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Subsurface soil biological activity respond quickly to a cessation in tillage and integrated fertilizer management under dry land farming

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Beneficial of conventional tillage is not restricted to increase crop yield. Use of notillage (NT) improve and alter soil physical, chemical and biological activity that can be important towards sustainable agriculture. A deterrent for growers considering the transition to conservation tillage is the delay in soil response associated with the equilibration of the soil food web but subsurface can respond quickly to a cessation in tillage than surface soil. Although considerable literature exists on microbial and soil chemical changes under various tillage methods, little information exists on these changes under dry land farming conditions to a cessation in tillage. The objective of this study was to determine the quicker response of subsoil or surfacesoil to minimum tillage (MT) and conventional tillage (CT) and biofertilizers (*Bacillus coagulans*, B), Phosphorus fertilization (P) and integrated P and B (PB) under the wheat *(Triticum aestivum L* vr. Sardari) growing season. The experimental design was split plot laid out in a randomized block design with three replications that tillage practises was in the main plot. The field trial is located in the dryland semiarid crop. Three tillage practices implemented on a texturally uniform and level field site under winter wheat were: (i) conventional tillage (CT), with moldboard ploughing followed by harrowing once with a springtine harrow; (ii) reduced tillage (RTC), with ducksfoot cultivator with a springtine harrow, and (iii) with moldboard ploughing with the moldboard detached (RT). Results obtained showed that tillage methods and PB significantly affected mycorrhiza colonization rate and soil microbial activities. At 5–20 cm, alkaline phosphatase (ALP) enzymes and Dehydrogenase activity (DHA) was greater than at 0–5 cm when wheat was under RTC or RT. At 5–20 cm B inoculant and PB increased ALP and DHA, respectivily. Result showed no significantly deifier in Substrate respiration (SR) in the 0-to 5-cm layer when wheat was under MT OR CT. Substrate-induced respiration (SIR) was higher in the 0- to 5- cm layer when wheat was under MT. SR and SIR were higher when wheat was inoculated with BP. Result indicated that transition to conservation tillage is the delay in soil response but subsurface soil can respond quickly to a cessation in tillage under the semiarid area condition.

Key words: wheat, dry land farming, reduced tillage, soil biological

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Introduction

A large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture, Drought stress, soil erosion, Low P availability, Low soil biological activity (SBA) and organic matter. Alteration of soil conditions by tillage practices has complex effects on soil characteristics thereby affecting environmental conditions, evaporation, water infiltration, soil erosion, loss of soil structure, the growth and activity of soil microorganisms, mycorrhiza symbiosis and consequently, nutrient dynamics.

Conservation tillage is used to conserve soil nutrients and structure, increase sequestration of soil carbon, and to provide habitat and substrate for biota (Hendrix *et al.,* 1998; Lal *et al.,* 1998; Paustian *et al.,* 2000; Holland, 2004; Simmons and Coleman, 2008). Tillage method has been shown by numerous works significantly alter the microflora of soil. Most often, imposition of conservation tillage, especially no tillage (NT), has resulted in increased microbial populations and activities in the more surficial layers, compared with conventional tillage (CT). However, a deterrent for growers considering the transition to conservation tillage is the delay in soil response (e.g. increased soil carbon, efficient nutrient cycling, impacts on yield) associated with the equilibration of the soil food web (Phatak *et al.,* 1999). But Simmons and Coleman (2008) showed that subsurface can respond quickly to a cessation in tillage than surface soil.

Low P availability limits plant growth in many alkaline soils. P deficiency is mainly caused by strong adsorption of H_2PO to calcium (Ca), which turns large proportions of total P into forms that are unavailable to plants. The improvement of P nutrition of plants has been the most recognized beneficial effect of mycorrhizas and other phosphate-solubilising microorganism. A large group of beneficial microorganisms in the rhizosphere are the phosphate-solubilising, such as Bacillus sp and arbuscular mycorrhiza Fungi (AMF). Their effects may be of great interest in soils with scarce assimilable P, such as those in semiarid agroecosystems. Nevertheless, the effectiveness of phosphate solubilisation by microorganisms inoculated directly into the soil under field conditions is unclear because of the possible re-fixation of phosphate ions on their way to the root surface. Arbuscular mycorrhizal (AM) fungi are widely beneficial fungi, symbiotically associated with higher plant roots. An increasing number of experiments has shown that AM alters plant water relations and prevents drought stress under certain conditions (Auge´, 2001) that can more essential under dry land farming. The network of mycorrhizal hyphae extending in the surrounding of root surfaces is an important inoculum source when roots senesce. Disruption of this network is a proposed mechanism by which conventional tillage (CT) reduces root

colonization and P absorption. In the same way, hyphae and colonized root fragments are transported to the upper soil layer, decreasing and diluting their activity as viable propagules for the succeeding crop in rotation.

Wheat (*Triticum aestivum*) is an essential component of global food security providing a direct staple food for millions of mankind and indirectly as a feed crop for animals. In Iran, dry land farming is practised on about one third of the arable land. Winter wheat, the main crop on a large part of the Iran semi arid region, is conventionally cultivated as a single crop per year followed by more than three months of summer bare fallow. During the past 30 years, wheat yield has been increased by fertilizer applications, but this practice has resulted in increasing soil water depletion. Currently, over 60% of the wheat grown in Iran is under semi-arid dry land farming conditions. Its climate is mostly semiarid, with annual precipitation ranging from 150–550 mm in the south to 500–750 mm in the north.

The present study was conducted in a morainic Agrudalf with a sandy loam texture and subangular aggregates in the upper horizons to determine the effect of minimum tillage (MT) and conventional tillage (CT) and integrated P of chemical and phosphate solubilising bacteria (*Bacillus coagulans*, B) on soil biological activity, mycorrhiza colonization rate under the wheat (*Triticum aestivum* L vr. Sardari) to determinate if there is quick response of different soil layer to MT or Biofertilizer.

Materials and methods

The experimental field is located on the experimental farm of Ilam University at 31° 58′ N and 45° 24′ E. The soil is a morainic Agrudalf with a sandy loam texture and subangular aggregates in the upper horizons, in a semiarid region with a mean annual rainfall of 365 mm. The rainfall is restricted to six months a year, from November to January, with negligible rainfall during spring and no rainfall in summer (May–August). The average maximum temperature from May to July is very high (30.5–42 °C), with a mean of 28 °C. In October, temperature falls to a minimum of 15 °C, and reaches a maximum of 45 °C in August. The soil at the site is classified as medium black, clayey, and shallow (15–30 cm in depth). The soil is characterized by low organic matter (0.8%). Across the locations, the soil pH ranges from 6.6 to 6.8, available phosphorus (P) was 10.1–10.32 mg kg^{-1}, available potassium (K) 163–288 kg ha^{-1}, cation exchange capacity 7.6–10.1 (CEC), organic matter from 0.8% to 0.9%, mycorrhizal spore propagules 100–150 kg^{-1} soil and P solubilising micro organism 2.1–3.2 × 10^2 CFU g^{-1} soil.

The experimental design was a split-plot design with three randomized complete blocks, with the main plot treatments with three tillage practices

implemented for one year on a texturally uniform and level field site under winter wheat were: (i) conventional tillage (CT), with moldboard ploughing to 25–28 cm depth followed by harrowing once with a springtine harrow to about 4–6 cm depth with wheat residue removed in the field; (ii) reduced tillage (RTC), with ducksfoot cultivator with a springtine harrow to 4 to 6 cm depth with 70% wheat residue retained in the field, and (iii) with moldboard ploughing with the moldboard detached and 35% (RT) wheat residue retained in the field. The subplot treatments included P fertilizer (60 $kgha^{-1}$), *Bacillus coagulans* (10^7 CFU mL^{-1} of inoculum, B)] and integrated P fertilizer and B [60 kg P + *Bacillus coagulans* (10^7 CFU mL^{-1} of inoculum)]. The experimental period was from May 2008 to October 2009.

To investigate the effects of treatments on soil biological activity, five times during the growing season (26 April–6 October) according to wheat grow stage (at Vegetative phase, tillering initiated, late tillering, Stem extension and Ear emergence) 100g soil cores were taken from each of the three replicates, collected from the surface layer (0- to 5-cm) of soil. Samples of soil (100 g) were kept separately in 750-mL plastic containers in the laboratory. Soil water content in the containers was maintained at 30% (dry weight basis). Soils were sieved through a 2-mm mesh, to remove organic debris and gravel and to destroy large aggregates.

Substrate respiration (SR) Substrate-induced respiration (SIR) was determined by adding 5 ml of glucose solution (32 mg ml^{-1}) to 25 g subsamples of soil and placing them in 1-L jars for 6 h. The carbon dioxide (CO_2) respired during this period, was trapped in 20 ml of 0.02 M NaOH, and subsequently measured by titration with HCl to a phenolpthalein endpoint after adding excess $BaCl_2$ (Anderson, 1982).

The activities of alkaline phosphatase (ALP) and Dehydrogenase activity (DHA) were measured from surface layer (0–to 5-cm) and subsoil layer (5- to 20-cm) at wheat ear emergence growth stage. ALP enzymes were measured as described by Tabatabai (1994). Briefly, a fresh soil sample of 1 g was placed in a 50-mL test tube, to which one drop of toluene and 4 ml of modified universal buffer (pH 11 for ALP) was added. The samples were incubated with p-nitrophenyl phosphatase at 37.1ºC for 60 min. After filtration, the yellow colour intensity was measured by spectrophotometer at 420 nm. The enzyme activities were expressed as mg p-nitrophenol (PNP) released g^{-1} soil h^{-1}. The measurements were carried out in three replicates and the activity of enzymes averaged for all three replicates.

DHA was determined according to García *et al.* (1997). For this, 1 g of soil was exposed to 0.2 ml of 0.4% INT (2-p-iodophenyl-3-p-nitrophenyl-5-phenyltetrazolium chloride) in distilled water for 20 h at 22°C in darkness. The

INTF (iodo-nitrotetrazolium formazan) formed was extracted with 10 ml of methanol by shaking vigorously for 1 min and filtering though a Whatman No. 5 filter paper. INTF was measured spectrophotometrically at 490 nm.

Root samples were collected for the determination of root mycorrhizal colonization, when wheat plants were at Lag phase. Roots were thoroughly washed and cut into 1 cm lengths, cleared in 2.5% KOH, acidified with 1% HCl and stained with 0.05% trypan Blue for 24 h (Phillips and Hayman 1970). The percentage of root colonization was measured by the grid-line intersect method (Giovanetti and Mosse, 1990) under a dissecting microscope at 50_ magnification.

The analysis of variance (ANOVA) was based for a split-plot randomized complete block design. All measured variables were assumed to be normally distributed and statistical analysis by ANOVA was performed using SAS software (SAS, 1990). The normal distribution of the data was determined using the Shapiro–Wilk W-test. The significance of the differences between treatments was estimated using the LSD range test, and a main effect or interaction was deemed significant at $P < 0.05$.

Results

Both SR and SIR in the surface layer (0– to 5- cm) under both reduced tillage (RTC and RT) and ploughed (CT) wheat increased maximum from wheat sowing to vegetative phase growth stage (autumn) and then declined to minimum when wheat was at tillering phase growth stage (winter) and was nearly constant from stem extension to ear emergence, spring (Figs. 1 and 3).

Averaged over locations and sampling times, SR in the 0- to 5-cm layer was not significantly deifier under reduced tillage (RT or RTC) and CT (Fig. 1). The SIR in the 0- to 5-cm layer under CT and RTC was higher than RD at vegetative phase of wheat growth stage (Fig. 3). At tillering phase, rate of SIR under RT was higher than CT or RTC. At Stem extension and Ear emergence of wheat growth stage, soil under CT had the highest SIR (Fig. 2). Result showed a sustain trend rate in SIR under RD during wheat growing season (Fig. 2).

SR and SIR in the 0- to 5-cm layer under BP was significantly increased, being nearly twice (87% greater) that under P (Figs. 3 and 4).

Table 1. Effects of soil tillage system and P, *Bacillus coagulans* and integrated P and *Bacillus coagulan* under the wheat *(Triticum aestivum*) dry land farming on mycorrhiza on DHA and ALP enzyme activities.

Treatment [a]	AMF colonization rate (%)	Phosphatase (mg p-nitrophenol g^{-1} soil h^{-1})		DHA (µg INTF g^{-1} h^{-1})	
		from the top 5 cm of soil	from the depth 20 cm of soil	from the top 5 cm of soil	from the depth 20 cm of soil
RTC	36.2a	261.6	284.3a	410	422.4a
RT	33.6a	256	267.a	378	320.91
CT	26.1b	254	239b	395	234.4c
$LSD_{(0.05)}$ [a]	4.6	35.42	24.3	78.8	53.3
F [b]	9.77**	0.14^{ns}	5.25*	1.44^{ns}	61.7***
BP	28.4b	254.5	268.4ab	415.5	372.07a
B	40.1a	263.5	280.7a	391.7	327b
P	27.3b	253	241.4b	376.9	278c
$LSD_{(0.05)}$ [a]	5.17	21.7	30.7	57.76	36.9
F [b]	17.75***	0.23^{ns}	4.05*	2.23^{ns}	15.26***
intraction	1.83^{ns}	0.74^{ns}	0.72	1.24^{ns}	1.46^{ns}

[a]Least significant differences between treatments at $P < 0.05$; [b]** F values significant at $P < 0.01$; [b]*** F values significant at $P < 0.001$; b ns F values no significant at $P < 0.05$; RTC reduced tillage with ducksfoot cultivator; RT = moldboard ploughing with the moldboard detached; CT = conventional tillage with moldboard ploughing; P = chemical phosphate fertilizer; B = *Bacillus coagulans*; BP = integrated phosphate fertilizer and *Bacillus coagulans* .

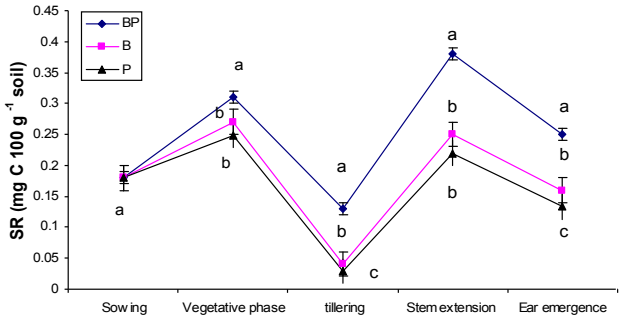

Fig. 1. Respond substrate respiration (SR) to P, *Bacillus coagulans* and integrated P and Bacillus coagulan under the wheat (*Triticum aestivum*) dry land farming in a wheat growing season. P = chemical phosphate fertilizer; B = *Bacillus coagulans*; BP = integrated phosphate fertilizer and *Bacillus coagulan*.

At wheat ear emergence growth stage, AM colonization rate was significantly higher when wheat was under RTC or RT compared with CT (Table 2). Wheat plants inoculated with B had significantly higher mycorrhiza colonization rate (10 % greater) (Table 2).

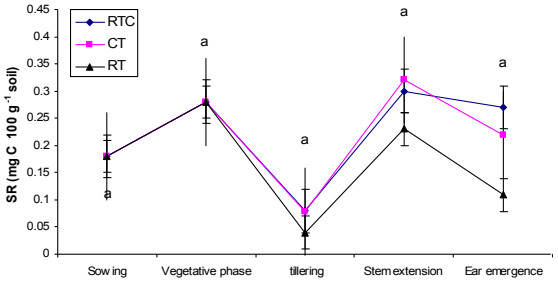

Fig. 2. Respond substrate respiration (SR) to minimum tillage (MT) and conventional tillage (CT) under the wheat *(Triticum aestivum*) dry land farming in a wheat growing season. RTC reduced tillage with ducksfoot cultivator; RT = moldboard ploughing with the moldboard detached; CT = conventional tillage with moldboard ploughing.

Result showed that ALP and DHA activity in the surface layer (0 to 5 cm) under both reused tillage (RTC and RT) and ploughed (CT) wheat was nearly constant (Table 2). At wheat ear emergence growth stage, in the 5- to 20-cm layer, ALP activity and DHA were higher when wheat was under RTC or RT than in the CT (Table 2). At this time, in the 0- to 5-cm layer, there was little change in ALP activity and DHA from the treatments involving inoculation with B that were not significant. But rhizosphere soil at 5-20 cm depth from the treatments involving inoculation with B and PB had significantly higher ALP activity and DHA, respectively (Table 2).

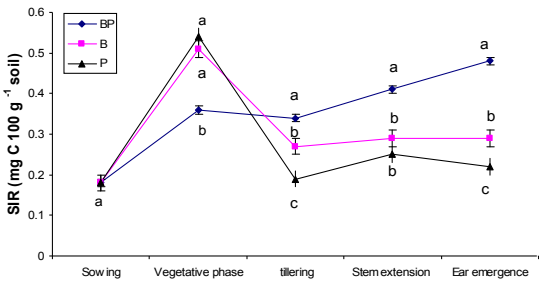

Fig. 3. Substrate-induced respiration (SIR) to P, *Bacillus coagulans* and integrated P and *Bacillus coagulan* under the wheat *(Triticum aestivum*) dry land farming in a wheat growing season. P = chemical phosphate fertilizer; B = *Bacillus coagulans*; BP = integrated phosphate fertilizer and *Bacillus coagulan.*

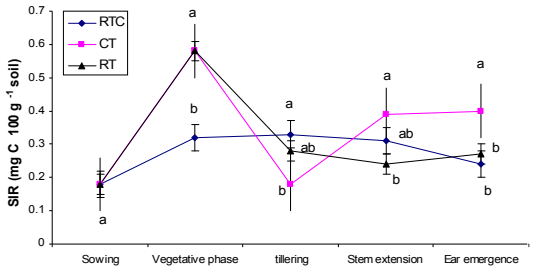

Fig. 4. Substrate-induced respiration (SIR) to minimum tillage (MT) and conventional tillage (CT) under the wheat (*Triticum aestivum*) dry land farming in a wheat growing season. RTC reduced tillage with ducksfoot cultivator; RT = moldboard ploughing with the moldboard detached; CT = conventional tillage with moldboard ploughing.

Discussion

Result showed no significantly difference in SR in the 0- to 5-cm layer when wheat was under RTC or RT compared with CT. ALP and DHA varied with treatments. At 5–20 cm, ALP and DHA was greater than at 0–5 cm when wheat was under RTC or RT. This indicates that minimum tillage probably influenced ALP and DHA more at the subsurface than at the surface soil. Fewer reports have appeared in the literature concerning the temporal effects on soil biological activity under NT, compared with CT under dry land farming. In accord with this observation, soil microbial biomass C (SMB), as a measure of the total microbial tissue of vegetative bacteria and fungi, has also often been found to similarly respond to tillage method (Doran 1987; Staley *et al.,* 1988; Carter, 1991; McCarty *et al.,* 1995). Lynch and Panting (1980, 1982) showed that SMB in the surface layer (0–15 cm) under both direct-drilled (NT) and ploughed (CT) wheat (*Triticum aestivum* L.) was nearly constant from autumn to spring, and increased to a maximum during the summer, then declined to about the autumn concentration. SMB was not significantly different between tillage methods until harvest in late August, when it was 33 to 77% greater under NT than CT. Granatstein *et al.* (1987), using a wheat–barley (*Hordeum vulgare* L.)–pea (*Pisum sativum* L.) rotation site, reported little change in SMB in 5-cm deep soil increments to 30 cm under either tillage method from April to September, then a large increase in the 0- to 5-cm layer in October, but only under NT. In wheat–legume rotations, Van Gestel *et al.* (1992) found near-linear decreases in SMB from mid-winter to autumn in the 0- to 2.5-cm layer under both CT and NT. the only study that has examined tillage method effects on SMB (actually, biomass N) specifically and frequently over the growing season is that of Carter and Rennie (1984), who used four sites on Chernozemic soils planted with spring wheat. For the 0- to 5-

cm layer, increases in biomass N during the early growing season were greater under zero tillage (NT) than shallow tillage (CT), and then declined to about the same level by the end of the growing season. Greater ALP and DHA at 5–20 cm may due to undisruption nich or habitat of microorganism. In semiarid rejoin, higher soil moisture content at subsurface soil than surface soil creates a higher population of micro organism at this depth (data not shown). May when the surface soil that is not richer of microorganism when incorporated into the soil by plowing and replaced with the subsurface soil cause to decrease in soil biological activity.

This experiment indicated an increased in SR when wheat was inoculated with BP. Low P availability limits plant growth in many alkaline soils. Maybe when plants are subjected to P, plant biomass increased and thereby may increased release of exudates containing energy-rich carbon compounds root exudates.

At 0–5 cm, ALP and DHA didn't affected by P, B and PB. At 5–20 cm B inoculant increased ALP. Other study indicates that P addition substantially decreased the activities of the ALP enzymes (Raiesi and Ghollarata, 2006). It was indicated that the activities of enzymes involved in P transformation are inversely related to P availability (Tadano *et al.,* 1993) and under P limited conditions its high demand, resulting in an increase in phosphatase activity, as occurred in low P conditions of this study. Therefore it seems that any decrease in the available phosphate may cause an overall increase in phosphatase activity. When plants are subjected to P deficiency, secretion of ACP from roots is a regular reaction (Fox and Comerford, 1992; Gilbert *et al.,* 1999; Richardson *et al.,* 2001).

At 5–20 cm PB inoculant increased DHA. Soil microbial activity including soil respiration and enzyme activities, and the size of microbial biomass, have been shown to depend on P fertilization and the presence of AM fungi in the soil–plant system (Amador and Jones, 1993; Wright and Reddy, 2001; Wamberg *et al.,* 2003; Lo´pez-Gutie´rrez *et al.,* 2004; Baligar *et al.,* 2005; Marschner and Timonen, 2006). Phosphorus fertilization may affect soil microbial respiration and biomass, especially soil enzymes, with variable results depending on the soil P status. Phosphorus additions resulted in increased microbial respiration in soils with low P contents, but not in soils with high P contents (Amador and Jones, 1993; Smith, 2005). In contrast, P fertilization had an inhibitory effect on microbial respiration and substrate-induced respiration in a pine forest floor, while no effects on microbial metabolic quotients (qCO2) were detected (Thirukkumaran and Parkinson, 2000). This experiment carried out in the semiarid rejoin with high calcareous soils and low P contents. In calcareous soils, a large proportion of P is found as

precipitated calcium-phosphate minerals, which are insoluble and unavailable to plants in the short-term (Stro¨m *et al.,* 2005). Consequently, P fertilization may frequently lead to increased crop growth and production. Then, in this experiment may integrated P fertilization and B additions resulted in increased DHA.

Result showed SIR was higher in the 0- to 5- cm layer when wheat was under CT compared with RTC or RT at vegetative phase, stem extinction and ear emergence. Under CT, subsoil that contains higher microorganism compared to surface soil take up to the surface of soil. Therefore when this soil added with an induced source of nutrient, Glocuse, SIR increased.

Our experiments have shown that SR and SIR increased during the early growing season. This enhanced SR and SIR may be related to the increased release of exudates containing energy-rich carbon compounds derived from host plant root assimilates, soil structure (Johansson *et al.,* 2004), initiated rain season and decrease high temperature at autumn which may affect SR and SIR.

SR and SIR decreased during tillerin phase of wheat growth (winter). This decline may be related to the lower temperature from mid-autumn to mid winter. SR and SIR increased during wheat stem extension and was nearly constant at ear emergence but hadn't return back to its maximum rate as during the early growing season. During this wheat growth stage (spring to summer) temperature binging to increased and soil water content decline that may caused to decrease SR and SIR.

Different tillage management introduce different mycorrhiza colonization rate. Result showed that Low degree of tillage could be beneficial to AM colonization. Tillage causes a physical disruption of fungal mycelia and may change physicochemical properties of the soil (Johansson *et al.,* 2004). Mixing of soil may negatively affected AM colonisation of plant roots, due to disruption of the extraradical mycelium (McGonigle and Miller, 1996). B led to increase mycorrhiza colonization rate. It is suggested that microbes, e.g., N fixing bacteria or P solubilising bacteria, may synergistically interact with AM fungi (Puppi, 1994). Isolation of bacteria from spores showed that several genera, including *Pseudomonas* and *Corynebacterium*, enhanced spore germination. Carpenter-Boggs *et al.* (1995) tested the stimulatory effects of *actinomycetes* and *Streptomyces orientalis* on *Gigaspora margarita* spore germination and found that amounts of volatile compounds produced by the isolates correlated well with AM spore germination. Conversely, other studies using pasteurisation, fumigation or sterilisation of soils have demonstrated that the presence of some soil bacteria may also inhibit spore germination (Tommerup, 1985) or AM sporulation (Ross, 1980; Wilson, 1988). However we are not sure that B inoculant increase AM colonization rate because this

higher rate of mycorrhiza colonization rate obtained from compare of between plots that applied with P and plots that inoculated with B. And intensive research indicated that mycorrhiza colonization under higher nutrient conditions and fertilizer addition, as for example, phosphorous is less certain when soil nutrient is lower.

Semi-arid and arid regions imply prolonged dryness, and are used with respect to the climate itself, and the land below it. In such regions the ability to produce agricultural crops is restricted. Usually on semiarid lands the potential evaporation of water from the land is high, Soil prone erosion and a large proportion of P is found as precipitated calcium-phosphate minerals, which are insoluble and unavailable to plants in the short-term. Because of the low rainfall and consequently reduced plant growth, organic material is produced slowly. Yet, again because of low rainfall, it may be broken down slowly as well. The amount of organic material in the soil, and thus the potential fertility, is likely to be high in semi-arid zones, low in deserts. Tillage results in soil erosion, loss of organic matter, decreased water infiltration, loss of soil structure, decreased soil fertility and a reduction in overall soil quality due to the destruction of soil aggregates and structure (Parr *et al.,* 1992; Paustian *et al.,* 1997; Allmaras *et al.,* 2000; Nyakatawa *et al.,* 2000) that can more under dry land farming. Tillage increases decomposition of crop residues and changes the structure of the soil food web by relocating food resources and exposing protected carbon (Hendrix *et al.,* 1986; Moore and deRuiter, 1991; Beare *et al.,* 1992; Wardle, 1995). This experiment showed that conventional tillage under semiarid regoins that plants subjected to several limited factor such as water and nutrient, affected soil biological activity and mycorrhiza symbiosis. Water is the most limiting factor for crop production under dryland farming in semiarid areas. Therefore, any options that alter mycorrhiza symbiosis can affect plant water relations and prevents drought stress. Results showed that subsurface can respond quickly to a cessation in tillage than surface soil. A deterrent for growers considering the transition to conservation tillage is the delay in soil response (e.g. increased soil carbon, efficient nutrient cycling, impacts on yield) associated with the equilibration of the soil food web (Simmons and Coleman, 2008). This evidence that belowground food webs can respond quickly to a cessation in tillage suggests that the delay in soil response may be due more to the time required to build organic matter than to a slow response by the biota (Simmons and Coleman, 2008). This experiment showed conventional tillage increased soil biological activity and mycorrhiza symbiosis under dry land farming. Result indicated that use of biofertilizer specially, such as P solubilising bacteria, and integrated of biofertilizer and chemical fertilizer, P, had the better influence on soil biological activity.

References

Allmaras, R.R., Schomberg H.H., Douglas C.L. and Dao T.H. (2000). Soil organic carbon sequestration potential of adopting conservation tillage in US croplands. J. Soil Water Conserv 55: 365–373.

Amador, J.A. and Jones, R.D. (1993). Nutrient limitations on microbial respiration in peat soils with different total phosphorous content. Soil Biol. Biochem. 25: 793–801.

Anderson, J.P.E. (1982). Soil respiration. In: Page, A.L. (Ed.), Methods of Soil Analysis, Part 2, Chemical and microbiological properties, Agronomy Monograph No. 9, 2nd Edition. ASA-SSSA, Madison, WI.

Auge´, R.M. (2001). Water relations, drought and vesicular arbuscular mycorrhizal symbiosis. Mycorrhiza 11: 3–42.

Baligar, V.C., Wright, R.J. and Hern, J.L. (2005). Enzyme activities in soil influenced by levels of applied sulfur and phosphorus. Commun. Soil Sci. Plant Anal. 36: 1727–1735.

Beare, M.H., Parmalee, R.W., Hendrix, P.F., Cheng, W., Coleman, D.C. and Crossley, J.R.D.A. (1992). Microbial and faunal interactions and effects on litter nitrogen and decomposition in agroecosystems. Ecol. Mon. 62, 569–591. Biochem. 35: 1349–1357.

Carpenter-Boggs, L., Loynachan, T.E. and Stahl, P.D. (1995). Spore germination of Gigaspora margarita stimulated by volatiles of soil-isolated actinomycetes. Soil Biology and Biochemistry 27: 1445–1451.

Carter, M.R. (1991). The influence of tillage on the proportion of organic carbon and nitrogen in the microbial biomass of medium-textured soils in a humid climate. Biol. Fertil. Soils. 11: 135–139.

Carter, M.R. and Rennie, D.A. (1984). Dynamics of soil microbial N under zero and shallow tillage for spring wheat, using 15N urea. Plant Soil. 76: 157–164.

Doran, J.W. (1987). Microbial biomass and mineralizable nitrogen distributions in no-tillage and plowed soils. Biol. Fertil. Soils. 5: 68–75.

Raiesi, F. and Ghollarata, M. (2006). Interactions between phosphorus availability and an AM fungus (Glomus intraradices) and their effects on soil microbial respiration, biomass and enzyme activities in a calcareous soil. Pedobiologia 50: 413—425

Fox, T.R. and Comerford, N.B. (1992). Rhizosphere phosphatase activity and phosphatase hydrolyzable organic phosphorus in two forested spodosols. Soil Biol. Biochem. 24: 579–583.

Garcı´ a, C., Herna´ndez, M.T. and Costa, F. (1997). Potential use of dehydrogenase activity as an index of microbial activity in degraded soils. Communication in Soil Science and Plant Nutrition. 28: 123–134.

Gilbert, G.A., Knight, J.D., Allan, D.L. and Vance, C.P. (1999). Acid phosphatase activity in phosphorus-deficient white lupin roots. Plant Cell Environ. 22: 801–810.

Giovanetti, M. and Mosse, B. (1990). An evaluation of techniques for measuring vesicular arbuscular mycorrhizal infection in roots.New Phytol. 84: 489–500.

Granatstein, D.M., Bezdicek, D.F., Cochran, V.L., Elliott, L.F. and Hammel, J. (1987). ongterm tillage and rotation effects on soil microbial biomass, carbon and nitrogen. Biol. Fertil. Soils. 5: 265–270.

Hendrix, P.F., Franzluebbersm, A.J. and McCracken, D.V. (1998). Management effects on carbon accumulation and loss in soils on the southern Appalachian Piedmont of Georgia, USA. Soil Till. Res. 47: 245–251.

Hendrix, P.F., Parmelee, R.W., Crossley, Jr. D.A., Coleman, D.C., Odum, E.P. and Groffman, P.M. (1986). Detritus food webs in conventional and no-tillage agroecosystems. BioScience 36: 374–380.

Holland, J.M. (2004). The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence. Agric. Ecosyst. Environ. 103: 1–25.

Johansson, J.F, Paul, L.R. and Finlay, R.D. (2004). Microbial interactions in the mycorrhizosphere and their significance for sustainable agriculture. FEMS Microbiology Ecology 48: 1–13.

Lal, R., Kimble, J.M., Follet, R.F. and Cole, C.V. (1998). The Potential of U.S. Cropland to Sequester Carbon and Mitigate the Greenhouse Effect. Ann Arbor Press, Chelsea, MI.

Lo´pez-Gutie´rrez, J.C., Toro, M. and Lo´pez-Herna´ndez, D. (2004). Arbuscular mycorrhiza and enzymatic activities in the rhizosphere of Trachypogonplumosus Ness. In three acid savanna soils. Agric. Ecosyst. Environ. 103: 405–411.

Lynch, J.M and Panting, L.M. (1980). Cultivation and the soil biomass. Soil Biol. Biochem. 12: 29–33.

Lynch, J.M. and Panting, L.M. (1982). Effects of season, cultivation and nitrogen fertilizer on the size of the soil microbial biomass. J. Sci. Food Agric. 33: 249–252.

Marschner, P. and Timonen, S. (2006). Bacterial community composition and activity in rhizospheres of roots colonised by arbuscular mycorrhizal fungi. In: Mukerji, K.G., Manoharachary, C., Singh, J. (Eds.), Microbial Activity in the Rhizosphere. Springer, Berlin, pp. 139–154.

McCarty, G.W., Meisinger, J.J. and Jenniskens, F.M.M. (1995). Relationships between total-N, biomass-N and active-N in soil under different tillage and N fertilizer treatments. Soil Biol. Biochem. 27: 1245–1250.

McGonigle, T.P. and Miller, M.H. (1996). Development of fungi below ground in association with plants growing in disturbed and undisturbed soils. Soil Biology & Biochemistry. 28: 263–269.

Moore, J.C. and deRuiter, P.C. (1991). Temporal and spatial heterogeneity of trophic interactions within belowground food webs. Agric. Ecosyst. Environ. 34: 371–397.

Nyakatawa, E.Z., Reddy, K.C. and Mays, D.C. (2000). Tillage, cover cropping and poultry litter effects of cotton II Growth and Yield parameters. Agron. J. 92: 1000–1007.

Parr, J.F., Papendick, R.I., Hornick, S.B. and Meyer, R.E. (1992). Soil quality: attributes and relationship to alternative and sustainable agriculture. Am. J. Altern. Agric. 7: 5–11.

Paustian, K., Collins, H.P. and Paul, E.A. (1997). Management controls on soil carbon. In: Paul, E.A., Paustian, K., Elliott, E.T., Cole, C.V. (Eds.), Soil Organic Matter in Temperate Agroecosystems: Long Term Experiments in North America. CRC Press, Boca Raton, FL, pp. 15–49.

Paustian, K., Six, J., Elliott, E.T. and Hunt, H.W. (2000). Management options for reducing CO2 emissions from agricultural soils. Biogeochemistry, 48: 147–163.

Phatak, S.C., Reed, R., Fussell, W., Lewis, W.J. and Harris, G.H. (1999). Crimson clover cotton relay cropping with conservation tillage system. In: Hook, J.E. (Ed.), Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture, Tifton, GA, pp. 184–188.

Phillips, J.M. and Hayman, D.S. (1970). Improved procedures for clearing roots and staining parasitic and vesicular–arbuscular mycorrhizal fungi for rapid assessment of infection. Trans. Br. Mycol. Soc. 55: 158–161.

Puppi, G., Azcon, R. and Hoflich, G. (1994). Management of positive interactions of arbuscular mycorrhizal fungi with essential groups of soil microorganisms. In: Impact of Arbuscular Mycorrhizas on Sustainable Agriculture and Natural Ecosystems (Gianinazzi, S. and Schuepp, H., Eds.), pp. 201–215. Birkhauser Verlag, Basel, Switzerland.

Richardson, A.E., Hadobas, P.A. and Hayes, J.E. (2001). Extracellular secretion of *Aspergillus phytase* from Arabidopsis roots enables plants to obtain phosphorus from phytate. Plant J. 25: 641–649.

Ross, J.P. (1980). Effect of nontreated soil on sporulation of vesicular-arbuscular mycorrhizal fungi associated with soybean. Phytopathology, 70: 1200–1205.

SAS. (1990). SAS Procedure Guide, Version 6, 3rd Edition. SAS Institute, Cary, NC, 705 pp.

Simmons, B.L., Coleman D.C. (2008). Microbial community response to transition from conventional to conservation tillage in cotton fields. Applied soil ecology 40: 518 – 528

Smith, V.R. (2005). Moisture, carbon and inorganic nutrient controls of soil respiration at a sub-Antarctic. island. Soil Biol. Biochem. 37: 81–91.

Staley, T.E., Edwards, W.M., Scott C.L. and Owens, L.B. (1988). Soil microbial biomass and organic component alterations in a no-tillage chronosequence. Soil Sci. Soc. Am. J. 52: 998–1005.

Stro¨m, L., Owen, A.G., Godbold, D.L. and Jones, D.L. (2005). Organic acid behavior in a calcareous soil implications for rhizosphere nutrient cycling. Soil Biol. Biochem. 37: 2046–2054.

Tabatabai, M.A. (1994). Soil enzymes. In: Weaver, R.W., Angle, J.S., Bottomley, P.S. (Eds.), Methods of Soil Analysis, Part 2: Microbiological and Biochemical Properties. Soil Science Society of America, Madison, pp. 903–948.

Tadano, T., Ozowa, K., Satai, M., Osak, M. and Matsui, H. (1993). Secretion of acid phosphatase by the roots of crop plants under phosphorus-deficient conditions and some properties of the enzyme secreted by lupine roots. Plant Soil, 156: 95–98.

Thirukkumaran, C.M. and Parkinson, D. (2000). Microbial respiration, biomass, metabolic quotient and litter decomposition in a lodgepole pine forest floor amended with nitrogen and phosphorous fertilizers. Soil Biol. Biochem. 32: 59–66.

Tommerup, I.C. (1985). Inhibition of spore germination of vesicular-abuscular mycorrhizal fungi in soil. Transactions of the British Mycological Society, 85: 267–278.

Van, Gestel M., Ladd, J.N. and Amato, M. (1992). Microbial biomass responses to seasonal change and imposed drying regimes at in creasing depths of undisturbed topsoil profiles. Soil Biol. Biochem. 24: 103–111.

Wamberg, C., Christensen, S., Jakobsen, I., Mu¨ller, A.K. and Sørensen, S.J. (2003). The mycorrhizal fungus (*Glomus intraradices*) affects microbial activity in the rhizosphere of pea plants (*Pisum sativum*). Soil Biol. Biochem. 35: 1349–1357.

Wardle, D.A. (1995). Impacts of disturbance on detritus food webs in agro-ecosystems of contrasting tillage and weed management practices. In: Begon, M., Fitter, A.H. (Eds.), Advances in Ecological Research. Academic Press Inc., New York, pp. 105–185.

Wilson, G.W.T., Hetrick, B.A.D. and Kitt, D.G. (1988). Suppression of mycorrhizal growth-response of big bluestem by nonsterile soil. Mycologia 80: 338–343.

Wright, A.L. and Reddy, K.R. (2001). Phosphorus loading effects on extracellular enzyme activity in Everglades wetland soils. Soil Sci. Soc. Am. J. 65: 588–595.

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