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☐ is
This thesis ☒ is not to be regarded as confidential. Diane E Stott
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RELATIONSHIPS BETWEEN SOIL BIOLOGICAL AND CHEMICAL CHARACTERISTICS AND SURFACE SOIL STRUCTURAL PROPERTIES FOR USE IN SOIL QUALITY

A Thesis

Submitted to the Faculty

of

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by

Mateugue Diack

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

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Dedicated To My Family

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ABSTRACT

Diack, Mateugue. Ph.D., Purdue University, May 1997. Relationships Between Soil Biological and Chemical Characteristics and Surface Soil Structural Properties for Use in Soil Quality. Major Professor: Diane E. Stott.

While there are many long-term management studies on soil productivity and pest management, few have looked at the long-term effects on surface soil structure and how changes'are related to the soil biology and biochemistry. This study was conducted on a 16-year integrated pest management field where several tillage and crop rotation combinations were available. Sealing index, as a measure of soil aggregate stability, decreased with decreasing tillage intensity. Mowever, final infiltration rate was highest in chisel plow system. Total organic C and N, microbial biomass C, soil carbohydrates and soil enzyme activities were significantly greater in conservation systems as compared to conventional practices. A simple and sensitive method of optimizing fluorescein diacetate hyclrolysis was developed and used in these soils. This enzymatic activity is involved in lipid metabolism which is ubiquitous to all living cells. Bulk density was negatively correlated with soil enzyme activity. Tillage appeared to play a major role in the soil property changes with crop rotation system differences

being minor. Using soil erodibility as the baseline, a set of soil quality indicators was developed. For soil quality rating, a standard scoring function was developed, and the three management systems were rated from the lowest to the highest : moldboard plow ~ no-till < chisel plow due to the unsual nature of this no-till field. Results suggest that soil biochemical and biological properties are potential indicators of soil quality with regard to soil erodibility.

CHAPTER 1

LITERATURE REVIEW

The progressive degradation of agricultural soils is a worldwide problem which manifests itself with on-site and off-site consequences. The three principal forms of soil degradation are physical, chemical and biological. Physical degradation leads to a deterioration of soil properties that can have a serious impact on water infiltration and plant growth. Chemical degradation processes can lead to a rapid decline in soil quality, resulting in nutrient depletion, acidification, and salinization, leading to physical and biological degradation. Biological degradation includes reductions in organic matter content, declines in the amount of carbon from biomass, and decreases in the activity and diversity of soil fauna which in turn, can lead to physical degradation. The resulting outcome of soil degradation is a decline in soil quality that consequently, will affect soil and water conservation, soil productivity, sustainable agriculture and land use. Therefore, it is imperative to sustain the soil resource base by maintaining or enhancing soil quality.

1.1. Defining Soil Quality

Soil quality can be defined'as the degree of suitability to the specific functions that soils perform in a given ecosystem. The terms soil quality and soil health are currently used interchangeably in the scientific literature and popular press. Scientists prefer soil quality and farmers prefer soil health (Harris et al., 1994). While the term 'soil quality' is relatively new, it is well known that soils vary in quality and that soil cluality changes in response to use and management (Larson et al., 1994). The National Research Council (USA) recommends a definition of soil quality as the capacity of the soil to promote the growth of plants; protect watersheds by regulating infiltration and partitioning of precipitation; and prevent water and air pollution by buffering potential pollutants. This definition of soil quality is so far the most complete for it associates soil productivity, water storage and environmental quality.

Although the quality of a soil can be defined, it still cannot be seen or measured directly from the soil alone, but is inferred from soil characteristics and soil behavior under defined conditions. As Stewart (1992) mentioned, there is no single measurement that can quantify soil quality. However, there are certain characteristics, particularly when considered together, that may be good indicators.

With the increasing concern about the declining in soil productivity, the issue of how healthy a soil can remain with long term intensive use is also being raised. This is because in general, the quality of a soil can be maintained or enhanced by good management practices; and also seriously degraded, sometimes irreversibly, with poor practices.

1.2. Soit Quality Effects

For years, soil degradation and management problems, causing loss of soil productivity, were only considered for agricultural soils. The capability of the soil to partition water and regulate infiltration rates were not considered in the search for soil quality indices.

Scattered information exist on the impact of crop and tillage management on soil organic matter transformations and the subsequent effects on soil structure. However, when put together, we do not know how soil biological and biochemical characteristics change as soil management changes, nor, what impact soil management practices have on soil organic matter quality and the subsequent effects on soil structure and erodibility.

1.2.1. Management Practices

Management practices include crop rotations, fertilizer application, residue management and tillage operations. Residue management is interrelated with tillage practices', and it is difficult to separate soil property effects of the residues per se from the effects of tillage operations (Kladivko, 1994). Conservation tillage systems involve the combined effects of different tillage intensities and different residue placements, both affecting the magnitude and location of soil physical property changes. In addition, many long-term field studies on residue management also utilize different crop rotations, so that changes in soil physical properties are the combined result of residues, tillage, and crop rotations (Black et al., 1979).

Crop rotations, tillage operations and fertilizer applications can alter the soil structure through their Impacts on soil disturbance and mixing, and on soil organic matter accumulation and mineralization. Increased yield may be one of the most practical justifications for reintroducing crop rotations (Wikner, 1990). However, increased emphasis on crop residue management to reduce soil erosion may also encourage crop rotations because they can largely eliminate the crop yield decreases observed between no-tillage and conventional tillage production practices (Karlen et al., 1991). Currently, the need to develop crop management practices'with better water-use efficiency may be one o1' the strongest incentives for adopting crop rotations. Crops should be managed in a rotation sequence so that complementary root systems fully exploit available water and nutrients (Karlen and Sharpley, 1994).

As far as soil quality effects are concerned, the need to reduce negative on- and off-site impacts of agricultural practices will probably provide one of the major incentives for reihtroducing crop rotations into farm management plans.

Kay (1990) reached a similar conclusion in stating that a major goal for agricultural research will be to identify and promote cropping systems which sustain soil productivity and minimize deterioration of the environment. To assess the effects of soil and crop management practices such as crop rotation on both factors, several projects focus on the concept of soil quality as an assessment tool (Karlen et al., 1992; Karlen and Doran, 1993; Doran and Parkin, 1994; Karlen and Stott, 1994). Using different crop rotations may improve soil quality by more closely mimicking natural ecosystems than mono-culture (Karlen et al., 1992). This would occur because temporal and spatial diversity across the landscape would increase. Furthermore, management strategies that maintain or add soil carbon are likely to improve the quality of the soil resources, through improvement of soil structure and infiltration rates, and increases in biodiversity, biological activity, nutrient cycling and water retention.

Critical factors being included in most soil quality assessments with regard to water partitioning involve measurements of soil structure, aggregation, bulk density, water infiltration, water retention, soil erosivity, and organic matter (Karlen and Stott, 1994). All of these. factors are influenced by management practices. Therefore, it is logical to examine the effects of management practices on the various soil quality indicators.

1.2.2. Soil Structure

Soil structure is the arrangement of sand, silt, and clay particles in soil, bound together. into aggregates of various sizes by organic and inorganic materials (Tisdall, 1996). Soil aggregates, the primary units of soil structure, are formed through the aggregation process whereby organic matter is retained in soil. Such retention can be characterized by both relatively short-term storage in macroaggregates or long-term sequestration in microaggregates (Carter and Stewart, 1996). Soil structural stability is the ability of aggregates and pores to remain intact when subjected to stress, e.g. when aggregates are wetted quickly, mechanical fracturing from tillage, and chemical rupture . In the field, the stability of these aggregates and the pores between them affect the movement and storage of water, aeration, erosion, biological activity and crop growth.

It has been observvkd that a field's soil structure differs due to crop type (Kay, 1990). This difference is not solely due to absolute amount of plant residues returned to the soil, nor to tillage practices. The characteristics of plant species being grown, the sequence of different species, and the frequency of harvest are all aspects of cropping systems that affect soil structure by influencing the formation of biopores by plant roots and soil fauna. According to Bullock (1992), abandonment of multiyear rotations in favor of short rotations has generally resulted in a degradation of soil structure as measured by soil aggregate stability, bulk density, water infiltration rate, and soil erosion. Much of the blame for this degradation is attributed to decreases in soil organic matter content, but Bruce et al. (1990) found the relationships to be complex and easily erased or modified by tillage. Langdale et al. (1992) reported that crop rotations did not affect soil physical properties on selected Ultisols, but these findings are not predominant in the literature.

1.2.3. Water Infiltration and Retention

Infiltration is of particular interest, for it is one of the determining factors of water partitioning and soil erodibility. If water is to be conserved in the soil and made available to plants, Ht must first pass through the soil surface. The movement of water into the soil by infiltration may be limited by any restriction to the flow of water through the soil profile. Although such restriction often occurs at the soil surface, it may also occur at some point in the lower ranges of the soil profile. The most important factors influencing the rate of infiltration have to do with the physical characteristics of the soil and the cover on the soil surface.

Soil organic matter content, water infiltration rate, and aggregate stability all increased as proportion of sod in the rotation increased (Adams et al., 1964). Wischmeier and Mannering (1965) also reported a positive correlation between water infiltration rate and soil organic matter content for several midwestern soils with organic matter concentrations from 1 to 14%. Allison (1973) attributed increased water infiltration to improved soil structure and higher soil organic matter content. Recent farming systems studies in Iowa support this conclusion, i.e., steady-state infiltration rneasurements were somewhat higher for longer rotations where soil organic matter concentrations were slightly higher than those for shorter rotations (Logsdon et al., 1993; Jordhal and Karlen, 1993).

The importance of soil as a medium for water storage is well established due to the benefit of water-holding capacity to crop production and soil erosion. Management practices'impact soil organic matter and ultimately affect the capacity of the soil to store water. However, Bullock (1992) concluded that crop rotation did not benefit production by increasing water-holding capacity, even in situations such as long-term pastures which resulted in substantial increases in soil organic matter content. This conclusion is based on several studies. Among these are results frorn Jamison (1953) who stated that organic matter has a large water-holding capacity and that most of the water is held at potentials far less than -1.5 MPa, the potential at which water is not sufficiently available for survival of'most plants. Other studies show that increased soil aggregation results in decreased plant available water (Jamison, 1953; Hillel, 1980). Bullock (1992) stated that this occurred because a larger fraction of the water is held at potentials less than -1.5 MPa and because of an increase in macropore volume and'a decrease in the micropore volume. Hudson (1994) used a critical review of literature on soil organic matter effects on plant available water capacity to argue against this position. He found that for sand, silt loam, and silt clay loam soils, the volume of water held at field capacity increased at muçh faster rate than that held at the permanent wilting point. Hudson (1994) concluded that on a volumetric basis, soil organic matter is an important determinant of available water-holding capacity, thus indicating a re-evaluation of crop rotational effects on plant available water might be warranted.

1.2.4. Bulk Density

Management practices that return greater amounts of residue to the soil usually result in the lower soil bulk density. Therefore, continuous corn will frequently result in lower bulk densities than corn-soybean rotations, even though crop rotation generally results in greater grain yield (Bullock, 1992). Hageman and Shrader (1979) found that after 20 years, soil bulk density following continuous corn was slightly lower than after a 4-year corn, oats, meadow, and meadow rotation (1.13 vs. 1.17 g cm-‘, respectively). They concluded that as soil organic matter increases, soil bulk density decreases. Logsdon et al. (1993) reported that bulk densities were sometimes lower and the volume of large pores was slightly higher in fields where a 5-year corn, soybean, corn, oats, and meadow rotation was being used compared to that for a 2-year corn and soybean rotation.

However, reduced tillage does not always result in lower bulk density as compared to conventional systems. Researchers and farmers have become concerned that continuous conservation tiliage, especially no-till, may cause soil compaction, and there have been recommendations to plow or cultivate no-till fields every few years in order to alleviate any surface compaction (0-30 cm) that may occur (Larney and Kladivko, 1989). Also, crop rotation, sometimes, does not reduce bulk density as expected. Hammel (1989) measured bulk density and soil inipedance after 10 years of continuous management in a long-term tillage-rotation experiment on Palouse (fine-silty, mixed, mesic Ultic Haploxeroll) and Naff (fine-silty, mixed, rnesic Ultic Argixeroll) silt loann soils. He concluded that crop rotation did not significantly influence either soil property.

1.2.5. <u>Soil Erodibility</u>

Soil erosion requires two processes: (1) detachment of soil particles, and (2) transportation of the soil material by erosive agents such as water or wind. Soil detachment associated with water erosion can be initiated by raindrops or overland water flow during a rainfall event. Detachment by wind in'volves skipping, or saltation of soil particles across the soil surface. Soil management practices such as crop residue placement, application of animal manure, or using crop rotation can have both direct and indirect effects on soil physical properties which subsequently affect the detachment process (Bullock, "1992). Reganold (1988) found a 16-cm difference in topsoil depth between adjacent organic and conventional farms in the palouse region of northwestern US. This difference was attributed to significantly greater erosion on the conventional farm between 1948 and 1985: He concluded that the difference in erosion rates was due to crop rotation since the organic farm included green manure crops within the rotation, while the conventional farm did not. Contrat-y to the benefit of rotations which include forages or other surface cover during the spring, 2-year corn and soybean rotations can result in greater soil erosion than continuous corn (Bullock, 1992). For example, over an 18-year period, soil loss from a 2-year corn and soybean rotation was 45% higher than that from continuous corn (van Doren et al., 1984). This often occurs because the amount of residue following soybean is very low (Stewart et al., 1976; Laflen and Moldenhauer, 1979; Papendick and Elliott, 1984). Alberts et al. (1985) reported that soybean production results in an annual soil loss 3.4 times greater than that seen with corn production but noted that differences in erosion were not simply a function of less biomass. They concluded that corn residue is better at preventing soil erosion than soybean residue, even when they are present in similar amounts. Laflen and Moldenhauer (1979) , in a 7-year study, found that average annual soil losses were about 40% greater when corn followed soybean than when corn followed corn. They concluded the difference was caused by a “soil effect” because major differences in soil loss occurred during the period 30 to 60 days after planting, a point at which canopy development and residue cover were almost identical.

1.2.6. Soil Organic Matter

Soil organic matter could be the soil quality indicator for which the most information relative to management practices exists, but it could be also the indicator for which the most unanswered questions remain. Soil management affects soil organic matter quantitatively and qualitatively. While the quantity of soil organic matter can'be related to the amount of plant and animal residues present in the soil, the quality of soil organic matter is represented by the chemical and biochemical composition of these residues. Factors affecting soil organic matter include rotation length, losses caused by tillage practices, mineralization, and interaction with fertilization application.

1.2.6.1. Rotation Length

Crop rotations that involve several different crops generally increase soil organic matter content. This increase is presumably a major factor that beneficially affects subsequent crops and contributes to the rotation effect (Bullock, 1992). Hussain et al. (1988) reported increased soil organic matter content with a 2-year corn and soybean rotation, but such findings are the exception. Generally, this short rotation results in lower soil organid matter levels than continuaus corn, even though it provides a rotation effect (Dick et al., 1986a,b). The primary cause for this response appears to be that soybean produces less biomass than corn. Results from Havlin et at. (1990)

demonstrated that including grain, sorghum in a rotation, rather than growing continuous soybean, increased organic carbon and nitrogen in the soit. They concluded that increasing the quantity of residue returned to the soil through higher yields or through greater use of high residue crops in the rotation, combined with reduced tillage, could improve soil productivity. Jurna et al. (1993) concluded that after 50 years of research on Gray Luvisolic soils at the Breton Plots in Alberta, Canada, soil organic matter content is about 20% higher where a 5-year rotation has been used than where a 2-year, wheat and fallow rotation was followed: Similarly, Unger (1968) found that when tillage treatments were kept constant, continuous cropping resulted in a significant increase in soil organic matter concentrations compared to a trop-fallow system.

1.2.6.2. Tillage Losses

Tillage, which inverts or mixes the soil, introduces large amounts of oxygen into the soil and stimulates aerobic microbial consumption of organic matter as a food source. When virgin eastern Oregon soils were cultivated, some lost over 25% of their organic matter in 20 years, with 35 to 40% being lost in 60 years (Rasmussen et al., 1989). Tillage for weed control during fallow period was the primat-y cause for the loss of soil organic matter. Ridley and Hedlin (1968) found that after 37 years, soils which had initial organic matter contents of nearly 10% had 7.2% organic matter if cropped every year, compared to 3.7% in those fallowed every other year. Soils fallowed after every two or three crops had intermediate soil organic matter concentrations.

Use of no-till systems can reduce the rate of soil organic matter loss, but not completely stop it. Collins et al. (1992) reported that after 58 years total soil and microbial biomass carbon and nitrogen were significantly greater in annual-cropping treatments than for wheat-fallow rotations. They concluded that residue management (i.e., reduced tillage) significantly affected the level of microbial biomass cardon and that annual cropping significantly reduced declines in both soil organic matter and soil microbial biomass. Similarly, Havlin et al. (1990) found that compared to native grassland, a 12-year wheat and fallow rotation resulted in total soil organic matter concentrations that were 4, 14, and 16% lower with no-till, stubble mulch, and conventional tillage , respectively.

1.2.6.3. Mineralization Effects

Frequently, crop rotation benefits derived from organic matter are attributed to the release of nitrogen through mineralization. However, Doran and Smith (1987) reported that relationships among soil organic matter content, management practices including crop rotations, and nitrogen availability were not always predictable, constant, or direct. It is generally accepted that soil organic matter affects many parameters that could be indicators of soil quality influencing mineral availability. These effects include increased water infiltration

(Wischmeier and Mannering, 1965; Adams et al., 1970; Allison, 1973; MacRae and Mehuys, 1985), improved aggregate formation and stability (Fahad et al., 1982; MacRae and Mehuys, 1985), lower bulk density (De Kimpe et al., 1982), higher water retention capacity (Hudson, 1994), improved soil aeration, and reduced soil erosion' (USDA, 1980; Bezdicek, 1984; Reganold, 1988).

Commercial agriculture has altered both the quafity and quantity of soil organic matter in many soils (Robinson et al., 1994). Often, these soils may have taken hundreds or even thousands of years to reach stable soil organic matter conditions (Rasmussen et al., 1989). Destruction of soil organic matter by short rotations does not continue unabated until the soil is devoid of organic matter, but rather the soil organic matter reaches an equilibrium level (Allison, 1973; MacRae and Mehuys, 1985). When alternative tillage or crop rotations are used, a new equilibriutn point is established.. For instance, Larson et al. (1972) indicated that the addition of 5 Mg/ha of maize and alfalfa residue applied annually could maintain organic carbon at a level of 1.8%. However, this soil organic matter level is considerably lower than that found in its precultivation state. No-till and reduced tillage (Karlen et al., 1989, 1991) cropping systems have shown gradual increases in soil organic matter content when compared to more intensive tillage management practices. Different crop rotations seem to result in different soil organic matter equilibrium levels, but Miller and tarson

(1990) predict that soil organic matter concentrations will never return to levels observed in their undisturbed state.

1.2.6.4. Fertilizer and Manure Interactions

Application of nitrogen, phosphorus, potassium, and sulfur fertilizer and animal manure to Gray Luvisolic soils increased soil organic matter by iricreasing crop yields (Juma et al., 1993). They also reported that application of manure increased soil organic matter even more than fertilizer. This presumably occurred because in abdition'to its nutrient value, the 9 Mg ha-' of manure added each year represented an additional source of organic mat-ter. The report by Juma et al. (1993) supports conclusions by Boyle et al. (1989) who suggested that returning carbon to the soil is "a necessary expense that insures a sustainable harvest." 'Both support suggestions by Karlen et al. (1992) that crop rotation, cover crops, and conservation tillage are the practices most likely to improve soil quality.

1.2.7. Soil Organic Matter Attributes

1.2.7.1. Soil Oraanic Carbon and Nitroaen

Organic C and N contents in soil are a result of a complex biochemical interaction between substrate additions of C and N in fertilizers and 'in plant and animal residues, and losses of C and N through microbial decomposlition, mineralization, and erosion. Water soluble organic carbon is a very active soil organic component, and flow of C through soluble C pool supplies substrate for biomass turnover (McGill et al., 1986). Changes in inputs, such as fertilizers ancl residues (Janzen 1987a,b; Campbell et al. 1991a), which regulate soil microbial activity and mineralization rates will ultimately be reflected in the total organic C and N content of soil. Moisture, and probably to a greater degree, temperature are the factors most strongly influencing mineralization rates in soil (Stanford et al. 1973; Stanford and Epstein 1974; Campbell et al. 1981). The relative impact of managernent practices on soil organic C and N levels will change with soil climate.

Changes in soil quality can be assessed by comparing the organic matter parameters between fields subjected to specific agricultural practices as referenced to defined objectives. The assessment of organic C and N as indicators of soil quality should include consideration of inherent soil properties ancl site-specific processes (Gregorich et al., 1994). For instance, texture plays an important role in determining the amount of organic matter that may be stabilized in soil. Soils with relatively high clay contents tend to stabilize and retain more organic matter than those with low clay contents (Jenkinson, 1977; Ladd et al., 1990). Removal of organic-rich topsoil by erosion is a process that influences the level of organic matter in soil (Voroney et al., 1981; Gregorich and Anderson, 1985). Soil redistribution by tillage and water and /or wind erosion can have a major impact on the total amount of soil organic C and N (de Jong and Kachanoski, 1988). Therefore, estimates of soil erosion and deposition may be required wheh assessing changes in soil organic matter quality, particularly when comparing land use and management practices that affect the percentage of surface area of soil covered by residues.

The C:N ratio may also provide information on the capacity of the soil to store and recycle energy and nutrients. In agricultural soils, the C:N ratio is relatively constant and is usually within a narrow range, from 10 to 12. Agricultural practices such as cultivation, fertilization and residue management influence the soil C:N!ratio. Several studies have shown that the C:N ratio becomes narrower wifh cultivation (Voroney et al., 1981; Campbell and Souster, 1982; Bowman et al., 1990). After six years of corn production, Liang and MacKenzie (1992) reported that the C:N ratio increased within 3 years in soils under continuous corn receiving high levels of N fertilizer. Rasmussen et al. (1980) found that long-term changes in soil C:N ratios were proportional to the rate of N loss; C:N ratios were highest in soils receiving manure or pea vines. They suggested that the residue treatments influenced the C:N ratio because the turnover of C was delayed by a deficiency of available N for microbial decomposition.

1.2.7.2. Light Fraction and Macroorganic Matter

The light fraction and macroorganic portions of soil organic matter are mainly plant residues; however, residues derived from animals and microorganisms may also be present in various stages of decomposition. The light fraction, also called free or noncomplexed soil organic matter, is considered to be decomposing plant and aniimal residues with a relatively high C:N ratio, a rapid turnover, and a specific density considerably lower than that of soils minerals (Christensen, 1992). The macroorganic matter includes the organomineral complexed soil organic matter which is taken to be the comparatively more processed decomposition product "true humus" with a narrow C:N ratio, a slower turnover rate, and a higher specific density due to its intimate association with soil minerals (Monnier et al., 1962; Greenland and Ford, 1964; Greenland, 1965a, 1971). These pools are significant to soil organic matter turnover in agricultural soils because they serve as a readily decomposable substrate for soil microorganisms and as a short-term reset-voir of plant nutrients. A large portion of the microbial population and enzyme activity in soil is associated with the light fraction (Kanazawa and Filip, 1986). Soil respiration rates are also correlated with the light fraction content (Janzen et al., 1992).

The light fraction usually represents 0.1 to 4% of the total weight of cultivated topsoils but has up to 15 times more C and 10 times more N than the whole soil (Dalal and Mayer, 1986, 1987; Janzen et al., 1992). Chemical characterization of the light fraction has indicated that it is in an intermediate state of decomposition between fresh plant tissue and soil organic matter. Compared to plant tissue, the light fraction has a relatively narrow C:N ratio (Molloy et al., 1983) and high ash content (Spycher et al., 1983), suggesting that it has undergone some decomposition and/or humification.

The light fraction and macroorganic matter provide information on the extent to which plant residues have been processed by the decomposer community in soifs. These fractions are generally free of mineral particles and therefore, lack the protection from decomposition that such particles impart (Sollins et al., 1984). Thus, the light fraction (Bonde et al., 1992) and macroorganic matter (Christensen, 1987; Gregorich et al., 1989) have been shown to decompose quickly compared wfth organic matter in whole soil or associated with mineral particle fractions, despite having a wide C:N ratia.

Macroorganic matter is rapidly depleted when a soil is broughf under cultivation. A Chernozemic soil cultivated for 4 years had a light traction 40% less than a native equivalent, with a 76% smaller light fraction after 90 years of cultivation (Tiessen and Stewart, 1983). Sirnilarly, it is increased rapidly when a degraded soil is put into a continuous forage crop such as alfalfa (Angers et al., 1990). The rate of loss of organic C from the light fraction was 2 to 11 times greater than from the macroorganic matter fraction in five Australian soils (Dalal and Mayer, 1986). Gregorich et al. (1996) reported that more than 70% of the C in the light fraction had turned over whereas only 16% of the C associated with the coarse silt fraction had turned over since the start of maize cropping in an Ontario soil. Janzen et al. (1992) found that the range of light fraction C in soils from different cropping rotations was twice as great as the range of total organic C content.

The dominant influence of plant-derived materials in the light fraction is reflected in its response to inputs of residue to the soil; its utility as an indicator of organic matter quality in agricultural soils is linked to this factor.

The light fraction and macroorganic matter can be a valid indicator of soil quality in several respects. As a nonhumified fraction of organic matter, the size of the light fraction is a balance between residue inputs and persistence, and decomposition as determined by the soil environment (Gregorich and Janzen, 1996). The light fraction and macroorganic matter constitute a relatively large amount of C and N contained in a small mass of soil and may contain a large portion of the total C in soil. It has been repot-ted that light fractions are enriched in carbohydrates relative to whole soils and macroorganic matter fractions (Oades, 1972; Whitehead et al., 1975; Molloy et al., 1977; Murayama et al., 1979; Dalal and Henry, 1988). Most of this labile material is unprotected by soil mineral particles and has a short turnover time, which gives the Eight fraction a prominent role as a C substrate and source of nutrients. From 3 to 26% of the light-fraction carbon may be present in carbohydrates (Cambardella and Elliott, 1993). Also, in contrast to rnacroroorganic matter fractions, the light fractions may show considerable variation in sugar composition in the soil organic matter. These pools are respohsive to management practices and may provide an earlier indication of the effects of soil management and cropping systems than the total amount of organic rnatter in soils.

127.3. Soil Carbohydrates

Carbohydrates have been estimated to constitute between 5 to 25% the total soil organic C and thereby they are the second most abondant component of humus (Chesire, 1979). Soil carbohydrates originate from plants, animals, and microorganisms, their composition varying accordingly. Most of the carbohydrate fraction is present as a mixture of complex polysaccharides, which in turn are composed of monosaccharides. Five monosaccharides usually represent more than 96% of the total hydrolyzable carbohydrates: glucose dominates, followed by galactose, mannose, arabinose, and xylose. Galactose and mannose are believed to be produced mainly by microbes, whereas arabinose and xylose originate mostly from plants (Cheshire, 1977).

Carbohydrates may contribute to soil quality primarily through their role in the formation and stabilization of soil structure. Of all the organic matter fractions in soil, the polysaccharides, because of their chemical structures, are likely to be the most readily available source of energy for microorganisrns (Chesire, 1979).

Physical protection of these polysaccharides may, however, reduce this availability.

Soil carbohydrates have been primarily studied in relation to soil aggregation. Several studies have found good correlations between carbohydrate content and soil macroaggregate stability (Haynes and Swift, 1990; Angers et al., 1993b); however, others have not (Carter et al., 1994). Other components of the soil organic matter such as the hydrophobic aliphatic fraction (Capriel et al., 1990), fungal hyphae and actinomycetes (Tisdall and Oades, 1979) are probably involved in macroaggregate stability.

Angers et al. (1993a) found that the ratio of both mild-acid and hot water soluble carbohydrates to total organic C was greater under no-till than under moldboard plowed soil after three cropping seasons, suggesting an enrichment of labile carbohydrates in the organic matter under reduced tillage. Similar results have been obtained previously by Angers and Mehuys (1989), when comparing the effects of cropping to alfalfa , barley, and corn on dilute-acid hydrolyzable carbohydrates. Haynes et al. (1991) also found that hot-water soluble and dilute-acid hydrolyzable carbohydrates changed more rapidly than total organic C when management practices were changed from arable to pasture. These results suggest that these labile fractions of the carbohydrate pool could be sensitive indicators of changes in organic matter quality, especially in comparisons of cropping systems. The involvement of labile carbohydrates in the short-term changes in aggregate stability should reinforce this suggestion.

1.2.7.4. Microbial Biomass

Microbial biomass is a critical attribute of soil organic matter quality and soil quality as it provides ah indication of a soils' ability or capacity to store and recycle nutrients and energy. As a measure of organic matter quality, it also serves as a sensitive indicator of change and of future trends in organic matter levels and equilibria (Gregorich et al., 1994). Microbial biomass is a key variable of soil organic'matter, functioning both as an agent for the transformation and cycling of organic matter and plant nutrients within the soil and as a sink (during immobilization) or source (during rnineralization) of labile nutrients. The microbial component açcounts for 1-3% and 2-6% of soil organic C and N, respectively (Jenkinson, 1988). Thus, it serves within the soil as a store of labile organic matter.

Due to its dynamic nature, microbial biomass quickly responds to changes in soil management and soil perturbations (Carter, 1986) and to soil environment (Insam et al., 1989; Skopp et ai., 1990; Duxbury and Nkambule, 1994). The utility of the soil microbial biomass measurement is illustrated in its use as an independent parameter to validate organic matter models (Jenkinson, 1990;

Paustian et al., 1992). Microbial biomass is also related to various soil structure indices (Carter, 1992; Angers et al., 1993b).

The determination of microbial biomass does not by itself provide information on microbial activity (Jenkinson, 1988). Some rneasure of soil microbial biomass turnover, such as respired CO_2 or enzyme activity, is required to assess microbial activity (Brookes., 1985; Anderson and Domsch, 1986; Anderson and Domsch, 1993; Sparling and Ross, 1993). Long-term studies of microbial biomass can provide inforrnation on changes in the amount and nutrient content of biomass over time, which can be associated with differences in microbial activity and organic matter quality (Carter, 1986; Duxbury and Nkambule, 1994). The absolute amount of biomass at any one time cannot indicate whether soil organic matter quality is increasing or decreasing (Gregorich et al., 1994) but, the microbial biomass can be compared to a related soil parameter. For example, the ratio of microbial biomass C to total organic C (Anderson and Domsch, 1986, 1989; Wu and Brookes, 1988; Carter, 1991) or the ratio of respired CO,-C to microbial C (Anderson and Domsch, 1986, 1990) provides a measure of organic matter dynamics.

Studies using the ratio of microbial biomass C to total organic C have demonstrated the utility of this index to monitor organic matter changes in agricultural systems (Carter and Rennie, 1982; Anderson and Domsch, 1989; Carter, 1991; Sparling, 1992). In most cases, the ratio must be assessed against a local reference or baseline (e.g., grassland) in the same soil type (Carter, 1991). A high ratio is more likely desirable as compared to low ratio. Differences in soil clay content, mineralogy, and vegetation can influence the proportion of microbial'biornass C in total organic C (Sparling, 1992). Thus, the application of the ratio 'index is mainly confined within similar soil types and cropping systems.

1.2.7.5. Soil Enzymes

Soil enzymes are largely of microbial origin and can be used as indicators of soil quality if their activities are affected by environmental variables and farming practices. Soil enzymes are proteins that are synthesized by plants and soil organisms during metabolism and are found in living organisms (biotic enzymes), in dead cells of microbial and plant tissues (abiotic enzymes), or complexed with organic and mineral colloids (Dick, 1994). The total enzyme activity of a soil depends on the amount of extra- and intra-cellular enzyrnes (Skujins 1967). A system of heterogeneous soif enzymes operating in a cascade manner controls the decomposition of soil organic matter and human-added amendments. Plant residue components must be depolymerized and transformed before becoming the backbone of soil humus. β-glucosidase depolymerizes cellulose into subunits of glucose that can be used by soil heterotrophs as carbon and energy sources. Other important enzymes are a-glucosidases and β-galactosidases

(Tabatabai, 1988). Mineralization of soil organic-N to NH_4^+ is accomplished by a series of enzymatic reactions involving proteases, deaminases, amidases and ureases. Arylsulfatases and acid and alkaline phosphomonoesterases control the S and P dynamics in tèrrestrial ecosystems. The hydrolysis of fluorescein diacetate, suggested as a general measurement of microbial activity, involves a group of enzymes such as lipases, proteases, and esterases (Schnürer et al., 1982; Diack et al., 1996).

Enzyme activities are critical indicators of soil organic matter quality because enzymes control nutrient release for plant and microbial growth (Skujins, 1978; Burns, 1978), gas exchange between soils and atmosphere (Conrad et al., 1983), and soil physical properties (Martens et al., 1992). It has been suggested that soil enzyme activities be used as biochemical/biological indicators of soil quality (Dick, 1994). The sensitivity of soil enzymes to environmental and management practices can be quantified using two approaches: measuring enzyme-related activities and determining kinetic parameters as defined by the Michaelis-Menten model.

In general, soil enzyme activities are directly proportional to the content of soil organic matter (Skujins, 1967; Frankenberger and Dick, 1983; Baligar and Wright, 1991; Baligar et al., 1991). Soil enzyme activities are higher in surface than in subsurface horizons and follow the distribution of organic C in the soil profile (Baligar and Wright, 1991; Baligar et al., 1991; Frankenberger and

Tabatabai, 1991). Erosion and excessive tillage, whicti decrease soil organic matter content and the thickness of the A horizon, may therefore induce losses in total amount and activity of enzymes by diluting the concentration of organic: C in cultivated Ap horizons with soil from the B horizon. Overgrazing and erosion resulted in decreased enzyme activities in semi-arid soils (Sarkisyan and Shur-Bagdasaryan, 1967). Temporal fluctuations of enzyme activities are related mainly to differences in soil moisture and are almost independent of small variations in soil organic C and N (Ross, 1984).

Soil enzyme activities respond to cultivation, additions of fertilizer and organic amendments. Adenosine deaminase activity has been shown to contribute significantly to mineralization and was higher in an Andept under forest than under cultivation (Sato et ai., 1986). Cultivation of native grasslands and forest ecosystems decreased soil organic C and the activities of dehydrogenases, ureases, phosphomonoesterases and arylsulfatases in a soil climosequence of the Canadian prairies, and the activity of these enzymes decreased even further in crop rotation systems that include summerfallow (Dormaar, 1983; Gupta and Germida, 1986). Fields cropped to green manure for 27 years showed significantly higher activities of ureases, phosphomonoesterases and dehydrogenases than those receiving inorganic fertilizers (Bolton et al., 1985), which is consistent with results reported for a Belgian soil (Verstraete and Voets, 1977). Addition of plant materials significantly increased β-glucosidase activity relative to that measured with additions of poultry manure and sewage sludge (Martens et al., 1992). Different cropping systems produced a significant effect on β-glucosidase activity within 2 years, even though there was no measurable difference in total C content (Dick, 1994).

While many studies have looked at the effects of long-term management on soil productivity, little has been done to understand how long-term management affects the development of surface soil structure. This is especially critical for the processes involved in crusting, surface seal development and water infiltration rates. Microbial activity affects the development of surface soil structure through the transformations and accumulation of organic matter whereby organo-mineral complexes, polysaccharides and root exudates are formed and act as binding agents for the stabilization of the soil structure. With the increasing interest in the soil microbial activity and its importance in integrated ecosystems studies, it is necessary to find good methods of measuring microbial activity in the soil. One promising method is fluorescein diacetate hydrolysis. This enzymatic activity is involved in lipid metabolism which is ubiquitous among all living cells. The çurrent method determines the level of activity of enzymes present outside of the cells, by measuring the hydrolysis of fluorescein diacetate. It was developed for use with pure microbial cultures, and has not been optimized for the soil environment.

The objectives of this research were to determine: 1) how variations in soil surface structure, affecfed by long-term management, are related to the changes in soil biological and bidchemical properties; 2) how fluorescein diacetate hydrolytic activity responds to long-term management as a biological indicator of soil quality; 3) and finally to clevelop a simple and rapid method to assay fluorescein diacetate hydrolysis, specifically optimized for soil.

HYPOTHESES

1). Soil managed with no-till has the best soil quality while soil managed with moldboard plow has the worst quality.

2). Enzyme activity, microbial biomass, total organic carbon, total nitrogen, and soil carbohydrate contents increase with no-till systern.

3). Bulk density decreases whereas infiltration rate and soil resistance to penetration increase as induced by increase in soil biological and biochemical properties with no-till system.

4). Sealing index, a new method of measuring aggregate stability, decreases with no-till system.

ASSUMPTIONS

Basing the definition of soil quality on its capacity to partition water and regulate infiltration thus decreasing soil erodibility, the criteria of a high quality soil are: high aggregate stability, high infiltration rate, low crusting and surface sealing and good crop productivity.

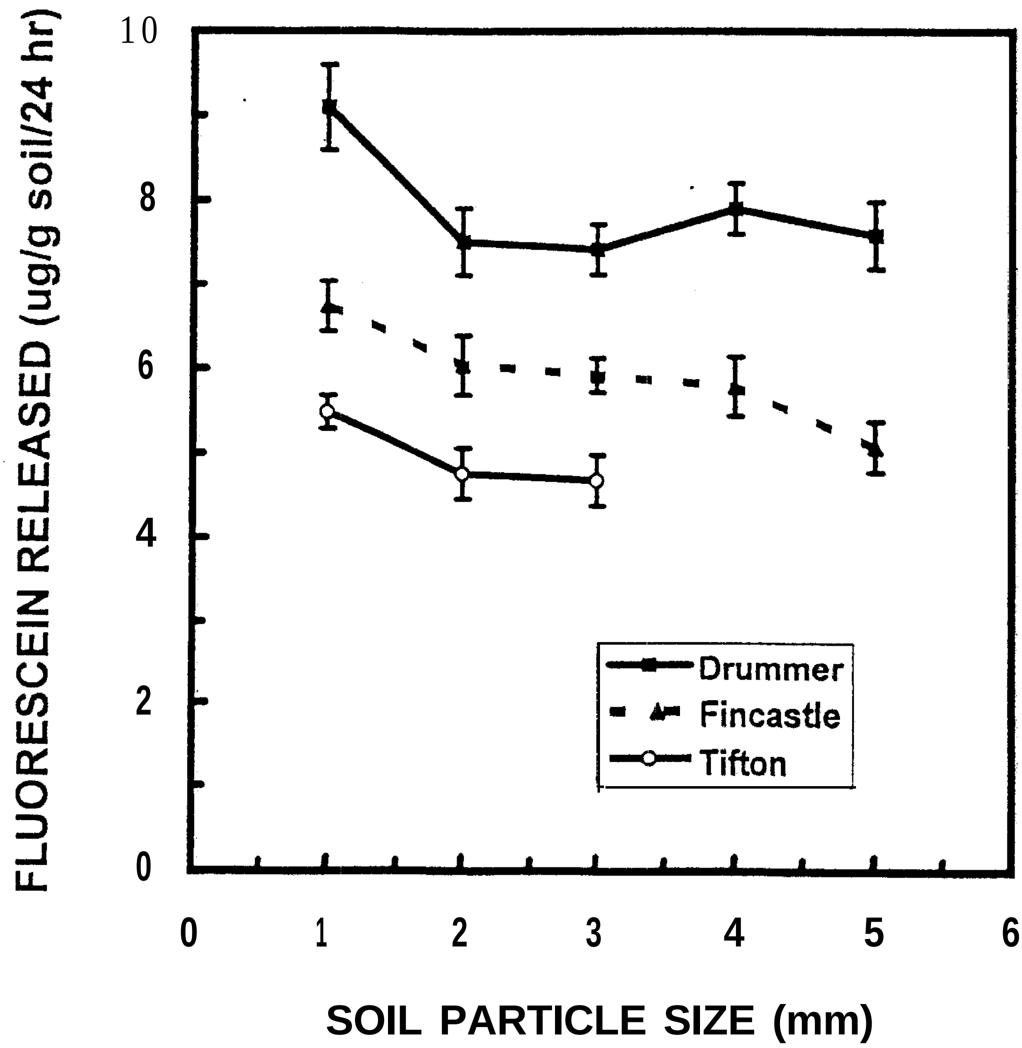

Figure 2.9. Effect of soil particle size on release of fluorescein during FDA hydrolysis assay in soiis. Means of three replicates are shown. Bars represent standard deviations at given particle size.

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CHAPTER 2

OPTIMIZATION OF FLUORESCEIN DIACETATE (FDA) HYDROLYSIS ASSAY IN SOILS

2.1. Abstract

The hydrolysis of fluorescein diacetate (3',6'-diacetylfluorescein [FDA]) has been suggested as a general measurement of microbial activity in soil. This is because lipase, protease and esterase are the enzyrnes involved in the hydrolysis. Following hydrolysis, fluorescein is released and is measured spectrophotometrically. The objective of this study vvas to optimize the FDA hydrolysis assay for soil. The method developed involves extraction and determination of the fluorescein released when 2.5 g of soil are incubated with 50 mL of 60 mM buffered, (pH 7.0) sodium phosphate solution at 35°C for 24 hours. Results showed that FDA hydrolysis was optimum at buffer pH 7.0 and the soil enzyrnes were denatured at temperatures above 50°C. The initial rates of fluorescein release followed zero-order kinetics. Three soils were used in the study: a silty clay loam, a silt loam and a sand. The FDA hydrolysis in three soils studied ranged from 1.8 to 9.0 µg fluorescein released per g soil per 24 hour incubation, with more hydrolysis occurring in the silty clay loam.

2.2. Introduction

During the past few years, the interest in the size and activity of the soil micrabial biomass has increased, partly because of the importance of this information in integrated ecosystems studies. Total microbial activity is a good general measure of organic matter turnover in natural habitats as about 90% of the energy flows through microbial decomposers (Heal and McLean, 1975).

Fluorescein diacetate (3',6'-diacetylfluorescein [FDA]) has been used to measure microbial activity in soils (Brunius, 1980; Lundgren, 1981; Schnürer and Rosswall, 1982). FDA is hydrolyzed by a number of different enzymes, such as proteases, lipases and esterases. The equation of the reaction is:

$$3',6'\text{-Fluorescein diacetate} + H_2O \rightarrow \text{Fluorescein} + 2(CH_3COOH)$$

The product of this enzymatic conversion is fluorescein, which can be visualized within cells by fluorescence microscopy (Gustaf, 1980; Lundgren, 1981). Fluorescein released in soil can also be measured by spectrophotohietry (Swisher and Caroll, 1'980; Schnürer and Rosswall, 1982). A search of the scientific literature revealed little information (Schnürer and Rosswall, 1982) on the factors affecting the FDA hydrolysis in soils. Also, the current method for measuring FDA hydrolysis was not developed for use in agricultural soils but for pure microbial culture@.

The objective of the investigation was to develop a simple and rapid method to assay fluorescein diacetate hydrolysis, specifically optimized for soil, that can be used as a biochemical/biological indicator of soil cluality.

2.3. Materials and Methods

Three surface soil samples, selected to obtain a wide range in pH, organic C, total N and texture (Table 2.1), were used. The samples were air-dried and crushed to pass the appropriate size screen where needed. FDA hydrolysis was determined by the method described by Diack et al., (1996).

Various properties of the FDA hydrolytic activity in soils were studied. These factors included time of incubation, optimum pH buffer, temperature of incubation, substrate concentration, extracting solution concentration, vessel type and capacity, amount of soil, soil particle size and adsorption capacity.

To determine the incubation time, 2 g of air-dried soil (<2 mm) were placed In a centrifuge tube. Simultaneously, 10 $\mu g\ mL^{-1}$ of FDA was added as lipase substrate to 50 mL of 60 mM sodium phosphate buffered to pH 7.6. The mixture was incubated at 24°C on a rotary shaker for 1 to 72 h. The choice of 2 g of soil, 60 mM of sodium phosphate, buffered at pH 7.6 and 24°C incubation was based on Schnürer and Rosswall, (1982). Their results showed that FDA hydrolysis by pure cultures of *Fusarium culmorum* increased linearly with mycelium addition in shaken cultures and after inoculation into sterile soil. Also, the buffering capacity was sufficient to keep the pH at 7.6 for the duration of the experiment.

To determine the influence of pH, 2 g of air-dried soil, (<2 mm) were placed in a centrifuge tube containing 50 mL of 60 mM, sodium phosphate added with FDA (10 µg mL^{-1}). The different pHs tested ranged from 4.0 to 10. The buffer solution was adjusted to each pH value using HCl IN. The samples were shaken while incubated at 24°C for 24 hr.

In studies on the effect of temperature, 2 g af air-dried soil, (<2 mm), were placed in each centrifuge tube containing 50 mL of 60 mM, pH 7.0 sodium phosphate and FDA (10 µg mL^{-1}) as substrate. The samples were incubated on a rotary shaker at temperatures ranging from 22 to 70°C for 24 hr.

To determine the optimum substrate concentration, 2 g of air-dried soil (<2 mm) were placed in each centrifuge tube. 50 mL of 60 mM, pH 7.0 Na_3PO_4 and FDA substrate were added and the mixture was incubated at 35°C on a rotary shaker for 24 hr. The FDA concentration tested ranged from 0 to 30 µg mL^{-1}.

To study the influence of Na_3PO_4 concentration, 2 g of air-dried soil (<2 mm) were placed in a centrifuge tube containing 50 mL (30 to 150 mM, pH 7.0) sodium phosphate and FDA (10 µg mL^{-1}). The samples were shaken while incubated at 35°C for 24 hr.

To determine the effect of the amount of sodium phosphate on the FDA hydrolysis, 2 g of air-dried soil (<2 mm) were placed in a centrifuge tube containing 25 to 150 mL (60 mM, buffered at pH 7.0) sodium phosphate and with FDA (10 µg mL^{-1}). Each mixture was incubated at 35°C on a rotary shaker for 24 hr.

The influence of vessel type and size was studied by placing 2 g of air-dried soil (<2 rnm) in each erlenmeyer flask (Pyrex glass) or centrifuge tube (Polypropylene) of different capacities (100 to 250 mL). Each erlenmeyer and centrifuge tube contained 50 mL (60 mM, buffered at pH 7.0) Na_3PO_4 and FDA (10 µg mL^{-1}). Each mixture was incubated at 35°C on a rotary shaker for 24 hr.

To deterrnine how much soil was needed for optimum FDA hydrolytic activity a range of sample weights (1 to 5 g) of air-dried soil (<2 mm) was placed in a centrifuge tube, containing 50 mL (60 mM, buffered at pH 7.0) sodium phosphate added with FDA (10 µg mL^{-1}). Each mixture was incubated at 35°C on a rotary shaker for 24 hr.

The influence of soil aggregate size range was studied by crushing to pass soils through screen sizes ranging from 4.76 to 0.5 mm. For each sample, 2.5 g of air-dried soil were placed in centrifuge tube, containing 50 mL (60 mM, buffered at pH 7.0) sodium phosphate and FDA (10 µg mL^{-1}). Each mixture was incubated at 35°C on a rotary shaker for 24 hr.

To determine the adsorption capacity of hydrolyzed FDA to soil, fluorescein was used at 2 ,5 and 10 µg mL^{-1} and added to the soil sample in lieu of FDA substrate lipase as usual. FDA was hydrolyzed by placing a 150-mL flask with fluorescein at given concentration and sodium phosphate solution in a boiling water bath for 30 min. The soil solutions were shaken on a rotary shaker while incubated at 35°C for 60 min.

2.4. Method for Assay-of FDA hydrolysis

This method for assay of FDA hydrolysis was developed after all the factoss involved in the assay were studied for optimization.

Reagents

Sodium phosphate Buffer (60 mM, pH 7.0). Dissolve 22.74 g of Na_3PO_4, 12 H_2O in deionized water, dilute the solution to 1 liter, and adjust the p H to 7.0 with 1 N hydrochloric acid. Add 10 mg of fluorescein diacetate, lipase substrate $C_{24}H_{16}O_7$ (Sigma Chemical Co.), to the sodium phosphate buffer.

Fluorescein $C_{20}H_{12}O_5$, (Aldrich Chemical Co. Milwaukee, WI) for standards.

Procedure:

Place 2.5 g of air-daied soil, sieved to pass 2 mm, in a 100-mL centrifuge tube, add 50 mL of 60 mM, pH 7.0, sodium phosphate buffer. Stopper the tube, and incubate it on a rotary shaker at 35°C for 24 hours. Add 2 mL of acetone (50% [vol/vol]) to terminate the FDA hydrolysis. Then centrifuge the soil suspension at 3840 g for 5 min. Filter the supernatant through a W4 atman no. 42 qualitative filter paper. Transfer the filtrate to a colorimeter tube (Bausch & Lomb Spectronic 21 DV, Arlington Heights, IL) and measure the yellow fluorescein color intensity at 490 nm. To perform control on each soil, follow the procedure described above without any addition of substrate. Calculate the concentration1 of fluorescein released by reference to a calibration graph plotted from the results obtained with standards containing 0, 0.2, 0.4, 0.6, 0.8, and 1.0 mg of fluorescein solution. To prepare the standard solution, dissolve 10 mg of fluorescein in 10 mL hot 95% ethanol (65°C), add 40 mL of 60 mM, pH 7.0 Na_3PO_4 buffer. The solution has a yellow fluorescein color and is very stable over time. Pipette 0, 0.1, 0.2, 0.3, 0.4, and 0.5 mL of the standard FDA solution in a 50-mL volumetric flask. Bring to volume using sodium phosphate buffer, shake to homogenize the solution, and measure the absorbance at 490 nm.

2.5. Results and Discussion

The method developed for the assay of fluorescein diacetate (FDA) hydrolysis in soils is based on colorimetric determination of fluorescein released in soils extracts. Studies of factors affecting the release of fluorescein during incubation aided optimization of this assay. There is a linear relationship between the amount of fluorescein and color intensity at 490 nm (Figure 2.1).

The factors studied included time of incubation, pH buffer, temperature of incubation, substrate concentration, concentration and volume of buffer solution, reaction vessel type and capacity, amount of soil, soil particle size range and adsorption capacity.

2.5.1. Time of Incubation ,

In the three soils, the release of fluorescein during FDA hydrolysis increased linearly up to 24 hr (Fig. 2.2). Formation of fluorescein was proportional ta-the incubation time for the first 24 hr. Schnürer and Rosswall (1982) also reported a linear relationship between FDA hydrolysis in soils and incubation time. The observed relationship indicates that the method developed measures enzymatic hydrolysis of FDA and it is not complicated by microbial growth or assimilation of enzymatic products by microorganisms. Enzyme-catalyzed reactions usually show linear relationships between the amount of products formed and the time of incubation (Deng and Tabatabai, 1994). Skujins (1967) suggested that an assay for soil enzymes should not require incubation times longer than 24 hr, because the risk of error through microbial activity increases with increasing incubation time.

2.52. Temperature of Incubation

A study of FDA hydrolysis in soils as a function of temperature showed optimum activity at 35°C (Fig. 2.3) under the conditions of the described assay. Schnürer and Rosswall, (1982) and Lundgren (1981) used 24 or 22°C as incubation temperatures, respectively, in their studies of FDA hydrolysis. This increase in incubation temperature may be explained by the fact that the temperature needed to inactivate enzymes in soil is about 10°C higher than that needed to inactivate the enzyme in the absence of soil (Tabatabai and Bremner, 1970; Browman and Tabatabai, 1978).

Denaturation of FDA hydrolytic enzyme occurred at 50°C and resulted in a brownish coloration of the solution. This temperature is 15°C lower than the temperature required (65°C) to denature amidase (Frankenberger and Tabatabai, 1980), arylsulfatase (Tabatabai and Bremner, 1970), and inorganic pyrophosphatase (Dick and Tabatabai, 1978) in soils. The activity of enzymes decreases with increasing temperature because of enzyme inactivation at some temperature above this range.

2.5.3. Effect of Buffer pH

Optimal activity of FDA hydrolytic soil enzymes was observed at pH 7.0 (Figure 2.4). This is close to the 7.6 pH buffer that Schnürer and Rosswall (1982) used in their study. This optimal pH value is also within the 5.5 to 8.5 pH range that Lundgren (1981) used in studying FDA as a stain for metabolically active bacteria in soil. FDA has been reported to spontaneously degrade to fluorescein in slightly alkaline (pH ≥ 8.0) solutions (Ziegler and al., 1975; Brunius, 1980). At low pH values (≤ 5.0), nonbiological hydrolysis of FDA may occur (Schnürer and Rosswall, 1982). The effect of pH buffer on FDA hydrolysis is critical because the H^+ concentration in the reaction solution affects the ionization groups of the enzyme protein and influences the substrat& ionization state. For effective interaction between the substrate and enzyme, the ionizable groups of both the substrate and the active site of the enzyme must be in their proper states, to maintain the correct conformations.

2.5.4. Substrate Concentration

For valid assay of enzyrnatic activity, it is necessary to ensure that the enzyme substrate concentration is not limiting the rate of the reaction during the assay procedure. A study of the effect of varying substrate concentration showed that 10 $\mu g\ mL^{-1}$ substrate concentration was satisfactory for the FDA hydrolysis assay (Figure 2.5). Schnürer and Rosswall (1982) and Lundgren (1981) used the same substrate concentration for measuring FDA hydrolysis in litter and pure cultures, respectively. At this concentration, the soil enzymes seemed to be saturated with the substrate, and the reaction rate essentially followed zero-order kinetics.

2.5.5. Amount of Buffer Solution and Vessel Tvpe

Altering the amount of the buffer solution affects the amount of fluorescein released (Figure 2.6). Using the same concentration of sodium phosphate buffer solution, as the volume increased, the amount of fluorescein released increased linearly. This is Ibecause increasing the amount of buffer solution would increase the amount of substrate to the soil solution for the same amount of soil thus, increasing the amount of fluorescein released during FDA hydrolysis.

The type of vessel, either the glass erlenmeyer flasks or the polypropylene centrifuge tubes showed no significant difference in the amount of fluorescein released (Figures 2.6 and 2.7). Both the glass and polypropylene centrifuge tubes were inert with respect to the FDA hydrolytic enzymes.

2.5.6. Amount of Soil

The relationship between the amount of fluorescein released and the amount of soil is linear up to 5 g soil for all three soils (Figure 2.8). These results are consistent with the observations of Schnürer and Rosswall (1982). This linear relationship is further evi'dence that the procedure developed measures FDA hydrolysis, and neither the substrate concentration nor the amount of fluorescein formed influence the reaction rate of these soil enzymes. The data (Figure 2.8) show that 2.5 g of air-dried soil seem more indicated than 2.0 g for an optimum release of fluorescein during FDA hydrolysis.

2.5.7. Soil Aqaregate Size

Varying the soil aggregate size range showed that enzymatic activity is affected by soil aggregate size in the reaction solution. As the size of soil aggregate increases, the amount of fluorescein released decreased (Figure 2.9). Most of the changes in fluorescein release occur from 1 to 2 mm, with little drop after 2 mm aggregate size. This is most likely because the larger aggregate have less total surface area per gram of soil in contact with the reacting solution.

2.5.8. capacityon

Adsorption capacity is defined as the ability of a soil to fix FDA and thereby reduce the amount of fluorescein released. The mineral composition of the soil and its structure most likely determine the adsorption capacity. The adsorption of hydrolyzed FDA to soil was calculated as the adsorbed fluorescein (known amount of fluorescein minus released fluorescein) divided by the known amount.

Adsorption capacity was proportional to the amount of fluorescein released by these soils during the FDA hydrolysis. The adsorption capacity was 67, 48 and 34% for the silty clay loam, silt loam and the sandy loam soils respectively. Higher organic matter and clay contents, generating highly negative charge at the active site of the Drummer silty clay loam soil, probably result in higher adsorption of the FDA during hydrolysis.

2.6. Conclusions

The method developed to determine FDA hydrolysis is certainly one of a number of methods used for the assessment of microbial activity in samples from natural habitats. All methods have their limitations, and the development of one for a particular investigation is determined by a number of factors. This method differs from Schnürer and Rosswall (1982) at least in the pH buffer (7.0 vs. 7.6), ' time of incubation (24 vs, l-3 hr), incubation temperature (35 vs. 22-24°C) and the amount of soit (2.5 vs. l-li.7 g). This method of measuring FDA hydrolysis has the advantage of being simple and sensitive, and it should prove useful, especially for studies of soil microbial activity and organic matter accumulation and transformations.

Table 2.1. Properties of the soils used.

Soil	pH	Organic C (%)	Total N (%)	Clay (%)	Sand (%)
Drummer	5.72	2.72	0.328	40	13
Fincastle	5.00	1.24	0.147	22	20
Tifton	6.35	0.50	0.067	11	80

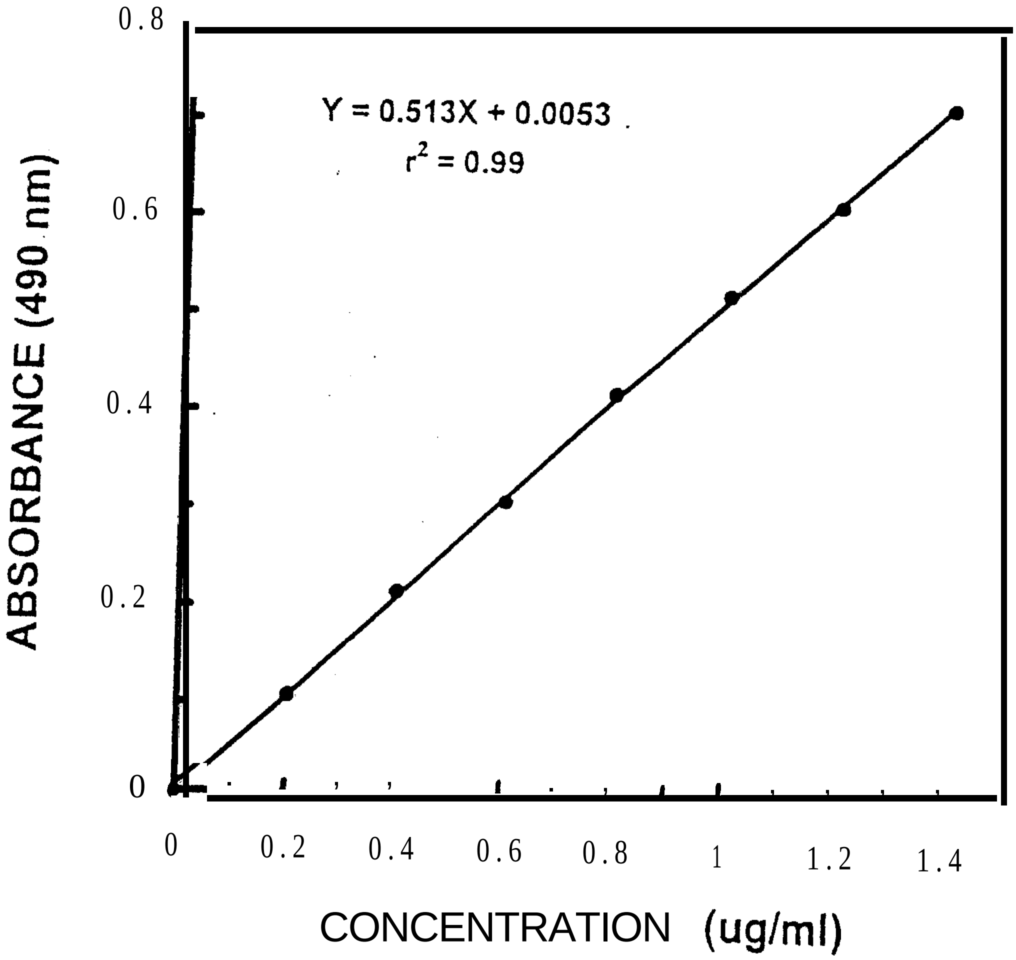


Figure 2.1. Calibration graph plotted from the results obtained with standards of fluorescein solution.

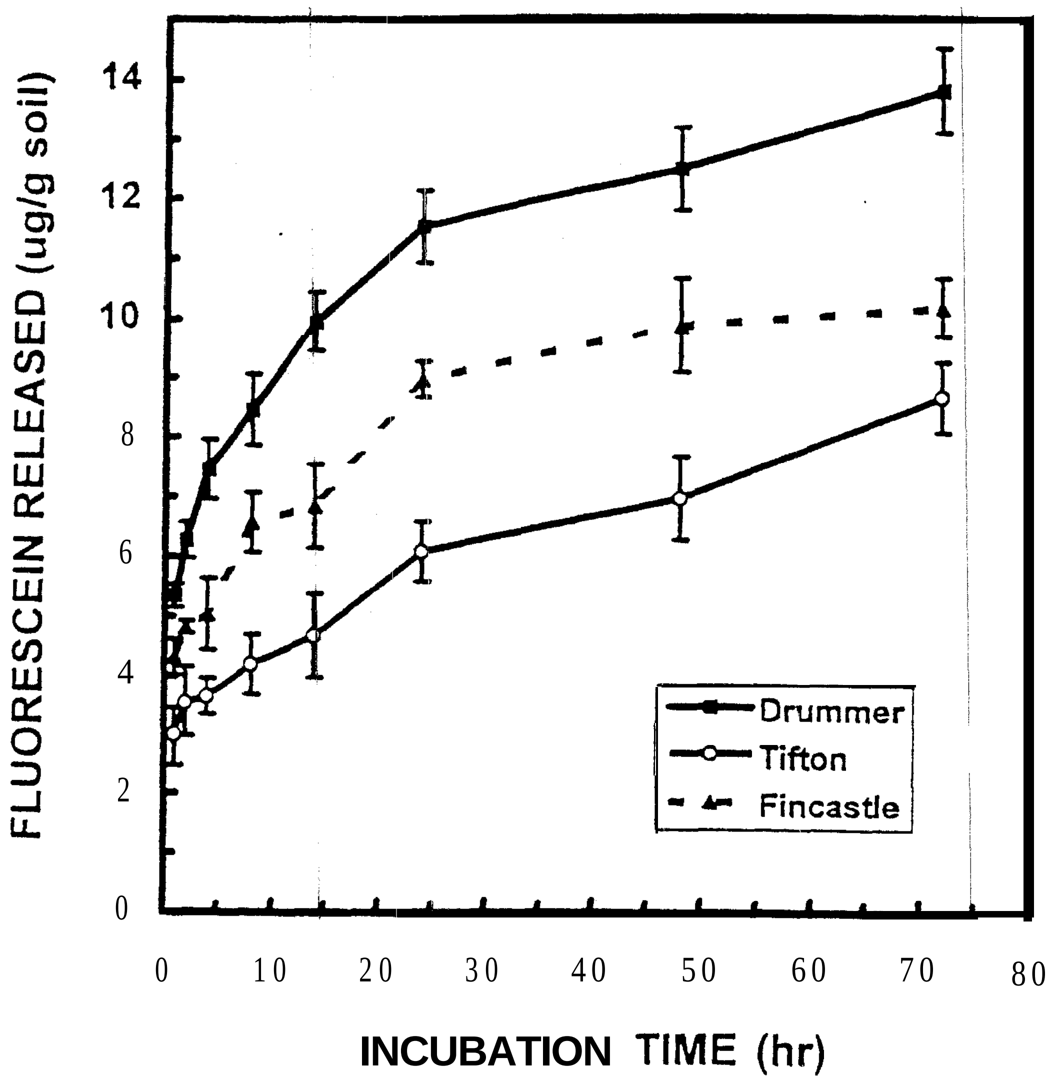


Figure 2.2. Effect of incubation time on release of fluorescein during FDA hydrolysis assay in soils. Means of three replicates are shown. Bars represent standard deviations at given time.

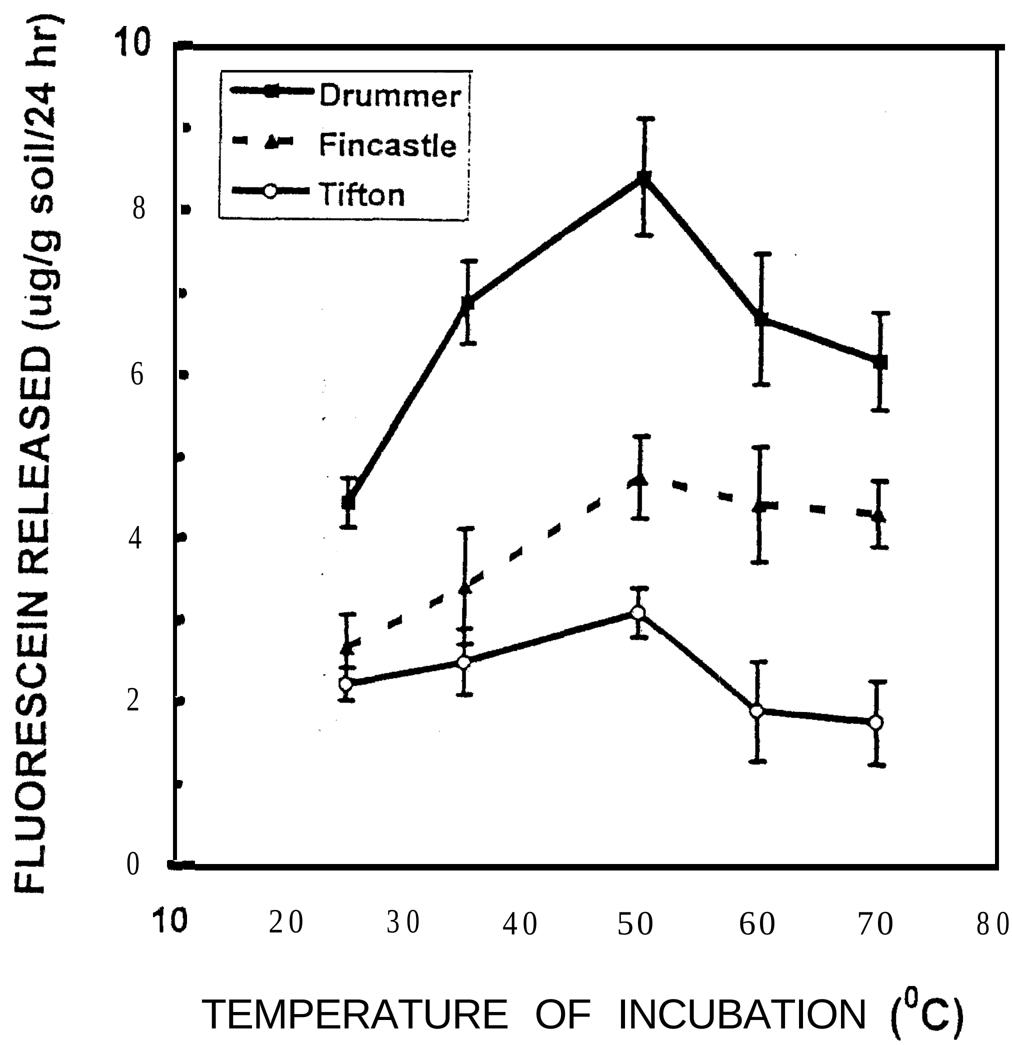


Figure 2.3. Effect of incubation temperature on release of fluorescein during FDA hydrolysis assay in soils. Means of three replicates are shown. Bars represent standard deviations at given time.

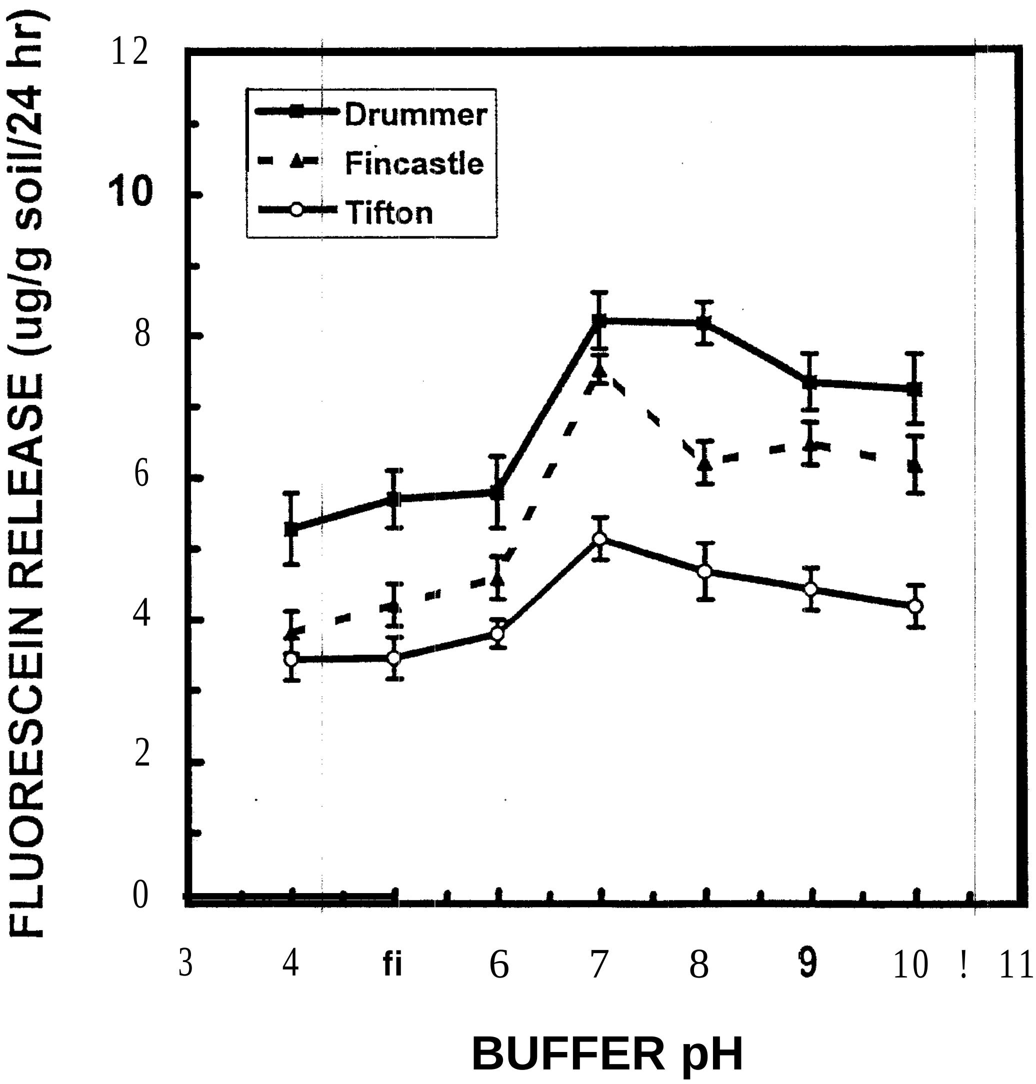


Figure 2.4. Effect of pH of buffer on release of fluorescein during FDA hydrolysis assay in soils. Means of three replicates are shown. Bars represent standard deviations at given pH unit.

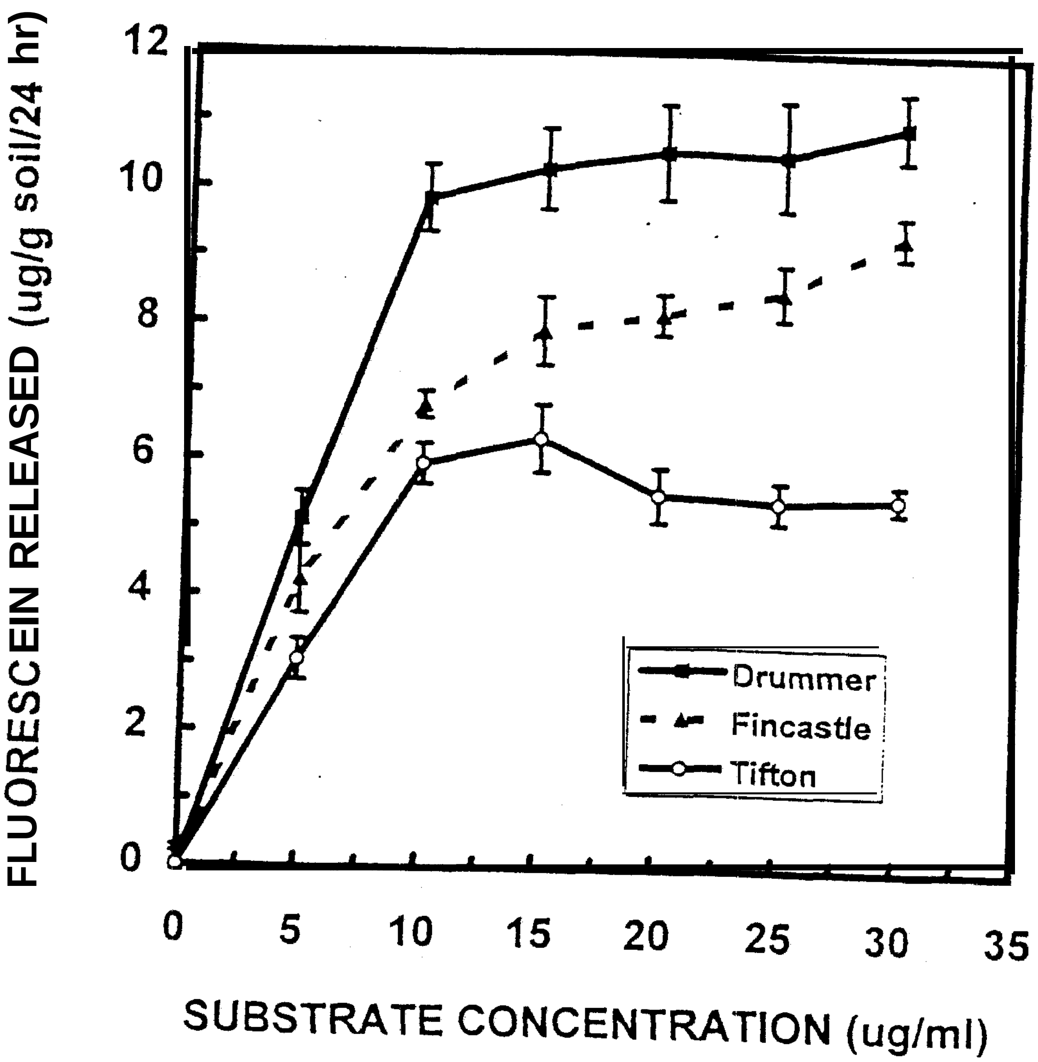


Figure 2.5 Effect of substrate concentration on release of fluorescein in FDA hydrolysis assay in soils. Means of three replicates are shown. Bars represent standard deviations at given concentration.

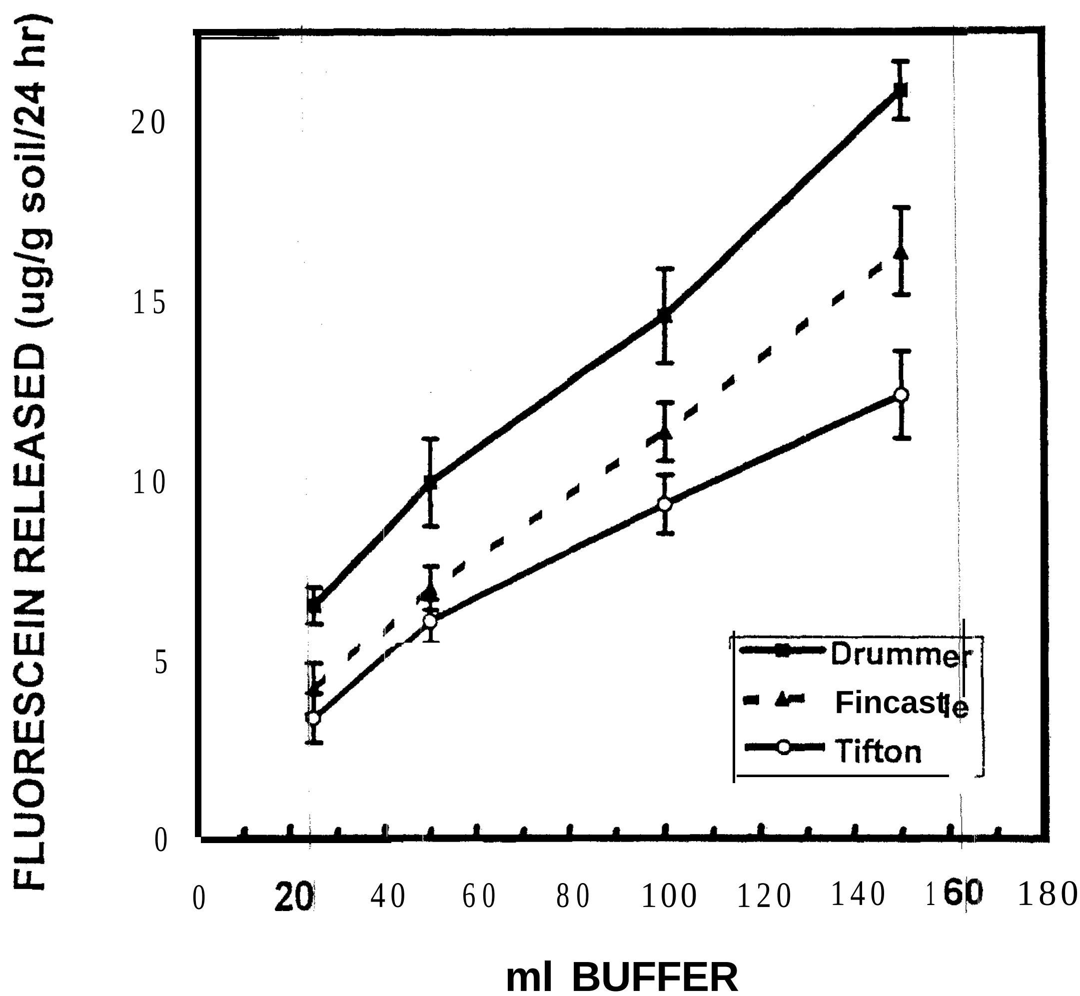


Figure 2.6. Effect of volume of buffer solution on release of fluorescein during the FDA hydrolysis assay in soils, as the substrate concentration was constant. Erlenmeyer flasks were used as the reaction vessels. Means of three replicates are shown. Bars represent standard deviations at given volume.

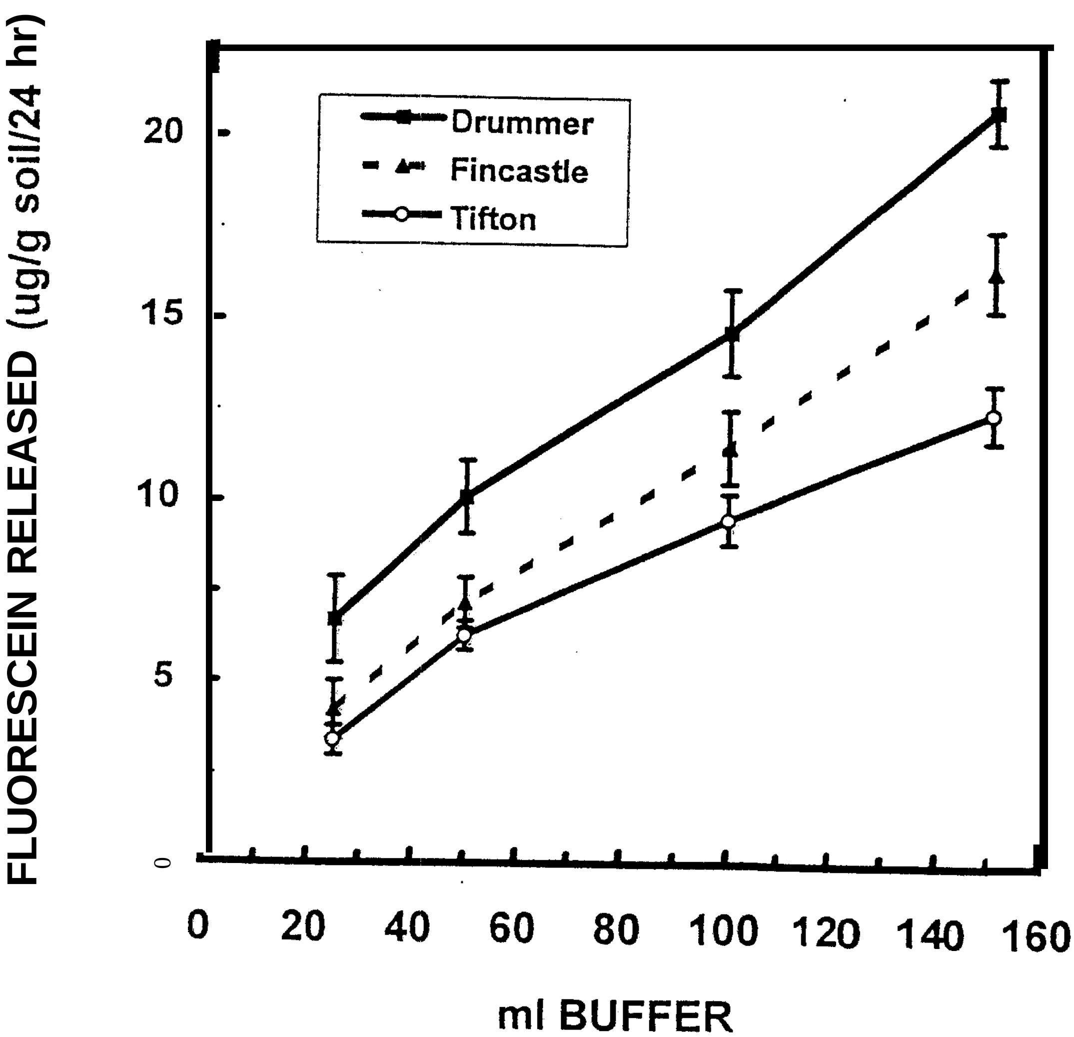


Figure 2.7 Effect of volume of buffer solution on release of fluorescein during the FDA hydrolysis assay in soils, as the substrate concentration was constant. Polypropylene centrifuge tubes were used as the reaction vessels. Means of three replicates are shown. Bars represent standard deviations at given volume.

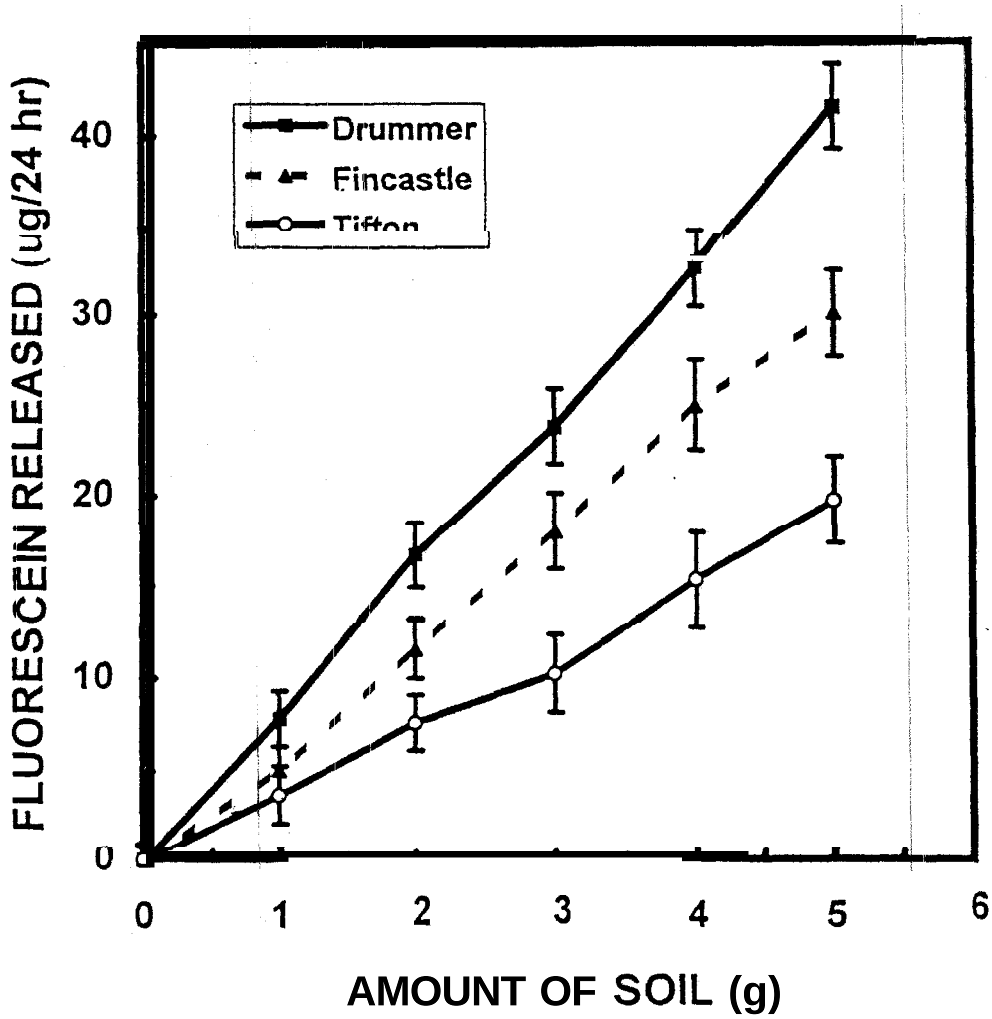


Figure 2.8. Effect of amount of soil on release of fiuorescein in FDA hydrolysis assay in soils. Means of three replicates are shown. Bars reprisent standard deviations at given amount.

Ziegler, GB., Ziegler, E. and R. Witzenhausen. 1975. Nachweis der stoffwechselaktivitat von mikroorganismen durch vital-fluorochromierung mit 3',6'-diacetylfluorescein. Zentralblatt fur bakteriologie. Parasitenkunde, infektions-krankheiten und hygiene, Abt. 1 Orig., Reihe A 230:252-264.

CHAPTER 3

RELATIONSHIPS BETVVEEN SOIL BIOLOGICAL AND CHEMICAL CHARACTERISTICS AND SURFACE SOIL STRUCTURAL PROPERTIES FOR USE IN SOIL QUALITY

3.1. Abstract

With the progressive degradation of agricultural soils, there is new emphasis on usiing the concept of soil quality as a sensitive and dynamic way to document the condition of soils, how they respond to management changes, and their resilience to stress. This study relates soil structural characteristics to soil biological and biochemical properties under various management systems. Soil erodibility was used as the baseline to develop a set of soil quality indicators. The study was conducted on a 16-year integrated pest management field where several tillage and crop rotation combinations are available. Sealing index, as a measure of aggregate stability using a Griffith fall velocity tube, decreased with decreasing tillage intensity. However, infiltration rate was highest in the chisel plow system. Total organic C and N, microbial biomass C, soil carbohydrates and soil enzyme activities were significantly greater in conservation systems as

compared to conventiona! tillage practices. Bulk density was negatively correlated with soil enzyme activities. Tillage appeared to be the major contributor in the soil property changes with crop rotation system differences being minor. Using a standard scoring function for developing a soil quality rating, the three management systems were rated from the lowest to the highest: moldboard plow ~ no-till < chisel plow. The results suggest that soil biochemical and biological properties are potential indicators of soil quality with regard to crusting and erodibility.

3.2. Introduction

The key to sustaining the soil resource base is to maintain, or enhance soil quality. Soil quality can be defined as the degree of suitability to the specific functions that soils perform in a given ecosystem. The terms soil quality and soil health are currently used interchangeably in the scientific literature and popular press. Scientists prefer soil quality while farmers prefer soil health (Harris et al., 1994). While the term 'soil quality' is relatively new, it is well known that soils vary in quality and that soil quality changes in response to use and management (Larson et al., 1994). The National Research Council (USA) recommends a definition of soil quality as the capacity of the soil to promote the growth of plants; protect watersheds by regulating infiltration and partitioning of precipitation; and prevent water and air pollution by buffering potential pollutants.

Although we can define soil quality as the degree of suitability to the functions that soils perform in an ecosystem, soil quality cannot be seen or measured directly from the soil alone but is inferred from soil characteristics and soil behavior under defined conditions. As Stewart (1992) pointed out, there is no single measurement that can quantify soil quality. However, there are certain characteristics, particularly when considered together, that are good indicators.

Over time, a soil may be sustained in its ability to function as a viable component of an ecosystem,, it may be degraded, or it may be improved or aggraded. The success of soil conservation efforts and management in maintaining soil quality depends on an understanding of how soil responds to agricultural use and practice over time (Gregorich et al., '1994). Methods to quantify soil quality must assess changes in selected soil attributes over time in order to be useful for determining best management strategies. Present approaches to quantify soil quality are concerned with either characterization of different facets or attributes of quality (descriptive approach), or are concerned with the identification of specific indicators or parameters that will assess the ability OF capacity of an attribute to function in a desired manner (indicative approach). Quantifying soii quality requires that a data set be defined, comprising measures of various soil attributes or critical properties as key indicators (Larson and Pierce, '1991). To characterize how soil quality changes over relatïvely short time periods, these critical properties must be sensitive to changes in soil management, soil disturbances and inputs into the soil system.

So far, most work done on, or ideas about, soil quality assessment (Parr et al., 1992; Doran et al., 1994; Harris et al., 1994; Karlen and Stott., 1994; Larson et al., 1994) have mentioned the necessity of measuring almost all the soil physical, chemical, and biological characteristics to determine soil quality indicators.

Severat studies have looked at the effects of long,-term management on soil productivity, while the effects of long-term management on the susceptibility of soils to crust formation, surface sealing and runoff production has received little attention. A crust forms when surface aggregates disintegrate, filling pore space with fine particles. The surface seal that results from this aggregate breakdown impedes water infiltration, leading to runoff and erosion. Such seals may also interfere with seedling emergence, leading to poor crop stands. Generally, organic matter is considered to be a cementing agent that should stabilize soil structure and decrease soil susceptibility to crust formation and surface sealing. As several studies have'focused on soil quality in terrns of soil productivity, very few studies have explored soil quality as related to the capacity of the soif to partition water and regulate infiltration.

The objectives of this research were to determine: 1) how variations in soil surface structure, affected by long-term management, are related to the changes in soil biological and biochemical properties, and 2) how fluorescein diacetate hydrolytic activity responds to long,-term management as a biological indicator of soil quality.

HYPOTHESES

1). Soil managed with no-till has the best soil quality while soil managed with moldboard plow has the worst quality.

2). Enzyme activity, microbial biomass, total organic carbon, total nitrogen, and soil carbohydrate contents increase with no-till system.

3). Bulk density decreases whereas infiltration rate and soil resistance to penetration increase as induced by increase in soil biological and biochemical properties with no-till system.

4). Sealing index, a new method of measuring aggregate stability, decreases with no-till system.

ASSUMPTIONS

Basing the definition of soil quality on its capacity to partition water and regulate infiltration thus decreasing soil erodibility, the criteria of a high quality soil are: high aggregate stability, high infiltration rate, low crusting and surface sealing and good crop productivity.

3.3. Materials and Methods

3.3.1. General field plan and cultural practices of the IPM Plots

The Integrated Pest Management (IPM) plots, located at the Agronomy Research Center at Pur-due University, West Lafayette IN, constitute a field of 16.2 ha of predominantly Drurnmer silty clay loam (fine-loamy, mixed, mesic Typic Haplaquoll). The site had an initial pH of 6.4 and an organic matter content of 4.6%. A split-plot design with four replications was utilized. The whole plots were factorial combinations of crop rotation and tillage treatments randomized in each replication. Tillage treatment for each whole plot always remained the same. Subplot units were weed management systems randomized within each whole plot and atways remained the same (Schreiber, 1992). Plots had various widths (9 to 15 m) and 90 m long with 1.5 m grass strips between each whole plot. Between each subplot, a 6-m-wide tilled area was maintained weed free as well as a 1.5-m strip at each end. This layout reduced weed encroachment from any border area and permitted the use of large field equipment for tillage, planting, and crop harvesting.

3.3.1.1. Tillage Systems

Three primat-y tillage systems were selected for a wide range of soil management. The most intensive was conventional moldboard plowing in the fall with secondary spring tillage for final seedbed preparation. This tillage completely inverted the top 15 to 18 cm of soil and left little crop residue on the surface. This system also included one cultivation in row crops. The intermediate tillage level was a fall chisel plowing using a straight shank, with secondary spring tillage for final seedbed preparation. This tool left approximately 30% cover of the previous crop residue on the soil surface. The third system was a no-till system in which the crop was seeded directly into the previous crop residue with no soil preparation. This system left 90 to 95% cover of the previous crop residue on the surface. Primary tillage was performed in the fall. Final soil preparation in the spring for the conventional and chisel plow systems utilized a field cultivator equipped with a rolling basket followed by a shallow rototiller. Row crops were cultivated once each season except in no-till.

3.3.1.2. Crop Rotations

The four rotation systerns were continuous corn, continuous soybean, a two-year rotation between corn and soybean with each crop grown each year, and a three-year rotation among corn, soybean, and wheat, with each crop grown each year. The soil sampes were collected after corn for corn/soybean and after wheat for corn/soybean/wheat rotations.

3.3.1.3. Weed Manaaement Systems.

Three levels of weed management were achieved by applying different amounts of herbicides. A minimum level of weed control used herbicides at half the recommended rates. A moderate level represented average farmer use of herbicide concentrations. The maximum level was herbicide use at maximum alfowed levels according to label clearance. Only one weed management, the intermediate level, was considered in this study because it is the most typically used by farmers in the region.

3.32. Soil Sampling and Preparation

The soil samples were collected during the early spring of 1995, prior to seedbed preparation. From each plot, two opposite sampling points along one diagonat were used for infiltration rate measurement. Each point was equidistant between one corner and the center of a plot. Around each infiltration sampling point, four soil cores (0 to 7.5cm depth) were taken using a soil probe for biochemical analyses, as well as four soil cores using a brass ring for bulk density measurement at the 0 to 7.5-cm depth, and four soil samples at the soil surface (0 to 5-cm depth) for aggregate stability. The soil samples collected were rstored in an ice chest with ice and later prepared as appropriate for analysis.

3.3.3. Physical Proper-ties

3.3.3.1. Infiltration Rate

The infiltration rate was :measured by water ponding method, using a 1-m^2 galvanized box with a 15-cm height. The source of the deionized water used for water ponding was the Soil Erosion Research Lab, and the water was transported to the site by truck in a 300-gallon tank. The truck was parked on the roadways between replicates and the amount of water poured through a long hose. The flow rate was controlled using a valve. A mechanical point gauge (Model R 81, EPIC, INC., New York, NY), placed on the edge of the infiltration box and a stopwatch allowed the measurement (in mm) of the falling water head over time (min). Measurements were taken over a two-hour period at increments of 2.5 or 5 min for the first 50 min and 10 rnin thereafter. Steady-state infiltration rates were calculated by taking the average of the last few readings and dividing by the elapsed time (10 min).

3.3.3.2. Soil Penetrability

The soil penetrability was determined in the field by a static penetration method using a cone penetrometer (Bradford, 1988). Like the soit sample collection, the soil penetrability was measured at each of the four sides of the infiltration points. The readings were done at 7.5, 15, 22.5 and 30-crn depths.

The targeted positions were the row axes and the upper interrow shoulders, and discernible wheel tracks were avoided.

3.3.3.3. Butk Density

The bulk density of the soil was measured by the core method (Blake et al., 1986). The core sampler consists of two cylinders fitted one inside the other. The outer one extends above and below the inner to accept a hammer at the upper end and to form a cutting edge at the lower end. The inside cylinder is the sample holder. To collect the soil samples, we pressed the sampler on a cleared soil surface, and inserted it to 7.5 cm. Then, using a shovel, we carefulfy removed the sampler and its contents so as to preserve the natural structure and packing of the soil as nearly as possible. We separated the two cylinders, and retained the undisturbed soil in the inner cylinder. Finally, we trimmed the soil extending beyond each end of the sample holder (inner cylinder) flush with each end with a straight-edge knife. To measure the bulk density, we transferred the soil to a preweighed aluminum can, placed it in an oven at 105°C overnight, and weighed it. The bulk density is the oven-dry mass of the sample divided by the sample volume.

3.3.3.4. Soil Aaaregate Stability as Measured by the Sealing Index

Soil aggregate stability was measured on wet and dry samples (see photographs), using a Griffith fall velocity tube (Hairsine and McTainsh, 1986) as modified by Stott (1996). Using the following procedures, soil aggregate stability was expressed by the sealing index of a soil. The sealing index of a soil (SI) is defined as the ratio of the wet to dry fall velocity at 50% mass (V_{50}) of the soil sample. The closer to 1 the sealing index, the more stable the soil aggregates. As the sealing index increases, (SI > 1), the susceptibility of the soil to undergo surface sealing or slaking increases. This is because when measuring the fall velocity for wet aggregates, the soil particles are slowly wetted first so that they can maintain their structure and mass while falling along the Griffith tube whereas for dry aggregates, the fall velocity is measured when the air-dried soit particles are poured directly into the Griffith tube. Using the fall velocity for the slowly wetted soil aggregates as a reference, the stability of the aggregates thereby depends upon the fall velocity for dry aggregates. If the dry soil aggregates have low stability, they tend to loose their structure and disintegrate as soon as they hit the water column in the Griffith tube. As a result, these dry aggregates fall rnuch slower than the larger wet aggregates and consequently, the sealing index for the soil becomes greater than 1.

3.3.3.4.1. Wet Aggregate Measurement

Ten grams of soil were prewetted and pfaced into a tut-off syringe filled with deionized water. We filled the Griffith tube with deionized water and removed air bubbles. Then, we filled the pan assembly with deionized water and placed numbered trays consecutively around the pan assembty to collect samples. The time intervals used were 10 sec, 20 sec, 30 sec, 1 min, 2 min, 5 min and 8 min. When sampling was completed, we removed the trays. We transferred the soil from the trays into numbered preweighed crucibles, and put them in an oven to dry at 105°C overnight.

3.3.3.4.2. Dry Aggreaate Measurement

The same procedure for the wet aggregates was used with the exception that the soil samples were kept dry when they were poured into the Griffith tube for fall velocity measurement.

3.3.4. Chemical Properties

3.3.4.1. Total C. H and N

Total organic carbon, hydrogen and nitrogen were determined by dry combustion, using a LECO CHN-600 (Leco Corp., St Joseph, MI). 200 mg of air-dried soil, crushed to pass through a 2-mm sieve were weighed in a tin capsule and inserted in the LECO CHN for simultaneous measurements of total

C, H and N by dry combustion. Prior to analysis, presence of $CaCO_3$ in the soil was tested with HCl and there was none.

3.3.4.2. Dissolved Organic Carbon

Soil was air-dried and crushed to pass through a 2-mm sieve. Ten grams of air-dried soil and 25 mL of distilled water were placed into a 250-mL centrifuge tube. We let it shake for 2 hours, using a platform shaker, and we centrifuged it at 3840 g for 5 minutes. Then, we filtered 'the supernatant with a Whatman no. 42 qualitative filter paper. We took 200 μL aliquot from the filtrate and measured the total organic carbon using a Dohrmann DC-l 90 Total Organic Carbon Analyzer.

3.3.4.3. Soil carbohydrates

Soil carbohydrates were measured from the light-fraction and macroorganic matter of the soil. The method described by Strickland et al. (1987) was used to separate light- and heavy-fraction organic materials from soil. Briefly, 25 grams of air-dried soil were dispersed by stirring (1800 rpm for 30 seconds) in 200 mL of NaI solution (density = 1 .7 g cm"). Suspensions were immediately centrifuged at 4086 g for 10 minutes. The supernatant containing the light fraction (LF) was decanted onto a Whatman no. 50 filter and vacuum-filtered. The macroorganic matter fraction (heavy fraction) residues were resuspended twice in fresh NaI solution and the light fractions were combined. Light and heavy fractions were washed three times by vacuum filtration with 1.0 M NaCl (50 mL) and then washed three times with deionized water. Each fraction was washed into preweighed tins with deionized water, dried at 105°C ovemight and weig hed.

The determ'ination of carbohydrate content in the organic material fractions was done using a phenol-sulfuric acid assay (Dubois et al., 1956). To 200 µg of finely ground organic material., 400 µL of 5% phenol was added. Then 1 .O mL of concentrated H_2SO_4 was added rapidly and directly to the solution sut-face without touching the sides of the spectrocolorimeter tube . The solution was left undisturbed for 10 minutes before shaking vigorously, and we measured the absorbance at 490 nm after letting the sample settle for a further 30 minutes.

3.3.5. Biochemical Properties

3.3.5.1. Microbial biomass

Microbial biomass was determined using the chloroform fumigation-incubation (Horwath et al., 1994). Because of the carcinogenic-volatile properties of chloroform, all work was done in a fume hood. A 50-mL beaker containing 35 mL of ethanol-free chloroform and antibumping granules was placed together with a 30-grarn field moist soil sample into a vacuum desiccator. The desiccator was lined with moist filter paper to prevent desiccation of soil samples during fumigation. The desiccator was evacuated until the chloroform boiled vigorously. This was repeated three times for 3 minutes each, letting air pass back into the desiccator to facilitate the distribution of the chloroform throughout the soit. The desiccator was then evacuated a fourth time until the chloroform boiled vigorously for 2 minutes, the valve on the desiccator was closed, and the desiccator placed in the dark at 25°C for 48 hours. Unfumigated samples were also kept in the dark, in desiccator or mason jars at 25°C while fumigatian proceeded. Following this period, the chloroform and filter papers were removed under the hood, and the desiccator evacuated 3 minutes for eight times, letting air pass into the desiccator to remove residual chloroforrn. Following the removal of the chloroform, the fumigated soil samples were placed in mason jars. Fumigated soil samples were adjusted to optimum soil moisture content (55% of the water-holding capacity). 1 .O mL of deionized water was added to the bottom of each mason jar to prevent desiccation. The soils were then incubated in closed, gas tight mason jars under standard conditions (25°C in the dark) for 10 days. A vial containing 1 .O mL of NaOH 2M was placed into each mason jar to trap the CO, mineralized over this period. Blanks consisting of jars without soil, along with trapped CO_2 in the NaOH were measured by a potentiometric method (Golterman, 1970) using an automatic titrator (Model DL 25, Mettler Instrument Corp., Hightstown NJ).

3.3.5.2. Enzyme Activity

β-glucosidase (Eivazi et al., 1988), arylsulfatase (Tabatabai et ai., 1970) and fluorescein diacetate hydrolytic (Diack et al., 1996) activities in soils were determined .

Method for Fluorescein diacetate (FDA) hydrolysis assay in soils

The buffer used in this assay was 60 mM sodium phosphate adjusted to pH 7.0 with hydrochloric acid (1 N) to the sodium phosphate buffer.

The procedure was as follows: 1) place 2.5 g of air-dried soil, sieved to pass 2 mm, in a 100-mL centrifuge tube; 2) add 50 mL of sodium phosphate buffer (60 mM, pH 7.0), and 10 mg of fluorescein diacetate (Sigma Chemical Co.); 3) stopper the tube and place it on a rotary shaker at 35°C for 24 hours; 4) add 2 mL of acetone (50% [vol/vol]) centrifuge the soil suspension at 3840 g for 5 minutes; 5) filter the supernatant using a Whatman no. 42 filter paper; 6) transfer the filtrate to a spectrophotometer tube and measure the yellow color intensity at 490 nm. The hydrolyzed FDA concentration was calculated from a standard curve equation obtained with standards containing 0, 0.2, 0.4, 0.6, 0.8, and 1 .0 mg of fluorescein solution. To prepare the standard solution, 10 mg of fluorescein was dissolved in 10 mL hot 95% ethanol (65°C), and sodium phosphate buffer (60 mM, pH 7.0). Into 50-mL Erlemeyer flasks, 0, 0.1, 0.2, 0.3, 0.4, or 0.5 ml of the solution was added. We completed to volume with sodium phosphate buffer, shook it to homogenize the solution, and measured the absorbance at 490 nm.

3.4. Statistical Analysis

3.4.1. Experimental design

The experimental design was a completely randomized block, in which the twelve treatment combinations chosen were composed of four cropping systems and three tillages. The tillage systems were moldboard plow, chisel plow and no-till, and the cropping systems were continuous corn, continuous soybean, corn/soybean and corn/soybean/wheat. Three field replicates were used as blocks, and in each block, we did two measurements for infiltration rates and eight measurements (four around each infiltration point) for all other soil properties.

3.4.2. Data Analysis

Anatysis of variance, covariance and stepwise regressions were run on the data to determine differences among treatments and any relationships between soil physical properties and biochemical characteristics using the PC-SAS, Version 6.09 (Statistical Analysis System, 1985).

3.5. Results

3.5.1. Soil Physical Properties

3.5.1.1. Bulk Density

For bulk density, no significant differences (P = 0.05) in the rnean values were obsetved among tillage or crop rotation systems (Tables 3.1 and 3.2).

3.5.1.2. Soil Penetrability

The only depth of soil'penetrability used in this analysis was 7.5 cm, so that direct comparisons with all the other measurements taken at the same depth could be made, (see Table C, Appendices for data from greater depths). There were significant differences in mean values for soil penetration resistance at 7.5 cm depth among tillage systerns (Table 3.1). Soil penetrability in no-tilt system was 92 and 148% greater than in chisel and moldboard plow systems respectively. Among crop rotation treatments (Tables 3.2), there were no significant differences in soit resistance to penetration at P = 0.05.

3.5.1.3. Water Infiltration Rate,

The mean values for final water infiltration rates were significantly different among tillages (Tables 3.1) as well as among crop rotation systems (Table 3.2). Steady-state infiltration rate in chisel plow system was 115% greater than in no-till and 32% greater than in moldboard plow system. in crop rotation systems, final water infiltration rates in continuous corn increased 20% over both continuous soybean and corn/soybean, and 56% over corn/soybean/wheat rotation.

351.4. Sealing index

Mean sealing index among tillage treatments (Table 3.1) was significantly different., In no-till system, sealing index was 24 and 44% lower than in chisel and moldboard plow treatments respectively. For continuous soybean, sealing index had 15, 21, and 24% decrease over corn/soybean/wheat, corn/soybean and continuous corn respectively (Table 3.2), but the differences were statistically significant only for the continuous soybean vs. all other treatments.

3.5.2. Soil Chemical Properties

352.1. Total Organic Carbon

The mean concentrations for total organic carbon were not significantly different among tillage (Tables 3.1) or crop rotation systems (Table 3.2) Total organic carbon concentrations in no-till systems were only 13% greater than in moldboard plow, and 7% greater than in chisel plow system. In crop rotation systems, corn/soybean had mean concentrations for total organic carbon almost equal to that for corn/soybean/wheat rotation and continuous corn, and 7% higher than that for continuous soybean.

3.5.2.2. Total Nitrogen

Total nitrogen mean concentrations were significantly different ($P \leq 0.01$) among crop rotation systems, but in tillage systems, the mean values were significant at P = 0.05 (Table 3.1). In no-tilt system, the mean concentrations for total nitrogen (Table 3.2) were 10 and 6% higher than in chisel and moldboard plow systems respectively. For continuous soybean, the mean values for total nitrogen were 15, 32 and 37% greater than for corn/soybean, corn/soybean/wheat and continuous corn rotations respectively.

3.5.2.3. Dissolved Oraanic Carbon

Highly significant differences in mean concentrations for dissolved organic carbon among tillages (Table 3.1) and among crop rotations systems (Table 3.2) were shown. Mean values for dissolved organic carbon in no-till were 40% greater than in chisel plow and 44% greater than in moldboard plow. In crop rotation systems, mean concentrations for corn/soybean/wheat rotation were 27, 22 and 5% higher than cornkoybean, continuous soybean and continuous corn respectivety.

3.53. Soil Biochemical Properties

353.1 Microbial Biomass C

Microbial biomass had mean values significantly different among tillage systems (Table 3.1) as well as among crop rotations (Table 3.2). Mean concentrations in no-till were 151 and 57% greater than in moldboard plow and chisel plow systems respectively. In crop rotation systems, the me& values for corn/soybean were 18, 29 and 32% greater than continuous soybean, corn/soybean/wheat and continuous corn respectively.

3.5.3.2. Enzyme Activities

Differences in mean values for fluorescein released from FDA hydrolysis were highly significant from one tillage system to another (Table 3.1). Mean values observed in no-till were 14 and 30% greater than in chisel and moldboard plow systems respectively. In crop rotation systems (Table 3.2), the mean values for FDA hydrolytic activity in continuous soybean were not significantly different from that in continuous corn, but they were 18% higher than both

systems. On the other hand, bulk density, final infiltration rates and aggregate stability as measured by sealing index (Figures 3.2, 3.3 and 3.4 respectively) have decreased as management moves from intensive to conservation practices.

The soil resistance to penetration at 7.5cm depth (Figure 3.1) shows that conventional tillage, patticularly moldboard plow, associated with each crop rotation, resulted in looser top soif than the no-till system. Many researchers have found increased resistance to soil penetration at the surface of no-till (Larney and Kladivko, 1989; Heard et ai., 1988). Heard et al., (1988) suggested

70% greater than in corn/soybean, continuous soybean and continuous corn systerns respectively. For arylsulfatase activity, the mean concentrations in no-till were 37 and 84% greater than in chisel plow and moldboard plow respectively. In crop rotation systems (Figure 3.12), continuous soybean had a mean value 9% higher than in corn/soybean/wheat, and 24% greater than in both continuous corn and corn/soybean. From these three enzyme activities in soil, FDA hydrolysis was chosen for the evaluation of soil quality (Table 3.3).

353.3. Soil Carbohydrates

The mean concentrations for total carbohydrates were significantly different among tillages (Table 3.1) as well as among crop rotation systems (Table 3.2). The mean values in no-till system were 117 and 135% greater than in chisel and moldboard plow systems respectively. As far as crop rotation system is concerned, mean concentrations for total carbohydrates for continuous soybean were 64, 25 and 34% higher than continuous corn, corn/soybean and corn/soybean/wheat rotations;, .

3.6. Discussion

The long-term management practices have induced changes in the soil physical properties for the field. These changes have resulted in increased soil resistance to penetration (Figure 3.1) from conventional to conservation tillage systems. On the other hand, bulk density, final infiltration rates and aggregate stability as measured by sealing index (Figures 3.2, 3.3 and 3.4 respectively) have decreased as management moves from intensive to conservation practices.

The soil resistance to penetration at 7.5-cm depth (Figure 3.1) shows that conventional tillage, particularly moldboard plow, associated with each crop rotatian, resulted in looser top soil than the no-till system. Many researchers have found increased resistance to soil penetration at the surface of no-till (Larney and Kladivko, 1989; Heard et al., 1988). Heard et ai., (1988) suggested that soif with low organic matter content and poor structure would benefit more from conservation tillage practices than soils that are initially well structured, such as the soil we worked with. The effect of crop residues might ease soil penetrability at a shallower depth than what we measured, for example in the first 3 cm. Kladivko (1994) suggested that crop residues are more elastic than mineral soil and they have a larger relaxation ratio (ratio of bulk density of test material under specified stress to the bulk density after stress is removed). Also, crop residues have a much lower bulk density than mineral soil particles; thus, overall soil bulk density is reduced by a simple dilution effect of the residues in the soil in the narrower depth increment near the surface. Other researchers have suggested that crop residues may reduce the susceptibility of a soil to compactibility and perhaps the resistance to penetration (Soane, 1990;

Guerif, 1979). Unger (1984) found significant differences in resistance to penetration (via cone penetrorneter) due to tillage effects at 30-cm depth, some of which were attributed to differences in soil moisture content. He concluded fhat penetration reststance of the soii was highest for the no-till and disk and lowest for the moldboard plow treatment. Bradford (1986) stated that soil factors influencing penetration resistance were water content, bulk density, soil compressibility, soil strength parameters and soil structure.

Even though no significant difference is shown for bulk density as a function of the management practices, no-till system, associated with each of the four rotations, presents just a slightly lower bulk density than the titled systems (Figure 3.2). This difference between no-till and other tillage systems agrees with several authors' findings (Black, 1973; Lal et al., 1980; Ktadivko, 1994). Crop residues have lower density than the soil, and when left on the surface, the light fractions tend to slowly mix with the soil surface as the decomposition proceeds naturally and by the action of soil fauna (Kladivko 1994). Other researchers have found that residue incorporation by tillage initially decreases bulk density compared to'no-till systems with surface residues, due to the loosening action of the tillage operation and the immediate incorporation of the low-density residue (Griffith et. al., 1986; Hill, 1990). Effects of tillage and incorporation of residues may not remain throughout an entire cropping cycle, however. The slight difference observed among tillages may also be due to the timing of the sampling (early spring). At this period, the soil temperature rises and with the rainfall resuming, residue decomposition speeds up thus, increases the bulk density in no-till systems. Also, the no-tilt system over the long term may induce a compaction effect on this particular silty clay loam soil. This effect could impede the expected decrease in surface bulk density for the no-till system.

Changes in water infiltration rates between different management practices (Figure 3.3) were characterized by overall highest values for conventional tillage and particularly chisel plow. Tillage effect made significant difference in final infiltration rates (Table 3.1). This result is not consistent with what is generally known, as no-till often increases infiltration with the protective action of surface crop residues (Steiner, 1994; Kladivko, 1994; Alberts et al., 1994; Sims et al., 1994). No-tillage soils typically contain greater percentage of macropores than tilled soils and, in addition, soils under no-till develop relatively permanent water-conducting channels such as worm holes and root channels (Zachmann et al., 1987). liowever, the infiltration was measured using a ponding method and not a sprinkler. If we did use a sprinkler method, no-till system could have lower runoff and thus greater infiltration than the tilled systern, due to a better soil structure and surface residue protection. Also, during the infiltration test, we observed few earthworms in the no-till plots (less than 10 per m^2). Kladivko (1993) found earthworm populations as high as 20 per m^2 in no-till continuous corn and 140 per m^2 in no-till soybean in silty clay loam soils near Lafayette, IN. The relatively low number- of earthworms observed in the IPM plots may not be high enough to have a significant effect on soil physical processes. The return of macroporous structure to soils, when tillage is reduced, encourages the rapid movement of water through the profile, reducing ponding and runoff at the surface. Baver (1972) reported that porosity of soils determines the permeability of soil to water, and also determines the water retention at a given suction. The soil characteristics which affect the hydraulic conductivity are related to the pore geometry, i.e., the pore size distribution and the tortuosity of the soil pores (Ghildhyal et al., 1987). Generally, a soil higher in organic matter content in the A horizon, would have a better structure and a better aggregate stability which would increase its hydraulic conductivity and infiltration rate. Our result showing the highest infiltration rate under chisel plow agrees with Meek et al. (1992). A situation such as the no-till system is susceptible to compaction due to the long-term rnanagement and low number of earthworms, whereas chisel plow, as an intermediate tillage intensity, would appear to maintain infiltration rate at a refatively hig h level.

As observed with the previous soil physical properties, changes in sealing index as a measure of soil aggregate stability (Table 3.1) were mainly induced by degrees in tillage intensities, resulting from differences in amount of crop residues left on the soil surface. No-till combined with continuous soybean

(Figure 3.5), presented the lowest sealing index, resulting in most stable soil aggregates . This is probably due to the high contents of readily available carbon and nitrogen in the soybean residues as compared to corn and wheat residues. Aggregate stability controls in part the resistance of surface aggregates to forces of raindrop impact, surface flow and slaking. The potential for a soil to seal increases as the stability of aggregates decreases. We used a “non-standard” aggregate stability test as indicated by the sealing because it relates best to crust formation as associated with low organic matter and low aggregate stability. Also, our criteria of high soil quality were set for a conservation system in which soil erosion would mainly occur by water due to soil crusting or slaking (chemical/biological processes) but not by meçhanical disruption due to tillage intensity. For these reasons, measuring soil aggregate stability by the sealing index seemed more appropriate.

This effect of no-till on the aggregate stability is consistent with what Tiessen et al., (1983); Adem, (1984); Hadas, (1987); Tisdall, (1996); Carter and Stewart, (1996) have found. Kay (1990) observed that the structure of a soil varies with the crop type grown on the soil. The difference is not solely due to absolute amount of plant residues returned to the soil, nor to tillage practices. The characteristics of corn, soybean and wheat being grown, the sequence of these different species, and the frequency of harvest are all aspects of crop rotation systems that affect soil structure by influencing the formation of biopores by plant roots and soil fauna.

The soil chemical properties also have varied from conventional system to conservation practices. While total organic carbon (Figures 3.5) did not vary significantly, total nitrogen (Figure 3.6) and dissolved organic carbon (Figure 3.7) have increased from conventional to conservation practices.

Except for total organic carbon, soil chemical and biological property changes were influenced by both tillage and crop rotation practices (Tables 3.2 and 3.3). The non-significant difference in total organic carbon between tillages and crop rotations seems unusual to some extent, but may be due to a spatial variability among plots within blocks.

Annual plowing of soil generally results in accelerated decomposition of organic matter along with mixing of crop residues. Soils under no-till contain organic matter predominantly at the surface and in some cases contain more organic matter than the typical plowed soils (Tyler et al., 1983). Greater carbon levels associated with reduced tillage are most likely the result of less decomposition, which is a direct function of lack of mixing and dilution. The influence of tillage on organic carbon distribution was demonstrated by Doran (1980, 1987), in a study of microbial biomass changes as associated with tillage systems; Rice and Smith (1984) in studying short-term immobilization of fertilizer nitrogen at the surface of no-till and plowed soils; and Blevins et al. (1'983) as they studied the influence of conservation tilfage on soil properties. Plant residues' at the surface are exposed to an environment different from that in which they are incorporated. Through the action of no-till on crop residues, organic matter apparently is maintained due to additions from the decaying plant roots and lower soil temperature in the no-till system. This effect results in reduced organic matter loss from oxidation. When crop residues are incorporated to the depth of tillage with moldboard plowing, higher soil temperatures lead to increased oxidation and lower organic matter level. At the surface, crop residues are exposed to desiccation; thus water activity often may be limiting for microbial growth (Sims et al., 1994). In this study, microbial biomass, like any other soil property, was measured within the top 7.5 cm of the soil profile, where soil moisiure content was significantly different between tillage practices. This increase in moisture content under no-till may support the fact that microbial activity was much higher under no-till than under conventional tillage (Figure 3.8). Microbial activity in most terrestrial systems is primarily heterotrophic, driven by plant carbon. Thus, organisms and the organic material derivatives are expected ta develop proportionally to the available carbon (Figures 3.6, 3.7 and 3.9). Organic carbon and nitrogen contents in soil are a result of a complex biochemical interaction between substrate additions of C and N in fertitizers and in plant and animal residues, and losses of C and N through microbial decomposition and mineralization and erosion. Changes in residue inputs induced by different Mages, and fertilizers (Jansen 1987a, b; Campbell et al., 1991a.) which regulate soil microbial activity and mineralization rates, are reflected in the total organic C and N content of soif.

The soil microbial biomass (Figure 3.8), soil carbohydrates (Figure 3.9) and soil enzyme activities (Figures 3.10, 3.11 and 3.12) have increased with conservation practices. Changes in soil carbohydrates were significantly different within both tillage systems and crop rotation practices. Because soil carbohydrates originate from plants, animals and microorganisms (Gregorich et al., 1994) and undergo transformations in the soil environment, and because of the high amount of crop residues prevailing under no-tilt, soil carbohydrate contents predominate in conservation practices as compared to conventional practices (Figure 3.9). The high value for soil carbohydrates observed in no-till continuous soybean may be explained by the nature of the residues, legumes, characterized by their high nitrogen and simple sugar contents as compared to corn and wheat which are cereats (Diack, 1994). This particular management practice seems to show the best relationship between sealing index and soil carbohydrates (Figures 3.4 and 3.9). One effect of high organic matter content at the soil surface is to increase porosity, especially increasing the volume of large interaggregate pores. On the other hand, the volume of intermediate-size pores is likely to be somewhat greater in a lower organic matter content soil, while the interaggregate micropores remain unaffected. This result is consistent with a number of researchers who found that although carbohydrates make up only 10 to 20% of the organic rnatter in soil, the stability of aggregates is often correlated with the concentration of carbohydrate in soil (Rennie et al., 1954; Oades, 1972; Burns and Davies, 1986; Tisdall, 1994).

Soil enzyme activities, along with soil carbohydrates, showed significant differences within both tillage systems and crop rotation practices. Tlhe enzyme activities measured in no-till were higher than in conventional tillage, within the same crop rotation, for FDA hydrolysis as well as β-glucosidase and arylsulfatase activities. In general, soil enzyme activities are directly proportional to the content of soil organic matter (Skujins, 1967; Frankenberger and Dick, 1983; Baligar and Wright, 1991; Baligar et al., 1991). The enzyme activities measured on the same soil samples by three different methods, fluorescein diacetate, β-glucosidase and arylsulfatase hydrolysis, showed the same pattern (Figures 3.10, 3.11 and 3.12). Fluorescein diacetate hydrolysis is a good indicator of microbial activity (Diack et al., 1996), and it is involved in lipid metabolism, ubiquitous among all living cells. β-glucosidase hydrolysis, producing important energy sources for soil organisms, plays a major role in degradation of carbohydrates in soils (Eivazi and Tabatabai, 1987; Dick and Miller, 1992). Arylsulfatases, hydrolyzing organic sulfate esters, have been detected in plants, animals and microorganisms (Tabatabai and Bremner, 1969). Perrucci (1992) found rates of fluorescein diacetate hydrolysis in soils amended with municipal compost measured over a 3-year period to be highly correlated with activities of arylsulfatase and microbial biomass C. β-glucosidases and arylsulfatases are well established in response to soil management practices however each responds specifically to the soil management. Because it is involved in lipid metabolism, ubiquitous among all living cells, fluorescein diacetate hydrolysis was'chosen among the three enzyme activities (Table 3.3) for the soil quality evaluation.

Stepwise regressions show linear relationships between bulk density and soil enzyme activity (Figure 3.13). The equation is the following:

$$BD = -0.000017*ENZ + 1.51 \tag{3.1}$$

This result is consistent with Dick et al. (1988a) who found highly significant negative correlations between bulk density and activities of dehydrogenase, phosphatase and arylsulfatase in compacted and uncompacted forest soils. Furthermore, in 7 of 10 enzymes tested, Martens et al. (1992) found significant negative correlations with soil bulk density, and in five enzymes significant positive correlations with cumulative water infiltration rates. The relationship seems to indicate that soil enzymes indirectly participate in soil structure development. And, if is true that decomposers are the primary source of soil enzymes, then it is possible that a correlative relationship exists between soil enzymes and soif structural parameters.

Soil organic matter, basically derives from the root system turnover and the fraction of the aboveground biomass of the residue left on the soil surface. The quantity of the soil organic rnatter depends on the amount of root biomass, and the amount of the readily degradable fraction of the aboveground biomass of the crop residue. The quality of the organic matter depends on the degree of degradability of both raot system and aboveground biomass, in other words, the quality of the organic matter is a function of the chemical composition of root system and aboveground biomass, both characteristic of the crop type (Stott, 1993). Soil temperature and moisture content as environmental factors and soil microbes are known to affect the decomposition rate of these residue types, however, they all depend on the tillage system, which determines the location of each residue type in the soil.

It has been suggested that crop rotation, involving longer periods of sequential crops, generally increases soil organic matter content. The four rotation systems used in this study involve corn, soybean and wheat. Corn and wheat are cereal crops, and they both bear grains on top of the aboveground biomass, It has been shown that these crop types have usually the highest total nitrogen content on the part of the aboveground biomass which is in the vicinity of the grains (Diack, 1994). This means that when these crops are harvested, crop residue that is left on the soil surface has lower nitrogen content than the top part harvested. Also, the readily available carbon, in the form of sugars, is concentrated in the root system of these crops. Stott (1996) found that the aboveground biomass of wheat residues released a greater amount of dissolved organic carbon during the decay process than corn residues. Also, soybean is a tegume, and its total nitrogen content is concentrated on top of the aboveground biomass and the readily available carbon in the root system. Therefore, the chemical composition of these residues, whether the residues are left on the soil surface or inverted into the soil to a certain depth, seems to affect the transformations of the soil organic matter quantitatively and qualitatively during the crop rotations. As a result, soil chemical effects and biological properties on soil physical properties may be attributed to the quality of the soil organic matter.

Tillage is the major contributor in these soil property changes. This emphasizes the rote that tillage, as the principal soil management practice even when combined with trop-rotation, plays in the evaluation of soil quality.

Soil organic matter is considered to encompass a set of attributes rather than being a single entity. Included among the attributes and discussed here are total soil organic carbon and nitrogen, microbial biomass, soil carbohydrates from the light fractions and enzymes. These attributes are involved in various soil processes, such as those related to water storage, soil structure and biological activity. Soil structural' processes, such as the formation and stabilization of aggregates and macropores, are affected by the total organic matter, microbial biomass ancl carbohydrates. Attributes such as microbial biomass, enzymes and mineralizable C and N are measures of biological activity in soils.

Concerns about the-effects of agricultural practices on the environment and the effect of the environment on soil erodibility have stimulated interest in quantifying their impact on soil quality. Use of a set of soil propet-ties, comprising a number of soil biochemical properties sensitive to management, perturbations and inputs to the soil, is a critical step for assessing soil quality.

3.7. Soil Quality Indicators

For many years, nations have sought policies to protect their agricultural soils against degradation and to improve them to ensure sustainable food production for future generations. Yet recent assessments conducted on regional and global scales indicate that the ravages of human-induced degradation (soil erosion, saliniization, organic matter decline, etc.) are causing loss of millions of hectares of agricultural land every year. In addition1 to assessments of degradation, a more quantitative assessment is needed of how farming practices are affecting the capacity of the soil to produce food and perform certain environmental functions (i.e. soil quality) and whether the capacity is being degraded, aggraded, or is remaining unchanged.

3.7.1. Conceptual soit quality model

The criteria for a high-quality soil were based on the ability of the soil to partition water and regulate infiftration thus decreasing soil erodibility. To develop a quantitative soit index as related to water partitioning and decreasing soil erodibility, subjective, qualitative, and quantitative measurements of all appropriate and meaningful biochemical and physical indicators must be combined in a consistent and reproducible manner.

The functions chosen for the soil quality indices as related to water partitioning and infiltration were derived from the sensitivity analysis of the WEPP (Water Erosion Prediction Project) (Nearing et al., 1990b). A systems engineering technique was applied by Karlen and Stott (1994) to define a soit quality rating with regard to erosion by water to provide a mechanism for assigning relative weights to each function. Within each level, relative weights are given to each indicator. These weights may change over time or location, depending on priorities or uncontrollable factors, but the approach or framework for developing a quantitative procedure for evaluating soil quality is constant.

It has been suggested that the primary function of soil with high quality, relative to water erodibility, is to accommodate entry of the water into the soil matrix through the infiltration rate and capacity (Karlen and Stott, 1994). If the water can enter the soil, it will not run off, and thus initiate the erosion process. Based on this rationale, we suggest that this function be given a weight of 0.4 or

40%. For water to be able to enter the soil matrix, resistance of the surface structure to degradation and transport away from the surface are assumed to be the next two most critical functions. The remaining 0.6 or 60% is assigned to the functions of facilitating water transport, decreasing erodibility and resisting degradation at the surface, and these functions interact with sustaining plant growth. In the definition of soil quality, the ability of the soil to sustain plant growth is assumed to be less important than the process contributing to water entry and transport or to aggregate formation and stability. Obviously, these assumptions and weights would not be true if soil quality were being assessed with regard to crop productivity. However, the proposed framework can be easily modified and used to compute a series of soil qwality indices relative to various problems.

After assigning relative weights to the functions necessary for a soil to resist erosion by water, physical, chemical and biological indicators useful for evaluating those functions can be identified and prioritized. To quantify soil quality relative to the function of accommodating water entry into a soil, we use a direct measure of infiltration rate which, we think, is the first function.

With regard to facilitating water transport and absorption as a second function, bulk density and soil penetrability are used to assess the soil quality.

A third function of a soil with high quality relative to decreasing crusting is measured by the sealing indlex: and this third function is closely related to a fourth function which is to resist structural degradation. Critical indicators for assessing this function of resisting soil degradation include measurements of, total organic carbon, dissolvecl organic carbon, soil ? OC carbohydrates, microbial biomass and enzyme activity.

The fifth function, the ability to sustain plant growth, is much more dependent on the development of the root system through soil nitrogen and the effect of the root system on reducing soil erodibility.

However, this primarily refllects the soil quality assessment problem that was chosen. If this assessment had been made relative'to crop productivity, groundwater quality, or even food safety, indicators identified in this section would have been much different with very different weights.

3.7.2. Conceptual approach for rating a quality of soil (Karlen and Stott., 1994)

An approach for developing a soil quality rating is as follows:

1) Star-t out by defining soit quality;

2) set goals for high-quality soil;

3) set criteria for high-quality soil in order to determine soil quality indices;

4) rank criteria according to goals and definition of soil quality;

5) give a weight to each parameter according to the rank of criteria;

6) add up all weighted parameters to obtain a numerical value for a given soil.

The value of each soil represents its quality rating based on the standard scoring function "more is better".

The model used is the following:

$$\text{Soil Quality (Q)} = q_{we}\,(wt) + q_{wt}\,(wt) + q_{de}\,(wt) + q_{rd}\,(wt) + q_{spg}\,(wt) \qquad (3.2)$$

where

q_{we} is the rating for accommodating water entry

q_{wt} is the rating for water transport and absorption

q_{de} is the rating for decreasing erodibility

q_{rd} is the rating for resisting degradation

q_{spg} is the rating for supporting plant growth

wt is the weighting factor for each function

3.7.3. Evaluation Mechanics

Having identified critical soil functions and potential physical, chernical and biological indicators that will be used to assess soil quality relative to its ability to resist erosion by water, it is essential to develop a mechanism to combine the distinctly different functions and indicators. This can be done by using standard scoring functions (Figure 3.14) that were developed for systems engineering problems (Wymore, 1993). Four of the most common shapes for scoring functions are referred to as "more is better", "less is better", "an optimum range" and "undesirable range". For this evaluation, we have chosen "more is better", as to compare the soil quality level between no-till, chisel plow and moldboard plow systems.

Standard scoring functions enable us to directly convert soil property mean values to unitless numerical values on a 0 to 1 scale. The procedure begins by selecting the appropriate physical, chemicat and biological properties of soil that affect a particular function related to soil erosion. An appropriate scoring function and realistic baseline and threshold values for each indicator are established. All indicators affecting a particular function are grouped together as shown in Table 3.3, and assigned a relative weight based on importance. All weights sum to 1 .O or 109%. After scoring each factor, the value is multiplied by the appropriate weight. When all indicators for a particular function have been scored, we then have a matrix that can be summed to provide a soil quality rating as related to erosion by water.

3.7.4. Procedure for convertina, the soil data in a 0 to 1 scale (Wymore, 1993)

The set of all scoring functions for the function f is defined as follows:

$$SFS(f) = FNS(RNG(fj, RLS[0,1]). \qquad (3.3)$$

where

SFS is the set of scoring functions for a given function

FNS is the set of functions

RNG is the range of functions

RLS is the set of real numbers.

Example of a scoring function

If A is a set of soil property data,

$\{s, t\} \subseteq$ RLS such that $s < t$, and

$f \in$ FNS (A,ONTO, RLS[s, t]), then

$g = \{(x, y): x \in RLS(s, t); y \in RLS[0,1]; y = (x - s) / (t - s)\}$, (3.4)

So, for "more is better", $y = (x - s) / (t - s)$, whereas for "less is better",

$y = 1 - (x - s) / (t - s)$, for every $x \in A$.

To be conformed with our hypotheses, for the conversion of these soil data into a 0 to 1 scale, we will be using "more is better", for final infiltration rate, total organic carbon, dissolved organic carbon, total nitrogen, soil carbohydrates, microbial biomass and enzyrne activity (FDA hydrolysis). As for bulk density, soil penetrability and sealing index, "less is better" will be used.

Example:

The mean value for final infiltration rate in no-till is 1.26 cm hr^{-1}. Using equation (3.4), $y = (x - s) / (t - s)$ where

y is the value of the soil property converted into the 0 to 1 scale

x is the value of the soil property to be converted into the 0 to 1 scale

s and t are any real numbers c'hosen such that $s < x < t$.

To choose s and t values as real numbers, we decide that s equal 0, the lowest possible value for these soit data and t be the highest value among the tillage data, within the particular soil property, plus 10% of its value (Table 3.1). For final infiltration rate (Table 3.1), the highest value is 2.71 cm/hr. And 10% of 2.71 = 0.27; therefore, still using equation (3.4),

For no-til, y = (x - s) / (t - s) = (1.26 - 0) / ([2.71 + 0.27] - 0) = 1.26 / 2.98 = 0.42.

This approach gives converted values in the 0 to 1 scale, and these values are consistent with the data in Table 3.1 in terms of statistical differences.

3.7.5. <u>Soil Quality Assessment for Three IPM Tillage Systems.</u>

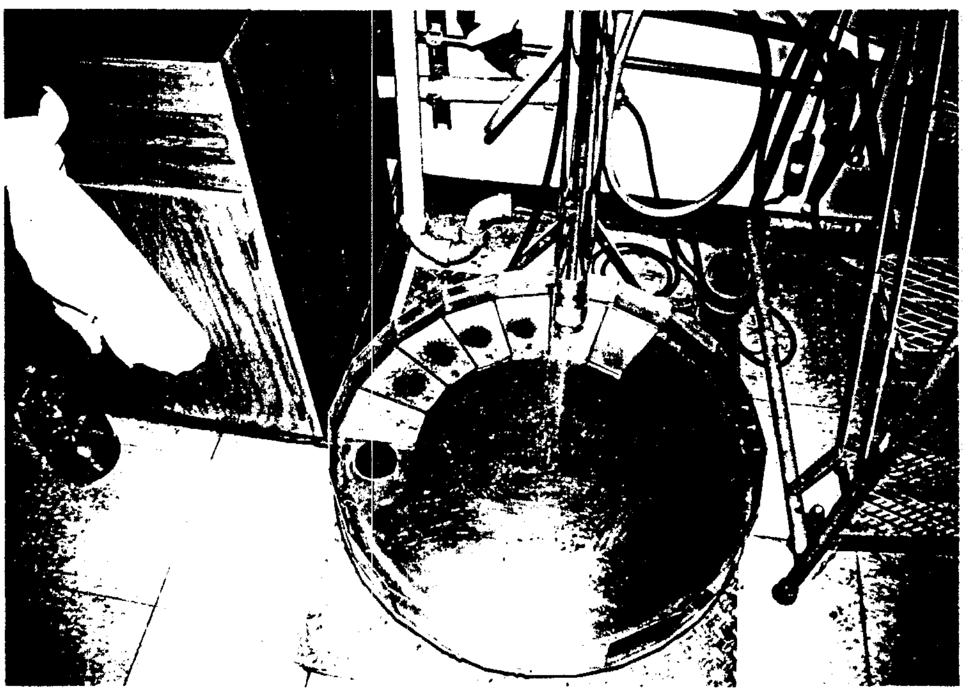
$$Q = [\text{infiltration } (wt_i)] + [\text{bulk density } (wt_b)] + [\text{penetrability } (wt_p)] + [\text{sealing index } (wt_{si})] + [\text{total carbon } (wt_{tc})] + [\text{dissolved organic carbon } (wt_d)] + [\text{carbohydrates } (wt,) + [\text{rnicrobial biomass } (wt_m)] + [\text{enzyme activity (FDA) } (wt_e)] + [\text{total N } (wt_{tn})] = \quad (3.5)$$

Within the same soil function (Table 3.3), the sum of weighted indicators determines the level of that fumction. The sum of these functions determines the level of soil quality. These results show that chisel plow system has the highest soil quality level as related to water erosion. This result is consistent with the actual status of the no-till in this specific field. No-till system in this particular field has depressional areas, very low infiltration rates as compared to the common no-till systems.

3.8. Conclusions

The results showed that soil management practices did effectively influence soil structural characteristics which were closely related to the soil chemical and biochemical properties. Tillage system was the major contributor in these physical changes as they were induced by changes in soil chemical and biochemical properties. Crop rotation combined with tillage system did affect soil biochemical properties such as microbial biomass C, soil carbohydrates and enzyme activities. The results suggest that these soil parameters are potential indicators of soil quality with regard to crusting and erodibility. Soil organic matter, as characterized to distinguish biological and biochemical properties, is a key attribute to soil quality. These soil properties, as they change due to management practices, can be used to evaluate the soil quality of a given ecosystem. Some relationships show that almost all the soil indicators are interrelated supporting the idea that there is no single indicator that can quantify a soil quality. These indicators ought to be considered together for a complete soil quality assessment. Use of a set of data, comprising a number of soil biochemical properties sensitive to management, disturbances, and inputs to the soil, is a critical first step for assessing soil quality. Efforts to define and quantify soil quality are not new, but reaching a consensus with regard to the specific criteria required for its evaluation have been difficutt. This study has c:ontributed to the understanding of soil quality by establishing a consensus with regard to a set of standard conditions to be used for evaluation. What needs to be done in terms of soil quatity is to develop a minimum data set which would be a set of indicators that are temporacily and spatially representative of the soil status. In that way, this study could be expanded to a wider range of soils. The approach used for developing soil quality rating is a promising step towards a more comprehensive assessment of soil quality.

Photograph 3.1, The Griffith tube for measuring soit aggregate stability.



Photograph 3.2. Pan assemby containing trays for collecting soil aggregates.

Table 3.1. Comparison of soil properties mean **values among** tillages.

	Tillage Means		
Soii Properties*	Moldboard Plow	Chisei Plow	No-Till
Bulk Density (g cm^{-3})	1.41 ± 0.1 a	1.40 ± 0.1 a	1.38 ± 0.1 a
Soil Penetrability (kgf cm”)	1.24 ± 0.5 a	1.61 ± 0.6 b	3.08 ± 1.2 c
Final Infiltration Rate (cm hr^{-1})	2.06 ± 0.9 b	2.71 ± 1.3 c	1.26 ± 0.6 a
Seaiing index	1.77 ± 0.4 a	1.52 ± 0.3 ab	1.23 ± 0.2 bc
Total Organic Carbon (%)	2.30 ± 0.6 a	2.44 ± 0.3 a	2.60 ± 0.4 a
Total Nitrogen (%)	0.31 ± 0.1 a	0.30 ± 0.1 a	0.33 ± 0.1 b
Dissolved Organic Carbon (ppm)	57.00 ± 16.1 a	58.61 ± 12.9 a	82.31 ± 16.2 b
Microbial Biomass C (µg g^{-1} soil)	400.89 ± 121.0 a	643.87 ± 273.7 b	1008.63 ± 148.9 c
Enzyme Activity (FDA) (µg g^{-1} soil/24 hr)	5.69 ± 1.3 a	6.49 ± 1.7 b	7.41 ± 1.3 c
Soil Carbohydrates (LF and HF) (%)	1.84 ± 0.4 a	2.00 ± 0.4 a	4.33 ± 1.4 b

Values within each row, followed by the same ietter, are not significantly different by Student-Newman-Keuls range test at P = 0.05. FDA = fluorescein diacetate; LF = light fraction; HF = heavy fraction,
*Unless otherwise indicated, soil samples were collected at 0 to 7.5cm depth.

Table 3.2. Comparison of soil properties mean values among crop rotations

	Crop Rotation Means			
Soil Properties*	Corn/Corn	Soybean/Soybean	Corn/Soybean	Corn/Soybean/Wheat
Bulk Density (g cm”)	1.38 ± 0.7 a	1.41 ± 0.1 a	1.38 ± 0.1 a	1.40 ± 0.1 a
Soil Penetrability (kgf cm^{-2})	2.08 ± 1.1 a	1.78 ± 0.7 a	2.16 ± 1.6 a	1.88 ± 0.8 a
Final Infiltration Rate (cm hr^{-1})	2.43 ± 0.9 b	2.03 ± 1.6 a	2.03 ± 1.0 a	1.56 ± 0.8 a
Seaiing Index	1.62 ± û.3 a	1.31 ± 0.1 ab	1.58 ± 0.2 a	i.5 ± 0.2 a
Total Organic Carbon (%)	2.45 ± 0.3 b	2.34 ± 0.6 ab	2.51 ± 0.4 b	2.49 ± 0.4 b
Total Nitrogen (%)	0.27 ± 0.1 a	0.37 ± 0.1 c	0.32 ± 0.1 b	0.28 ± 0.1 a
Dissolved Organic C (ppm)	70.51 ± 12.9 b	60.68 ± 14.2 a	58.43 ± 19.9 a	74.27 ± 23.3 bc
Microbial Biomass C (µg g^{-1} soil)	614.46 ± 336.7 a	685.89 ± 314.7 a	808.46 ± 251 .l b	628.24 ± 338.7 a
Enzyme Activity (FDA) (µg g^{-1} soil/24 hr)	7.06 ± 1.6 b	7.06 ± 2.1 b	6.00 ± 1.2 a	6,00 ± 0.9 a
Soil Carbohydrates (LF and HF) (%)	2.10 ± 0.7 a	3.45 ± 2.3 c	2.76 ± 1.1 b	2.58 ± 0.6 ab

Values within each row, followed by the same letter, are not significantly different by Student-Newman-Keuls range test at P = 0.05. FDA = fluorescein diacetate; LF = light fraction; HF = heavy fraction
*Unless otherwise indicated, soil samples were collected at 0 to 7.5-cm depth.

Table 3.3. Soil quality functions, indicators and ratings as related to soil erosion by water.

Functions	Indicators	Weights	No-till	Chisel Plow	Moldboard Plow
Accommodate water entry	Infiltration	0.40	0.168	0.364	0.274
Facilitate water transport and absorption	Bulk density	0.05	0.006	0.005	0.005
	Soil penetrability	0.05	0.005	0.026	0.032
Decrease erodibility	Sealing Index	0.225	0.083	0.050	0.023
Resist degradation	Total Organic Carbon	0.05	0.046	0.043	0.040
	Dissolved organic carbon	0.05	0.045	0.033	0.032
	Soil carbohydrates	0.05	0.046	0.021	0.018
	Microbial biomass C	0.05	0.046	0.029	0.035
	Enzyme activity (FDA)	0.05	0.046	0.040	0.020
Sustain plant growth	Total nitrogen	0,025	0.023	0.021	0.021
	Score		0.51	0.63	0.50

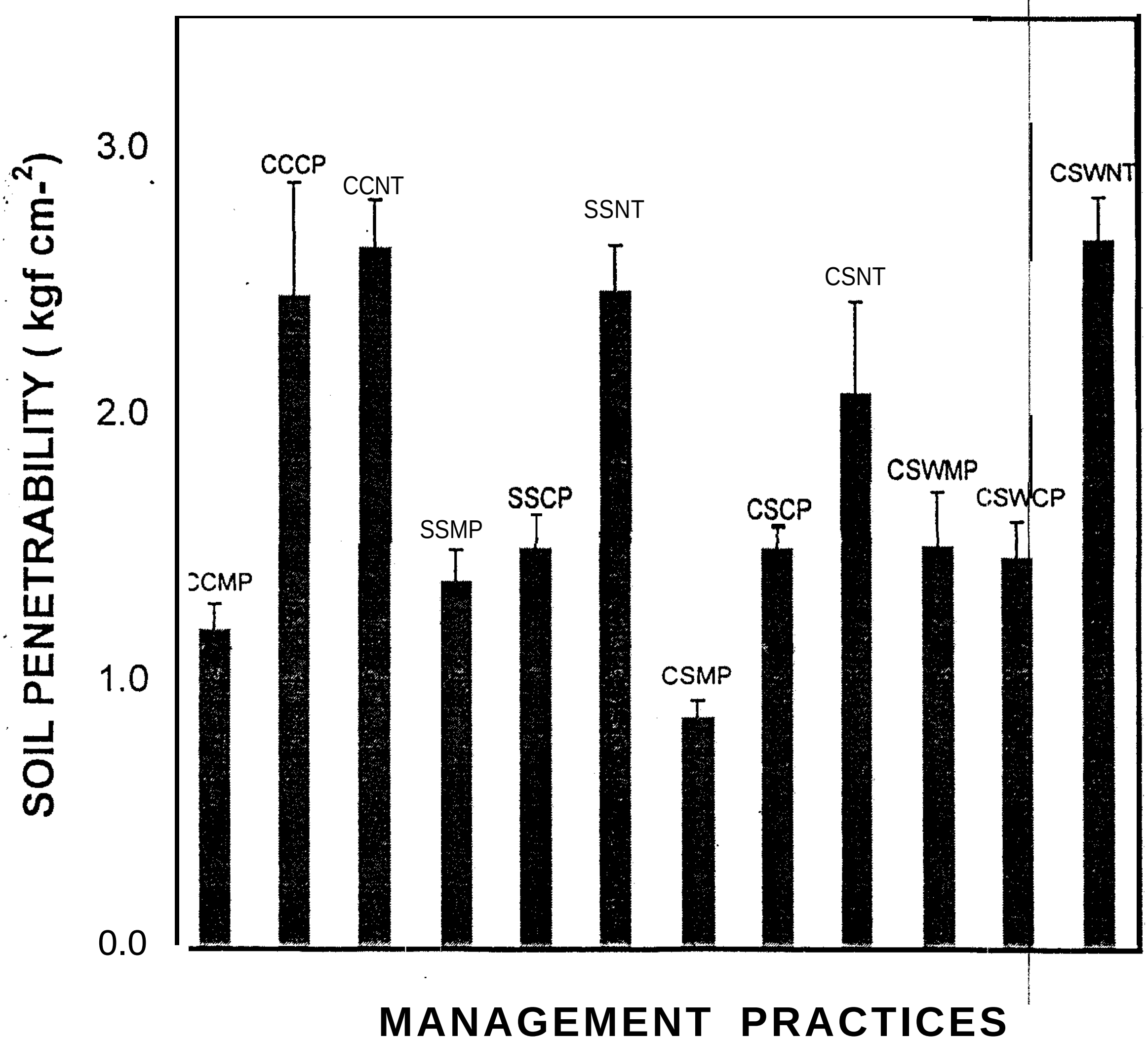


Figure 3.1. Effect of managernent practices on soil resistance to penetration. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybeankoybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/ soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

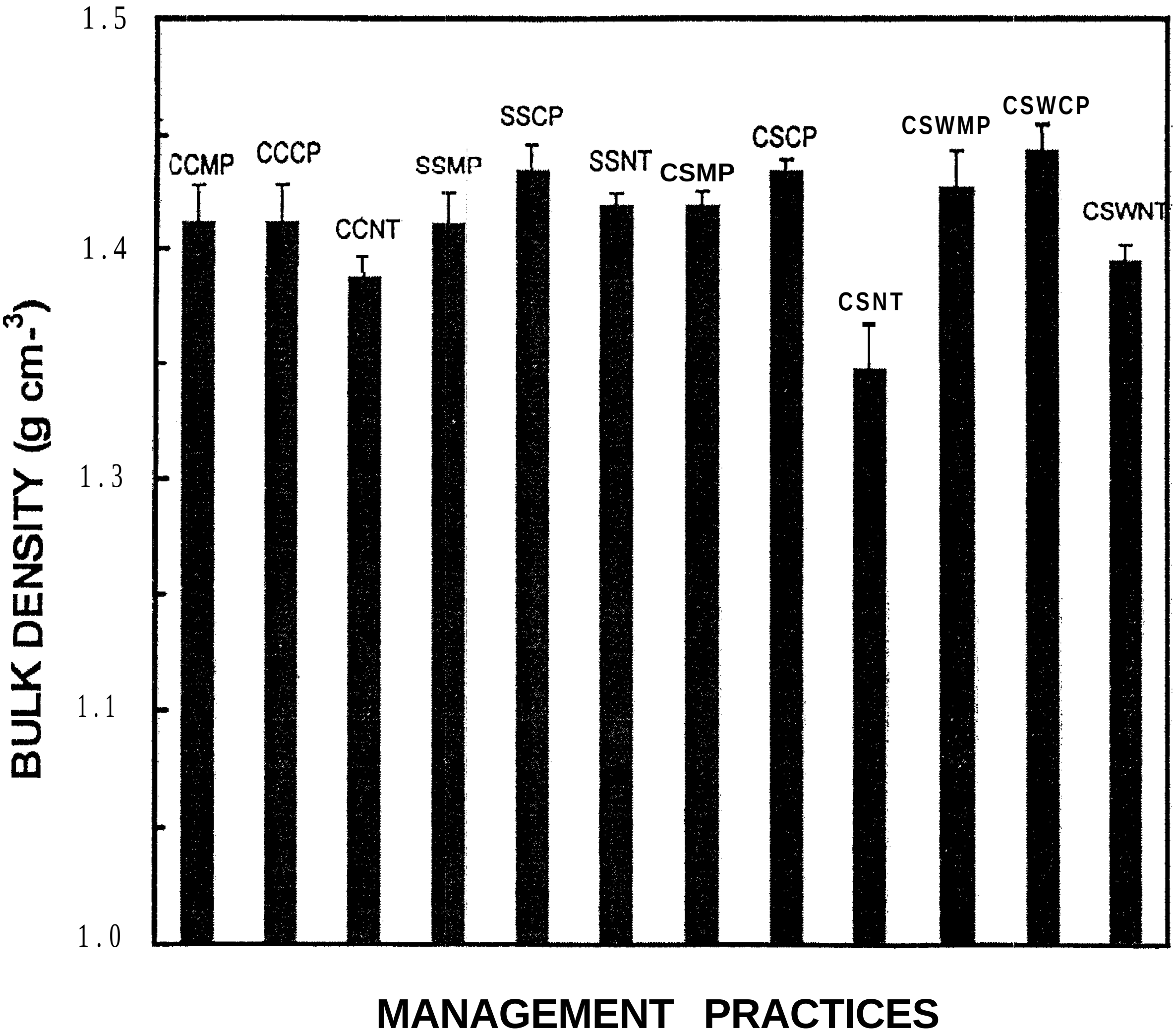


Figure 3.2. Effect of management practices on soit bulk density. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-tilt; SSMP = soybean/soybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/ soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

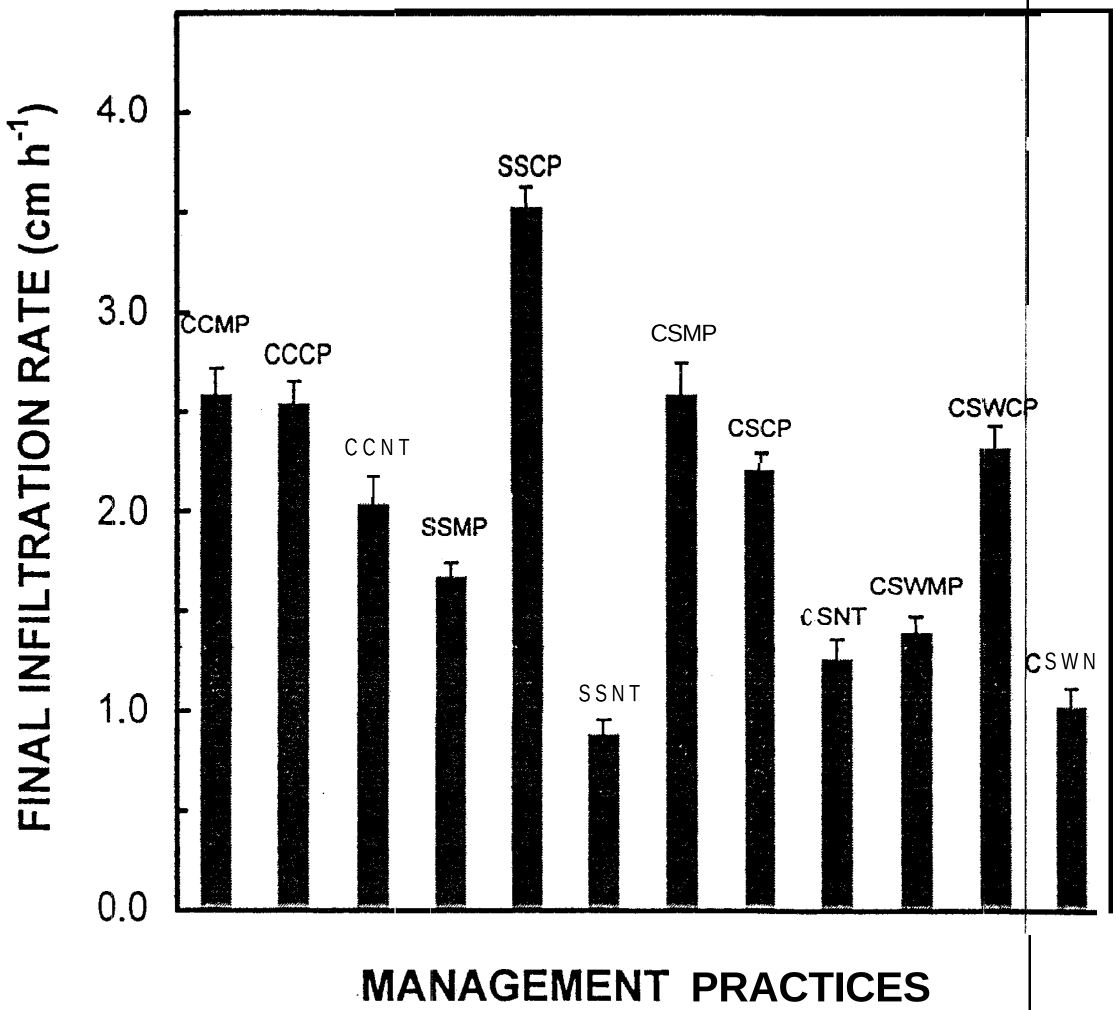


Figure 3.3. Effect of management practices on final infiltration rate. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybeankoybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-titi.

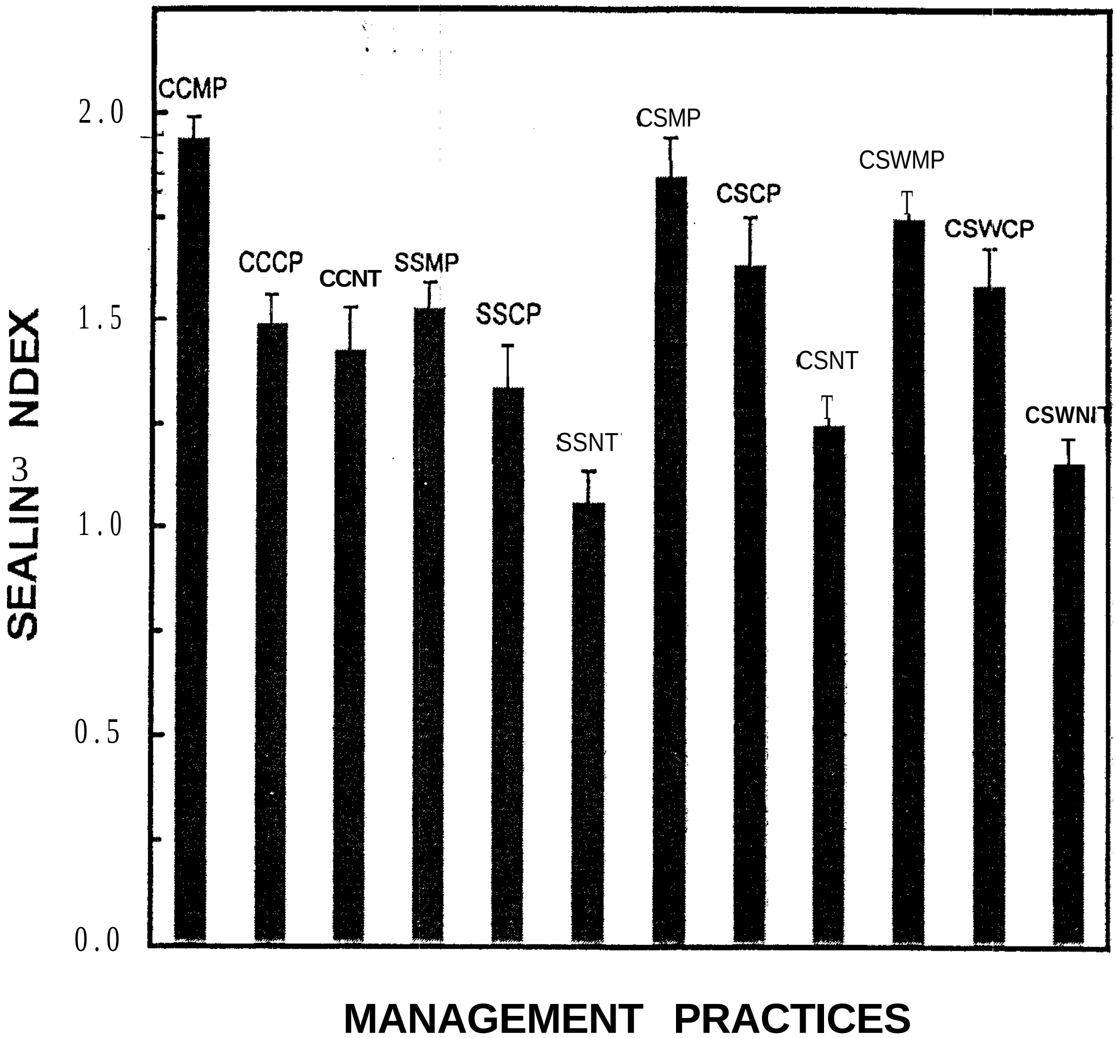


Figure 3.4. Effect of managernent practices on seafing index. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybean/soybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

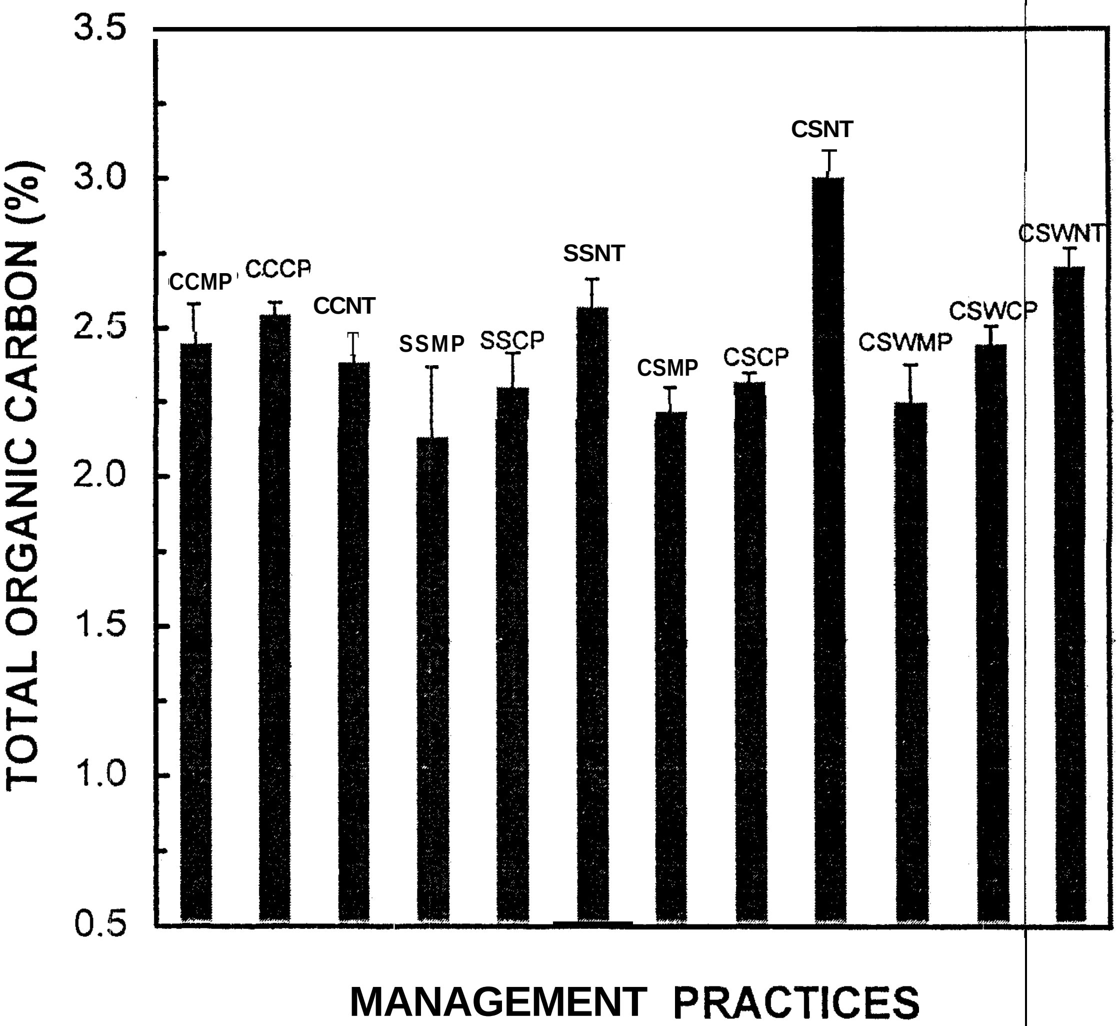


Figure 3.5. Effect of management practices on soil organic carbon. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybeankoybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/ soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

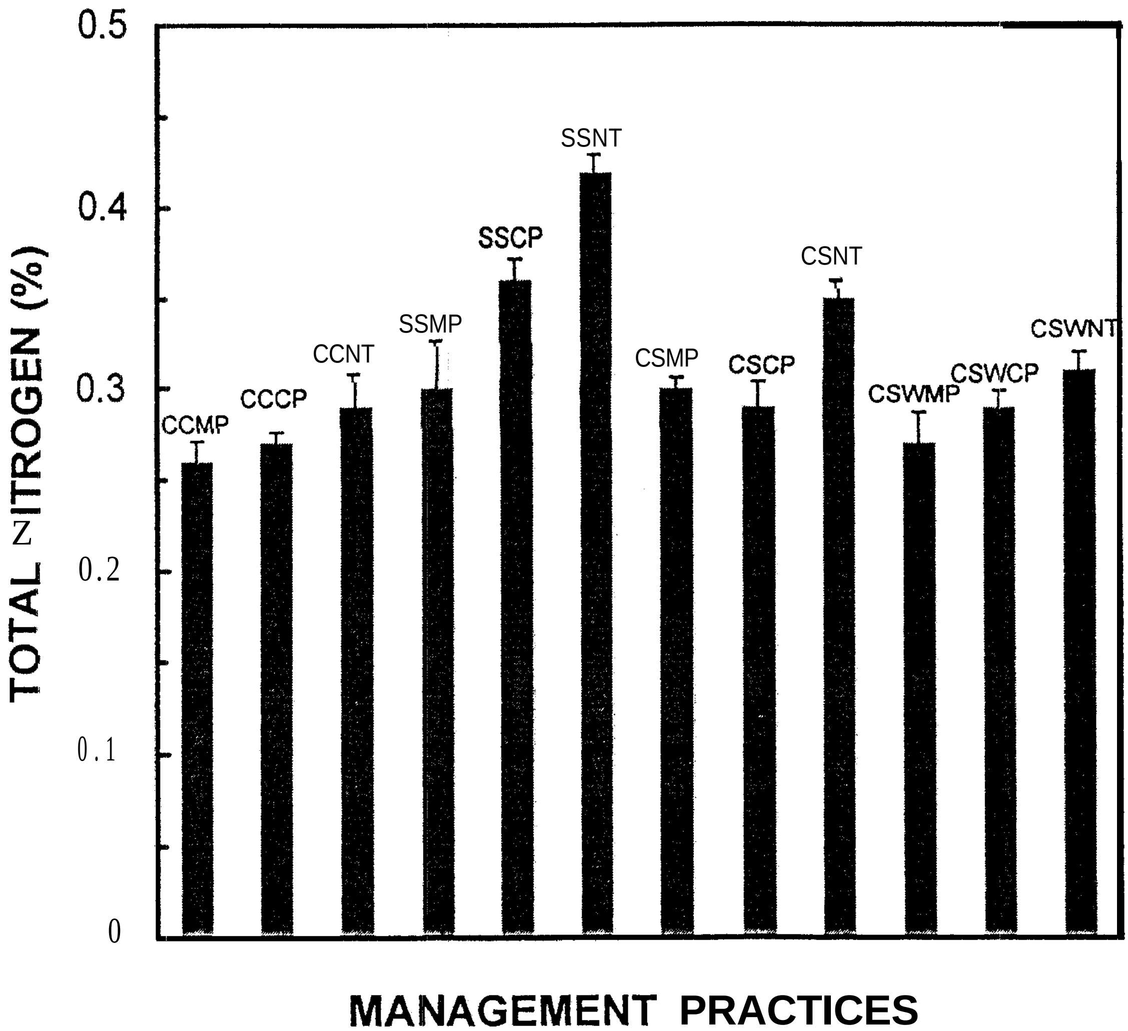


Figure 3.6. Effect of management practices on soil total nitrogen. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybeanlsoybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

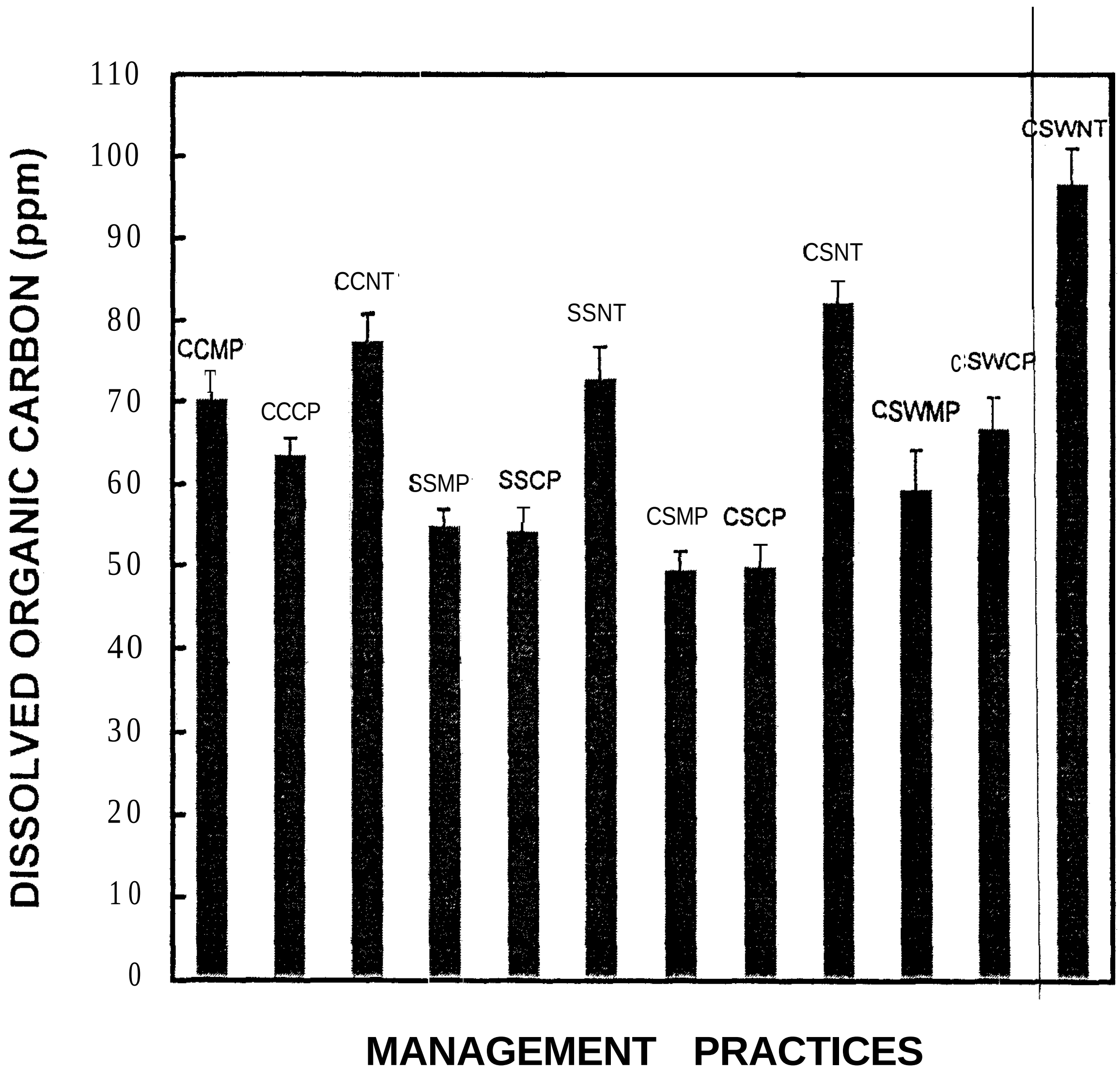


Figure 3.7. Effect of management practices on soil dissolved organic carbon. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybean/soybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean/wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

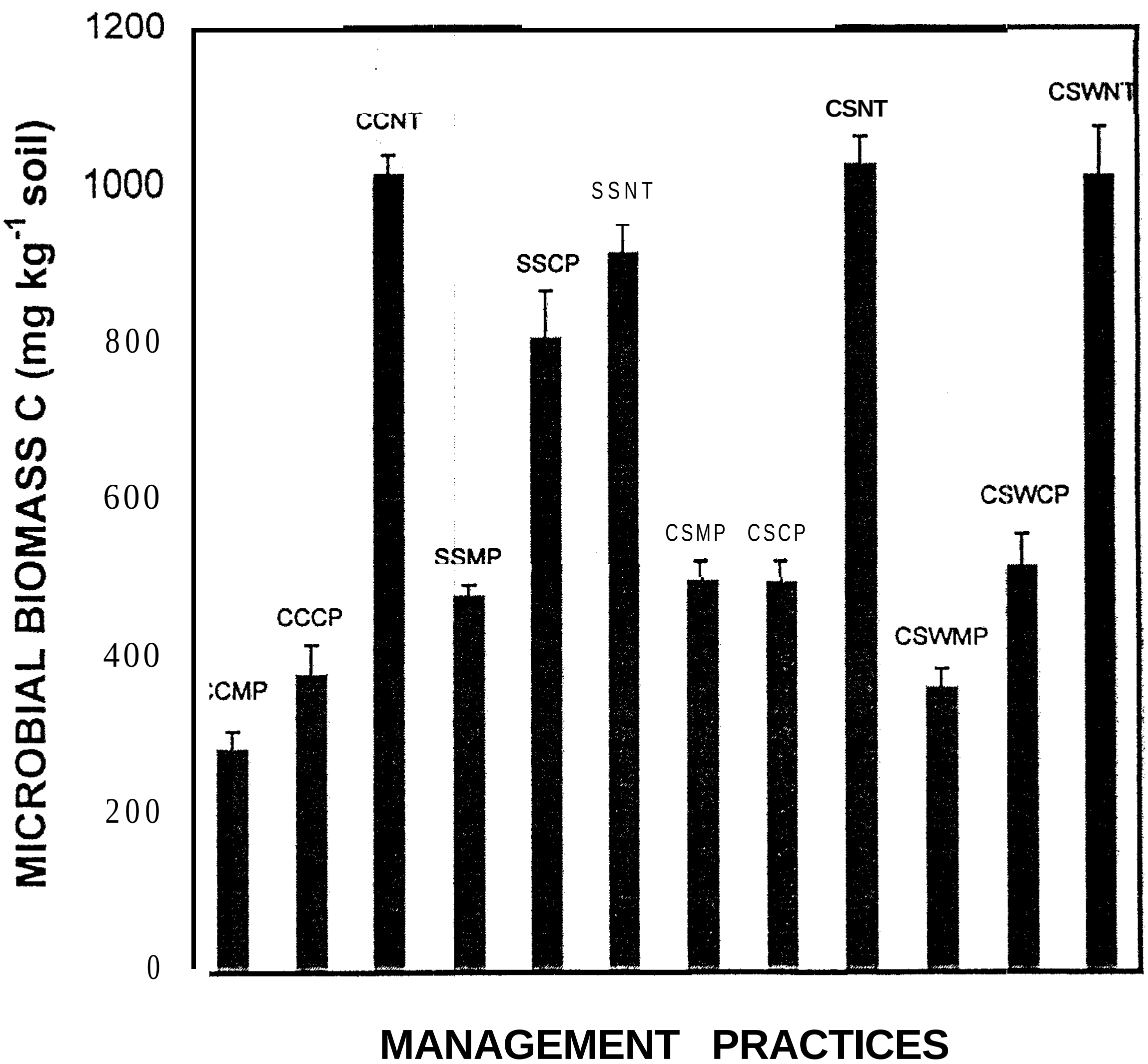


Figure 3.8. Effect of management practices on soil microbial biomass. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybeankoybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/ soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

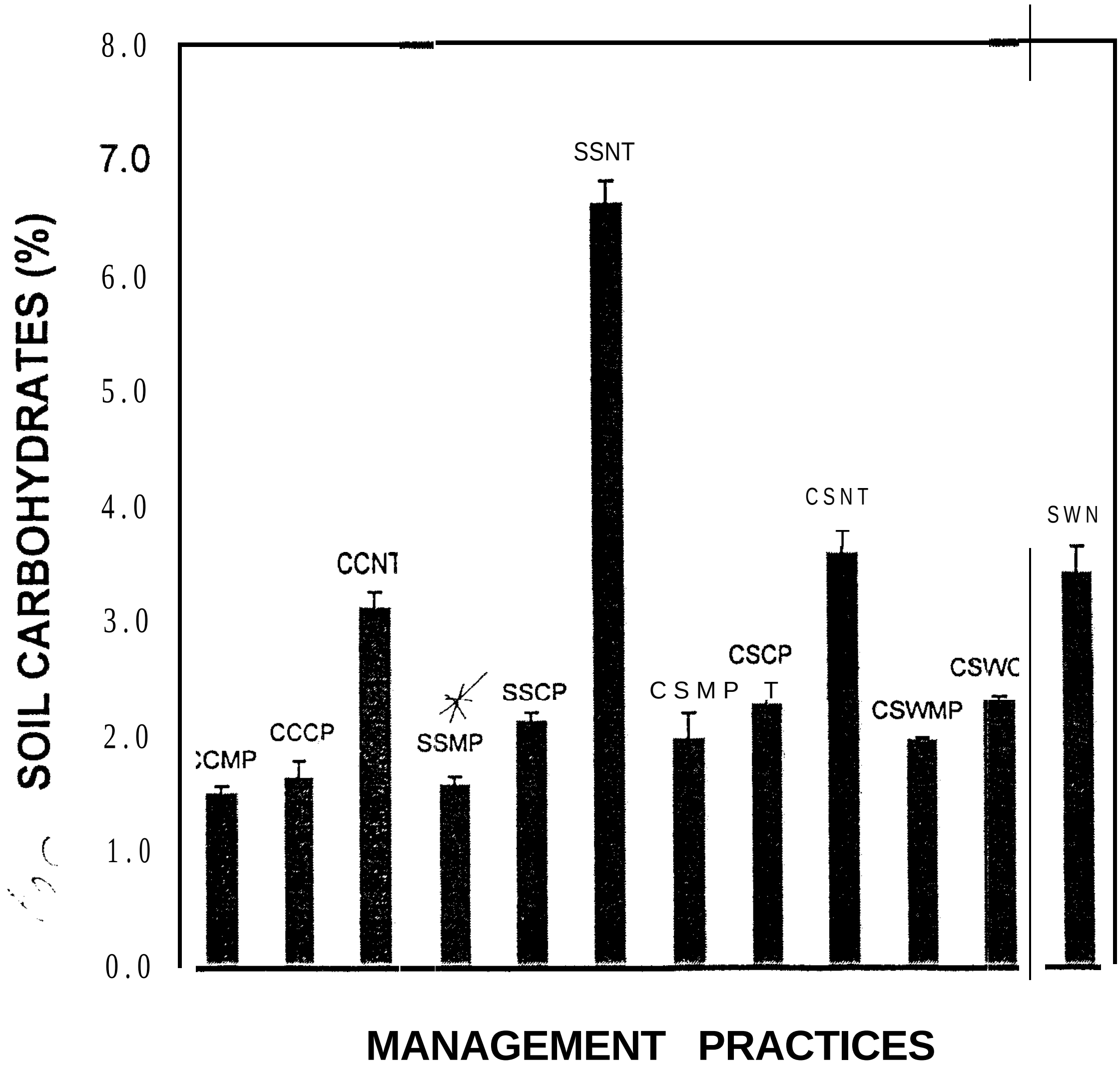


Figure 3.9. Effect of management practices on soil carbohydrates. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chis l plow; CCNT = corn/corn-no-till; SSMP = soybeankoybean-moldb ard plow; SSCP = soybean/soybean-chisel plow; SSNT = soyb n/ soybean-no-till; CSMP = corn/soybean-moldboard plow; CC P = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CS MP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

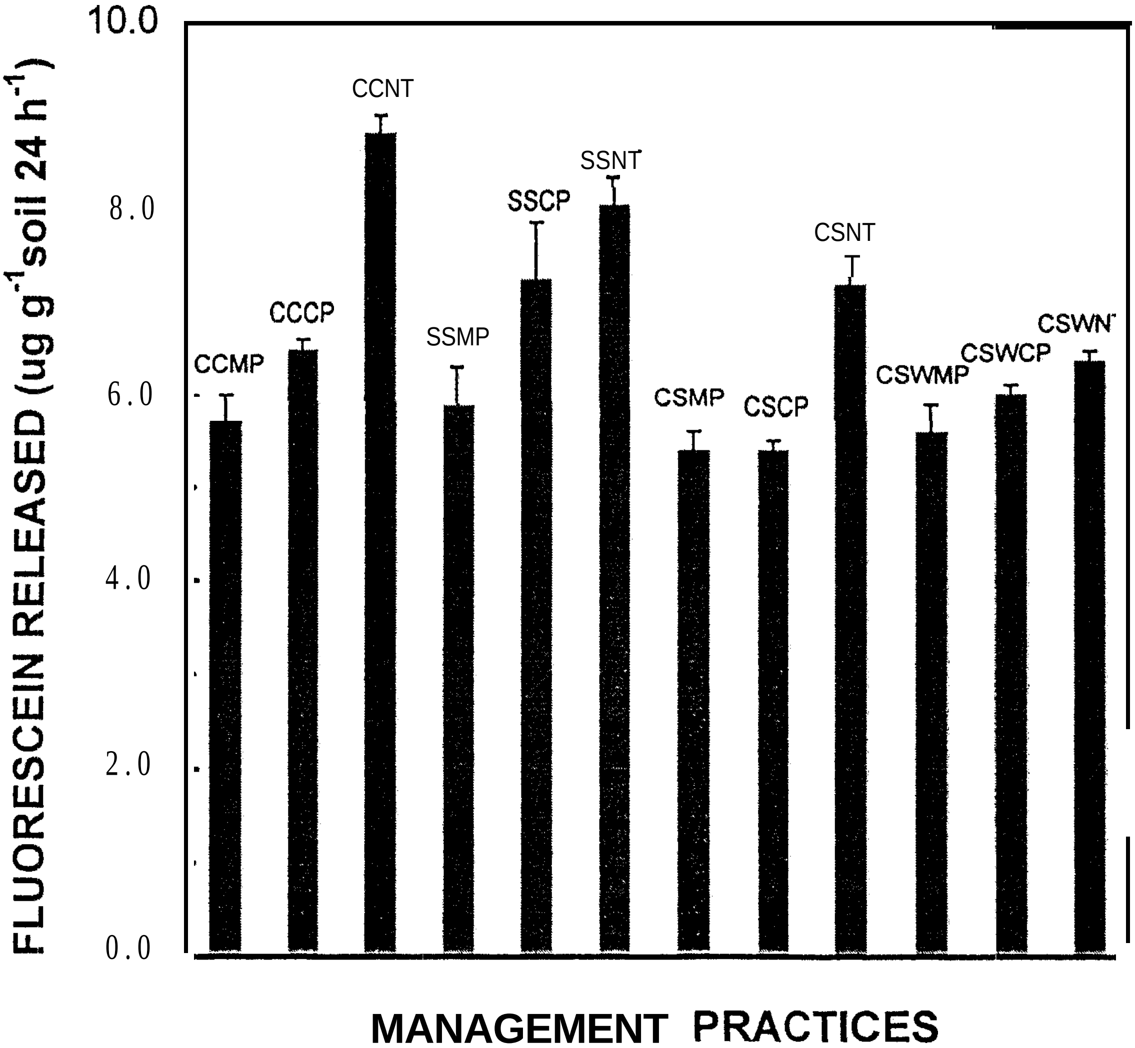


Figure 3.10. Effect of management practices on fluorescein diacetate hydrolysis in soils. Bars represent standard deviations at each given management. CCMP = corn/corn-moldboard plow; CCCP = corn/ corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybean/ soybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/soybean-no-till; CSMP = cornkoybean- mold board plow; CSCP = corn/soybean-chisel plow; CNSNT = corn/ soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/ soybean/wheat-no-till.

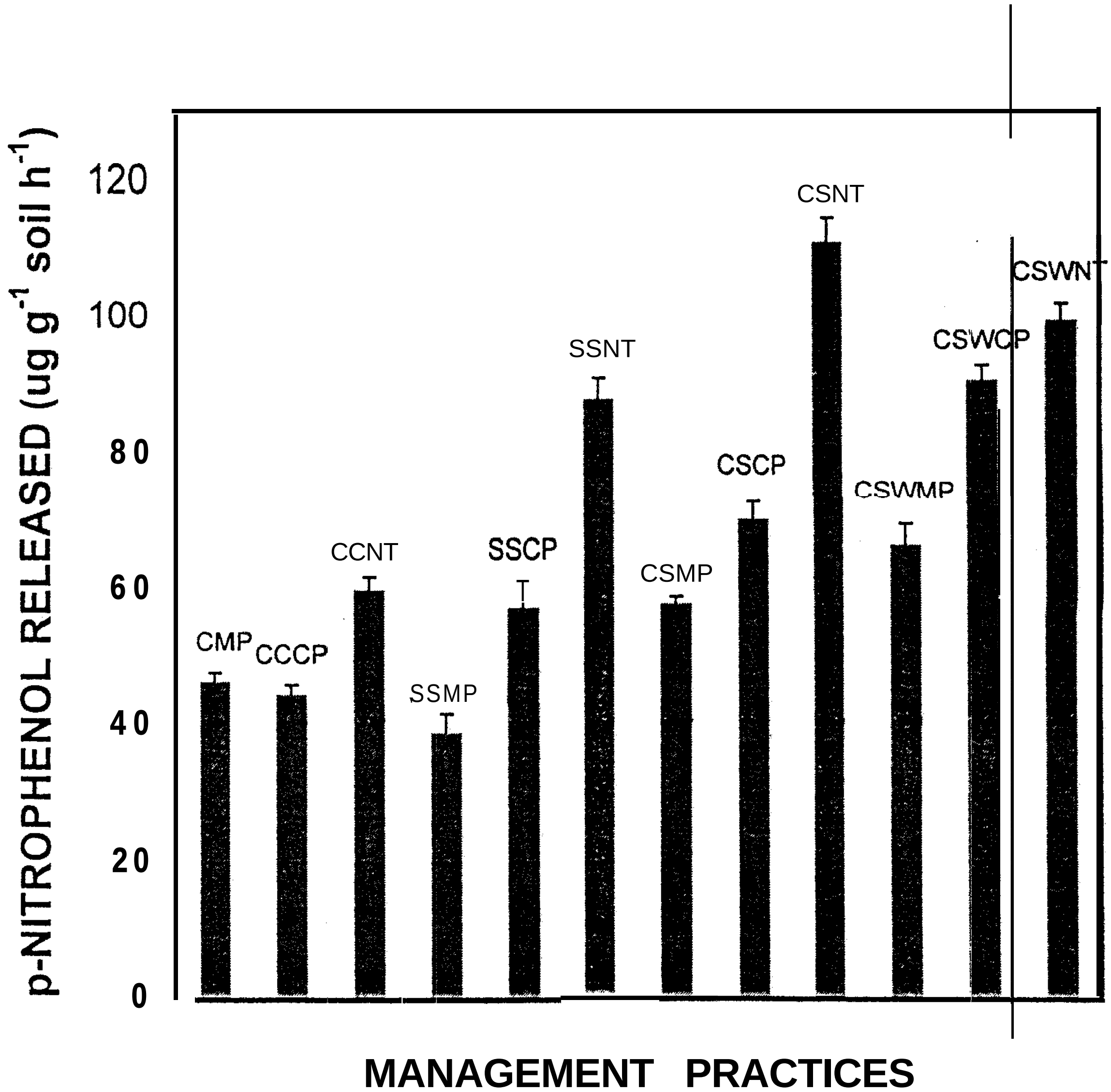


Figure 3.11. Effect of management practices on β-glucosidase activity in soils. Bars represent standard deviations at each given management. CCMP = corn/corn-mold board plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybean/soybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean/wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

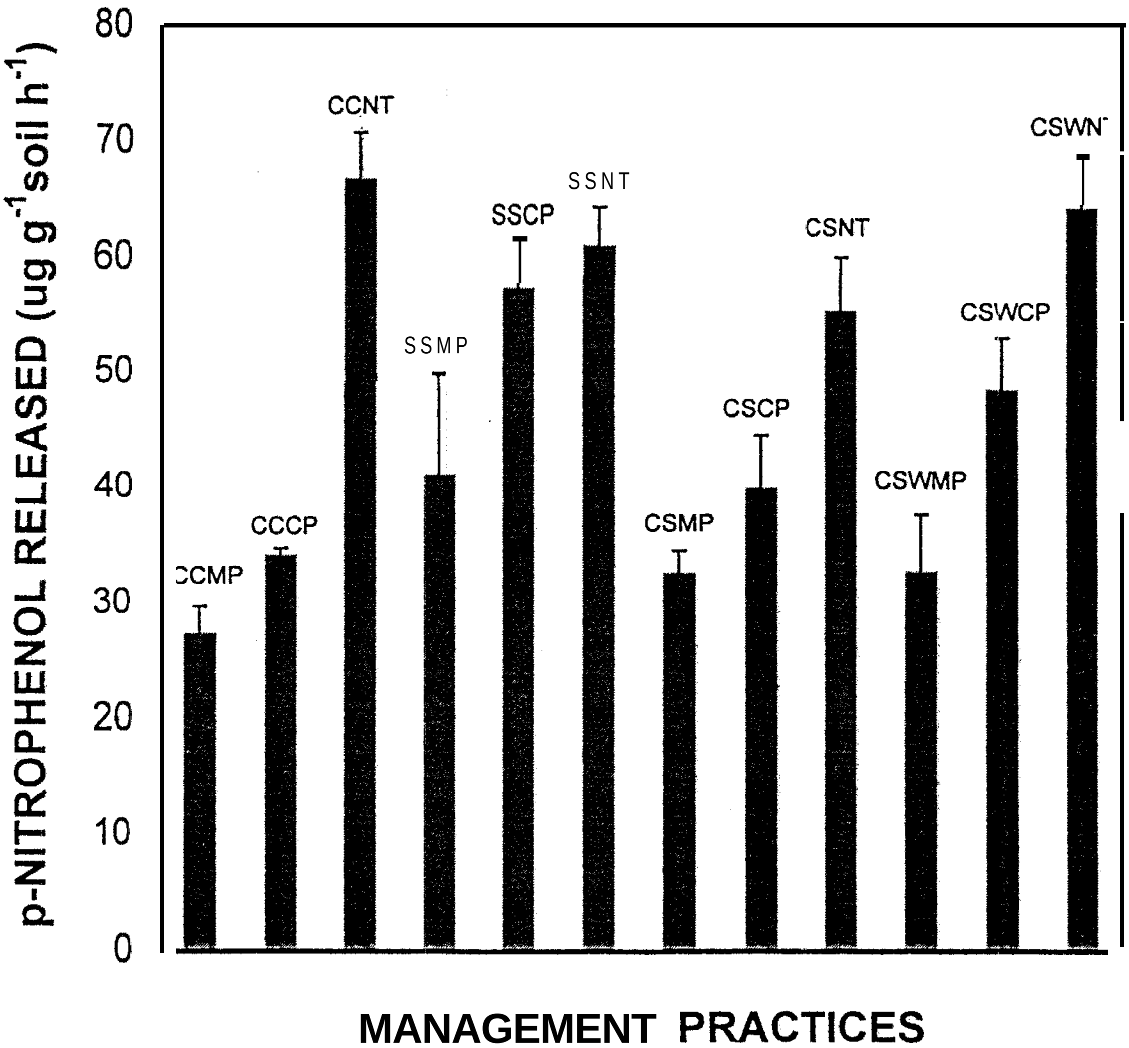


Figure 3.12.. Effect of management practices on arylsulfatase activity in soils. Bars represent standard deviations at each management. CCMP = corn/corn-moldboard plow; CCCP = corn/corn-chisel plow; CCNT = corn/corn-no-till; SSMP = soybean/soybean-moldboard plow; SSCP = soybean/soybean-chisel plow; SSNT = soybean/ soybean-no-till; CSMP = corn/soybean-moldboard plow; CSCP = corn/soybean-chisel plow; CSNT = corn/soybean-no-till; CSWMP = corn/bean/wheat-moldboard plow; CSWCP = corn/soybean /wheat-chisel plow; CSWNT = corn/soybean/wheat-no-till.

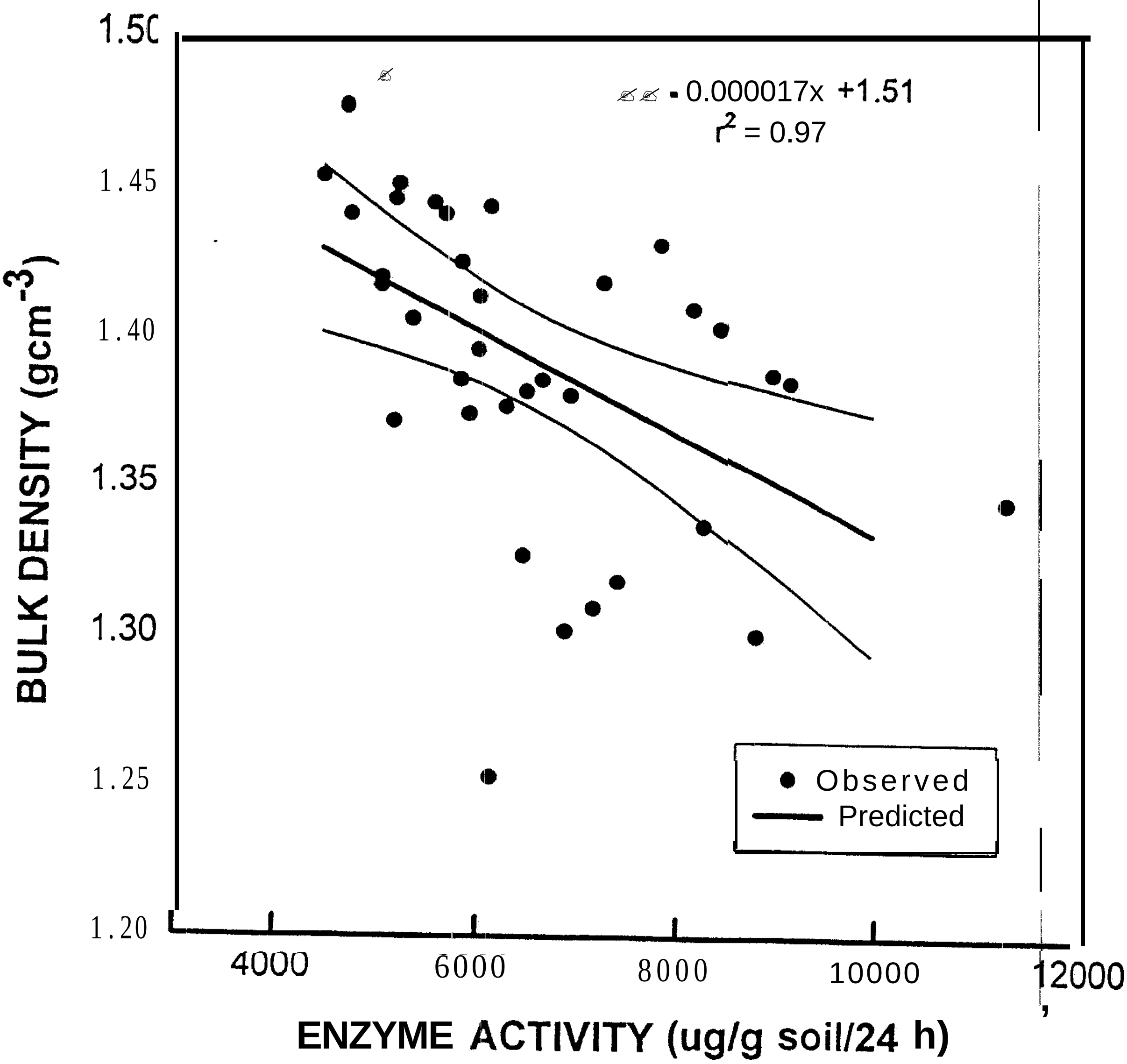


Figure 3.13. Relationship between soil bulk density and fluorescein diacetate hydrolylitic activity as soil management changes.

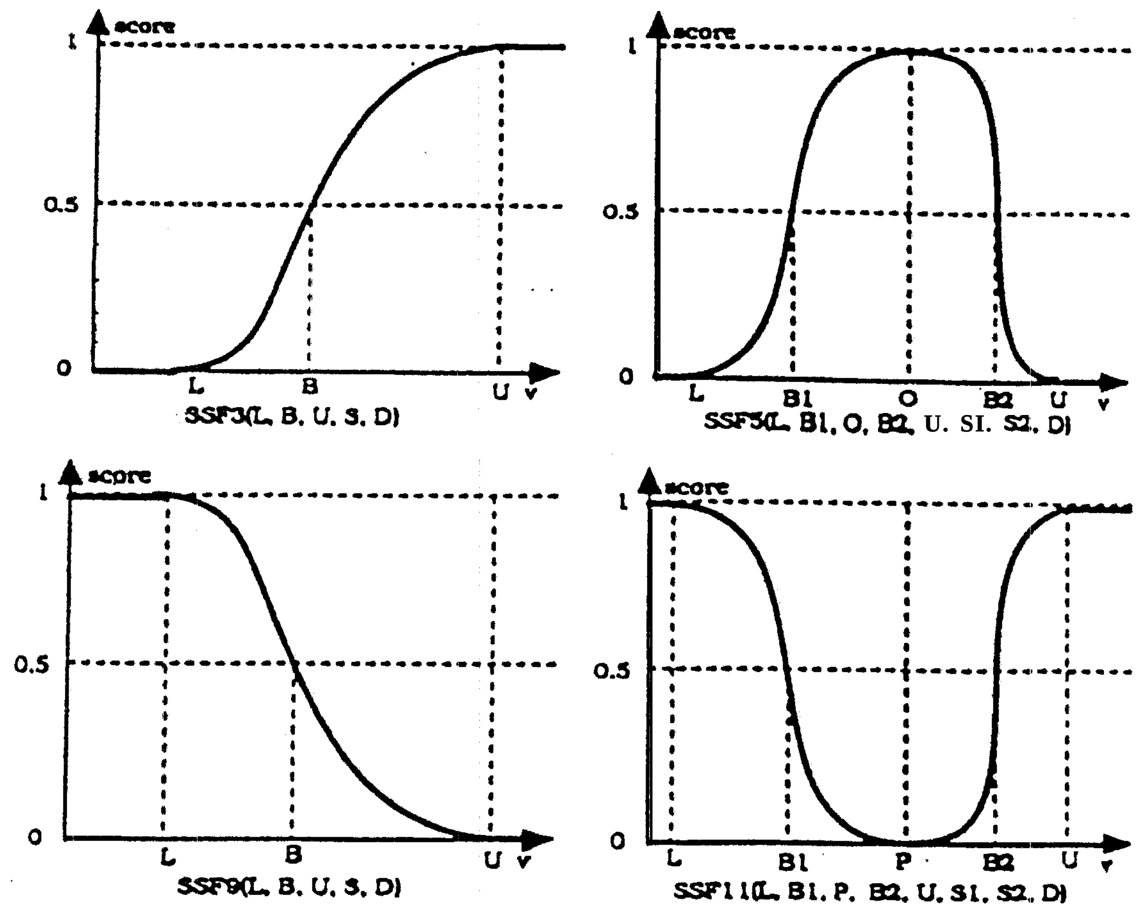


Figure 3.14. General shapes for standard scoring functions. The upper left indicates "more is better", the upper right "an optimum range", the lower left "less is better", and the lower right "an undesirable range". The letters L, B, U, and S refer to the lower threshold, baseline, upper threshold, and slope values, respectively. The D value would be the domain over which the function is described. (adapted from Wymore, 1993 and SSSA, Special Publication no. 35 with Permission).

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APPENDICES

Table A. Moisture content on the IPM plots

Samples	Can #	Can wt(g)	Soil+can(g)	Dry soil+can(g)	Dry soit(g)	Moisture(g)	%Moisture
Rep2 P13 A	B-101	62.82	344.14	297	234.18	47.14	20.13
Rep2 P13 A	B-31	63.68	390.72	341.29	277.61	49.43	17.81
Rep2 P13 A	B-130	61.73	343.95	298.25	236.52	45.7	19.32
Rep2 P13 A	B-70	63.3	348.95	298.93	235.63	50.02	21.23
Rep2 P13 B	B-116	63.59	385.87	311.49	247.9	74.38	30.00
Rep2 P13 B	E3-46	62.48	427.04	352.54	290.06	74.5	25.68
Rep2 P13 B	B-141	63.33	396.72	341.05	277.72	55.67	20.05
Rep2 P13 B	B-14	63.21	441.88	359.17	295.96	82.71	27.95
Rep2 P12. A	B-l 16	63.59	312.29	266.08	202.49	46.21	22.82
Rep2 P12. A	B-l 12	63.14	269.8	231.4	168.26	38.4	22.82
Rep2 P12: A	20	64.12	281.72	239.13	175.01	42.59	24.34
Rep2 P12: A	2	66.47	287.74	241.07	174.6	46.67	26.73
Rep2 P12: B	B-100	61.31	311.8	260.69	199.38	51.11	25.63
Rep2 P12: B	B-14	63.21	308.46	252.97	189.76	55.49	29.24
Rep2 P12: B	B-28	63.3	309.1	257.59	194.29	51.51	26.51
Rep2 P12: B	B-132	61.73	343.62	269.6	207.87	74.02	35.61
Rep2 P2 A	AB-24	62.6	353.38	300.31	237.71	53.07	22.33
Rep2 P2 A	AB-9	63.23	330.36	285.25	222.02	45.11	20.32
Rep2 P2 A	AB-13	65.81	347.45	301.1	235.29	46.35	19.70
Rep2 P2 A	AB-10	61.6	328.93	280.18	218.58	48.75	22.30
Rep2 P2 B	AB-55	61.82	324.16	285.09	223.27	39.07	17.50
Rep2 P2 B	AB-47	63.14	377.55	329.18	266.04	48.37	18.18
Rep2 P2 B	AB-91	63.13	371.23	323.19	260.06	48.04	18.47
Rep2 P2 B	AB-78	63.76	331.76	289.58	225.82	42.18	18.68
Rep2 P14 A	B-141	63.33	336.05	296.49	233.16	39.56	16.97
Rep2 P14 A	B-66	62.37	248.05	217.63	155.26	30.42	19.59
Rep2 P14 A	B-25	62.95	320.49	277.28	214.33	43.21	20.16
Rep2 P14 A	B-33	62.36	285.74	256.11	193.75	29.63	15.29
Rep2 P14 B	B-40	62.73	287.85	246.86	184.13	40.99	22.26
Rep2 P14 B	91	62.87	348.89	307.41	244.54	41.48	16.96
Rep2 P14 B	AB-75	63.63	316.54	278.02	214.39	38.52	17.97
Rep2 P14 B	AB-52	63.61	258.99	222.73	159.12	36.26	22.79
Rep2 P10 A	B-61	62.24	395.77	342.69	280.45	53.08	18.93
Rep2 P10 A	33	65.23	440	375.42	310.19	64.58	20.82
Rep2 P 1 0 A	B-25	62.95	359.12	312.1	249.15	47.02	18.87
Rep2 P10 A	AB-1 1	63.62	372.3	322.01	258.39	50.29	19.46
Rep2 P10 B	B-82	66.67	412.47	356.62	289.95	55.85	19.26
Rep2 P10 B	58	63.74	382.34	325.69	261.95	56.65	21.63
Rep2 PI 0 B	B-l 06	61.07	429.3	369.54	308.47	59.76	19.37
Rep2 P10 B	D-05	62.73	405.5	350.81	288.08	54.69	18.98
Rep2 P1 .A	B-46	62.48	369.8	329.13	266.65	40.67	15.25
Rep2 PI A	B-100	61.31	358.73	311.95	250.64	46.78	18.66
Rep2 P1 A	B-28	63.3	361.56	318.12	254.82	43.44	17.05
Rep2 P1 A	B-1111	63.47	341.29	303.4	239.93	37.89	15.79
Rep2 P1 B	B-l 30	61.73	346.88	300.98	239.25	45.9	19.18
Rep2 P1 B	B-l 32	61.73	363.12	312.37	250.64	50.75	20.25
Rep2 P1 B	B-l 5	61.58	385.08	332.27	270.69	52.8'1	19.51

Rep2 P1 B	B-73	62.4	344.08	295.22	232.82	48.86	20.99
Rep2 P15 A	20	64.12	374.2	303.29	239.17	70.91	29.65
Rep2 P15 A	47	36.82	251.47	202.03	165.21	49.44	29.93
Rep2 P15 A	91	62.87	318.69	260.89	198.02	57.8	29.19
Rep2 P15 A	15	63.44	332.39	266.14	202.7	66.25	32.68
Rep2 P15 B	31	66.84	344.21	276.45	209.61	67.76	32.33
Rep2 P15 B	46	64.72	343.93	291.8	227.08	52.53	22.96
Rep2 P15 B	53	37.17	229.82	170.08	132.91	59.74	44.95
Rep2 P15 B	33	65.23	285.87	224.07	158.84	61.8	38.91
Rep2 P6 A	B-31	'63.68	378.07	317.79	254.11	60.28	23.72
Rep2 P6 A	B-28	63.3	350.27	293.67	230.37	56.6	24.57
Rep2 P6 A	B-140	63.38	311.48	261.6	198.22	49.88	25.16
Rep2 P6 A	B-100	61.31	353.66	292.76	231.45	60.9	26.31
Rep2 P6 B	B-18	62.51	350.18	285.78	223.27	64.4	28.84
Rep2 P6 B	B-l 12	63.14	319.63	271.17	208.03	48.46	23.29
Rep2 P6 B	B-104	62.59	364.51	298.04	235.45	56.47	23.98
Rep2 P6 B	B-l 32	61.73	328.78	271.03	209.3	57.75	27.59
Rep2 P5 A	AB-14	62.99	453.81	370.84	307.85	82.97	26.95
Rep2 P5 A	91	62.87	347.55	299	236.13	48.55	20.56
Rep2 P5 A	B-40	62.73	343.01	299.5	236.77	43.51	18.38
Rep2 P5 A	AB-55	61.82	375.18	311.21	249.39	63.97	25.65
Rep2 P5 B	AB-39	63.82	344.97	283.23	219.41	61.74	28.14
Rep2 P5 B	AB-47	63.14	264.56	235.71	172.57	48.85	28.31
Rep2 P5 B	AB-52	63.61	343.73	300.2	236.59	43.53	18.40
Rep2 P5 B	AB-75	63.63	391.32	334.99	271.36	56.33	20.76
Rep2 P3 A	B-79	61.71	303.72	252.31	190.6	51.41	26.97
Rep2 P3 A	B-101	62.82	292.9	248.9	186.08	44	23.65
Rep2 P3 A	B-38	62.92	302.81	257.06	194.14	45.75	23.57
Rep2 P3 B	AB-43	62.67	303.69	259.74	197.07	43.95	22.30
Rep2 P3 B	B-1111	63.47	367.33	319.47	256	47.86	18.70
Rep2 P3 B	B-73	62.4	325.53	273.28	210.88	52.25	24.78
Rep2 P3 B	B-46	62.48	342.66	274.34	211.86	68.32	32.25
Rep2 P7 A	B-l 8	62.51	352.93	312.76	250.25	40.17	16.05
Rep2 P7 A	B-27	62.93	356.09	302.7	239.77	53.39	22.27
Rep2 P7 A	B-38	62.92	373.58	328.99	266.07	44.59	16.76
Rep2 P7 A	B-140	63.38	370.64	330.2	266.82	40.44	15.16
Rep2 P7 B	B-14	63.21	387.13	334.85	271.64	52.28	19.25
Rep2 P7 B	B-112	63.14	358.64	309.98	246.84	48.66	19.71
Rep2 P7 B	B-116	63.59	380.88	338.39	274.8	42.49	15.46
Rep2 P7 B	B-79	61.71	351.21	309.04	247.33	42.17	17.05
Rep2 P4 A	B-23	62.53	356.22	308.45	245.92	47.77	19.43
Rep2 P4 A	B-85	62.6	348.5	302.37	239.77	46.13	19.24
Rep2 P4 A	B-54	66.1	352.12	301.63	235.53	50.49	21.44
Rep2 P4 A	B-70	63.3	375.25	329.63	266.33	45.62	17.13
Rep2 P4 B	911	64.12	405.18	359.88	295.76	45.3	15.32
Rep2 P4 B	B-29	62.32	362.23	322.95	260.63	39.28	15.07
Rep2 P4 B	B-42	62.59	337.83	287.27	224.68	50.56	22.50
Rep2 P4 B	c-22	63.66	327.18	288.06	224.4	39.12	17.43

Table A. Confinued

Samples	Can #	Can wt(g)	Soil+can(g)	Dry soil+can(g)	Dry soil(g)	Moisture(g)	%Moisture
Rep3 P13 A	AB-1 05	61.6	398.22	346.61	285.01	51.61	18.11
Rep3 P13 A	AB-43	62.67	410.78	366.02	303.35	44.76	14.76
Rep3 P13 A	AB-52	63.61	414.4	371.99	308.38	42.41	13.75
Rep3 P13 A	AB-107	60.65	389.03	339.99	279.34	49.04	17.56
Rep3 P13 B	B-54	66.1	385.98	348.72	282.62	37.26	13.18
Rep3 P13 B	B-28	63.3	391	347.09	283.79	43.91	15.47
Rep3 P13 B	B-42	62.59	421.66	378.87	316.28	42.79	13.53
Rep3 P13 B	B-79	67.71	389.02	347.26	285.55	41.76	14.62
Rep3 P12 A	B-54	66.1	271.47	246.49	180.39	24.98	13.85
Rep3 P12 A	B-42	62.59	319.75	274.5	211.91	45.25	21.35
Rep3 P12 A	B-106	61.07	299.72	247.91	186.84	51.81	27.73
Rep3 Pi2 A	AB-91	63.13	364.4	308.4	245.27	56	22.83
Rep3 P12 B	B-61	62.24	295.95	253.48	191.24	42.47	22.21
Rep3 P12 B	IB-82	66.67	327.01	288.96	222.29	38.05	17.12
Rep3 P12 B	AB-105	61.6	287.71	247.81	186.21	39.9	21.43
Rep3 P12 B	AB-78	63.76	303.78	257.71	193.95	46.07	23.75
Rep3 P2 A	AB-144	62.99	330.89	289.01	226.02	41.88	18.53
Rep3 P2 A	AB-89	63.15	372.66	318.67	255.52	53.99	21.13
Rep3 P2 A	AB-75	63.63	383.1	334.66	271.03	48.44	17.87
Rep3 P2 A	AB-9 1	63.13	333.14	286.66	223.53	46.48	20.79
Rep3 P2 E3	B-l 16	63.59	369.12	315.96	252.37	53.16	21.06
Rep3 P2 E3	13-40	62.73	361.38	317.46	254.73	43.92	17.24
Rep3 P2 E3	El-731	63.46	394.58	333.76	270.3	60.82	22.50
Rep3 P2 E3	13-27	62.93	389.13	344.05	281.12	45.08	16.04
Rep3 P14 A	B-1111	63.47	362.05	330.53	267.06	31.52	11.80
Rep3 P14 A	13-28	63.3	333.79	304.7	241.4	29.09	12.05
Rep3 P14 A	B-79	61.71	317.69	289.04	227.33	28.65	12.60
Rep3 P14 A	B-15	61.58	379.76	341.86	280.28	37.9	13.52
Rep3 P14 B	IB-73	62.4	327.2	287.27	224.87	39.93	17.76
Rep3 P14 B	El-l 04	62.59	377.54	326.25	263.66	51.29	19.45
Rep3 P14 B	B-38	62.92	359.07	316.99	254.07	42.08	16.56
Rep3 P14 B	B-l 02	61.73	327.37	290.42	228.69	36.95	16.16
Rep3 P10 A	El-116	63.59	314.19	275.79	212.2	38.4	18.10
Rep3 PI 0 A	B-79	61.71	383.35	340.96	279.25	42.39	15.18
Rep3 PI0 A	B-61	62.24	331.18	280.05	217.81	51.13	23.47
Rep3 P10 A	B-25	62.95	383.46	331.92	268.97	51.54	19.16
Rep3 P10 B	2	66.47	345.04	298.58	232.11	46.46	20.02
Rep3 P10 B	AB-114	63.62	327.3	281.71	218.09	45.59	20.90
Rep3 P10 B	46	64.72	316.51	272.48	207.76	44.03	21.19
Rep3 PI0 B	B-54	66.1	371.19	317.6	251.5	53.59	21.31
Rep3 P1 A	B-14	63.21	342.84	289	225.79	53.84	23.85
Rep3 PI A	B-31	63.68	355.03	300.42	236.74	54.61	23.07
Rep3 P1 A	B-130	61.73	342.02	286.85	225.12	55.17	24.51
Rep3 PI A	B-73	62.4	372.8	312.15	249.75	60.65	24.28
Rep3 P1 B	B-l 00	61.31	316.71	274.62	213.31	42.09	19.73
Rep3 P1 B	B-85	62.6	334.03	288.59	225.99	45.44	20.11
Rep3 P1 B	B-l 32	61.73	336.52	283.67	221.94	52.85	23.81

Rep3 PI B	B-82	66.67	391.47	332.12	265.45	59.35	22.36
Rep3 P15 A	B-l 32	61.73	322.01	275.81	214.08	46.2	21.58
Rep3 P15 A	B-46	62.48	343.97	286.04	223.56	57.93	25.91
Rep3 P15 A	B-100	61.31	353.05	305.92	244.61	47.13	19.27
Rep3 P15 A	B-79	61.71	349.39	280.8	219.09	68.591	31.31
Rep3 P15 B	D-l 1	63.98	341.93	295.76	231.78	46.17	19.92
Rep3 P15 B	B-28	63.3	329.18	273.52	210.22	55.66	26.48
Rep3 P15 B	B-140	36.38	365.1 1	305.62	269.24	59.49	22.10
Rep3 P15 B	B-105	62.82	363.58	296.23	233.41	67.35	28.85
Rep3 P6 A	B-18	62.51	345.8	284.67	222.16	61.13	27.52
Rep3 P6 A	B-111	63.47	302.15	254.98	191.51	47.17	24.63
Rep3 P6 A	B-73	62.4	354.32	301.42	239.02	52.9	22.13
Rep3 P6 A	B-31	63.68	350.47	291.91	228.23	58.56	25.66
Rep3 P6 B	B-l 5	61.58	345.7	298.9	237.32	46.8	19.72
Rep3 P6 B	B-l 04	62.59	312.34	269.82	207.23	42.52	20.52
Rep3 P6 B	B-38	62.92	350.78	303.29	240.37	47.49	19.76
Rep3 P6 B	B-l 12	63.14	351.97	294.2	231.06	57.77	25.00
Rep3 P5 A	B-140	63.38	334.34	288.71	225.33	45.63	20.25
Rep3 P5 A	B-33	62.36	327.46	281.06	218.7	46.4	21.22
Rep3 P5 A	911	64.12	318.89	279.18	215.06	39.711	i8.46
Rep3 P5 A	B-18	62.51	364.28	311.08	248.57	53.2	21.40
Rep3 P5 B	B-l 12	63.14	353.1	319.04	255.9	34.06	13.31
Rep3 P5 B	B-l 00	61.31	418.76	368.25	306.94	50.511	16.46
Rep3 P5 B	B-27	62.93	323.88	281.06	218.13	42.82	19.63
Rep3 P5 B	B-66	62.37	349.09	296.47	234.1	52.62	22.48
Rep3 P3 A	B-23	62.53	261.56	221.73	159.2	39.83	25.02
Rep3 P3 A	114	62.98	298.98	243.09	180.11	55.89	31.03
Rep3 P3 A	B-l 16	63.59	281.97	231.21	167.62	50.76	30.28
Rep3 P3 A	96	62.28	278.6	240.01	177.73	38.59	21.71
Rep3 P3 B	AB-52	63.61	321.46	277.23	213.62	44.23	20.70
Rep3 P3 B	AB-9	63.23	330.15	276.79	213.56	53.36	24.99
Rep3 P3 B	B-85	62.6	359.8	307.16	244.56	52.64	21.52
Rep3 P3 B	AB-135	65.81	385.11	320.64	254.83	64.47	25.30
Rep3 P7 A	AB-91	63.13	355.79	305.11	241.98	50.68	20.94
Rep3 P7 A	Ai3-47	63.14	355.75	303.36	240.22	52.39	21.81
Rep3 P7 A	B-61	62.24	365.69	312.37	250.13	53.32	21.32
Rep3 P7 A	AB-55	61.82	401.25	340.21	278.39	61.04	21.93
Rep3 P7 f3	AB-43	62.67	351.74	295.69	233.02	56.05	24.05
Rep3 P7 B	AB-144	62.99	362.83	306.49	243.5	56.34	23.14
Rep3 P7 B	96	62.28	381.49	327.6	265.32	53.89	20.31
Rep3 P7 B	AB-9	63.23	373.37	315.61	252.38	57.76	22.89
Rep3 P4 A	B-23	62.53	402.21	361.07	298.54	41.14	13.78
Rep3 P4 A	46	64.72	400.58	362.19	297.47	38.39	12.91
Rep3 P4 A	B-70	63.3	429.54	379.48	316.18	50.06	15.83
Rep3 P4 A	B-29	62.32	423.82	371.94	309.62	51.88	16.76
Rep3 P4 B	47	36.82	334.22	297.06	260.24	37.16	14.28
Rep3 P4 B	B-38	62.92	463.49	414.07	351.15	49.42	14.07
Rep3 P4 B	F-l	66.25	445.6	395.6	329.35	50	15.18
Rep3 P4 B	32	36.65	336.31	297.47	260.82	38.84	14.89

Table A. Continued

Samples	Can #	Can wt(g)	Soil+can(g)	Dry soil+can(g)	Dry soil(g)	Moisture(g)	% Moisture
Rep4 P13 A	B-106	61.07	354.61	302.67	241.6	51.94	21.50
Rep4 P13 A	B-101	62.82	336.75	293.23	230.41	43.52	18.89
Rep4 P13 A	B-40	62.73	379.34	332.71	269.98	46.63	17.27
Rep4 P13 A	B-1111	63.58	354.07	304.11	240.53	49.96	20.77
Rep4 P13 B	B-79	61.71	403.16	358.54	296.83	44.62	15.03
Rep4 P13 B	El-104	62.59	380.37	333.14	270.55	47.23	17.46
Rep4 P13 B	B-100	61.31	379.77	337.36	276.05	42.41	15.36
Rep4 P13 B	B-27	62.93	398.5	360.27	297.34	38.23	12.86
Rep4 P12 A	Es-112	63.14	322.22	256.78	193.64	65.44	33.79
Rep4 P12 A	B-130	61.73	260.04	226.52	164.79	33.52	20.34
Rep4 P12 A	B-15	61.58	288.99	238.01	176.43	50.98	28.90
Rep4 P12 A	IB-31	63.68	358.55	264.27	200.59	94.28	47.00
Rep4 P12 B	Es-141	63.33	318.05	262.41	199.08	55.64	27.95
Rep4 P12 B	B-54	66.1	329.21	278.43	212.33	50.78	23.92
Rep4 P12 B	Es-140	63.38	310.9	231.17	167.79	79.73	47.52
Rep4 P12 B	B-61	62.24	293	242.21	179.97	50.79	28.22
Rep4 P2 A	B-29	62.32	385.73	333.8	271.48	51.93	19.13
Rep4 P2 A	B-42	62.59	349.85	295.04	232.45	54.81	23.58
Rep4 P2 A	B-132	61.73	352.67	301.72	239.99	50.95	21.23
Rep4 P2 A	B-66	62.37	400.5	340.62	278.25	59.88	21.52
Rep4 P2 B	B-70	63.3	325.41	275.46	212.16	49.95	23.54
Rep4 P2 B	B-18	62.51	376.58	314.96	252.45	61.62	24.41
Rep4 P2 B	13-82	66.67	357.7	313.91	247.24	43.79	17.71
Rep4 P2 B	B-38	62.92	301.01	257.14	194.22	43.87	22.59
Rep4 P14.A	B-14	63.21	365.24	305.93	242.72	59.31	24.44
Rep4 P14 A	13-23	62.53	273.63	239.56	177.03	34.07	19.25
Rep4 P14 A	13-73	62.4	337.7	284.91	222.51	52.79	23.72
Rep4 P14 A	B-28	63.3	308.96	257.79	194.49	51.17	26.31
Rep4 P14 B	B-85	62.6	372.46	319.54	256.94	52.92	20.60
Rep4 P14 B	B-25	62.95	342.32	294.68	231.73	47.64	20.56
Rep4 P14 B	B-33	62.36	333.95	285.41	223.05	48.54	21.76
Rep4 P14 B	B-116	63.59	400.53	342.73	279.14	57.8	20.71
Rep4 P10 A	lB-46	62.48	399.18	349.57	287.09	49.61	17.28
Rep4 P10 A	AB-144	62.99	380.05	334.31	271.32	45.74	16.86
Rep4 P10 A	AB-55	61.82	379.42	328.48	266.66	50.94	19.10
Rep4 P10 A	AB-114	63.62	394.8	346.69	283.07	48.11	17.00
Rep4 P10 B	Es-731	63.46	348.73	305.89	242.43	42.84	17.67
Rep4 P10 B	AB-91	63.13	337.77	296.62	233.49	41.15	17.62
Rep4 P10 B	AB-43	62.67	344.7	307.83	245.16	36.87	15.04
Rep4 P10 B	9 1	62.87	377.32	335.04	272.17	42.28	15.53
Rep4 Pl.4	f\B-89	63.15	393	343.84	280.69	49.16	17.51
Rep4 Pl.4	58	63.74	376.06	328.39	264.65	47.67	18.01
Rep4 PI A	114	62.98	397.28	351.28	288.3	46	15.96
Rep4 P1 A	D-05	62.73	379.12	334.97	272.24	44.15	16.22
Rep4 P1 B	3 1	66.84	380.57	336.09	269.25	44.48	16.52
Rep4 P1 B	2	66.47	363.58	334.55	268.08	29.03	10.83
Rep4 P1 B	F-2	63.76	378.46	336.61	272.85	41.85	15.34

Rep4 PI B	AB-47	63.14	344.31	305.66	242.52	38.65	15.94
Rep4 P15 A	004	66.25	379.15	300.8	234.55	78.35	33.40
Rep4 P15 A	F-3	65.42	369.5	297.18	231.76	72.32	31.20
Rep4 P15 A	D-l 1	63.98	334.5	259.62	195.64	74.88	38.27
Rep4 P15 A	c-122	63.11	378.75	293.22	230.11	85.53	37.17
Rep4 P15 B	117	62.92	359.31	282.12	219.2	77.19	35.21
Rep4 PI5 B	AB-107	60.65	301.36	235.92	175.27	65.44	37.34'
Rep4 P15 B	AB-105	61.6	371.69	289.17	227.57	82.52	36.26
Rep4 P15 B	D-07	61.64	374.23	286.71	225.07	87.52	38.89
Rep4 P6 A	B-70	63.3	339.96	281.7	218.4	58.26	26.68
Rep4 P6 A	B-l 5	61.58	363.38	301.71	240.13	61.67	25.68
Rep4 P6 A	B-25	62.95	355.99	297.83	234.88	58.16	24.76
Rep4 P6 A	B-46	62.48	365.57	307.35	244.87	58.22	23.78
Rep4 P6 B	B-116	63.59	348.64	285.15	221.56	63.49	28.66
Rep4 P6 E3	B-28	63.3	397.92	321.19	257.89	76.73	29.75
Rep4 P6 B	B-61	62.24	345.69	275.75	213.51	69.94	32.76
Rep4 P6 B	B-54	66.1	328.89	273.38	207.28	55.51	26.78
Rep4 P5 A	AB-39	63.82	333.64	277.77	213.95	55.87	26.11
Rep4 P5 A	AB-75	63.63	414.74	352.87	289.24	61.87	21.39
Rep4 P5 A	40	37.1	288.48	246.31	209.21	42.17	20.16
Rep4 P5 A	c-22	63.66	379.58	324.39	260.73	55.19	21.17
Rep4 P5 B	AB-135	65.81	339.42	281.32	215.51	58.1	26.96
Rep4 P5 B	911	64.12	357.47	309.04	244.92	48.43	19.77
Rep4 P5 B	20	64.12	352.97	297.0%	232.96	55.89	23.99
Rep4 P5 B	AB-78	63.76	358.63	301.91	238.15	56.72	23.82
Rep4 P3 A	AB-55	61.82	375.07	306.5	244.6%	68.57	28.02
Rep4 P3 A	AB-91	63.13	294.11	226.26	163.13	67.85	41.59
Rep4 P3 A	D-05	62.73	323.92	255.3	192.57	68.62	35.63
Rep4 P3 A	AB-89	63.15	392.02	311.18	248.03	80.84	32.59
Rep4 P3 A	B-79	61.71	351.08	292.71	231	58.37	25.27
Rep4 P3 A	B-31	63.68	382.65	301.78	238.1	80.87	33.96
Rep4 P3 A	B-1111	63.47	353.8	289.98	226.51	63.82	28.18
Rep4 P3 A	B-38	62.92	338.89	265.91	202.99	72.98	35.95
Rep4 P7 A	AB-114	63.62	385.25	337.1	273.48	48.15	17.61
Rep4 P7 A	24	63.19	355.03	314.45	251.26	40.58	16.15
Rep4 P7 A	17	66.47	412.79	361.32	294.85	51.47	17.46
Rep4 P7 A	12	65.64	424.9	369.51	303.87	55.39	18.23
Rep4 P7 B	58	63.74	373.31	328.51	264.77	44.8	16.92
Rep4 P7 B	31	66.84	373	323.11	256.27	49.89	19.47
Rep4 P7 B	B-62	64.16	367.75	321.04	256.88	46.71	18.18
Rep4 P7 B	B-73	62.4	393.49	333.93	271.53	59.56	21.93
Rep4 P4 A	B-79	61.71	380.17	333.47	271.76	46.7	17.18
Rep4 P4 A	B-l 5	61.58	367.29	316.35	254.77	50.94	19.99
Rep4 P4 A	B-46	62.48	375.03	321.99	259.51	53.04	20.44
Rep4 P4 A	B-104	62.59	382.14	343.89	281.3	38.25	13.60
Rep4 P4 B	B-40	62.73	363.59	321.86	259.13	41.73	16.10
Rep4 P4 B	B-25	62.95	293.68	264.68	201.73	29	14.38
Rep4 P4 B	B-116	63.59	383.35	336.75	273.16	46.6	17.06
Rep4 P4 B	B-54	66.1	356.73	325.5	259.4	31.23	12.04

Table B. Bulk density on the IPM plots

Samples	R.int.diam.(cm)	R. ht (cm)	Soil vol.(cm3)	Dry soil wt (g)	BD (g/cm3)
Rep2 P13 A	5.4	3	68.67	88.01	1.28
Rep2 PI3 A	5.4	3	68.67	91.27	1.33
Rep2 P13 A	5.4	3	68.67	91.73	1.34
Rep2 P13 A	5.4	3	68.67	86.73	1.26
Rep2 P13 B	5.4	3	68.67	85	1.24
Rep2 P13 B	5.4	3	68.67	89.12	1.30
Rep2 P13 B	5.4	3	68.67	93.44	1.36
Rep2 P13 B	5.4	3	68.67	93.79	1.37
Rep2 P12 A	5.4	3	68.67	98.89	1.44
Rep2 P12 A	5.4	3	68.67	101.99	1.49
Rep2 P12 A	5.4	3	68.67	91.21	1.33
Rep2 PI2 A	5.4	3	68.67	99.85	1.45
Rep2 P12 B	5.4	3	68.67	75.96	1.11
Rep2 P12 B	5.4	3	68.67	88.19	1.28
Rep2 P12 B	5.4	3	68.67	74.86	1.09
Rep2 P12 B	5.4	3	68.67	82.88	1.21
Rep2 P2 A	5.4	3	68.67	84.07	1.22
Rep2 P2 A	5.4	3	68.67	82.86	1.21
Rep2 P2 A	5.4	3	68.67	90.05	1.31
Rep2 P2 A	5.4	3	68.67	93.06	1.36
Rep2 P2 B	5.4	3	68.67	92.38	1.35
Rep2 P2 B	5.4	3	68.67	92.53	1.35
Rep2 P2 B	5.4	3	68.67	85.5	1.25
Rep2 P2 B	5.4	3	68.67	94.08	1.37
Rep2 P14 A	5.4	3	68.67	89.86	1.31
Rep2 P14 A	5.4	3	68.67	79.32	1.16
Rep2 P14 A	5.4	3	68.67	96.23	1.40
Rep2 P14 A	5.4	3	68.67	103.67	1.51
Rep2 P14 B	5.4	3	68.67	100.7	1.47
Rep2 P14 B	5.4	3	68.67	98.2	1.43
Rep2 P14 B	5.4	3	68.67	95.9	1.40
Rep2 P14 B	5.4	3	68.67	94.52	1.38
Rep2 P10 A	5.4	3	68.67	99.84	1.45
Rep2 PI0 A	5.4	3	68.67	102.35	1.49
Rep2 P10 A	5.4	3	68.67	101.36	1.48
Rep2 P10 A	5.4	3	68.67	96.02	1.40
Rep2 P10 B	5.4	3	68.67	101.28	1.47
Rep2 P10 B	5.4	3	68.67	99.64	1.45
Rep2 PI0 B	5.4	3	68.67	93.76	1.37
Rep2 PI0 B	5.4	3	68.67	100.35	1.46
Rep2 P1 A	5.4	3	68.67	94.76	1.38
Rep2 PI A	5.4	3	68.67	88.24	1.28
Rep2 P1 A	5.4	3	68.67	86.02	1.25
Rep2 PI A	5.4	3	68.67	84.48	1.23
Rep2 PI B	5.4	3	68.67	92.08	1.34
Rep2 PI B	5.4	3	68.67	93.42	1.36
Rep2 PI B	5.4	3	68.67	93.12	1.36

Rep2 PI B	5.4	3	68.67	92.41	1.35
Rep2 P15 A	5.4	3	68.67	94.34	1.37
Rep2 P15 A	5.4	3	68.67	93.07	1.36
Rep2 P15 A	5.4	3	68.67	99.74	1.45
Rep2 P15 A	5.4	3	68.67	97.22	1.42
Rep2 P15 B	5.4	3	68.67	92.47	1.35
Rep2 P15 B	5.4	3	68.67	90.58	1.32
Rep2 P15 B	5.4	3	68.67	88.03	1.28
Rep2 P15 B	5.4	3	68.67	99.26	1.45
Rep2 P6 A	5.4	3	68.67	97.81	1.42
Rep2 P6 A	5.4	3	68.67	99.61	1.45
Rep2 P6 A	5.4	3	68.67	102.58	1.49
Rep2 P6 A	5.4	3	68.67	91.83	1.34
Rep2 P6 B	5.4	3	68.67	94.4	1.37
Rep2 P6 B	5.4	3	68.67	97.45	1.42
Rep2 P6 B	5.4	3	68.67	94.61	1.38
Rep2 P6 B	5.4	3	68.67	96.82	1.41
Rep2 P5 A	5.4	3	68.67	91.2-l	1.33
Rep2 P5 A	5.4	3	68.67	93.04	1.35
Rep2 P5 A	5.4	3	68.67	89.57	1.30
Rep2 P5 A	5.4	3	68.67	96.38	1.40
Rep2 P5 B	5.4	3	68.67	94.85	1.38
Rep2 P5 B	5.4	3	68.67	88.09	1.28
Rep2 P5 B	5.4	3	68.67	92.67	1.35
Rep2 P5 B	5.4	3	68.67	94.02	1.37
Rep2 P3 A	5.4	3	68.67	102.35	1.49
Rep2 P3 A	5.4	3	68.67	97.75	1.42
Rep2 P3 A	5.4	3	68.67	96.7	1.41
Rep2 P3 A	5.4	3	68.67	89.54	1.30
Rep2 P3 A	5.4	3	68.67	93.65	1.36
Rep2 P3 A	5.4	3	68.67	102.7	1.50
Rep2 P3 A	5.4	3	68.67	86.56	1.26
Rep2 P3 A	5.4	3	68.67	93.61	1.36
Rep2 P7 A	5.4	3	68.67	92.66	1.35
Rep2 P7 A	5.4	3.	68.67	93.28	1.36
Rep2 P7 A	5.4	3	68.67	94.8	1.38
Rep2 P7 A	5.4	3	68.67	100.84	1.47
Rep2 P7 B	5.4	3	68.67	93.32	1.36
Rep2 P7 B	5.4	3	68.67	94.49	1.38
Rep2 P7 B	5.4	3	68.67	95.35	1.39
Rep2 P7 B	5.4	3	68.67	95.82	1.40
Rep2 P4 A	5.4	3	68.67	88.22	1.28
Rep2 P4 A	5.4	3	68.67	91.83	1.34
Rep2 P4 A	5.4	3	68.67	94.8	1.38
Rep2 P4 A	5.4	3	68.67	87.81	1.28
Rep2 P4 B	5.4	3	68.67	95.44	1.39
Rep2 P4 B	5.4	3	68.67	90.63	1.32
Rep2 P4 B	5.4	3	68.67	92.45	1.35
Rep2 P4 B	5.4	3	68.67	93.08	1.36

Table B. Continued

Samples	R.int.diam.(cm)	R. ht (cm)	Soit vol.(cm3)	Dry soit wt (g)	BD (g/cm3)
Rep3 P13 A	5.4	3	68.67	102.63	1.49
Rep3 P13 A	5.4	3	68.67	99.72	1.45
Rep3 P13 A	5.4	3	68.67	100.28	1.46
Rep3 P13 A	5.4	3	68.67	89.49	1.30
Rep3 P13 B	5.4	3	68.67	106.51	1.55
Rep3 P13 B	5.4	3	68.67	1 06.88	1.56
Rep3 P13 B	5.4	3	68.67	98.39	1.43
Rep3 P13 B	5.4	3	68.67	93.91	1.37
Rep3 P12 A	5.4	3	68.67	96.39	1.40
Rep3 P12 A	5.4	3	68.67	99.98	1.46
Rep3 P12 A	5.4	3	68.67	96.56	1.41
Rep3 P12 A	5.4	3	68.67	97.14	1.41
Rep3 P12 B	5.4	3	68.67	103.68	1.51
Rep3 P12 B	5.4	3	68.67	78.49	1.14
Rep3 P12 B	5.4	3	68.67	95.64	1.39
Rep3 P12 B	5.4	3	68.67	94.28	1.37
Rep3 P2 A	5.4	3	68.67	104.83	1.53
Rep3 P2 A	5.4	3	68.67	96.2	1.40
Rep3 P2 A	5.4	3	68.67	92.82	1.35
Rep3 P2 A	5.4	3	68.67	87.11	1.27
Rep3 P2 B	5.4	3	68.67	105.48	1.54
Rep3 P2 B	5.4	3	68.67	99.2	1.44
Rep3 P2 B	5.4	3	68.67	106.4	1.55
Rep3 P2 B	5.4	3	68.67	100.86	1.47
Rep3 P14 A	5.4	3	68.67	101.48	1.48
Rep3 PI4 A	5.4	3	68.67	99.15	1.44
Rep3 P14 A	5.4	3	68.67	99.8	1.45
Rep3 P14 A	5.4	3	68.67	100.1	1.46
Rep3 P14 B	5.4	3	68.67	98.51	1.43
Rep3 P14 B	5.4	3	68.67	98.51	1.43
Rep3 P14 B	5.4	3	68.67	100.26	1.46
Rep3 P14 B	5.4	3	68.67	96.55	1.41
Rep3 P10 A	5.4	3	68.67	99.43	1.45
Rep3 P10 A	5.4	3	68.67	94.29	1.37
Rep3 P10 A	5.4	3	68.67	98.81	1.44
Rep3 P10 A	5.4	3	68.67	98.19	1.43
Rep3 P10 B	5.4	3	68.67	95.38	1.39
Rep3 P10 B	5.4	3	68.67	97.3	1.42
Rep3 P10 B	5.4	3	68.67	94.79	1.38
Rep3 P10 B	5.4	3	68.67	97.96	1.43
Rep3 P1 A	5.4	3	68.67	94.99	1.38
Rep3 PI A	5.4	3	68.67	93.8	1.37
Rep3 P1 A	5.4	3	68.67	98.14	1.43
Rep3 P1 A	5.4	3	68.67	91.57	1.33
Rep3 P1 B	5.4	3	68.67	99.29	1.45
Rep3 PI B	5.4	3	68.67	89.53	1.30
Rep3 P1 B	5.4	3	68.67	90.77	1.32

Rep3 P1 B	5.4	3	68.67	95.97	1.40
Rep3 P15 A	5.4	3	68.67	103.72	1.51
Rep3 P15 A	5.4	3	68.67	94.34	1.37
Rep3 P15 A	5.4	3	68.67	102.98	1.50
Rep3 P15 A	5.4	3	68.67	89.27	1.30
Rep3 P15 B	5.4	3	68.67	94.8	1.38
Rep3 P15 B	5.4	3	68.67	86.67	1.26
Rep3 P15 B	5.4	3	68.67	91.13	1.33
Rep3 P15 B	5.4	3	68.67	94.26	1.37
Rep3 P6 A	5.4	3	68.67	87.75	1.28
Rep3 P6 A	5.4	3	68.67	101.39	1.48
Rep3 P6 A	5.4	3	68.67	99.27	1.45
Rep3 P6 A	5.4	3	68.67	100.42	1.46
Rep3 P6 B	5.4	3	68.67	98.89	1.44
Rep3 P6 B	5.4	3	68.67	103.77	1.51
Rep3 P6 B	5.4	3	68.67	96.78	1.41
Rep3 P6 B	5.4	3	68.67	94.05	1.37
Rep3 P5 A	5.4	3	68.67	93.83	1.37
Rep3 P5 A	5.4	3	68.67	96.65	1.41
Rep3 P5 A	5.4	3	68.67	91.74	1.34
Rep3 P5 A	5.4	3	68.67	97.13	1.41
Rep3 P5 B	5.4	3	68.67	100.16	1.46
Rep3 P5 B	5.4	3	68.67	100.44	1.46
Rep3 P5 B	5.4	3	68.67	97.4	1.42
Rep3 P5 B	5.4	3	68.67	101.52	1.48
Rep3 P3 A	5.4	3	68.67	104.94	1.53
Rep3 P3 A	5.4	3	68.67	100.11	1.46
Rep3 P3 A	5.4	3	68.67	103.35	1.50
Rep3 P3 A	5.4	3	68.67	96.56	1.41
Rep3 P3 B	5.4	3'	68.67	83.31	1.21
Rep3 P3 B	5.4	3'	68.67	93.12	1.36
Rep3 P3 B	5.4	3'	68.67	102.9	1.50
Rep3 P3 B	5.4	3'	68.67	86.68	1.26
Rep3 P7 A	5.4	3	68.67	101.84	1.48
Rep3 P7 A	5.4	3	68.67	98.29	1.43
Rep3 P7 A	5.4	3	68.67	104.88	1.53
Rep3 P7 A	5.4	3	68.67	93.11	1.36
Rep3 P7 B	5.4	3	68.67	99.54	1.45
Rep3 P7 B	5.4	3	68.67	89.97	1.31
Rep3 P7 B	5.4	3	68.67	99.44	1.45
Rep3 P7 B	5.4	3	68.67	92.61	1.35
Rep3 P4 A	5.4	3	68.67	94.3	1.37
Rep3 P4 A	5.4	3	68.67	88.23	1.28
Rep3 P4 A	5.4	3	68.67	99.39	1.45
Rep3 P4 A	5.4	3	68.67	96.03	1.40
Rep3 P4 B	5.4	3	68.67	102.77	1.50
Rep3 P4 B	5.4	3	68.67	103.91	1.51
Rep3 P4 B	5.4	3	68.67	96.71	1.41
Rep3 P4 B	5.4	3	68.67	110.52	1.61

Table B. Continued

Samples	R.int.diam.(cm)	R. ht (cm)	Soil vol.(cm3)	Dry soil wt (g)	BD (g/cm3)
Rep4 P13 A	5.4	3	68.67	98.9	1.44
Rep4 Pi3 A	5.4	3	68.67	101.03	1.47
Rep4 P13 A	5.4	3	68.67	103.77	1.51
Rep4 P13 A	5.4	3	68.67	98.09	1.43
Rep4 P13 B	5.4	3	68.67	103.28	1.50
Rep4 P13 B	5.4	3	68.67	106.98	1.56
Rep4 P13 B	5.4	3	68.67	81.83	1.19
Rep4 P13 B	5.4	3	68.67	104.87	1.53
Rep4 P12 A	5.4	3	68.67'	97.42	1.42
Rep4 P12 A	5.4	3	68.67	78.96	1.15
Rep4 P12 A	5.4	3	68.67	91.98	1.34
Rep4 P12 A	5.4	3	68.67	87.39	1.27
Rep4 P12 B	5.4	3	68.67	81.49	1.19
Rep4 P12 B	5.4	3	68.67	87.93	1.28
Rep4 P12 B	5.4	3	68.67	80.09	1.17
Rep4 P12 B	5.4	3	68.67	82.57	1.20
Rep4 P2 A	5.4	'3	68.67	92.98	1.35
Rep4 P2 A	5.4	3	68.67	98.65	1.44
Rep4 P2 A	5.4	3	68.67	83.5	1.22
Rep4 P2 A	5.4	3	68.67	84	1.22
Rep4 P2 B	5.4	3	68.67	89.91	1.31
Rep4 P2 B	5.4	3	68.67	94.31	1.37
Rep4 P2 B	5.4	3	68.67	86.56	1.26
Rep4 P2 B	5.4	3	68.67	99.31	1.45
Rep4 P14 A	5.4	3	68.67	101.58	1.48
Rep4 P14 A	5.4	3	68.67	96.42	1.40
Rep4 P14 A	5.4	3	68.67	94.22	1.37
Rep4 P14 A	5.4	3	68.67	91.56	1.33
Rep4 P14 B	5.4	3	68.67	76.24	1.11
Rep4 P14 B	5.4	3	68.67	105.68	1.54
Rep4 P14 B	5.4	3	68.67	97.2	1.42
Rep4 P14 B	5.4	3	68.67	104.66	1.52
Rep4 P10 A	5.4	3	68.67	95.3	1.39
Rep4 P10 A	5.4	3	68.67	95.06	1.38
Rep4 P10 A	5.4	3	68.67	103.57	1.51
Rep4 P10 A	5.4	3	68.67	94.48	1.38
Rep4 P10 B	5.4	3	68.67	96.02	1.40
Rep4 P10 B	5.4	3	68.67	91.52	1.33
Rep4 P10 B	5.4	3	68.67	105.24	1.53
Rep4 P10 B	5.4	3			
Rep4 P1 A	5.4	3	68.67	106.85	1.56
Rep4 P1 A	5.4	3	68.67	98.76	1.43
Rep4 P1 A	5.4	3	68.67	97.94	1.43
Rep4 P1 A	5.4	3	68.67	110.12	1.60'
Rep4 P1 B	5.4	3	68.67	105.66	1.54
Rep4 P1 B	5.4	3	68.67	98.85	1.44
Rep4 P1 B	5.4	3	68.67	97.71	1.42

Rep4 Pl B	5.4	3	68.67	101.43	1.48
Rep4 P15 A	5.4	3	68.67	86.2	1.26
Rep4 P15 A	5.4	3	68.67	99.17	1.44
Rep4 P15 A	5.4	3	68.67	100.16	1.46
Rep4 P15 A	5.4	3	68.67	98.02	1.43
Rep4 P15 B	5.4	3	68.67	90.98	1.32
Rep4 Pi5 B	5.4	3'	68.67	92.02	1.34
Rep4 P15 B	5.4	3	68.67	95.87	1.40
Rep4 P15 B	5.4	3	68.67	95.89	1.40
Rep4 P6 A	5.4	3	68.67	100.61	1.47
Rep4 P6 A	5.4	3	68.67	100.61	1.47
Rep4 P6 A	5.4	3	68.67	101.45	1.48
Rep4 P6 A	5.4	3	68.67	98.57	1.44
Rep4 P6 B	5.4	3	68.67	93.53	1.36
Rep4 P6 B	5.4	3	68.67	95.25	1.39
Rep4 P6 B	5.4	3	68.67	97.17	1.41
Rep4 P6 B	5.4	3	68.67	98.09	1.43
Rep4 P5 A	5.4	3	68.67	102.02	1.49
Rep4 P5 A	5.4	3	68.67	106.28	1.55
Rep4 P5 A	5.4	3	68.67	95.79	1.39
Rep4 P5 A	5.4	3	68.67	99.77	1.45
Rep4 P5 B	5.4	3	68.67	92.12	1.34
Rep4 P5 B	5.4	3	68.67	93.37	1.36
Rep4 P5 B	5.4	3	68.67	103.71	1.51
Rep4 P5 B	5.4	3	68.67	98.72	1.44
Rep4 P3 A	5.4	3	68.67	87.31	1.27
Rep4 P3 A	5.4	3	68.67	92.49	1.35
Rep4 P3 A	5.4	3	68.67	102.35	1.49
Rep4 P3 A	5.4	3	68.67	101.65	1.48
Rep4 P3 B	5.4	3	68.67	88.24	1.28
Rep4 P3 B	5.4	3	68.67	92.36	1.34
Rep4 P3 B	5.4	3	68.67	104.73	1.53
Rep4 P3 B	5.4	3	68.67	92.1	1.34
Rep4 P7 A	5.4	3	68.67	98.65	1.44
Rep4 P7 A	5.4	'3	68.67	92.43	1.35
Rep4 P7 A	5.4	3	68.67	94.97	1.38
Rep4 P7 A	5.4	3	68.67	91.91	1.34
Rep4 P7 B	5.4	'3	68.67	98.55	'1.44
Rep4 P7 B	5.4	3	68.67	99.73	1.45
Rep4 P7 B	5.4	3	68.67	97.65	1.42
Rep4 P7 B	5.4	3	68.67	97.97	1.43
Rep4 P4 A	5.4.	3	68.67	104.99	1.53
Rep4 P4 A	5.4	3	68.67	98.48	1.43
Rep4 P4 A	5.4	3	68.67	104.23	1.52
Rep4 P4 A	5.4	3	68.67	99.37	1.45
Rep4 P4 B	5.4	3	68.67	103.33	1.50
Rep4 P4 B	5.4	3	68.67	101.26	1.47
Rep4 P4 B	5.4'	3	68.67	98.22	1.43
Rep4 P4 B	5.4	3	68.67	101.99	1.49

Table C. Soil resistance to penetration on the IPM plots

Sampies	3" depth	6" depth	9" depth	12" depth
Rep2 Pl 3 A	5	10	20	80
Rep2 P13 A	5	10	20	30
Rep2 P13 A	10	20	35	90
Rep2 P13 A	20	40	80	120
Mean	10	20	35.75	8 0
Force (kgf/cm2)	0.7	1.41	2.73	5.63
Rep2 P13 B	20	25	40	70
Rep2 P13 B	20	40	40	100
Rep2 P13 B	20	40	50	90
Rep2 P13 B	10	15	20	45
Mean	17.5	30	37.5	76.25
Force (kgf/cm2)	1.23	2.11	2.64	5.37
Rep2 P12 A	140	100	140	150
Rep2 P12 A	80	70	100	120
Rep2 P12 A	40	50	80	110
Rep2 P12 A	120	140	140	160
Mean	95	90	115	135
Force (kgf/cm2)	6.69	-6.34	8.1	9.5
Rep2 P12 B	4 0	80	100	120
Rep2 P12 B	40	80	100	140
Rep2 P12 B	80	120	140	160
Rep2 P12 B	60	90	120	140
Mean	55	92.5	115	140
Force (kgf/cm2)	3.87	6.51	8.1	9.86
Rep2 P2 A	10	40	60	90
Rep2 P2 A	10	40	80	90
Rep2 P2 A	10	2 0	60	70
Rep2 P2 A	20	40.	80	90
Mean	12.5	35	70	85
Force (kgf/cm2)	0.88	2.46	4.93	5.98
Rep2 P2 B	40	40	100	100
Rep2 P2 B	30	40	80	120
Rep2 P2 B	20	40	80	100
Rep2 P2 B	20	60	80	120
Mean	27.5	45	85	122.5
Force (kgf/cm2)	1.94	'3.17	5.98	8.62
Rep2 P14 A	20	30'	60	80
Rep2 P14 A	25	40	80	110
Rep2 P14 A	30	40	90	100
Rep2 P14 A	60	80	100	100
Mean	33.75	47.5	82.5	97.5
Force (kgf/cm2)	2.38	3.34	5.81	6.86
Rep2 P14 B	30	60	100	110
Rep2 P14 B	30	40	80	100
Rep2 P14 B	20	20	65	80
Rep2 P14 B	20	40	60	100

Mean	25	40	76.25	9 7 . 5
Force (kgf/cm2)	1.76	2.82	5.37	6.86
Rep2 P10 A	40	60	80	120
Rep2 P10 A	30	35	60	80
Rep2 P10 A	15	20	25	90
Rep2 P10 A	15	25	25	50
Mean	21.5	35	47.5	85
Force (kgf/cm2)	1.51	2.46	3.34	5.98
Rep2 P10 B	10	35	20	30
Rep2 P10 B	1 5	'15	20	40
Rep2 PI0 B	15	25	45	80
Rep2 PI0 B	35	35	60	100
Mean	1 a.75	27.5	36.25	62.5
Force (kgflcm2)	1.32	1.94	2.55	4.4
Rep2 PI A	20	25	45	70
Rep2 PI A	5	10	20	50
Rep2 PI A	10	20	25	50
Rep2 PI A	10	30	50	80
Mean	11.25	21.25	35	62.5
Force (kgf/cm2)	0.79	1.5	2.46	4.4
Rep2 PI B	10	20	30	50
Rep2 P1 B	20	25	30	70
Rep2 PI B	20	25	50	70
Rep2 PI B	20	25	30	50
Mean	17.5	23.75	35	60
Force (kgf/cm2)	1.23	1.67	2.46	4.22
Rep2 P15 A	30	60	70	85
Rep2 P15 A	20	50	70	90
Rep2 P15 A	30	45	60	80
Rep2 P15 A	30	55	80	100
Mean	27.5	52.5	70	88.75
Force (kgf/cm2)	1.94	3.7	4.93	6.25
Rep2 P15 B	30	40	55	90
Rep2 P15 B	30	45	60	85
Rep2 P15 B	40	55	70	80
Rep2 P15 B	40	60	70	90
Mean	35	50	63.75	86.25
Force (kgf/cm2)	2.46	3.52	4.49	6.07
Rep2 P6 A	30	45	65	85
Rep2 P6 A	20	30	40	50
Rep2 P6 A	30	40	60	75
Rep2 P6 A	30	40	70	85
Mean	27.5	38.75	58.75	73.75
Force (kgf/cm2)	1.94	2.73	4.14	5 . 1 9
Rep2 P6 B	25	40	60	70
Rep2 P6 B	20	30	60	80
Rep2 P6 B	20	35	60	80
Rep2 P6 B	30	40	60	80
Mean	23.75	36.25	60	77.5

Force (kgf/cm2)	1.67	2.55	4.22	5.46
Rep2 P5 A	35	60	80	110
Rep2 P5 A	20	40	80	100
Rep2 P5 A	40	60	80	100
Rep2 P5 A	35	40	100	120
Mean	32.5	50	85	107.5
Force (kgf/cm2)	2.29	3.52	5.98	7.57
Rep2 P5 B	25	40	60	60
Rep2 P5 B	20	25	60	100
Rep2 P5 B	20	25	80	100
Rep2 P5 B	40	50	90	100
Mean	26.25	35	72.5	90
Force (kgf/cm2)	1.85	2.46	5.1	6.34
Rep2 P3 A	30	45	70	90
Rep2 P3 A	50	60	70	90
Rep2 P3 A	40	65	90	100
Rep2 P3 A	20	40	70	80
Mean	35	52.5	75	90
Force (kgf/cm2)	2.46	3.7	5.28	6.34
Rep2 P3 B	40	60	70	80
Rep2 P3 B	70	75	90	100
Rep2 P3 B	40	60	70	90
Rep2 P3 B	30	40	60	80
Mean	45	58.75	72.5	87.5
Force (kgf/cm2)	3.17	4.14	5.1	6.16
Rep2 P7 A	10	10	20	40
Rep2 P7 A	5	15	25	50
Rep2 P7 A	10	10	15	60
Rep2 P7 A	10	10	20	80
Mean	8.75	11.25	20	57.5
Force (kgf/cm2)	0.62	0.79	1.41	4.05
Rep2 P7 B	10	10	20	30
Rep2 P7 B	10	20	20	25
Rep2 P7 B	10	15	30	60
Rep2 P7 B	10	15	20	50
Mean	10	15	22.5	41.25
Force (kgf/cm2)	0.7	1.06	1.58	2.9
Rep2 P4 A	40	40	80	80
Rep2 P4 A	10	20	40	80
Rep2 P4 A	10	20	40	70
Rep2 P4 A	40	40	40	80
Mean	25	30	50	77.5
Force (kgf/cm2)	1.76	2.11	3.52	5.46
Rep2 P4 B	80	50	60	100
Rep2 P4 B	15	20	40	80
Rep2 P4 B	10	20	25	40
Rep2 P4 B	10	20	30	65
Mean	28.75	27.5	38.75	71.25
Force (kgf/cm2)	2.02	1.94	2.73	5.02

Table C. Continued

Samples	3" depth	6" depth	9" depth	12" depth
Rep3 PI 3 A	20	25	20	30
Rep3 P13 A	5	20	25	40
Rep3 P13 A	5	'15	20	40
Rep3 P13 A	40	40	45	60
Mean	17.5	25	27.5	42.5
Force (kgf/cm2)	Y.23	1.76	1.94	2.99
Rep3 P13 B	20	40	50	60
Rep3 P13 B	5	'15	20	30
Rep3 P13 B	20	20	40	45
Rep3 P13 B	10	'15	20	30
Mean	13.75	22.5	32.5	41.25
Force (kgf/cm2)	0.97	1.58	2.29	2.90
Rep3 P12 A	35	'70	80	90
Rep3 P12 A	60	'70	75	90
Rep3 Pi2 A	45	60	70	80
Rep3 P12 A	30	45	65	85
Mean	42.5	61.25	72.5	86.25
Force (kgf/cm2)	2.99	4.31	5.10	6.07
Rep3 P12 B	40	60	85	120
Rep3 P12 B	40	50	70	90
Rep3 P12 B	40	60	70	85
Rep3 P12 B	55	80	90	110
Mean	43.75	62.5	78.75	101.25
Force (kgf/cm2)	3.08	4.40	5.54	7.13
Rep3 P2 A	20	30	40	70
Rep3 P2 A	10	25	50	70
Rep3 P2 A	20	25	35	50
Rep3 P2 A	20	25	60	80
Mean	17.5	26.25	46.25	67.5
Force (kgf/cm2)	1.23	1.85	3.26	4.75
Rep3 P2 B	20	20	20	20
Rep3 P2 B	60	40	60	50
Rep3 P2 B	110	60	80	80
Rep3 P2 B	120	80	100	100
Mean	77.5	50	65	62.5
Force (kgf/cm2)	5.46	3.52	4.58	4.40
Rep3 P14 A	10	40	80	100
Rep3 P14 A	20	40	60	80
Rep3 P14 A	10	30	50	60
Rep3 P14 A	10	30	50	80
Mean	12.5	35	60	80
Force (kgf/cm2)	0.88	2.46	4.22	5.63
Rep3 P14 B	20	30	40	60
Rep3 P14 B	20	40	60	70
Rep3 P14 B	10	30	40	60
Rep3 P14 B	20	25	40	60

Mean	17.5	31.25	45	62.5
Force (kgf/cm2)	1.23	2.20	3.17	4.40
Rep3 P10 A	20	30	40	60
Rep3 P10 A	50	5	20	40
Rep3 PI0 A	15	20	40	45
Rep3 PI0 A	20	25	35	60
Mean	26.25	20	33.75	5 1 . 2 5
Force (kgf/cm2)	1.85	1.41	2.38	3.61
Rep3 P10 B	10	15	45	40
Rep3 P10 B	10	30	40	60
Rep3 P10 B	20	40	80	90
Rep3 P10 B	20	25	25	40
Mean	15	27.5	47.5	57.5
Force (kgf/cm2)	1.06	1.94	3.34	4.05
Rep3 PI A	20	25	50	60
Rep3 PI A	20	30	50	90
Rep3 P1 A	20	45	80	90
Rep3 P1 A	15	20	25	50
Mean	18.75	30	51.25	72.5
Force (kgf/cm2)	1.32	2.11	3.61	5.10
Rep3 P1 B	20	25	45	75
Rep3 P1 B	20	20	30	40
Rep3 P1 B	10	20	60	80
Rep3 PI B	5	20	35	60
Mean	13.75	21.25	42.5	63.75
Force (kgf/cm2)	0.97	1.50	2.99	4.49
Rep3 P15 A	50	70	80	90
Rep3 P15 A	60	70	75	60
Rep3 P15 A	40	80	90	85
Rep3 P15 A	55	70	75	80
Mean	51.25	72.5	80	78.75
Force (kgf/cm2)	3.61	5.10	5.63	5.54
Rep3 P15 B	60	70	45	75
Rep3 P15 B	40	50	45	65
Rep3 P15 B	40	60	70	75
Rep3 P15 B	40	50	65	70
Mean	45	57.5	56.25	71.25
Force (kgf/cm2)	3.17	4.05	3.96	5.02
Rep3 P6 A	40	50	60	75
Rep3 P6 A	30	40	50	80
Rep3 P6 A	40	50	60	70
Rep3 P6 A	40	60	70	95
Mean	37.5	50	60	80
Force (kgf/cm2)	2.64	3.52	4.22	5.63
Rep3 P6 B	60	70	90	120
Rep3 P6 B	40	60	70	85
Rep3 P6 B	40	60	80	110
Rep3 P6 B	60	70	90	120
Mean	50	65	82.5	108.75

Force (kgf/cm2)	3.52	4.58	5.81	7.66
Rep3 P5 A	10	20	25	45
Rep3 P5 A	20	40	65	80
Rep3 P5 A	5	20	45	45
Rep3 P5 A	10	40	50	50
Mean	11.25	30	46.25	55
Force (kgf/cm2)	0.79	2.11	3.26	3.87
Rep3 P5 B	15	20	60	70
Rep3 P5 B	20	30	45	60
Rep3 P5 B	20	30	40	50
Rep3 P5 B	15	20	50	65
Mean	17.5	25	48.75	61.25
Force (kgf/cm2)	1.23	1.76	3.43	4.31
Rep3 P3 A	60	80	95	105
Rep3 P3 A	60	90	120	140
Rep3 P3 A	40	50	60	90
Rep3 P3 A	50	60	100	110
Mean	52.5	70	93.75	111.25
Force (kgf/cm2)	3.70	4.93	6.60	7.83
Rep3 P3 B	40	50	60	70
Rep3 P3 B	20	40	60	80
Rep3 P3 B	40	50	65	85
Rep3 P3 B	40	70	90	100
Mean	35	52.5	68.75	83.75
Force (kgf/cm2)	2.46	3.70	4.84	5.90
Rep3 P7 A	10	40	40	40
Rep3 P7 A	20	30	40	40
Rep3 P7 A	20	30	40	60
Rep3 P7 A	10	20	40	50
Mean	15	30	40	47.5
Force (kgf/cm2)	1.06	2.11	2.82	3.34
Rep3 P7 B	20	20	60	120
Rep3 P7 B	15	40	80	100
Rep3 P7 B	20	40	60	80
Rep3 P7 B	10	20	80	100
Mean	16.25	30	70	100
Force (kgf/cm2)	1.14	2.11	4.93	7.04
Rep3 P4 A	20	40	20	55
Rep3 P4 A	20	40	30	50
Rep3 P4 A	20	30	35	60
Rep3 P4 A	20	30	30	90
Mean	20	35	28.75	63.75
Force (kgf/cm2)	1.41	2.46	2.02	4.49'
Rep3 P4 B	15	20	40	60
Rep3 P4 B	20	25	40	55
Rep3 P4 B	25	20	30	60
Rep3 P4 B	10	20	30	70
Mean	17.5	21.25	35	61.25
Force (kgf/cm2)	1.23	1 50	2.46	4.31

Table C. Continued

Samples	3" depth	6" depth	9" depth	12" depth
Rep4 P13 A	30	20	20	50
Rep4 P13 A	40	35	35	80
Rep4 P13 A	36	40	30	60
Rep4 P13 A	20	20	30	60
Mean	31.5	28.75	28.75	62.5
Force (kgf/cm2)	2.22	2.02	2.02	4.40
Rep4 P13 B	40	35	50	100
Rep4 P13 B	35	40	50	90
Rep4 P13 B	30	3 5	40	95
Rep4 P13 B	50	20	50	100
Mean	38.75	32.5	47.5	96.25
Force (kgf/cm2)	2.73	2.29	3.34	6.78
Rep4 P12 A	30	40	60	100
Rep4 P12 A	90	80	85	100
Rep4 P12 A	50	90	95	100
Rep4 P12 A	40	60	100	120
Mean	52.5	67.5	85	105
Force (kgf/cm2)	3.70	4.75	5.98	7.39
Rep4 P12 B	50	95	80	70
Rep4 P12 B	35	50	80	30
Rep4 P12 B	65	60	80	80
Rep4 P12 B	90	80	80	80
Mean	60	71.25	80	65
Force (kgf/cm2)	4.22	5.02	5.63	4.58
Rep4 P2 A	40	50	100	95
Rep4 P2 A	35	80	90	90
Rep4 P2 A	60	40	110	110
Rep4 P2 A	50	40	120	110
Mean	46.25	52.5	105	101.25
Force (kgf/cm2)	3.26	3.70	7.39	7.13
Rep4 P2 B	20	20	80	90
Rep4 P2 B	40	70	130	120
Rep4 P2 B	10	40	80	100
Rep4 P2 B	40	40	100	110
Mean	27.5	42.5	97.5	105
Force (kgf/cm2)	1.94	2.99	6.86	7.39
Rep4 P14 A	25	10	15	55
Rep4 P14 A	25	45	25	70
Rep4 P14 A	10	20	40	30
Rep4 P14 A	10	25	35	70
Mean	17.5	25	28.75	56.25
Force (kgf/cm2)	1.23	1.76	2.02	3.96
Rep4 P14 B	20	35	40	45
Rep4 P14 B	35	40	55	35
Rep4 P14 B	5	20	55	60
Rep4 P14 B	15	35	65	90

Mean	18.75	32.5	53.75	57.5
Force (kgf/cm2)	1.32	2.29	3.78	4.05
Rep4 PI0 A	15	20	40	50
Rep4 P10 A	5	20	30	40
Rep4 P10 A	40	40	40	60
Rep4 Pi 0 A	2 0	30	40	40
Mean	20	27.5	37.5	47.5
Force (kgf/cm2)	1.41	1.94	2.64	3.34
Rep4 PI0 B	15	20	20	30
Rep4 P10 B	15	2 0	40	40
Rep4 PI0 B	40	35	40	60
Rep4 PI0 B	35	40	40	85
Mean	26.25	28.75	35	53.75
Force (kgf/cm2)	1.85	2.02	2.46	3.78
Rep4 PI A	25	70	60	90
Rep4 P1 A	40	40	50	60
Rep4 P1 A	10	15	20	20
Rep4 P1 A	30	40	35	100
Mean	26.25	41.25	41.25	67.5
Force (kgf/cm2)	1.85	2.90	2.90	4.75
Rep4 PI B	20	20	40	110
Rep4 P1 B	15	30	50	50
Rep4 PI B	10	40	35	80
Rep4 P1 B	15	30	40	80
Mean	15	30	41.25	80
Force (kgf/cm2)	1.06	2.11	2.90	5.63
Rep4 P15 A	30	60	100	100
Rep4 P15 A	40	60	130	130
Rep4 P15 A	40	65	85	110
Rep4 P15 A	40	130	110	120
Mean	37.5	66.25	i06.25	115
Force (kgf/cm2)	2.64	4.66	7.48	8.10
Rep4 P15 B	40	60	80	90
Rep4 PI5 B	30	40	70	110
Rep4 P15 B	20	60	90	130
Rep4 P15 B	30	60	80	100
Mean	30	55	80	107.5
Force (kgf/cm2)	2.11	3.87	5.63	7.57
Rep4 P6 A	40	60	95	125
Rep4 P6 A	30	60	115	120
Rep4 P6 A	30	60	85	100
Rep4 P6 A	25	'70	85	115
Mean	31.25	62.5	95	115
Force (kgf/cm2)	2.20	4.40	6.69	8.10
Rep4 P6 B	35	50	65	110
Rep4 P6 B	55	100	110	140
Rep4 P6 B	40	80	100	115
Rep4 P6 B	30	60	80	120
Mean	40	72.5	88.75	121.25

Force (kgf/cm2)	2.82	5.10	6.25	8.54
Rep4 P5 A	40	40	80	100
Rep4 P5 A	20	60	100	130
Rep4 P5 A	2'0	80	110	145
Rep4 P5 A	15	60	80	140
Mean	23.75	60	92.5	1 28.75
Force (kgf/cm2)	1.67	4.22	6.51	9.06
Rep4 P5 B	20	60	80	90
Rep4 P5 B	20	60	80	90
Rep4 P5 B	10	20	60	95
Rep4 P5 B	15	20	60	80
Mean	16.25	40	70	88.75
Force (kgf/cm2)	1.14	2.82	4.93	6.25
Rep4 P3 A	5	50	80	95
Rep4 P3 A	20	50	80	100
Rep4 P3 A	40	80	105	115
'Rep4 P3 A	35	60	105	120
Mean	25	60	92.5	107.5
Force (kgf/cm2)	1.76	4.22	6.51	7.57
Rep4 P3 B	40	60	80	100
Rep4 P3 B	20	60	90	110
Rep4 P3 B	30	60	100	115
Rep4 P3 B	35	70	100	120
Mean	31.25	62.5	92.5	111.25
Force (kgf/cm2)	2.20	4.40	6.51	7.83
Rep4 P7 A	10	'35	60	80
Rep4 P7 A	20	40	60	85
Rep4 P7 A	20	40	55	70
Rep4 P7 A	10	30	60	75
Mean	15	36.25	58.75	77.5
Force (kgf/cm2)	1.06	2.55	4.14	5.46
Rep4 P7 B	10	40	60	85
Rep4 P7 B	10	45	75	90
Rep4 P7 B	5	5	20	45
Rep4 P7 B	10	20	35	85
Mean	8.75	27.5	47.5	76.25
Force (kgf/cm2)	0.62	1.94	3.34	5.37
Rep4 P4 A	5	15	20	40
Rep4 P4 A	20	20	40	100
Rep4 P4 A	20	20	40	60
Rep4 P4 A	15	20	20	40
Mean	15	18.75	30	60
Force (kgf/cm2)	1.06	1.32	2.11	4.22
Rep4 P4 B	15	20	60	80
Rep4 P4 B	5	10	40	40
Rep4 P4 B	5	20	40	100
Rep4 P4 B	20	20	40	60
Mean	11.25	17.5	45	70
Force (kgf/cm2)	0.79	1.23	3.17	4.93

Table D. Water infiltration rate on the IPM plots

Samples	T (mn)	ElapsedT	W.h(cm)	Ir(cm/hr)	Samples	T (mn)	ElapsedT	W.h(cm	Ir(cm/hr)
Pi R 2A	2.5	2.5	4.1	112.8	PI R 3B	30	5	2.3	27.6
Pi R 2A	5	2.5	2.5	60	. Pi R 3B	35	5	1.9	22.8
PI R 2A	7.5	2.5	3.1	74.4	PI R 3B	40	5	2	24
Pi R 2A	10	2.5	2.2	52.8	PI R 3B	50	10	1.8	21.6
PI R 2A	12.5	2.5	1.9	45.6	PI R 3B	60	10	3.7	22.2
Pi R 2A	15	2.5	2.2	52.8	PI R 38	70	10	3.1	18.6
PI R 2A	20	5	3.6	43.2	Pi R 3B	80	10	3.2	19.2
PI R 2A	25	5	3.6	43.2	P1 R 3B	90	10	3.4	18.6
Pi R 2A	30	5	3.1	37.2	PI R 3B	100	10	3	18
Pi R 2A	35	5	3.2	38.4	Pi R 3B	110	10	3.1	18.6
Pi R 2A	40	5	2.8	33.6	PI R 3B	120	10	3	18
Pi R 2A	50	10	5.9	35.4	PI R 4A	1.5	1.5	1.6	64
Pi R 2A	60	10	5.2	31.2	P1 R 4A	3	1.5	1.5	60
PI R 2A	70	10	4.9	29.4	PI R 4A	4.5	1.5	1.3	52
PI R 2A	80	10	4.3	25.8	P I R 4A	6	1.5	1.4	56
PI R 2A	90	10	4.3	25.8	PI R 4A	7.5	1.5	1.2	48
PI R 2A	100	10	4.5	27	, PI R 4A	9	1.5	1.2	48
Pi R 2A	110	10	4.4	26	Pi R 4A	12	3	1.9	38
PI R 2A	120	10	4.5	26	P I R 4A	15	3	1.8	36
Pi R 3A	2.5	2.5	5.3	127.2	PI R 4A	18	3	1.5	30
P1 R 3A	5	2.5	3.5	84	P1 R 4A	21	3	1.3	26
Pi R 3A	7.5	2.5	3.1	88.8	PI R 4A	26	5	2.4	28.8
P1 R 3A	10	2.5	2.8	67.2	PI R 4A	31	5	2.7	32.4
Pi R 3A	12.5	2.5	3	72	Pi R 4A	36	5	2.5	30
PI R 3A	15	2.5	3.1	74.4	P1 R 4A	41	5	2.5	30
PI R 3A	20	5	6.1	73.2	Pi R 4A	51	10	3.6	21.6
Pi R 3A	25	5	5.2	62.4	P i R 4A	61	10	3.5	21
PI R 3A	30	5	5.1	61.2	PI R 4A	71	10	3.7	22.2
PI R 3A	35	5	4.1	56.4	PI R 4A	81	10	3.6	21.6
Pi R 3A	40	5	4.3	51.6	PI R 4B	1.5	1.5	1.5	60
PI R 3A	50	10	7.1	42.6	P1 R 4B	3	1.5	1.6	64
Pi R 3A	60	10	6.3	37.8	Pi R 4B	4.5	1.5	1.5	60
Pi R 3A	70	10	6.7	40.2	P1 R 4B	6	1.5	1.4	56
PI R 3A	80	10	6.9	41.4	PI R 4B	7.5	1.5	0.8	32
PI R 3A	90	10	6.9	41.4	P1 R 4B	9	1.5	0.7	28
PI R 3A	100	10	6.6	40.8	PI R 4B	12	3	1.6	32
PI R 3A	110	10	6.9	41.4	P1 R 4B	15	3	1.7.	34
PI R 3A	120	10	6.7	40.2	Pi R 4B	18	3	1.4	28
P1 R 3B	2.5	2.5	2.9	69.6	P1 R 4B	21	3	1.5	30
PI R 3B	5	2.5	1.9	45.6	PI R 4B	26	5	2.5	30
PI R 3B	7.5	2.5	1.5	36	P1 R 4B	31	5	2.9	34.8
PI. R 3B	10	2.5	1.6	38.4	PI R 4B	36	5	2.5	30
P1 R 3B	12.5	2.5	1.4	33.6	P1 R 4B	41	5	2.6	31.2
Pi R 3B	15	2.5	1.4	33.6	PI R 4B	51	10	3.8	22.8
Pi R 3B	20	5	2.7	28.8	PI R 4B	61	10	3.7	22.2
PI R 3B	25	5	2.3	27.6	PI R 4B	71	10	3.8	22.8
					Pi R 4B	81	10	3.6	21.6

Table D. Continued

Samples	T (min)	ElapsedT	W.h(cm)	Ir(cm/hr)	Samples	T (min)	ElapsedT	W.h(cm)	Ir(cm/hr)
P2 R 2A	2.5	2.5	5.5	132	P2 R 4A	18	3	3.4	40.8
P2 R 2A	5	2.5	3.4	81.6	P2 R 4A	23	5	3.4	40.8
P2 R 2A	7.5	2.5	3.3	79.2	P2 R 4A	28	5	6.5	39
P2 R 2A	10	2.5	2.7	64.8	P2 R 4A	33	5	2.3	31.8
P2 R 2A	12.5	2.5	2.8	67.2	P2 R 4A	38	5	5.1	30.6
P2 R 2A	15	2.5	2.6	62.4	P2 R 4A	48	10	4.7	28.2
P2 R 2A	20	5	6.8	71.6	P2 R 4A	58	10	4.6	27.6
P2 R 2A	25	5	5.7	68.4	P2 R 4A	68	10	4.6	27.6
P2 R 2A	30	5	5.6	67.2	P2 R 4A	78	10	4.5	27
P2 R 2A	35	5	5.2	62.4	P2 R 4B	1.5	1.5	1.3	52
P2 R 2A	40	5	3.7	57.2	P2 R 4B	3	1.5	1.1	44
P2 R 2A	50	10	7.7	46.2	P2 R 4B	4.5	1.5	0.9	36
P2 R 2A	60	10	6.5	39.6	P2 R 4B	6	1.5	0.8	32
P2 R 2A	70	10	7.1	42	P2 R 4B	7.5	1.5	0.8	32
P2 R 2A	80	10	7	42	P2 R 4B	9	1.5	0.4	16
P2 R 2A	90	10	7	42	P2 R 4B	12	3	1.3	26
P2 R 2A	100	10	7	42	P2 R 4B	15	3	1.1	22
P2 R 2A	110	10	7.1	42.6	P2 R 4B	18	3	1.1	22
P2 R 2A	120	10	7	42	P2 R 4B	23	5	1.9	22.8
P2 R 3A	2.5	2.5	3.6	67.2	P2 R 4B	28	5	1.8	21.6
P2 R 3A	5	2.5	2.9	40.8	P2 R 4B	33	5	1.6	22.8
P2 R 3A	7.5	2.5	2.6	28.8	P2 R 4B	38	5	2.5	19.2
P2 R 3A	10	2.5	2.4	36	P2 R 4B	48	10	2.4	15
P2 R 3A	12.5	2.5	2.2	31.2	P2 R 4B	58	10	2.6	14.4
P2 R 3A	15	2.5	2.1	28.8	P2 R 4B	68	10	2.6	15.6
P2 R 3A	20	5	4	26.4	P2 R 4B	78	10	2.4	14.4
P2 R 3A	25	5	3.8	24					
P2 R 3A	30	5	3.5	28.8					
P2 R 3A	35	5	3.4	27.6					
P2 R 3A	40	5	3.4	22.8					
P2 R 3A	50	10	6.5	19.2					
P2 R 3A	60	10	5.3	18.2					
P2 R 3A	70	10	5.1	18					
P2 R 3A	80	10	4.7	16.2					
P2 R 3A	90	10	4.6	15.6					
P2 R 3A	100	10	4.6	15.6					
P2 R 3A	110	10	4.5	16.2					
P2 R 3A	120	10	4.6	15.6					
P2 R 4A	1.5	1.5	2.9	69.6					
P2 R 4A	3	7.5	2.6	62.4					
P2 R 4A	4.5	1.5	2.4	57.4					
P2 R 4A	6	1.5	2.2	52.8					
P2 R 4A	7.5	1.5	2.1	50.4					
P2 R 4A	9	1.5	4	48					
P2 R 4A	12	3	3.8	45.6					
P2 R 4A	15	3	3.5	42					

Table D. Continued

Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)	Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)
P3 R 2B	2.5	2.5	2.3	55.2	P3 R 3B	30	5	1.4	16.8
P3 R 2B	5	2.5	2.3	55.2	P3 R 3B	35	5	1.2	14.4
P3 R 2B	7.5	2.5	1.7	40.8	P3 R 3B	40	5	1.3	15.6
P3 R 2B	10	2.5	1.6	38.4	P3 R 3B	50	10	2.4	14.4
P3 R 2B	12.5	2.5	1.4	33.6	P3 R 3B	60	10	2.4	14.4
P3 R 2B	15	2.5	1.4	33.6	P3 R 3B	70	10	2.3	13.8
P3 R 2B	20	5	2.7	32.4	P3 R 3B	80	10	2.4	14.4
P3 R 2B	25	5	2.6	31.2	P3 R 3B	90	10	2.2	13.2
P3 R 2B	30	5	2.6	31.2	P3 R 3B	100	10	2.1	12.6
P3 R 2B	35	5	2.4	28.8	P3 R 3B	110	10	2.2	13.2
P3 R 2B	40	5	2.4	28.8	P3 R 3B	120	10	2.2	13.2
P3 R 2B	50	10	4.3	27.6	P 3 R 4A	2.5	2.5	1.9	45.6
P3 R 2B	60	10	4.4	26.4	P 3 R 4A	5	2.5	1.8	43.2
P3 R 2B	70	10	4.4	25.8	P 3 R 4A	7.5	2.5	1.5	36
P3 R 2B	80	10	4.3	27	P 3 R 4A	10	2.5	1.4	33.6
P3 R 2B	90	10	4.5	26.4	P3 R 4A	12.5	2.5	1.5	36
P3 R 2B	100	10	4.4	26.4	P 3 R 4A	15	2.5	1.6	38.4
P3 R 2B	110	10	4.3	25.8	P3 R 4A	20	5	2.5	30
P3 R 2B	120	10	4.4	26.4	P 3 R 4A	25	5	2.2	26.4
P3 R 3A	2.5	2.5	1.6	38.4	P 3 R 4A	30	5	2.1	25.2
P3 R 3A	5	2.5	1.4	33.6	P 3 R 4A	35	5	2	24
P3 R 3A	7.5	2.5	1.1	26.4	P 3 R 4A	40	5	2.1	25.2
P3 R 3A	10	2.5	0.9	26.6	P 3 R 4A	50	10	3.5	21
P3 R 3A	12.5	2.5	1.1	26.6	P 3 R 4A	60	10	3.3	19.8
P3 R 3A	15	2.5	0.9	26.4	P3 R 4A	70	10	3.4	20.4
P3 R 3A	20	5	2.1	25.2	P 3 R 4A	80	10	3.5	21
P3 R 3A	25	5	1.8	21.6	P 3 R 4A	90	10	3.4	20.4
P3 R 3A	30	5	1.7	20.4	P 3 R 4A	100	10	3.3	19.8
P3 R 3A	35	5	1.4	16.8	P 3 R 4B	2.5	2.5	1.5	36
P3 R 3A	40	5	1.4	16.8	P 3 R 4B	5	2.5	1.2	28.8
P3 R 3A	50	10	3.2	19.2	P 3 R 4B	7.51	2.5	1.1	26.4
P3 R 3A	60	10	3.7	22.2	P 3 R 4B	10	2.5	0.9	21.4
P3 R 3A	70	10	3.3	19.8	P 3 R 4B	12.5	2.5	0.9	21.4
P3 R 3A	80	10	3	18	P 3 R 4B	15	2.5	1	24
P3 R 3A	90	10	3	18	P 3 R 4B	20	5	2.5	30
P3 R 3A	100	10	3	18	P 3 R 4B	25	5	2.2	26.4
P3 R 3A	110	10	3.1	18.6	P 3 R 4B	30	5	2.1	25.2
P3 R 3A	120	10	2.9	17.4	P 3 R 4B	35	5	1.7	20.4
P3 R 3B	2.5	2.5	1.5	36	P 3 R 4B	40	5	1.8	21.6
P3 R 3B	5	2.5	1.1	26.4	P 3 R 4B	50	10	3.9	23.4
P3 R 3B	7.5	2.5	1	24	P 3 R 4B	60	10	3.6	21.6
P3 R 3B	10	2.5	0.8	19.2	P 3 R 4B	70	10	4	24
P3 R 3B	12.5	2.5	0.9	21.6	P 3 R 4B	80	10	3.9	21.6
P3 R 3B	15	2.5	0.8	19.2	P 3 R 4B	90	10	4	24
P3 R 3B	20	5	1.8	21.6	P 3 R 4B	100	10	3.8	22.8
P3 R 3B	25	5	1.6	19.2					

Table D. Continued

Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)	Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)
P4 R 2A	2.5	2.5	5.9	141.6	P4 R 3A	35	5	1.7	20.4
P4 R 2A	5	2.5	3.3	79.2	P4 R 3A	40	5	1.8	21.6
P4 R 2A	7.5	2.5	3	72	P4 R 3A	50	10	1.8	10.8
P4 R 2A	10	2.5	2.5	60	P4 R 3A	60	10	1.8	10.8
P4 R 2A	12.5	2.5	2.1	50.4	P4 R 3A	70	10	3.5	9
P4 R 2A	15	2.5	2.1	50.4	P4 R 3A	80	10	1.3	7.8
P4 R 2A	20	5	3.7	44.4	P4 R 3A	90	10	1.2	7.2
P4 R 2A	25	5	3.2	38.4	P4 R 3A	100	10	1.1	6.6
P4 R 2A	30	5	2.7	32.4	P4 R 3A	110	10	1.2	7.2
P4 R 2A	35	5	2.3	27.6	P4 R 3A	120	10	1	6
P4 R 2A	40	5	2.6	31.2	P4 R 3B	2.5	2.5	2	48
P4 R 2A	50	10	4.2	25.2	P4 R 3B	5	2.5	1.3	31.2
P4 R 2A	60	10	4.7	28.2	P4 R 3B	7.5	2.5	1.1	26.4
P4 R 2A	70	10	3.4	20.4	P4 R 3B	10	2.5	1.2	28.8
P4 R 2A	80	10	3.1	18.6	P4 R 3B	12.5	2.5	0.4	9.6
P4 R 2A	90	10	3.2	19.2	P4 R 3B	15	2.5	0.5	12
P4 R 2A	100	10	3.1	18.6	P4 R 3B	20	5	0.9	10.8
P4 R 2A	110	10	3	18	P4 R 3B	25	5	0.8	9.6
P4 R 2A	120	10	3.1	18.6	P4 R 3B	30	5	0.5	6
P4 R 2B	2.5	2.5	3.5	84	P4 R 3B	35	5	1.2	14.4
P4 R 2B	5	2.5	2.8	67.2	P4 R 3B	40	5	1.2	14.4
P4 R 2B	7.5	2.5	2	48	P4 R 3B	50	10	1	6
P4 R 2B	10	2.5	1.7	40.8	P4 R 3B	60	10	1.2	7.2
P4 R 2B	12.5	2.5	1.8	43.2	P4 R 3B	70	10	1.1	6.6
P4 R 2B	15	2.5	1.6	38.4	P4 R 3B	80	10	1.1	6.6
P4 R 2B	20	5	2.9	34.8	P4 R 3B	90	10	1.1	6.6
P4 R 2B	25	5	3	36	P4 R 3B	100	10	1.1	6.6
P4 R 2B	30	5	2.6	31.2	P4 R 3B	110	10	1.1	6.6
P4 R 2B	35	5	2.6	31.2	P4 R 3B	120	10	1	6
P4 R 2B	40	5	2.2	26.4	P4 R 4A	2.5	2.5	6.J	160.8
P4 R 2B	50	10	5	30	P4 R 4A	5	2.5	3	72
P4 R 2B	60	10	4.1	24.6	P4 R 4A	7.5	2.5	2.7	64.8
P4 R 2B	70	10	3.7	22.2	P4 R 4A	10	2.5	2.4	57.6
P4 R 2B	80	10	3.6	21.6	P4 R 4A	12.5	2.5	2.3	55.2
P4 R 2B	90	10	3.7	22.2	P4 R 4A	15	2.5	1.9	45.6
P4 R 2B	100	10	3.5	21	P4 R 4A	20	5	4	48
P4 R 2B	110	10	3.6	21.6	P4 R 4A	25	5	3.4	40.8
P4 R 2B	120	10	3.6	21.6	P4 R 4A	30	5	3.5	42
P4 R 3A	2.5	2.5	3	72	P 4 R 4A	35	5	2.8	33.6
P4 R 3A	5	2.5	2.2	52.8	P4 R 4A	40	5	2.5	3 0
P4 R 3A	7.5	2.5	1.3	31.2	P4 R 4A	50	10	5.8	34.8
P4 R 3A	10	2.5	1.1	26.4	P4 R 4A	60	10	6	36
P4 R 3A	12.5	2.5	1.2	28.8	P4 R 4A	70	10	6	36
P4 R 3A	15	2.5	1.1	26.4	P4 R 4A	80	10	3.3	19.8
P4 R 3A	20	5	1.6	19.2	P4 R 4A	90	10	3.6	21.6
P4 R 3A	25	5	1.6	19.2	P4 R 4A	100	10	3.9	23.4
P4 R 3A	30	5	1.6	19.2	P4 R 4A	110	10	3.8	22.8

Table D. Continued

Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)	Samples	T (min)	Elapsed	W.h(cm)	(cm/hr)
P 5 R 2A	2.5	2.5	4.3	103.2,	P 5 R 3A	35	5	4.6	55.2
P 5 R 2A	5	2.5	3.7	88.8	P5 R 3A	40	5	4.7	56.4
P 5 R 2A	7.5	2.5	3.4	81.6	P 5 R 3A	50	10	8.1	50.4
P 5 R 2A	10	2.5	2.6	62.4	P 5 R 3A	60	10	7.9	47.4
P 5 R 2A	12.5	2.5	3.2	76.4	P 5 R 3A	70	10	7.9	47.4
P 5 R 2A	15	2.5	2.6	62.4	P 5 R 3A	80	10	7.7	46.2
P 5 R 2A	20	5	5.5	66	P 5 R 3A	90	10	7.6	45.6
P 5 R 2A	25	5	5.2	62.4	P5 R 3A	100	10	7	42
P 5 R 2A	30	5	5.1	61.2	P 5 R 3A	110	10	7.5	45
P 5 R 2A	35	5	5	60	P 5 R 3A	120	10	7.6	45.6
P 5 R 2A	40	5	4.7	56.4	P 5 R 3B	2.5	2.5	5.5	132
P 5 R 2A	50	10	7.13	46.8	P 5 R 3B	5	2.5	4.2	100.8
P 5 R 2A	60	10	7.13	46.8	P 5 R 3B	7.5	2.5	4.6	110.4
P 5 R 2A	70	10	7.7	46.2	P 5 R 3B	10	2.5	3.3	79.2
P 5 R 2A	80	10	7.7	46.2	P 5 R 3B	12.5	2.5	3.4	81.6
P 5 R 2A	90	10	7.6	45.2	P 5 R 3B	15	2.5	3.3	79.2
P 5 R 2A	100	10	7.7	46.2	P5 R 3B	20	5	5.9	70.8
P 5 R 2A	110	10	7.8	46.8	P 5 R 3B	25	5	5.6	67.2
P 5 R 2A	120	10	7.7	46.2	P 5 R 3B	30	5	4.5	54
P 5 R 2B	2.5	2.5	5.1	122.4	P 5 R 3B	35	5	5.1	61.2
P 5 R 2B	5	2.5	3.4	81.6	P 5 R 3B	40	5	4.4	52.8
P 5 R 2B	7.5	2.5	3.8	91.2	P 5 R 3B	50	10	9.3	55.8
P 5 R 2B	10	2.5	3.4	89.6	P 5 R 3B	60	10	9	54
P 5 R 2B	12.5	2.5	3.7	88.8	P 5 R 3B	70	10	a.9	53.4
P 5 R 2B	15	2.5	3	72	P 5 R 3B	80	10	8.9	53.4
P 5 R 2B	20	5	6.2	74.4	P 5 R 3B	90	10	8.8	52.8
P 5 R 2B	25	5	5.9	70.8	P 5 R 3B	100	10	a.9	53.4
P 5 R 2B	30	5	5.5	66	P 5 R 3B	110	10	8.8	52.8
P 5 R 2B	35	5	5.1	61.2	P 5 R 3B	120	10	a.8	52.8
P 5 R 2B	40	5	5.3	63.6	P 5 R 4A	2.5	2.5	2.8	67.2
P 5 R 2B	50	10	7.8	46.8	P 5 R 4A	5	2.5	2.1	50.4
P 5 R 2B	60	10	8	48	P 5 R 4A	7.5	2.5	1.9	45.6
P 5 R 2B	70	10	7.9	47.4	P 5 R 4A	10	2.5	1.5	36
P 5 R 2B	80	10	7.8	46.8	P 5 R 4A	12.5	2.5	1.7	40.8
P 5 R 2B	90	10	7.9	47.4	P 5 R 4A	15	2.5	1.3	31.2
P 5 R 2B	100	10	8	48	P 5 R 4A	20	5	2.5	30
P 5 R 2B	110	10	7.3	47.4	P 5 R 4A	25	5	2.2	26.4
P 5 R 2B	120	10	7.5	46.8	P 5 R 4A	30	5	2.1	25
P 5 R 3A	2.5	2.5	6.5	156	P 5 R 4A	35	5	2	24
P 5 R 3A	5	2.5	4.5	108	P 5 R 4A	40	5	1.2	14.4
P 5 R 3A	7.5	2.5	3.5	86.4	P5 R 4A	50	10	1.9	11.4
P 5 R 3A	10	2.5	3.4	81.6	P 5 R 4A	60	10	1.9	11.4
P 5 R 3A	12.5	2.5	3.6	86.4	P 5 R 4A	70	10	1.7	10.2
P 5 R 3A	15	2.5	2.9	69.6	P 5 R 4A	80	10	1.a	10.8
P 5 R 3A	20	5	5.9	70.8	P 5 R 4A	90	10	1.9	11.4
P 5 R 3A	25	5	4.8	57.6	P 5 R 4A	100	10	1.9	11.4
P 5 R 3A	30	5	4.6	55.2	P5 R 4B	2.5	2.5	1.4	33.6

Table D. Continued

Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)	Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)
P 6 R 2A	2.5	2.5	0.8	19.2	P 6 R 3A	35	5	0.8	9.6
P 6 R 2A	5	2.5	0.6	14.4	P 6 R 3A	40	5	0.9	10.8
P 6 R 2A	7.5	2.5	0.6	14.4	P6 R 3A	50	10	1.9	11.4
P 6 R 2A	10	2.5	0.6	14.4	P 6 R 3A	60	10	1.7	10.2
P 6 R 2A	12.5	2.5	0.5	12	P 6 R 3A	70	10	1.7	10.2
P 6 R 2A	15	2.5	0.4	9.6	P 6 R 3A	80	10	1.7	10.2
P 6 R 2A	20	5	1	12	P 6 R 3A	90	10	1.7	10.2
P 6 R 2A	25	5	1	12	P 6 R 3A	100	10	1.8	10.8
P 6 R 2A	30	5	1	12	P 6 R 3A	110	10	1.7	10.2
P 6 R 2A	35	5	0.9	10.8	P 6 R 3A	120	10	1.7	10.2
P 6 R 2A	40	5	1	12	P 6 R 3B	2.5	2.5	0.5	12
P 6 R 2A	50	10	2	12	P 6 R 3B	5	2.5	0.3	7.2
P 6 R 2A	60	10	2	12	P 6 R 3B	7.5	2.5	0.2	4.8
P 6 R 2A	70	10	1.8	10.8	P 6 R 3B	10	2.5	0.3	7.2
P 6 R 2A	80	10	1.9	11.4	P 6 R 3B	12.5	2.5	0.2	4.8
P 6 R 2A	90	10	2.1	12.6	P 6 R 3B	15	2.5	0.5	4.8
P 6 R 2A	100	10	1.9	11.4	P 6 R 3B	20	5	0.5	6
P 6 R 2A	110	10	2	12	P 6 R 3B	25	5	0.4	6
P 6 R 2A	120	10	1.9	11.4	P 6 R 3B	30	5	0.4	4.8
P 6 R 2B	-2.5	2.5	0.8	19.2	P 6 R 3B	35	5	0.4	4.8
P 6 R 2B	5	2.5	0.7	16.8	P 6 R 3B	40	5	0.5	6
P 6 R 2B	7.5	2.5	0.7	16.8	P 6 R 3B	50	10	0.7	4.2
P 6 R 2B	10	2.5	0.6	14.4	P 6 R 3B	60	10	0.8	4.8
P 6 R 2B	12.5	2.5	0.5	12	P 6 R 3B	70	10	0.9	5.4
P 6 R 2B	15	2.5	0.6	14.4	P 6 R 3B	80	10	0.9	5.4
P 6 R 2B	20	5	1.1	13.2	P 6 R 3B	90	10	0.8	4.8
P 6 R 2B	25	5	1.3	15.6	P 6 R 3B	100	10	0.9	5.4
P 6 R 2B	30	5	1.3	15.6	P 6 R 3B	110	10	0.9	5.4
P 6 R 2B	35	5	0.9	10.8	P 6 R 3B	120	10	0.9	5.4
P 6 R 2B	40	5	0.9	10.8	P 6 R 4A	2.5	2.5	0.6	14.4
P 6 R 2B	50	10	2.1	12.6	P 6 R 4A	5	2.5	0.4	9.6
P 6 R 2B	60	10	2	12	P 6 R 4A	7.5	2.5	0.3	7.2
P 6 R 2B	70	10	1.9	11.4	P 6 R 4A	10	2.5	0.5	12
P 6 R 2B	80	10	2	12	P 6 R 4A	12.5	2.5	0.4	9.6
P 6 R 2B	90	10	2	12	P 6 R 4A	15	2.5	0.3	7.2
P 6 R 2B	100	10	2	12	P 6 R 4A	20	5	0.7	8.4
P 6 R 2B	110	10	2.1	12.6	P 6 R 4A	25	5	0.7	8.4
P 6 R 2B	120	10	2	12	P 6 R 4A	30	5	0.7	8.4
P 6 R 3A	2.5	2.5	0.8	19.2	P 6 R 4A	35	5	0.6	7.2
P 6 R 3A	5	2.5	0.6	14.4	P 6 R 4A	40	5	0.5	6
P 6 R 3A	7.5	2.5	0.6	14.4	P 6 R 4A	50	10	1.1	6.6
P 6 R 3A	10	2.5	0.6	14.4	P 6 R 4A	60	10	1.1	6.6
P 6 R 3A	12.5	2.5	0.5	12	P 6 R 4A	70	10	1.3	7.8
P 6 R 3A	15	2.5	0.5	12	P 6 R 4A	80	10	1.8	10.8
P 6 R 3A	20	5	1	12	P 6 R 4A	90	10	1	6
P 6 R 3A	25	5	1	12	P 6 R 4A	100	10	1	6
P 6 R 3A	30	5	1	12	P 6 R 4A	110	10	0.9	5.4

Table D. Continued

Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)	Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)
P 7 R 2A	2.5	2.5	4.7	112.8.	P 7 R 3A	35	5	2.1	25.2
P 7 R 2A	5	2.5	4.5	108	P 7 R 3A	40	5	1.4	16.8
P 7 R 2A	7.5	2.5	3.8	91.2	P 7 R 3A	50	10	4.1	24.6
P 7 R 2A	10	2.5	3.2	76.8	P 7 R 3A	60	10	3.6	21.6
P 7 R 2A	12.5	2.5	3	72	P 7 R 3A	70	10	3.9	23.4
P 7 R 2A	15	2.5	2.6	62.4	P7 R 3A	80	10	3.5	21
P 7 R 2A	20	5	4.8	57.6	P7 R 3A	90	10	3.7	22.2
P 7 R 2A	25	5	4.7	56.4	P 7 R 3A	100	10	3.5	21
P 7 R 2A	30	5	4.2	50.4	P7 R 3A	110	10	3.8	22.8
P 7 R 2A	35	5	3.3	39.6	P7 R 3A	120	10	3.6	21.6
P 7 R 2A	40	5	3.4	40.8	P 7 R 3B	2.5	2.5	7	168
P 7 R 2A	50	10	4.5	27	P 7 R 3B	5	2.5	3.7	88.8
P 7 R 2A	60	10	5.4	32.4	P 7 R 3B	7.5	2.5	2.8	67.2
P 7 R 2A	70	10	4.9	29.4	P7 R 3B	10	2.5	2.3	55.2
P 7 R 2A	80	10	4.8	28.8	P7 R 3B	12.5	2.5	3.7	88.8
P 7 R 2A	90	10	4.9	29.4	P 7 R 3B	15	2.5	3.8	91.2
P 7 R 2A	100	10	4.8	28.8	P 7 R 3B	20	5	3.6	43.2
P 7 R 2A	110	10	4.8	28.8	P7 R 3B	25	5	2.6	31.2
P 7 R 2A	120	10	4.8	29.4	P7 R 3B	30	5	1.9	22.8
P 7 R 2B	2.5	2.5	4.8	115.2	P 7 R 3B	35	5	2.2	26.4
P 7 R 2B	5	2.5	2.4	57.6	P 7 R 3B	40	5	2.1	25.2
P 7 R 2B	7.5	2.5	2.2	52.8	P 7 R 3B	50	10	4.5	27
P 7 R 2B	10	2.5	2	48	P 7 R 3B	60	10	4.6	27.6
P 7 R 2B	12.5	2.5	1.8	43.2	P 7 R 3B	70	10	4.5	27
P 7 R 2B	15	2.5	1.8	43.2	P 7 R 3B	80	10	4.4	26.4
P 7 R 2B	20	5	3	36	P 7 R 3B	90	10	4.6	27.6
P 7 R 2B	25	5	2.8	33.6	P7 R 3B	100	10	4.5	27
P 7 R 2B	30	5	2.6	31.2	P 7 R 3B	110	10	4.E	27.6
P 7 R 2B	35	5	2.4	28.8	PJ R 3B	120	10	4.5	27
P 7 R 2B	40	5	2.3	27.6	P 7 R 4A	2.5	2.5	6	144
P 7 R 2B	50	10	5.5	33	P 7 R 4A	5	2.5	4.1	146
P 7 R 2B	60	10	5.2	31.2	P 7 R 4A	7.5	2.5	1.8	108
P 7 R 2B	70	10	4.1	24.6	P 7 R 4A	10	2.5	3.3	79.2
P 7 R 2B	80	10	41	24.6	P 7 R 4A	12.5	2.5	4.7	112.8
P 7 R 2B	90	10	4.2	25.2	P 7 R 4A	15	2.5	2.4	57.6
P 7 R 2B	100	10	4.1	24.6	P7 R 4A	20	5	2.5	60
P 7 R 2B	110	10	4.2	25.2	P 7 R 4A	25	5	5.4	64.8
P 7 R 2B	120	10	4.1	24.6	P 7 R 4A	30	5	4	48
P 7 R 3A	2.5	2.5	5.7	136.8	P 7 R 4A	35	5	4.1l	35.14
P 7 R 3A	5	2.5	3.5	84	P 7 R 4A	40	5	3.:3	19.8
P 7 R 3A	7.5	2.5	2.7	64.8	P 7 R 4A	50	10	1.8	2.1.6
P 7 R 3A	10	2.5	2.1	50.4	P 7 R 4A	60	10	4.4	26.4
P 7 R 3A	12.5	2.5	3.2	76.8	P 7 R 4A	70	10	2.1'	16.2
P 7 R 3A	15	2.5	2.6	62.4	P 7 R 4A	80	10	l.t3	10.8
P 7 R 3A	20	5	3.1	35.2	P 7 R 4A	90	10	1.4	8.4
P 7 R 3A	25	5	2.4	28.8	P 7 R 4A	100	10	1.13	7.8
P 7 R 3A	30	5	2.3	27.6	P 7 R 4A	110	10	1.3	7.8

Table D. Continued

Samples	T (min)	Elapsed	W.h(cm)	Ir (cmlhr)	Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)
P 10 R 2A	2.5	2.5	3.9	93.6	P 10 R 3A	30	5	2.4	28.8
P 10 R 2A	5	2.5	2.6	62.4	P 10 R 3A	35	5	2.3	27.6
P 10 R 2A	7.5	2.5	2.4	57.4	P 10 R 3A	40	5	1.9	22.8
P 10 R 2A	10	2.5	1.9	45.6	P 10 R 3A	50	10	3.2	19.2
P 10 R 2A	12.5	2.5	2.2	52.8	P 10 R 3A	60	10	3.1	18.6
P 10 R 2A	15	2.5	1.6	38.4	P 10 R 3A	70	10	3	18
P 10 R 2A	20	5	3.9	46.8	P 10 R 3A	80	10	2.7	16.2
P 10 R 2A	25	5	3	36	P 10 R 3A	90	10	2.6	15.6
P 10 R 2A	30	5	3.2	38.4	P 10 R 3A	100	10	2.6	15.6
P 10 R 2A	35	5	2.7	32.4	P 10 R 3A	110	10	2.7	16.2
P 10 R 2A	40	5	3.1	37.2	P 10 R 3A	120	10	2.6	15.6
P 10 R 2A	50	10	5	30	P 10 R 3B	2.5	2.5	2.9	69.6
P 10 R 2A	60	10	4.7	28.2	P 10 R 3B	5	2.5	2.3	62.4
P 10 R 2A	70	10	4.9	29.4	P 10 R 3B	7.5	2.5	2.7	64.8
P 10 R 2A	80	10	4.9	29.4	P 10 R 3B	10	2.5	1.8	43.2
P 10 R 2A	90	10	4.8	28.8	P 10 R 3B	12.5	2.5	1.8	43.2
P 10 R 2A	100	10	4.9	29.4	P 10 R 3B	15	2.5	1.4	33.6
P 10 R 2A	110	10	4.8	28.8	P 10 R 3B	20	5	3.6	43.2
P 10 R 2A	120	10	4.9	29.4	P 10 R 3B	25	5	2.8	33.6
P 10 R 2B	2.5	2.5	4.4	105.6	P 10 R 3B	30	5	2.6	31.2
P 10 R 2B	5	2.5	3.5	84	P 10 R 3B	35	5	2.4	28.8
P 10 R 2B	7.5	2.5	2	48	P 10 R 3B	40	5	2.3	27.6
P 10 R 2B	10	2.5	2.2	52.8	P 10 R 3B	50	10	5	30
P 10 R 2B	12.5	2.5	2	48	P 10 R 3B	60	10	5	30
P 10 R 2B	15	2.5	1.8	43.2	P 10 R 3B	70	10	4.7	28.2
P 10 R 2B	20	5	3	36	P 10 R 3B	80	10	3.1	18.6
P 10 R 2B	25	5	2.6	31.2	P 10 R 3B	90	10	3.1	18.6
P 10 R 2B	30	5	2.5	30	P 10 R 3B	100	10	3	18
P 10 R 2B	35	5	2.2	26.4	P 10 R 3B	110	10	3.1	18.6
P 10 R 2B	40	5	2.3	27.6	P 10 R 3B	120	10	3	18
P 10 R 2B	50	10	5	30	P 10 R 4A	1.5	1.5	1.9	76
P 10 R 2B	60	10	4.3	25.8	P 10 R 4A	3	1.5	1.5	60
P 10 R 2B	70	10	4.2	25.2	P 10 R 4A	4.5	1.5	1.3	52
P 10 R 2B	80	10	4	24	P 10 R 4A	6	1.5	1.3	52
P 10 R 2B	90	10	4.2	25.2	P 10 R 4A	7.5	1.5	1.2	48
P 10 R 2B	100	10	4.2	25.2	P 10 R 4A	9	1.5	1.1	44
P 10 R 2B	110	10	4.1	24.6	P 10 R 4A	12	3	2	40
P 10 R 2B	120	10	4.2	25	P 10 R 4A	15	3	1.9	38
P 10 R 3A	2.5	2.5	2.8	67.2	P 10 R 4A	18	3	1.8	36
P 10 R 3A	5	2.5	1.7	40.8	P 10 R 4A	21	3	1.9	38
P 10 R 3A	7.5	2.5	1.2	28.8	P 10 R 4A	26	5	2.8	33.6
P 10 R 3A	10	2.5	1.5	36	P 10 R 4A	31	5	2.7	32.4
P 10 R 3A	12.5	2.5	1.3	31.2	P 10 R 4A	36	5	2.5	30
P 10 R 3A	15	2.5	1.2	28.8	P 10 R 4A	41	5	2.6	31.2
P 10 R 3A	20	5	2.2	26.4	P 10 R 4A	51	10	4.6	27.6
P 10 R 3A	25	5	2	24	P 10 R 4A	61	10	4.5	27
					P 10 R 4A	71	10	4.6	27.6

Table D. Continued

Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)	Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)
P 12 R 2A	2.5	2.5	0.8	'19.2	P 12 R 3A	35	5	1.7	20.4
P 12 R 2A	5	2.5	0.9	21.6	P 12 R 3A	40	5	...	20.4
P 12 R 2A	7.5	2.5	0.8	19.2	P 12 R 3A	50	10	3.3	19.8
P 12 R 2A	10	2.5	0.7	16.8	P 12 R 3A	60	10	3.4	20.4
P 12 R 2A	12.5	2.5	0.7,	16.8	P 12 R 3A	'70	10	3.1	18.6
P 12 R 2A	15	2.5	0.7	16.8	P 12 R 3A	80	10	3.2,	19.2
P 12 R 2A	20	5	1.3	15.6	P 12 R 3A	90	10	3.1	18.6
P 12 R 2A	25	5	1.3	15.6	P 12 R 3A	100	10	3	19.2
P 12 R 2A	30	5	'1.2	14.4	P 12 R 3A	110	10	3.1	18
P 12 R 2A	35	5	1.1	13.2	P 12 R 3A	120	10		18.6
P 12 R 2A	40	5	'1.1	13.2	P 12 R 3B	2.5	2.5	1	24
P 12 R 2A	50	10	2.4	14.4	P 12 R 3B	5	2.5	0.8	19.2
P 12 R 2A	60	10	2.1	12.6	P 12 R 3B	7.5	2.5	0.7	16.8
P 12 R 2A	70	10	2.2	13.2	P 12 R 3B	10	2.5	0.6	14.4
P 12 R 2A	80	10	2	12	P 12 R 3B	12.5	2.5	0.6	14.4
P 12 R 2A	90	10	2.2	13.2	P 12 R 3B	15	2.5	1.3	14.4
P 12 R 2A	100	10	2	12	P 12 R 3B	20	5	1.3	15.6
P 12 R 2A	110	10	2.1	12.6	P 12 R 3B	25	5		15.6
P 12 R 2A	120	10	2	12	P 12 R 3B	30	5	1.2	14.4
P 12 R 2B	2.5	2.5	2.4	57.6	P 12 R 3B	35	5	1.3	15.6
P 12 R 2B	5	2.5	'1.8	43.2	P 12 R 3B	40	5	1.2	14.4
P 12 R 2B	7.5	2.5	1.6	38.4	P 12 R 3B	50	10	2.5	15
P 12 R 2B	10	2.5	1	24	P 12 R 3B	60	10	2.4	14.4
P 12 R 2B	12.5	2.5	1	24	P 12 R 3B	'70	10	2.5	15
P 12 R 2B	15	2.5	'1.7	40.8	P 12 R 3B	80	10	2.5	15
P 12 R 2B	20	5	2.3	27.6	P 12 R 3B	90	10	2.4	14.4
P 12 R 2B	25	5	2	24	P 12 R 3B	100	10	2.5	15
P 12 R 2B	30	5	2.2	26.4	P 12 R 3B	110	10	2.3	13.8
P 12 R 2B	35	5	1.9	22.8	P 12 R 3B	120	10	2.5	15
P 12 R 2B	40	5'	1.8	21.6	P 12 R 4A	1.5	1.5	0.4	16
P 12 R 2B	50	10	4.1	24.6	P 12 R 4A	3	1.5	0.3	12
P 12 R 2B	60	10	3.7	22.2	P 12 R 4A	4.5	1.5	0.3	12
P 12 R 2B	70	10	3.7	22.2	P 12 R 4A	6	1.5	0.3	12
P 12 R 2B	80	10	3.7	22.2	P 12 R 4A	7.5	1.5	0.2	8
P 12 R 2B	90	10	3.8	22.8	P 12 R 4A	9	1.5	0.4	12
P 12 R 2B	100	10	3.7	22.2	P 12 R 4A	12	3	0.5	10
P 12 R 2B	110	10	3.8	22.8	P 12 R 4A	15	3	0.5	10
P 12 R 2B	12.0	10	3.7	22.2	P 12 R 4A	18	3	0.4	8
P 12 R 3A	2.5	2.5	1.7	40.8	P 12 R 4A	23	3	0.9	10.8
P 12 R 3A	5	2.5	1.3	31.2	P 12 R 4A	28	5	0.8	9.6
P 12 R 3A	7.5	2.5	1.2	28.8	P 12 R 4A	33	5	0.9	10.8
P 12 R 3A	10	2.5	1.1	26.4	P 12 R 4A	38	'5	0.7	8.4
P 12 R 3A	12.5	2.5	1.1		P 12				
P 12 R 3A	15	2.5	1	26.4 24	P 12 R 4A	48 58	10 5	0.5	3.6 3
P 12 R 3A	20	5	1.8	21.6	P 12 R 4A	68	10	0.6	3.6
P 12 R 3A	25	5	1.9	22.8	P 12 R 4A	78	10	0.5	3
P 12 R 3A	30	5	1.8	21.6	P 12 R 4B	1.5	1.5	0.7	28

Table D. Continued

Samples	T (min)	ElapsedT	W.h(cm)	Ir (cm/hr)	Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)
P 13 R 2A	2.5	2.5	3.2	76.8	P 13 R 3A	35	5	1.3	15.6
P 13 R 2A	5	2.5	2.5	60	P 13 R 3A	40	5	2.9	14.8
P 13 R 2A	7.5	2.5	2.1	50.4	P 13 R 3A	50	10	2.2	13.2
P 13 R 2A	10	2.5	1.9	45.6	P 13 R 3A	60	10	3	18
P 13 R 2A	12.5	2.5	1.8	43.2	P 13 R 3A	70	10	3	18
P 13 R 2A	15	2.5	1.8	43.2	P 13 R 3A	80	10	2.5	15
P 13 R 2A	20	5	1.9	45.6	P 13 R 3A	90	10	2.5	15
P 13 R 2A	25	5	3.2	38.4	P 13 R 3A	100	10	2.5	15
P 13 R 2A	30	5	2.6	31.2	P 13 R 3A	110	10	2.4	14.4
P 13 R 2A	35	5	2.2	26.4	P 13 R 3A	120	10	2.5	15
P 13 R 2A	40	5	1.8	21.6	P 13 R 3B	2.5	2.5	2.8	67.2
P 13 R 2A	50	10	3.4	20.4	P 13 R 3B	5	2.5	2	48
P 13 R 2A	60	10	2.9	17.4	P 13 R 3B	7.5	2.5	1	24
P 13 R 2A	70	10	2.8	16.8	P 13 R 3B	10	2.5	0.9	21.6
P 13 R 2A	80	10	2.8	16.8	P 13 R 3B	12.5	2.5	1.1	26.4
P 13 R 2A	90	10	2.6	15.6	P 13 R 3B	15	2.5	1	24
P 13 R 2A	100	10	2.6	15.6	P 13 R 3B	20	5	1	12
P 13 R 2A	110	10	2.5	15	P 13 R 3B	25	5	2.1	25.2
P 13 R 2A	120	10	2.6	15.6	P 13 R 3B	30	5	1.9	22.8
P 13 R 2B	2.5	2.5	2.7	64.8	P 13 R 3B	35	5	2	24
P 13 R 2B	5	2.5	1.9	45.6	P 13 R 3B	40	5	2.1	25.2
P 13 R 2B	7.5	2.5	1.6	38.4	P 13 R 3B	50	10	3.4	20.4
P 13 R 2B	10	2.5	1.4	33.6	P 13 R 3B	60	10	3.2	19.2
P 13 R 2B	12.5	2.5	1.2	28.8	P 13 R 3B	70	10	3.1	18.6
P 13 R 2B	15	2.5	1.1	26.4	P 13 R 3B	80	10	2.9	17.4
P 13 R 2B	20	5	2	24	P 13 R 3B	90	10	3	18
P 13 R 2B	25	5	1.7	20.4	P 13 R 3B	100	10	3.1	18.6
P 13 R 2B	30	5	1.6	19.2	P 13 R 3B	110	10	3	18
P 13 R 2B	35	5	1.7	20.4	P 13 R 3B	120	10	3	18
P 13 R 2B	40	5	1.5	18	P 13 R 4A	1.5	1.5	1.5	60
P 13 R 2B	50	10	3.2	19.2,	P 13 R 4A	3	1.5	1.4	56
P 13 R 2B	60	10	2.8	16.8	P 13 R 4A	4.5	1.5	1.2	53
P 13 R 2B	70	10	2.8	16.8	P 13 R 4A	6	1.5	1.1	40
P 13 R 2B	80	10	2.9	17.4'	P 13 R 4A	7.5	1.5	0.7	32
P 13 R 2B	90	10	2.7	16.2	P 13 R 4A	8.5	1	0.5	23.43
P 13 R 2B	100	10	2.6	15.6	P 13 R 4A	11	2.5	0.7	20.79
P 13 R 2B	110	10	2.5	15	P 13 R 4A	13.5	2.5	1	26.09
P 13 R 2B	120	10	2.6	15.6	P 13 R 4A	16	2.5	0.6	15.72
P 13 R 3A	2.5	2.5	4.5	108	P 13 R 4A	21	5	1.6	19.2
P 13 R 3A	5	2.5	2.6	62.4	P 13 R 4A	26	5	1.4	16.8
P 13 R 3A	7.5	2.5	3.2	76.8	P 13 R 4A	31	5	1.1	13.2
P 13 R 3A	10	2.5	1.6	38	P 13 R 4A	36	5	0.9	10.8
P 13 R 3A	12.5	2.5	1.3	31.2	P 13 R 4A	41	5	0.85	10.2
P 13 R 3A	15	2.5	1.5	36	P 13 R 4A	46	5	0.55	6.6
P 13 R 3A	20	5	2.2	26.4	P 13 R 4A	51	5	0.5	6
P 13 R 3A	25	5	2	24	P 13 R 4A	56	5	0.5	6
P 13 R 3A	30	5	2.1	25.2	P 13 R 4A	61	5	0.4	4.8

Table D. Continued

Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)	Samples	T (min)	ElapsedT	W.h(cm)	Ir (cmlhr)
P 14-R 2A	2.5	2.5	2.1	50.4	P 14 R 3A	35	5	3.9	46.8
P 14 R 2A	5	2.5	1.5	36	P 14 R 3A	40	5	3.8	45.6
P 14 R 2A	7.5	2.5	1.3	31.2	P 14 R 3A	50	10	7.7	46.2
P 14 R 2A	10	2.5	1.2	28.8	P 14 R 3A	60	10	7.3	43.8
P 14 R 2A	12.5	2.5	1	24	P 14 R 3A	70	10	6.8	40.8
P 14 R 2A	15	2.5	1	24	P 14 R 3A	80	10	6.4	38.4
P 14 R 2A	20	5	1.8	21.6	P 14 R 3A	90	10	6.4	38.4
P 14 R 2A	25	5	1.9	22.8	P 14 R 3A	100	10	6.1	36.6
P 14 R 2A	30	5	2.1	25.2	P 14 R 3A	110	10	6.1	36.6
P 14 R 2A	35	5	1.6	19.2	P 14 R 3A	120	10	6.2	37.2
P 14 R 2A	40	5	1.8	21.6	P 14 R 3B	2.5	2.5	2.9	69.6
P 14 R 2A	50	10	3.5	21	P 14 R 3B	5	2.5	2.1	50.4
P 14 R 2A	60	10	3.7	22.2	P 14 R 3B	7.5	2.5	2	48
P 14 R 2A	70	10	3.3	19.8	P 14 R 3B	10	2.5	2	48
P 14 R 2A	80	10	3.2	19.2	P 14 R 3B	12.5	2.5	1.7	40.8
P 14 R 2A	90	10	3.2	19.2	P 14 R 3B	15	2.5	1.7	40.8
P 14 R 2A	100	10	2.9	17.4	P 14 R 3B	20	5	3.4	40.8
P 14 R 2A	110	10	3.1	18.6	P 14 R 3B	25	5	3.1	37.2
P 14 R 2A	120	10	3.1	18.6	P 14 R 3B	30	5	3.2	38.4
P 14 R 2B	2.5	2.5	2.3	55.2	P 14 R 3B	35	5	2.7	32.4
P 14 R 2B	5	2.5	1.8	43.2	P 14 R 3B	40	5	2.8	33.6
P 14 R 2B	7.5	2.5	1.4	33.6	P 14 R 3B	50	10	5.6	33.6
P 14 R 2B	10	2.5	1.5	36	P 14 R 3B	60	10	5.3	31.8
P 14 R 2B	12.5	2.5	1.8	43.2	P 14 R 3B	70	10	5.1	30.6
P 14 R 2B	15	2.5	1.3	31.2	P 14 R 3B	80	10	5	30
P 14 R 2B	20	5	2.4	28.8	P 14 R 3B	90	10	5	30
P 14 R 2B	25	5	2.3	27.6	P 14 R 3B	100	10	4.9	29.4
P 14 R 2B	30	5	2.5	30	P 14 R 3B	110	10	4.9	29.4
P 14 R 2B	35	5	2.2	26.4	P 14 R 3B	120	10	5	30
P 14 R 2B	40	5	1.9	22.8	P 14 R 4A	1.5	1.5	1.8	72
P 14 R 2B	50	10	4.4	26.4	P 14 R 4A	3	1.5	1.3	52
P 14 R 2B	60	10	3.6	21.6	P 14 R 4A	4.5	1.5	1.4	56
P 14 R 2B	70	10	4.1	24.6	P 14 R 4A	6	1.5	1.7	68
P 14 R 213	80	10	3.6	21.6	P 14 R 4A	7.5	1.5	1.3	52
P 14 R 213	90	10	4	24	P 14 R 4A	9	1.5	1	40
P 14 R 213	100	10	3.6	21.6	P 14 R 4A	12	3	4.8	36
P 14 R 213	110	10	3.7	22.2	P 14 R 4A	15	3	1.8	36
P 14 R 2B	120	10	3.7	22.2	P 14 R 4A	18	3	1.9	38
P 14 R 3A	2.5	2.5	5	120	P 14 R 4A	21	3	1.6	32
P 14 R 3A	5	2.5	3.6	86.4	P 14 R 4A	26	5	1.9	22.8
P 14 R 3A	7.5	2.5	4.4	105.6	P 14 R 4A	31	5	1.5	18
P 14 R 3A	10	2.5	2.7	64.8	P 14 R 4A	36	5	1.8	21.6
P 14 R 3A	12.5	2.5	3.1	74.4	P 14 R 4A	46	10	3	18
P 14 R 3A	15	2.5	2.5	60	P 14 R 4A	56	10	3.1	18.6
P 14 R 3A	20	5	5	60	P 14 R 4A	66	10	3	18
P 14 R 3A	25	5	4.4	52.8	P 14 R 4A	76	10	3.1	18.6
P 14 R 3A	30	5	4.5	54	P 14 R 4B	1.5	1.5	1.8	72

Table D. Continued

Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)	Samples	T (min)	Elapsed	W.h(cm)	Ir (cm/hr)
P 15 R 2A	2.5	2.5	0.7	16.8	P 15 R 3A	35	5	1.6	19.2
P 15 R 2A	5	2.5	0.7	16.8	P 15 R 3A	40	5	1.4	16.8
P 15 R 2A	7.5	2.5	0.6	14.4	P 15 R 3A	50	10	2.6	15.6
P 15 R 2A	10	2.5	0.6	14.4	P 15 R 3A	60	10	2.5	15
P 15 R 2A	12.5	2.5	0.5	12	P 15 R 3A	70	10	2.6	15.6
P 15 R 2A	15	2.5	0.6	14.4	P 15 R 3A	80	10	2.4	14.4
P 15 R 2A	20	5	1	1 2	P 15 R 3A	90	10	2.5	15
P 15 R 2A	25	5	1	12	P 15 R 3A	100	10	2.4	14.4
P 15 R 2A	30	5	1.1	13.2	P 15 R 3A	110	10	2.2	13.2
P 15 R 2A	35	5	0.9	10.8	P 15 R 3A	120	10	2.4	14.4
P 15 R 2A	40	5	1	12	P 15 R 3B	2.5	2.5	1.6	38.4
P 15 R 2A	50	10	1.7	10.2	P 15 R 3B	5	2.5	1.3	31.2
P 15 R 2A	60	10	1.8	10.8	P 15 R 3B	7.5	2.5	0.9	21.6
P 15 R 2A	70	10	2	12	P 15 R 3B	10	2.5	1	24
P 15 R 2A	80	10	1.7	10.2’	P 15 R 3B	12.5	2.5	1	24
P 15 R 2A	90	10	1.7	10.2,	P 15 R 3B	15	2.5	0.9	21.6
P 15 R 2A	100	10	1.6	9.6	P 15 R 3B	20	5	1.5	18
P 15 R 2A	110	10	1.7	10.2	P 15 R 3B	25	5	1.6	19.2
P 15 R 2A	120	10	1.7	10.2	P 15 R 3B	30	5	1.4	16.8
P 15 R 2B	2.5	2.5	0.3	7 . 2	P 15 R 3B	35	5	1.2	14.4
P 15 R 2B	5	2.5	0.2	4.8	P 15 R 3B	40	5	1.2	14.4
P 15 R 2B	7.5	2.5	0.2	4.8	P 15 R 3B	50	10	2.5	15
P 15 R 2B	10	2.5	0.1	2.4	P 15 R 3B	60	10	2.2	13.2
P 15 R 2B	12.5	2.5	0.2	4.8	P 15 R 3B	70	10	2.4	14.4
P 15 R 2B	15	2.5	0.1	4.8	P 15 R 3B	80	10	2.2	23.2
P 15 R 2B	20	5	0.3	2.4	P 15 R 3B	90	10	2.3	13.8
P 15 R 2B	25	5	0.3	3.6	P 15 R 3B	100	10	2	12
P 15 R 2B	30	5	0.2	3.6	P 15 R 3B	110	10	2	12
P 15 R 2B	35	5	0.3	2.4	P 15 R 3B	120	10	2	12
P 15 R 2B	40	5	0.2	3.6	P 15 R 4A	2.5	2.5	0.8	19.2
P 15 R 2B	50	10	0.5	2.4	P 15 R 4A	5	2.5	0.7	16.8
P 15 R 2B	60	10	0.4	3	P 15 R 4A	7.5	2.5	0.7	16.8
P 15 R 2B	70	10	0.4	2.4	P 15 R 4A	9	2.5	0.6	14.4
P 15 R 2B	80	10	0.4	2.4	P 15 R 4A	11.5	2.5	0.3	7.2
P 15 R 2B	90	10	0.4	2.4	P 15 R 4A	14	2.5	0.6	14.4
P 15 R 2B	100	10	0.4	2.4	P 15 R 4A	19	5	1	12
P 15 R 2B	110	10	0.4	2.4	P 15 R 4A	24	5	0.8	9.6
P 15 R 2B	120	10	0.5	2.5	P 15 R 4A	29	5	0.9	1 0 . 8
P 15 R 3A	2.5	2.5	2	48	P 15 R 4A	34	5	0.8	12
P 15 R 3A	5	2.5	1.4	33.6	P 15 R 4A	44	5	1.9	11.4
P 15 R 3A	7.5	2.5	1.2	28.8	P 15 R 4A	54	10	2	12
P 15 R 3A	10	2.5	1.1	26.4	P 15 R 4A	64	10	2.2	13.2
P 15 R 3A	12.5	2.5	1	24	P 15 R 4A	74	10	1.9	11.4
P 15 R 3A	15	2.5	1.1	26.4	P 15 R 4A	84	10	1.5	9
P 15 R 3A	20’	5	1.8	21.6	P 15 R 4A	94	10	2.3	13.8
P 15 R 3A	25	5	1.6	19.2	P 15 R 4A	104	10	2	12
P 15 R 3A	30	5	1.5	18	P 15 R 4B	2.5	2.5	1.1	26.4

Table E. Total organic carbon in the IPM plots

Samples	Soil wt (g)	C (%)	Samples	Soil wt (g)	C (%)	Samples	Soil wt (g)	C (%)
Rep2 PI A	0.2184	2.93,	Rep3 P1 A	0.2296	2.61	Rep4 PI A	0.2428	1.82
Rep2 P1 A	0.1903	3.03	Rep3 P1 A	0.2039	2.93	Rep4 P1 A	0.1888	1.73
Rep2 P1 A	0.2342	2.82	Rep3 PI A	0.1988	2.6	Rep4 PI A	0.1848	1.87
Rep2 P1 A	0.1973	2.99	Rep3 P1 A	0.2278	2.81	Rep4 P1 A	0.2447	1.89
Rep2 P1 B	0.1932	2.96	Rep3 P1 B	0.1758	2.7	Rep4 P1 B	0.1982	1.58
Rep2 P1 B	0.2173	2.66	Rep3 PI B	0.1996	2.6	Rep4 Pi B	0.2126	1.63
Rep2 P1 B	0.2104	2.54	Rep3 P1 B	0.2184	2.81	Rep4 PI B	0.2391	1.79
Rep2 P1 B	0.2078	2.7	Rep3 P1 B	0.2303	2.79	Rep4 P2 A	0.2454	1.78
Rep2 P2 A	0.186	2.54	Rep3 P2 A	0.2204	2.63	Rep4 P2 A	0.1762	2.47
Rep2 P2 A	0.2309	2.29	Rep3 P2 A	0.2442	2.85	Rep4 P2 A	0.1993	2.96
Rep2 P2 A	0.2122	2.35	Rep3 P2 A	0.194	2.75	Rep4 P2 A	0.1868	2.46
Rep2 P2 A	0.2224	2.55	Rep3 P2 A	0.1783	2.82	Rep4 P2 B	0.2054	2.49
Rep2 P2 B	0.2109	2.38	Rep3 P2 B	0.2035	2.84	Rep4 P2 B	0.1491	2.72
Rep2 P2 B	0.2172	2.4	Rep3 P2 B	0.2203	2.23	Rep4 P2 B	0.2121	2.62
Rep2 P2 B	0.1799	2.38	Rep3 P2 B	0.2422	2.44	Rep4 P2 B	0.1507	2.63
Rep2 P2 B	0.1978	2.4	Rep3 P2 B	0.2351	2.2	Rep4 P3 A	0.1815	2.6
Rep2 P3 A	0.2407	2.1	Rep3 P3 A	0.2408	1.97	Rep4 P3 A	0.2216	2.63
Rep2 P3 A	0.2429	2.17	Rep3 P3 A	0.2474	1.85	Rep4 P3 A	0.1815	2.83
Rep2 P3 A	0.2673	1.86	Rep3 P3 A	0.1796	2.25	Rep4 P3 A	0.1767	2.82
Rep2 P3 A	0.236	2.41	Rep3 P3 A	0 2261	2.69	Rep4 P3 B	0.2144	2.62
Rep2 P3 B	0.2424	1.6	Rep3 P3 B	0.2014	2.92	Rep4 P3 B	0.2126	2.94
Rep2 P3 B	0.2498	2.18	Rep3 P3 B	0 2274	1.82	Rep4 P3 B	0.2169	2.96
Rep2 P3 B	0.248	2.33	Rep3 P3 B	0.2287	2.01	Rep4 P3 B	0.1905	2.95
Rep2 P3 B	0.2459	2.31	Rep3 P3 B	0.2262	1.46	Rep4 P4 A	0.1982	3.46
Rep2 P4 A	0.1684	3.42	Rep3 P4 A	0.2031	1.23	Rep4 P4 A	0.2341	1.53
Rep2 P4 A	0.1591	3.28	Rep3 P4 A	0.2603	1.35	Rep4 P4 A	0.2418	1.93
Rep2 P4 A	0.198	3.4	Rep3 P4 A	0 2312	1.27	Rep4 P4 A	0.2566	2.03
Rep2 P4 A	0.2152	3.19	Rep3 P4 A	0 1943	1.3	Rep4 P4 B	0.2438	2.04
Rep2 P4 B	0.2187	3.37	Rep3 P4 B	0.1924	1.14	Rep4 P4 B	0.2082	1.62
Rep2 P4 B	0.2381	3.13	Rep3 P4 B	0.2216	1.17	Rep4 P4 B	0.2378	2.09
Rep2 P4 B	0.2247	3.28	Rep3 P4 B	0 2577	1.14	Rep4 P4 B	0.249	1.92
Rep2 P4 B	0.225	3.33	Rep3 P4 B	0.2116	1.25	Rep4 P5 A	0.2382	1.77
Rep2 P5 A	0.26	3.18	Rep3 P5 A	0.2058	2.76	Rep4 P5 A	0.2376	2.06
Rep2 P5 A	0.2146	2.55	Rep3 P5 A	0.2084	3	Rep4 P5 A	0.2078	1.97
Rep2 P5 A	0.2359	3.07	Rep3 P5 A	0.1673	2.8	Rep4 P5 A	0.2318	1.99
Rep2 P5 A	0.2568	3.01	Rep3 P5 A	0.2171	2.82	Rep4 P5 B	0.2675	2.21
Rep2 P5 B	0.2001	2.86	Rep3 P5 B	0.1964	2.26	Rep4 P5 B	0.1933	2.42
Rep2 P5 B	0.1944	0.311	Rep3 P5 B	0.2007	2.12	Rep4 P5 B	0.2138	2.55
Rep2 P5 B	‘0.1746	2.95	Rep3 P5 B	0.1673	1.91	Rep4 P5 B	0.1734	2.53
Rep2 P5 B	0.1527	3.04	Rep3 P5 B	0.2147	2.14	Rep4 P6 A	0.1972	2.31
Rep2 P6 A	0.1868	2.12	Rep3 P6 A	0.19	1.78	Rep4 P6 A	0.2199	2
Rep2 P6 A	0.2087	2.65	Rep3 P6 A	0.1705	2.06	Rep4 P6 A	0.1726	2.15
Rep2 P6 A	0.2209	2.35	Rep3 P6 A	0 2117	1.91	Rep4 P6 A	0.2409	2.28
Rep2 P6 A	0.2186	2.73	Rep3 P6 A	0.2312	2.12	Rep4 P6 B	0.2313	2.09
Rep2 P6 B	0.2087	2.68	Rep3 P6 B	0.2381	2.01	Rep4 P6 B	0.2159	2.48
Rep2 P6 B	0.2257	2.66	Rep3 P6 B	0.2307	1.87	Rep4 P6 B	0.1903	2.67
Rep2 P6 B	0.219	2.7	Rep3 P6 B	0.2184	1.94	Rep4 P6 B	0.1515	2.72

Rep2 P6 B	0.2459	2.86	Rep3 P6 B	0.2284	1.69	Rep4 P7 A	0.2186	2.81
Rep2 P7 A	0.2043	2.18	Rep3 P7 A	0.1959	2.03	Rep4 P7 A	0.2331	2.49
Rep2 P7 A	0.1863	2.37	Rep3 P7 A	0.2038	2.31	Rep4 P7 A	0.1819	2.39
Rep2 P7 A	0.2306	2.18	Rep3 P7 A	0.1938	2.58	Rep4 P7 A	0.1724	2.57
Rep2 P7 A	0.2152	2.95	Rep3 P7 A	0.2375	2.08	Rep4 P7 B	0.1944	2.56
Rep2 P7 B	0.2083	2.55	Rep3 P7 B	0.211	2.15	Rep4 P7 B	0.2156	2.37
Rep2 P7 B	0.1895	2.25	Rep3 P7 B	0.2049	2.12	Rep4 P7 B	0.2164	2.22
Rep2 P7 B	0.2043	2.07	Rep3 P7 B	0.1554	2.15	Rep4 P7 B	0.1782	2.4
Rep2 P7 B	0.1712	2.17	Rep3 P7 B	0.2504	2.23	Rep4 P10 A	0.1992	2.2
Rep2 P10 A	0.2474	2.17	Rep3 P10 A	0.2098	2.31	Rep4 P10 A	0.2145	2.76
Rep2 P10 A	0.2398	2.12	Rep3 P10 A	0.2199	2.29	Rep4 P10 A	0.2044	1.88
Rep2 PI0 A	0.2432	2.07	Rep3 PI0 A	0.2235	2.32	Rep4 PI0 A	0.2376	1.76
Rep2 P10 A	0.2454	2.01	Rep3 PI0 A	0.2261	2.4	Rep4 P10 B	0.1944	2.16
Rep2 P10 B	0.2335	2.17	Rep3 P10 B	0.2239	2.28	Rep4 P10 B	0.2065	1.89
Rep2 P10 B	0.224	2.02	Rep3 P10 B	0.2209	2.8	Rep4 PI0 B	0.2038	1.9
Rep2 P10 B	0.1943	2.65	Rep3 PI0 B	0.2119	3.16	Rep4 PI0 B	0.2442	1.92
Rep2 P10 B	0.2383	1.44	Rep3 PI0 B	0.2112	2.89	Rep4 P12 A	0.1326	3.46
Rep2 P12 A	0.2058	2.13	Rep3 P12 A	0.2087	2.2	Rep4 P12 A	0.1484	2.75
Rep2 P12 A	0.1989	3	Rep3 P12 A	0.1318	2.54	Rep4 P12 A	0.1514	3.93
Rep2 P12 A	0.2024	3.07	Rep3 P12 A	0.1938	2.87	Rep4 P12 A	0.1724	3.16
Rep2 P12 A	0.1906	3.34	Rep3 P12 A	0.1664	2.54	Rep4 P12 B	0.1758	3.52
Rep2 P12 B	0.1846	3.29	Rep3 P12 B	0.2295	2.66	Rep4 P12 B	0.1443	2.8
Rep2 P12 B	0.2177	3.29	Rep3 P12 B	0.1675	2.57	Rep4 P12 B	0.2087	3.68
Rep2 P12 B	0.1947	3.08	Rep3 P12 B	0.16	2.99	Rep4 P12 B	0.1667	3.51
Rep2 P12 B	0.2028	3.09	Rep3 P12 B	0.1939	2.41	Rep4 P13 A	0.2216	2.04
Rep2 P13 A	0.1873	3.24	Rep3 P13 A	0.1983	2.16	Rep4 P13 A	0.2055	1.77
Rep2 P13 .A	0.2248	2.96	Rep3 P13 A	0.2151	2.33	Rep4 P13 A	0.1855	2.08
Rep2 P13 A	0.2205	2.73	Rep3 P13 A	0.2126	2.18	Rep4 P13 A	0.2124	1.76
Rep2 P13 A	0.1663	2.97	Rep3 P13 A	0.2422	2.2	Rep4 P13 B	0.2331	1.76
Rep2 P13 B	0.2051	3.18	Rep3 P13 B	0.2077	1.66	Rep4 P13 B	0.2318	1.96
Rep2 P13 B	0.2264	3.3	Rep3 P13 B	0.2223	'1.68	Rep4 P13 B	0.2132	1.9
Rep2 P13 B	0.1357	3.08	Rep3 P13 B	0.1848	1.63	Rep4 P13 B	0.2279	1.83
Rep2 P13 B	0.2037	3.25	Rep3 P13 B	0.21 II	1.77	Rep4 P14 A	0.184	2.57
Rep2 P14 A	0.196	2.71	Rep3 P14 A	0.21	2.35	Rep4 P14 A	0.1672	2.34
Rep2 P14 A	0.1903	2.82	Rep3 P14 A	0.1364	1.9	Rep4 P14 A	0.1979	2.4
Rep2 P14 A	0.2193	2.87	Rep3 P14 A	0.1712	2.21	Rep4 P14 A	0.1706	2.65
Rep2 P14 A	0.1922	2.61	Rep3 P14 A	0.2085	'1.94	Rep4 P14 B	0.2558	2.29
Rep2 P14 B	0.1885	2.73	Rep3 P14 B	0.2204	2.22	Rep4 P14 B	0.2065	2.36
Rep2 P14 B	0.213	2.67	Rep3 P14 B	0.1952	2.41	Rep4 P14 B	0.1599	2.32
Rep2 P14 B	0.1941	2.62	Rep3 P14 B	0.1787	1.88	Rep4 P14 B	0.213	2.27
Rep2 P14 B	0.2421	2.7	Rep3 P14 B	0.1721	2.53	Rep4 P15 A	0.1948	2.41
Rep2 P15 A	0.2399	2.23	Rep3 P15 A	0.236	2.11	Rep4 P15 A	0.2117	2.92
Rep2 P15 A	0.1877	2.44	Rep3 P15 A	0.206	2.28	Rep4 P15 A	0.1897	3.25
Rep2 P15 A	0.2025	3.54	Rep3 P15 A	0.1868	2.1	Rep4 PI 5 A	0.1887	2.82
Rep2 P15 A	0.1606	2.43	Rep3 P15 A	0.1825	2.43	Rep4 P15 B	0.2395	3.26
Rep2 P15 B	0.1682	2.87	Rep3 P15 B	0.2122	3.47	Rep4 P15 B	0.155	3.31
Rep2 P15 B	0.2272	2.9	Rep3 P15 B	0.1782	2.25	Rep4 P15 B	0.2295	3.113
Rep2 P15 B	0.2359	2.85	Rep3 P15 B	0.2392	1.96	Rep4 P15 B	0.1957	3.34
Rep2 P15 B	0.1763	2.77	Rep3 P15 B	0.1947	2.03			

Table F. Total nitrogen in the IPM plots

Samples	Soil wt (g)	N (%)	Samples	Soil wt (g)	N (%)	Samples	Soil wt (g)	N (%)
Rep2 PI A	0.2184	0.3	Rep3 PI A	0.2296	0.26	Rep4 PI A	0.2428	0.2
Rep2 P1 A	0.1903	0.31	Rep3 PI A	0.2039	0.29	Rep4 PI A	0.1888	0.22
Rep2 PI A	0.2342	0.28	Rep3 PI A	0.1988	0.28	Rep4 PI A	0.1848	0.34
Rep2 PI A	0.1973	0.33	Rep3 P1 A	0.2278	0.28	Rep4 PI A	0.2447	0.2
Rep2 PI B	0.1932	0.29	Rep3 PI B	0.1758	0.26	Rep4 P1 B	0.1982	0.2
Rep2 Pi B	0.2173	0.32	Rep3 P1 B	0.1996	0.3	Rep4 P1 B	0.2126	0.19
Rep2 Pi B	0.2104	0.25	Rep3 PI B	0.2184	0.27	Rep4 P1 B	0.2391	0.18
Rep2 PI B	0.2078	0.27	Rep3 PI B	0.2303	0.28	Rep4 P1 B	0.2454	0.18
Rep2 P2: A	0.186	0.29	Rep3 P2 A	0.2204	0.22	Rep4 P2 A	0.1762	0.26
Rep2 P2: A	0.2309	0.23	Rep3 P2 A	0.2442	0.27	Rep4 P2 A	0.1993	0.29
Rep2 P2 A	0.2122	0.22	Rep3 P2 A	0.194	0.28	Rep4 P2 A	0.1868	0.28
Rep2 P2: A	0.2224	0.28	Rep3 P2 A	0.1783	0.28	Rep4 P2 A	0.2054	0.27
Rep2 P2: B	0.2109	0.27’	Rep3 P2 B	0.2035	0.28	Rep4 P2 B	0.1491	0.31
Rep2 P2 B	0.2172	0.27	Rep3 P2 B	0.2203	0.27	Rep4 P2 B	0.2121	0.26
Rep2 P2 B	0.1799	0.22	Rep3 P2 B	0.2422	0.24	Rep4 P2 B	0.1507	0.37
Rep2 P2 B	0.1978	0.25	Rep3 P2 B	0.2351	0.24	Rep4 P2 B	0.1815	0.33
Rep2 P3 A	0.2407	0.18	Rep3 P3 A	0.2408	0.19	Rep4 P3 A	0.2216	0.31
Rep2 P3 A	0.2429	0.2	Rep3 P3 A	0.2474	0.2	Rep4 P3 A	0.1815	0.4
Rep2 P3 A	0.2673	0.23	Rep3 P3 A	0.1796	0.26	Rep4 P3 A	0.1767	0.4
Rep2 P3 A	0.236	0.23	Rep3 P3 A	0.2261	0.26	Rep4 P3 A	0.2144	0.29
Rep2 P3 B	0.2424	0.17	Rep3 P3 B	0.2014	0.78	Rep4 P3 B	0.2126	0.3
Rep2 P3 B	0.2498	0.22	Rep3 P3 B	0.2274	0.26	Rep4 P3 B	0.2169	0.38
Rep2 P3 B	0.248	0.25	Rep3 P3 B	0.2287	0.22	Rep4 P3 B	0.1905	0.33
Rep2 P3 B	0.2459	0.26	Rep3 P3 B	0.2262	0.2	Rep4 P3 B	0.1982	0.43
Rep2 P4 A	0.1684	0.49	Rep3 P4 A	0.2031	0.24	Rep4 P4 A	0.2341	0.27
Rep2 P4 A	0.1591	0.53	Rep3 P4 A	0.2603	0.18	Rep4 P4 A	0.2418	0.33
Rep2 P4 A	0.198	0.49	Rep3 P4 A	0.2312	0.25	Rep4 P4 A	0.2566	0.28
Rep2 P4 A	0.2152	0.44	Rep3 P4 A	0.1943	0.29	Rep4 P4 A	0.2438	0.31
Rep2 P4 B	0.2187	0.47	Rep3 P4 B	0.1924	0.26	Rep4 P4 B	0.2082	0.3
Rep2 P4 B	0.2381	0.44	Rep3 P4 B	0.2216	0.22	Rep4 P4 B	0.2378	0.32
Rep2 P4 B	0.2247	0.48	Rep3 P4 B	0.2577	0.25	Rep4 P4 B	0.249	0.3
Rep2 P4 B	0.225	0.42	Rep3 P4 B	0.2116	0.24	Rep4 P4 B	0.2382	0.29
Rep2 P5 A	0.26	0.42	Rep3 P5 A	0.2058	0.44	Rep4 P5 A	0.2376	0.35
Rep2 P5 A	0.2146	0.34	Rep3 P5 A	0.2084	0.46	Rep4 P5 A	0.2078	0.3
Rep2 P5 A	0.2359	0.44	Rep3 P5 A	0.1673	0.44	Rep4 P5 A	0.2318	0.36
Rep2 P5 A	0.2568	0.43	Rep3 P5 A	0.2171	0.5	Rep4 P5 A	0.2675	0.34
Rep2 P5 B	0.2001	0.46	Rep3 P5 B	0.1964	0.37	Rep4 P5 B	0.1933	0.41
Rep2 P5 B	0.1944	0.45	Rep3 P5 B	0.2007	0.35	Rep4 P5 B	0.2138	0.43
Rep2 P5 B	0.1746	0.49	Rep3 P5 B	0.1673	0.43	Rep4 P5 B	0.1134	0.45
Rep2 P5 B	0.1527	0.51	Rep3 P5 B	0.2147	0.32	Rep4 P5 B	0.1972	0.41
Rep2 P6 A	0.1868	0.35	Rep3 P6 A	0.19	0.31	Rep4 P6 A	0.2199	0.35
Rep2 P6 A	0.2087	0.41	Rep3 P6 A	0.1705	0.37	Rep4 P6 A	0.1726	0.35
Rep2 P6 A	0.2209	0.33	Rep3 P6 A	0.2117	0.32	Rep4 P6 A	0.2409	0.33
Rep2 P6 A	0.2186	0.43	Rep3 P6 A	0.2312	0.31	Rep4 P6 A	0.2313	0.34
Rep2 P6 B	0.2087	0.43	Rep3 P6 B	0.2381	0.32	Rep4 P6 B	0.2159	0.39
Rep2 P6 B	0.2257	0.38	Rep3 P6 B	0.2307	0.31	Rep4 P6 B	0.1903	0.42
Rep2 P6 B	0.219	0.41	Rep3 P6 B	0.2184	0.31	Rep4 P6 B	0.1515	0.44

Rep2 P6 B	0.2459	0.42	Rep3 P6 B	0.2284	0.3	Rep4 P6 B	0.2186	0.39
Rep2 P7 A	0.2043	0.37	Rep3 P7 A	0.1959	0.34	Rep4 P7 A	0.2331	0.36
Rep2 P7 A	0.1863	0.4	Rep3 P7 A	0.2038	0.33	Rep4 P7 A	0.1819	0.41
Rep2 P7 A	0.2306	0.34	Rep3 P7 A	0.1938	0.37	Rep4 P7 A	0.1724	0.4
Rep2 P7 A	0.2152	0.41	Rep3 P7 A	0.2375	0.31	Rep4 P7 A	0.1944	0.4
Rep2 P7 B	0.2083	0.35	Rep3 P7 B	0.211	0.31	Rep4 P7 B	0.2156	0.35
Rep2 P7 B	0.1895	0.39	Rep3 P7 B	0.2049	0.34	Rep4 P7 B	0.2164	0.37
Rep2 P7 B	0.2043	0.33	Rep3 P7 B	0.1554	0.35	Rep4 P7 B	0.1782	0.36
Rep2 P7 B	0.1712	0.38	Rep3 P7 B	0.2504	0.32	Rep4 P7 B	0.1992	0.37
Rep2 PI0 A	0.2474	0.22	Rep3 PI0 A	0.2098	0.3	Rep4 PI0 A	0.2145	0.29
Rep2 PI0 A	0.2398	0.2	Rep3 P10 A	0.2199	0.25	Rep4 P10 A	0.2044	0.18
Rep2 P10 A	0.2432	0.21	Rep3 P10 A	0.2235	0.32	Rep4 PI0 A	0.2376	0.16
Rep2 PI0 A	0.2454	0.25	Rep3 P10 A	0.2261	0.29	Rep4 P10 A	0.1944	0.24
Rep2 PI0 B	0.2335	0.22	Rep3 P10 B	0.2239	0.27	Rep4 PI0 B	0.2065	0.19
Rep2 P10 B	0.224	0.26	Rep3 P10 B	0.2209	0.31	Rep4 PI0 B	0.2038	0.1
Rep2 P10 B	0.1943	0.3	Rep3 PI0 B	0.2119	0.33	Rep4 PI0 B	0.2442	0.14
Rep2 PI0 B	0.2383	0.17	Rep3 P10 B	0.2112	0.29	Rep4 PI0 B	0.1326	0.47
Rep2 P12 A	0.2058	0.19	Rep3 P12 A	0.2087	0.32	Rep4 P12 A	0.1484	0.31
Rep2 P12 A	0.1989	0.32	Rep3 P12 A	0.1318	0.26	Rep4 P12 A	0.1514	0.4
Rep2 P12 A	0.2024	0.26	Rep3 P12 A	0.1938	0.34	Rep4 P12 A	0.1724	0.42
Rep2 P12 A	0.1906	0.32	Rep3 P12 A	0.1664	0.44	Rep4 P12 A	0.1758	0.42
Rep2 P12 B	0.1846	0.37	Rep3 P12 B	0.2295	0.27	Rep4 P12 B	0.1443	0.34
Rep2 P12 B	0.2177	0.44	Rep3 P12 B	0.1675	0.26	Rep4 P12 B	0.2087	0.37
Rep2 P12 B	0.1947	0.91	Rep3 P12 B	0.16	0.38	Rep4 P12 B	0.1667	0.41
Rep2 P12 B	0.2028	0.39	Rep3 P12 B	0.1939	0.3	Rep4 P12 B	0.2216	0.25
Rep2 P13 A	0.1873	0.32	Rep3 P13 A	0.1983	0.22	Rep4 P13 A	0.2055	0.16
Rep2 PI 3 A	0.2248	0.36	Rep3 P13 A	0.2151	0.27	Rep4 P13 A	0.1855	0.3
Rep2 P13 A	0.2205	0.33	Rep3 P13 A	0.2126	0.26	Rep4 P13 A	0.2124	0.26
Rep2 P13 A	0.1663	0.41	Rep3 P13 A	0.2422	0.22	Rep4 P13 A	0.2331	0.18
Rep2 P13 B	0.2951	0.34	Rep3 P13 B	0.2077	0.18	Rep4 P13 B	0.2318	0.22
Rep2 P13 B	0.2264	0.34	Rep3 P13 B	0.2223	(3.18	Rep4 P13 B	0.2132	0.22
Rep2 P13 B	0.1357	0.56	Rep3 P13 B	0.1848	0.22	Rep4 P13 B	0.2279	0.22
Rep2 PI 3 B	0.2037	0.3	Rep3 P13 B	0.2111	0.21	Rep4 P13 B	0.184	0.48
Rep2 P14 A	0.196	0.37	Rep3 P14 A	0.21	0.26	Rep4 P14 A	0.1672	0.28
Rep2 P14 A	0.1903	0.29	Rep3 P14 A	0.1364	0.29	Rep4 P14 A	0.1979	0.28
Rep2 P14 A	0.2193	0.32	Rep3 P14 A	0.1712	0.27	Rep4 P14 A	0.1706	0.29
Rep2 P14 A	0.1922	0.28	Rep3 P14 A	0.2085	0.24	Rep4 P14 A	0.2558	0.23
Rep2 P14 B	0.1885	0.26	Rep3 P14 B	0.2204	0.22	Rep4 P14 B	0.2065	0.26
Rep2 P14 B	0.213	0.3	Rep3 P14 B	0.1952	0.29	Rep4 P14 B	0.1599	0.27
Rep2 P14 B	0.1941	0.29	Rep3 P14 B	0.1787	0.23	Rep4 P14 B	0.213	0.26
Rep2 P14 B	0.2421	0.29	Rep3 P14 B	0.1721	0.23	Rep4 P14 B	0.1948	0.32
Rep2 P15 A	0.2399	0.27	Rep3 P15 A	0.236	0.23	Rep4 P15 A	0.2117	0.3
Rep2 P15 A	0.1877	0.29	Rep3 P15 A	0.206	0.21	Rep4 P15 A	0.1897	0.37
Rep2 P15 A	0.2025	0.4	Rep3 P15 A	0.1868	0.21	Rep4 P15 A	0.1887	0.32
Rep2 P15 A	0.1606	0.29	Rep3 P15 A	0.1825	0.27	Rep4 P15 A	0.2395	0.34
Rep2 P15 B	0.1682	0.27	Rep3 P15 B	0.2122	0.32	Rep4 P15 B	0.155	0.35
Rep2 PI 5 B	0.2272	0.38	Rep3 P15 B	0.1782	0.29	Rep4 P15 B	0.2295	0.33
Rep2 P15 B	0.2359	0.35	Rep3 P15 B	0.2392	0.24	Rep4 P15 B	0.1957	0.31
Rep2 P15 B	0.1763	0.34	Rep3 P15 B	0.1947	0.36	Rep4 P15 B		

Table G. Dissolved organic carbon on the IPM plots

Samples	Soil wt(g)	Water(ml)	Total C(ppm)	Inorg.C(ppm)	TOrg.C(ppm)
Rep2 P13 A	10.0318	25	92.76	5.38	87.38
Rep2 P13 A	10.0372	25	104.4	4.93	99.45
Rep2 P13 A	10.0169	25	77.63	5.12	72.52
Rep2 P13 A	10.016	25	92.31	6.68	85.63
Rep2 P13 B	10.0283	25	88.67	7.69	80.98
Rep2 P13 B	10.0525	25	100.5	6.51	93.99
Rep2 Pi3 B	10:0304	25	84.22	11.4	72.82
Rep2 P13 B	10.0348	25	77.02	6.51	70.51
Rep2 P12 A	10.0058	25	93.52	1.32	92.19
Rep2 P12 A	10.0132	25	62.55	2.34	60.22
Rep2 P12 A	10.0211	25	94.41	1.23	93.18
Rep2 P12 A	‘10.0173	25	90.74	1.29	89.45
Rep2 P12 B	10.041	25	96.46	1.57	94.88
Rep2 P12 B	10.0174	25	71.96	1.1	70.86
Rep2 P12 B	10.0242	25	96.37	2.08	94.28
Rep2 P12 B	10.0422	25	99.08	2.8	96.22
Rep2 P2 A	10.0295	25	67.32	3.88	63.44
Rep2 P2 A	10.0047	25	65.47	3.44	62.03
Rep2 P2 A	10.0107	25	58.01	3.37	54.64
Rep2 P2 A	10.0075	25	55.54	2.73	52.82
Rep2 P2 B	1 0.0354	25	66.43	6.71	59.72
Rep2 P2 B	10.0191	25	55.79	2.85	52.93
Rep2 P2 B	10.037	25	57.51	5.03	52.48
Rep2 P2 B	10.0374	25	60.26	3.09	57.17
Rep2 P14 A	10.0393	25	54.99	3.45	51.55
Rep2 P14 A	10.0038	25	112.3	6.52	105.7
Rep2 P14 A	10.0167	25	72.17	5.09	67.08
Rep2 P14 A	10.0155	25	78.95	3.29	75.66
Rep2 P14 B	10.0363	25	59.03	8.73	50.31
Rep2 P14 B	10.0253	25	63.2	14.3	48.9
Rep2 P14 B	10.0394	25	37.85	7.74	30.11
Rep2 P14 B	10.0326	25	61.6	9.75	51.64
Rep2 P10 A	10.0274	25	53.32	4.45	48.88
Rep2 P10 A	10.011	25	65.01	4.49	60.52
Rep2 P10 A	10.022	25	64.75	4.25	60.5
Rep2 P10 B	10.0432	25	32.79	1.98	30.81
Rep2 P10 B	10.0408	25	56.89	2.73	54.76
Rep2 P10 B	10.0225	25	74.82	6.18	68.64
Rep2 P10 B	10.0418	25	42.91	1.33	41.58
Rep2 P1 A	10.0485	25	77.6	7 35	70.25
Rep2 P1 A	10.0038	25	50.75	3.7	47.05
Rep2 P1 A	10.0127	25	83.73	3.88	79.85
Rep2 PI A	10.005	25	112.9	6.12	106.8
7 Rep2 PI B	10.0646	25	76.39	344	72.96
Rep2 P1 B	10.0319	25	40.96	2.81	38.14
Rep2 PI B	10.0224	25	109.3	6.43	102.9

Rep2 P15 A	10.0241	25	72.11	1.49	70.63
Rep2 P15 A	10.0047	25	87.64	2.05	85.59
Rep2 P15 A	10.0108	25	140.6	3.28	137.4
Rep2 P15 A	10.0154	25	84.29	1.14	83.15
Rep2 P15 B	10.0286	25	66.85	0.66	66.2
Rep2 P15 B	10.0288	25	66.39	1.72	64.67
Rep2 P15 B	10.8036	25	111.1	0.26	110.8
Rep2 P15 B	10.0356	25	73.17	1.19	71.98
Rep2 P6 A	10.0032	25	87.19	4.39	82.8
Rep2 P6 A	10.0015	25	75.95	4.09	71.86
Rep2 P6 A	10.0035	25	87.36	3.77	83.59
Rep2 P6 A	10.0088	25	109	4.19	104.9
Rep2 P6 B	10.0058	25	75.02	3.07	71.95
Rep2 P6 B	10.0852	25	98.52	4.56	93.97
Rep2 P6 B	10.0153	25	91.69	6.25	85.43
Rep2 P6 B	10.0354	25	82.49	3.72	78.77
Rep2 P5 A	10.0101	25	92.08	6.78	85.3
Rep2 P5 A	10.0338	25	75.29	9.58	65.71
Rep2 P5 A	10.0032	25	52.08	5	47.08
Rep2 P5 A	10.0011	25	73.89	6.95	66.95
Rep2 P5 B	10.057	25	45.97	4.16	41.81
Rep2 P5 B	10.016	25	93.17	5.82	87.35
Rep2 P5 B	10.0043	25	49.68	5.7	43.99
Rep2 P5 B	10.0069	25	41.36	6.33	35.03
Rep2 P3 A	10.0128	25	95.97	5.8	90.17
Rep2 P3 A	10.0646	25	409.5	4.71	104.8
Rep2 P3 A	10.0191	25	85.01	3.46	81.55
Rep2 P3 A	10.0229	25	41.87	1.75	40.12
Rep2 P3 B	10.0743	25	171.4	12.32	159.1
Rep2 P3 B	10.0975	25	78.55	4.84	73.71
Rep2 P3 B	10.0548	25	87.2	4.34	82.87
Rep2 P3 B	10.0154	25	55.21	1.71	53.5
Rep2 P7 A	10.0345	25	32.02	1.1	30.92
Rep2 P7 A	10.0093	25	48.14	0.92	47.22
Rep2 P7 A	10.0019	25	33	6.43	26.57
Rep2 P7 A	10.0122	25	42.14	1.14	41
Rep2 P7 B	10.0205	25	28.54	5.64	22.9
Rep2 P7 B	10.01	25	30.82	4.53	26.29
Rep2 P7 B	10.016	25	53.57	1.36	52.21
Rep2 P7 B	10.011	25	48.79	0.93	47.87
Rep2 P4 A	10.0072	25	61.94	3.53	58.41
Rep2 P4 A	10.0141	25	25.2	2.59	22.61
Rep2 P4 A	10.0218	25	80.55	7.45	73.1
Rep2 P4 A	10.0092	25	58.07	6.02	52.05
Rep2 P4 B	10.0398	25	72.55	5.38	67.16
Rep2 P4 B	10.0016	25	63.33	5.47	57.86
Rep2 P4 B	10.0053	25	60.31	4.21	56.09
Rep2 P4 B	10.0079	25	59.6	5.47	54.13

Table G. Continued

Samples	Soil wt(g)	Water(ml)	Total C(ppm)	Inorg.C(ppm)	Org.C(ppm)
Rep3 P13 A	10.0265	25	59.03	8.73	50.31
Rep3 P13 A	10.05	25	63.2	14.2	48.9
Rep3 P13 A	10.0271	25	37.85	7.74	30.11
Rep3 P13 A	10.0281	25	61.6	9.75	51.84
Rep3 P13 B	10.0374	25	49.93	9.08	40.85
Rep3 P13 B	10.0048	25	50.19	17.71	32.48
Rep3 P13 B	10.0052	25	34.9	9.23	25.67
Rep3 P13 B	10.006	25	55.92	6.2	49.72
Rep3 PI;! A	10.0447	25	79.32	1.98	77.34
Rep3 PIL! A	10.0748	25	88.67	2.1	86.57
Rep3 P12 A	10.0158	25	58.87	2.35	56.77
Rep3 P12 A	10.0144	25	63.93	2.18	61.75
Rep3 P12 B	10.0066	25	79.83	2.8	77.03
Rep3 P12 B	10.0253	25	82.59	3.01	79.58
Rep3 Pli! B	10.014	25	71.33	2.52	68.81
Rep3 P12 B	10.0329	25	76.92	2.33	74.59
Rep3 P2 A	10.0623	25	69.46	3.58	65.88
Rep3 P2 A	10.0475	25	49.16	3.37	45.79
Rep3 P2 A	10.0535	25	64.53	2.94	61.59
Rep3 P2 A	10.0827	25	50.89	2.26	48.63
Rep3 P2 B	10.0057	25	80.39	4.56	75.83
Rep3 P2 B	10.0908	25	52.92	1.75	51.17
Rep3 P2 B	10.0682	25	75.13	2.83	72.3
Rep3 P2 B	10.0312	25	73.15	2.27	70.88
Rep3 P14 A	10.0318	25	62.1	4.35	57.75
Rep3 P14 A	10.0117	25	68.35	5.62	62.73
Rep3 P14 A	10.0258	25	45.13	4.1	41.03
Rep3 P14 A	1.0422	25	62.72	3.49	59.23
Rep3 P14 B	10.0014	25	62.89	7.81	55.08
Rep3 P14 B	10.0113	25	81.02	10.21	70.81
Rep3 P14 B	10.0084	25	70.11	6.83	63.28
Rep3 P14 B	10.0027	25	76.32	7.75	69.07
Rep3 P10 A	10.043	25	69.53	4.63	64.9
Rep3 P10 A	10.0242	25	86.04	5.64	80.4
Rep3 P10 A	10.0023	25	57.43	6.95	50.49
Rep3 P10 A	10.0131	25	76.19	4.12	72.07
Rep3 P10 B	10.0139	25	43.76	4.37	39.38
Rep3 P10 B	10.0073	25	49.33	3.66	45.66
Rep3 P10 B	10.0368	25	68.47	2.53	65.93
Rep3 P10 B	10.0294	25	41.1	3.94	37.16
Rep3 PI A	10.0364	25	66.46	3.61	62.85
Rep3 P1 A	10.0708	25	55.65	2.33	53.32
Rep3 P1 A	10.0308	25	76.81	3.54	73.27
Rep3 P1 A	10.0602	25	64.34	2.39	61.95
Rep3 PI B	10.048	25	46.06	1.9	44.16
Rep3 P1 B	10.0654	25	38.21	1.8	36.41
Rep3 P1 B	10.0388	25	56.85	2.65	54.2

Rep3 P1 B	10.0759	25	47.74	2.21	45.52
Rep3 P15 A	10.0098	25	11.95	0.54	99.92
Rep3 P15 A	10.028	25	101.4	1.48	99.88
Rep3 P15 A	10.0199	25	66.52	0.1	66.42
Rep3 P15 A	10.0331	25	84.07	0.5	83.52
Rep3 P15 B	10.0201	25	81.62	1.37	80.25
Rep3 P15 B	10.0269	25	84.68	1.53	83.15
Rep3 P15 B	10.0028	25	120.7	1.14	119.6
Rep3 P15 B	10.0331	25	86.47	1.96	84.51
Rep3 P6 A	10.0202	25	98.56	4.96	93.6
Rep3 P6 A	10.0018	25	68.46	3.66	64.79
Rep3 P6 A	10.0184	25	78.12	1.38	76.74
Rep3 P6 A	10.0202	25	90.96	2.17	88.79
Rep3 P6 B	10.0087	25	77.07	2.21	74.87
Rep3 P6 B	10.0149	25	116.4	2.56	113.8
Rep3 P6 B	10.0152	25	68.01	2.11	65.9
Rep3 P6 B	10.0193	25	72	3.34	68.66
Rep3 P5 A	10.008	25	39.28	5.38	33.9
Rep3 P5 A	10.0234	25	40.43	4.56	35.86
Rep3 P5 A	10.0521	25	59.66	6.4	53.26
Rep3 P5 A	10.0173	25	25.79	3.52	22.27
Rep3 P5 B	10.0021	25	46.83	2.45	44.38
Rep3 P5 B	10.0422	25	70.22	7.02	63.2
Rep3 P5 B	10.0061	25	38.2	2.72	35.45
Rep3 P5 B	10.0458	25	47.77	3.02	44.75
Rep3 P3 A	10.0165	25	116.9	6.14	110.8
Rep3 P3 A	10.0075	25	82.92	3.43	79.49
Rep3 P3 A	10.0067	25	83.35	7.4	75.95
Rep3 P3 A	10.0441	25	89.97	4.54	85.43
Rep3 P3 B	10.066	25	71.22	3.05	68.17
Rep3 P3 B	10.022	25	27.1	3.03	24.07
Rep3 P3 B	10.0305	25	123	15.71	107.2
Rep3 P3 B	10.0047	25	55.03	7.32	47.71
Rep3 P7 A	10.0595	25	60.69	1.71	58.98
Rep3 P7 A	10.0577	25	20.52	0.86	19.66
Rep3 P7 A	10.0279	25	45.08	6.75	38.33
Rep3 P7 A	10.0367	25	44.34	5.69	38.65
Rep3 P7 B	10.0053	25	50.24	2.8	47.43
Rep3 P7 B	10.0154	25	39.59	2.88	36.71
Rep3 P7 B	10.0071	25	49.66	2.49	47.17
Rep3 P7 B	10.0503	25	39.04	1.89	37.15
Rep3 P4 A	10.0224	25	62.43	5.64	56.98
Rep3 P4 A	10.0343	25	50.94	7.96	42.98
Rep3 P4 A	10.0397	25	33.34	3.56	29.98
Rep3 P4 A	10.0223	25	51.45	6.71	44.74
Rep3 P4 B	10.0338	25	44.62	7.07	37.55
Rep3 P4 B	10.0134	25	41.6	5.17	36.43
Rep3 P4 B	10.0047	25	63.66	6.11	57.55
Rep3 P4 B	10.0065	25	77.24	8.09	69.15

Table G. Continued

Samples	Soil wt(g)	Water(rnl)	Total C(ppm)	Inorg.C(ppm)	TOrg.C(ppm)
Rep4 P13 A	10.0066	25	40.97	4.6	36.37
Rep4 P13 A	10.0043	25	88.67	14.54	74.13
Rep4 PI 3 A	10.0187	25	47.87	8.99	38.88
Rep4 P13 A	10.0284	25	58.46	8.35	49.9
Rep4 P13 B	10.0144	25	49.43	10.92	38.5
Rep4 P13 B	10.0363	25	72.59	13.89	58.71
Rep4 P13 B	10.0027	25	71.33	6.11	65.22
Rep4 P13 B	10.0265	25	77.26	7.96	69.66
Rep4 PI2 A	10.0086	25	124.6	4.21	120.4
Rep4 PI:! A	10.0083	25	84.24	1.92	82.27
Rep4 P12 A	10.0323	25	92.61	0.99	91.62
Rep4 PI:! A	10.014	25	105.9	2.3	103.6
Rep4 P12 B	10.0062	25	79.32	4.33	74.98
Rep4 P12 B	10.011	25	II 3.3	2.85	109.4
Rep4 PI2 B	10.0087	25	59.55	1.66	57.89
Rep4 P12 B	10.008	25	58.63	2.48	56.15
Rep4 P2 A	10.0038	25	71.05	1.61	69.44
Rep4 P2 A	10.0412	25	57.75	1.35	56.4
Rep4 P2 A	10.0104	25	80.37	1.64	78.73
Rep4 P2 A	10.0986	25	93.86	7.02	86.84
Rep4 P2 B	10.087	25	80.54	7.07	72.47
Rep4 P2 B	10.0179	25	99.27	7.27	92
Rep4 P2 B	10.0043	25	67.9	2.32	65.58
Rep4 P2 B	10.0125	25	58.16	2.09	56.08
Rep4 PI4 A	10.0212	25	80.13	6.51	73.62
Rep4 PI4 A	10.0116	25	82.34	9.72	72.59
Rep4 P14 A	10.0185	25	78.12	5.31	72.81
Rep4 P14 A	10.0152	25	79.11	6.48	72.63
Rep4 P14 B	10.035	25	90.14	3.69	86.44
Rep4 PI4 B	10.0158	25	96.66	4.55	92.11
Rep4 PI4 B	10.0208	25	95.04	2.5	92.54
Rep4 PI4 B	10.0175	25	82.08	2.39	79.69
Rep4 PI0 A	10.0403	25	43.04	2.29	40.75
Rep4 P10 A	10.0088	25	40.3	2.81	37.49
Rep4 P10 A	10.0131	25	76.5	6.7	69.8
Rep4 P10 A	10.0583	25	32.88	6.7	26.18
Rep4 P10 B	10.0262	25	34.22	11.4	22.82
Rep4 P10 B	10.0276	25	27.02	6.51	20.51
Rep4 P10 B	10.0121	25	35.01	3.64	31.38
Rep4 P10 B	10.0398	25	72	3.71	68.29
Rep4 Pi A	10.0489	25	102.9	7.91	95.02
Rep4 P1 A	10.0279	25	87.66	6.67	80.99
Rep4 P1 A	10.0434	25	90.94	7.09	83.85
Rep4 P1 A	10.0506	25	88.57	7.22	81.35
Rep4 PI B	10.0184	25	78.72	5.32	73.39
Rep4 P1 B	10.0054	25	95.07	6.36	88.72
Rep4 PI B	10.0818	25	68.46	4.73	63.73

Rep4 P1 B	10.09	25	107.6	9.57	98.01
Rep4 P15 A	10.0161	25	96.28	0.35	95.94
Rep4 P15 A	10.0378	25	103.9	1.21	102.7
Rep4 P15 A	10.0371	25	99.77	1.94	97.83
Rep4 P15 A	10.0247	25	98.28	1.16	97.13
Rep4 P15 B	10.018	25	134.6	2.14	132.5
Rep4 P15 B	10.0212	25	135.5	2.37	133.2
Rep4 P15 B	10.0102	25	155.5	3.58	152
Rep4 P15 B	10.0253	25	102.4	2.37	100.1
Rep4 P6 A	10.0394	25	53.02	0.4	52.62
Rep4 P6 A	10.0078	25	49	98	48.02
Rep4 P6 A	10.0284	25	62.31	0.61	61.7
Rep4 P6 A	10.0493	25	42.68	0.99	41.68
Rep4 P6 B	10.0163	25	53.72	2.35	51.37
Rep4 P6 B	10.0299	25	43.57	0.96	42.61
Rep4 P6 B	10.0297	25	61.52	2.78	58.74
Rep4 P6 B	10.0198	25	70.67	1.89	68.84
Rep4 P5 A	10.0342	25	73.44	5.38	68.06
Rep4 P5 A	10.0232	25	62.29	5.68	56.61
Rep4 P5 A	10.0238	25	81.98	6.42	75.56
Rep4 P5 A	10.0124	25	48.77	3.55	45.21
Rep4 P5 B	10.0505	25	74.24	6.14	68.1
Rep4 P5 B	10.0058	25	62.11	4.24	57.88
Rep4 P5 B	10.0204	25	69.54	5.17	64.37
Rep4 P5 B	10.0057	25	66.11	4.69	61.42
Rep4 P3 A	10.0346	25	71.22	3.05	68.17
Rep4 P3 A	10.0762	25	27.1	3.03	24.07
Rep4 P3 A	10.0101	25	123	15.71	107.2
Rep4 P3 A	10.0173	25	55.03	7.32	47.71
Rep4 P3 B	10.0011	25	103	7.88	95.11
Rep4 P3 B	10.0475	25	43.9	3.27	40.63
Rep4 P3 B	10.0172	25	11.9	6.93	93.97
Rep4 P3 B	10.0247	25	111.8	7.79	104
Rep4 P7 A	10.0164	25	57.82	2.15	55.67
Rep4 P7 A	10.0453	25	90.93	5.45	85.47
Rep4 P7 A	10.019	25	59.72	2.06	57.66
Rep4 P7 A	10.0135	25	50.14	1.85	48.29
Rep4 P7 B	10.0229	25	47.25	3.63	43.62
Rep4 P7 B	10.0463	25	61.52	2.73	58.79
Rep4 P7 B	10.0278	25	39.31	1.49	37.82
Rep4 P7 B	10.0105	25	38.23	3.21	35.02
Rep4 P4 A	10.0068	25	49.87	5.22	44.69
Rep4 P4 A	10.059	25	84.69	9.06	75.03
Rep4 P4 A	10.0193	25	72.53	6.57	65.95
Rep4 P4 A	10.018	25	68.44	7.39	61.06
Rep4 P4 B	10.0546	25	86.38	7.77	78.61
Rep4 P4 B	10.0184	25	53.91	6.68	47.24
Rep4 P4 B	10.0168	25	62.27	6.02	56.25
Rep4 P4 B	10.0067	25	82.76	10.31	72.44

Table H. Microbial biomass in the IPM plots

SAMPLE	NO	RESULT ml HCL	IDENT Fum./Unf.	WEIGHT (g)	NaOH meq	Kc	M.C. (%)	:02-c j/g soil
PI R2A	1	0.34547	fumigated	21.68	2	0.45	55	324.65
P1 R2A	2	0.26065	fumigated	20.08	2	0.45	55	225.37
PI R2A	3	0.10792	unfumigat.	20.56	2	0.45	55	
P1R2B	4	0.43904	fumigated	20.51	2	0.45	55	444.92
PI R2B	5	0.36134	fumigated	20.58	2	0.45	55	360.34
PI R2B	6	0.37529	fumigated	20.09	2	0.45	55	360.20
PI R2B	7	0.13106	unfumigat.	20.38	2	0.45	55	
PI R3A	a	0.35733	fumigated	20.33	2	0.45	55	356.78
PI R3A	9	0.11253	unfumigat.	20.39	2	0.45	55	
P1R3B	10	0.39167	fumigated,	21.98	2	0.45	55	392.26
P1R3B	11	0.22131	fumigated	22.9	2	0.45	55	156.08
P1R3B	12	0.21604	fumigated	21.04	2	0.45	55	162.46
PI R3B	13	0.10068	unfurnigat.	21.15	2	0.45	55	
PI R4A	14	0.29806	fumigated	21.93	2	0.45	55	247.28
PI R4A	15	0.23797	fumigated	21.04	2	0.45	55	173.12
PI R4A	26	0.11504	unfumigat.	20.65	2	0.45	55	
PI R4B	17	0.2456	fumigated	20.09	2	0.45	55	217.08
P1R4B	18	0.19457	fumigated	20.6	2	0.45	55	1 38.02
PI R4B	19	0.19752	fumigated	20.04	2	0.45	55	146.24
P1R4B	20	0.16809	fumigated	20.25	2	0.45	55	101.66
PI R4B	21	0.09861	unfurnigat.	20.79	2	0.45	55	
P2R2A	22	0.42039	fumigated	20.03	2	0.45	55	452.11
P2R2A	23	0.5961	fumigated	20.58	2	0.45	55	693.00
P2R2A	24	0.59365	fumigated	20.63	2	0.45	55	687.80
P2R2A	25	0.34824	fumigated	20.8	2	0.45	55	332.59
P2R2A	26	0.11476	unfumigat.	20.04	2	0.45	55	
P2R2B	27	0.51133	fumigated	22.12	2	0.45	55	477.99
P2R2B	28	0.52352	fumigated	20.52	2	0.45	55	532.86
P2R2B	29	0.50011	fumigated	2'1.03	2	0.45	55	486.95
P2R2B	30	0.15449	unfurnigat.	20.06	2	0.45	55	
P2R3A	31	0.65374	fumigated	20.05	2	0.45	55	733.22
P2R3A	32	0.6829	fumigated	20.64	2	0.45	55	754.12
P2R3A	33	0.62081	fumigated	20.67	2	0.45	55	664.02
P2R3A	34	0.75389	fumigated	20.61	2	0.45	55	857.28
P2R3A	35	0.15758	unfurnigat.	20.05	2	0.45	55	
P2R3B	36	0.75959	fumigated	21.73	2	0.45	55	800.38
P2R3B	37	0.893	fumigated	20.85	2	0.45	55	1023.75
P2R3B	38	0.74949	fumigated	20 23	2	0.45	55	844.94
P2R3B	39	0.93552	fumigated	20.74	2	0.45	55	1089.92
P2R3B	40	0.1726	unfumigat.	21 .a4	2	0.45	55	
P2R4A	41	0.99011	fumigated	20.14	2	0.45	55	1183.71
P2R4A	42	0.83857	fumigated	21.96	2	0.45	55	881.14
P2R4A	43	0.95686	fumigated	20.03	2	0.45	55	1141.03
P2R4A	44	0.83958	fumigated	20.96	' 2	0.45	55	924.61
P2R4A	45	0.18551	unfumigat.	20.69	2	0.45	55	
P2R4B	46	0.91406	fumigated	21 47	2	0.45	55	1004.74

Table H. Continued

SAMPLE	NO	RESULT ml HCl	IDENT Fum./Unf.	WEIGHT (g)	NaOH meq	KC	M.C. (%)	CO2-C ug/g soil
P3R2A	1	0.86947	fumigated	20.76	2	0.45	55	1125.36
P3R2A	2	0.92254	fumigated	20.24	2	0.45	55	1231.96
P3R2A	3	0.82461	fumigated	20.33	2	0.45	55	1083.78
P3R2A	4	0.82832	fumigated	20.91	2	0.45	55	1058.97
P3R2A	5	0.08099	unfwmigat.	20.31	2	0.45	55	
P3R2B	6	0.79295	fumigated	20	2	0.45	55	942.76
P3R2B	7	0.83188	fumigated	20.64	2	0.45	55	969.41
P3R2B	8	0.76181	fumigated	20.21	2	0.45	55	887.31
P3R2B	9	0.98006	fumigated	20.26	2	0.45	55	1204.30
P3R2B	10	0.15659	unfumigat.	20.64	2	0.45	55	
P3R3A	11	0.97415	fumigated	20.05	2	0.45	55	1284.85
P3R3A	12	0.58221	fumigated	20.87	2	0.45	55	677.92
P3R3A	13	0.77228	fumigated	20.29	2	0.45	55	974.86
P3R3A	14	0.83104	fumigated	20.27	2	0.45	55	1061.71
P3R3A	15	0.10471	unfumigat.	20.72	2	0.45	55	
P3R3B	16	0.78523	fumigated	20.3	2	0.45	55	1029.96
P3R3B	17	0.9143	fumigated	20.99	2	0.45	55	1178.30
P3R3B	18	0.80468	fumigated	20.48	2	0.45	55	1049.05
P3R3B	19	0.8405	fumigated	20.12	2	0.45	55	1120.57
P3R3B	20	0.07958	unfumigat.	20.7	2	0.45	55	
P3R4A	21	0.63536	fumigated	20.74	2	0.45	55	738.17
P3R4A	22	0.90564	fumigated	20.93	2	0.45	55	1114.09
P3R4A	23	0.5895	fumigated	20.19	2	0.45	55	690.98
P3R4A	24	0.65667	fumigated	20.38	2	0.45	55	782.19
P3R4A	25	0.11866	unfumigat.	20.33	2	0.45	55	
P3R4B	26	0.70216	fumigated	20.34	2	0.45	55	885.92
P3R4B	27	0.43982	fumigated	20.84	2	0.45	55	493.68
P3R4B	28	0.79146	fumigated	20.27	2	0.45	55	1019.51
P3R4B	29	0.65267	fumigated	20.91	2	0.45	55	791.64
P3R4B	30	0.094	unfumigat.	20.95	2	0.45	55	
P4R2A	31	0.65279	fumigated	20.79	2	0.45	55	292.09
P4R2A	32	1.118	fumigated	20.95	2	0.45	55	947.81
P4R2A	33	0.64374	fumigated	20.7	2	0.45	55	280.41
P4R2A	34	0.73899	fumigated	20.9	2	0.45	55	412.76
P4R2A	35	0.44784	unfumigat.	20.55	2	0.45	55	
P4R2B	36	0.65169	fumigated	20.34	2	0.45	55	515.85
P4R2B	37	0.49333	fumigated	20.04	2	0.45	55	289.44
P4R2B	38	0.47365	fumigated	20.72	2	0.45	55	251.79
P4R2B	39	0.71788	fumigated	20.44	2	0.45	55	609.28
P4R2B	40	0.29757	unfumigat.	20.67	2	0.45	55	
P4R3A	41	0.70483	fumigated	20.08	2	0.45	55	885.80
P4R3A	42	0.2011	fumigated	20.23	2	0.45	55	141.45
P4R3A	43	0.37478	fumigated	20.5	2	0.45	55	390.62
P4R3A	44	0.65165	fumigated	20.37	2	0.45	55	795.84
P4R3A	45	0.10452	unfumigat.	20.92	2	0.45	55	
P4R3B	46	0.16698	fumigated	20.23	2	0.45	55	101.85

Table H. Continued

SAMPLE	NO	RESULT ml HCl	IDENT Fum./Unf.	WEIGHT (g)	NaOH meq	Kc	M.C. (%)	CO2-C ug/g soil
P5R2A	1	0.27828	fumigated	20.21	2	0.45	55	294.10
P5R2A	2	0.30174	fumigated	20.02	2	0.45	55	331.61
P5R2A	3	0.2863	fumigated	20.9	2	0.45	55	295.76
P5R2A	4	0.22667	fumigated	20.28	2	0.45	55	217.68
P5R2A	5	0.07768	unfumigat.	20.09	2	0.45	55	
P5R2B	6	0.42026	fumigated	20.63	2	0.45	55	569.71
P5R2B	7	0.20876	fumigated	20.38	2	0.45	55	269.21
P5R2B	8	0.20876	fumigeted	20.05	2	0.45	55	273.64
P5R2B	9	0.32581	fumigated	20.27	2	0.45	55	441.77
P5R2B	10	0.02359	unfumigat.	20.13	2	0.45	55	
P5R3A	11	0.30898	fumigated	20.38	2	0.45	55	289.46
P5R3A	12	0.2361	fumigated	20.19	2	0.45	55	185.23
P5R3A	13	0.3613	fumigated	20.19	2	0.45	55	368.97
P5R3A	14	0.47474	fumigated	20.23	2	0.45	55	534.39
P5R3A	15	0.10988	unfumigat.	20.31	2	0.45	55	
P5R3B	16	0.40366	fumigated	20.15	2	0.45	55	473.34
P5R3B	17	0.2196	fumigated	20.9	2	0.45	55	195.41
P5R3B	18	0.42143	fumigated	20.99	2	0.45	55	479.48
P5R3B	19	0.3332	fumigated	20.98	2	0.45	55	355.10
P5R3B	20	0.08176	unfumigat.	20.59	2	0.45	55	
P5R4A	21	0.18037	fumigated	20.84	2	0.45	55	255.66
P5R4A	22	0.17276	fumiga ted	20.66	2	0.45	55	246.98
P5R4A	23	0.12623	fumigated	20.09	2	0.45	55	185.36
P5R4A	24	0.11785	fumigated	20.35	2	0.45	55	170.79
P5R4A	25	0.00055	unfumigat.	20.35	2	0.45	55	
P5R4B	26	0.5275	fumigated	20.31	2	0.45	55	843.38
P5R4B	27	0.5299	fumigated	20.87	2	0.45	55	1629.52
P5R4B	28	0.4573	fumigated	20.2	2	0.45	55	543.91
P5R4B	29	0.61259	fumigated	20.27	2	0.45	55	769.03
P5R4B	30	0.08649	unfumigat.	20.79	2	0.45	55	
P6R2A	31	0.59448	fumigated	20.7	2	0.45	55	707.13
P6R2A	32	0.65783	fumigated	20.6	2	0.45	55	801.68
P6R2A	33	0.72951	fumigated	20.39	2	0.45	55	914.10
P6R2A	34	0.52818	fumigated	20.34	2	0.45	55	623.07
P6R2A	35	0.10046	unfumigat.	20.77	2	0.45	55	
P6R2B	36	0.61704	fumigated	20.59	2	0.45	55	'735.03
P6R2B	37	0.64322	fumigated	20.32	2	0.45	55	'782.97
P6R2B	38	1.09998	fumigated	20.3	2	0.45	55	1450.42
P6R2B	39	0.90053	fumigated	20.79	2	0.45	55	1131.98
P6R2B	40	0.10626	unfumigat.,	20.44	2	0.45	55	
P6R3A	41	0.52724	fumigated	20.56	2	0.45	55	617.22
P6R3A	42	0.96952	fumigated	20.42	2	0.45	55	1'263.21
P6R3A	43	0.92303	fumigaled	20.63	2	0.45	55	1183.58
P6R3A	44	0.97948	fumigaled	20.85	2	0.45	55	1251.31
P6R3A	45	0.09895	unfumigat.	20.46	2	0.45	55	
P6R3B	46	0.98484	fumigated	20.5	2	0.45	55	1264.00

Table H. Continued

SAMPLE	NO	RESULT ml HCl	IDENT Fum./Unf.	WEIGHT (g)	NaOH meq	Kc	M.C. (%)	CO2-C ug/g soil
P7R2A	1	0.41237	fumigated	20.61	2	0.45	55	474.29
P7R2A	2	0.42254	fumigated	20.16	2	0.45	55	499.82
P7R2A	3	0.20929	fumigated	20.34	2	0.45	55	184.76
P7R2A	4	0.38232	fumigated	20.26	2	0.45	55	438.54
P7R2A	5	0.08246	unfumigat.	20.4	2	0.45	55	
P7R2B	6	0.39295	fumigated	20.26	2	0.45	55	431.36
P7R2B	7	0.3188	fumigated	20.09	2	0.45	55	325.65
P7R2B	8	0.46181	fumigated	20.3	2	0.45	55	531 .01
P7R2B	9	0.56593	fumigated	20.26	2	0.45	55	684.33
P7R2B	10	0.098	unfumigat.	20.39	2	0.45	55	
P7R3A	11	0.50471	fumigated	20.8	2	0.45	55	580.20
P7R3A	12	0.58221	fumigated	20.74	2	0.45	55	692.60
P7R3A	13	0.37228	fumigated	20.47	2	0.45	55	397.86
P7R3A	14	0.43104	fumigated	20.59	2	0.45	55	480.10
P7R3A	15	0.09741	unfumigat.	20.62	2	0.45	55	
P7R3B	16	0.48523	fumigated	20.64	2	0.45	55	432.36
P7R3B	17	0.39143	fumigated	20.58	2	0.45	55	298.57
P7R3B	18	0.48046	fumigated	20.6	2	0.45	55	426.34
P7R3B	19	0.47958	fumigated	20.21	2	0.45	55	433.27
P7R3B	20	0.18405	unfumigat.	20.43	2	0.45	55	
P7R4A	21	0.63536	fumigated	20.99	2	0.45	55	769.07
P7R4A	22	0.51866	fumigated	20.32	2	0.45	55	624.26
P7R4A	23	0.5895	fumigated	20.37	2	0.45	55	725.77
P7R4A	24	0.45667	fumigated	20.53	2	0.45	55	528.41
P7R4A	25	0.09054	unfumigat.	20.51	2	0.45	55	
P7R4B	26	0.50216	fumigated	20.72	2	0.45	55	472.90
P7R4B	27	0.43982	fumigated	20.77	2	0.45	55	382.83
P7R4B	28	0.41094	fumigated	20.4	2	0.45	55	347.83
P7R4B	29	0.65267	fumigated	20.29	2	0.45	55	702.71
P7R4B	30	0.17146	unfumigat.	20.53	2	0.45	55	
P10R2A	31	0.74784	fumigated	20.53	2	0.45	55	956.23
P10R2A	32	1.118	fumigated	20.66	2	0.45	55	1481.08
P10R2A	33	0.64374	fumigated	20.66	2	0.45	55	800.92
P10R2A	34	0.73899	fumigated	20.7	2	0.45	55	935.71
P10R2A	35	0.085279	unfumigat.	20.28	2	0.45	55	
P10R2B	36	0.65169	fumigated	20.4	2	0.45	55	729.64
P10R2B	37	0.79757	fumigated	20.92	2	0.45	55	918.12
P10R2B	38	0.77365	fumigated	20.74	2	0.45	55	891.92
P10R2B	39	0.71788	fumigated	20.56	2	0.45	55	819.35
P10R2B	40	0.14933	unfumigat.	20.87	2	0.45	55	
P10R3A	41	0.70483	fumigated	20.25	2	0.45	55	786.98
P10R3A	42	0.62011	fumigated	20.25	2	0.45	55	663.02
P10R3A	43	0.87478	fumigated	20.43	2	0.45	55	1026.52
P10R3A	44	0.65165	fumigated	20.62	2	0.45	55	696.44
P10R3A	45	0.16698	unfumigat.	20.41	2	0.45	55	
P10R3B	46	1.02387	fumigated	20.42	2	0.45	55	1336.39

Table H. Continued

SAMPLE	NO	RESULT ml HCl	IDENT Fum./Unf.	WEIGHT (g)	NaOH meq	Kc	M.C. (%)	CO2-C µg/g soil
P12R2A	1	0.84784	fumigated	20.65	2	0.45	55	1094.16
P12R2A	2	1.118	fumigatcsd	20.57	2	0.45	55	1487.56
P12R2A	3	0.74374	fumigated	20.54	2	0.45	55	949.85
P12R2A	4	0.83899	fumigated	20.6	2	0.45	55	1084.09
P12R2A	5	0.085279	unfurnigat.	20.79	2	0.45	55	
P12R2B	6	0.75169	fumigated	20.89	2	0.45	55	854.37
P12R2B	7	0.89757	fumigated	20.74	2	0.45	55	1068.95
P12R2B	8	0.87365	fumigated	20.55	2	0.45	55	1044.35
P12R2B	9	0.81788	fumigated	20.97	2	0.45	55	944.63
P12R2B	10	0.14933	unfurnigat.	20.6	2	0.45	55	
P12R3A	11	0.80483	fumigated	20.95	2	0.45	55	902.11
P12R3A	12	0.72011	fumigated	20.54	2	0.45	55	797.91
P12R3A	13	0.87478	fumigated	20.2	2	0.45	55	1038.21
P12R3A	14	0.75165	fumigated	20.09	2	0.45	55	862.30
P12R3A	15	0.16698	unfurnigat.	20.6	2	0.45	55	
P12R3B	16	1.02387	fumigated	20.57	2	0.45	55	1326.65
P12R3B	17	0.89744	fumigated	20.77	2	0.45	55	1133.52
P12R3B	18	0.81069	fumigated	20.62	2	0.45	55	1017.11
P12R3B	19	0.73636	fumigated	20.6	2	0.45	55	911.18
P12R3B	20	0.10286	unfurnigat.	20.44	2	0.45	55	
P12R4A	21	0.75133	fumigated	20.84	2	0.45	55	904.67
P12R4A	22	0.79457	fumigated	20.77	2	0.45	55	969.40
P12R4A	23	0.8279	fumigated	20.81	2	0.45	55	1015.00
P12R4A	24	0.8748	fumigated	20.82	2	0.45	55	1081.25
P12R4A	25	0.11503	unfurnigat.	20.32	2	0.45	55	
P12R4B	26	0.87913	fumigated	20.63	2	0.45	55	1061.32
P12R4B	27	0.85658	fumigated	20.81	2	0.45	55	1020.04
P12R4B	28	0.70421	fumigated	20.66	2	0.45	55	808.92
P12R4B	29	0.83313	fumigated	20.89	2	0.45	55	982.87
P12R4B	30	0.14017	unfumigat.	20.86	2	0.45	55	
P13R2A	31	0.37878	fumigated	20.43	2	0.45	55	415.53
P13R2A	32	0.38386	fumigated	20.96	2	0.45	55	412.20
P13R2A	33	0.34579	fumigated	20.72	2	0.45	55	362.53
P13R2A	34	0.29886	fumigated	20.62	2	0.45	55	296.86
P13R2A	35	0.09227	unfumigat.	20.6	2	0.45	55	
P13R2B	36	0.24227	fumigated	20.7	2	0.45	55	232.74
P13R2B	37	0.25228	fumigated	20.9	2	0.45	55	244.71
P13R2B	38	0.2429	fumigated	20.71	2	0.45	55	233.53
P13R2B	39	0.37227	fumigated	20.5	2	0.45	55	422.91
P13R2B	40	0.07967	unfumigat.	20.53	2	0.45	55	
P13R3A	41	0.22902	fumigated	20.45	2	0.45	55	216.39
P13R3A	42	0.3087	fumigated	20.72	2	0.45	55	327.51
P13R3A	43	0.22987	fumigated	20.38	2	0.45	55	218.37
P13R3A	44	0.22902	fumigated	20.44	2	0.45	55	216.50
P13R3A	45	0.07967	unfumigat.	20.84	2	0.45	55	
P13R3B	46	0.3194	fumigated	20.64	2	0.45	55	360.72

Table H. Continued

SAMPLE	NO	RESULT ml HCl	IDENT Fum./Unf.	WEIGHT (g)	NaOH meq/L	Kc	M.C. (%)	CO2-C uglg soit
P14R2A	1	0.47878	fumigated	20.66	2	0.45	55	554.32
P14R2A	2	0.38386	fumigated	20.8	2	0.45	55	415.37
P14R2A	3	0.44579	fumigated	20.72	2	0.45	55	505.53
PI 4R2A	4	0.66661	fumigated	20.75	2	0.45	55	820.12
PI 4R2A	5	0.09227	unfumigat.	20.13	2	0.45	55	
P14R2B	6	0.25228	fumigated	20.47	2	0.45	55	249.85
P14R2B	7	0.27561	fumigated	20.9	2	0.45	55	277.78
P14R2B	8	0.2429	fumigated	20.99	2	0.45	55	230.42
P14R2B	9	0.37227	fumigated	20.59	2	0.45	55	421.06
P14R2B	10	0.07967	unfumigat.	20.64	2	0.45	55	
P14R3A	11	0.22902	fumigated	20.48	2	0.45	55	235.69
P14R3A	12	0.3194	fumigated	20.67	2	0.45	55	363.08
P14R3A	13	0.34434	fumigated	20.46	2	0.45	55	402.93
P14R3A	14	0.3696	fumigated	20.61	2	0.45	55	436.31
P14R3A	15	0.06611	unfumigat.	20.94	2	0.45	55	
P14R3B	16	0.37529	fumigated	20.27	2	0.45	55	447.86
P14R3B	17	0.20353	fumigated	20.64	2	0.45	55	193.27
P14R3B	18	0.3669	fumigated	20.42	2	0.45	55	432.40
PI 4R3B	19	0.3845	fumigated	20.71	2	0.45	55	451.53
P14R3B	20	0.0689	unfumigat.	20.28	2	0.45	55	
P14R4A	21	0.4243	fumigated	20.75	2	0.45	55	520.32
P14R4A	22	0.5895	fumigated	20.45	2	0.45	55	767.31
P14R4A	23	0.6504	fumigated	20.96	2	0.45	55	834.73
P14R4A	24	0.53366	fumigated	20.95	2	0.45	55	670.03
P14R4A	25	0.05991	unfumigat.	20.18	2	0.45	55	
P14R4B	26	0.47826	fumigated	20.8	2	0.45	55	529.30
P14R4B	27	0.53274	fumigated	20.45	2	0.45	55	617.30
P14R4B	28	0.6847	fumigated	20.76	2	0.45	55	824.96
P14R4B	29	0.53945	fumigated	20.7	2	0.45	55	619.45
P14R4B	30	0.10669	unfumigat.	20.75	2	0.45	55	
P15R2A	31	0.7512	fumigated	20.84	2	0.45	55	812.90
PI 5R2A	32	0.8429	fumigated	20.83	2	0.45	55	943.72
P15R2A	33	0.9374	fumigated	20.35	2	0.45	55	1103.58
P15R2A	34	0.69613	fumigated	20.43	2	0.45	55	749.34
PI 5R2A	35	0.17945	unfumigat.	20.74	2	0.45	55	
PI 5R2B	36	0.8976	fumigated	20.41	2	0.45	55	1199.08
P15R2B	37	0.8342	fumigated	20.63	2	0.45	55	1095.23
Pi 5R2B	38	0.9587	fumigated	20.6	2	0.45	55	1275.90
P15R2B	39	1.0703	fumigated	20.96	2	0.45	55	1411.75
P15R2B	40	0.07163	unfumigat.	20.16	2	0.45	55	
P15R3A	41	0.66619	fumigated	20.57	2	0.45	55	847.95
P15R3A	42	0.8156	fumigated	20.54	2	0.45	55	1064.72
PI 5R3A	43	0.6588	fumigated	20.6	2	0.45	55	836.09
P15R3A	44	0.77002	fumigated	20.61	2	0.45	55	995.58
Pi 5R3A	45	0.07751	unfumigat.	20.96	2	0.45	55	
P15R3B	46	0.7551	fumigated	20.65	2	0.45	55	907.89

Table I. Carbohydrates in the IPM plots

Samples	Soil wt(g)	% CHO	Samples	Soil wt(g)	% CHO	Samples	Soil wt(g)	% CHO
Rep2 PI A	'10.0085	1.25	Rep3 PI A	10.0205	1.15	Rep4 PI A	10.0157	1.15
Rep2 PI A	10.0065	1.81	Rep3 P1 A	10.0229	1.67	Rep4 PI A	10.0361	1.52
Rep2 PI A	10.01259	1.34	Rep3 PI A	10.0509	1.34	Rep4 PI A	10.0846	1.34
Rep2 P1 A	'10.0388	1.55	Rep3 PI A	10.0875	1.55	Rep4 PI A	10.0378	1.55
Rep2 PI B	10.0379	1.11	Rep3 PI B	10.016	1.11	Rep4 P1 B	10.0261	1.11
Rep2 PI B	'10.1589	1.95	Rep3 P1 B	10.0375	2.04	Rep4 PI B	10.0223	2.04
Rep2 PI B	10.2305	1.76	Rep3 PI B	10.0166	1.76	Rep4 PI B	10.0151	1.76
Rep2 Pi B	'10.0367	1.99	Rep3 PI B	10.0765	1.15	Rep4 PI B	10.0151	1.32
Rep2 P2 A	'10.0846	2.12	Rep3 P2 A	10.0275	2.35	Rep4 P2 A	10.018	1.67
Rep2 P2 A	'10.0378	1.95	Rep3 P2 A	10.0279	1.95	Rep4 P2 A	10.018~	1.34
Rep2 P2 A	'10.0256	1.99	Rep3 P2 A	10.0223	1.57	Rep4 P2 A	10.0794	1.55
Rep2 P2 A	'10.1578	2	Rep3 P2 A	10.0157	2.01	Rep4 P2 A	10.087~	1.43
Rep2 P2 B	10.024	1.11	Rep3 P2 B	10.0151	1.11	Rep4 P2 B	10.079:	2.04
Rep2 P2 B	'10.0238	1.54	Rep3 P2 B	10.0267	1.53	Rep4 P2 B	10.079;	1.76
Rep2 P2 B	'10.0256	1.33	Rep3 P2 B	10.018	1.24	Rep4 P2 B	10.033:	1.15
Rep2 P2 B	10.4813	1.5	Rep3 P2 B	10.0795	1.78	Rep4 P2 B	10.052:	1.52
Rep2 P3 A	'10.0276	2.53	Rep3 P3 A	10.0229	2.53	Rep4 P3 A	10.087	1.95
Rep2 P3 A	'10.0256	2.36	Rep3 P3 A	10.087	2.36	Rep4 P3 A	10.0264	1.57
Rep2 P3 .A	10.0457	1.99	Rep3 P3 A	10.0797	2.04	Rep4 P3 A	10.0874	2.01
Rep2 P3 .A	'10.1389	2.13	Rep3 P3 A	10.033	1.86	Rep4 P3 A	10.0544	1.97
Rep2 P3 B	10.0532	2.07	Rep3 P3 B	10.0509	2.07	Rep4 P3 B	10.0797	3.65
Rep2 P3 B	10.0157	2.03	Rep3 P3 B	10.0525	2.89	Rep4 P3 B	10.0248	3.27
Rep2 P3 B	'10.0267	2.57	Rep3 P3 B	10.0264	1.87	Rep4 P3 B	10.020:	3.48
Rep2 P3 B	10.018	1.89	Rep3 P3 B	10.0874	1.89	Rep4 P3 B	10.016;	3.38
Rep2 P4 .A	'10.0242	1.11	Rep3 P4 A	10.0875	1.53	Rep4 P4 A	10.033	2.89
Rep2 P4 .A	'10.0795	1.53	Rep3 P4 A	10.0547	1.74	Rep4 P4 A	10.027:	3.48
Rep2 P4 .A	10.087	1.76	Rep3 P4 A	10.0248	1.54	Rep4 P4 A	10.015'	2.89
Rep2 P4 .A	'10.0797	2	Rep3 P4 A	10.0797	2	Rep4 P4 A	10.0229	2.91
Rep2 P4 B	10.055	1.25	Rep3 P4 B	10.0374	1.25	Rep4 P4 B	10.0509	2.89
Rep2 P4 B	10.033	1.81	Rep3 P4 B	10.0457	1.81	Rep4 P4 B	10.087:	1.87
Rep2 P4 B	10.0525	1.34	Rep3 P4 B	10.1389	1.14	Rep4 P4 B	10.0374	1.89
Rep2 P4 B	10.0264	1.95	Rep3 P4 B	10.0532	1.48	Rep4 P4 B	10.037~	2.18
Rep2 P5 A	10.0202	3.1	Rep3 P5 A	10.0085	3.1	Rep4 P5 A	10.0264	1.74
Rep2 P5 A	10.0874	2.53	Rep3 P5 A	10.0065	3.65	Rep4 P5 A	10.0374	1.54
Rep2 P5 ,A	'10.0547	3.27	Rep3 P5 A	10.01259	3.27	Rep4 P5 A	10.0166	2
Rep2 P5 ,A	10.0248	3.83	Rep3 P5 A	10.0388	3.48	Rep4 P5 A	10.0765	1.7
Rep2 P5 B	10.0188	2.38	Rep3 P5 B	10.0379	2.38	Rep4 P5 B	10.0874	1.81
Rep2 P5 B	10.0205	2.89	Rep3 P5 B	10.1589	2.89	Rep4 P5 B	10.0279	1.14
Rep2 P5 B	10.016	3.3	Rep3 P5 B	10.2305	3.48	Rep4 P5 B	10.022:	1.48
Rep2 P5 B	10.0275	2.78	Rep3 P5 B	10.0367	2.89	Rep4 P5 B	10.0085	1.42
Rep2 P6 A	'10.0322	5.18	Rep3 P6 A	10.0846	5.18	Rep4 P6 A	10.054'	7.26
Rep2 P6 A	10.0151	7.26	Rep3 P6 A	10.0378	7.26	Rep4 P6 A	10.0375	7.89
Rep2 P6 A	10.0229	8.74	Rep3 P6 A	10.0256	7.89	Rep4 P6 A	10.0841	6.58
Rep2 P6 A	10.0509	6.6	Rep3 P6 A	10.1578	6.58	Rep4 P6 A	10.024	6.73
Rep2 P6 B	10.0194	4.89	Rep3 P6 B	10.024	5.42	Rep4 P6 B	10.024	4.15
Rep2 P6 B	10.0875	4.15	Rep3 P6 B	10.0238	4.15	Rep4 P6 B	10.076	7.15
Rep2 P6 B	10.0374	7.52	Rep3 P6 B	10.0256	7.15	Rep4 P6 B	10.053:	8.56

Rep2 P6 B	10.0166	8.01	Rep3 P6 B	10.4813	8.56	Rep4 P6 B	10.0242	6.32
Rep2 P7 A	10.0765	3.3	Rep3 P7 A	10.0276	3.3	Rep4 P7 A	10.055	1.53
Rep2 P7 A	10.0279	2.12	Rep3 P7 A	10.0322	2.12	Rep4 P7 A	10.0202	1.24
Rep2 P7 A	10.0223	2.78	Rep3 P7 A	10.0151	2.56	Rep4 P7 A	10.0188	1.78
Rep2 P7 A	10.0085	2.53	Rep3 P7 A	10.0229	2.48	Rep4 P7 A	10.0322	1.42
Rep2 P7 B	10.0379	2	Rep3 P7 B	10.0509	2.57	Rep4 P7 B	10.0194	2.36
Rep2 P7 B	10.0846	2.03	Rep3 P7 B	10.0194	1.96	Rep4 P7 B	10.052	2.04
Rep2 P7 B	10.024	2.38	Rep3 P7 B	10.0875	2.14	Rep4 P7 B	10.0264	1.86
Rep2 P7 B	1 0.0276	3.1	Rep3 P7 B	10.0374	2.96	Rep4 P7 B	10.18	2.2
Rep2 P10 A	10.0532	2.08	Rep3 PI 0	10.0166	2.08	Rep4 PI0	10.0765	2.12
Rep2 PI0 A	10.0242	1.11	Rep3 PI0	10.0765	1.11	Rep4 P10	10.845	2.56
Rep2 P10 A	10.055	1.53	Rep3 P10	10.0279	1.65	Rep4 PI0	10.0478	2.48
Rep2 P10 A	10.0202	1.25	Rep3 PI0	10.0223	1.25	Rep4 PI0	10.256	2.62
Rep2 P10 B	10.0085	1.89	Rep3 P10	10.0085	1.89	Rep4 PI0	10.0525	1.96
Rep2 P10 B	10.0065	2	Rep3 P10	10.0379	2	Rep4 P10	10.0264	2.14
Rep2 P10 B	10.01259	1.76	Rep3 P10	10.0846	1.76	Rep4 P10	10.0286	2.96
Rep2 P10 B	10.0388	1.28	Rep3 PI0	10.024	1.33	Rep4 P10	10.0546	2.41
Rep2 P12 A	10.0379	3.56	Rep3 P12	10.0276	4.25	Rep4 P12	10.0247	4.96
Rep2 P12 A	10.1589	4.96	Rep3 P12	10.0532	4.96	Rep4 P12	10.2305	3.99
Rep2 P12 A	10.2305	3.99	Rep3 P12	10.0242	3.99	Rep4 P12	10.0367	4.87
Rep2 P12 A	10.0367	4.56'	Rep3 P12	10.055	4.87	Rep4 P12	10.0846	4.52
Rep2 P12 B	10.0846	2.98	Rep3 P12	10.0202	3.98	Rep4 PI2	10.0378	3.58
Rep2 P12 B	10.0378	3.58	Rep3 P12	10.0085	3.58	Rep4 P12	10.0256	4.01
Rep2 P12 B	10.0256	4.01	Rep3 P12	10.0065	4.01	Rep4 Pi2	10.1578	3.78
Rep2 P12 B	10.1578	3.78	Rep3 P12	10.01259	3.78	Rep4 P12	10.024	3.84
Rep2 P13 A	10.024	2.08	Rep3 P13	10.0388	2.08	Rep4 P13	10.0238	1.96
Rep2 P13 A	10.0238	1.96	Rep3 P13	10.0379	1.96	Rep4 P13	10.0256	2.53
Rep2 P13 A	10.0256	2.53	Rep3 P13	10.0279	2.53	Rep4 P13	10.4813	1.26
Rep2 P13 A	10.4813	1.18	Rep3 P13	10.0223	1.26	Rep4 P13	10.0065	1.96
Rep2 P13 B	10.0276	2.14	Rep3 P13	10.0157	2.14	Rep4 P13	10.03259	1.87
Rep2 P13 B	10.0188	1.87	Rep3 PI 3	10.0151	1.87	Rep4 P13	10.0388	2.34
Rep2 P13 B	10.0322	2.46	Rep3 PI 3	10.0267	2.34	Rep4 P13	10.0379	1.61
Rep2 P13 B	10.0194	1.61	Rep3 PI 3	10.018	1.61	Rep4 P13	10.1589	1.99
Rep2 P14 A	10.0085	2.53	Rep3 P14	10.0795	2.33	Rep4 P14	10.2305	2.18
Rep2 P14 A	10.0379	2.18	Rep3 P14	10.0229	2.18	Rep4 P14	10.0367	1.99
Rep2 P14 A	10.0846	1.99	Rep3 Pi4	10.087	1.99	Rep4 P14	10.0846	2.86
Rep2 P14 A	10.024	2.86	Rep3 P14	10.0797	2.86	Rep4 P14	10.0378	2.34
Rep2 P14 B	10.0276	3.14	Rep3 P14	10.033	3.14	Rep4 P14	10.0256	2.34
Rep2 P14 B	10.0532	2.34	Rep3 P14	10.0509	2.34	Rep4 P14	10.1578	1.85
Rep2 P14 B	10.0242	1.86	Rep3 P14	10.0525	1.85	Rep4 P14	10.024	2.13
Rep2 P14 B	10.055	2.07	Rep3 P14	10.0264	2.13	Rep4 P14	10.0238	2.37
Rep2 P15 A	10.0202	5.23	Rep3 P15	10.0085	5.23	Rep4 P15	10.0256	3.63
Rep2 P15 A	10.0188	2.36	Rep3 P15	10.0379	3.63	Rep4 P15	10.4813	3.14
Rep2 P15 A	10.0322	3.14	Rep3 P15	10.0846	3.14	Rep4 P15	10.0276	4.15
Rep2 P15 A	10.0194	4.08	Rep3 P15	10.024	4.15	Rep4 P15	10.016	4.04
Rep2 P15 B	10.0205	3.26	Rep3 P15	10.276	3.26	Rep4 P15	10.0275	3.15
Rep2 P15 B	10.016	3.15	Rep3 P15	10.0532	3.15	Rep4 P15	10.0151	3.25
Rep2 P15 B	10.0275	2.87	Rep3 P15	10.0242	3.25	Rep4 P15	10.0229	2.87
Rep2 P15 B	10.0151	2.47	Rep3 P15	10.0188	2.87	Rep4 P15	10.0509	3.13

Table J. FDA hydrolysis on the IPM plots

Samples	Soil (g)	Absorbce	Fluoresc.	Samples	Soit (g)	Absorbce	Fluoresc.
Rep2 Pi .A	2.5319	0.377	7847.9	Rep2 P7 A	2.5009	0.238	15076.27
Rep2 PI .A	2.5261	0.457	9490.86	Rep2 P7 A	2.5097	0.231	4950.34
Rep2 PI .A	2.513	0.32	6743.34	Rep2 P7 A	2.5058	0.52	10857.21
Rep2 PI .A	2.5022	0.401	8433.1	Rep2 P7 A	2.518	0.246	15222.32
Rep2 PI B	2.5219	0.329	6902.61	Rep2 P7 B	2.5147	0.266	15637.17
Rep2 PI B	2.5269	0.338	7071.67	Rep2 PJ B	2.5034	0.233	4986.38
Rep2 P1 B	2.5457	0.291	6072.32	Rep2 P7 B	2.5069	0.23	4918.03
Rep2 P2 .A	2.5219	0.259	5478.69	Rep2 P7 B	2.5019	0.233	4989.37
Rep2 P2 ,A	2.5114	0.277	5869128	Rep2 P10 A	2.5168	0.279	5897.45
Rep2 P2 ,A	2.5177	0.363	7606.9	Rep2 P10 A	2.5086	0.265	5630.43
Rep2 P2 A	2.5193	0.266	5626.88	Rep2 PI0 A	2.5131	0.256	5436.63
Rep2 P2 B	2.5081	0.439	9190.5	Rep2 P10 A	2.5132	0.275	5824.25
Rep2 P2 B	2.5059	0.337	7110.46	Rep2 P10 B	2.5061	0.217	4653.49
Rep2 P2 B	2.5115	0.331	6972.05	Rep2 P10 B	2.508	0.189	4077.23
Rep2 P2 B	2.5372	0.349	7265.37	Rep2 PI0 B	2.5017	0.222	4764.2
Rep2 P3 A	2.5074	0.25	5326.23	Rep2 PI0 B	2.5209	0.239	5073.86
Rep2 P3 A	2.5156	0.453	9448.6	Rep2 P12 A.	2.5009	0.468	13811.83
Rep2 P3 A	2.517	0.367	7690.54	Rep2 P12 A	2.5157	0.377	7898.44
Rep2 P3 A	2.5157	0.474	9876.46	Rep2 P12 A	2.5033	0.375	7896.58
Rep2 P3 B	2.5172	0.552	11460.19	Rep2 P12 A	2.5169	0.508	110564.74
Rep2 P3 B	2.5313	0.435	9025.2	Rep2 P12 B	2.5049	0.434	13099.84
Rep2 P3 B	2.5284	0.503	10415.24	Rep2 P12 B	2.5109	0.354	17443.63
Rep2 P3 B	2.5328	0.394	8189.43	Rep2 P12 B	2.5071	0.446	19337.4
Rep2 P4 A	2.531	0.378	7870.96	Rep2 P12 B	2.5094	0.392	8224.91
Rep2 P4 A	2.5134	0.442	9232.35	Rëp2 P13 A	2.5	0.343	17250.36
Rep2 P4 A	2.517	0.45	9382.2	Rep2 Pi3 A	2.5238	0.306	6429.91
Rep2 P4 A	2.5135	0.386	8089.04	Rep2 P13 A	2.5127	0.302	b376.65
Rep2 P4 B	2.5053	0.445	9323.63	Rep2 P13 A	2.5018	0.308	6527.46
Rep2 P4 B	2.5128	0.373	7825.89	Rep2 P13 B	2.5121	0.424	3869.55
Rep2 P4 B	2.504	0.488	10209.42	Rep2 P13 B	2.5286	0.331	6924.9
Rep2 P4 B	2.5287	0.196	4185.87	Rep2 P13 B	2.5101	0.378	7936.5
Rep2 P5 A	2.5116	0.694	14371.25	Rep2 P13 B	2.5053	0.332	7009.78
Rep2 P5 A	2.5148	0.55	11444.9	Rep2 P14 A	2.5126	0.303	6397.32
Rep2 P5 A	2.508	0.479	9981.99	Rep2 P14 A	2.5193	0.333	3991.19
Rep2 P5 A	2.5192	0.551	11481.78	Rep2 P14 A	2.5279	0.283	5952.73
Rep2 P5 B	2.5144	0.63	13039.46	Rep2 P14 A	2.521	0.29	jYII.46
Rep2 P5 B	2.5004	0.535	11126.11	Rep2 P14 B	2.5273	0.277	5832.35
Rep2 P5 B	2.5154	0.567	11844.94	Rep2 P14 B	2.5287	0.367	(654.96
Rep2 P5 B	2.5179	0.316	6655.32	Rep2 P14 B	2.5072	0.34	7168.16
Rep2 P6 A	2.5026	0.253	5401.83	Rep2 P14 B	2.5147	0.276	15841.17
Rep2 P6 A	2.5112	0.5	10461.83	Rep2 P15 A	2.5075	0.349	j7351.43
Rep2 P6 A	2.5223	0.362	7606.16	Rep2 P15 A	2.5177	0.252	5345.2
Rep2 P6 A	2.5063	0.345	7226.94	Rep2 P15 A	2.5451	0.294	3134.22
Rep2 P6 B	2.502	0.422	8849.14	Rep2 P15 A	2.5326	0.261	5496.05
Rep2 P6 B	2.5064	0.478	10012.55	Rep2 P15 B	2.5092	0.274	5813.09
Rep2 P6 B	2.5134	0.381	8009.62	Rep2 P15 B	2.5016	0.304	3445.95
Rep2 P6 B	2.5148	0.359	7538.27	Rep2 P15 B	2.5052	0.205	4409.43

Table J. Continued

Samples	Soil (g)	Absorbce	Fluoresc.	Samples	Soil (g)	Absorbce	Fluoresc.
Rep3 PI A	2.5017	0.289	6138.11	Rep3 P6 B	2.5063	0.265	5647.09
Rep3 PI A	2.5285	0.231	4896.3	Rep3 P7 A	2.5208	0.216	4606
Rep3 P1 A	2.5041	0.253	5394.71	Rep3 P7 A	2.5111	0.202	4337.78
Rep3 PI A	2.5301	0.245	5177.07	Rep3 P7 A	2.5127	0.253	5376.25
Rep3 PI B	2.5158	0.247	5247.28	Rep3 P7 A	2.5088	0.21	4505.34
Rep3 PI B	2.5186	0.198	4243.39	Rep3 P7 B	2.5074	0.267	5674.04
Rep3 PI B	2.5176	0.247	5243.53	Rep3 P7 B	2.5158	0.253	5369.62
Rep3 PI B	2.5177	0.236	5019.18	Rep3 P7 B	2.5287	0.23	4875.63
Rep3 P2 A	2.5188	0.332	6972.21	Rep3 P7 B	2.5104	0.26	5524.22
Rep3 P2 A	2.5249	0.322	6752.19	‘Rep3 PI0	2.5047	0.275	5844.07
Rep3 P2 A	2.5134	0.342	7191.29	Rep3 P10	2.5108	0.295	6238.45
Rep3 P2 A	2.5035	0.272	5785.34	Rep3 P1 0	2.5163	0.273	5776.3
Rep3 P2 B	2.5008	0.274	5832.61	Rep3 P10	2.5029	0.301	6381.12
Rep3 P2 B	2.5093	0.238	5076.87	Rep3 P10	2.5231	0.298	6269.03
Rep3 P2 B	2.5242	0.293	6164.69	Rep3 PI0	2.5163	0.268	5674.36
Rep3 P2 B	2.5144	0.239	5086.98	Rep3 P10	2.5248	0.239	5066.03
Rep3 P3 A	2.518	0.361	7565.25	Rep3 P10	2.5041	0.323	6828.76
Rep3 P3 A	2.5243	0.412	8582.82	Rep3 P12	2.508	0.344	7247.69
Rep3 P3 A	2.5042	0.389	8180.54	Rep3 P12	2.5205	0.345	7232.1
Rep3 P3 A	2.5185	0.33	6932.3	Rep3 P12	2.5077	0.281	5959.76
Rep3 P3 B	2.5076	0.384	8067.16	Rep3 P12	2.5011	0.422	8867.54
Rep3 P3 B	2.5049	0.453	9488.96	Rep3 P12	2.503	0.378	7959.01
Rep3 P3 B	2.505	0.306	6478.16	Rep3 P12	2.505	0.253	5392.77
Rep3 P3 B	2.506	0.575	11982.24	Rep3 P12	2.5031	0.252	5376.37
Rep3 P4 A	2.5022	0.204	4394.21	Rep3 P12	2.7039	0.242	5169.78
Rep3 P4 A	2.5229	0.191	4093.82	Rep3 PI 3	2.5099	0.333	7017.37
Rep3 P4 A	2.5209	0.252	5338.41	Rep3 P13	2.5066	0.21	4509.3
Rep3 P4 A	2.5089	0.211	4525.61	Rep3 P13	2.5126	0.27	5723.55
Rep3 P4 B	2.5079	0.228	4875.15	Rep3 P13	2.5068	0.268	5695.87
Rep3 P4 B	2.5015	0.27	5734.28	Rep3 P13	2.5064	0.233	4980.41
Rep3 P4 B	2.5121	0.2	4313.41	Rep3 P13	2.5074	0.197	4241.88
Rep3 P4 B	2.5316	0.209	4479	Rep3 PI 3	2.5194	0.23	4893.63
Rep3 P5 A	2.5065	0.421	8788	Rep3 P13	2.5129	0.212	4538.82
Rep3 P5 A	2.5056	0.402	8439.1	Rep3 P14	2.5183	0.276	5832.82
Rep3 P5 A	2.5128	0.342	7213.68	Rep3 P14	2.5115	0.241	5133.7
Rep3 P5 A	2.5073	0.319	6723.46	Rep3 P14	2.5255	0.277	5836.51
Rep3 P5 B	2.5169	0.281	5960.71	Rep3 P14	2.5103	0.266	5515.23
Rep3 P5 B	2.5099	0.294	6202.95	Rep3 P14	2.5044	0.183	3960.19
Rep3 P5 B	2.5065	0.334	7037.81	Rep3 P14	2.5009	0.269	5729.82
Rep3 P5 B	2.5044	0.359	7559.03	Rep3 P14	2.5026	0.263	5602.93
Rep3 P6 A	2.5213	0.337	7085.3	Rep3 P14	2.219	0.324	6800.9
Rep3 P6 A	2.5281	0.347	7270.5	Rep3 P15	2.5252	0.344	7-I 98.32.
Rep3 P6 A	2.5049	0.318	6062.47	Rep3 P15	2.5193	0.29	6115.59
Rep3 P6 A	2.5142	0.289	6130.26	Rep3 PI 5	2.5043	0.29	6152.22
Rep3 P6 B	2.5053	0.202	4332.43	Rep3 P15	2.5109	0.329	6932.85
Rep3 P6 B	2.5098	0.282	5985.95	Rep3 P15	2.5189	0.342	7175.59
Rep3 P6 B	2.5012	0.19	4094.75	Rep3 P15	2.5033	0.399	8388.41

Table J. Continued

Samples	Soil (g)	Absorbce	Fluoresc.	Samples	Soil (g)	Absorbce	Flu resc.
Rep4 P1 A	2.5046	0.263	5598.46	Rep4 P6 B	2.5096	0.294	62 3.93
Rep4 PI A	2.5045	0.215	4615.49	Rep4 P7 A	2.5332	0.253	53 2.74
Rep4 PI A	2.531	0.265	5580.6	Rep4 P7 A	2.5154	0.26	55 3.24
Rep4 P1 A	2.5086	0.221	4730.65	Rep4 P7 A	2.5024	0.271	57 7.38
Rep4 Pi B	2.5276	0.268	5649	Rep4 P7 A	2.5076	0.256	54 8.56
Rep4 P1 B	2.5236	0.219	4661.87	Rep4 P7 B	2.5051	0.25	5: 3.12
Rep4 PI B	2.521	0.242	5134.71	Rep4 P7 B	2.52	0.254	53 1.03
Rep4 P1 B	2.531	0.204	4344.21	Rep4 P7 B	2.528	0.249	52 2.54
Rep4 P2 A	2.5018	0.329	6958.07	Rep4 P7 B	2.5205	0.222	47 8.66
Rep4 P2 A	2.5236	0.301	6328.78	Rep4 P10	2.5096	0.245	52 9.36
Rep4 P2 A	2.5178	0.344	7219.48	Rep4 P10	2.5026	0.249	53 5.95
Rep4 P2 A	2.5082	0.27	5733.59	Rep4 PI0	2.506	0.191	41 1.43
Rep4 P2 B	2.5241	0.299	6286.87	Rep4 P10	2.5067	0.221	47 4.23
Rep4 P2 B	2.5117	0.318	6705.98	Rep4 P10	2.5097	0.23	49 2.54
Rep4 P2 B	2.513	0.353	7416.99	Rep4 P10	2.5162	0.268	56 4.59
Rep4 P2 B	2.5154	0.239	5084.96	Rep4 PI0	2.5105	0.242	51 6.18
Rep4 P3 A	2.513	0.433	9050.1	Rep4 P10	2.5089	0.24	51 8.58
Rep4 P3 A	2.5261	0.481	9977.85	Rep4 P12	2.52	0.291	61 4.25
Rep4 P3 A	2.5145	0.341	7167.75	Rep4 P12	2.5087	0.265	56 0.21
Rep4 P3 A	2.5111	0.611	12693.36	Rep4 P12	2.5109	0.3	63 0.36
Rep4 P3 B	2.5177	0.354	7423.52	Rep4 P12	2.5216	0.305	64 5.17
Rep4 P3 B	2.5122	0.448	9359.29	Rep4 P12	2.5088	0.273	57 3.57
Rep4 P3 B	2.5094	0.325	6855.22	Rep4 P12	2.5154	0.315	66 4.93
Rep4 P3 B	2.5235	0.496	10293.16	Rep4 P12	2.5228	0.279	58 3.42
Rep4 P4 A	2.502	0.228	4829.51	Rep4 P12	2.5149	0.295	62 8.28
Rep4 P4 A	2.5085	0.124	2754.28	Rep4 Pi3	2.5086	0.212	4! 16.6
Rep4 P4 A	2.5238	0.209	4485.43	Rep4 P13	2.5019	0.185	40 5.16
Rep4 P4 A	2.5013	0.216	4600.52	Rep4 P13	2.5155	0.225	47 9.24
Rep4 P4 B	2.5148	0.21	4518.85	Rep4 P13	2.5136	0.247	52 1.87
Rep4 P4 B	2.5309	0.219	4678.19	Rep4 P13	2.5057	0.2	43)6.18
Rep4 P4 B	2.5166	0.271	5702.44	Rep4 P13	2.5184	0.203	4: 15.58
Rep4 P4 B	2.5142	0.281	5938.69	Rep4 P13	2.5061	0.185	39 98.44
Rep4 P5 A	2.5254	0.301	6377.3	Rep4 P13	2.5104	0.199	42 '7.68
Rep4 P5 A	2.5033	0.251	5308.58	Rep4 P14	2.5097	0.296	62 61.62
Rep4 P5 A	2.536	0.308	6523.55	Rep4 Pi4	2.5148	0.275	58 20.54
Rep4 P5 A	2.5398	0.366	7612.7	Rep4 P14	2.5187	0.262	55 16.75
Rep4 P5 B	2.5143	0.212	4526.39	Rep4 P14	2.5145	0.282	59 54.05
Rep4 P5 B	2.5206	0.236	5025.97	Rep4 P14	2.5085	0.333	70 21.29
Rep4 P5 B	2.5091	0.212	4524.95	Rep4 P14	2.5058	0.281	59 64.28
Rep4 P5 B	2.5008	0.258	5486.19	Rep4 P14	2.5007	0.239	5' 14.85
Rep4 P6 A	2.5034	0.316	6679.49	Rep4 P14	2.5274	0.301	6: 19.26
Rep4 P6 .A	2.5267	0.446	9351.2	Rep4 PI 5	2.5329	0.338	70 54.92
Rep4 P6 A	2.5262	0.324	6787.98	Rep4 P15	2.5066	0.36	75 79.19
Rep4 P6 A	2.5034	0.426	8860.66	Rep4 PI 5	2.5155	0.349	7: 28.05
Rep4 P6 B	2.5151	0.415	8715.95	Rep4 P15	2.5384	0.257	54 12.66
Rep4 P6 B	2.5149	0.359	7533.18	Rep4 P15	2.5208	0.31	65 18.96
Rep4 P6 B	2.5165	0.396	8288.52	Rep4 P15	2.5015	0.38	8 04.8

Table K. B-Glucosidase activity on the IPM plots

Samples	Soi! (g)	Absorbce	P-nitrph.	Samples	Soil (g)	Absorbce	P-nitrph.
Rep2 PI A	1.0231	0.687	52.45	Rep2 P7 A	1.0481	0.683	50.90
Rep2 PI A	1.0168	0.65	49.97	Rep2 P7 A	1.0242	0.92	69.90
Rep2 PI A	1.0124	0.702	54.14	Rep2 P7 A	1.0348	0.719	54.23
Rep2 PI A	1.0045	0.645	50.20	Rep2 P7 A	1.0283	0.762	57.80
Rep2 PI B	1.029	0.648	49.23	Rep2 P7 B	1.0274	0.771	58.52
Rep2 PI B	1.022	0.668	51.07	Rep2 P7 B	1.0197	0.644	49.38
Rep2 P1 B	1.0166	0.659	50.66	Rep2 P7 B	1.0238	0.655	50.01
Rep2 P2 A	1.029	0.563	42.87	Rep2 P7 B	1.0135	0.673	51.88
Rep2 P2 A	1.0479	0.551	41.22	Rep2 P10	1.0186	0.743	56.91
Rep2 P2 A	1.0097	0.481	37.44	Rep2 P10	1.0437	0.769	57.46
Rep2 P2 A	1.0384	0.484	36.63	Rep2 P10	1.0301	0.765	57.92
Rep2 P2 B	1.0256	0.447	34.31	Rep2 P10	1.0258	0.835	63.41
Rep2 P2 B	1.0224	0.496	38.11	Rep2 P10	1.0324	0.944	71.13
Rep2 P2 B	1.0398	0.46	34.81	Rep2 P10	1.025	0.981	74.42
Rep2 P2 B	1.0125	0.463	35.97	Rep2 PI 0	1.0193	0.921	70.31
Rep2 P3 A	1.0189	0.538	41.41	Rep2 P10	1.0128	0.732	56.40
Rep2 P3 A	1.0225	0.634	48.49	Rep2 P12	1.0411	1.183	88.20
Rep2 P3 A	1.043	0.558	41.93	Rep2 P12	1.0145	1.224	93.62
Rep2 P3 A	1.0251	0.699	53.25	Rep2 P12	1.0364	1.833	136.86
Rep2 P3 B	1.023	0.897	68.25	Rep2 P12	1.0221	1.813	137.27
Rep2 P3 B	1.0185	0.791	60.54	Rep2 P12	1.0225	1.407	106.66
Rep2 P3 B	1.0238	0.694	52.94	Rep2 P12	1.0258	1.643	124.02
Rep2 P3 B	1.0261	0.897	68.04	Rep2 P12	1.017	1.623	123.58
Rep2 P4 A	1.0157	0.742	57.00	Rep2 P12	1.0242	1.683	127.22
Rep2 P4 A	1.0265	0.713	54.22	Rep2 P13	1.0261	1.04	78.77
Rep2 P4 A	1.0132	0.735	56.61	Rep2 P13	1.0337	0.946	71.19
Rep2 P4 A	1.0194	0.757	57.92	Rep2 P13	1.0298	1.071	80.80
Rep2 P4 B	1.0249	0.623	47.55	Rep2 PI 3	1.0344	1.075	80.74
Rep2 P4 B	1.0398	0.634	47.68	Rep2 P13	1.0264	0.948	71.85
Rep2 P4 B	1.0279	0.62	47.19	Rep2 P13	1.0183	1.185	90.33
Rep2 P4 B	1.0173	0.637	48.97	Rep2 P13	1.0463	1.236	91.66
Rep2 P5 A	1.0456	0.614	45.95	Rep2 P13	1.0539	1.193	87.86
Rep2 P5 A	1.0315	0.523	39.79	Rep2 P14	1.0255	1.294	97.87
Rep2 P5 A	1.012	0.46	35.76	Rep2 P14	1.0383	0.974	72.95
Rep2 P5 A	1.0211	0.498	38.31	Rep2 P14	1.0235	1.157	87.76
Rep2 P5 B	1.0164	0.561	43.25	Rep2 P14	1.0383	0.926	69.39
Rep2 P5 B	1.0128	0.557	43.10	Rep2 P14	1.0254	1.135	85.95
Rep2 P5 B	1.0271	0.693	52.69	Rep2 P14	1.0412	1.09	81.32
Rep2 P5 B	1.0291	0.324	25.00	Rep2 P14	1.0345	1.116	83.78
Rep2 P6 A	1.0142	1.425	108.90	Rep2 P14	1.0345	1.785	133.54
Rep2 P6 A	1.0342	1.203	90.28	Rep2 P15	1.0379	0.908	68.09
Rep2 P6 A	1.0215	1.053	80.10	Rep2 P15	1.0354	1.13.	84.75
Rep2 P6 A	1.02	1.073	81.73	Rep2 P15	1.024	1.705	128.90
Rep2 P6 B	1.0238	1.34	101.49	Rep2 PI 5	1.0358	0.865	65.03
Rep2 P6 B	1.032	1.425	107.02	Rep2 P15	1.0398	0.97	72.55
Rep2 P6 B	1.0227	1.254	95.13	Rep2 P15	1.051	1.455	107.29
Rep2 P6 B	1.0223	1.29	97.88	Rep2 P15	1.0391	1.139	85.11

Table K. Continued

Samples	Soil (g)	Absorbce	P-nitrph.	Samples	Soil (g)	Absorbce	P-nitrph.
Rep3 P1 A	1.0208	0.615	47.14	Rep3 P6 B	1.0146	0.769	5 .11
Rep3 P1 A	1.0275	0.616	46.91	Rep3 P7 A	1.0117	0.782	6 1.26
Rep3 PI A	1.0301	0.6	45.59	Rep3 P7 A	1.0139	0.849	6 1.22
Rep3 P1 A	1.0133	0.609	47.03	Rep3 P7 A	1.039	0.722	5 .24
Rep3 P1 B	1.0334	0.662	50.06	Rep3 P7 A	1.0185	1.019	7 .77
Rep3 P1 B	1.0409	0.669	50.22	Rep3 P7 B	1.0388	0.779	5 .47
Rep3 P1 B	1.0148	0.634	48.86	Rep3 P7 B	1.0274	0.725	5 51.07
Rep3 P1 B	1.0222	0.654	50.01	Rep3 P7 B	1.0219	0.645	4 91.35
Rep3 P2 A	1.0378	0.616	46.44	Rep3 P7 B	1.0244	0.801	601.94
Rep3 P2 A	1.0232	0.642	49.06	Rep3 P10	1.0269	0.792	60.12
Rep3 P2 A	1.012	0.683	52.72	Rep3 PI0	1.0371	0.906	6'7.99
Rep3 P2 A	1.0255	0.647	49.32	Rep3 PI0	1.0365	1.072	801.35
Rep3 P2 B	1.0309	0.639	48.47	Rep3 P10	1.011	0.964	74.16
Rep3 P2 B	1.0097	0.617	47.81	Rep3 PI0	1.0288	1.139	8 51.97
Rep3 P2 B	1.0148	0.618	47.64	Rep3 P10	1.0304	1.208	9 01.98
Rep3 P2 B	1.0406	0.555	41.80	Rep3 PI0	1.0401	1.182	8 81.21
Rep3 P3 A	1.0295	0.747	56.61	Rep3 P10	1.0278	1.219	9 21.04
Rep3 P3 A	1.0203	0.788	60.21	Rep3 P12	1.0312	0.784	5 1.27
Rep3 P3 A	1.0305	0.836	63.20	Rep3 P12	1.0147	1.315	1(3.51
Rep3 P3 A	1.024	0.646	49.32	Rep3 P12	1.0207	1.355	1(2.93
Rep3 P3 B	1.0249	0.931	70.68	Rep3 P12	1.0216	1.633	12 3.78
Rep3 P3 B	1.0142	0.713	54.88	Rep3 P12	1.0237	1.226	9: .93
Rep3 P3 B	1.021	0.799	61 .00	Rep3 P12	1.023	1.493	11 3.08
Rep3 P3 B	1.0284	0.702	53.30	Rep3 P12	1.0437	1.413	1(1.94
Rep3 P4 A	1.0188	0.392	30.39	Rep3 P12	1.0167	0.915	7 01.03
Rep3 P4 A	1.0138	0.389	30.31	Rep3 PI 3	1.0461	0.886	6 51.93
Rep3 P4 A	1.0359	0.412	31.37	Rep3 P13	1.0364	0.801	6 01.24
Rep3 P4 A	1.0166	0.388	30.15	Rep3 PI 3	1.0303	0.76	57.53
Rep3 P4 B	1.031	0.419	32.04	Rep3 PI 3	1.0263	0.869	6 51.93
Rep3 P4 B	1.0211	0.403	31.15	Rep3 PI 3	1.0364	0.778	5 .53
Rep3 P4 B	1.0217	0.413	31.88	Rep3 P13	1.0446	0.722	5 .95
Rep3 P4 B	1.0251	0.398	30.65	Rep3 PI 3	1.0487	0.643	4 .94
Rep3 P5 A	1.0181	0.324	25.27	Rep3 PI 3	1.0314	0.691	5 21.32
Rep3 P5 A	1.0327	0.316	24.32	Rep3 P14	1.0383	1.052	7 81.73
Rep3 P5 A	1.0426	1.054	78.55	Rep3 P14	1.0339	1.043	7 3.40
Rep3 P5 A	1.0307	1.066	80.36	Rep3 P14	1.04	1.219	9 1.96
Rep3 P5 B	1.0255	0.871	66.13	Rep3 P14	1.0151	1.034	7 3.17
Rep3 P5 B	1.018	0.845	64.65	Rep3 P14	1.0365	1.455	1 18.79
Rep3 P5 B	1.0165	0.795	60.96	Rep3 P14	1.0354	0.98	7 3.60
Rep3 P5 B	1.0306	1.057	79.69	Rep3 P14	1.0383	1.157	8 5.51
Rep3 P6 A	1.0235	1.2	91.00	Rep3 P14	1.0268	1.267	9 5.73
Rep3 P6 A	1.0394	0.925	69.25	Rep3 PI 5	1.0426	1.605	1 9.22
Rep3 P6 A	1.0209	1.041	79.24	Rep3 P15	1.0362	1.415	1 15.85
Rep3 P6 A	1.0332	0.722	54.54	Rep3 P15	1.0258	1.385	1 14.67
Rep3 P6 B	1.0237	0.987	74.97	Rep3 P15	1.0406	1.375	1 12.44
Rep3 P6 B	1.0353	0.926	69.59	Rep3 P15	1.0297	1.225	9 2.32
Rep3 P6 B	1.0171	1.25	95.35	Rep3 PI 5	1.0566	1.325	9 7.25

Table K. Continued

Samples	Soil (g)	Absorbce	P-nitrph.	Samples	Soil (g)	Absorbce	P-nitrph.
Rep4 P1 A	1.0152	0.561	43.31	Rep4 P6 B	1.0143	1.189	90.99
Rep4 PI A	1.0258	0.531	40.61	Rep4 P7 A	1.0181	0.797	61.02
Rep4 PI A	1.0034	0.536	41.90	Rep4 P7 A	1.0342	0.814	61.33
Rep4 PI A	1.0239	0.544	41.66	Rep4 P7 A	1.0299	0.826	62.49
Rep4 P1 B	1.0312	0.573	43.53	Rep4 P7 A	1.0417	0.698	52.32
Rep4 PI B	1.0297	0.503	38.36	Rep4 P7 B	1.0469	0.864	64.27
Rep4 P1 B	1.0047	0.506	39.55	Rep4 P7 B	1.0148	0.658	50.68
Rep4 P1 B	1.0503	0.461	34.53	Rep4 P7 B	1.0243	0.647	49.38
Rep4 P2 A	1.0145	0.675	51.98	Rep4 P7 B	1.0231	0.757	57.71
Rep4 P2 A	1.0171	0.678	52.08	Rep4 P10	1.0331	0.805	60.73
Rep4 P2 A	1.0375	0.577	43.56	Rep4 P10	1.0247	0.84	63.86
Rep4 P2 A	1.0468	0.584	43.69	Rep4 P10	1.027	0.977	73.98
Rep4 P2 B	1.0174	0.677	51.99	Rep4 P10	1.0126	0.823	63.33
Rep4 P2 B	1.0366	0.677	51.02	Rep4 P10	1.0195	1.066	81.24
Rep4 P2 B	1.0194	0.67	51.36	Rep4 PI 0	1.0229	0.834	63.52
Rep4 P2 B	1.0248	0.548	41.92	Rep4 PI0	1.0219	0.862	65.69
Rep4 P3 A	1.0215	0.857	65.34	Rep4 P10	1.0208	0.837	63.87
Rep4 P3 A	1.0163	0.505	39.02	Rep4 P12	1.0205	1.743	132.21
Rep4 P3 A	1.0206	1.02	77.68	Rep4 P12	1.0303	1.863	139.91
Rep4 P3 A	1.0116	0.932	71.68	Rep4 P12	1.0403	1.643	122.30
Rep4 P3 B	1.0186	1.17	89.17	Rep4 P12	1.0255	1.693	127.81
Rep4 P3 B	1.0277	0.795	60.30	Rep4 P12	1.0296	1.453	109.37
Rep4 P3 B	1.0471	0.87	64.69	Rep4 P12	1.0291	1.643	123.63
Rep4 P3 B	1.0247	0.837	63.63	Rep4 P12	1.0358	1.401	104.85
Rep4 P4 A	1.0172	0.443	34.29	Rep4 P12	1.0275	1.297	97.91
Rep4 P4 A	1.0248	0.429	32.99	Rep4 P13	1.0466	0.69	51.49
Rep4 P4 A	1.0298	0.427	32.68	Rep4 P13	1.0275	0.993	75.14
Rep4 P4 A	1.0346	0.346	26.50	Rep4 P13	1.0274	0.824	62.49
Rep4 P4 B	1.0167	0.417	32.34	Rep4 P13	1.0307	0.62	47.06
Rep4 P4 B	1.0115	0.424	33.04	Rep4 P13	1.0312	0.782	59.13
Rep4 P4 B	1.0292	0.404	30.98	Rep4 P13	1.0233	0.846	64.39
Rep4 P4 B	1.0156	0.419	32.53	Rep4 P13	1.0575	0.859	63.26
Rep4 P5 A	1.0318	0.884	66.70	Rep4 P1 3	1.0317	0.741	56.04
Rep4 P5 A	1.0425	0.882	65.87	Rep4 P14	1.0258	1.325	100.17
Rep4 P5 A	1.0393	0.998	74.66	Rep4 P14	1.0443	1.305	96.92
Rep4 P5 A	1.0254	0.83	63.06	Rep4 P14	1.0402	1.337	99.67
Rep4 P5 B	1.0208	1.129	85.89	Rep4 P14	1.0213	1.537	116.58
Rep4 P5 B	1.0316	0.882	66.56	Rep4 P14	1.0335	1.168	87.73
Rep4 P5 B	1.0162	0.956	73.17	Rep4 P14	1.027	1.199	90.61
Rep4 P5 B	1.0118	0.956	73.49	Rep4 P14	1.0312	1.168	87.93
Rep4 P6 A	1.0194	1.229	93.55	Rep4 P14	1.0367	1.347	100.75
Rep4 P6 A	1.0126	1.031	79.13	Rep4 P15	1.0298	1.347	101.42
Rep4 P6 A	1.0379	1.108	82.91	Rep4 P15	1.0284	1.475	111.14
Rep4 P6 A	1.0227	1.124	85.35	Rep4 P15	1.0462	1.29	95.64
Rep4 P6 B	1.0307	1.585	119.10	Rep4 P15	1.0485	1.585	117.08
Rep4 P6 B	1.0173	1.2	91.55	Rep4 P15	1.0379	1.207	90.25
Rep4 P6 B	1.022	1.498	113.57	Rep4 P15	1.0211	1.455	110.43

Table L. Arylsulfatase activity in the IPM plots

Samples	Soil (g)	Absorbce	P-nitrph.	Samples	Soil (g)	Absorbce	P-nitrph.
Rep2 PI A	1.0496	0.312	15.75	Rep2 P6 B	1.0378	1.272	33.39
Rep2 P1 A	1.0415	0.286	14.60	Rep2 P7 A	1.0375	0.627	3-I.51
Rep2 PI A	1.0267	0.319	16.46	Rep2 P7 A	1.0318	0.71	35.81
Rep2 P-l A	1.0375	0.365	18.56	Rep2 P7 A	1.0214	0.688	35.07
Rep2 PI B	1.028	0.3	15.49	Rep2 P7 A	1.0339	0.5	25.32
Rep2 P1 B	1.0402	0.31	15.80	Rep2 P7 B	1.0221	0.64	32.64
Rep2 P1 B	1.026	0.341	17.57	Rep2 P7 B	1.0308	0.559	28.33
Rep2 P1 B	1.0301	0.49	24.92	Rep2 P7 B	1.0211	0.677	34.53
Rep2 P2 A	1.0375	0.95	47.48	Rep2 P7 B	1.0295	0.437	22.29
Rep2 P2 A	1.0299	0.694	35.08	Rep2 P10 A	1.0366	0.596	30.01
Rep2 P2 A	1.0409	0.61	30.57	Rep2 P10 A	1.022	0.576	29.43
Rep2 P2 A	1.0315	0.466	23.69	Rep2 P10 A	1.0231	0.396	20.37
Rep2 P2 B	1.302	0.551	22.12	Rep2 P10 A	1.021	0.486	24.94
Rep2 P2 B	1.0396	0.881	43.98	Rep2 P10 B	1.0389	0.384	19.47
Rep2 P2 B	1.0336	0.978	49.05	Rep2 P10 B	1.0464	0.424	21.29
Rep2 P2 B	1.0229	0.301	15.61	Rep2 P10 B	1.0483	0.42	21.06
Rep2 P3 A	1.0362	1.519	75.71	Rep2 P10 B	1.0299	0.519	26.37
Rep2 P3 A	1.0367	1.529	76.17	Rep2 P12 A	1.0282	1.546	77.65
Rep2 P3 A	1.0349	1.759	87.71	Rep2 P12 A	1.0317	1.766	38.33
Rep2 P3 A	1.0331	1.854	92.58	Rep2 P12 A	1.0312	1.866	33.34
Rep2 P3 B	1.0365	1.459	72.72	Rep2 P12 A	1.024	1.456	73.46
Rep2 P3 B	1.0214	1.529	77.31	Rep2 P12 B	1.0403	1.209	60.13
Rep2 P3 B	1.019	1.779	90.08	Rep2 P12 B	1.0323	1.546	77.34
Rep2 P3 B	1.0112	1.529	78.09	Rep2 P12 B	1.0393	1.185	59.00
Rep2 P4 A	1.0267	0.417	21.35	Rep2 P12 B	1.0337	2.015	00.51
Rep2 P4 A	1.0335	0.479	24.29	Rep2 P13 A	1.028	0.409	20.93
Rep2 P4 A	1.0234	0.483	24.73	Rep2 P13 A	1.0312	0.347	17.78
Rep2 P4 A	1.0268	0.646	32.79	Rep2 P13 A	1.0357	0.522	26.37
Rep2 P4 B	1.0176	0.48	24.72	Rep2 P13 A	1.0427	0.489	24.57
Rep2 P4 B	1.0314	0.51	25.88	Rep2 P13 B	1.0314	0.505	25.63
Rep2 P4 B	1.0347	0.6	30.26	Rep2 P13 B	1.0212	0.403	20.76
Rep2 P4 B	1.023	0.461	23.64	Rep2 P13 B	1.0385	0.403	20.42
Rep2 P5 A	1.0343	0.674	33.94	Rep2 P13 B	1.0316	0.536	27.17
Rep2 P5 A	1.0288	0.611	30.98	Rep2 P14 A	1.0483	1.799	88.54
Rep2 P5 A	1.0282	0.979	49.36	Rep2 P14 A	1.0262	1.918	96.40
Rep2 P5 A	1.0232	0.533	27.24	Rep2 P14 A	1.0402	1.182	58.80
Rep2 P5 B	1.0351	0.854	42.84	Rep2 P14 A	1.0132	1.669	85.03
Rep2 P5 B	1.0407	1.386	68.83	Rep2 P14 B	1.0174	1.419	72.07
Rep2 P5 B	1.0438	0.769	38.30	Rep2 P14 B	1.0421	0.938	46.68
Rep2 P5 B	1.0258	1.0125	51.15	Rep2 P14 B	1.0184	0.676	34.57
Rep2 P6 A	1.0403	0.734	36.70	Rep2 P14 B	1.0339	1.133	56.73
Rep2 P6 A	1.0236	0.914	46.32	Rep2 P15 A	1.0142	1.589	80.90
Rep2 P6 A	1.0368	1.025	51.23	Rep2 P15 A	1.0439	1.419	70.24
Rep2 P6 A	1.01	1.686	86.16	Rep2 P15 A	1.0231	1.336	67.51
Rep2 P6 B	1.03	1.786	89.47	Rep2 P15 A	1.0256	1.659	83.50
Rep2 P6 B	1.0147	1.911	97.14	Rep2 P15 B	1.0307	1.815	90.85
Rep2 P6 B	1.041	1.945	96.36	Rep2 PI5 B	1.0371	1.669	83.07

Table L. Continued

Samples	Soil(g)	Absorbce	P-nitrph.	Samples	Soil(g)	Absorbce	P-nitrph.
Rep3 PI A	1.0233	0.527	26.94	Rep3 P6 B	1.0437	0.523	26.21
Rep3 PI A	1.0193	0.588	30.11	Rep3 P7 A	1.0305	0.777	39.19
Rep3 PI A	1.0254	0.534	27.23	Rep3 P7 A	1.0205	0.677	34.55
Rep3 P1 A	1.0196	0.551	28.24	Rep3 P7 A	1.0243	0.779	39.53
Rep3 P1 B	1.0232	0.588	30.00	Rep3 P7 A	1.0369	0.593	29.85
Rep3 PI B	1.0351	0.497	25.14	Rep3 P7 B	1.0298	0.321	16.51
Rep3 P1 B	.0422	0.812	40.48	Rep3 P7 B	1.0324	1.086	54.48
Rep3 P1 B	.0395	0.62	31.11	Rep3 P7 B	1.0273	0.747	37.82
Rep3 P2 A	1.0404	0.78	38.97	Rep3 P7 B	1.0276	1.516	76.20
Rep3 P2 A	1.0314	0.607	30.70	Rep3 PI0	1.0226	0.638	32.52
Rep3 P2 A	1.0404	0.726	36.31	Rep3 P10	1.0252	0.629	31.99
Rep3 P2 A	1.0202	0.691	35.27	Rep3 P10	1.0307	0.49	24.90
Rep3 P2 B	1.0243	0.591	30.12	Rep3 PI0	1.0245	0.739	37.52
Rep3 P2 B	1.0252	0.568	28.94	Rep3 P10	1.0419	2.045	101.20
Rep3 P2 B	1.0282	0.575	29.20	Rep3 PI0	1.0264	1.172	59.09
Rep3 P2 B	1.0224	0.851	43.22	Rep3 PI0	1.0299	1.163	58.44
Rep3 P3 A	1.025	1.579	79.54	Rep3 PI0	1.0398	1.26	62.67
Rep3 P3 A	1.0299	1.26	63.28	Rep3 P12	1.0201	0.673	34.36
Rep3 P3 A	1.0283	0.839	42.37	Rep3 P12	1.029	0.458	23.35
Rep3 P3 A	1.0289	1.439	72.26	Rep3 P12	1.0444	0.746	37.15
Rep3 P3 B	1.041	0.791	39.49	Rep3 Pi2	1.0317	1.646	82.36
Rep3 P3 B	1.0372	0.427	21.63	Rep3 P12	1.0265	0.675	34.25
Rep3 P3 B	1.0154	1.285	65.44	Rep3 P12	1.0365	0.814	40.80
Rep3 P3 B	1.0248	0.445	22.79	Rep3 P12	1.0264	0.776	39.30
Rep3 P4 A	1.0131	0.3	15.71	Rep3 P12	1.0363	1.008	50.41
Rep3 P4 A	1.0202	0.293	15.25	Rep3 P13	1.0387	0.431	21.80
Rep3 P4 A	1.0328	0.292	15.02	Rep3 P13	1.0201	0.49	25.16
Rep3 P4 A	1.0384	0.248	12.76	Rep3 P13	1.0232	0.405	20.82
Rep3 P4 B	1.0295	0.2	10.48	Rep3 P13	1.0348	0.397	20.19
Rep3 P4 B	1.0375	0.165	8.67	Rep3 P13	1.0343	0.326	16.68
Rep3 P4 B	1.0439	0.244	12.50	Rep3 P13	1.0306	0.342	17.54
Rep3 P4 B	1.0178	0.223	11.76	Rep3 P13	1.0307	0.319	16.39
Rep3 P5 A	1.0411	1.779	88.17	Rep3 P13	1.0269	0.331	17.05
Rep3 P5 A	1.0313	1.977	98.86	Rep3 P14	1.0482	0.599	29.82
Rep3 P5 A	1.0287	1.379	69.28	Rep3 P14	1.0289	0.615	31.18
Rep3 P5 A	1.0199	1.659	83.97	Rep3 P14	1.02	0.844	42.97
Rep3 P5 B	1.0292	1.619	81.21	Rep3 P14	1.0309	1.439	72.12
Rep3 P5 B	1.0268	0.933	47.13	Rep3 P14	1.0208	0.733	37.36
Rep3 P5 B	1.0245	1.213	61.26	Rep3 P14	1.0233	1.285	64.94
Rep3 P5 B	1.0254	0.798	40.44	Rep3 P14	1.031	0.254	13.15
Rep3 P6 A	1.0205	0.424	21.83	Rep3 P14	1.0409	1.315	65.32
Rep3 P6 A	1.0353	0.747	37.53	Rep3 P15	1.0219	0.823	41.83
Rep3 P6 A	1.0404	1.376	68.36	Rep3 P15	1.0357	0.69	34.69
Rep3 P6 A	1.0454	0.328	16.60	Rep3 P15	1.0212	0.68	34.68
Rep3 P6 B	1.034	1.916	95.57	Rep3 PI 5	1.0169	1.834	93.04
Rep3 P6 B	1.0385	1.616	80.34	Rep3 P15	1.0313	1.479	74.08
Rep3 P6 B	1.0249	0.866	43.86	Rep3 P15	1.0452	0.786	39.09

Table L. Continued

Samples	Soil (g)	Absorbce	P-nitrph.	Samples	Soil (g)	Absorbce	P-nitrph.
Rep4 P1 A	1.0401	1.78	88.30	Rep4 P7 A	1.0361	0.592	29.82
Rep4 P1 A	1.0415	0.45	22.67	Rep4 P7 A	1.0359	0.658	33.10
Rep4 PI A	1.0232	0.453	23.23	Rep4 P7 A	1.0361	0.417	21.16
Rep4 PI A	1.0258	0.655	33.27	Rep4 P7 A	1.0293	0.565	28.67
Rep4 P1 B	1.0361	0.424	21.50	Rep4 P7 B	1.0495	0.511	25.48
Rep4 P1 B	1.022	0.851	43.24	Rep4 P7 B	1.036	0.507	25.62
Rep4 P1 B	1.0443	0.432	21.73	Rep4 P7 B	1.0327	0.549	27.79
Rep4 P2 A	1.0471	0.609	30.34	Rep4 P7 B	1.0385	0.425	21.50
Rep4 P2 A	1.0345	0.346	17.67	Rep4 P10	1.026	0.569	28.97
Rep4 P2 A	1.026	1.162	58.62	Rep4 PI0	1.0283	1.706	35.62
Rep4 P2 A	1.0292	0.466	23.74	Rep4 P10	1.0347	0.872	13.75
Rep4 P2 B	1.0305	1.52	76.18	Rep4 P10	1.027	0.322	16.60
Rep4 P2 B	1.0302	0.379	19.39	Rep4 P10	1.0315	0.833	41.94
Rep4 P2 B	1.024	0.648	32.98	Rep4 P10	1.0284	1.536	77.14
Rep4 P2 B	1.0237	0.478	24.47	Rep4 PI0	1.0342	0.534	27.00
Rep4 P3 A	1.0464	1.849	91.15	Rep4 P10	1.0435	0.819	10.77
Rep4 P3 A	1.0324	0.764	38.48	Rep4 P12	1.036	1.031	51.56
Rep4 P3 A	1.0299	1.609	80.66	Rep4 P12	1.0459	1.056	52.30
Rep4 P3 A	1.0258	0.814	41.22	Rep4 P12	1.0331	0.596	30.11
Rep4 P3 B	1.0296	1.135	57.07	Rep4 P12	1.0348	0.872	43.74
Rep4 P3 B	1.0361	1.851	92.16	Rep4 P12	1.032	0.928	16.64
Rep4 P3 B	1.0206	1.41	71.39	Rep4 P12	1.035	0.2038	10.61
Rep4 P3 B	1.0189	1.409	71.46	Rep4 P12	1.0222	0.797	10.52
Rep4 P4 A	1.0168	1.849	93.81	Rep4 P12	1.0393	1.656	32.25
Rep4 P4 A	1.0291	1.659	83.22	Rep4 P13	1.0258	1.031	52.08
Rep4 P4 A	1.0381	1.509	75.08	Rep4 P13	1.0356	1.056	32.82
Rep4 P4 A	1.0217	1.509	76.29	Rep4 P13	.0284	0.596	30.25
Rep4 P4 B	1.0473	1.659	81.77	Rep4 P13	.0343	0.872	43.76
Rep4 P4 B	1.043	1.852	91.60	Rep4 P13	1.0324	0.928	46.63
Rep4 P4 B	1.0203	1.889	95.50	Rep4 P13	1.0298	2.038	32.04
Rep4 P4 B	1.0348	1.639	81.77	Rep4 P13	1.0475	0.797	39.54
Rep4 P5 A	10.269	1.254	6.32	Rep4 P13	1.032	1.656	32.83
Rep4 P5 A	1.0217	1.649	83.32	Rep4 P14	1.036	0.502	25.37
Rep4 P5 A	1.0472	1.556	76.73	Rep4 P14	1.0253	1.203	30.71
Rep4 P5 A	1.0152	1.476	75.11	Rep4 P14	1.0184	0.802	40.92
Rep4 P5 B	1.0431	1.696	83.92	Rep4 P14	1.0219	0.423	21.75
Rep4 P5 B	1.0307	1.716	85.92	Rep4 P14	1.0258	0.549	27.97
Rep4 P5 B	1.0312	1.476	73.94	Rep4 P14	1.0297	0.574	29.11
Rep4 P5 B	1.0356	1.286	64.22	Rep4 P14	1.0414	0.581	29.13
Rep4 P6 A	1.0442	1.0361	51.41	Rep4 P14	1.0254	0.709	35.99
Rep4 P6 A	1.0283	1.0359	52.19	Rep4 P15	1.0185	1.819	92.14
Rep4 P6 A	1.0211	1.0361	52.57	Rep4 P15	1.0257	0.749	37.98
Rep4 P6 A	1.0305	1.0293	51.75	Rep4 P15	1.0145	0.404	20.95
Rep4 P6 B	1.0226	.0495	53.17	Rep4 P15	1.0332	1.308	65.46
Rep4 P6 B	1.0278	1.036	52.22	Rep4 P15	1.0293	0.388	19.85
Rep4 P6 B	1.0276	1.0327	52.07	Rep4 P15	1.0392	1.479	73.52
Rep4 P6 B	1.0261	1.0385	52.44	Rep4 P15	1.0214	0.752	38.29

Table M. Analysis of variance of the soil physical properties.

Source of variation	df	Mean Square			
		Bulk Density	Soil Penetrability	Infiltration Rate	Sealing Index
Block	2	0.005 *	0.022 ns	400.431 ns	14.411 ns
Crop rotation	3	0.005 ns	0.563 ns	225.633 ns	30.972 ns
Tillage	2	0.005 ns	22.743 [illegible]	1271.582 **	126.236 *
Crop rotationxTillage	6	0.017 ns	1.679 ns	173.658 ns	17.060 ns
Experimental Error	22	0.004 ns	1.063 **	140.613 **	33.230 **
Sampling Error	36	0.003	0.305	37.922	5.194

** Significant at 1% probability; * significant at 5% probability; ns = not signifrcant.

Table N. Analysis of variance of the soil chemical properties.

Source of variation	df	Mean Square		
		Total Carbon	Total Nitrogen	Dissolved Organic C
Block	2	1.22 ns	0.01 ns	630.33 ns
Crop rotation	3	0.11 ns	0.03 **	1045.71 *
Tillage	2	0.54 ns	0.01 ns	4820.83 **
Crop rotationxTillage	6	0.38 ns	0.01 ns	352.74 ns
Experimental Error	22	0.41 **	0.01 **	278.01 **
Sampling Error	36	0.04	0.001	89.03

** Significant at 1% prabability;; * significant at 5% probability; ns = not significant.

Table 0. Analysis of variance of the soil biological properties.

Source of variation	df	Mean Square		
		Microbial Activity	Enzyme Activity	Carbohydrates
Block	2	30865.04 ns	17620962.74 **	0.001 ns
Crop rotation	3	‘140629.09 ns	6781324.30 *	5.68 **
Tillage	2	21241125.83 **	17710444.50 **	46.56 **
Crop rotationxTillage	6	68719.91 ns	3718809.36 ns	5.38 **
Experimental Error	22	50148.57 **	2215673.76 **	0.09 ns
Sampling Error	36	15998.25	430235.57	0.09

** Significant at 1% probability;, * significant at 5% proba bility; ns = not significant.

VITA

VITA

Mateugue Diack was born in January 7 1955, and grew up in a small town until graduating from High School, in Louga, Republic of Senegal, West Africa. He is a citizen of the same country. He began his higher education at the University Institute of Technology of Dakar, Senegal. In July 1977, he obtained an associate degree in Chemical Engineering. He then worked for 12 years as a research assistant in Soil Chemistry/Soil Fertility in an agricultural research center in Senegal. He is married since 1985 and has three children. In August 1991, he came to Purdue University, West Lafayette. IN and obtained a BS degree in International Agronomy in August 1992. In December 1994, he obtained a MS degree in Agronomy (Soil Microbiology, Soil Erosion), under the guidance of Dr. Diane E. Stott. His Ph.D. research, completed in May 1997, is presented in this thesis. He is currently a member of the American Society of Agronomy, American Soil and Water Conservation, Soil Quality Group of America and Sigma Xi - scientific research society. He was recipient of an Agronomy Department Award (1992), recognizing student for excellency and a Leonard B. Clore Scholarship (1992) for outstanding achievement.