BIOLOGICAL AND CHEMICAL CONTROL OF DESERT LOCUST AND GRASSHOPPERS IN EGYPT.

By

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B.Sc. Agric. Sci. (Economic Entomology), Fac. Agric., Cairo Univ., ١٩٨٢

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THESIS

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SUPERVISION SHEET

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ABSTRACT

This study was conducted to evaluate the performance of spinosad (Tracer ٢٤SC®) and its efficacy on acridid pests (desert locust, *Schistocerca gregaria* and several species of grasshoppers) in comparison with both conventional pesticides, chlorpyrifos and malathion in the laboratory on one side and with chlorpyrifos under the field conditions on the other side.

Also, to evaluate efficacy of the fungus, *Metarhizium anisopliae* var. *acridum* (Green Muscle®) on the target pests under the egyptian environmental conditions at different periods in some places in Egypt which considered favorable breeding sites.

Also, laboratory trails were carried out, to test the effect of spinosad combined with *M. anisopliae* var. *acridum* spores on their viability.

It could be concluded from the present study that, spinosad proved as a successful agent to control both locust and grasshoppers under the egyptian conditions. At concentration of ٦٥ml/١٠٠L water spinosad caused ٧٥٪ mortality among *S. gregaria* after ٢٤hr that reached ١٠٠٪ after ٤٨hr., while chlorpyrifos caused ٨٥٪ and ١٠٠٪ mortality after ٢٤ and ٤٨ hr., respectively. When it was applied against common grasshoppers at concentration of ٥٠ml/١٠٠L water, it caused ٨٣,٣٪ and ١٠٠٪ mortality after ٢٤ and ٤٨hr., respectively; meanwhile chlorpyrifos caused ٨٥٪ and ١٠٠٪ after the same periods, respectively.

The fungus *M. anisopliae* var. *acridum* showed promising results for locust and grasshoppers control. A dose of ٥٠g/ha. fungus diluted in diesel resulted in an optimal mortality of locusts and grasshoppers in the cages during ٢١ days, followed by ٥٠g/ha. dose diluted in vegetable oil.

The combined application of spinosad at sublethal doses with *M. anisopliae* var. *acridum* demonstrated novel tool to control locust and grasshopper in Egypt, where spinosad could overcome the delay in action of the fungus providing reasonable rapid action, also the combined application reduces the cost of control operation.

Key words: Spinosad, *Metarhizium anisopliae*, Locust, Grasshoppers, Biological control, (Tracer ٢٤SC®), (Green Muscle®).

INTRODUCTION

The pests which belong to family Acrididae (grasshoppers and locusts) are major economic pests of crops and grasslands throughout the world's dry zones. Their attacks attract much public attention. Locusts are the only insect pests mentioned in the Bible, also mentioned in Quran (Lomer *et al.*, ١٩٩٣).

Desert locust, *Schistocerca gregaria* (Forskal) is probably the oldest migratory pest in the world. It is one of most important crop pests eats approximately their own weight of fresh vegetation every day (٢g). It differs from ordinary grasshoppers in its ability to change its behavior and to migrate over long distances. Swarms often contain ٥٠ million individuals per km^{٢} could eat ١٠٠٠ tons of fresh vegetation daily during migration (Coper, ١٩٨٢).

In Egypt, there are several different species of grasshoppers *i.e.*: *Euprepocnemis plorans*, *Hetracris annulosa*, *Acridella nasuta*, *Acrotylus insubricus*, *Chrotogonus homalodemus* and *Aiolopus strepens*, as well as the tree locust, *Anacredium aegyptium* and the migratory locust, *Locusta migratoria migratorioides* existing all year round. Among the species of grasshoppers known in Egypt only two species that cause serious damage to cultivated crops specially in the new reclaimed lands, these are *Euprepocnemis plorans* (Charp.) and *Heteracris annulosa* (Walker) (Orthoptera: Acrididae) (Nakhla, ١٩٥٧). Recently, *Euprepocnemis plorans* caused serious damage to maize (*Zea mays*) cultivation in Sharkia and Dakahlia governorates and other new reclaimed lands. El-Maghraby *et al.* (٢٠٠٩) and Abdelatef *et al.* (٢٠١٠).

The most effective method for controlling locust and grasshopper outbreaks involves the use of synthetic chemical insecticides. The numerous of pesticides used for control during upsurges and plagues caused environmental risk and affected non-target organisms. For example, during the major locust plague during the ١٩٨٠s, about ١٣ million liters of insecticides were applied. The large scale repeated application of insecticides, raised concern about the possible impact on the environment as well as on human health (Anonymous, ١٩٩٠). Also, the last desert locust upsurge that developed in West Africa in late ٢٠٠٣ and by mid-٢٠٠٥ affected ٢٦ countries in Africa, the near East and Southern Europe. Nearly ٢٠ million ha. of desert locust infestation were treated with pesticides (Anonymous, ٢٠٠٦).

Due to the environmental and pest-resistance problems associated with chemical pesticides, now there is an increasing interest for the exploitation of biological control agents available as commercial products or those still under development. Consequently, the environmental pollution by chemical pesticides such as toxicity to non-target organisms (Tingle, ١٩٩٦) and humans (Pretty, ١٩٩٦) has led to new strategies and development of environmental friendly alternatives to control locusts and grasshoppers based on microbial control agents (Johnson and Goettel, ١٩٩٣; Lomer *et al.,* ٢٠٠١ and Lange, ٢٠٠٥).

The spinosyns, derived from the actinomycete, *Saccharopolyspora spinosa,* were discovered in the ١٩٨٠s, two of them, spinosyn A and D, have strong insecticidal activity with low levels of mammalian toxicity and relatively little toxicity to non-target insects. Technical grade spinosad is the naturally occurring blend of spinosyns. Spinosad probably act as an agonist at the post-synaptic cholinergic ion channels and GABA-gated ion channels (Thompson *et al.*, ٢٠٠٠ and Watson, ٢٠٠١).

Uses of bio-control agents are considered relatively suitable and promising alternatives to chemical pesticides for controlling acridid pests (Van Huis, ١٩٩٢). Recent advances in biological control researches, coupled with improved surveillance and intelligence, could make big differences when the next round in the battle is fought. Such bio-products could make it possible to sharply reduce the amount of chemical pesticides used (FAO, ٢٠٠٧ and Van Der Valk, ٢٠٠٧).

The new control strategies aim to keep locusts and grasshoppers in low densities in order to prevent the development of upsurges and plague and that is by the use of relatively safe materials such as pathogenic organisms. The entomopathogenic fungus, *Metarhizium anisopliae* var. *acridum,* has received considerable attention as a viable alternative to chemical pesticides;

also it is highly specific to Acrididae which the majority of economically important grasshoppers and locusts belong. At field application rates, it is considered safe to non–target Hymenoptera, Coleoptera and Homoptera (Prior, ١٩٩٧), and to mammals (El–Kadi *et al.,* ١٩٩٣; Zimmermann, ١٩٩٣).

Combined applications of entomopathogens and sublethal dosages of synthetic insecticides or other biological control agents have been proposed as a strategy to improve the efficacy of microbial control agents (Anderson *et al.,* ١٩٨٩). Several studies have reported additive or synergistic effects from the combination of entomopathogens, mostly fungi, with insecticides. Mixtures of spinosad with insect pathogens demonstrated synergism when applied with the fungus *Metarhizium anisopliae* against the exotic wireworms (Ericsson *et al.,* ٢٠٠٧).

The aim of the present study was to evaluate the susceptibility of the desert locust, *S. gregaria* to spinosad as a new relatively safe bio-control agent in the laboratory as well as the susceptibility of the grasshopper *E. plorans* to the combination of spinosad (Tracer ٢٤SC®) and the fungus, *M. anisopliae* var. *acridum* (Green Muscle®); and to study the performance of spinosad and *M. anisopliae* var. *acridum* as bio-control agents under the Egyptian environmental conditions against desert locust, *S. gregaria* and some of grasshoppers (Orthoptera: Acrididae) in comparison with the conventional insecticides, chlorpyrifos (Pestban ٤٥٪ ULV and Pestban ٤٨٪ EC) under the Egyptian environmental conditions.

MATERIALS AND METHODS

١. Pesticides

a. Spinosad

Spinosad (Tracer ٢٤SC®) is a product derived from the metabolites of the natural actinomycetes-bacteria, *Saccharopolyspora spinosa* under the trade name Tracer ٢٤SC. Spinosad contains spinosyns A and D. Spinosyn A is ٢-[(٦-deoxy-٢, ٣, ٤-tri-O-methyl-alpha-L-mannopy-ranosyl) oxy)-١٣-[(٥-dimethylamino) tetrahydro-٦-methyl-٢ H-pyran-٢-yl) oxy)-٩-ethyl-٢, ٣, ٣a, ٥a, ٥b, ٦, ٩, ١٠, ١١, ١٢, ١٣, ١٤, ١٦a, ١٦btetradecahydro-١٤-methyl-١ H-as-indaceno (٣, ٢-d) oxacyclododecin-٧, ١٥-dione (Fig ١).

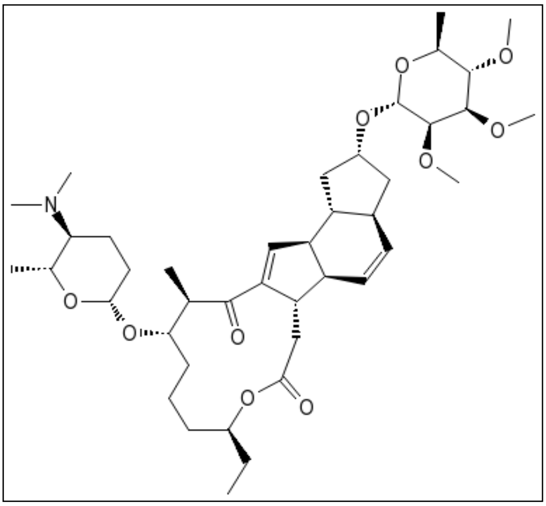

Fig. ١. Chemical structure of spinosyn A.

While spinosyn D is ٢-((٦-deoxy-٢, ٣, ٤-tri-O-methyl-alpha-L-mannopyranosyl)oxy)-١٣-((٥-(dimethylamino) tetrahydro-٦-methy l-٢ H-pyran-٢-yl) oxy)- ٩-ethyl ٢, ٣, ٣a, ٥a, ٥b, ٦, ٩, ١٠, ١١, ١٢, ١٣, ١٤, ١٦a, ١٦ btetradecahydro, ١٤ dimethyl-١ H - as - indaceno (٣, ٢-d) oxacyclododecin -٧, ١٥- dione (Fig. ٢).

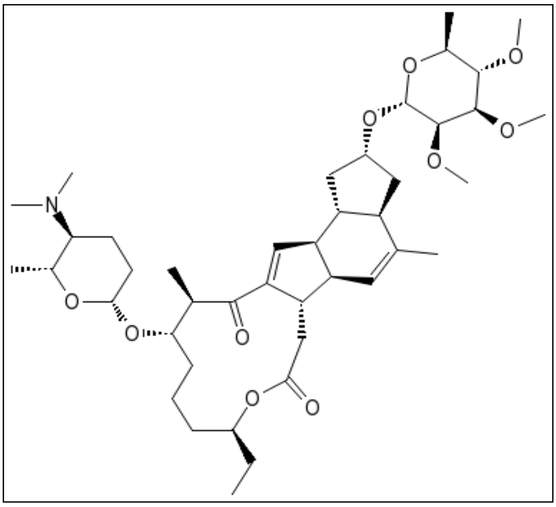

Fig. ٢. Chemical structure of spinosyn D.

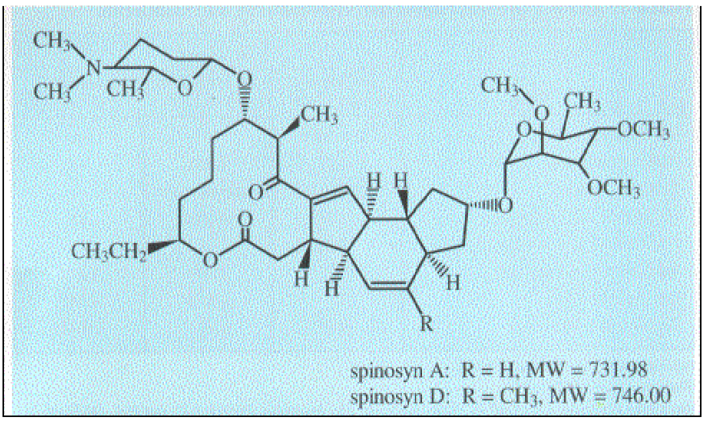

Fig. ٣. Spinosad, the active ingredient is a mixture of spinosyn A and spinosyn D.

b. Chlorpyrifos

Chlorpyrifos is a crystalline organophosphate insecticide (*O*, *O*-diethyl *O*-٣, ٥, ٦-trichloropyridin-٢-yl phosphorothioate); its trade name is Pestban ٤٨٪EC (Fig. ٤).

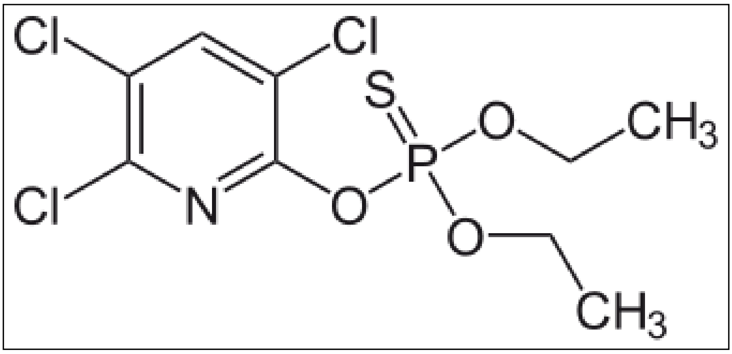

Fig.٤. Chemical structure of chlorpyrifos.

c. Malathion

Malathion is an organophosphate insecticide (Diethyl [dimethoxypho-sphinothioyl)thio]butanedioate), it's trade name is Malatox ٥٧٪EC (Fig. ٥).

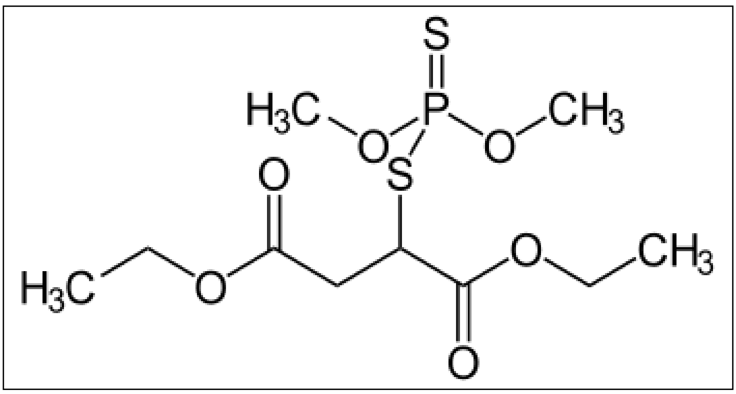

Fig.٥. Chemical structure of malathion.

d. Metarhizium anisopliae* var. *acridum

Spores of *M. anisopliae* var. *acridum* used in this study were from isolate IMI٣٣٠١٨٩, kindly provided by (Biological Control Products), South Africa, *via* FAO-CRC (Central Region Committee for desert locust control).

٢. Laboratory test insects

a. Desert locust, *Schistocerca gregaria* (Forskal)

Desert locust, *S. gregaria* ٢nd and ٤th nymphal instars were used in the laboratory bioassay of the tested insecticides (spinosad, chlorpyrifos and malathion). The locust parents were collected from Elba Mountains near the Egyptian-Sudanese borders (Fig.٦), and kept under crowded conditions in the breading room (Fig.٧) at the Egyptian Locust and Grasshopper Research Dep., Plant Protection Research Institute, following the technique described by Hunter, ١٩٦١.

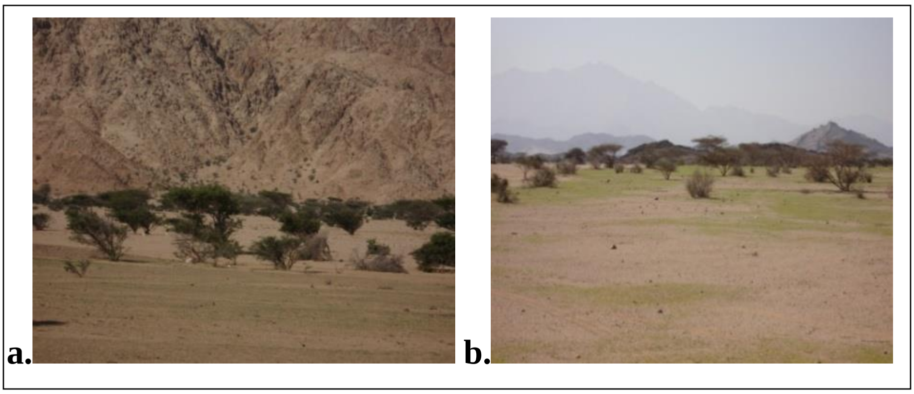

Fig. ٦. Desert Locust breeding areas.

a. **Elba Mountains near the Egyptian-Sudanese borders.**
b. **Wadi Diib near Elba Mountains.**

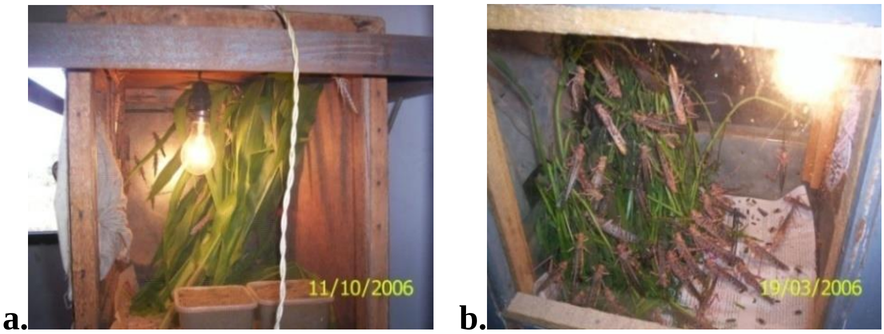

Fig. ٧. (a., b.) Desert Locust reared under crowded conditions in the breeding room at the Egyptian Locust and Grasshopper Research Dep., Plant Protection Research Institute, Agric. Research Center (ARC).

b. Grasshopper, *Euprepocnemis plorans* (Charp.)

Adults of the common grasshopper, *E. plorans* were collected from Dakahlia Governorate (Fig.٨) and reared in the breading room as for *S. gregaria*. Then after one generation, ١ week old adults were used to study the effect of spinosad and *M. anisopliae* var. *acridum* combination.

Fig. ٨. Grasshopper breeding area.

٣. Pesticides bioassay

Different concentrations were prepared from each insecticide. Sixty nymphs were fed on air dried maize leaves previously dipped in ١٠٠ ml of each concentration for ٥ minutes, then divided into ٣ replicates; each replicate was kept in a plastic cage (Fig.٩) in the rearing room at ٣١±١°C and RH ٦٥٪, and observed. The mortality rates were recorded ٢٤ hrs. after treatment, then the data were subjected to probit analysis according to Finney (١٩٧١) to calculate concentration mortality responses and its regression lines.

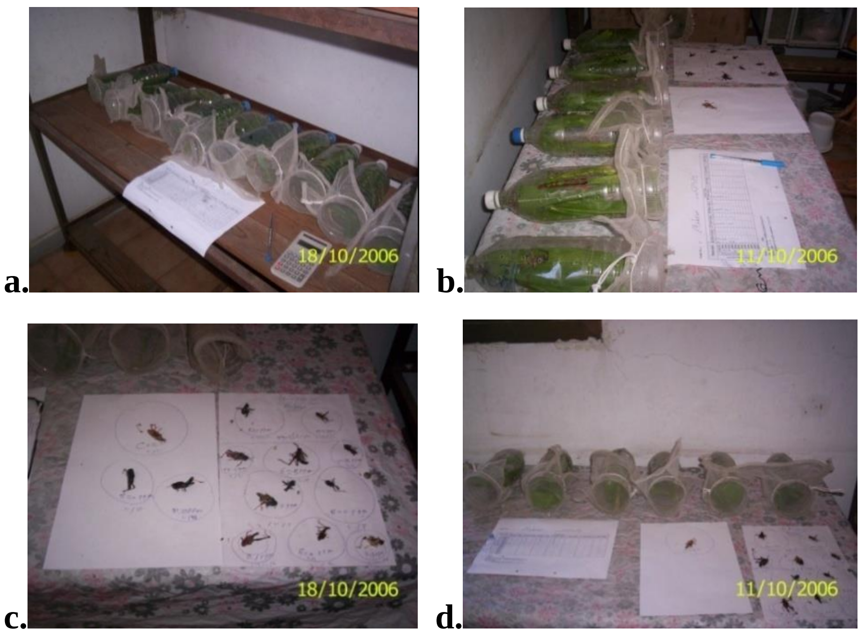

Fig. ٩. (a, b, c, d) Bioassay of pesticides laboratory trials.

٤. Field trials

Both spinosad and chlorpyrifos were tested in two field trails against desert locust *S. gregaria* at Wadi Diib south of Egypt (٢٢ ١٠ N/٢٨ ٣٨ E), and against common grasshopper at El-Baharia Oasis (٢٨ ٠٢ N/٣٦ ٢٢ E). Also, the fungus *M. anisopliae* var. *acridum* was tested separately against common grasshopper at El-Baharia Oasis and desert locust *S. gregaria* at Sharq El-Owainat region (٢٢ ١٩ N/٢٨ ٤٥ E) and Abu-Ramad region (٢٢ ٢٤ N/٣٦ ٢٤ E).

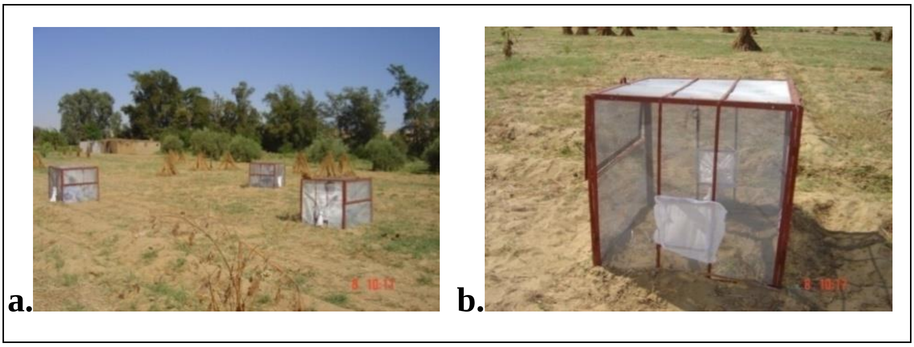

Fig. ١٠. Cages of field trials at El-Baharia Oasis, Western Desert.

a. Spinosad and chlorpyrifos trials

١. Spinosad and chlorpyrifos trials in Abu-Ramad region

Three concentrations (٣٠, ٤٠ and ٦٥ml/١٠٠L water) of spinosad were used in the field while chlorpyrifos was used at the recommended concentration, at Wadi Diib south of Egypt in Abu-Ramad region near the Egyptian-Sudanese borders. The desert locust individuals were collected and kept in bottomless wooden cages (Fig.٧) with wire-gauze sides (١ X ١ X ١m٣), each cage contained ٢٠ nymphs and ٣٠ fledglings immature and mature adults/m². The suitable amount and concentration of each pesticide was applied into each cage using spinning disk sparyer, then the upper cover was placed, the mortality values were recorded after ٧٢hr. post treatment. Each treatment was replicated ٣ times. The area where the trial was conducted was covered by natural vegetation and light grasses, in a sandy soil.

٢. **Spinosad and chlorpyrifos trials in El-Baharia Oasis**

The same trial was done at El-Baharia Oasis with slight modification, ٣ concentrations of spinosad (٢٥, ٤٠ and ٥٠ml/١٠٠L water) and chlorpyrifos at the recommended concentration were tested. Each cage contained ٥٠ individuals of the dominant species of grasshoppers (*Acridella nasuta, Acrotylus insubricus, Chrotogonus homalodemus*, *Euprepocnemis plorans, Hetracris annulosa, Catantops axillaries, Aiolopus strepens* and the local locust, *Anacredium aegyptium*). The mortalities were recorded after ٩٦hr. post treatment, the area of the trial was cultivated with alfalfa (*Medicago sativa*) and light grasses in sandy loam soil.