Mobility of N, P, ethoprophos in three upland soils as affected by chemical fertilizer and composted manure under soybean-cultivated lysimeters

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Abstract
Lysimeter experiment (dia. 300 mm, soil length 350 mm) with soybean cultivation were conducted to investigate the effect of chemical fertilizer and compost on the mobility of N, P, and ethoprophos-a nematocide and an organophosphorus compound in three upland soils that were obtained from different agricultural sites of Korea: mesic Typic Dystrudepts (hill slope soil, Soil A); mixed, mesic Typic Udifluvents (floodplain soil, Soil B); artificially disturbed soils (soils under plastic-film house, Soil C).. Before treatments were implemented, soils were stabilized by repeated drying and wetting procedure for two weeks. Two types of treatments were applied to the lysimeters, application of urea at 60 kg N /ha plus KH_2PO_4 at 80 kg P_2O_5/ha, and N-based application of composted manure considered to be 16.5% availability, with ethoprophos at 10 kg a.i. /ha. Soybean was grown for 46 days, and had 191 mm irrigation through seven occasions. The above-ground biomass and surface soil (0~15 cm) were sampled at 15, 21, 31, and 46 days after sowing. The soil solution was sampled at 25 cm depth, belonging to subsurface soil (16~35 cm). Inorganic N and P concentration in surface soil were highly correlated with N and P content of soybean leaf. Compost application enhanced P availability in Soils A and B, while chemical fertilizer facilitated N availability in all soils. Ethoprophos content of surface soil was not significantly different between treatments. Meanwhile, ethoprophos concentration in soil solution in Soil A was the highest, but was considerably reduced by composted manure. Therefore, the results suggested that composted manure could cause lower mobility than chemical fertilizer for ethoprophos.

Key Words
Lysimeter, compost, urea, nitrate, phosphate, ethoprophos, soybean.

Introduction
The impact of horticultural and agricultural uses of pesticides and nutrients on water quality generally starts as they leave the original point of application, i.e., through leaching or runoff, rather than the presence in soil (Pierzynski *et al.* 1994). Chemical fertilizer and composted manure generally cause the change in soil nutrient status and physico-chemical and biological properties, and thereby affect the migration potential of nutrients and pesticides from field. Less research, however, has been devoted to their effect on mobility of nutrients and pesticides. It is imperative that nutrient and pesticides are together considered to grasp the potential risk of non-point source on water quality in target soil. In this study, thus, lysimeter experiment, with soybean cultivation was conducted to investigate the effect of soil characteristics and inputs (chemical fertilizer, compost) on mobility of N, P, and ethoprophos.

Methods
Six plastic lysimeters of internal diameter 300mm and depth 400mm were packed with sea sand to 5mm from the bottom, and then with air-dried and sieved soils (< 2mm) described in table 1 to 450 mm from the top of sea sand. To ensure uniform packing, the lysimeters were packed in increments of 100 mm. Two treatments were set up. In treatment I upper 120mm soil was incorporated with urea (5 ^{15}N atom%) 0.91g, KH_2PO_4 1.08 g, and 1.413g Mocap (a.i. 5%), equivalent to 10 kg a.i. ethoprohos /ha. In treatment II upper 120mm soil was incorporated with 100.95g composted manure, N-based application considering 16.5% N availability, and 1.413g Mocap (a.i. 5%). TDR was used to measure the soil's volumetric water content. Three-rod TDR probe (2 mm in diameter and 200 mm long) and soil solution samplers (2 mm diam. and 50 or 100 mm long) were installed horizontally into the lysimeters at the depth of 250 mm from soil surface. To determine water content of surface soil, three-rod probe was obliquely installed into lysimeters covered with from 50 mm to 150mm depth. Soil temperature sensors were installed at the depth of 100 and 250 mm from soil surface. TDR and soil temperature measurements were made daily between 15:00~18:00 at which nearly maximum soil temperature was maintained. Seven soybean (*Glycine max* Merr.) seeds were sowed in each

lysimeter. After germination, three seedlings were thinned and each four plant was sampled at 15, 21, 31, and 46 days after sowing, respectively. Sampled plants were analysed for dry biomass, N, and P content. At the same time, surface soil (0-15 cm) was sampled and analysed for N, P, and ethoprophos and the soil solution was sampled at the depth of 25 cm, belonging to subsurface soil (16-35 cm). In addition, at final sampling time, subsurface soil (16-35 cm) was sampled and analyzed for N, P, and ethoprophos followed by Sparks (1996) and Han et al. (2003). Tap water was surface-irrigated with a dripper to supply water.

Table 1. The physico-chemical properties of soils and composted manure used.

		Soil A	Soil B	Soil C	Compost
pH (1:1)		4.97	5.04	5.66	7.23[a]
Organic C (g/kg)		8.1	15	32.4	302.8
Total N (g/kg)		0.58	1.33	2.78	25.3
C/N ratio		14.1	11.3	11.6	12
Total P (g/kg)		0.24	0.51	3.86	18.79
C/P ratio		33.8	29.4	8.3	16.1
CEC (cmol/kg)		7.5	11.2	14.2	NA[c]
Mineral N	NH_4^+-N	8.3	48.3	18.8	510.2 (2.0)[b]
(mg/kg)	NO_3-N	5	57.1	9.8	2372.0 (9.4)
Soil texture	Sand	624.1	440	607.9	NA
(g/kg)	Silt	270.9	413.2	292.7	NA
	Clay	105	146.8	99.4	NA

[a] The ratio of soil:water was 1:5.; [b] % of total compost-N; [c] Not Applicable.

Results

During experiment, NH_4^+-N contents in surface soil were a range of 0-18, 0-25 and 0-35 mg/kg and NO_3^--N contents were 2-27, 5-65, and 0-45 mg/kg in Soils A, B, and C, respectively. Soils A and C had maximum mineral-N content in surface soil on day 21 but a Soil B by day 32. Mineral-N content in surface soil was generally much higher in T I than in T II, whereas soluble NO_3^--N content in subsurface soil had slightly lower in T I than that in T II at initial time after treatments.

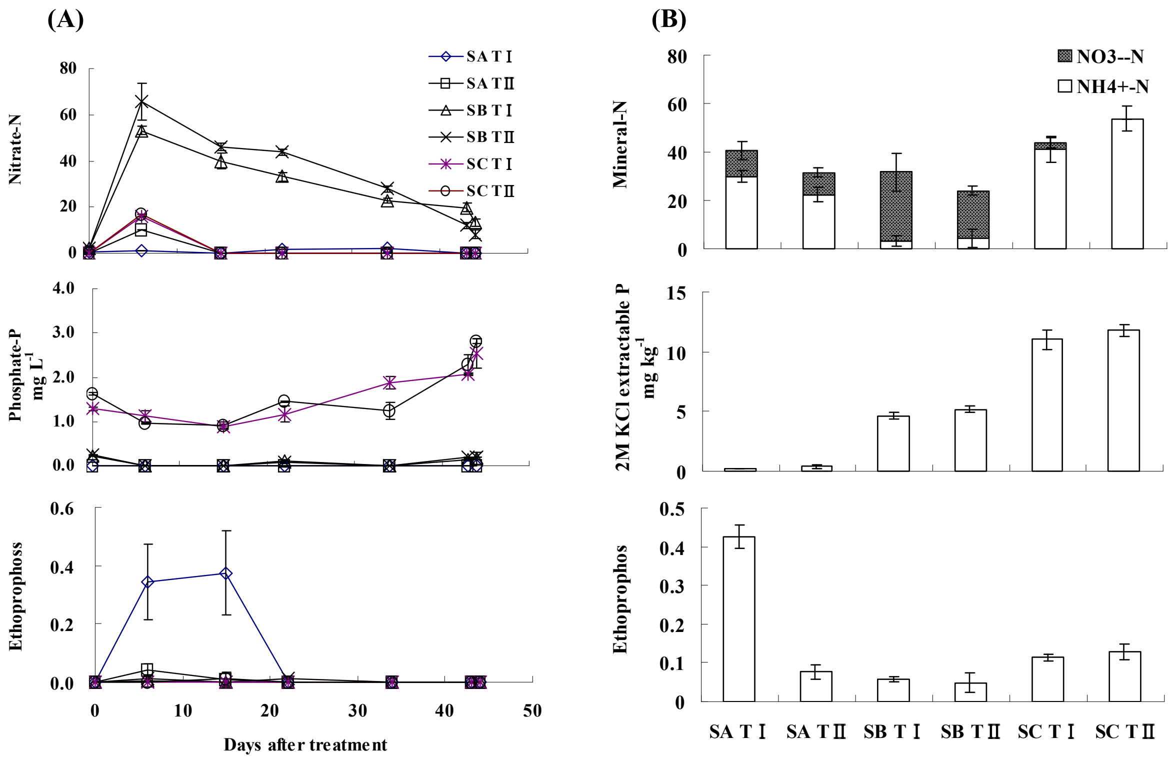

Figure 1. (A) Soluble nitrate-N, phosphate-P, and ethoprophos content per soil volume in subsurface soil, (B) Mineral-N, 2M KCl extractable P, and ethoprophos content in subsurface soil at final sampling. SA, SB, and SC indicate Soils A, B, and C, respectively; T I and T II indicate chemical fertilizer and compost treatment, respectively. Values are the means of triplications. Vertical bars indicate standard deviations of the means.

The nitrate concentration in soil solution of subsurface soil decreased with soybean growth, whereas phosphate concentration did not. This suggested that the P concentration in the soil solution did not readily decrease due to continuous P supply from a P accumulated matrix. More careful P management, therefore, was essentially required because P loss could hardly be controlled in P accumulated soil**.** The initial concentration of ethoprophos when incorporated with soil was 5.76±0.87 mg soil/kg. During experiment, the ranges of ethoprophos content in surface soil was 0.05-0.11, 0.16-2.7, and 0.27-1.66 mg/kg for Soils A, B, and C, respectively. Soil A had an abrupt decrease in ethoprophos content by day 14^{th} and then was almost constant. Unlike Soil A, Soils B and C had a decreasing pattern with time in ethoprophos content. Contrasted with the surface soil, soluble ethoprophos content in the subsurface soil was much higher in Soil A than those in the other soils, especially soils with chemical fertilizer treatment.

Conclusion

This study suggested that vertical movement of nitrate, phosphate, and ethoprophos was relatively high in Soil B, Soil C, and Soil A, respectively, depending on water transport and sorption characteristics. In addition, it was concluded that composted manure resulted in lower mobility for ethoporphos than chemical fertilizer

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