

Effects of Humic Material, Compost, Chicken Manure, Deetoka, Vigriphol, Agrostemin, and Chemical Fertilizers on Corn, N-fertilizer Efficiency and Soil Hardness

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ABSTRACT

An experiment was conducted using large pots and low-fertility soil to compare the effects of humic material, compost, chicken manure, Dectoka, Vigriphol, Agrostemin and foliar chemical fertilizers on corn, the efficiency of N from urea and soil hardness. Planting was done in three successive croppings.

The humic material at 42.5 l ha⁻¹ and the compost at 6.25 ha⁻¹ when applied alone were equally effective but superior to low-rate chemical fertilizer in their growth-promoting on corn. However, chicken manure at 6.25 t ha⁻¹ was about twice as effective as those two materials. The humic material, compost, Deetoka, Vigriphol, Agrostemin, foliar K fertilizer and foliar NPK fertilizer, when applied in combination with adequate rate of chemical fertilizers, were not effective in promoting growth of corn plants whereas chicken manure when applied in combination with adequate-rate chemical fertilizers were much less effective than when applied alone. The growth-promoting effects of humic material, compost and chicken manure were primarily due to the supplies of the fertilizer elements thereof. The humic material was more effective in decreasing soil hardness than the compost and the chicken manure. The humic material, compost, Deetoka, Vigriphol and Agrostemin did not affect the assimilation of mineral N in soil whereas chicken manure reduced the assimilation of mineral N in soil through dilution effect of the mineral N released thereof. Considering both the cost of materials and crop response, chicken manure should be most recommended to use for corn production.

Key words: chemical fertilizers, corn, N-fertilizer efficiency, organic manures, soil hardness

INTRODUCTION

Many materials for crop and soil treatments to improve crop production have been introduced into the market. These include humic material, Deetoka, Vigriphol and Agrostemin. They have been recommended by the producers for applying either by spraying on the crop or applied into soil and claimed to increase crop yields and improve soil physical properties. Some authors reported

positive responses in crop yields to humic acids application (e.g., Flaig, 1968; Khristeva, 1970; Kononova and Alexandrova, 1971; Tan and Tantiwitramanond, 1983) and in the N uptake from soils (e.g., Kononova and Alexandrova, 1971; Rauthan and Schnitzer, 1981). Humic acids have also been reported to improve soil tilth or workability of the soil (Inukai and Shibuya, 1959; Swictechowski, 1960). Tanyadee *et al.* (1994) summarised results of experiments on

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humic material done in Thailand. The results showed no significant grain yield response of paddy rice grown in strongly acidic soils and in an acid sulfate soil but increased in grain yield of Kawdokmali-105 rice grown in Roi-Et soil series, a coarse-textured, low-fertility soil, when humic material was used in combination with chemical fertilizers. Increases in yields of vegetables on application of humic acids were also observed and conclusion was drawn that humic acid could be used to replace farm yard manures and compost.

This paper presents results of a study on effects of a humic material, Deetoka, Vigriphol and Agrostemin applied to corn plants and/or soil according to the producer's instruction in comparison to chicken manure, compost and chemical fertilizers which are common materials for increasing crop yields and/or soil improvement. Timely foliar K and NPK fertilizers were also included as timely foliar K fertilizer has been reported to increase yields and quality of corn (Suwanarit and Sestapukdee, 1989).

MATERIALS AND METHODS

Experimental Design and Treatments

An experiment was conducted using large pots. Each pot contained 23 kg soil. The soil was Korat soil series with very low fertility. It had a loamy sand texture, pH 5.2, 0.8% organic matter, 10 ppm available P by Bray II Method and 45 ppm NH_4OAc -extractable K. A randomized complete block design with 15 treatments and 3 replications was employed. One Suwan-1 corn plant was grown in each pot. The treatments were as the following.

- C = Control, without any treatment.
 F = application of chemical fertilizers at an equivalent rate of 8, 8 and 4 kg N, P_2O_5 , and K_2O rai^{-1} (6.25 rai = 1 ha) by mixing with the soil at planting.
 F1 = application of chemical fertilizers at an equivalent rate of 16, 16 and 8 kg N, P_2O_5 ,

and K_2O rai^{-1} by mixing with the soil at planting.

- H = application of humic material, at an equivalent rate of 6.8 l rai^{-1} (approximately 3 times of the rate recommended by the producer). Humic material of 0.5 ml was dissolved in 100 ml water and then applied to one pot by spraying on the soil surface.
 Cp = application with compost at an equivalent rate of 1,000 kg rai^{-1} by mixing with the soil before planting.
 Ch = application with chicken manure at an equivalent rate of 1,000 kg rai^{-1} by mixing with the soil before planting.
 FH = as F and H
 FCp = as F and Cp
 FCh = as F and Ch
 FDs = as F and, in addition, application of Deetoka at an equivalent rate of 6.8 l rai^{-1} applied in the same way as the humic material in H.
 FDF = as F and, in addition, foliar application of Deetoka at the producer's recommended rate (0.5 ml l^{-1}) and times (by spraying on corn leaf at 3, 4 and 5 weeks after sowing). Spraying was done so that the solution started to run on the leaf surface.
 FV = as F and, in addition, foliar application of Vigriphol in a similar way as Deetoka. The applied solution was prepared by dissolving 20 ml Vigriphol in 20 l water.
 FA = as F and, in addition, application of Agrostemin-1 by mixing with the seeds (16 g per 2 kg seeds) and Agrostemin-2 by dissolving 73.7 g of the material in 100 ml water for spraying on one plant at the 5 leaf stage.
 FKf = as F and, in addition, foliar application of 1.00% KCl solution on the third day after 50% anthesis.
 FFF = as F and, in addition, 1.00% solution of a 20-20-20 foliar fertilizer applied by the same timing and method as Kf.

The humic material, Deetoka and Vigriphol were those on sale in Thailand. Deetoka were local products. Vigriphol was an imported products.

Agrostemins were imported products containing, according to the producer, (1) phytohormonal complex (Cytokinin complex, Gibereline complex and Auxin in small parts), (2) amino acids, organic acids and derivatives of organic acids (Tryptophan, Glutamic acid, Orcialanine, Alantoinic acid, Alantoin and Adenine) and (3) inhibitors (apcisine acids, unsaturated aliphatic hydrocarbons and cyclic inhibitors). The active ingredient consisted of 9.09% of groups (1) and (3) and 90.91% of group (2). Each type of Agrostemin consisted of 1.00% of active ingredient and 99.00% neutral carrier substance, Mg_2SiO_4 . The specific constituents of Agrostemin-1 and Agrostemin-2 were not given by the producer. The N, P and K fertilizers were applied as urea, triple superphosphate and muriate of potash. Urea with 1.745% ^{15}N atom excess were used for the relevant treatments for assessing effects of the substances on efficiency of the N fertilizer.

Planting and Parameter Measurements

Corn plants were grown in three successive croppings. However, the treatments were applied only either before planting of crop I or to the plants of crop I. Harvests were done after crop maturity in the case of crop I and at 50% tasseling in the cases of crop II and crop III. Tap water was given liberally via saucers with water spraying on to the soil surface only when necessary to keep the soil surface moist. Penetration resistance, measured with a penetrometer with graphic recorder, was used as an index of soil hardness. The measurement was done after the harvest of crop I when the undisturbed soil in the pot had been left to dry out in the sun and protected from rains for about one month. Each pot was measured in triplicate and the mean value was taken as the value for the pot. The

plant samples were analysed for N contents by semi-micro Kjeldhal method by digesting with mixed acids as described by Jackson (1958) followed by determination of total N with Kjeldahl distillation (Bremner, 1965). The ^{15}N contents were determined by ^{15}N emission spectrometry with a Jasco N-150 emission spectrometer. % FUE, i.e. percent fertilizer use efficiency, was calculated by the following formulae.

$$\% \text{ Ndff} = \frac{\% \text{ }^{15}\text{N a.e. in plant}}{\% \text{ }^{15}\text{N a.e. in fertilizer}} \times 100$$

$$\text{Fertilizer-N yield} = \frac{\% \text{ Ndff}}{100} \times (\text{total N yield of plant})$$

$$\% \text{ FUE} = \frac{\text{Total fertilizer-N yield}}{\text{Rate of N fertilizer}} \times 100$$

RESULTS AND DISCUSSION

Plant Yields

Grain yields and total dry matter yields (dry matter of the aerial parts) from crop I (Figuer 1) showed that all of the treatments increased growth and yield of corn. However, chicken manure applied alone or in combination with the lower rate chemical fertilizer was so much more effective than the other treatments that they gave total dry matters which were 2.0 - 4.4 folds of those of the other treatments. Humic material applied alone was comparable to the higher rate chemical fertilizers. The compost applied alone tended to be more effective than the lower rate chemical fertilizers.

It may be note-worthy that application of the lower-rate chemical fertilizers in combination with

chicken manure produced lower plant yields than application of chicken manure alone. This was presumably due to the imbalance of nutrient elements induced by the application of chemical fertilizers. The marked superiority of chicken manure applied alone to the chemical fertilizers applied alone suggested that the soil was deficient not only in the fertilizer elements but also in other elements.

Humic material, compost, Deetoka, Vigriphol, Agrostemin, foliar K and the foliar chemical fertilizers when applied in combination with the lower-rate chemical fertilizers showed not only no advantage but also depressive effects. This suggested that the effects on plant yields of these materials were primarily from the supply of the fertilizer elements (N, P and K). Application of these materials in combination with the low-rate chemical fertilizers had presumably induced nutrient imbalance which in turn reduced plant

yields. This was well supported by the depressive effects of the low-rate chemical fertilizers when applied in combination with chicken manure discussed above.

N Yield and % FUE

Total N in the aerial parts of corn (Figure 2) showed that no significant advantage was obtained from application of humic material, compost, Deetoka, Vigriphol, Agrostemin, foliar K or foliar chemical fertilizers when they were applied in combination with the lower-rate chemical fertilizers. In contrast, application of chicken manure in combination with the lower-rate chemical fertilizers markedly increased the total N to about 4 folds of that from application of the lower-rate chemical fertilizer alone. Humic material, compost, Deetoka, Vigriphol and Agrostemin tended to reduce % FUE, with Deetoka showing the highest trend

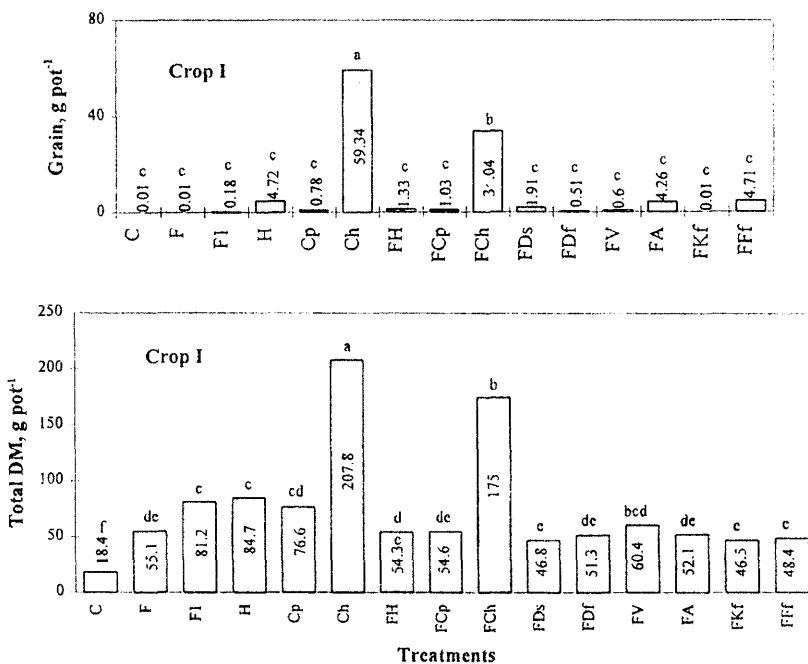


Figure 1 Dry grain and total dry matter (total DM) of corn as affected by different treatments. Bars with a common letter were not different by DMRT₀₅, % CV: 137.6 for grain; 18.7 for total DM.

(Figure 2). Chicken manure, however, markedly decreased % FUE. This depressive effect of chicken manure on % FUE was presumably due to the dilution of the native soil N by the fertilizer N. The same applied to the depressive trends of the other materials. None of the materials investigated increased the efficiency of mineral N in soil.

Soil Hardness

Penetration resistance at 5-cm and 10-cm depths (Figure 3) showed that all the treatments, including F but FH, showed only trends to reduce hardness of the soil. This was presumably due to the effects of the increased root systems of the treatments. FH treatment, i.e., application of humic material in combination with the lower rate chemical fertilizers, significantly reduced the hardness at 5-cm depth but showed only a trend of decrease in the hardness at 10-cm depth, whereas H treatment

significantly decreased hardness at 10-cm depth. These evidences suggested that the chemical fertilizers had induced fixation of the humic material, which was applied by dissolving in water spraying on the soil surface, resulting in concentration of the applied humic material near the soil surface. The reduction in penetration resistance suggested that the humic material had induced more soil aggregation than all of the other materials.

Residual Effects on Plant Growth

Total dry matter from crops II & III were given in Figure 4. In crop II, only chicken manure, both when applied alone and when applied in combination with the lower-rate chemical fertilizers, and compost applied in combination with the lower-rate chemical fertilizers showed positive residual effects. In crop III, only compost, both when applied alone and when applied in combi-

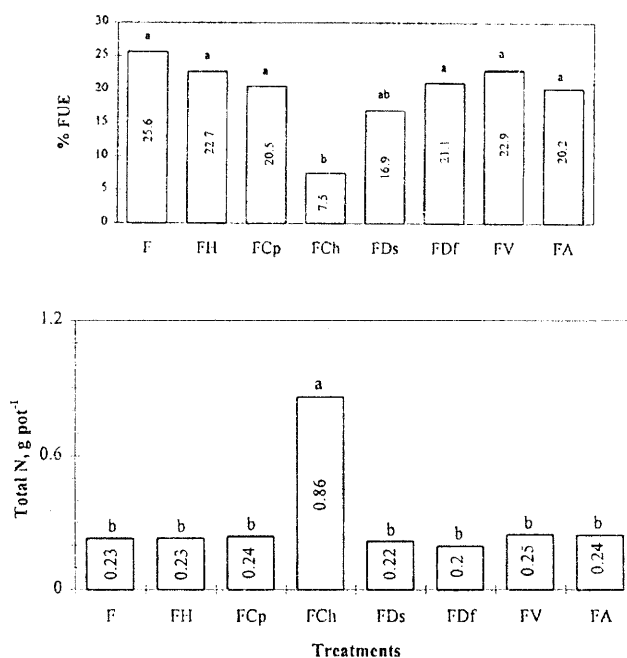


Figure 2 Total N in the aerial parts and % N fertilizer recovered in the aerial parts (% FUE) of Crop-I corn as affected by different treatments. % CV: 38.1 for total N; 31.1 for % FUE. Refer to Figure 1 for captions.

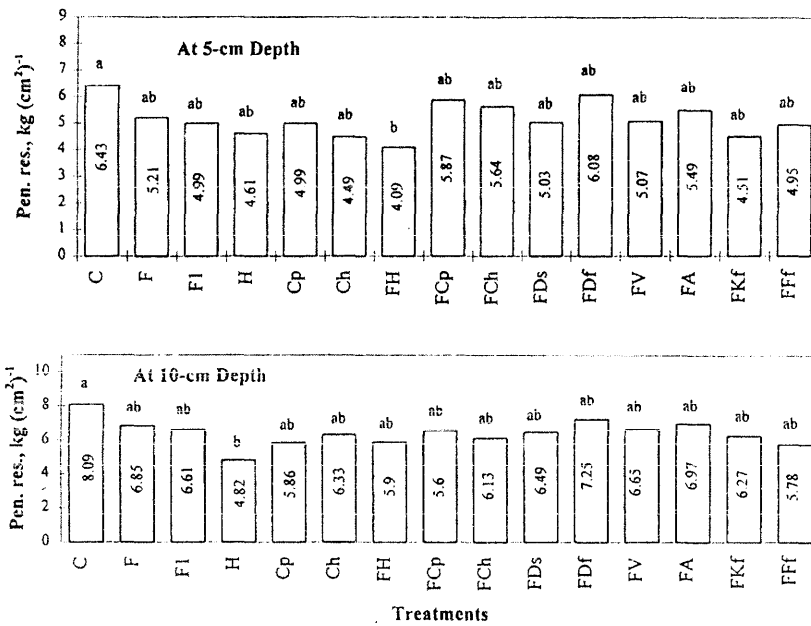


Figure 3 Penetration resistance of soil at 5-cm and 10-cm depths as affected by different treatments. % CV: 22.6 for 5-cm depth; 22.4 for 10-cm depth. Refer to Figure 1 for captions.

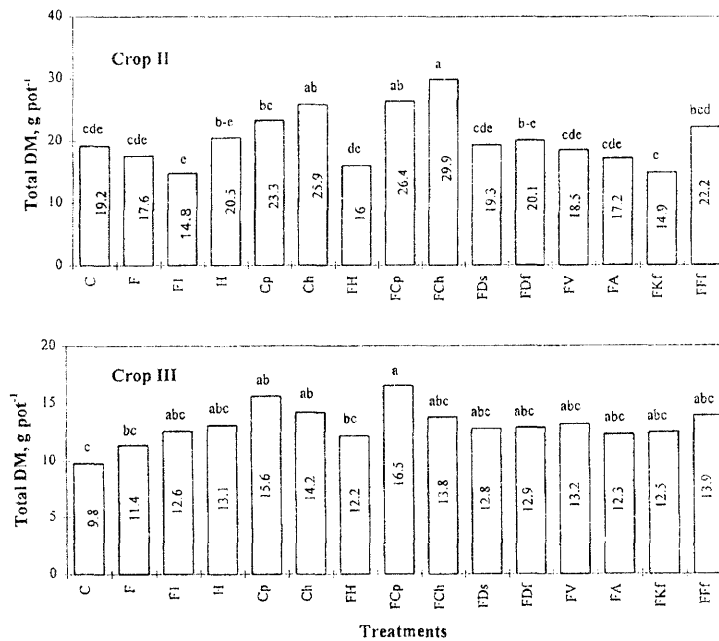


Figure 4 Total dry matter (total DM) of corn plants from crops II & III as affected by different treatments. % CV: 16.3 for crop II; 16.4 for crop III. Refer to Figure 1 for captions.

nation with the lower-rate chemical fertilizers and chicken manure applied alone showed significant positive residual effects. It was therefore clear that the effects on crop yield of compost and chicken manure last longer than that of the humic material.

CONCLUSIONS AND RECOMMENDATION

From the present experiment, conclusions may be drawn and recommendation can be made as the following.

1) The humic material at 6.8 l rai⁻¹ and compost at 1 t rai⁻¹ when applied alone were comparable but superior to the lower-rate fertilizer in their growth-promoting effects on corn grown in low-fertility soils. However, chicken manure at 1 t rai⁻¹ was about twice as effective as these two materials.

2) The humic material, compost, Deetoka, Vigriphol, Agrostemin, foliar K fertilizer and foliar NPK fertilizer, when applied in combination with adequate rate of chemical fertilizers, were not effective in promoting growth of corn plants whereas chicken manure when applied in combination with adequate-rate chemical fertilizers was much less effective than when applied alone.

3) The growth-promoting effects of humic material, compost and chicken manure were primarily due to the supplies of the fertilizer elements thereof.

4) The humic material at 6.8 l rai⁻¹ was more effective in promoting soil aggregation than compost at 1 t rai⁻¹ and chicken manure at 1 t rai⁻¹.

5) The humic material, compost, Deetoka, Vigriphol and Agrostemin did not significantly affect the assimilation of mineral N in soil whereas chicken manure reduced the assimilation of mineral N in soil through dilution effect of the mineral N released thereof.

6) Considering with cost of materials and

crop response, chicken manure should generally be most recommendable.

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