol 2-verde	Landor	Pflanzl. Öle, Meeralgen, ätherische Öle, Pflanzenextrakte, Limonen-Terpene, Alkohol							für Gülle und Kompost
Amelgo-verde	Amelgo	Pflanzl. Öle, Meeralgen, ätherische Öle, Pflanzenextrakte, Limonen-Terpene, Alkohol							für Gülle und Kompost
• Biorga Kompost-Blitz	Hauert	Kartoffelprotein, Malz, Vinasse, Kräuter	60	5	1	3			für Kompost
Biorott	Andermatt	Mikroorganismenkonzentrat, Melasse		7					für Kompost
Biosuza	Guignard	Mikroorganismen							für Gülle
Biovin-Kompostaktivator	Enpro	Traubenkerne, Gesteinsmehl							für Kompost
Biplantol Kompost	Plantosan	Nähr- und Wirkstoffe in homöopathischer Konzentration							für Kompost
Biplantol plus	Plantosan	Nähr- und Wirkstoffe in homöopathischer Konzentration							für Rindergülle, Mist und Kompost
Biplantol plus SG	Plantosan	Nähr- und Wirkstoffe in homöopathischer Konzentration							für Schweinegülle, Hühner- und Pferdemist
Casibac CP	Casanova	Mikroorganismen							für Gülle und Mist
Casibac P15	Casanova	Mikroorganismen							für Gülle ohne Stroh
CMC-Kompoststarter 550	Verora	Erde, Gesteinsmehl, Mikroorganismen							für Kompost
Compolit/Tradilit	Comptoir	Bakterien, Algenkalk, Zuckerrohrmelasse							für Einstreue und Mist
• Composter *)	Hauert	Hühnermist, Malz, Vinasse, Kartoffelprotein, Traubentrester	60	5	1.5	3		0.6	für Kompost

ff. Düngerzusätze

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Compostol natura	Socora	Ätherische Öle, Fettsäure, Terpene, Alkohol							für Gülle, Mist
Enzymix	Farmtech	Meeresalgen, Dolomit, Nährsubstrat für Enzyme	8	1.2	0.5	0.6	3.3	1.6	für Gülle, Mist und Kompost
Gartenaktiv KR+	Wytor	Algen, Hühnerfedern		5	3		10	1.2	für Kompost
Glenor Kr+	Wytor	Meeresalgen, natürliche Ionenaustauscher, Aktivatoren							für Gülle
Gülle 2000	Holistic	Gesteinsmehl aus Diabas			0.4	2.2	1.7	4	für Gülle
Hasolit B Pulver	Landor	Meeresalgenkalk					30	2.6	für Gülle und Kompost
Hasorgan MC flüssig	Landor	Braunalgenextrakt				3.3			für Gülle
HE Confort	Wytor	Kalk, Algen					20	2.9	
Kompost 2000	Holistic	Gesteinsmehl aus Diabas			0.4	2.2	1.7	4	für Kompost
Micro Tonic	Ledona	Natriumsulfat, Wasserauszug von Kräutermischung, Spurenelemente							für Gülle, Mist und Kompost; Na 1.6 %
Microbactor	Landor	Bakterienkulturen							für Gülle
MicrobeLift	Landor	Bakterienkulturen							für Gülle, Mist und Kompost
Microsan	Agrisan	Pilz-, Bakterienkulturen, Weizenkleie	7			8	4		für Gülle, Mist und Kompost
Penergetic-g	Penergetic	Calciumcarbonat, Quarzmehl							für Gülle
Penergetic-k	Penergetic	Calciumcarbonat, Quarzmehl							für Kompost
Plocher g-Gülle & Jauche	Huplo	Calciumcarbonat							
Plocher g-Schweinegülle	Huplo	Calciumcarbonat							
Plocher k-Kompost & Mist	Huplo	Calciumcarbonat							
Progénia-Einstreupulver	Marthy	Monocalciumphosphat, Siliziumdioxid, Kohlenhydrate, Eukalyptusextrakte			16				für Gülle und Mist
PRP Gülle Fix	PRP	Meeresalgenkalk, Meersalz, Lignosulfonate, Spurenelemente					24	1.5	für Gülle
Schnellkomposter Liquid	Ledona	Natriumsulfat, Wasserauszug von Kräutermischung, Spurenelemente, Melasse							für Kompost; Na 1.4 %
Seso	Verora	Wasser, Melasse, Mikroorganismen							
Sojall-Bio-Power	Ritter	Calcium- und Magnesiumcarbonat							
Sojall-Micro-Power	Ritter	Melasse							
Terra Biosa	Biosa	Kohlehydrat, Kräuter, Mikroorganismen, EM1							für Kompost und Boden
Tominmehl	Andermatt	Basalt-Urgestein							
Tradilyse/Fertilyse	Comptoir	Bakterien, Algenkalk, Zuckerrohrmelasse							für Gülle und Mist

Pflanzenstärkungsmittel

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Bentosan	Agrisan	Bentonit, Meeresalgen, Medizinalpflanzen							
Biplantol Contra X2	Plantosan	Nähr- und Wirkstoffe in homöopath. Konzentration, äth. Öle, Rapsöl							
Biplantol Rose	Plantosan	Nähr- und Wirkstoffe in homöopathischer Konzentration							
Biplantol SOS	Plantosan	Nähr- und Wirkstoffe in homöopathischer Konzentration							
Biplantol vital	Plantosan	Nähr- und Wirkstoffe in homöopathischer Konzentration							
Crop-Set	Schneiter	Yuccaextrakt, Fermentationsprodukt aus Lactobazillus acidophilus		3					
Equisan	Agrisan	Ackerschachtelhalm							
Floraforce	Bioflora	Traubenzuckerderivat, Milchsäure, Pflanzenextrakte, versch. Zuckerarten		1.2	0.2	0.7	0.3	0.1	
Humixa-Normal	Farmtech	Extrakt aus Wurmhumus	38	3.5	0.3	16			
Humixa-Polivalente	Farmtech	Extrakt aus Wurmhumus	38	3.5	0.3	16			
Microsan-P	Agrisan	Gesteinsmehl, Pflanzenmehl							
NaturPur Bodenstärker	Mauser	Kalisulfat, Spurenelemente, Wasserauszug von Kräutermischung				2.1			
NaturPur Pflanzenstärker	Mauser	Kalisulfat, Netzmittel, Spurenelemente, Wasserauszug von Kräutermischung				2.1			
Penergetic-p	Penergetic	Calciumcarbonat, Quarzmehl							
Penergetic-p (flüssig)	Penergetic	Melasse							
Pflanzenblauwasser	PRP	Wasser, Kalium, Kupfer, Spurenelemente				7			Cu 0.02 %
Plant Tonic	Ledona	Kalisulfat, Netzmittel, Spurenelemente, Wasserauszug von Kräutermischung				2.1			
Plocher p-Kaleaf Blattstärkung	Huplo	Patentkali							
Plocher p-Melasse-Blatt	Huplo	Melasse							
Plocher p-Pflanzenaktiv-Kaleaf	Huplo	Patentkali							
Plocher p-Pflanzenstärkung	Huplo	Calciumcarbonat							
Plocher p-Pflanzenstärkung-Dolomit	Huplo	Dolomit							
Plocher p-Pflanzenvital	Huplo	Dolomit							
Plocher p-Pflanzenvital-Kaleaf	Huplo	Patentkali							
Plocher p-Wurzelraum I	Huplo	Dolomit							
Plocher p-Wurzelraum II	Huplo	Melasse							

ff. Pflanzenstärkungsmittel

Handelsname	Firma	Zusammensetzung	OS %	N %	P_2O_5 %	K_2O %	Ca %	Mg %	Bemerkungen
Plocher p-Wurzelraum III	Huplo	Patentkali							
Proposan 40 MG/ML	Agrisan	Propolis, Alkohol, Flavonoide		5.8	0.7	2.3			
Sojall-Vitanal	Ritter	Zuckermelasse, Bakterienkulturen							
Stärkungsmittel TMF für Pflanzen	TMCE	Kalium-, Magnesiumsulfat, Algenextrakt, Spurenelemente				2.9		0.3	S 2.8 %, Na 1.1 %
Stubble-Aid	Schneiter	Yuccaextrakt, Fermentationsprodukt aus Lactobazillus acidophilus		3					
Targanic	AJE	Fulvosäuren							
Turf-Set	Schneiter	Yuccaextrakt, Fermentationsprodukt aus Lactobazillus acidophilus		3					
Urtisan	Agrisan	Brennnessel							
Vermi-Sol 1	Racroc	Extrakt aus Vermikompost, Speiseessig							
Vitasel A.M.C.Plus	Hedel								
Vitasel Vinea plus	Hedel	Meeresalgen, Ton							

Blatt- und Spurenelementdünger

Der Einsatz von Spurenelementdüngern (Eisen, Mangan, Kupfer, Molybdän, Zink, Bor) sowie von rasch wirksamen Kalzium- und Magnesium Blattdüngern ist an folgende Bedingungen geknüpft:

- Vorliegen einer Bodenanalyse der entsprechenden Parzelle (max. 4 Jahre alt)
- Ausgeschiedene Kontrollparzelle (ohne Behandlung)
- Dokumentation der Wirkung des Spurenelementeinsatzes

Der Einsatz der bezeichneten Produkte ist **meldepflichtig (mp)** (siehe Spalte Bemerkungen) und muss **vor der Anwendung** bei der **Zertifizierungsstelle** gemeldet werden. Das Meldeformular ist erhältlich bei:
bio.inspecta, Ackerstrasse, Postfach, 5070 Frick, Tel. 062 865 63 00, Fax: 062 865 63 01, E-Mail admin@bio-inspecta.ch

Verwendete Abkürzungen: (B) Bor, (Ca) Kalzium, (Cu) Kupfer, (Fe) Eisen, (Mg) Magnesium, (Mn) Mangan, (Mo) Molybdän, (N) Stickstoff, (S) Schwefel, (Zn) Zink
mp = meldepflichtig

Düngertyp/ Handelsname	Firma	Zusammensetzung	Ca %	Mg %	Fe %	Mn %	B %	Mo %	Bemerkungen
Bor (B)									
Borax	Hauert	Natriumtetraborat					15		mp
Bortrac	Landor	Polybor					15		mp, flüssig
Microbor	Leu	Polybor					15		mp, flüssig
Calcium (Ca)									
Calciumchlorid	Schneiter	Calciumchlorid	12						mp
Chlorcal-220	Agribort Fully	Calciumchlorid	16						mp
Stopit	Landor	Calciumchlorid	12						mp
Tip	Leu	Calciumchlorid	12						mp

ff. Blatt- und Spurenelementdünger

Düngertyp/ Handelsname	Firma	Zusammensetzung	Ca %	Mg %	Fe %	Mn %	B %	Mo %	Bemerkungen
Eisen (Fe)									
Aton Fe	Optisol	Fe aminosäurekomplexiert			5.3				mp, N 2 %, flüssig
Optifer 11	Optima	Eisenchelat aus der Rinde der Hemlockstanne			11				Pulver
Optifer 6 flüssig	Optima	Eisenchelat aus der Rinde der Hemlockstanne			6				
Optifer Fe++	Landor	Eisenchelat aus der Rinde der Hemlockstanne			6				
Magnesium (Mg)									
Bittersalz	Kali, Landor	Magnesiumsulfat		10					mp, S 3 %
Kieserit	Hauert, Landor, Kali	Magnesiumsulfat		16					mp, S 20 %
Mangan (Mn)									
Mangansulfat	Hauert	Mangansulfat				32			mp
Mantrac	Landor	Mangancarbonat				50			mp, flüssig
Micro-Mangan	Leu	Mangancarbonat				50			mp, flüssig
Optima Mn++	Landor	Manganchelat aus der Rinde der Hemlockstanne				6			
Molybdän (Mo)									
Natriummolybdat	Hauert	Natriummolybdat						40	mp
Zink (Zn)									
Zinksulfat	Hauert	Zinksulfat							mp, Zn 23 %
Zintrac	Landor								mp, flüssig, Zn 70 %

Handelssubstrate

Analysen gemäss FAW-Flugschrift 113 (1995)

Substratzuschlagsstoffe und Torfersatzprodukte: siehe auch unter «Bodenverbesserer»

Handelsname	Firma	Zusammensetzung	NH_4-N µmol/l	NO_3-N µmol/l	P µmol/l	K µmol/l	Salz µS/cm	pH (H_2O)	Bemerkungen
Presstopferden									
Belflor Presstopferde	Bachmann	Torf (60 %), Grüngutkompost, Rindenhumus, Horn, Malz	300-600	1500-3000	100-200	2000-3000	600-1000	6.0-6.8	Herstellungsdatum ja
Eco Grond (Brill)	Nieth	Torf (70 %), Grüngutkompost, Hornmehl	800-1200	5000-6000	600-1200	5000-7000	800-1200	5.5-6.5	Herstellungsdatum ja
Floragard Bio-Presstopferde	Floragard, Landi/ fenaco	Torf (70 %), Grüngutkompost, Malz, Vinasse	3420	3160	900	3190	1270	6.2	Herstellungsdatum nein
Klasmann KKS Bio-Potgrond	Schweizer	Torf (70 %), Grüngutkompost, Hornmehl, Dolophos	600-1200	3000 - 6000	500-800	2500-3500	1000-1800	6.0-6.5	Herstellungsdatum ja
Leureko A (Anzuchterde)	Leureko	Torf (50 %), Grüngutkompost, Landerde	50-200	1200 - 3400	70-170	4200-6400	900 - 1900	6.8-7.2	Herstellungsdatum ja
Ökohum-Bio-Presstopferde	Ökohum	Torf (70 %), Grüngutkompost	500-1000	2000-3000	200-500	5000 - 7000	1000 - 1500	6.8-7.3	Herstellungsdatum ja
Presstopferde 142	Ricoter	Torf (60 %), Kompost, Holzhackschnitzel, Hornspäne, Sand	400-800	1600-3200	500-1000	3000-6000	zirka 1400	zirka 6.5	Herstellungsdatum nein, mit Zusatzdüngung auch für Jungpflanzenanzucht
Statohum Bio-Presstopf	Patzer	Torf (70 %), Kompost, Hornmehl							Herstellungsdatum ja
Terreau B2	Landi/ fenaco	Torf (70 %), Grüngutkompost, Federmehl, Vinasse							Herstellungsdatum nein
Tref EKO 1	GVZ	Torf (65 %), Kokos, kompostierte Rinde, organischer Mischdünger	2350	850	900	1500	700-1100	5.6-6.2	Herstellungsdatum ja
Anzuchterden (Torfanteil: 51-70 %)									
Bio Statohum II	Patzer	Torf (65 %), Kompost, Hornmehl							für Topf, Herstellungsdatum nein
Eco Start (Brill)	Nieth	Weiss-/Schwarztorf (70 %), Grüngutkompost, Hornmehl							Herstellungsdatum ja
Floragard Bio-Kräuteranzuchterde	Floragard, Landi/ fenaco	Torf (70 %), Grüngutkompost, Flachsschaben, Malz, Vinasse, Phytoperls	5100	930	590	5060	1700	6.8	Herstellungsdatum nein
frux Kräutererde Anzuchtsubstrat	Patzer	Torf (70 %), Kompost, Hornmehl, Horngries	600-1200	2000-4000	500-800	2000-3000	600-1200	6.0	Herstellungsdatum nein
Klasmann KKS Bio Traysubstrat	Schweizer	Torf (70 %), Kompost, Hornspäne, Hornmehl	600-1200	3000 - 6000	500-800	2500 - 3500	1000 - 1800	6.0	Herstellungsdatum ja
Tref EKO 2	GVZ	Torf (65 %), Kokos, kompostierte Rinde, organische Mischdünger	2350	850	800	1500	700-1100	5.6-6.2	Herstellungsdatum ja

ff. Handelssubstrate

Analysen gemäss FAW-Flugschrift 113 (1995)

Handelsname	Firma	Zusammensetzung	NH_4-N µmol/l	NO_3-N µmol/l	P µmol/l	K µmol/l	Salz µS/cm	pH (H_2O)	Bemerkungen
Anzucht-, Topf- und Universalerden (Torfanteil: 31-50 %)									
Belflor Jungpflanzensubstrat	Bachmann	Torf (40 %), Grüngutkompost, Rindenhumus, See-, Chinaschilf, Landerde, Horn, Malz	300-600	1500-3000	100-200	2000-3000	800-1000	6.5-7.0	Herstellungsdatum ja
Eco Pot (Brill)	Nieth	Weiss-/Schwarztorf (50 %), Grüngutkompost, Holzfasern, Hornmehl, Horngries							Herstellungsdatum ja
Floragard-Bio-Topferde	Floragard, Landi/ fenaco	Torf (50 %), Kompost, Malz, Vinasse, Flachsschäben, Ton	3800	4600	880	6400	1900	6.7	für salztolerante Pflanzen, Herstellungsdatum nein
Gärtnererde Biopflanzen	Landi/ fenaco	Torf (50 %), Kompost, Malz, Vinasse, Flachsschäben, Ton	3800	4600	880	6400	1900	6.7	für salztolerante Pflanzen, Herstellungsdatum nein
Tref EKO 5	GVZ	Torf (45 %), Kokos, kompostierte Rinde, Rinde, organischer Mischdünger	2900	970	950	1700	800-1200	5.6-6.2	Herstellungsdatum ja
Anzucht-, Topf- und Universalerden (Torfanteil: 1-30 %)									
Bio-Erde	Terre	Torf (30 %), Kompost, Schwarzerde, Fasern, Ton, Sand	800	1900	20	6700	1300	6.9-7.0	Herstellungsdatum nein
Bio-Erde mit Torf	Ökohum	Torf (25 %), Kompost, Lava, Bims, Kokosfaser, Hornmehl, Hornspäne	1000-3000	3000-5000	400-600	2000-3500	1000-1500	5.0-7.0	für Anzucht, Herstellungsdatum nein
Biosol Universalerde mit Torf	Bachmann	Torf (30 %), Grüngutkompost, Rindenhumus, See-, Chinaschilf, Holzfaser, Landerde, Horn, Malz	600-1200	3000-6000	200-400	5000-6000	1000-1500	6.5-7.0	für Anzucht und Topf, Herstellungsdatum ja
Coco-Mix	Ökohum	Torf (25 %), Kokosstaub, Kokoslasern	0-100	0-100	0-100	1500-2500	400-700	5.0-6.0	Zuschlagsstoff für Substrate
Floragard Bio-Universalerde	Floragard, Landi/ fenaco	Torf (25 %), Kompost, Malz, Vinasse, Flachsschäben, Rindenhumus	6160	1670	220	6430	1850	6.6	für salztolerante Pflanzen, Herstellungsdatum nein
Klasmann KKS Bio Kräutersubstrat	Schweizer	Torf (30 %), Kompost, Kokospeat, Hornmehl	800-1400	2000-5000	500-800	3000-5000	1500-2000	6.0	Herstellungsdatum ja
Klasmann KKS Bio Topfsubstrat	Schweizer	Torf (30 %), Grüngutkompost, Kokospeat, Ton, Hornmehl	600-1200	3000-6000	500-800	2500-3500	1200-2000	6.0	Herstellungsdatum ja
Leureko C (Containererde)	Leureko	Kompost, Landerde, Hanffasern, Torf (5 %)	80-300	1500-4200	40-110	4200-6400	1200-2300	7.0-7.4	für Container, Herstellungsdatum ja
Leureko PT (Pflanzenerde)	Leureko	Kompost, Hanffasern, Torf (20 %)	30	2300	80	6200	1100	7.5	Herstellungsdatum ja
Lignostrat Typ Bio (Archut)	Kurras	Weisstorf (30 %), Rindenhumus, Vulkanton, Hornmehl, Hornspäne							Topferde, Herstellungsdatum ja
Swissfiber 2	Bachmann	Torf (30 %), Holzfasern, Seeschilf, Chinaschilf (kompostiert), Meeresalgen, Urgesteinsmehl							Zuschlagsstoff für Substrate
Universalerde	Vollenweider	Torf (30 %), Kompost, Landerde		4000-7000 **	30-150	5000-20000	2000-2500	7-7.5	für Topf- und Balkonpflanzen, Herstellungsdatum ja, **N_{min}

ff. Handelssubstrate

Analysen gemäss FAW-Flugschrift 113 (1995)

Handelsname	Firma	Zusammensetzung	NH_4-N µmol/l	NO_3-N µmol/l	P µmol/l	K µmol/l	Salz µS/cm	pH (H_2O)	Bemerkungen
Anzucht-, Topf- und Universalerden (torffrei)									
• Aussaaterde Belflor Bio	Bachmann	Kompost, aufgefasertes Nadelholz, Sand	500	3000	200	4000	800-1000	6.8	für Aussaaten und Stecklingsvermehrung, Herstellungsdatum ja
• Aussaaterde Bio-Line	Ricoter	Torfersatz (Toresa organic), Kompost, Kokopeat, Sand	100-500	900-2500	400-800	4000-8000	1300-1900	7.0-7.5	Herstellungsdatum nein, für Hobbygarten
• Balkonerde Bio-Line	Ricoter	Torfersatz (Toresa organic), Kompost, Kokospeat, Landerde	100-500	1900-5500	400-800	4000-8500	1500-2200	7.0-7.5	Herstellungsdatum nein, für Hobbygarten
Bio-Erde ohne Torf	Ökohum	Kompost, Lava, Bims, Kokosfaser, Hornmehl, Hornspäne	500-1000	2000-3000	300-600	5500-7500	1100-1600	7.0-7.5	für Stauden und Container, Herstellungsdatum nein
Bio-Universalerde	Ökohum	Grüngutkompost, Koko Ter, Bims	500-1000	2000-3000	300-600	5000-7000	1100-1600	6.8-7.5	Herstellungsdatum nein
Biosol Universalerde ohne Torf	Bachmann	Grüngutkompost, Rindenhumus, See-, Chinaschilf, Holzfaser, Landerde, Horn, Malz	600-1200	3000-6000	200-400	5000-6000	1000-1500	6.5-7.0	für Anzucht und Topf, Herstellungsdatum ja
Biotopp torffrei, Blumenerde	Floragard, Landi/fenaco	Rindenhumus, Holzfasern, Grüngutkompost	680-1600	60-140	160-400	5300-12000	830-1900	6.6-7.4	Herstellungsdatum nein
Chinaschilf kompostiert	Maurer	Chinaschilf, Gras, Ton							Zuschlagstoff für Substrate, Torfersatz
Coco-Ter	Ökohum	Kokosstaub							Zuschlagstoff für Substrate, Torfersatz
frux Öko-Blumenerde	Patzer	Holzfaser, Kompost, Ton	600-1200	2000-4000	600-1000	3000-4000			Herstellungsdatum nein
Gärtnererde	Maurer	Kompost, Landerde, Chinaschilf, Toresa organic		8100	1300	16000	1700	7.3	für Universalerde, Herstellungsdatum nein
Geranienerde	Weiherhus	Kompost, Landerde, Chinaschilf	50-300	5000-8000	10-100	8000-12000	1500-2500	6.5-7.5	für Terrassen- und Balkonerde, Herstellungsdatum nein
• Komposterde Belflor Bio	Bachmann	Kompost, Landerde, Horn, Malz	600	10000	300	4000	1000-1200	6.8	für Balkon- und Gartenpflanzen, Herstellungsdatum ja
Leureko P (Pflanzenerde)	Leureko	Kompost, Landerde, Hanffasern	120-300	1500-4200	70-170	5300-7500	1200-2300	7.0-7.4	Pflanzenerde, Herstellungsdatum ja
• Oecoplan Aussaaterde	Coop	Kompost, Kokospeat, Torfersatz (Toresa Organic), Sand	100-500	900-2500	400-800	4000-8000	1300-1500	7.0-7.5	für Haus und Garten, Herstellungsdatum nein
• Oecoplan Balkonpflanzenerde	Coop	Torfersatz (Toresa organic), Kompost, Kokospeat, Landerde	100-500	1900-5500	400-800	4000-8500	1500-2200	7.0-7.5	Herstellungsdatum nein, für Hobbygarten
• Oecoplan Torfersatz	Coop	Holzhackschnitzel, Kompost, organischer Dünger							Bodenverbesserung, Zuschlagstoff für Substrate, Torfersatz
Rasenerde	Weiherhus	Kompost, Landerde, Sand	80	500	75	2290	2010	7.9	Herstellungsdatum nein
Swissfiber 1 Torfersatz	Bachmann	Holzfasern Seeschilf, Chinaschilf (kompostiert, Meeresalgen, Urgesteinsmehl							Zuschlagstoff für Substrate, Torfersatz
Universalerde	Weiherhus	Kompost, Landerde, Chinaschilf	50	200	90	307	2390	7.9	Herstellungsdatum nein
• Universalerde	Ricoter	Torfersatz (Toresa organic), Kompost, Kokospeat, Holzhäcksel, Hornspäne	500-2000	1500-3000	200-400	4000-6000	1800-2600	7.0-7.5	Herstellungsdatum nein
• Zimmerpflanzenerde	Ricoter	Kokpeat, Kompost, Toresa organic	1300	2700	250	10000	2500	7.3	Herstellungsdatum nein

3 Zugelassene Stallfliegenmittel

Die Liste der Stallfliegenmittel ist gegliedert nach Mitteln zur Bekämpfung der adulten (ausgewachsenen) Stallfliegen sowie Mitteln zur Bekämpfung von Fliegenmaden. Sie ist alphabetisch nach Hauptwirkstoffen gruppiert. Pro Produkt sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Wirkstoffe und das Anwendungsgebiet angegeben. Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt.
Ebenfalls zugelassen sind folgende Produkte: insektizidfreie Fliegenschnüre, -bänder und -fallen sowie geeignete Elektrogeräte.

Mittel zur Bekämpfung der adulten Stallfliegen

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Pyrethrin				
Bio-Insektizid 5001	Mastal	frei	Pyrethrin	gebrauchsfertig
Bio-2000	Gisga	frei	Pyrethrin	gebrauchsfertig
BG-1000 Insektizid-Natur	Baumgartner	frei	Pyrethrin	gebrauchsfertig
Fly-End Natur-Insektizid EC	Agro-Hygiene	frei	Pyrethrin	
Pyrethrin, Pflanzenextrakte				
Bio-3000 Naturinsektizid	Gisga	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Brumm-ex	Bischof	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Fly-End Natur-Insektizid	Agro-Hygiene	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Lussolin 351	Lussolin	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
PY-BIO Naturinsektizid	Siber Hegner, Spicosa	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Pyri-Fly	Andermatt	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Rütazil	Gisga	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Spinosad (Fermentationsprodukt von Bodenmikroorganismen)				
Biospin	Omya	5	Spinosad	Köder (Granulat)

Mittel zur Fliegenmadenbekämpfung

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Mikroorganismen				
DeLaval Larvicide Bio	DeLaval	frei	Bacillus thuringiensis	
Natürliche Feinde				
Güllefliegen	Andermatt, Landi Reba		Ophyra aenescens	gegen Fliegenmaden in Schwemmkanälen
Schlupfwespen	Andermatt, Landi Reba		Nasonia vitripennis, Muscidifurax zaraptor	gegen Fliegenmaden in Tiefstreu
Neem (Azadirachtin)				
Biocid Larvenfrei	Gisga	5	Azadirachtin	gegen Fliegenmaden in Tiefstreu

4 Empfohlene Ektoparasitenmittel

Die Liste der Ektoparasitenmittel enthält vorzugsweise einzusetzende, rezeptfreie Produkte, welche richtlinienkonform sind. Auf tierärztliche Verordnung dürfen andere Produkte eingesetzt werden. Im Seuchenfall gelten die Anordnungen der Behörden.

Pro Produkt sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Wirkstoffe und das Anwendungsgebiet angegeben. Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt.

Mittel zur Raumbehandlung

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Pyrethrin				
Fly-End Natur Akarizid EC	Agro-Hygiene	frei	Pyrethrin	
Pyrethrin, Pflanzenextrakte				
PY-BIO Naturinsektizid	Siber Hegner	frei	Pyrethrin, Pflanzenextrakte	gebrauchsfertig
Silikate				
Bio Floh-frei	Interferm	frei	Silikate	gebrauchsfertig
Bio-Flohpuder	Andermatt	frei	Silikate	gebrauchsfertig
Gallo-Sec	Andermatt	frei	Silikate	gegen Vogelmilben/gebrauchsfertig

5 Zugelassene Siliermittel

Die Liste der zugelassenen Siliermittel ist gegliedert nach Mitteln zur Verbesserung des Gärverlaufs und zur Hemmung der Gärschädlinge (entsprechend der Liste A der RAP) und Mitteln gegen Nachgärungen und Schimmelbefall (entsprechend der Liste B der RAP). Für die Produkte sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Wirkstoffe und Bemerkungen angegeben. Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt.

Mittel zur Verbesserung des Gärverlaufes und zur Hemmung der Gärschädlinge

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Bemerkungen
Milchsäurebakterien				
Biomax	Gisga, Omya	frei	Milchsäurebakterien	
Biosil R	Künzle	frei	Milchsäurebakterien	
Bonsilage	Schaumann	frei	Milchsäurebakterien	flüssig und Granulat
Equilact	Comptoir	frei	Milchsäurebakterien	
Flurina-Sil	Grüninger	frei	Milchsäurebakterien	
Ger C3	Germaco	frei	Milchsäurebakterien	
Kliba 870	Provimi Kliba	frei	Milchsäurebakterien	
Kroni 905 Bactosil Forte	Kroni	frei	Milchsäurebakterien	
Kroni 906 Bactosil Konzentrat	Kroni	frei	Milchsäurebakterien	
Lalsil RG	Trinova	frei	Milchsäurebakterien	
Multifor-Sil B	Multiforsa	frei	Milchsäurebakterien	
Naturasil-Konzentrat	Interferm	frei	Milchsäurebakterien	wasserlösliches Konzentrat
Navetin Silo	Protector, Union	frei	Milchsäurebakterien	wasserlösliches Konzentrat
Sila-Bac	Schweizer	frei	Milchsäurebakterien	flüssig und Granulat
Silo Inoculant WS	Trinova	frei	Milchsäurebakterien	flüssig
Topsilage	Naveta, Protector, Trofino, Union	frei	Milchsäurebakterien	wasserlösliches Konzentrat und Granulat
Andere				
Früchtesirup 8895	Provimi Kliba	frei	Zuckersirup	
Früchtesirup	Agrokorn	frei	Zuckersirup	

Bemerkung:

Alle Produkte sind für leicht bis schwer silierbares Futter bewilligt. Produkte auf der Basis von Milchsäurebakterien sind beim schwer silierbaren Futter nur wirksam, wenn entweder im Futter genügend Zucker vorhanden ist oder dem Futter genügend Nährsubstrat (Zucker, Dextrose, Melasse) zugesetzt wird.

Mittel gegen Nachgärungen und Schimmelbefall

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Bemerkungen
Milchsäurebakterien				
Bonsilage Mais	Schaumann	frei	Milchsäurebakterien	flüssig; prov. zugelassen
Bonsilage Plus	Schaumann	frei	Milchsäurebakterien	flüssig und als Granulat
Sila-Bac Stabilizer	Schweizer	frei	Milchsäurebakterien	wasserlöslich

6 Empfohlene Reinigungs- und Desinfektionsmittel

Die Liste der Reinigungs- und Desinfektionsmittel enthält vorzugsweise einzusetzende Substanzen und Handelsprodukte, deren Wirksamkeit nachgewiesen ist und deren Zusammensetzung nachweislich den Anforderungen des biologischen Landbaus entspricht.
Zur **Reinigung** sollten die unten aufgeführten reinen Substanzen sowie auf diesen basierende Handelsprodukte eingesetzt werden. Handelsprodukte zur Reinigung sind hier nicht namentlich aufgeführt. Zur **Flächendesinfektion** sollten die unten aufgeführten reinen Stoffe und Handelsprodukte eingesetzt werden. Im Seuchenfall gelten die Anordnungen der Behörden.
Für Handelsprodukte sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Wirkstoffe und das Anwendungsgebiet angegeben. Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt. Für reine Substanzen sind nur Name und Giftklasse aufgeführt.

Flächendesinfektions- und Hygienemittel

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Diverse reine Stoffe				
Wasser, Dampf		frei		
Wasserstoffperoxid		3		
Alkohol (Ethanol)		frei		
Natürliche Pflanzenessenzen				
Säuren				
Ameisensäure		3		
Essigsäure		3		
Milchsäure		4		
Oxalsäure		2		
Peressigsäure		2		
Zitronensäure		5		
Laugen und alkalisch reagierende Salze				
Ätzkali (Kaliumhydroxid)		2		
Ätznatron (Natriumhydroxid)		2		
Kalkmilch (Calciumhydroxid)		4		
Natriumcarbonat		5		

ff. Flächendesinfektions- und Hygienemittel

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Handelsprodukte				
Ewabo Aldekol Des 2000	Agro-Hygiene	3	Peroxid-Verbindungen, organ. Säuren, oberflächenaktive Substanzen	saures Flächendesinfektionsmittel; zugelassen für amtlich angeordnete Desinfektionen
Hygosan 901	Kroni	frei	Mineralsalze, Tonerden	Hygienemittel
Jet 5	Andermatt	3	Peroxid-Verbindungen, organ. Säuren	saures Flächendesinfektionsmittel
Sojall-Desy clean	Ritter	frei	Peroxid-Verbindungen, organ. Säuren	saures Flächendesinfektionsmittel
Stall-Aktiv-Forte	Kroni	frei	Mineralsalze, Tonerden	Hygienemittel

Bemerkung:

Die in der Bio-Verordnung ebenfalls genannten reinen Stoffe Natriumhypochlorit und Formaldehyd, sowie Produkte auf Jodbasis werden nicht empfohlen, da sie stark giftig und schlecht abbaubar sind.

7 Empfohlene Reinigungs- und Entkeimungsmittel für Milchproduktionsbetriebe

Die Liste der vorzugsweise einzusetzenden Reinigungs- und Entkeimungsmittel für Biomilchproduktionsbetriebe ist gegliedert nach Reinigungsmitteln für allgemeine, von Hand ausgeführte Reinigungsarbeiten (FAM Gruppe A/1), sauren Milchsteinlösemitteln zur Entfernung bestehender Milchsteinbeläge (FAM Gruppe A/3b), sauren Milchsteinlösemitteln zur Verhütung des Entstehens von Milchstein (FAM Gruppe A/3c) und kombinierten Reinigungs- und Entkeimungsmitteln für Milchgeschirr sowie für Melk- und Milchkühlanlagen in Milchproduktionsbetrieben (FAM Gruppe C/4). Für jedes Produkt sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Anwendungskonzentration und pH-Wert bei der Gebrauchskonzentration angegeben. Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt.

Die Gliederung dieser Liste entspricht derjenigen der FAM-Liste der Reinigungs- und Entkeimungsmittel. Aufgeführt sind nur die Mittel für Milchproduktionsbetriebe, nicht jedoch diejenigen für Verarbeitungsbetriebe. Die hier aufgeführten Produkte werden empfohlen, weil sie keine unerwünschten Inhaltstoffe, wie z.B. Enzyme und chlorabspaltende Produkte enthalten, und leicht abbaubar sind (OECD Test 302B).

Detaillierte Angaben zur erfolgreichen Reinigung und Entkeimung von Melkanlagen, sowie zu den Anforderungen, entnehmen Sie bitte dem Merkblatt «Reinigung und Entkeimung der Melkanlagen in Biomilchproduktionsbetrieben» (siehe Anhang).

Gruppe A/1: Reinigungsmittel für allgemeine, von Hand auszuführende Reinigungsarbeiten

Handelsbezeichnung	Firma	Giftklasse	Konzentration in %	pH *
Amstutz Oeko	Amstutz	frei	1.0	2.6
Bio Reminal = Bio-klar	Künzle	3	0.5	11.8
Bio-443 AP	Halag	4	0.5	9.1
Bio-444 AF	Halag	4	0.5	10.1

Gruppe A/3b: Saure Milchsteinlösemittel zur Entfernung bestehender Milchsteinbeläge

Handelsbezeichnung	Firma	Giftklasse	Konzentration in %	pH *
Bioacid	Halag	5	2.0	2.3
Bio-532 P	Halag	4	2.0	1.9
Blaha-vit Plus	Blaser	3	1.0	2.0
Halacid-ALTAG	Halag	3	2.0	1.9
Halacid-P	Halag	2	2.0	1.5
Halacid-S	Halag	3	1.0	1.6

Gruppe A/3c: Saure Milchsteinlösemittel zur Verhütung des Entstehens von Milchstein

Handelsbezeichnung	Firma	Giftklasse	Konzentration in %	pH *
Amstutz Oeko	Amstutz	frei	1.0	2.6
Bioacid	Halag	5	0.5	2.6
Bio Reminox = Bio-Pur	Künzle	3	0.5	3.0
Bio-532 P	Halag	4	0.5	2.4
Blaha-vit Plus	Blaser	3	1.0	2.0
Halacid-ALTAG	Halag	3	0.5	2.2
Halacid-P	Halag	2	0.5	2.0
Halacid-S	Halag	3	0.5	1.9

Gruppe C/4: Kombinierte Reinigungs- und Entkeimungsmittel für Milchgeschirr sowie für Melk- und Milchkühlanlagen in Milchproduktionsbetrieben

Handelsbezeichnung	Firma	Giftklasse	Konzentration in %	pH *
Bioacid	Halag	5	0.5	2.6
Bio Reminox = Bio-Pur	Künzle	3	0.5	3.0
Blaha-vit Plus	Blaser	3	1.0	2.0

* Der pH-Wert bezieht sich auf die Gebrauchskonzentration.

8 Zugelassene Produkte zur Bekämpfung von Bienenkrankheiten

Die Liste mit den Produkten zur Bekämpfung von Bienenkrankheiten ist gegliedert nach Heilmitteln gegen Varroamilben und Produkten von Bekämpfung der Wachsmotten. Die Heilmittel gegen Varroamilben (Handelsprodukte) sind von der Interkantonalen Kontrollstelle für Heilmittel (IKS) zugelassen. Die reinen Substanzen gegen Varroamilben und die Produkte zur Wachsmottenbekämpfung sind vom Zentrum für Bienenforschung (FAM, Bern-Liebefeld) empfohlen. Die Anwendungsempfehlungen dieser Institutionen sind einzuhalten.
In der Liste der Handelsprodukte zur Bekämpfung von Bienenkrankheiten sind Handelsbezeichnung, Verkaufsfirma, Giftklasse, Wirkstoffe und das Anwendungsgebiet angegeben. Für reine Substanzen sind Name und Giftklasse aufgeführt. Adressen und Telefonnummern der Verkaufsfirmen sind am Schluss der Hilfsstoffliste aufgeführt.

Heilmittel gegen Varroamilben

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Reine Stoffe				
Ameisensäure		3		
Milchsäure		4		
Oxalsäure		2		
Handelsprodukte				
Illertisser Milben-Platten	Meier	frei	Ameisensäure	
Krämerplatte	Andermatt	frei	Ameisensäure	

Produkte zur Bekämpfung der Wachsmotten

Handelsbezeichnung	Firma	Giftklasse	Wirkstoffe	Anwendungsgebiet/Bemerkungen
Reine Stoffe				
Ameisensäure		3		
Essigsäure		3		
Handelsprodukte				
B 401	Apivet	frei	Bacillus thuringiensis	
Mellonex	Andermatt	frei	Bacillus thuringiensis	

9 Index der Produkte

Handelsname	Seite
Abdeckmaterial Ricoter	29
Actilith	29
Adalia Marienkäferlarven	15
Agri P15	21
Agri PK 0.8.20	23
Agricol	28
Agrifum	22
Agro Biosol	22
Agro-Düngkalk	25
Algada	28
Algalise L	29
Algalise P	29
Algamer compact	28
Algamer poudre	28
Algan	28
Algifol	28
Algobrun Nr. 1	28
Algobrun Nr. 2	28
Alkohol (Ethanol)	41
Amalgerol 2-verde	29
Ambly-Pack	16
Amblyseius cucumeris	16
Amblyseius cucumeris SR	16
Ameisensäure	41, 45
Ameisenstreumittel	6
Amelgo-verde	29
Amstutz Oeko	43, 44
Angibio 6	22
Aphelinus abdominalis	17
Aphidend	15
Aphidius colemani	17
Aphidius ervi	18
Aphidoletes aphidimyza	15
Aphi-Pack A abd	17
Aphi-Pack Aa	15
Aphi-Pack Am	17
Aphipar	17
Aq10	13
ASP 60	21
Aton Fe	33
Ätzkali (Kaliumhydroxid)	41
Ätznatron (Natriumhydroxid)	41
Audienz	13
Aussaaterde Bellflor Bio	36
Aussaaterde Bio-Line	36
Azadirachtin	11
Azocor 8	20
Azor Bio-Stickstoffdünger	20
B 401	45
Bacillus thuringiensis	13, 14
Baktur	13
Balkonerde Bio-Line	36
Baumpflaster/Arbal	19
Baumwachs kaltfl. Galopp	19
Beauveria-Schweizer	14
Bellflor Abdeckmaterial	29
Bellflor Gartenkompost	25
Bellflor Jungpflanzensubstrat	35
Bellflor Presstopferde	34
Bellflor Rindenhumus	25
Bentosan	31
BG-1000 Insektizid-Natur	37
Bihutherm	25
Bio 9-1-0.5	20
Bio Floh-frei	38
Bio Reminal = Bio-klar	43
Bio Reminox = Bio-Pur	44
Bio Statohum II	34
Bio-2000	37
BIO-3000 Naturinsektizid	37
Bio-443 AP	43
Bio-444 AF	43
Bio-532 P	44
Bioacid	44
Bioalgi Vegetali	24
Bio-Blatt Mehltaumittel	9
Biocid Larvenfrei	37
Biocorrettore Vegetale	24
Biodenit	25
Biodite Vegetale	24
Bioequi Vegetale	24
Bio-Erde	35
Bio-Erde mit Torf	35
Bio-Erde ohne Torf	36
Biofa Cocana RF	9
Biofitac PF1	28
Bio-Flohpuder	38
Biohumin	25
Bio-Insektizid 5001	37
Biolit	27
Biomax	39
Bioorti vegetale	24
Biophos	21
Biopro	13
Biopropol Vegetale	24
Biorga Kompost-Blitz	29
Biorga Meeresalgenkalk gekörnt	28
Biorga N flüssig	24
Biorga Natur Volldünger	22
Biorga NK flüssig	24
Biorga Rasendünger	22
Biorga Stickstoffdünger gekrümelt	20
Biorga Stickstoffdünger pelletiert	20
Biorga Stickstoffdünger Pulver	20
Biorga Terravital Abdeckmulch	29
Biorga Vegi	22
Biorott	29
Bibsil R	39
Bioslug-Schneckennematoden	15
Biosol	23
Biosol Universalerde mit Torf	35
Biosol Universalerde ohne Torf	36
Biospin	37
Biosuza	29
Biotopp torffrei, Blumenerde	36
Bio-Universalerde	36
Biovin	22
Biovin (flüssig)	24
Biovin-Kompostaktivator	29
Biplantol agrar	25
Biplantol Contra X2	31
Biplantol Kompost	29
Biplantol plus	29
Biplantol plus SG	29
Biplantol Rose	31
Biplantol SOS	31
Biplantol terra	25
Biplantol vital	31
Bittersalz	33
Blaha-vit Plus	44
Bocep Viti	6
Bocep Viti 230	6
Bonsilage	39
Bonsilage Mais	40
Bonsilage Plus	40
Borax	32
Bortrac	32
Bouillie bordelaise Disperss	8
Brumm-ex	37
Calcisol/Calcosol	25
Calciumchlorid	32
Calcodol 10	25
Capex 2	14
Carponem	15
Carpovirusine	14
Cartalit	29
Casibac CP	29
Casibac CP10	25
Casibac P15	29
Champi-Hum	25
Champion flow	8
Chaux à semer I	25
Chaux à semer III	25
Chinaschilf kompostiert	36
Chlorcal-220	32
Chrysal R01	19
Chrysal RVB	19
Clinosoil	27
CMC-Kompoststarter 550	29
Coco-Mix	35
Coco-Ter	36
Collit-Standard	22
Compolit/Tradilit	29
Compost Elite	25
Compost Junior	26
Composter	29
Compostol natura	30
Contans	14
Coop Oecoplan Biocontrol Ameisenstreupulver	6
Coop Oecoplan Biocontrol Insektizid	11
Coralite KR+ Pulver	28
Crop-Set	31
Cryptobug	15
Cryptolaemus montrouzieri	15
Cryptopack	15
Cueva	8
Cupravit blau	8
Cuprofix	9
Cuproxat flüssig/liquide LG	9
Dacnusa sibirica	18
Dacnusa sibirica/Diglyphus isaea	18
Dacnusa/Diglyphus	18
Decover Pinienrinde	29
DeLaval Larvicide Bio	37
Delfan	24
Delfin	13
Dickmaulrüssler-Nematoden	15
Diglyphus isaea	18
Dolokorn	25
Dolomit	25
Dolophos	21
Dolosul	25
Dünge-Kompost	26
E-2001	26
Eco Grond (Brill)	34
Eco Pot (Brill)	35
Eco Start (Brill)	34
Edasil G	27
Elementarer Schwefel	26
Elosal Schwefel Stäubemittel	10
Elosal Supra	10
EM1	28

Handelsname	Seite
Encarsia formosa	18
Engerlingspilz	14
En-Pack	18
En-Strip	18
Entomite	16
Entonem	16
Enzymix	30
Equilact	39
Equisan	31
Essigsäure	41, 45
Europerl	27
Ewabo Aldekol Des 2000	42
Fenicur	7
Fitoclin	27
Floraforce	31
Floragard Bio-Kräuteranzuchterde	34
Floragard Bio-Presstopferde	34
Floragard Bio-Universalerde	35
Floragard-Bio- Topferde	35
Florfluid	10
Fluidosoufre	10
Flurina Sil	39
Fly-End Natur Akarizid EC	38
Fly-End Natur-Insektizid	37
Fly-End Natur-Insektizid EC	37
Foodgreen	22
Frischkompost	26
Früchtesirup	39
Früchtesirup 8895	39
frux Kräutererde Anzuchtsubstrat	34
frux Öko-Blumenerde	36
Fumor blau	26
Fumor grün	22
FZB24 WG	13
Gallina Swiss	22
Gallitos	22
Gallmücken,	15
Gallo-Sec	38
Gärgut aus Kompogasanlagen	26
Gartenaktiv KR+	30
Gartenhumus	26
Gartenkompost Bio-Line	26
Gärtnererde	36
Gärtnererde Biopflanzen	35
Gaschell-Baumwachs	19
Genol Plant	12
Geolife	26
Ger C3	39
Geranienerde	36
Gerber Champignonerde	26
Glenactin 290B	28
Glenor Kr+	30
Goemar GA 14	28
Granukal	28
Granulit KR+	28
Granuphos 18	21
Granupom Neu	14
Guanumus	22
Gülle 2000	30
Güllefliegen	37
Haarmehl Pellets 4mm	21
Halacid-ALTAG	44
Halacid-P	44
Halacid-S	44
Hapa Kali	21
Hasler Düngkalk	25
Hasolit B Pulver	30
Hasolit Kombi granuliert	28
Hasorgan MC flüssig	30
HE Confort	30
Heliosol	5
Heliosoufre S	10
Herbaguano	22
Hersbrucker Gesteinsmehl	27
Hexabio	22
Hornmehl	21
Hornspäne	21
Hornspäne fein	21
Hornspäne mittel	21
Hornspäne SI fein, 1-4 mm	21
Hornspäne SII fein, 4-7 mm	21
Hühnermist gewürfelt	22
Humaform	26
Humin Vital WDG 70	5
Humixa-B	22
Humixa-Normal	31
Humixa-Polivalente	31
Humixa-R	24
Humosan Bodenaktivator	26
Humosan-Horngriess /Hornspäne	21
Humotin	22
Hygosan 901	42
Hypoaspis	16
Illertisser Milben-Platten	45
Isomate-C Plus	6
Isomate-CLR	6
Isomate-CTT	6
Isomate-OFM Rosso	6
Italpollina	22
Jet 5	42
Kalimagnesia (Patentkali)	21
Kalin	21
Kalisulfat 50 %	21
Kalkmilch (Calciumhydroxid)	41
Kalk-Steinmehl	25
Kieserit	33
Kirschenfliegen-Falle	6
Klasmann KKS Bio Kräutersubstrat	35
Klasmann KKS Bio Topfsubstrat	35
Klasmann KKS Bio Traysubstrat	34
Klasmann KKS Bio-Potgrond	34
Kliba 870	39
Klinofeed	27
Knospen Kompost	26
Kocide 2000	8
Kocide DF	8
Kohlensaurer Kalk	25
Kompost 2000	30
Komposterde	26
Komposterde Bellflor Bio	36
Kompostierter Mist	22
Koni WP	14
Krämerplatte	45
Kroni 905 Bactosil Forte	39
Kroni 906 Bactosil Konzentrat	39
Kuhmist gewürfelt	22
Kuhmist pelletiert	22
Kümmelöl	14
Kupfer 50 S	9
Kupfer 50/Cuivre 50	9
Kupfer 50/Cuivre 50 Hoko	9
Kupferhydroxid 50 Hoko	7, 8
Lac Balsam	19
Lalsil RG	39
Larvanem	15
Leptomastidea abnormis	18
Leptomastix dactylopii	18
Leureko A (Anzuchterde)	34
Leureko C (Containererde)	35
Leureko P (Pflanzenerde)	36
Leureko PT (Pflanzenerde)	35
Lignostrat Typ Bio (Archut)	35
Liquazor	24
Litho KR+	28
Litho Physalg 18	21
Lithomagnesium	28
Lithothamne Granulit	28
Lithothamne T400	28
Lussolin 351	37
Macrolophus	17
Madex 2	14
Madex 3	14
Magnesia-Kainit	21
Magnesiumkalk Dolomit	25
Maltaflor	22
Mangansulfat	33
Mantrac	33
Marienkäfer	15
Mator	26
Maxiflor P7	21
MBI 600	28
Mellonex	45
Metaphycus helvolus	18
Micro Tonic	30
Microbactor	30
MicrobeLift	30
Microbor	32
Micro-Mangan	33
Microperl	8
Microsan	30
Microsan-P	31
Microterys flavus	19
Microthiol Spécial Disperss	10
Miglyphus	18
Milchsäure	41, 45
Mineralöl Omya	11
Minex	18
Minierpack	18
Mirical	17
Multifor-Sil B	39
Myco-San	11
Myco-Sin	10
Napf-Steinmehl	27
Natriumcarbonat	41
Natriummolybdat	33
Natura Rindermist	22
Natural	11
Naturalis-L	14
Naturasil-Konzentrat	39
Natürliche Pflanzenessenzen	41
NaturPur Bodenstärker	31
NaturPur Pflanzenstärker	31
Naturrein Bodengranulat	26
Naturrein Magnesiumkalk	25
Naturrein Rasengrün	25
Navetin Silo	39
NeemAzal-T/S	11
Neemextrakt	11
Nemaplus	16
Nematoden	15, 16
Nematop	15
Netzschwefel 80 Spezial	10
Netzschwefel LG	10
Neudosan Neu	11
Novodor	14
Nu-Film-17	5
Oecoplan Abdeckmaterial	29
Oecoplan Aussaaterde	36
Oecoplan Balkonpflanzenerde	36
Oecoplan Torfersatz	36
Oenutri	23
Ökohum Bio-Langzeitdünger	22
Ökohum-Bio-Presstopferde	34
Optifer 11	33
Optifer 6 flüssig	33
Optifer Fe++	33
Optima Mn++	33
Optisol K+	23
Optisol Organo	26
Optisol Universel	22
Organische Pflanzennahrung Bellflor Bio	22

Organos 23
Ori-Pack 17
Orius insidiosus 17
Orius laevigatus Biopax 17
Orius majusculus 17
Oscorna Floracorn 22
Ovo Grit 12 25
Oxalsäure 41, 45
Oxychlorure de cuivre 9
Oxykupfer 50 9
Parexan N 12
Patentkali (Kalimagnesia) 21
Penergetic-g 30
Penergetic-k 30
Penergetic-p 31
Penergetic-p (flüssig) 31
Peressigsäure 41
Perlit 27
Pflanze 2000 27
Pflanzenblauwasser 31
Phyto-Pack 16
Phytoperls 22
Phytoseiulus persimilis 16
Phytoseiulus persimilis Biopax 16
Plant Tonic 31
Plocher g-Gülle & Jauche 30
Plocher g-Schweinegülle 30
Plocher k-Kompost & Mist 30
Plocher p-Kaleaf Blattstärkung 31
Plocher p-Melasse - Blatt 31
Plocher p-Pflanzenaktiv - Kaleaf 31
Plocher p-Pflanzenstärkung 31
Plocher p-Pflanzenstärkung-Dolomit 31
Plocher p-Pflanzenvital 31
Plocher p-Pflanzenvital-Kaleaf 31
Plocher p-Wurzelraum I 31
Plocher p-Wurzelraum II 31
Plocher p-Wurzelraum III 32
Polyversum 28
Presstopferde 142 34
Presswasser aus Kompogasanlage 24
Produkte siehe Fungizide 12
Progénia-Einstreupulver 30
Promanal Neu 11
Proposan 40 MG/ML 32
PRP Bodenmineral 26
PRP Gülle Fix 30
Pseudaphycus maculipennis 19
PY-BIO Naturinsektizid 37, 38
Pyrethrum FS 12
Pyri-Fly 37
Quassan 12
RAK 1+2 6
RAK 2 6
Rasenerde 26, 36
Raubmilben 16
Raubwanzen 17
Raupenleimring 6
Raupenleimring LG 6
Rebell Fruchtfliegenfalle 6
Rebell Holzbohrerfalle 6
Reifekompost 26
Reinor 22
Ricokalk 25
Rindenmulch 29
Ringolit 27
Rizinusschrot 23
Rotenon 12
Rütazil 37
Schlupfwespen 17, 18, 19, 37
Schnellkomposter Liquid 30
Schwefel 12
Seso 30
Sferosol 27
Sicid 12
Sila-Bac 39
Sila-Bac Stabilizer 40
Silico-Sec 15
Silo Inoculant WS 39
Siva 50 11
Skeetal 13
Soil Tonic 27
Sojall-Bio-Power 30
Sojall-Desy clean 42
Sojall-Micro-Power 30
Sojall-Vitanal 32
Solbac 13
Solbac Tabs 13
Solfo fluid 10
Solfovit WG 10
Solupotasse 21
Soufre mouillable 10
Spidex/Spidex-Plus 16
Spinosad 13
Spray Oil 7-E 11
Stall-Aktiv-Forte 42
Stammanstrich 19
Stärkungsmittel TMF für Pflanzen 32
Statohum Bio-Presstopf 34
Steinmehl mit Magnesium 27
Steinmehl siliziumreich 27
Stopit 32
Stubble-Aid 32
Sufralo 10
Sunspray 7-E 11
Swissfiber 1 Torfersatz 36
Swissfiber 2 35
Talent 14
Tangle-Trap 6
Targanic 32
Telmion 12
Terra Biosa 30
Terra fit 29
Terraform 27
Terreau B2 34
Thiovit Jet 10
Thripex/Thripex-plus 16
Thripor 17
Thripor L 17
Tillecur 19
Tip 32
TMS-B mineralischer Bodenverbesserer 27
Tominmehl 30
Topsilage 39
Torfersatz Belflor Bio 27
Torfersatz Bio-Line 27
Tradilyse/Fertilyse 30
Trapper 24
Trapper flüssig 24
Traunem 16
Tref EKO 1 34
Tref EKO 2 34
Tref EKO 5 35
Tri 002/003 28
Trichobox 19
Trichocap-Kapseln zum Werfen 19
Tricho-Fix 19
Trichogramma (Trichokarte) 19
Trichosafe 19
Trichosafe TS 19
Tri-Ton 28
Turf-Set 32
Ulmasud B 10
Universaldünger Or Brun 24
Universalerde 35, 36
Urgesteinsmehl 27
Urtisan 32
Valorga 23
Vaminoa 28
Vegesan Bio 24
Vegethumus 27
Vermi 27
Vermi-Sol 1 32
Vinasse 24
Vitalsel AM.C. 25
Vitasel A.M.C.Plus 32
Vitasel Vinea plus 32
Vitigran 50 9
Vivasol 23
Vulkamin 27
Wasser, Dampf 41
Wasserstoffperoxid 41
Wauwiler Champignon-Kompost 27
Weissöl S 11
Zimmerpflanzenerde 36
Zinksulfat 33
Zintrac 33
Zitronensäure 41
Zofal D 11

10 Adressen der Firmen

Kürzel	Adresse/E-Mail/Internet	Telefonnummer	Faxnummer
Agrano	Agrano AG, Ringstrasse 19, CH-4123 Allschwil hans.uwe.maier@agrano.ch, www.agrano.ch	061 487 72 00	061 487 72 75
Agribort Fully	Agribort SA, Route de la Gare, CH-1926 Fully	027 746 33 47	027 746 33 46
Agribort Riddes	Agribort Phyto SA, Route des Fruits, CH-1908 Riddes agribort.phyto@omedia.ch	027 306 94 14	027 306 94 15
Agrisan	Agrisan, Champs de la ville, CH-1544 Gletterens	026 667 24 81	026 667 24 81
Agro Kommerz	Agro Kommerz AG, Pfrundmoos 12, CH-6196 Marbach	034 493 93 96	034 493 41 72
Agro-Hygiene	Agro-Hygiene AG, Gartenstrasse 1C, CH-8636 Wald; oht@active.ch; www.flyend.ch	055 246 66 44	055 246 43 16
Agrokorn	Agrokorn, Industriestrasse 6, CH-9220 Bischofszell postmaster@agrokorn.ch; www.agrokorn.ch	071 424 72 40	071 424 72 92
Agroline	Agroline AG, Innere Margarethenstrasse 7, CH-4051 Basel	061 270 95 57	061 270 95 59
AJE	AJE GmbH, Sihleggstrasse 23, CH-8832 Wollerau; dreier@aje.ch	043 888 20 12	043 888 20 19
Amelgo	Amelgo AG, Freiestrasse 7, CH-8580 Amriswil	071 411 12 52	071 411 12 52
Amstutz	Amstutz Produkte AG, Luzernstrasse 11, CH-6274 Eschenbach	041 448 14 41	041 448 21 89
Andermatt	Andermatt Biocontrol AG, Stahlermatten 6, CH-6146 Grossdietwil; sales@biocontrol.ch, www.biocontrol.ch	062 917 50 00	062 917 50 01
Apivet	Apivet GmbH, Dentenbergstrasse 50, CH-3076 Worb	031 839 94 46	031 839 95 64
Arboris	Arboris-Verlag, Weidweg 33, CH-3032 Hinterkappelen arboris@bluewin.ch	031 901 21 36	031 901 21 05
Bachmann	Bachmann Chevroux SA, CH-1545 Chevroux	026 667 17 17	026 667 21 66
Baumgartner	Baumgartner AG, Stadelmatt, CH-6331 Unterhünenberg	041 780 74 02	
Bayer	Bayer (Schweiz) AG, Zweigniederlassung, CH-3052 Zollikofen www.bayer.ch	031 869 16 66	031 869 23 39
Bernasconi	Carlo Bernasconi AG, Station, CH-4252 Bärschwil	061 765 25 25	061 765 25 00
Biochemie	Biochemie GmbH, AT-6250 Kundl/Tirol	0043 533 8200 2286	0043 533 8200 42
Bioflora	Bioflora, Schadaustrasse 27, CH-3604 Thun hugobaumann@swissonline.ch	033 336 68 31	033 336 68 31
Bioline	Bioline Swiss Import, Rue des Primevères 4, CH-2345 Les Breuleux	032 954 10 00	032 954 10 00
Bioma	Bioma Agro Ecology AG, Postfach 607, CH-8134 Adliswil	091 840 10 15	091 840 10 19
Bionova	Bionova, Schöngrund, CH-6343 Rotkreuz; bionova-hygiene@bluewin.ch	041 280 22 11	041 280 55 11
Biophyt	Biophyt AG, Schulstrasse 13, CH-5465 Mellikon	056 250 50 42	056 250 50 43
Biosa	Biosa Schweiz, Saurenbachstrasse 32, CH-8708 Männedorf	01 790 35 82	01 790 35 83
Bischof	Urs Bischof, Chem. Techn. Produkte, Eschlen 55, CH-9404 Rorschacherberg	071 855 21 08	071 855 21 58
Bitex	Bitex PEROL AG, Wilhofweg 9, CH-6275 Ballwil info@bitexbimoid.ch, www.bitexbimoid.ch	041 448 13 13	041 448 13 40
Blaser	Blaser Swisslube AG, Winterseistrasse, CH-3415 Hasle-Rüegsau	034 460 01 01	034 460 01 00
Burri	Burri Agricide, CH-2555 Brügg/Biel-Bienne info@burri-agricide.ch, www.burri-agricide.ch	032 373 63 63	032 373 24 37
Casanova	Casanova Biotech, Gloriweidstrasse 16, CH-6403 Küsnacht a.R.	041 377 49 69	041 377 49 67
Comptoir	Comptoir commercial, Case postale 36, CH-2926 Boncourt gildasbabey@hotmail.com	032 426 80 50 079 250 35 18	032 426 80 51

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Coop	Grössere Coop-Filialen		
Coulette	Compostière la Coulette, CH-1092 Belmont	021 784 27 45	
DeLaval	DeLaval, Münchrütistrasse 2, Postfach, CH-6210 Sursee	041 926 66 11	041 921 38 76
Eco	Eco Proposte Gospi SA, Via Simen 3, CH-6904 Lugano	091 923 71 53	091 922 73 05
Enpro	Enpro Bio Kill AG, Undermülistrasse 28, CH-8320 Fehraltdorf	01 954 84 48	01 954 84 49
Farmtech	Natural Farm Technologies, Champs de la ville, CH-1544 Gletterens; fobegild@datacomm.ch	026 667 24 81	026 667 24 81
Feuerstein	ETS Feuerstein, 4 rue Saint-Georges, B.P. 2, FR-68480 Durmenach	0033 389 25 81 25	0033 389 25 80 33
Flora Geissler	Flora Geissler GmbH, Müliwisstrasse 212, CH-5467 Fisibach	043 433 10 20	043 433 10 21
Floragard	Floragard GmbH, Gerhard-Stalling-Strasse7, DE-26135 Oldenburg	0049 441 209 20	0049 441 209 22 92
Floristen	Schweizerischer Floristenverband, Allmendstrasse 13, CH-8102 Oberengstringen	01 751 81 81	01 751 81 71
Gassmann	Gassmann-Furrer, Eschenhof, CH-6252 Dagmarsellen	062 756 00 28	062 756 06 08
Gerber	Gerber Gerhard, Bernstrasse 61, CH-3125 Toffen	031 819 06 82	031 819 18 55
Germaco	Germaco SA, En Troveyres, CH-1143 Apples monique.schmutz@bluewin.ch	078 685 93 75	021 824 17 34
Germanier	Roger Germanier & Fils SA, La Fontaine, CH-1175 Lavigny www.germanier-lavigny.ch	021 808 58 75	021 808 58 25
Gisga	GISGA LA AG, Birkenstrasse 27, CH-6343 Rotkreuz; info@gisga.ch	041 798 03 33	041 798 03 30
Grüninger	Grüninger AG, Flurina-Kraftfutter, CH-8890 Flums info@grueningermuehlen.ch; www. grueningermuehlen.ch	081 733 12 07	081 733 28 00
Guignard	Importation + Diffusion, CH-1322 Croy	024 453 11 44	024 453 11 75
GVZ	GVZ, Aargauerstrasse 1, CH-8048 Zürich	01 271 22 11	01 271 76 73
Halag	Halag Chemie AG, Wittenwilerstrasse 31, CH-8355 Aadorf	052 368 01 68	052 368 01 79
Hauert	Hauert & Co. HGB Düngervertrieb, CH-3257 Grossaffoltern hauert@hauert.com, www.hauert.com	032 389 10 10	032 389 10 14
Hedel	Hedel sàrl, Route de la Pudrière 25, CH-1796 Courgevaux	076 370 54 83	026 422 10 54
Hoko	Hokochemie GmbH, Niesenweg 4, CH-3012 Bern postmaster@hoko.com, www.hoko.com	031 302 84 04	031 302 84 10
Holcim	Holcim SA, Route de Ferryres, CH-1315 La Sarraz	021 866 77 51	021 866 62 68
Holistic	holistic-forum nottwil, Hubelmatte 19, CH-6208 Oberkirch info@holistic.ch, www.holistic-forum.ch	041 937 19 37	041 937 19 34
Humosan	Humosan Dünger AG, Mittlbergstrasse 8, CH-9313 Muolen	071 411 00 30	071 411 31 88
Huplo	HUPLO GmbH, Dorfstrasse 42, CH-5054 Kirchleerau b-m.hunziker@bluewin.ch, www.plocher.de	062 726 26 08	062 726 26 04
Interferm	Interferm AG, Strangenstrasse 1a, CH-8304 Wallisellen office@interferm.ch; www.interferm.ch	01 839 10 10	01 839 10 19
Intertoresa	Intertoresa AG, Zweigbetrieb CTA, CH-4657 Dulliken	062 789 29 00	062 789 29 01
Isely	Jacques Isely, Chemin de Jorattez 3, CH-1052 Le Mont/Lausanne	021 652 07 34	021 652 20 24
Jud	Jud Geflügelzucht, Wengistrasse 11, CH-8722 Kaltbrunn	055 283 11 08	055 283 15 91
Kali	Kali AG/Potasse SA, Murtenstrasse 116, Postfach, CH-3202 Frauenkappelen; info@kali.ch, www.kali.ch	031 926 60 00	031 926 60 01
Kompogas	Kompogas AG, Rohrstrasse 36, CH-8152 Glattbrugg	01 809 71 00	01 809 71 10
Komposta	Komposta Natura, Dörflistrasse 25, CH-8192 Zweidlen	01 867 17 21	01 867 17 21
Kroni	KRONI, Locher & Co. AG, Bafflesstrasse 5, CH-9450 Altstätten entwicklung@kroni.ch; www.kroni.ch	071 757 60 60	071 757 60 65

Kürzel	Adresse/E-Mail/Internet	Telefonnummer	Faxnummer
Kuhn	Kuhn Champignon AG, Alpsteinstrasse 56, CH-9100 Herisau	071 353 77 77	071 353 77 76
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Kurras	Günter Kurras, Vertretungen im Gartenbau, CH-1041 Bottens	021 881 29 15	021 881 51 86
Kym	Kym Bennwil, Dürmetweg 2, CH-4457 Diegten	061 976 99 66	061 976 99 67
Landi Reba	Landi Reba AG, Lyonstrasse 18/Dreispitz, CH-4053 Basel www.trichogramma.ch	061 338 40 40	061 338 04 36
Landi/fenaco	Landi & fenaco, Erlachstrasse 5, CH-3001 Bern otto.reist@fenaco.com, www.pflanzenbau.ch	031 308 91 11	031 308 93 05
Landor	Landor AG, Auhafen, CH-4127 Birsfelden	061 377 70 13	061 377 70 77
Ledona	Ledona AG, Ottigenbühlstrasse 25, Pf. 262, CH-6031 Ebikon	041 440 10 01	041 440 10 42
Leu	Leu + Gygax AG, Fellstrasse 1, CH-5413 Birmenstorf	056 201 45 45	056 225 25 15
Leureko	Leureko AG, Baslerstrasse 14, CH-5080 Laufenburg info@leureko.ch, www.leureko.ch	062 874 00 84	062 874 16 05
Lussolin	Lussolin AG, Rotzbergstrasse 12, CH-6362 Stansstad	041 610 20 33	041 610 18 22
Maag	Syngenta Agro AG, Chemiestrasse, CH-8157 Dielsdorf	01 855 88 77	01 855 87 13
Marthy	Marthy Setz AG, Unterdorf 128, CH-5054 Kirchleerau	062 726 20 52	062 726 20 52
Mastal	Mastal AG, Geuenseestrasse 22, CH-6212 St. Erhard	041 921 06 16	041 921 83 86
Maurer	Maurer Gärtnerei, Bernstrasse 17, CH-3110 Münsingen	031 721 11 29	031 721 60 92
Mauser	Samen Mauser AG, Industriestrasse 24, CH-8404 Winterthur info@samen-mauser.ch, www. samen-mauser.ch	052 234 25 25	052 233 57 46
Meier	Meier R. Söhne AG, Bienenmeier, Fahrbachweg 1, CH-5444 Künten	056 485 92 50	056 485 92 05
Méoc	Méoc SA, CH-1906 Charrat	027 746 16 39	027 746 33 24
Multiforsa	Multiforsa AG, Postfach, CH-6312 Steinhausen/Zug multiforsa@multiforsa.ch; www. multiforsa.ch	041 749 49 49	041 749 49 99
Naveta	Naveta SA, CH-5027 Herznach; team@naveta.ch	062 878 17 18	062 878 17 20
Neogard	Neogard AG, Oberkulmerstrasse, CH-5728 Gontenschwil	062 767 00 50	062 767 00 67
Nieth	Robert Nieth, Brill-Erden-Vertrieb, Postfach 80, CH-6318 Walchwil; brill@brill-substrate.com, www.brill-substrate.com	041 758 18 76	041 758 18 47
Ökohum	Ökohum GmbH, altes Schulhaus, CH-8574 Illighausen	071 680 00 70	071 680 00 74
Omya	Omya AG, Postfach 32, CH-4665 Oftringen; wulff.hansen@omya.com; www.omya.ch	062 789 23 41	062 789 23 45
Optima	Optima-Werke, Aliothstrasse 60, CH-4142 Münchenstein	061 411 02 50	061 411 75 01
Optisol	Optisol, Route de l'Industrie 25, CH-1784 Courtepin anton.grub@optisol.ch	026 684 89 30	026 684 89 95
Pareno	Pareno Projekt AG, Neuhofstrasse 1, CH-6340 Baar	041 766 34 10	041 766 34 13
Patzer	Michael Bayer, Johann-Karl-Gretherstrasse 38, DE-79650 Schopfheim	0800 83 61 59	0800 83 61 66
Penergetic	Penergetic AG, Postfach 83, CH-8593 Kesswil	071 466 60 20	071 466 70 20
Plantosan	Plantosan AG, Thunstrasse 23/25, CH-3125 Toffen	031 819 10 81	031 819 54 47
Protector	Protector SA, CH-1522 Lucens; f.schori@protector.ch	021 906 15 15	021 906 85 54
Provimi Kliba	Provimi Kliba SA, Route Gollion 9, CH-1305 Penthalaz	021 861 95 11	061 861 96 99
PRP	Procédés Roland Pigeon SA, Z. I. Ouest, CH-1580 Avenches prpsa@bluewin.ch, www.prp-infos.ch	026 676 06 66	026 676 06 67
Racroc	Racroc AG, Rebenstrasse 16, Postfach 166, CH-3210 Kerzers	031 755 75 70	031 755 89 70
Radix	Radix AG, Amriswilerstrasse 30a, CH-9314 Steinebrunn	071 474 79 49	071 474 79 40
Reichmuth	Reichmuth AG, St. Antonstrasse 1, Pf. 416, CH-9450 Altstätten	071 755 27 39	071 755 27 49
Rem	Konsortium Rem, Jostenmattweg 4, CH-4222 Zwingen	061 761 11 43	061 761 15 38
Renovita	Renovita AG, Felseggstrasse 28, CH-9247 Henau	071 951 22 62	071 951 66 30

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Ricoter	Ricoter AG, Radelfingenstrasse 24-26, Postfach 150, CH-3270 Aarberg; info@ricoter.ch, www. ricoter.ch	032 391 63 00	032 391 62 34
Ritter	Ritter Karl, Radhof 3, CH-8460 Marthalen ritter@radhof.ch, www.sojall-naturen.ch	052 319 17 02	052 319 12 40
Rolusa	Rolusa, Postfach, CH-6011 Kriens	033 438 06 45	033 438 06 46
Schaumann	H.W. Schaumann AG, Marktgasse 27, CH-4900 Langenthal info@schaumann.ch	062 923 24 34	062 922 29 36
Scheidler	Scheidler Öko-Produkte, H. Badertscher, Ringstrasse 2, CH-3629 Kiesen	031 781 12 71	031 781 38 50
Schneiter	Schneiter AGRO AG, Gewerbeweg 4, CH-5103 Möriken www.schneiteragro.ch	062 893 28 83	062 893 28 84
Schweizer	Schweizer Eric Samen AG, Postfach 150, CH-3602 Thun info@schweizerseeds.ch, www.schweizerseeds.ch	033 227 57 57	033 227 57 58
Schweizerhall	Chem. Fabrik Schweizerhall, Elsässerstrasse 231, CH-4013 Basel	061 326 81 11	061 326 83 83
SiberHegner	SiberHegner & Co. AG, Wiesenstrasse, 8, Postfach 888, CH-8034 Zürich	01 386 73 11	01 386 77 11
Siegfried	Siegfried Agro AG/SA, Henzmannstrasse 17 A, CH-4800 Zofingen	062 746 80 00	062 746 80 08
Socora	Socora Handels AG, Pestalozzistrasse 2, CH-9001 St. Gallen	071 220 33 00	
Spicosa	Spicosa, Hammerstrasse 7, CH-6312 Steinhausen	041 741 30 61	041 740 01 24
StGBS	Stadtgärtnerei und Friedhöfe, Rittergasse 4, CH-4001 Basel baumschule@stadtgaertnerei-bs.ch	061 701 40 10	061 701 40 25
Syngenta	Syngenta Agro AG, Chemiestrasse, CH-8157 Dielsdorf	01 855 88 77	01 855 87 13
Terre	Terre Suisse AG, Erdmischwerk, CH-9450 Altstätten	071 755 66 11	071 755 66 12
Thurella	Thurella, Bucher Strasse 2, CH-9322 Egnach info@thurella.ch	071 474 79 10	071 474 79 28
Timac	Timac SA, Rue de Lausanne 35 CH-1950 Sion eric.bara@worldonline.fr	027 322 79 89	027 323 13 19
TMCE	TMCE SA, Grand Record 7, CH-1040 Echallens	021 881 20 63	
Trinova	Trinova AG, Grossfeldweg 2, Postfach 343, CH-8855 Wangen info@trinova.ch; www.trinova.ch	055 450 60 60	055 460 29 96
Triton	Triton Biotech International AG, Greifengasse 1, CH-4001 Basel	061 685 95 61	061 685 95 60
Trofino	Trofino-Mischfutterwerk, Mühle Burgholz, CH-4753 Oey-Diemtigen; info@muehle-burgholz.ch; www.muehle-burgholz.ch	033 681 82 22	033 681 82 20
UFA AG	UFA AG, Hofmattstrasse 40, CH-3360 Herzogenbuchsee	062 956 62 64	062 956 63 75
Ulrich	Ulrich & Partner GmbH, Neuhushof 6, CH-6144 Zell ulrich@step-up.ch, www.steinmehle.ch	041 988 25 55	041 988 25 55
Union	Union Futter Zentrum AG, CH-5012 Schönenwerd	062 858 50 11	062 858 50 12
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Verora	Verora GmbH, Gstei, CH-6313 Edlibach f.abaecherli@datacomm.ch	041 755 32 48	041 755 32 12
Vivasol	Vivasol GmbH, Alphons-Aeby-Strasse 43, CH-3186 Düdingen info@vivasol.ch	026 493 51 80	026 493 51 81
Vollenweider	Vollenweider AG, Tunnelstrasse 29, Postfach 1264, CH-2540 Grenchen; willi.kohler@vollenweider-ag.ch	032 654 99 87	032 654 99 69
Weiherhus	Weiherhus-Kompost, Rütihof, CH-6014 Littau	041 250 42 69	041 250 82 10
Welte	Hatto & Patrick Welte, Postfach 2301, CH-8280 Kreuzlingen	0049 7534 7400	0049 7534 1458
Wytor	Wytor SA, Diezikonerstrasse 10, CH-8637 Laupen	055 266 19 11	055 266 13 12

Anhang 1: Nicht mehr aufgeführte Produkte

Die folgenden Produkte sind in der Hilfsstoffliste 2003 nicht mehr aufgeführt. Vor dem 1. 1. 2003 eingekaufte Vorräte dürfen im Jahr 2003 noch aufgebraucht werden. Produkte mit geringfügigen Namensänderungen sind nicht aufgeführt.

Pflanzenschutzmittel

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Aktivmulch Terrafit
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Biofitac S1
Biogrond aktiv (Brill)
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Guanito
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Anhang 2: Literatur

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Effects of Plant Straws and Plant Growth Promoting Bacteria on the Reproduction of *Meloidogyne incognita* and Growth of Tomato

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ABSTRACT

An experiment was conducted to study the influence of *Pseudomonas fluorescens*, *Azotobacter chroococcum*, and straws of *Triticum aestivum*, *Oryza sativa*, *Zea mays*, *Sorghum vulgare* and *Pennisetum typhoides* alone and in combination on the multiplication of *Meloidogyne incognita* and on the growth of tomato. *P. fluorescens* was better at improving tomato growth and reducing galling and nematode multiplication than was *A. chroococcum*. Among straws, *P. typhoides* was better than *Z. mays* followed by *S. vulgare and T. aestivum* in improving tomato growth and reducing galling and nematode multiplication. Straw of *O. sativa* was least effective in reducing galling and nematode multiplication. Use of *P. fluorescens* with the straw *of P. typhoides* was the best combination for the management of *M. incognita* on tomato. However, improved management of *M. incognita* can also be obtained if straw *of Z. mays* is used with *P. fluorescens*, or *A. chroococcum* is used with the straw of *P. typhoides*.

INTRODUCTION

Nematodes cause about 20.6% world-wide yield loss (Sasser, 1989) and yield loss of tomato in India due to root-knot nematodes ranges from 39.7 to 46.0% (Bhatti & Jain, 1977; Reddy, 1985). Plants infected with *Meloidogyne* spp. show typical symptoms of root galling and this becomes a major constraint to the successful cultivation of this important crop.

The rhizoplane and rhizosphere are colonized or otherwise occupied by many micro-organisms and some of these micro-organisms may provide front line defence against pathogen attack (Siddiqui & Mahmood, 1998). Bacteria are

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numerically the most abundant organisms in the field soils. Some of these bacterial strains have been given the name 'plant growth promoting rhizobacteria' as they improve plant growth by colonizing the root system and by suppressing deleterious rhizosphere microorganisms (Schroth & Hancock, 1982). Similarly, reduction in the plant parasitic nematode population has also been reported by the addition of mature crop straws (Johnson, 1963; Patrick *et al.*, 1965; Jasy & Koshy, 1992). Use of decomposed plant straw and bacteria may protect plants against plant pathogens in the field (Siddqui & Mahmood, 1999).

In the present study, an attempt was made to use *Pseudomonas fluorescens*, *Azotobacter chroococcum*, and plant straws; *Triticum aestivum (wheat)*, *Zea mays (maize)*, *Sorghum vulgare (sorghum)*, *Oryza sativa (rice)* and *Pennisetum typhoides (pearl millet)* for the management of *Meloidogyne incognita* on tomato.

MATERIAL AND METHODS

The root-knot nematode *Meloidogyne incognita* (Kofoid & White) Chitwood was the test pathogen. Two bacteria, *Pseudomonas fluorescens* and *Azotobacter chroococcum*, and plant straws of *T. aestivum*, *O. sativa*, *Z. mays*, *S. vulgare* and *P. typhoides* were applied alone and in combination to tomato (*Lycopersicon esculentum* cv. Pusa Ruby). The influence of these treatments on plant growth, galling and nematode reproduction was assessed in a glasshouse experiment. The experiment was repeated to confirm the results of the first experiment. Results were similar and data of the first experiment only are presented in this paper.

Preparation and sterilization of soil mixture

Sandy loam soil collected from a field belonging to the Botany Department, A.M.U., Aligarh was passed through a 10 mesh sieve. The soil, river sand and decomposed farmyard manure were mixed in the ratio of 3:1:1 and 15 cm diameter clay pots each were filled with 1 kg of the mixture. Water was poured into each pot to wet the soil before transferring them to an autoclave for sterilization at 137.9 kPa for 20 min. Sterilized pots were allowed to cool to room temperature before use.

Raising and maintenance of the test plant

The tomato seeds were surface sterilized with 0.1% mercuric chloride for 2 min and rinsed three times with sterile water. Seeds were sown in steam sterilized soil

(mixture of 3:1:1, soil : river sand : organic manure) in 25 cm clay pots. One week after germination, single seedlings was transplanted into each of the 15 cm diameter clay pots containing the steam sterilized soil. Two days after transplantation seedlings were subjected to the treatments listed in Table 1. Uninoculated plants served as controls and plants were kept on a glasshouse bench at 25–27°C. Pots were arranged in a randomized block design and each treatment was replicated five times. Pots were watered as needed and the experiment was terminated 60 days after inoculation.

Preparation of nematode inoculum

Large numbers of *Meloidogyne incognita* egg-masses were hand picked, using sterilized forceps from heavily infected aubergine (*Solanum melongena* L.) roots on which a pure culture of the nematode was maintained. These egg masses were washed in distilled water and then placed in 10 cm diameter, 15 mesh coarse sieves containing crossed layers of tissue paper and placed in Petri plates containing water just deep enough to contact the egg masses. The hatched juveniles were collected from the Petri plates every 24 h and fresh water was added to the Petri plates. The concentration of second stage juveniles of *M. incognita* in the water suspension was adjusted so that each ml contained 200 ± 5 nematodes. Ten ml of this suspension, i.e. 2000 freshly hatched juveniles, were added to each pot containing a tomato seedling.

Bacterial inoculum

Charcoal-soil based commercial cultures of two bacteria, *Pseudomonas* and *Azotobacter*, were obtained from the Department of Microbiology, G.B. Pant University of Agriculture and Technology, Pantnagar, U.T. and Division of Microbiology, I.A.R.I., New Delhi. One hundred g cultures of each were suspended separately in 1000 ml distilled water and 10 ml, equivalent to 1 g of culture, was added around each seedling. One g culture of *P. fluorescens* had 2.6×10^6 viable bacterial cells while *A. chroococcum* had 2.5×10^6 viable cell g^{-1} of culture.

Plant straws

Ten grams of composted plant straws of *T. aestivum*, *O. sativa*, *Z. mays*, *S. vulgae* and *P. typhoides* were added around each seedling in the pots, as shown in Table 1. Prior to use, plant straws had been allowed to decompose in separate containers for 6 months, with sufficient water being added at ten day intervals.

TABLE I

Effects of plant growth promoting bacteria and plant straws on the reproduction of *M. incognita* and growth of tomato.

Treatments*		Plant length (cm)	Plant fresh wt. (g)	Shoot dry wt. (g)	No. of galls per root system	Nemtode population	CFU of r
No bacterium	Control	67.5 o	63.2 op	14.12no	–	–	0.7 ×
Without	TA	72.9 jk	67.8 jk	14.93 jk	–	–	2.4 ×
M. incognita	OS	70.7 lm	65.6 lmn	14.50 lm	–	–	2.4 ×
	ZM	77.4 g	72.0 gh	15.83 g	–	–	2.9 ×
	PT	80.8 de	75.3 ef	16.52 ef	–	–	3.1 ×
	SV	75.6 hi	70.4 hi	15.45 hi	–	–	2.6 ×
With	Control	43.2 w	39.3 x	8.75 w	182 a	20950 a	0.6 ×
M. incognita	TA	51.8 u	46.7 v	10.10 u	93 c	10260 c	2.4 ×
	OS	48.2 v	43.2 w	9.52 v	102 b	11450 b	2.3 ×
	ZM	56.3 s	50.8 t	11.14 s	73 e	8190 e	2.7 ×
	PT	59.6 r	53.5 s	11.75 r	61 g	6870 g	3.0 ×
	SV	54.2 s	48.6 u	10.64 t	84 d	9350 d	2.5 ×
Pseudomonas	Control	75.3 hi	69.8 i	15.30 i	–	–	1.8 × 1
fluorescens	TA	79.8 ef	74.1 ef	16.32 ef	–	–	3.1 × 1
Without	OS	77.5 g	71.9 gh	15.78 gh	–	–	2.9 × 1
M. incognita	ZM	85.0 b	79.4 b	17.43 b	–	–	3.6 × 1
	PT	87.9 a	81.8 a	17.95 a	–	–	3.9 × 1
	SV	82.8 c	77.2 cd	16.96 cd	–	–	3.4 × 1
With	Control	67.5 o	62.2 pq	13.73 p	68 ef	7670 f	1.6 × 1
M. incognita	TA	70.5 m	64.9 mno	14.50 lm	53 h	5940 h	3.1 × 1
	OS	68.6 no	63.2 op	14.16 mno	60 g	6630 g	2.8 × 1
	ZM	74.2 ij	67.9 jk	14.95 jk	39 k	4380 j	3.6 × 1
	PT	76.8 gh	70.7 hi	15.57ghi	30 l	3350 k	3.7 × 1
	SV	72.3 k	66.4 klm	14.63 kl	46 ij	5170 i	3.3 × 1
Azotobacter	Control	72.1 kl	67.4 kl	14.85 k	–	–	1.5 × 1
chroococum	TA	76.8 gh	71.2 hi	15.65 gh	–	–	2.8 × 1
Without	OS	74.9 i	69.5 ij	15.26 ij	–	–	2.6 × 10
M. incognita	ZM	81.7 cd	75.6 de	16.64 de	–	–	3.2 × 10
	PT	84.6 b	79.5 bc	17.30 bc	–	–	3.5 × 10
	SV	79.2 f	73.7 fg	16. 18 f	–	–	3.0 × 10
With	Control	63.3 q	57.9 r	12.84 q	92 c	9940 c	1.2 × 10
M. incognita	TA	67.8 o	60.8 q	13.57 p	71 e	7840 ef	2.9 × 10
	OS	65.4 p	58.9 r	13.15 q	83 d	9250 d	2.7 × 10
	ZM	70.1 mn	64.5 no	14.19 mn	50 hi	5590 hi	3.2 × 10
	PT	73.2 jk	66.7 klm	14.72 kl	41 jk	4660 j	3.3 × 10
	SV	69.5 mn	62.3 pq	13.84 op	62 fg	6930 gh	2.9 × 10
	L.S.D p = 0.05	1.5	1.8	0.34	6	490	–

TA = *Triticum aestivum*, OS = *Oryza sativa*, ZM = *Zea mays*, PT = *Pennisetum typhoides*, SV = *Sorghum vulgare*. Different letters within one co represent values that are significantly different at p = 0.05.

Inoculation technique

For inoculation of *M. incognita* and bacteria, and the addition of decomposed plant straws, soil around the roots was carefully moved aside without damaging the roots. The inoculum suspensions and decomposed plant straws were poured or placed around the roots and the soil replaced. In the control treatments, where no bacterial inoculum and no plant straw was given, water was added in equal volume to the inoculum suspension. The bacterial and plant straw treatments were applied as shown in Table 1. There were 36 treatments (3 × 2 × 6) comprising three treatments of bacteria (no bacterium, *Pseudomonas* and *Azotobacter*) two treatment of nematodes (with *M. incognita* and without *M. incognita)* each tested with six plant straws (without straw, *T. aestivum, O. sativa, Z. mays, S. vulgare* and *P. typhoides*).

Observations

Plants were uprooted 60 days after inoculation and the root systems were gently rinsed. The plants were cut with a knife above the base of the root emergence zone and the length of shoots and roots were recorded in cm from the cut end to the top of the first leaf and the longest root, respectively. Excess water was removed by blotting before weighing shoots and roots separately. The number of galls per root system was counted. For dry weight determination, shoots were kept in envelopes at 60°C for 2–3 days.

A 250 g sub-sample of well mixed soil from each treatment was processed by Cobb's sieving and decanting followed by Baermann funnel extraction. Nematode suspensions were collected after 24 h, and the numbers of nematodes were counted in five aliquots of 1 ml suspension from each sample. The means of the five counts were used to calculate the population of nematodes per kg soil. To estimate the number of juveniles, eggs and females inside the roots, 1 g sub-samples of root were macerated for 30 to 40 s in a Waring blender and counts were made from the suspension thus obtained. Total number of nematodes present in the roots were calculated by multiplying the number of nematodes present in 1 g of root by the total weight of root. The size of the galls were also measured in different treatments and histopathological study of galls from different treatments permitted differences in size of giant cells to be observed. For histopathological studies nematode infected roots from different treatments were embedded in wax and sectioned using a microtome and observations of giant cells were made under a microscope.

To isolate bacteria from roots, 1 g root samples were rinsed with tap water and homogenized in a known amount of sterile distilled water. A serial dilution of root supension was plated on to nutrient agar and Jensen's medium to observe the growth of *P. fluorescens* and *A. chroococcum,* respectively. The plates were incubated for 24 h at 37°C and the total number of colonies formed in 1 g of root was calculated from the serial dilutions and presented as colony forming units (CFU) per g of root.

Statistical analysis

The entire data set was analysed as a single three factor experiment, i.e. bacteria × nematode × plant straws (Dospekhov, 1984). Moreover, the effects of bacteria and plant straws on plant growth and their interactions were analysed. Least significant differences (L.S.D.) were calculated at p = 0.05 and Duncan's multiple range test was employed to test for significant differences between treatments.

RESULTS

Significant increase in the growth of tomato plants was observed when plants without nematodes were treated with *P. fluorescens, A. chroococcum* or decomposed plant straws (Table 1). Growth of plants without nematodes was improved to a greater extent with *P. fluorescens* than with *A. chroococcum.* Among decomposed plant straws, *P. typhoides* caused greater improvement in plant growth than did *Z. mays* or *S. vulgare*, while *O. sativa* straw caused least improvement in plant growth. When *P. fluorescens* was applied in combination with *P. typhoides* decomposed straw to plants without nematodes, the effect on plant growth was greater than with any other combined treatment. Root colonization was greater with *P. fluorescens* than with *A. chroococcum,* and root colonization was greater with *P. fluorescens* plus *P. typhoides* than with other combined treatment (Table 1).

Inoculation with *M. incognita* caused a significant reduction in plant growth compared with uninoculated controls (Table 1). Treatments with *P. fluorescens, A. chroococcum* and plant straws caused a significant increase in the growth of nematode-inoculated plants when compared with nematode-inoculated untreated plants. *P. fluorescens* caused greater increase in the growth of nematode-inoculated plants than did *A. chroococcum. Pennisetum typhoides* straw was most effective in increasing plant growth followed by *Z. mays, S. vulgare, T. aestivum* and *O. sativa.* Increase in the growth of nematode infected plants was greater with plant straw plus *P. fluorescens* than with plant straw with *A. chroococcum.* Application of *P. typhoides* with *P. fluorescens* to plants infected with nematodes caused the greatest increase in plant growth compared with any other combined treatment. Use of *Z. mays* straw with *P. fluorescens* or *P. typhoides* with *A. chroococcum* also provided an increase in plant growth of nematode infected plants but to significantly less extent than the use of *P.*

typhoides with *P. fluorescens*. Galling and nematode multiplication was reduced to a greater extent with *P. fluorescens* than with *A. chroococcum*. Individually, straw of *P. typhoides* was most effective in reducing galling and nematode multiplication followed by *Z. mays, S. vulgare, T. aestivum* and *O. sativa*. Use of *P. typhoides* with *P. fluorescens* resulted in greater reduction in galling and nematode multiplication than use of any other combined treatment. *Zea mays* with *P. fluorescens* also caused a reduction in galling and nematode multiplication similar to that caused by *P. typhoides* plus *A. chroococcum* (Table 1).

Colonization was greater with *P. fluorescens*, alone or with plant straw, than with *A. chroococcum* (Table 1). Highest root colonization was caused by *P. fluorescens* in the presence of *P. typhoides*. Giant cells and galls were smallest in size when *P. fluorescens* was used with *P. typhoides* and largest in the untreated nematode inoculated plants. Moreover, giant cells and galls were large where *O. sativa* was used while *P. typhoides* straw resulted in small size giant cells and galls.

DISCUSSION

The fluorescent pseudomonads tested were found to increase the growth of nematode-inoculated and uninoculated plants. Plant growth promoting pseudomonads may act through direct antagonism to pathogens, antibiotic production, competition with pathogens for essential nutrients such as iron and more directly through plant growth promotion (Gamliel & Katan, 1993; Siddiqui & Mahmood, 1998). In addition, an induced systemic resistance by fluorescent pseudomonads is also considered to be a mechanism for biocontrol of pathogens (Wei *et al.*, 1996). The sizes of *M. incognita* induced galls and giant cells were also smaller in roots treated with *P. fluorescens*. This was probably because *Pseudomonas* was a more aggressive root colonizer than the other tested bacterium, an important feature for introduced bacteria in the management of root pathogens (Suslow, 1982). *Azotobacter chroococcum* forms considerable quantities of biologically active substances such as vitamins of the B group, nicotinic acid, pantothenic acid, biotin, heteroauxin and gibberellins (Tilak, 1991), and has an ability to produce antipathogenic substances (Brown, 1962; Mishustin & Shilnikova, 1972), which probably resulted in improved growth of both nematode inoculated and uninoculated plants.

Use of decomposed plant straw may give benefits such as better soil structure, build up of antagonistic organisms, supply of plant nutrients and more suitable medium for plant growth (Southey, 1978). The combined use of decomposed plant straw with *P. fluorescens* resulted in the build up of a high *P. fluorescens* population, which probably had an adverse effect on nematode multiplication,

thereby resulting in a better plant growth. The use of the other test bacterium with plant straw resulted in less build up of bacterial population than the use of *P. fluorescens*. Nutrient content (NPK) was highest in the straw of *P. typhoides* followed by *Z. mays, S. vulgare, T. aestivum* and *O. sativa*, and better growth of tomato and greater reduction in nematode multiplication may be related to nutrient contents. Availability of nutrients may also be helpful for build up of a high bacterial population and root colonization, especially in combined treatments. That is why root colonization of bacteria was highest in *P. typhoides* straw treated plants and least in *O. sativa* treated ones. Although these straws are generally used for feeding animals besides other uses, they can also be used for improving tomato growth and reducing nematode multiplication with plant growth promoting bacteria.

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Yield Responses and Nutrient Utilization with the Use of Chopped Grass and Clover Material as Surface Mulches in an Organic Vegetable Growing System

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ABSTRACT

Trials were performed with red beet and white cabbage in 1998–2001 to assess the effects on yields and nutrient utilization of surface mulch (chopped grass and/or red clover). No other nutrients were applied. Nitrogen (N), phosphorus (P) and potassium (K) contents were measured in mulch, saleable products and above-ground plant residues. A single mulch application of about 12 Mg DM ha^{-1} increased the yields of both crops significantly. Mean yields of saleable products were increased from 27 to 33, and from 44 to 56 Mg FW ha^{-1} of red beet and white cabbage, respectively. However, the average apparent recoveries of mulch derived nutrients in above-ground plant parts, calculated by subtraction of uptakes in the control treatment, were only 13, 14 and 18% of N, P and K, respectively. Some 3–10% of the N supplied in mulch was found as mineral N at 0–60 cm soil depth after harvest, and in late autumn approximately half of the P and all the K supplied was found as P-AL or K-AL (ammonium lactate and acetic acid) plus acid-soluble K in the topsoil. Mulch application also increased the yield level of spring cereals grown in the following year by on average 0.6 Mg ha^{-1}, or 20%.

INTRODUCTION

Surface mulching with chopped fresh plant material is practised by a number of organic vegetable growers in Scandinavia. The method supplies crops with nutrients and thus increases vegetable yields; it suppresses annual weeds,

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TABLE 5

Content of easily-soluble plant nutrients according to modified Spurway-Lawton analysis and dry bulk density (D.b.d.) in compost substrates at start of growth tests.

	Control, mineral fertilizer (A)	FYMC low (B)	FYMC medium (C)	FYMC high (D)	FYMC very high (E)	HWC low (F)	HWC medium (G)	HWC high (H)	Commercial CM substrate (I)	Home-made CM substrate (J)
pH	5.6	4.1	5.1	6.2	6.6	3.6	3.9	4.3	6.5	5.8
EC (mS cm^{-1})	2.9	1.8	4.3	6.1	8.1	2.0	3.7	5.7	1.3	4.7
NO_3 (mg l^{-1})	95	67	176	247	265	105	210	404	27	527
NH_4 (mg l^{-1})	124	15	22	28	30	12	17	19	99	16
P (mg l^{-1})	67	70	211	280	295	31	50	91	54	112
K (mg l^{-1})	283	650	1845	2563	2869	396	743	1342	258	327
Mg (mg l^{-1})	98	45	110	153	175	37	53	79	121	155
S (mg l^{-1})	153	31	66	90	104	9	15	23	26	98
Ca (mg l^{-1})	903	182	286	430	505	119	223	425	656	1778
Na (mg l^{-1})	50	77	195	268	289	99	189	335	61	134
Cl (mg l^{-1})	18	162	434	609	666	198	396	746	104	140
Mn (mg l^{-1})	4.1	0.7	0.8	1.1	1.2	0.5	0.7	1.0	2.6	3.8
D.b.d. (g ml^{-1})	0.253	0.255	0.333	0.409	0.409	0.231	0.279	0.331	0.358	0.356

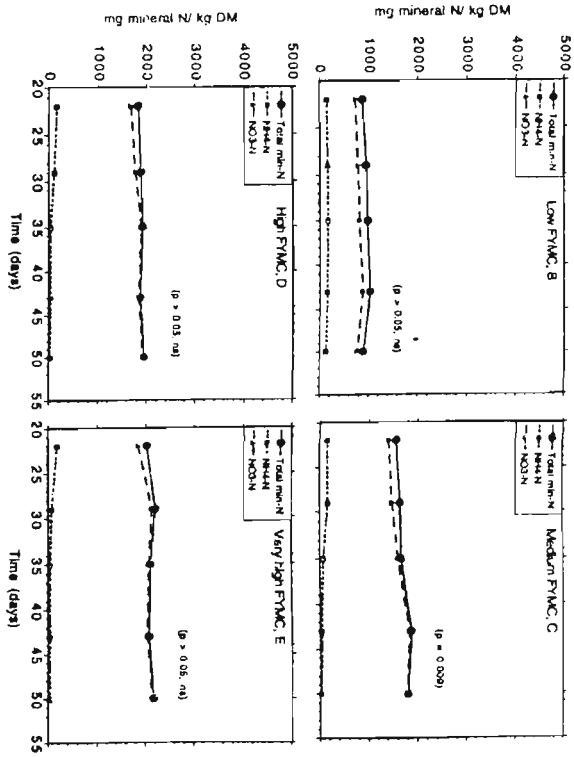

FIGURE 1. Concentrations of ammonium-N, nitrate-N and total mineral N in substrates based on farmyard manure compost (p-values are from analysis of variance for total mineral N day 29–50; n = 3 except for day 22 where n = 1).

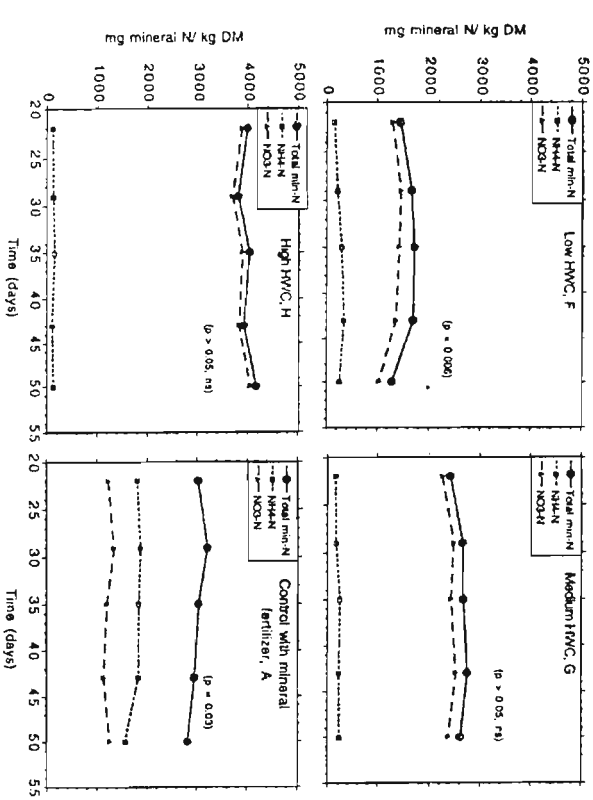

FIGURE 2. Concentrations of ammonium-N, nitrate-N and total mineral N in substrates based on household waste compost and the control with mineral fertilizer (p-values are from analysis of variance for total mineral N day 29–50; n=3 except for day 22 where n=1).

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Evaluation of Growing Media Containing Farmyard Manure Compost, Household Waste Compost or Chicken Manure for the Propagation of Lettuce (*Lactuca sativa* L.) Transplants

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ABSTRACT

Organic substrates, based on sphagnum peat and farmyard manure compost, household waste compost or chicken manure were tested for their suitability for plant propagation of lettuce. Net N mineralization in the substrates was followed, as well as uptake of plant nutrients and heavy metals in lettuce transplants. Net N mineralization from the compost-based substrates was not significantly secured and very low, about 1% of initial organic N content during the 28-day period from the time of sowing the lettuce to the end of the propagation period. In the two chicken manure substrates, net N mineralization was higher, 9 and 28%, respectively, during a period of 50 days, which included the 3 weeks from mixing of substrates until the start of the propagation period. However, it was not only the total amount of net N mineralized that differed considerably between the two chicken manure substrates but also the rate of nitrification. There was a strong negative correlation between pH in the substrates and Cd concentrations in transplants, resulting in unacceptably high Cd levels in transplants grown in substrates with very low pH. Of the tested organic substrates, the one with the lowest concentration of farmyard manure was the most suitable for plant propagation of lettuce.

INTRODUCTION

In organic vegetable pr[illegible]

according to the EU rules (EC Council regulation No 1935/95). Farmyard manure and chicken manure are examples of permitted fertilizers. At present, composted household waste is also allowed for a test period ending on 31 March 2002. The prerequisites for using this kind of compost are that the household waste is source separated and produced in a closed and controlled collection system accepted by the member country. Concentrations of metals must be lower than specific limit values.

Generally, important chemical factors for substrates used in plant propagation or container grown plants are pH, electric conductivity, levels of plant nutrients and the balance between nutrients (Bunt, 1988). The total N concentration of the substrate and the mineralization of the nitrogen are important when organic fertilizers are used in plant propagation. The plant must have access to mineral N from the beginning and continually during the propagation period. When composted materials are used as fertilizers in a substrate, it is of great importance that the material is sufficiently stabilized or 'mature' to avoid negative growth effects due to N immobilization, oxygen depletion or presence of phytotoxic compounds (Iglesias Jiménez & Pérez García, 1989). Nitrogen mineralization from composted materials is generally low (Castellanos & Pratt, 1981; Kirchmann, 1991; Båth & Rämert, 2000), whereas fresh chicken manure is known to give comparably higher N mineralization (Kirchmann, 1991; Aoyama & Nozawa, 1993; Båth & Rämert, 2000). However, it is not only the total amount of mineral N available that is important to the plant, but also the proportions of ammonium-N and nitrate-N. Plant uptake of other cations, i.e. calcium, magnesium and potassium, may be reduced when ammonia dominates. Experience suggests that the NH_4:NO_3 ratio should not exceed 1:1 (Bunt, 1988). The NH_4:NO_3 ratio is also one suggested indicator of compost maturity; a mature compost having a low NH_4:NO_3 ratio (Mathur *et al.*, 1993).

Increased yields in the field as a result of appropriate fertilization of the transplants were observed for several crops (reviewed by Masson *et al.*, 1991) including lettuce (Kratky & Mishima, 1981). Total N content of nursery plants, in contrast to the plant weight, has been shown to have a big influence on growth after planting; nursery plants of butterhead lettuce that were well supplied with N developed faster in the field, were harvested earlier and reached higher head weights compared with N deficient plants (Klages *et al.*, 1997). A high rate of N fertilization during plant propagation of celery, broccoli, lettuce, tomato (Masson *et al.*, 1991) and cauliflower (Schwaninger *et al.*, 2000) gave a higher yield in the field. Transplants with well-developed root systems are reported to recover more quickly from transplant shock (Weston & Zandstra, 1986).

The general aim of the present study was to test the suitability of different organic substrates for plant propagation of lettuce. Specific objectives were to follow the net N mineralization from the substrates and the uptake of plant nutrients and heavy metals in lettuce transplants. The study forms part of a larger interdisciplinary project which aims to better understand the dynamics of plants nutrient regulation and pest control by crops in organic lettuce farming (Rämert *et al.*, 2001).

MATERIALS AND METHODS

Substrates

All substrates in the study were based on sphagnum peat. The organic fertilizers used were farmyard manure compost (FYMC), household waste compost (HWC) and chicken manure (CM). Farmyard manure was composted together with straw (in proportions 1:0.56, dry weight) from rye wheat (*Triticale utile* L.). The initial C/N ratio was about 25. The composting was conducted in a heap (about 4 × 2 × 1 m; l × w × h), the first 2 months outdoors, during the autumn, and subsequently 6 months indoors at an ambient temperature of 18–20°C. The heap was turned and watered several times. Maximum temperature in the heap was 63°C and the ambient temperature was reached after about 5 months. There were a large number of earthworms (*Eisenia foetida*) in the FYMC which were removed. The compost was then sieved and frozen to kill any remaining worms and eggs. The final C/N ratio of the compost was 7.

Source separated household waste from Uppsala municipality (Eklind *et al.*, 1997) was mixed with straw from winter wheat (*Triticum aestivum* L.) and composted in insulated, rotatable, 125 l compost drums. The initial C/N ratio was about 23. A maximum temperature of 60°C was obtained in the compost, and the ambient temperature was reached after about 70 days. The compost was kept in the bins during maturation, the total composting time being about 6 months. The final C/N ratio was 11.

The FYMC and HWC were mixed with unlimed sphagnum peat. Four levels of FYMC was used (12, 26, 34, and 45% by volume; referred to 'low', 'medium', 'high' and 'very high' FYMC, respectively) and three levels of HWC (10, 18, and 34% by volume; referred to as 'low', 'medium' and 'high' HWC; Table 1). The aim with proportions used was to reach specific values of

TABLE 1

Treatments in plant propagation trial with lettuce.

A	Control with mineral fertilizer
B	Low farmyard manure compost (FYMC), 12%
C	Medium FYMC, 26%
D	High FYMC, 34%
E	Very high FYMC, 45%
F	Low household waste compost (HWC), 10%
G	Medium HWC, 18%
H	High HWC, 34%
I	Commercial chicken manure (CM) substrate
J	Home-made chicken manure (CM) substrate

electrical conductivity (EC). The EC of the sieved FYMC was about 10 mS cm^{-1} and of the HWC about 14 mS cm^{-1}.

Two substrates with dried, pelleted chicken manure were used. One was a commercial product ('Solmull', Hasselfors Garden, Sweden), containing 12 kg pelleted chicken manure, 3 kg limestone meal and 2 kg dolomite meal m^{-3} sphagnum peat. The other was a home-made substrate containing 10 kg pelleted chicken manure (Växtmäster; 'Den nya generationens hönsgödsel'), 5 kg bonemeal, 4 kg limestone meal and 2 kg milled 'Algomin' (a calcium and micronutrient rich meal made of red algae) m^{-3} sphagnum peat. The home-made substrate was mixed, and the commercial substrate emptied from the plastic bags 3 weeks before use. The substrates were stacked in small heaps in a greenhouse at 18-20°C and were aerated and watered weekly to promote mineralization and nitrification, and to avoid negative growth effects due to high ammonia levels. This is a common practice for substrates with dried chicken manure.

Sphagnum peat amended with lime and mineral fertilizers (180/75/210 g dm^{-3} substrate of N, P, K plus micro-nutrients) was used as the control. All substrates were sieved (9 mm mesh size) before use in the plant propagation and N mineralization trials.

Plant propagation trial

Iceberg lettuce (*Lactuca sativa* L. cv. Calgary) was sown in trays (Lännen Plantek, 40 × 40 cm, with 64 plants in each tray and 80 ml volume per plug) with the different substrate mixtures (Table 1). Of the 64 plants in each tray, 36 were used for the experiment and the remaining 28 were border plants. The relatively large plug size and the fertilizer concentrations in the substrate mixes were chosen with the aim of finding a cultivation system where supplementary feeding during the propagation period was not needed. The seeds were pelleted but without any chemical treatment. The trays were placed in a growth chamber at 20°C during germination, and after 3 days moved into a greenhouse. During the first 48 h in the greenhouse, the temperature was set to 20°C. Then, successively, the temperature was lowered, with night temperatures set 1–2 degrees lower than day temperatures. At the end of the propagation period, 4 weeks after sowing, night temperature was set to 10°C and day temperature 12°C; however, when it was sunny the temperature in the greenhouse was above 20°C. A randomized block design was used, with three blocks and each plot containing three trays (in total nine trays per treatment). The plants were watered with deionised water. *Bacillus thuringiensis* (Skeetal) was used for biological control of *Sciaridae* flies.

The germination rate was registered each day for 12 days after sowing. The number of weeds were determined 2 weeks after sowing and then removed from the trays. At the same time, plants were sampled and analysed for wet and dry

weight. After 3 and 4 weeks, respectively, assessments were made of plant colour (determined with RHS colour chart; the Royal Horticultural Society, London, U.K.) plant length, number of leaves, and wet and dry weight of plants. In the final assessment (after 4 weeks), concentrations of plant nutrients and heavy metals in the plants and root development were also determined. When plants were destructively sampled, 36 plants per block were used, i.e. all experimental plants in one tray, so that one of three trays in the plot was used on each sampling occasion.

Chemical analyses of substrates and plants

The growing media were analysed at the start of the plant propagation trial for total concentrations of plant nutrients and metals, ammonium-N, nitrate-N, easily soluble nutrients, pH and electrical conductivity. Analysis of most elements was done with an inductively coupled plasma emission spectrometer (ICP, Perkin Elmer Optima 3000) after dissolution in HNO_3. Lead (Pb) concentration in the transplants was determined using a graphite furnace atomic absorption spectrometer (Perkin-Elmer 4110ZL), since the concentration mostly was below the detection limit for the ICP. Organic carbon was measured by dry combustion and IR determination of CO_2 evolved (LECO analyser, U.S.A.). Total N was measured by a modified Kjeldahl method that includes nitrate (Bremner & Mulvaney, 1982). Ammonium-N and nitrate-N were determined colorimetrically (autoanalyser TRAACS 800, Bran Luebbe) after extraction with 2M KCl. All N analyses were carried out on wet, thawed material. Easily soluble nutrients of the substrates were analysed by the modified Spurway-Lawton method (Spurway & Lawton, 1949; Karlsson, 1960), commonly used in Sweden and Norway to analyse 'plant-available' nutrients. Samples were air-dried, milled, sieved through a 3 mm sieve, compacted in a cylinder and extracted 1:6 (v/v) with 0.018M acetic acid. Electrical conductivity and pH were determined in water extract, 1:4 (v/v).

Nitrogen mineralization trial

A study of the net N mineralization in the same substrates as in the plant propagation trial was conducted in trays without plants. The trays were placed under the same climatic conditions as the propagation trial and were watered carefully with deionised water with the aim of keeping sufficient humidity but avoiding leaching. A totally randomized design with one tray per plot and three replicates was used. Ammonium-N and nitrate-N concentrations were determined at the start and after 1, 2, 3 and 4 weeks. At the start, one general sample was taken from the substrate heap before filling the trays and mixing of

subsamples. On the other occasions, substrate from six plugs from each tray (= plot) was collected, pooled for each plot and frozen.

The chicken manure substrates were mixed or emptied from the plastic bags 3 weeks before filling the trays. They were placed in heaps, as described in more detail above, with no replicates. Concentrations of ammonium-N and nitrate-N were determined at mixing and 1, 2 and 3 weeks thereafter, the latter occasion being at the same as the start of the propagation trial. On these occasions, three samples, each consisting of ten subsamples, were taken from the mixtures and analysed separately. The net N mineralization was thus followed during 50 days in the chicken manure substrates and 28 days in the other substrates.

Statistical analyses

For germination data, a logistic model was fitted for each tray separately. The proportion of germinated seeds was fitted as a function of time using a generalized linear model (McCullagh & Nelder, 1989). The Genmod procedure of the SAS (1997) package was used for analysis. The link was a logit function and the distribution was assumed to be binomial. This resulted in an estimate of the intercept b_0 and the slope b_1 of each tray. These were used, in turn, to estimate the time GT_{50} at which 50% of the seeds had germinated. This was calculated as $GT_{50} = b_0/b_1$. The GT_{50} values for all trays were used in an analysis of variance that included treatment and block effect, using the GLM procedure of the SAS (1997) package.

Analysis of variance and correlation analysis were conducted with the software JMP (SAS, 1989) for wet and dry weight of transplants, plant length, and nutrient and heavy metal concentrations in the transplants.

Partial least square regression (PLSR) was performed with the software Unscrambler® (CAMO A/S, Trondheim, Norway). In the PLSR, one of the response parameters, dry weight per plant, at 2, 3 or 4 weeks was used at a time as the Y-matrix, and was predicted by using the data for chemical variables (pH, EC, total and easily soluble amounts of plant nutrients, total amounts of heavy metals) of the substrates as X-matrix. The estimated regression coefficients ß of the PLSR models describe the relation between independent and dependent variables. The PLSR models were tested with full cross-validation.

In the N mineralization study, t-tests were performed for the CM substrates to evaluate if changes in concentration of mineral N during the experiment were significant. For the other substrates, changes over time of total mineral N for each substrate were made by analysis of variance, day 29-50. The value for day 22, based on only one analysis of mineral N, was not included.

RESULTS

Chemical properties of the substrates

Total concentrations of plant nutrients and metals

The total N concentration was 3.5 % of dry matter in the FYMC and 2.4 % of dry matter in the HWC (Table 2). The concentrations of the other macro plant nutrients were also higher in the FYMC, except for calcium. The home-made CM substrate had higher total concentrations of plant nutrients than the commercial one, except for magnesium.

The HWC had higher concentrations of most metals than the FYMC. However, the metal concentrations of the HWC were below the EU limit values for composted household waste used in organic farming (Table 3). The cadmium

TABLE 2

Concentrations of macro plant nutrients in composts (before mixing with peat), chicken manure substrates and control with mineral fertilizer.

	FYMC (% of DM)	HWC (% of DM)	Commercial CM substrate (% of DM)	Home-made CM substrate (% of DM)	Control mineral fertilizer (% of DM)
N	3.53	2.44	1.00	1.60	0.88
P	0.63	0.59	0.14	0.54	0.16
K	3.07	2.41	0.28	0.37	0.35
Ca	3.14	3.58	2.52	4.50	3.43
Mg	0.70	0.39	0.43	0.29	0.48
S	0.45	0.39	0.16	0.23	0.31

TABLE 3

Concentrations of a number of metals in composts (before mixing with peat) and EU limits for composted household waste to organic farming.

	FYMC (mg kg^{-1} DM)	HWC (mg kg^{-1} DM)	EU limits (mg kg^{-1} DM)
Na	2904	5680	–
Cr	7.51	9.85	70
Mn	224	176	–
Ni	7.73	9.29	25
Cu	29.7	60.2	70*
Zn	102	120	200
Cd	0.35	0.54	0.7
Pb	5.7	35.3	45

*Copper can be tolerated in greater amounts if it can be shown that the farmland where the sludge is going to be spread has a need for copper supply

concentration in the control with mineral fertilizer and the home-made CM substrate was at the same level as in the compost-based substrates, whereas the commercial CM substrate had a slightly lower Cd concentration than the other substrates (Table 4). The control with a mineral fertilizer had a high copper concentration, just below the EU limit values mentioned, but above a Belgian standard for toxic levels of metals in substrates (50 ppm Cu for food crops; Bunt, 1988).

Easily soluble plant nutrients, pH and electrical conductivity

In the compost-amended substrates, concentrations of easily soluble plant nutrients reflected the mixing ratio between compost and sphagnum peat; the nutrient concentrations increased with increasing amounts of compost in the peat mix (Table 5). The FYMC substrates had high levels of easily soluble P and K, and also Na and Cl. In both FYMC and HWC substrates, the K/Mg ratio was very high, 11–17:1. Generally, the concentration of easily soluble nutrients was higher in the home-made CM substrate than the commercial one, as it was for total amounts of plant nutrients.

The pH was very low in the HWC-based substrates; pH 3.6 in the treatment with the lowest amount of compost and highest amount of peat and 4.3 in the treatment with the highest amount of compost. Also, the 'low FYMC' substrate had a low pH, 4.1. The electrical conductivity was lowest in the commercial CM compost (1.3 mS cm^{-1}) and highest in the 'very high FYMC' substrate (8.1 mS cm^{-1}).

Nitrogen mineralization

Net N mineralization was low or non-significant in the compost-based substrates during the 28-day experimental period (corresponding to the sowing time of the lettuce to the end of the propagation period). In the FYMC substrates, there tended to be a small decrease in ammonium-N and a slight increase in nitrate-N and total mineral N (Figure 1). Net mineralized N was 0.7–1.4% of initial organic N. The initial level of mineral N in the HWC substrates clearly corresponded to the different amount of compost used (Figure 2). The low and medium HWC substrates tended to have an increase in mineral N during the first week, but during the last week, mineral N tended to decrease. Net mineralized N was 2.4–3.4% of initial organic N. The control with mineral fertilizer showed a slight decrease in mineral N during the last week of the experiment (Figure 2).

Net N mineralization in the two CM substrates differed considerably (Figure 3). The concentration of mineral N increased significantly in the home-made substrate during the first week after mixing ($p = 0.001$ in a t-test comparing

TABLE 4

Concentrations of a number of metals in substrates.

	Control, mineral fertilizer (A) (mg kg^{-1} DM)	FYMC low (B) (mg kg^{-1} DM)	FYMC medium (C) (mg kg^{-1} DM)	FYMC high (D) (mg kg^{-1} DM)	FYMC very high (E) (mg kg^{-1} DM)	HWC low (F) (mg kg^{-1} DM)	HWC medium (G) (mg kg^{-1} DM)	HWC high (H) (mg kg^{-1} DM)	Commercial CM substrate (I) (mg kg^{-1} DM)	Home-made CM substrate (J)
Na	791	978	1620	1856	2091	1067	1837	3026	570	1668
Cr	2.20	3.73	5.27	5.26	5.06	2.15	3.90	7.61	1.94	2.61
Mn	192	82	144	149	157	40	49	83	138	126
Ni	1.27	3.83	5.15	5.50	5.78	2.16	3.01	4.94	1.68	1.61
Cu	69.1	9.4	18.2	17.1	20.7	5.3	11.5	25.3	9.0	20.0
Zn	79	43	64	63	76	30	54	64	59	51
Cd	0.33	0.25	0.31	0.27	0.34	0.27	0.29	0.41	0.17	0.28
Pb	17.7	11.5	10.0	8.7	8.1	14.1	14.1	19.5	10.3	11.0

Colour

The colour of the plants was very similar in all treatments. However, three-week-old plants in the weak HWC had a more yellow-green colour (between A144 and A145 on the RHS colour charts) than any other treatment (that all had colour A144). After 4 weeks, plants in most treatments still had colour A144, but plants in the low and medium HWC were paler green (colour between A144 and B144). The control with mineral fertilizer had a more blue-green colour (between A144 and B146).

Dry weight of transplants

The control plants and plants in low FYMC had significantly higher weights than the other treatments after 3 and 4 weeks (Figure 5). Among the different concentrations of FYMC, the plant weight decreased with increasing compost concentration at all assessments. Plants in the very high FYMC had the lowest weight throughout the test. Among the HWC treatments, plants in low HWC had the highest dry weight after 2 weeks. However, after 4 weeks there was no significant difference in weight between the HWC treatments. The dry weight was significantly higher in commercial than in home-made CM substrates at 2 and 3 weeks, but not after 4 weeks. There was a strong negative correlation

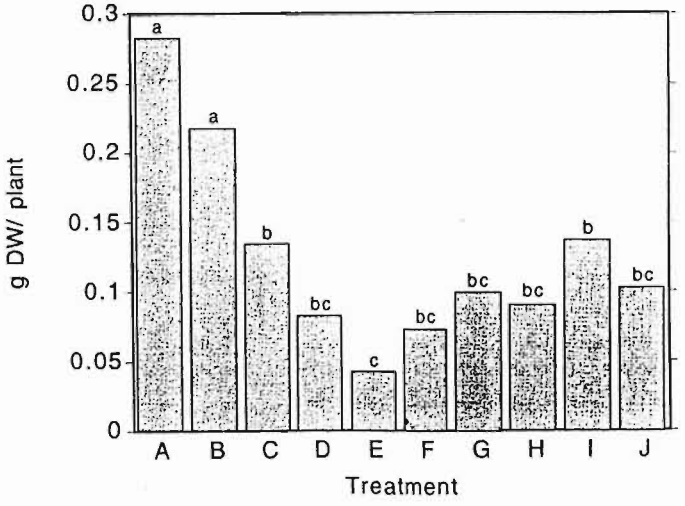

FIGURE 5. Dry weight of lettuce transplants 4 weeks after sowing. Values labelled with the same letter do not differ significantly at $p < 0.05$ (Tukey test). Treatments: A = control with mineral fertilizer, B = low FYMC, C = medium FYMC, D = high FYMC, E = very high FYMC, F = low HWC, G = medium HWC, H = high HWC, I = commercial CM media, J = home-made CM media

between electrical conductivity and dry weight per plant at 2 weeks (R^2 = –0.94), whereas the correlation between EC and DW per plant at 3 weeks was lower (R^2 = –0.57) and the correlation at 4 weeks was not significant.

Plant height, number of leaves and root development

The plant height after 4 weeks was significantly largest in the control treatment, followed by commercial CM substrate and low FYMC. Generally, plant height and plant weight reflected each other.

After 3 weeks, transplants in most treatments had developed three true leaves. Plants in very high FYMC had only two leaves. Plants in high FYMC, high HWC and home-made CM substrate had two-three leaves. After 4 weeks, the control plants and plants in low FYMC had developed five leaves, and plants in medium FYMC had four-five leaves. Plants in very high FYMC had only three-four leaves, whereas plants in all other treatments had developed four leaves.

At the end of the propagation period, 4 weeks after sowing, transplants in the control and low FYMC had the densest root development (Table 7). Plants in very high FYMC and in low HWC had very small root systems. There was a significant correlation (R^2 = 0.76) between root development and dry weight per plant at 4 weeks.

Plant nutrients and heavy metals in transplants

The N concentration in transplants was significantly highest in the control plants and lowest in plants in low FYMC (Figure 6). Also the phosphorus

TABLE 7

Root assessment after 4 weeks (1 = very weak root system, 5 = very dense root system) and number of weeds per tray after 2 weeks.

Treatment		Value (1–5)	Comment, root colour	Number of weeds per tray
A	Control, mineral fertilizer	5	White	0
B	Low FYMC	5		21.3
C	Medium FYMC	3–4	Brownish	60.7
D	High FYMC	2		67.7
E	Very high FYMC	1		51.7
F	Low HWC	1		1.0
G	Medium HWC	3		0
H	High HWC	3		0.3
I	Commercial CM substrate	4	White	0
J	Home-made CM substrate	3–4	White	0

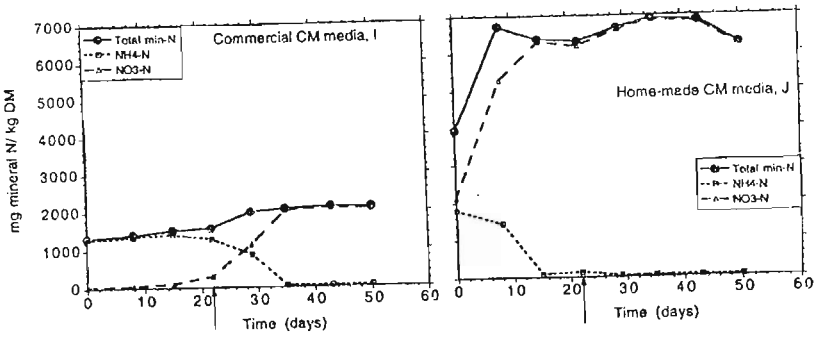

FIGURE 3. Concentrations of ammonium-N, nitrate-N and total mineral N in commercial and home-made chicken manure media. The arrow indicates the corresponding time for sowing of lettuce in the plant propagation trial.

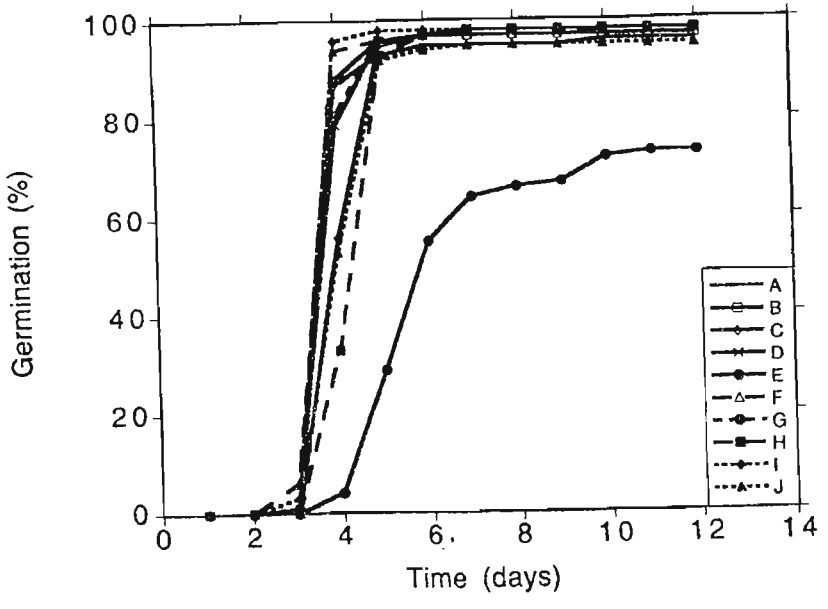

FIGURE 4. Germination of lettuce during the initial 12 days of the plant propagation trial.

mineral N day 0 with the mean for day 8–50). In contrast, mineral N in the commercial CM substrate changed very little before day 22, when there was a significant increase ($p = 0.001$ in a t-test comparing the mean concentration of mineral N day 0–22 with the mean for day 29–50). Moreover, the time for nitrification differed considerably between the two substrates. Very high levels of nitrate-N (> 5 g kg^{-1} dry matter) were present 1 week after mixing in the home-made substrate. In the commercial CM substrate, no appreciable nitrate-N concentration was measured before 3 weeks after mixing. Maximum nitrate-N concentration, about 2 g kg^{-1} dry matter, was reached 5 weeks after mixing, which corresponded to 2 weeks after sowing of lettuce in the plant propagation trial. Net mineralized N after 50 days (including the 3 weeks period from mixing until the start of the 4 week propagation period) was 9.2% of initial organic N in the commercial substrate and 28.0% of initial organic N in the homemade substrate.

Plant propagation trial

Germination

There were significant differences between treatments ($p = 0.0001$) with regard to GT_{50} (Table 6). Germination was delayed in the treatment with very strong FYMC. Also, the final germination percentage was significantly lower in this treatment; 73% compared with 95–98% in the other treatments (Figure 4). The time for 50% germination was also delayed in high HWC and home-made CM media, but they still achieved a high final germination percentage.

TABLE 6

Time at which 50% of the lettuce seeds had germinated.

	Treatment	GT_{50}
I	Commercial CM substrate	3.56 a
F	Low HWC	3.71 ab
G	Medium HWC	3.86 abc
B	Low FYMC	3.90 abc
D	High FYMC	3.91 abc
A	Control, mineral fertilizer	4.01 abcd
C	Medium FYMC	4.11 bcd
H	High HWC	4.38 cd
J	Home-made CM substrate	4.45 d
E	Very high FYMC	7.70 e

increase (Christensen, 1984; Eriksson, 1989; He & Singh, 1995). However, in other pot experiments, effects of pH on plant uptake of Cd were contradictory. Eriksson (1989) reported very high Cd concentrations in rapeseed plants at pH 4, with an exponential decrease when pH was increased to 7. In contrast, Cd concentrations in ryegrass in some cases tended to increase with increasing pH within the range of pH 4 and 6. He & Singh (1995) found that Cd concentration generally decreased with increasing pH in oats, carrot and spinach, but in ryegrass growing in loam soil there was an increase in Cd with increasing pH. Singh *et al.* (1995) reported decreasing Cd concentrations with increasing soil pH in carrot and wheat in two different soils, whereas the effect in lettuce was not consistent. Thus, the pH-Cd uptake relationship seems to be dependent on soil type and plant species.

In field trials (Andersson & Siman, 1991; McLaughlin *et al.*, 1994; Maier *et al.*, 1997), the effects of pH on Cd uptake often seem to be contradictory. The difference between field trials and pot experiments was stressed by Maier *et al.* (1997). They found decreasing Cd uptake in potato tubers at increasing pH, caused by liming, under glasshouse conditions, but no effect or even increasing Cd uptake with increasing pH in field experiments. Several explanations for the disagreement were suggested; for example ineffective mixing of lime throughout the root zone in the field, inadequate time of reaction for lime with soil, and competitive desorption of Cd^{2+} by Ca^{2+}.

Magnusson (2000) found a strong negative correlation between concentrations of Mn in soil at low pH and Cd in cauliflower and broccoli plants. The HWC in the present trial was low in Mn, and this may have contributed to the high Cd uptake in the lettuce transplants.

In Sweden, there is no current maximum permitted level of cadmium in food, but a suggested value in international discussions is 0.1 mg kg^{-1} FW for most cereals. WHO has suggested a maximum permitted level of 0.05 mg Cd kg^{-1} FW (Singh *et al.*, 1995). Lettuce transplants in all HWC treatments had higher Cd levels, the highest being 0.20 mg kg^{-1} FW in the medium HWC. The cadmium concentration in the consumable product, the lettuce head after field cultivation, will of course also depend a lot on the conditions in the field, since most of the growth takes place there. However, the results from the propagation trial provide a warning against growing lettuce in substrates or soils with low pH, especially when Cd levels, due to natural background levels or input by Cd-containing fertilizers or deposition, are high.

The current maximum permitted level of lead in leafy vegetables is 0.3 mg kg^{-1} FW (Jorhem & Sundström, 1993) and 0.1 mg kg^{-1} FW in other fruit and berries. The highest lead concentration, found in transplants grown in medium HWC, was 0.07 mg kg^{-1} FW, well below the maximum permitted value.

CONCLUSIONS

The low farmyard manure compost was the most suitable of the tested substrates for plant propagation of lettuce. However, substrates based on household waste compost or chicken manure also have the potential to be used in propagation of transplants for organic growing. However, it is important to optimize the substrate for each different organic fertilizer. Electrical conductivity is a critical factor for germination and plant growth, and has to be carefully adjusted. Also, it is important to avoid too low pH values due to the strong negative correlation between pH in the substrates and Cd concentrations in transplants, resulting in unacceptably high Cd levels in transplants grown in substrates with very low pH. The net N mineralization and nitrification in a substrate may also differ considerably with the same kind of fertilizer, which was the case with chicken manure in our trial. It is important to have ample time margins from mixing/unpacking until sowing when using substrates with dried and pelleted chicken manure.

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to have already then favoured the start of nitrification, as it did in the home-made CM substrate.

The decrease in mineral N observed in two of the treatments (control with mineral fertilizer and low HWC) during the last week may have been due to gasous losses of NH_3 or N_2, and/or leakage of nitrate, even if the trays were watered carefully with the aim of maintaining sufficient humidity but avoiding leaching.

Timing is important when preparing substrates with organic fertilizers so that the plant has access to mineral N from the start of the propagation period. In our trial, the proportion of NH_4-N was about 80% in commercial CM media at sowing. This is too high according to Bunt (1988). It was not until 1 week after sowing that NO_3-N began to dominate. However, the transplants in commercial and home-made CM media were of equal weight and had equal N concentration after 4 weeks. This is not in accordance with Tew Schrock & Goldsberry (1982), who found that growth of geranium and petunia seedlings in soil-less mixes was adversely affected when the proportion of NH_4-N of total mineral N was above 50%. Increasing the NH_4:NO_3 ratio from 0:1 to 1:0 caused a strong and progressive decline in the amount of Ca in the plant tissue. In our trial, the Ca concentration was lower in transplants grown in commercial than in the home-made CM substrate. However, this could also be explained by a twice as high Ca concentration in the home-made CM substrate.

Development and quality of transplants

The delayed germination as well as the low final germination percentage in the very high FYMC was most probably caused by the high electrical conductivity (8.1 mS cm^{-1}). In the high FYMC with EC 6.1 mS cm^{-1}, germination was not affected. Thus, the critical value for lettuce germination seems to lie between these values of EC. The electrical conductivity not only affected germination, but also the DW per plant at 2 weeks and, to a lesser degree, also after 3 weeks. After 4 weeks this effect had disappeared.

The chemical soil parameters could not explain the differences in DW per plant at 4 weeks in the PLSR. The soil analyses were done at the start of the experiment, and soil chemical properties may have changed considerably during the propagation period. Moreover, factors other than those measured may have been important for the plant development.

Generally, among the different concentrations of FYMC, the plant weight decreased with increasing compost concentration. This indicates that the lowest concentration chosen was too high to be able to define an optimal compost concentration in the substrate. However, the nutrients were not optimally balanced, and the plant growth in the lowest FYMC was probably checked to some extent by the low levels of N, Mg and S. No norm values for desirable

nutrient values of lettuce transplants have been reported, but according to Bergmann (1992), adequate ranges of mineral nutrient content (DM) in lettuce, i.e. fully developed inner leaves during head formation, are: 4.5–5.5% N, 0.45–0.7% P, 4.2–6.0% K, 1.2–2.1% Ca, 0.35–0.6% Mg, and 30–100 ppm Mn. Compared with these values, transplants in the low FYMC had rather too low a N concentration and only half the desirable Ca concentration. The other substrates based on FYMC and HWC also had too low a Ca concentration. Liming the substrate would undoubtedly have helped in this case. Also the Mg concentration was rather too low in transplants in the FYMC treatments, most probably due to the very high K/Mg ratios, 14–17:1. The suggested K/Mg ratio in substrate mixes for container-grown plants is 3:1 or less (Bunt, 1988). The P concentration was sufficient in transplants in all treatments. The K and Mn concentrations were above the adequate ranges according to Bergmann (1992).

The plants have not been followed in the field, but plants from different treatments may have developed differently. According to Weston & Zandstra (1986), transplants with a well-developed root system recover more quickly from transplant shock, and in the present trial the control plants and plants in the low FYMC developed a very good root system compared to the other treatments. The dry weight of transplants did not differ significantly between the treatment with mineral fertilizer and low FYMC. However, the N concentration was significantly higher in minerally fertilized transplants than in any other treatment, and this factor in nursery plants has been shown to be more important than plant weight for the growth after planting (Klages *et al.*, 1997).

Uptake of heavy metals

Different plant species vary considerably in their ability to translocate Cd to above-ground parts, and lettuce has a very high ability to perform such translocation at a given soil concentration (Bergmann, 1992). The total amounts of Cd in the tested substrates did not differ much. Instead, the high Cd concentration in lettuce transplants in the HWC substrates was most probably caused by the low pH in these substrates. The electrical conductivity of the HWC was so high that the proportion of peat ought to have been high when mixing it with HWC. Since unlimed peat was used, pH in these substrates was very low (3.6–4.3). The plant growth was also relatively low in the HWC substrates, which means that Cd was not diluted so much in the transplants.

A negative correlation between soil pH and Cd uptake of plants has been shown in several pot experiments with soil (Allison & Dzialo, 1981; Willaert & Verloo, 1992). The influence of pH is indirect and explained by Cd adsorption to negatively charged sites of clay particles and organic matter. The adsorption is pH dependent; with decreasing pH, protonation of the negatively charges sites increases and Cd adsorption decreases. Thus, the potential for plant uptake will

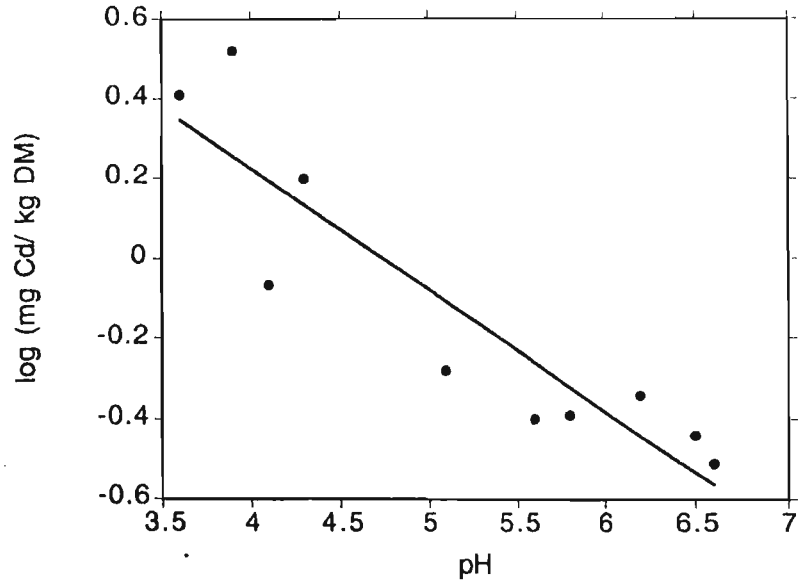

FIGURE 8. Cadmium concentrations in 4-week-old lettuce transplants as a function of pH in the substrate at start of the propagation period.

Multivariate analysis

The PLSR with all treatments showed that the soil parameters could quite well explain the variation in DW per plant at 2 weeks (R^2 = 0.69). The most influencial variables in the model were EC (ß = –0.154), Na (–0.129), NO_3 (–0.128), Cl (–0.117), Min N (–0.113), P (–0.106), and K (–0.009), which were all negatively correlated with the DW per plant at 2 weeks, and NH_4 (ß = 0.008), which was positively correlated. In contrast, the soil parameters could not explain at all the variation in DW per plant at 3 and 4 weeks.

DISCUSSION

Nitrogen mineralization in the substrates

Net N mineralization was low or non-significant in the compost-based substrates during the 28-day experimental period. This is in accordance with other studies where composted materials were used, for example composted animal manures (Castellanos & Pratt, 1981; Kirchmann, 1991), bark (Aoyama & Nozawa, 1993) or urban refuse (Beloso *et al.*, 1993; Båth & Rämert, 2000). However, Epstein *et al.* (1978) reported a somewhat higher net N mineralization, being 4–9% of initial organic N during a 15-week incubation study with sludge composts. The degree of compost stabilization or maturity is of great importance for the N mineralization, as pointed out by Iglesias Jiménez & Alvarez (1992). Using mature municipal refuse compost in a 6-month pot trial with perennial ryegrass, they found the percentage of apparent bioavailable N ranging from 16–21% of the total compost N. However, the FYMC and HWC used in our trial must also be considered very mature, as indicated by the low C/N ratios and NH_4:NO_3 ratios (Mathur *et al.*, 1993), but they still had a very low net N mineralization.

The comparatively high net N mineralization in the CM-based substrates, 9–28% of initial organic N during 50 days, can be explained by a large portion of easily available N present in poultry excreta (Kirchmann, 1991). In an incubation study with different soils, 2–11% of applied organic N was net mineralized from dried, pelleted and milled chicken manure during 160 days. An initial net N immobilization contributed to the relatively low total net N mineralization during the experiment, especially in clay soil (Båth & Rämert, 2000). In the present study, with soil-less CM substrates, no net N immobilization was recorded. However, net N immobilization may have occurred during the first week, before the first sampling.

The N turnover in the two CM substrates differed considerably concerning both amounts and time of net mineralization and nitrification. The most probable reason is differences in storage time and conditions before pelleting the chicken manure. The manure used in the home-made substrate appears to have been dried and pelleted very soon after mucking out the manure. Kirchmann (1991) reported 61% of total N in fresh poultry manure without any bedding material was in the form of uric acid. When such fresh poultry manure was incubated, 82% of the total N was released as inorganic N during the first week. In contrast, the same manure that had been stored under either aerobic or anaerobic conditions for 7 months showed no net N mineralization during 70 days of incubation (Kirchmann, 1991). The pellets used in the commercial CM substrate seemed to have a lower content of easily degradable N compounds (uric acid or proteins). This may be explained by decomposition of uric acid during storage before drying and pelleting the manure. Other factors influencing the content of uric acid in chicken manure are the feeding of the chickens (O'Dell *et al.*, 1960) and the amount of bedding material per chicken used (Kunkle *et al.*, 1981).

In the production of the commercial substrate, chicken manure pellets are added to peat and the substrate is immediately packed and compacted in plastic bags. (Pers. comm. Pia Holmberg, Hasselfors Garden, Sweden). Lack of oxygen in the plastic bags explains why no nitrate had been formed before the start of the experiment. However, aeration and wetting of the substrate on day 0 ought

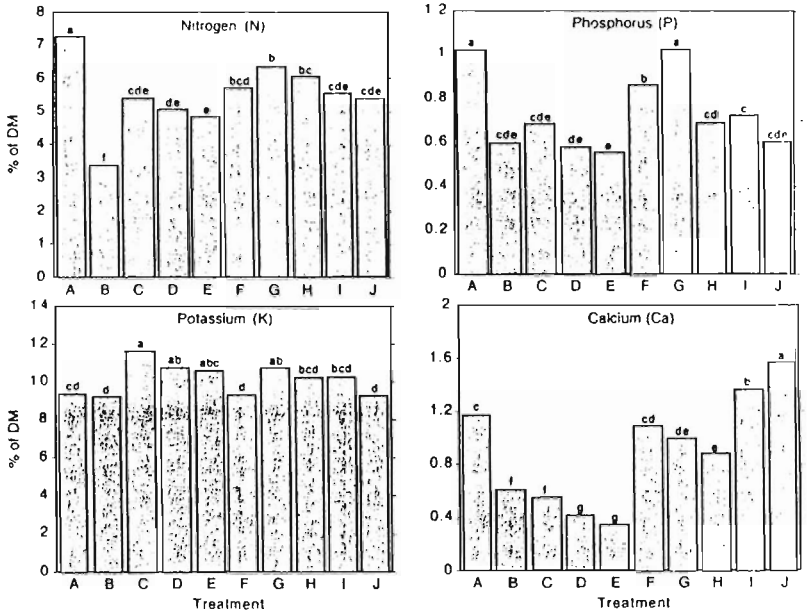

FIGURE 6. Concentrations of N, P, K and Ca in 4-week-old lettuce transplants. Values labelled with the same letter do not differ significantly at $p < 0.05$ (Tukey test). Abbreviations as in Figure 5.

concentration was highest in control plants, together with plants in medium HWC. Plants in low and medium HWC also had the highest concentrations of magnesium and sodium (data not shown), whereas plants in CM media had the highest calcium concentrations.

The concentration of cadmium was several times higher in lettuce transplants grown in the HWC substrates than in any other treatment (Figure 7). The highest concentration, 3.31 mg g^{-1} DM, was found in the 'medium HWC' treatment. There was a strong correlation between pH in the substrates and Cd concentration in plants, with the Cd concentration increasing exponentially with decreasing pH. When Cd concentration was logged, the data could be fitted to a line ($R^2 = 0.82$, $p < 0.001$; Figure 8). Also, lead and zinc concentrations were significantly negatively correlated to pH in the substrate, with highest concentrations in the low and medium HWC treatments. In contrast, the copper concentration was highest in transplants from the control with mineral fertilizer. There was no significant difference in nickel and chromium concentrations between the treatments.

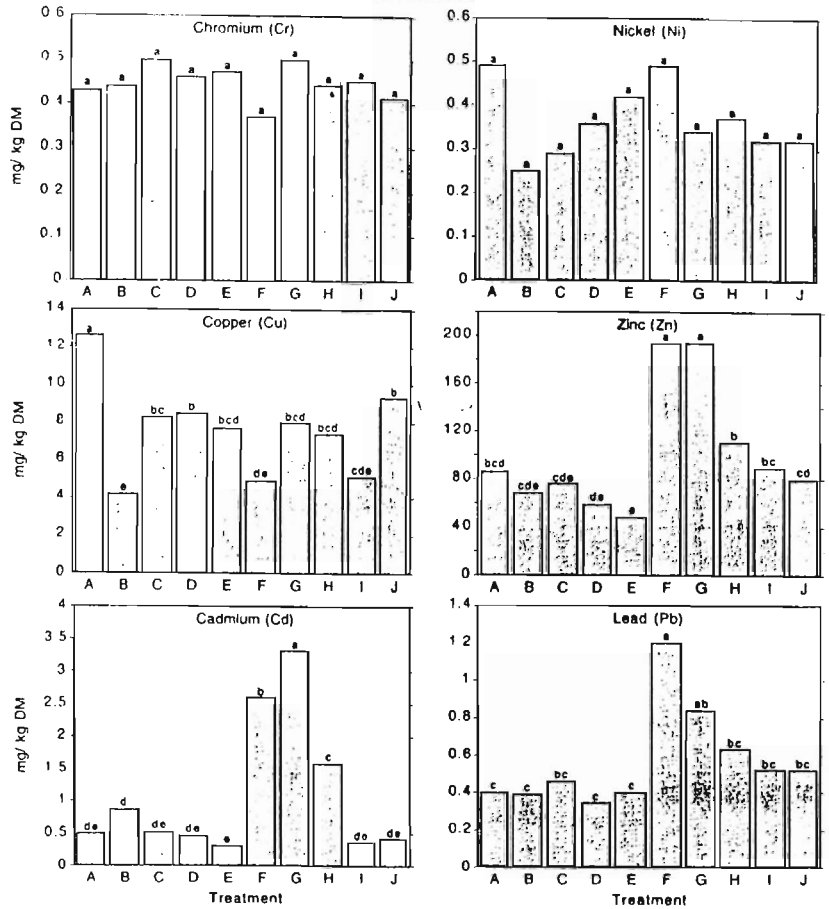

FIGURE 7. Concentrations of Cr, Ni, Cu, Zn, Cd and Pb in 4-week-old lettuce transplants. Values labelled with the same letter do not differ significantly at $p < 0.05$ (Tukey test). Abbreviations as in Figure 5.

Number of weeds

A substantial amount of weeds emerged in the FYMC substrates, with the largest amount, 68 weed plants per tray, occurring in the high FYMC (Table 7). In contrast, in the HWC substrates a maximum of one weed plant per tray occurred, and none at all in the control and the CM substrates.

EC – Council Regulation No 1935/95 of June 1995 amending Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. *Official Journal NO. L. 186, 05/08/1995 P.0001–0007.*

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Effect of Microbial Inocula on Mixed Solid Waste Composting, Vermicomposting and Plant Response

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To accelerate the process of composting, different microflora viz. *Pleurotus sajor-caju* (fungus), *Trichoderma harzianum* (fungus) and *Azotobacter chroococcum* (bacteria) were inoculated in different combinations into mixed solid waste, a mixture of municipal solid waste (MSW) and horticultural waste in the ratio of 70:30. The waste was decomposed for different time periods and then subjected to subsequent vermicomposting for a fixed period of one month. The compost produced was evaluated for nutrient levels and effects on mung bean (*Vigna radiata*) growth. A significant difference was observed in the quality of compost produced with the bioinoculants over control treatments where no bioinoculant was used. The combination of *P. sajor-caju*, *T. harzianum* and *A. chrocooccum* produced the highest quality compost. The percentage of mycorrhizal infection in mung bean was influenced by the three inoculants and crop growth was enhanced significantly with the combination of *P. sajor-caju*, *T. harzianum* and *A. chrocooccum* over other treatments.

Introduction

During composting, microorganisms secrete enzymes that degrade polymers such as starch, pectins, chitin and nucleic acids into simple compounds. In contrast, the breakdown of lignocellulose is slow. The interspersion of lignin with cellulose and hemicellulose in plant material makes lignocellulose residues relatively inaccessible to microbial attack (Alexander 1977). The degradation of lignocellulosic substrates through ordinary composting is a time consuming process (4-6 months). Various studies have shown that addition of bacterial products to organic wastes had little effect on the decomposition process (Tiquia *et al.* 1997; Tam *et al.* 1996, Chaw 1996). On the other hand, Sharma *et al.* (2000) observed that pretreatment of these substrates with more effective microorganisms i.e., bacteria, actinomycetes and various groups of fungi accelerated the decomposition process.

White rot fungi (i.e. basidiomycetes) are among the most promising microbial lignin degraders (Buswell and Odier 1987) due to their ability to produce lignin degrading enzymes, while fungi such as *Trichoderma* and others have been have been reported as effective bioinoculants for cellulose degradation (Sharma *et al.* 2000). Earlier studies have shown that inoculation with *Azotobacter* during composting accelerates the decomposition process and improves the quality of compost (Rasal *et al.* 1988; Sharma *et al.* 2000). The findings of Gerrits (1969), Hedger and Basuki (1982), Kirk and Fenn (1982) indicate that removal of protective lignin coating precedes the cellulolysis in degradation of lignocelluloses by the white rot fungi. Inoculation with these microorganisms might, thus, accelerate the process of decomposition by degrading the lignin portion of the waste that is relatively inaccessible to microbial attack. Also, inoculation with nitrogen-fixing bacteria such as *Azotobacter* may increase the nutrient value of the compost.

Earthworms not only accelerate the organic waste decomposition process but also improve the quality of compost. Earthworms decompose a wide range of agricultural, industrial and municipal waste (Hand and Greenshields 1989; Kale 1995) progres-

sively, converting them into humus. The mineral nutrients in earthworm casts are largely in forms that are readily available to the plants (Bridgens 1981; Ndegwa and Thompson 2001). There is evidence that interactions between earthworms and microorganisms not only provide available nutrients but also stimulate plant growth indirectly in other ways (Suman *et al.* 1999). Some species of earthworms such as *Lumbricus terrestris* depend mainly upon intact organic waste for nutrition whereas, other species such as *Eisenia foetida*, appear to prefer organic matter in an advanced stage of decomposition. So if the lignocellulosic waste is inoculated with mixed microbial cultures that can degrade it effectively and provide a useful substrate to earthworms (e.g., *E. foetida*), a quality compost could be produced at a faster rate. With this in view, experiments were conducted to identify and develop a consortium of microorganisms which would accelerate the composting process and enhance plant growth and soil fertility on a sustainable basis.

Methods

A field study was conducted at Micromodel, Indian Institute of Technology (IIT), Delhi to assess the interactions among different microorganisms including *Pleurotus sajor-caju* (fungus), *Trichoderma harzianum* (fungus) and *Azotobacter chroococcum* (bacteria), and between these microorganisms and earthworms for their potential to decompose mixed solid waste and to convert the mixed waste into useful compost.

Composting of Mixed Solid Waste with Bioinoculants and Subsequent Vermicomposting

Pure cultures of *Pleurotus sajor-caju* and *Azotobacter chroococcum* were obtained from the Indian Agricultural Research Institute (IARI), New Delhi and *Trichoderma harzianum* from Pantnagar Agricultural University, Pantnagar, U.P. Subculturing was done at the Centre for Rural Development and Technology, IIT, New Delhi.

Municipal solid waste (MSW) was collected at Micromodel through the ongoing IIT recycling programme, Delhi campus. This waste was manually sorted into recyclable and biodegradable portions. The recyclable waste consisted mainly of paper (5.6%), glass (2.2%), metals (2.4%), plastic (7.5%) and the biodegradable waste consisted of kitchen waste (43%) and inert material (39.3%). The kitchen waste consisting of vegetable waste, fruit waste, coir, and food waste was utilized for the present study. Since MSW was highly compact with limited porosity and low C/N ratio it was mixed with horticultural waste. To balance the C/N ratio of MSW (C/N= 20) three parts (w/w) of horticultural waste (C/N= 82.2) was added to seven parts of MSW. The horticultural waste was comprised of the cuttings of *Morus alba*, *Populus* sp. and *Bougainvillea sp.* collected during their pruning. The C/N ratio of the feedstock was 38.7.

The municipal solid waste used in the present study was collected on the first day. Both the MSW and horticultural waste were chopped into small pieces (1cm mesh or less) to facilitate mixing. 60 kg (wet weight) of this mixed feedstock was placed in cement pits (1m x 1m x 1m) and composted aerobically for 1 to 4 weeks during October 1999. Since mesophile namely *P. sajor-caju* was used for pre-decomposition the temperature had to be kept low and thus the depth of the compost was maintained at one foot. Pure cultures of *P. sajor-caju* and *T. harzianum* (both 500 gm mycelium per ton of substrate and 30 gm/60 kg substrate) and *A. chroococcum* (@ 50 ml/kg substrate having 10^6 viable cells per ml and 3 litres/60 kg substrate) were used to inoculate the appropriate treatments. The temperature was maintained in the range of 20 – 26°C. Moisture was maintained at about 60% of the water holding capacity by spraying with

water using a spray can. The composting material was manually turned at 15-day intervals. The following treatments were applied in three replicates:

- *P. sajor-caju*
- *P. sajor-caju* and *T. harzianum*
- *P. sajor-caju T. harzianum* and *A. chroococcum*
- Control (without any inoculation)

Sampling was done at 7-day intervals.

7, 14, 21 and 28 days pre-decomposed waste was then subjected to vermicomposting for a fixed time period of one month. Vermicomposting was carried out, in triplicate, in earthen pots (1ft height and 10 in. diameter) with one kg of predecomposed waste per pot using 10 earthworms (*Eisenia foetida*) in each pot. During vermicomposting the moisture was maintained at 60% by spraying with water periodically.

Composite samples (about 100gm) were collected from three sites in each pit during predecomposition (n=9). The predecomposed samples as well as the vermicomposted samples from all the replicate pits/pots were pooled together. The samples were dried at 80°C for 23 hours (APHA *et al.* 1989) and then ground to provide a homogeneous sample. Both pre- and post-vermicomposted waste was chemically analyzed for C, N, P, K, Ca, Mg, cellulose, hemicellulose and lignin by the following methods.

Carbon: Walkey and Black's rapid titration method (1934)

Nitrogen: Micro Kjeldahl method (Singh and Pradhan 1981)

Phosphorus was measured spectrophotometrically (Saxena 1998) while potassium was measured by the flame emission technique (Saxena 1998). Calcium and magnesium were determined by methods given by Saxena (1998). Cellulose, hemicellulose and lignin were fractionated sequentially by Dutta's method (1981).

Moisture was determined by drying the samples at 105°C for 24 hours while ash content was calculated using the formula: Carbon (%) = (100 – Ash %) 1.8 (Stentiford and Dodds 1992). All analyses were done in triplicates.

Interaction Among Microbial Inoculants, AM Fungi and Plant Roots

Different combinations of the microbial inocula for composting were used to study the interactions of these microflora with arbuscular mycorrhiza (AM) fungi and with the roots of mung bean (*Vigna radiata*). Experiments were conducted at Micromodel, IIT in earthen pots (15-inch height and 12-inch diameter) using three replicates. The soil and farmyard manure (FYM) ratio in each pot was 3:1 (w/w). The soil was loamy sand which contained 0.05% N, 0.0008% P and 0.007% K while FYM contained 1.1% N, 0.30% P and 0.62% K. Each pot contained 3.75kg of soil (oven dry basis) and 1.25kg FYM. The pots were maintained at a moisture content of 20% (oven dry basis). The pots were inoculated with 100g of root based AM inocula (200 spores/100g of soil). 15 mung bean seeds per pot were sown in three replicates. The following treatments were applied:

- *P. sajor-caju* (@ 500gm mycelium per ton substrate and 2.5gm mycelium per 50kg substrate) and AM
- *P. sajor-caju*, AM and *T. harzianum* (@ 500gm mycelium per ton substrate and 2.5gm mycelium per 50kg substrate)
- *P. sajor-caju*, AM, *T. harzianum* and *A. chroococcum* (@ 50ml/kg substrate having 10^6 viable cells per ml and 250ml/5kg substrate)
- Control (AM only)

Data pertaining to germination and survival percentage was recorded. Different growth parameters like stem height, fresh biomass and dry biomass of the plant, num-

ber of nodules and mycorrhizal infection were observed and recorded. The experiment was terminated after 3 months. Rhizosphere spore count was done by Gerdmann and Nicolson's (1963) method.

The data was analyzed statistically by two-way analysis of variance (ANOVA) and critical difference was calculated using the INDOSTAT software programme. Two-way analysis of variance is done when two independent factors might have an effect on the response variable of interest (Gupta 2001). The two independent factors in the present study are different treatments and time periods. In Table 2 and 3 both the F value and the F Probability (F Prob.) are indicated along with LSD. The F value is the ratio of the two variances while F Probability indicates the level of significance of the F value.

Results and Discussion

Composting of MSW

Data pertaining to chemical analysis of MSW, horticultural waste and the mixed waste is reported in Table 1. The mixed waste was found to be rich in lignin (30.21%) and hemicellulose (35.50%), although the cellulose content was relatively low (20.25%).

TABLE 1.
Chemical analysis of waste

S. No	Parameters	MSW (Percent dry weight)	Horticultural Waste (Percent dry weight)	MSW + Horticultural Waste (Percent dry weight)
1.	Carbon	20.00	137.00	40.50
2.	Nitrogen	1.60	1.66	1.28
4.	Phosphorus	0.24	0.019	0.20
5.	Potassium	0.28	1.27	0.30
6.	Calcium	1.90	1.55	1.65
7.	Magnesium	3.20	0.155	2.0
8	Cellulose	nd	nd	20.25
9.	Hemicellulose	nd	nd	35.50
10	Lignin	nd	nd	30.21
11	Moisture	90.00	nd	74.0
12.	Ash	64.00	nd	16.93

All values are calculated on a dry weight basis except moisture content and are given in percentage. All values are mean of three replicates; nd = Not determined

Table 2 shows clearly that 30 days of predecomposition of mixed waste treated with a mixed culture of the three inoculants i.e., *P. sajor-caju*, *T. harzianum* and *A. chroococcum* reduced the cellulose, hemicellulose and lignin content at a faster rate than when treated with *P. sajor-caju* and *A. chroococcum*, or *P. sajor-caju* alone (Table 2). The combination of the three inoculants decreased the lignin content from 30.21 to 20.21%, hemicellulose from 35.50 to 18.56% and cellulose from 18.21 to 6.18% after 30 days of predecomposition. The reduction in lignin, hemicellulose and cellulose suggests that these microorganisms played a significant ($p<0.001$) positive role in hastening the process of decomposition. The results on the effectiveness of *P. sajor-caju*, thus, corroborated earlier reports by Saha *et al.* (2000). These scientists reported a sharp decrease in the lignin content and C:N ratio of soft wood sawdust upon treatment with *P. sajor-caju*. Our results are also supported by the findings of Rasal *et al.* (1988) and Sharma *et al.* (1999). Rasal *et al.* (1988) who reported a rapid decomposition of sugarcane trash

TABLE 2.
Chemical analysis of microbially predecomposed mixed waste after different time periods

Treatments	Week	Parameters C (%)	N (%)	C:N Ratio	Cellulose (%)	Hemicellulose (%)	Lignin (%)
P. sajor-caju	1	44.76 ± 1.51	1.43 ± 0.04	30.86 ± 0.74	15.29 ± 0.07	31.36 ± 0.07	29.50 ± 0.07
	2	42.51 ± 0.85	1.62 ± 0.052	26.24 ± 0.87	12.75 ± 0.06	29.78 ± 0.06	26.00 ± 0.09
	3	40.5 ± 1.08	1.84 ± 0.06	22.01 ± 0.45	9.36 ± 0.07	28.50 ± 0.05	23.91 ± 0.04
	4	39.30 ± 0.55	1.85 ± 0.09	21.24 ± 0.74	9.23 ± 0.04	27.94 ± 0.05	20.26 ± 0.12
P. sajor-caju +	1	34.20 ± 1.40	1.45 ± 0.04	23.58 ± 0.64	14.33 ± 0.13	28.70 ± 0.06	29.36 ± 0.05
T. harzianum	2	32.85 ± 0.36	1.62 ± 0.02	20.57 ± 0.66	9.71 ± 0.08	26.94 ± 0.08	25.98 ± 0.10
	3	29.10 ± 0.73	1.85 ± 0.03	15.72 ± 0.78	9.15 ± 0.09	24.60 ± 0.03	23.56 ± 0.04
	4	28.80 ± 0.69	1.85 ± 0.05	15.56 ± 0.66	8.90 ± 0.08	24.31 ± 0.04	20.24 ± 0.07
P. sajor-caju +	1	31.75 ± 0.66	1.45 ± 0.05	22.03 ± 1.07	13.34 ± 0.14	22.87 ± 0.06	29.28 ± 0.04
T. harzianum +	2	27.30 ± 0.79	1.73 ± 0.04	15.78 ± 0.69	7.69 ± 0.10	19.96 ± 0.05	25.56 ± 0.05
A. chroococcum	3	24.30 ± 0.98	1.93 ± 0.07	12.59 ± 0.60	6.36 ± 0.04	18.70 ± 0.07	23.56 ± 0.07
	4	23.70 ± 1.13	1.93 ± 0.04	12.27 ± 0.89	6.18 ± 0.07	18.56 ± 0.04	20.21 ± 0.05
Control	0	49.50 ± 0.30	1.28 ± 0.05	38.70 ± 0.56	20.25 ± 0.12	35.50 ± 0.05	30.21 ± 0.14
	1	46.95 ± 0.36	1.30 ± 0.02	36.11 ± 0.79	18.21 ± 0.10	33.50 ± 0.10	30.21 ± 0.04
	2	43.86 ± 0.84	1.51 ± 0.04	29.04 ± 0.60	13.42 ± 0.07	32.46 ± 0.03	28.36 ± 0.12
	3	41.40 ± 1.27	1.75 ± 0.03	23.65 ± 1.15	11.44 ± 0.10	30.65 ± 0.04	26.72 ± 0.07
	4	40.50 ± 1.42	1.75 ± 0.02	23.14 ± 1.06	11.23 ± 0.06	29.67 ± 0.05	24.32 ± 0.04
F Value (for treatments)		798.92	41.19	598.78	39.13	418.92	11.95
F Prob.		0	0.00001	0	0	0	0
F Value (for time period)		184.03	309.09	414.51	72.94	93.75	103.13
F Prob.		0	0	0	0	0	0
CD at 5%		0.816	0.037	0.665	1.113	0.812	1.103

All values are calculated on a dry weight basis; All values are means and standard deviations of three replicates

upon inoculation with a mixture of the cellulolytic fungi, i.e., *Trichoderma viride, Trichurus spiralis, Paecilomyces fusisporus* and *Aspergillus sp.* along with nitrogen-fixing bacteria *Azotobacter*. Studies conducted by Sharma *et al.* (1999) on mixed plant residues showed that *Trichoderma reesei* reduced the decomposition time. This decline in lignin content may be due to the ability of *P. sajor-caju* to produce lignin peroxidase enzymes, which aids in lignin degradation (Bourbannais and Paice 1988; Saha *et al.* 2000). *P. sajor-caju* is also known to produce cellulose degrading enzymes namely endoglucanase and b-glucosidase (Rai and Saxena 1989). On the other hand, *T. harzianum* is a cellulase and xylanase producer and consequently helps in degrading cellulose and hemicellulose.

The decomposition rate was further enhanced when preinoculated predecomposed waste was subjected to subsequent vermicomposting with *E. foetida*. The data presented in Table 3 shows that subsequent vermicomposting of predecomposed organic waste pretreated with inoculants, enriched the compost significantly ($p<0.001$) in NPK with respect to the control. The compost produced with *P. sajor-caju, T. harzianum* and *A. chroococcum* and subsequent vermicomposting was found to be of superior quality over the compost prepared by only inoculating with microflora i.e. without subsequent vermicomposting. The C:N ratio decreased from 38.67 to 22.03 within 30 days where waste was treated with all three inoculants and finally to 10.67 after subsequent vermicomposting for one month. Likewise, an increase in NPK values was also significant ($p<0.001$) in compost produced after subsequent vermicomposting of 7-days decomposed waste treated with all the three inoculants. The microflora utilize carbohydrates during cell synthesis and ammonium nitrogen gets converted into pro-

TABLE 3:
Chemical analysis of vermicompost produced from predecomposed mixed waste after different time periods

Treatments	Week	Parameters C (%)	N (%)	C:N Ratio	P_2O_5 (%)	K_2O (%)	Cellulose (%)	Hemicellulose (%)	Lignin (%)
P. sajor-caju	1	32.40 ± 0.54	1.85 ± 0.44	17.51 ± 0.55	0.10 ± 0.02	0.41 ± 0.08	8.53 ± 0.43	27.71 ± 1.68	12.78 ± 0.67
	2	32.34 ± 1.09	1.86 ± 0.31	17.38 ± 0.44	0.11 ± 0.02	0.41 ± 0.05	8.53 ± 0.43	27.70 ± 0.90	12.78 ± 1.51
	3	32.34 ± 0.78	1.85 ± 0.45	17.48 ± 0.60	0.11 ± 0.02	0.41 ± 0.06	8.52 ± 0.51	27.70 ± 1.68	12.78 ± 0.99
	4	32.57 ± 0.52	1.85 ± 0.14	17.48 ± 0.51	0.11 ± 0.02	0.41 ± 0.17	8.52 ± 0.45	27.68 ± 0.90	12.76 ± 1.02
P. sajor-caju +	1	28.8 ± 0.69	2.00 ± 0.24	14.40 ± 0.62	0.11 ± 0.02	0.42 ± 0.12	8.17 ± 0.93	24.10 ± 0.81	12.63 ± 0.66
T. harzianum	2	28.8 ± 0.49	2.00 ± 0.177	14.40 ± 0.54	0.11 ± 0.02	0.42 ± 0.05	8.16 ± 0.75	24.09 ± 1.26	12.62 ± 0.75
	3	28.74 ± 0.82	2.01 ± 0.07	14.29 ± 0.48	0.12 ± 0.01	0.42 ± 0.13	8.16 ± 0.51	24.09 ± 0.34	12.62 ± 0.71
	4	28.74 ± .088	2.00 ± 0.24	14.37 ± 0.36	0.12 ± 0.02	0.42 ± 0.10	8.16 ± 0.72	24.07 ± 1.04	12.60 ± 0.62
P. sajor-caju +	1	22.20 ± 0.54	2.08 ± 0.09	10.67 ± 0.61	0.11 ± 0.02	0.43 ± 0.03	6.02 ± 1.17	17.98 ± 2.18	12.31 ± 0.65
T. harzianum +	2	22.20 ± 1.45	2.08 ± 0.15	10.67 ± 0.64	0.11 ± 0.01	0.43 ± 0.14	6.00 ± 0.50	17.98 ± 1.30	12.30 ± 0.52
A. chroococcum	3	22.20 ± 0.23	2.08 ± 0.32	10.73 ± 0.64	0.12 ± 0.02	0.43 ± 0.07	6.00 ± 1.31	17.96 ± 0.48	12.30 ± 0.87
	4	22.20 ± 0.45	2.08 ± 0.28	10.67 ± 0.40	0.12 ± 0.02	0.43 ± 0.04	6.00 ± 0.43	17.95 ± 2.17	12.30 ± 1.16
Control	1	34.08 ± 0.56	1.75 ± 0.14	19.47 ± 0.75	0.09 ± 0.04	0.35 ± 0.05	9.76 ± 0.76	29.56 ± 1.51	22.35 ± 0.97
	2	33.84 ± 0.92	1.76 ± 0.22	19.22 ± 0.77	0.09 ± 0.02	0.35 ± 0.07	9.71 ± 0.63	29.50 ± 0.94	22.12 ± 1.20
	3	33.72 ± 1.03	1.76 ± 0.26	19.15 ± 0.58	0.10 ± 0.03	0.37 ± 0.08	9.68 ± 0.75	29.46 ± 0.85	21.96 ± 0.84
	4	33.72 ± 0.54	1.76 ± 0.28	19.15 ± 0.68	0.10 ± 0.01	0.38 ± 0.06	9.60 ± 0.73	29.42 ± 0.62	21.90 ± 0.83
F Value (for treatments)		533.07	6339.94	512.90	120.78	63.07	9735.43	178803.5	10562.13
F Prob.		0	0	0	0	0	0	0	0
F Value (for time period)		0.05	1.60	0.08	38.35	2.02	1.76	4.21	1.35
F Prob.		0.98563	0.25611	0.96827	0.00002	0.18233	0.22468	0.04050	0.31959
CD at 5%		0.648	0.005	0.477	0.0028	0.115	0.048	0.058	0.148

All values are calculated on a dry weight basis; All values are means and standard deviations of three replicates; Vermicompost of one week predecomposed mixed waste; Vermicompost of two week predecomposed mixed waste; Vermicompost of three week predecomposed mixed waste; Vermicompost of four week predecomposed mixed waste

teinaceous nitrogen and is localized in the cell (Sharma *et al.* 1999;Singh and Sharma 2000) thus increasing the nitrogen concentration after 7 days of predecomposition. Also, *Azotobacter* might have played a vital role in enriching the compost through nitrogen fixation and promoting the growth of *P. sajor-caju* and *Trichoderma*. The ability of *Azotobacter* to synthesize auxins like indoleacetic acid and gibbrellins; vitamins like thiamine, riboflavin, pyridoxine, cyanocobalamin, nicotinic and pantothenic acid; and growth substances and antibiotics that suppress pathogens is well recognized (Subba Rao 1982). The gut of earthworms termed as bioreactor also provides suitable environment for the growth of microbes. The enhanced number of microbes mainly bacteria and actinomycetes (Parle 1963) might have accelerated the decomposition process. Our results are in agreement with those of Frederickson *et al.* (1997) who observed that the volatile solids content reduced significantly over the control when waste partially predecomposed for 2 weeks was vermicomposted for 6 weeks. Furthermore, it can be seen from **Table 4** that following inoculation with all three cultures of microorganisms, the number of earthworms increased significantly in a very short time (30 days) over other treatments. It is reported that fungi and protozoa ingested by the earthworms play an important role in promoting their growth (Flack and Hartenstein 1984). The partially decomposed substrate rich in nitrogen and fungi (*P. sajor-caju*), preferred by *Eisenia foetida*, might have increased the number of earthworms. Subsequent vermicomposting of inoculated predecomposed waste thus not only accelerates the decomposition process but also enriches the compost with nutrients.

TABLE 4.
Growth of earthworms (*Eisenia foetida*) on microbially decomposed mixed waste

S. No	Treatments	Growth of Earthworms	
		No. of Earthworms	No. of Cocoons
1	*P. sajor-caju*	21 ± 1.08	13 ± 1.20
2	*P. sajor-caju* + *T.harzianum*	31 ± 2.01	18 ± 0.98
3	*P. sajor-caju* + *T.harzianum* + *A. chroococcum*	33 ± 1.50	22 ± 1.35
4	Control	17 ± 1.02	8 ± 1.20
	CD at 5%	1.99	2.05

Initial number of earthworms inoculated=10

Interaction Studies with AM Fungi and Plant Root

The results on the effect of different composts prepared with the use of inoculants, on the growth of mung bean (*Vigna radiata*) are reported in Table 5. All the treatments enhanced both the germination and the survival percentage along with the height of the plants and percent of mycorrhizal infection over the control. In the control treatment where compost was prepared without using any inoculants, only 33% germination and 43% survival was observed. Conversely, the compost prepared with the microbial inoculants showed 51 to 64% germination and 52 to 58% survival. Maximum growth was observed with the compost where all three inoculants were applied. The compost that contained certain plant growth promoting hormones and enzymes produced by the inoculants, and with a higher content of NPK may explain its greater agronomic value. Similar results have been reported by Vazquez *et al.* (2000) where interaction between AM fungi and other microbial inoculants (*Azospirillum*, *Pseudomonas* and *Trichoderma*) was studied in the rhizosphere of maize plants. Increase in plant growth may also be attributed to the potential of these microflora to act as biocontrol agents.

Over the last few years *Trichoderma* has received considerable attention as a potential biocontrol agent for a number of soilborne pathogens (Chet 1987; Samuels 1996). Meera *et al.* (1995) reported the enhanced growth of cucumber in substrate amended with *T. harzianum*. *T. harzianum* stimulates the plant defense system by penetrating and growing in the epidermis and outer cortex and leading to the production of biochemical and structural compounds. Lima *et al.* (1997) reported that *Trichoderma* species attack other fungi by secreting lytic enzymes including b-1,3-glucanase and chitinolytic enzymes which play different roles in cell wall lysis during mycoparasitism (Vazquez-

TABLE 5.
Interaction among bioinoculants, mycorrhiza and growth of mung bean (*Vigna radiata*)

S.No	Treatment	Germination (%)	Survival (%)	Fresh Biomass (g)/pot	Dry Biomass (g)/pot	Stem Height (cm)	No of Nodules/ Plant	Mycorrhiza Infection (%)
1	P. sajor-caju	51.11 ± 1.33	51.84 ± 0.82	15.7 ± 1.13	1.72 ± 0.04	23.33 ± 1.25	3 ± 0.00	80 ± 5.00
2	P. sajor-caju + T.harzianum	59.50 ± 1.33	57.77 ± 0.72	25.66 ± 1.33	2.82 ± 0.11	25.26 ± 0.84	1 ± 1.00	90 ± 4.35
3	P. sajor-caju + T. harzianum + A. chroococcum	64.44 ± 1.09	58.17 ± 1.00	28.25 ± 1.14	3.10 ± 0.13	28.81 ± 1.01	1 ± 1.00	90 ± 4.35
4	Control	33.44 ± 3.41	42.96 ± 2.18	11.76 ± 0.66	1.29 ± 0.05	22.75 ± 1.75	3 ± 1.00	40 ± 5.0
	CD at 5%	3.66	2.48	2.06	0.18	2.37	1.63	8.83

All values are means and standard deviations of three replicates

Garciduenas *et al.* 1998). The antagonistic activity is also due to the production of antibiotics namely Trichodermin with antipathogenic activity which makes the compost pathoge-free (Ghisalberti and Sivasithamparam 1991) and hydrolytic enzymes (Harman *et al.* 1993; Haran *et al.* 1996) besides competition for nutrients in the rhizosphere (Chet 1987; Sivan and Chet 1993).

Mycorrhizal root infection may also be promoted by certain amino acids and enzymes produced by *P. sajor-caju* and in turn mycorrhiza facilitates the uptake of nutrients mainly phosphorus from soil by the plant roots (Sharma *et al.* 2000). It is well known that mycorrhizal infection can enhance the uptake of nutrients and water by plants (Hayman 1982; Perry *et al.* 1987). Thus, overall enhanced growth response by mung beans may be attributed to the supply of plant nutrients in available form released from compost and soil through microbial inoculants and biocontrol of certain soilborne pathogens.

Summary and Conclusions

The role of earthworms in improving soil fertility by converting the animal excreta, sewage sludge and agro-industrial wastes into compost is well-documented. But little attention has been paid to the utilization of earthworms in converting MSW into a useful organic amendment. Our study has shown that MSW in combination with horticultural waste can be converted into a valuable compost through aerobic composting by first inoculating efficient microbial inoculants followed by subsequent vermicomposting. It was observed that the microbial inoculants namely *P. sajor-caju*, and *T. harzianum* played a major role in accelerating the predecomposition process while *A. chroococcum* enriched the compost through nitrogen fixation. Though significant changes in the chemical properties of the feedstock during predecomposition with *P. sajor-caju* alone and in combination with *T. harzianum* were observed, the combination of all the three inoculants proved to have the greatest effect on composting rate. Vermicomposting (for one month) of the feedstock predecomposed for different time periods did not result in any significant change in the chemical properties of the composts but significantly improved plant growth properties. Thus it can be concluded that the minimum time required for the decomposition process is 37 days which includes predecomposition of the feedstock for 7 days followed by vermicomposting for one month. This reactor system thus proved to be useful with respect to reduction in the time period required for composting as well as enhancing the nutritional value of the final product. The compost proved to be beneficial for growth of mung bean (*Vigna radiata*) as it enhanced the mycorrhizal infection, which in turn enhanced the uptake of mineral nutrients and overall plant growth and biomass yield.

However, there are certain limitations of this reactor system. Firstly, the waste has to be partially decomposed, as *Eisenia foetida* prefers partially decomposed waste. Secondly the experiment has to be conducted under proper temperature conditions between 20-27°C as the mesophilic fungi, *P. sajor-caju*, is known to function most efficiently within this range. Also, MSW has to be mixed with horticultural waste to balance the C/N ratio, reduce the compactness and increase the porosity of the feedstock.

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