The Effect of Crop Residues on The Dynamism of Soil Microbial Biomass Carbon and Its Relation with Wheat Yield (N8019 variety)

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Abstract

Residue management and its recovery in soil especially in arid and semiarid regions is an available option to sustain agroecosystems. In order to investigate the effect of different residues on microbial activities, a four replicated field experiment performed as a CRB design on wheat. Five residues with different C:N ratio (including cotton، soybean، alfalfa، wheat and corn) in companion with pure urea and control treatment (without residue or fertilizer) were incorporated as <5 mm particles. The rate of residue and needed nitrogen to avoid immobilization were determined by determination C:N ratio and nitrogen index to provide 90 Kg $N.ha^{-1}$. The microbial biomass carbon was measured 49, 83, 99, 127, 165 and 175 days after experiment beginning by fumigation-extraction method. The results indicated that microbial biomass changes considerably during time without a predictable trend. Our findings revealed that microbial communities dynamism is highly correlated with temperature, but is not affected by soil moisture content. Also, we found that C:N ratio can not be considered as the best index to interpret biological activities during decomposition process. We found that Cellulose and Hemicellulose also should be analyzed. In this study, we analyzed the relationship between microbial biomass carbon rate of residue decomposition and its effect on yield.

Keywords: Crop residue, Decomposition, Nitrogen, Microbial community

Introduction

Plant residues have an important role as soil and water protecting factors and in recent decades have considered as an external input to protect soil organic matters and turn overing nutrients to soil. Decomposing plant residues are regarded as one of the essential processes in developing nutrients cycle, protecting of organic matters and mobilization nutrient resources in soil texture and microbial communities are the most important decomposing factors of plant residues. Microbial biomass has the key role in distributing nutrients in soil and regulating primary productions.

Organic materials are carbonic compounds which are produced by plants and soil microorganisms. Not only existing organic matter in soil detects the soil quality but also it is a proper index for its fertilization which the result of interaction between physical, chemical and biological characteristics of soil. Counting microorganisms is not an appropriate index to determine a microbial group in soil. Soil carbon is applied and emphasized as a comprehensive index of soil fertility. Soil organisms, temperature, tillage and chemical composition are most important factors influence the rate of plant residues decomposing. The rate of decomposing and N mineralization increases by increasing plant residues quality (Couteaux et al., 1995, Vanlauwe et al., 1996, Rice et al., 1994). Although residues quality is an important factor to determine C and N mineralization rate, but residue management technique is affecting factor on this process (Smith and Sharpley., 1990).

In Iran crop planting was previously alternative / uncovered. In these conditions, there was enough time for grazing and plant residues decomposing. But in recent years, because of different reasons as world increasing of crops production, planting facility and mechanized harvest and providing water and fertilizer required for farmers, the majority of farmers burn residues immediately after harvesting. In this way field is prepared earlier for future planting and some amounts of minerals like Ca, Mg, P and K are released. Carbon losing has been one of the permanent results of performing farming operations. Investigating carbon losing in some soils during the time has shown that low yield, erosion, insufficient fertilization, plant residue removing and compact tillage are regarded as factors of carbon losing. The contribution of residues in releasing nutrients depends on creating simultaneous nutrient releasing and nutrient demand of crop and producing this simultaneity has a vital role in minimizing nutrient losing.

The objective of this study was comparison of different plant residues (with various C:N ratio) on soil microbial biomass, supplying mineral nitrogen in soil and inspecting the effect of plant residues on grain yield in plant.

Material and methods

The study was conducted in 2009-10 in Gorgan university of agricultural sciences and natural resources. Gorgan, a(37˚45́ latitude and 54˚ 30΄ longitude at an altitude of around -13-m above sea level). The climate of the area is temperate, with a mean annual rainfall of 421.7 mm, most of the rain falling between septamber and January, and a mean annual air temperature of 18.5 ˚C with a minimum of 9.5 ˚C in winter and a maximum of 29.5 ˚C in summer. Soil samples were mixed thoroughly to obtain a composite sample for each plot. This result showed soil of area is loamy- clay silty. Some overall characteristics of soil are shown in Table 1. Experiment performed as a CRB design on wheat (N8019). Five residues with different C:N ratio (including cotton soybean، alfalfa، wheat and corn) in companion with pure urea and control treatment (without residue or fertilizer application) were incorporated as <5 mm particles. The rate of residue and needed nitrogen to avoid immobilization were determined by determination C:N ratio and nitrogen index to provide 90 Kg N.ha^{-1}. Total organic carbon (TOC) (the Walkley and Black method) and total nitrogen) (TN) (the Kejldahl method) also were measured.

Plant residues using in this experiment were cotton, maize, wheat and soybean. We calculated the amount of requiring residues for releasing the nitrogen (90 Kg .ha^{-1})as N index with regard to C:N ratio as well as mineral N fertilizer to prevent immobilization and added to soil. Required residues of each plant were calculated as 6467.37, 5988.05, 5621.9, 5824 and 5972 Kg.ha^{-1} for cotton, maize, wheat, soybean and alfalfa respectively and the amount of mineral N fertilizer required for these residues were estimated as 66.16, 75, 100, 125 and 58.33 Kg.ha^{-1} respectively. After that the amount of calculated residues and urea was mixed and by tilling in depth of 30 cm were added to soil. Phonologic stages including tillering, stem elongation, booting, anthesis, physiological ripening and harvest ripening were recorded by Zadox (1974) coding method during growth season. Microbial biomass C was measured by soil sampling from depth of 0-20 cm and yield was measured by destroying sampling during tillering, stem elongation, booting, anthesis, physiological ripening and harvest ripening stages.

Microbial biomass C was measured by extraction fumigation method (Anderson, 1987, Jenkinson, 1998).

Results and discussion

Table 2 show the results for analysis of variance of microbial biomass carbon rate during 6 stages of measurement. Based on these results, the effect of residues treatment on the microbial biomass carbon was signification at level of 5% probability in Anthesis, physiological ripening and harvest ripening stages. (127, 165 and 175 days after experiment). It seems one of reasons for lack of significant difference among residues in terms of microbial decomposition in first stages is that these ranges of residues don’t have much difference in terms of carbon content (fig 1) whereas, their major difference is about their nitrogen percentage. So, because the first step of decomposition for the release of nitrogen is decomposition of polysaccharide compounds , no difference has practically been observed among residues in this field.

Table2. Analysis of variance for microbial biomass carbon in treatments under experiment.

Harvest ripening	Phisyological ripening	Anthesis	Booting	Stem elongation	Tillering	df	S.O.V
5414.02	18730.3	23792.15	15676.53	50946.56	12473.45	3	Replication
79.38571*	2251.74*	26997.74*	61439.78 ^{ns}	14803.06 ^{ns}	64916.53 ^{ns}	6	Treatment
33.30723	1457.37	20606.18	115454.11	23955.11	96392.86	18	Error
						27	total

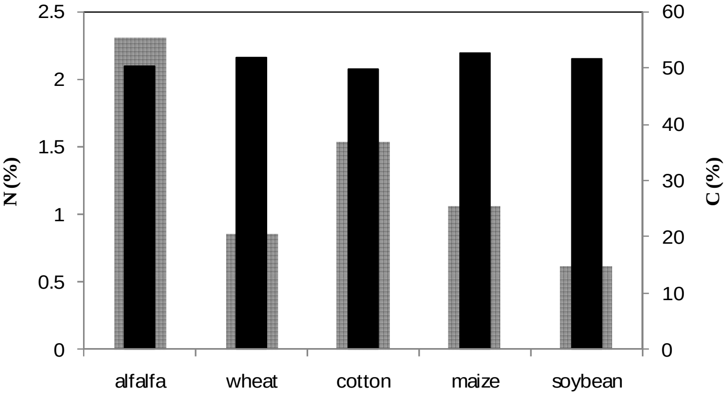

Fig1. Percentage of carbon and nitrogen in different studied treatments.

Step by step comparing the average of microbial biomass carbon showed any certain trend is not seen in terms of the absolute amount of released carbon (fig 2). But the accumulative changes trend of microbial biomass carbon was similar during this time in cotton, soybean, wheat, maize and alfalfa residues treatment and also most changes of microbial biomass carbon were made during the first 99 days and the last 10 days of growing season (fig 3). Accumulation change trend of microbial biomass carbon in six samplings showed that microbial biomass carbon remained constant during the third sampling of wheat growing stage (simultaneously with booting stage) and 99th day after beginning of experiment. After that between 16th day (physiological ripening) to 175th day (harvest ripening) the rate of carbon highly increased. This stage accompanied with fully tangible increase of temperature from average 21.7 ˚C to 26.4 ˚C (fig 4).

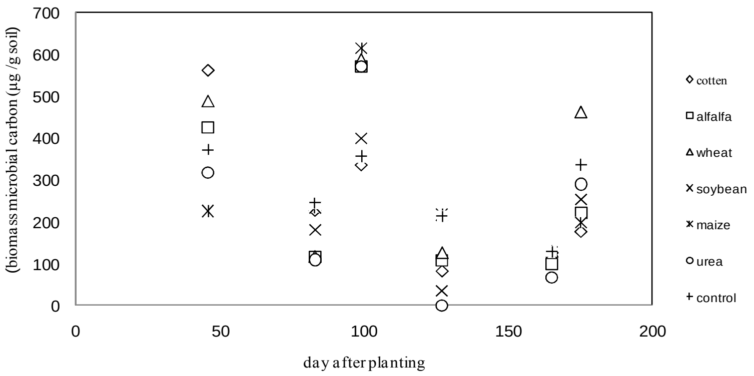

Fig 2. Changes of microbial biomass carbon during the taime.

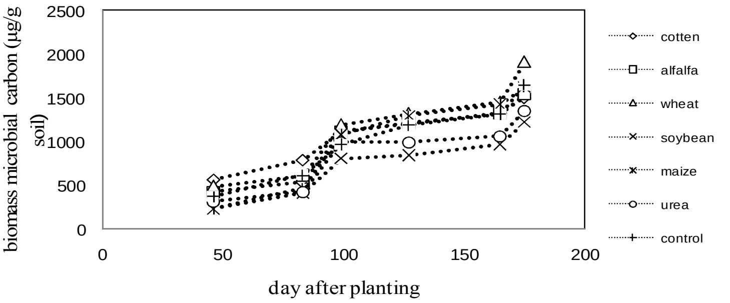

Fig 3. Accumulation changes of microbial biomass carbon during the taime.

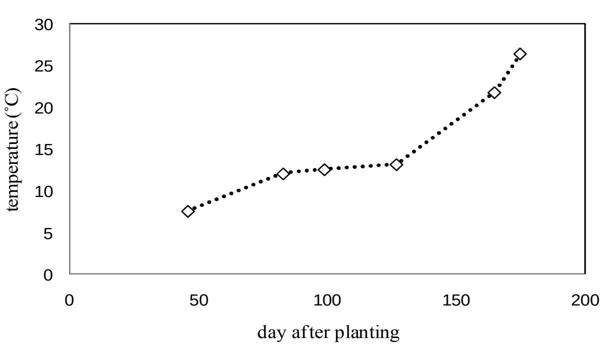

Fig4. The trend of mean temperature corresponding to each given sampling during variable growing stage

Based on research done in Germany, it has been noticed that mineralizing process in soil started at -1°C and its rate increases when the temperature gets to 10°C. the rate of this process also increases as much as 2.5 to 3 times at 10-30°C. it has been reported that the most favorable temperature for bacteria activities is 25 – 35°C (Fallah et al, 2006). In this study wheat residue were decomposed slowly by having high ratio of C:N (60.74) where as soybean was decomposed on the first days after cultivation by having low ratio of C:N (24) and high amount of nitrogen. It has removed microbial community's need by providing enough nitrogen. So much more nitrogen has been available to the plant which conforms to Edwards study (Edward et al, 1998). They have noticed that decomposition of soybean residue happens very fast in comparison with that of wheat residue which can be related to difference at substrata level of N solution and C:N ratio. Investigating average of microbial populations in two stages of tillering to stem elongation and booting to harvest ripening showed that in two treatments of wheat and maize residues (49.62 and 60.74 respectively with C:N ratio) and high percentage of lignin (14% and 7% respectively), trend of microbial population changes has been in decline for alfalfa and cotton residues (with C:N ratio 32.27, 21.78 and 1.4%, 7% of lignin table 3). This matter indicates that wheat and maize residues are decomposed later, that's why microbial activities of their polysaccharide compounds decomposition will continue to the end of the growing season.

Table 3. Mean microbial biomass carbon (μgr.gr^{-1} soil) during Tillering to Stem elongation and Anthesis to Harvest ripening.

control	urea	alfalfa	soybean	wheat	maize	cotten	Day after planting
307.1	212.25	270.1	203.35	302.6	230.35	392.9	Tillering- Stem elongation
275.65	231.34	249.41	198.96	348.85	289.42	179.06	Booting – Harvest ripening

Obtained grain yield in different treatments shows significant difference between observed treatment (with the lowest yield) and other treatments. Also, between residue treatment and urea is significant difference (fig 5). This matter indicates that residue treatment was well replace with urea under these conditions and made nitrogen available as much as the plant needed. Based on given data in fig (5), most difference of grain yield was seen between observed one and alfalfa treatment (1.4 ton.ha^{-1}) which has the lowest ratio of C:N after urea.

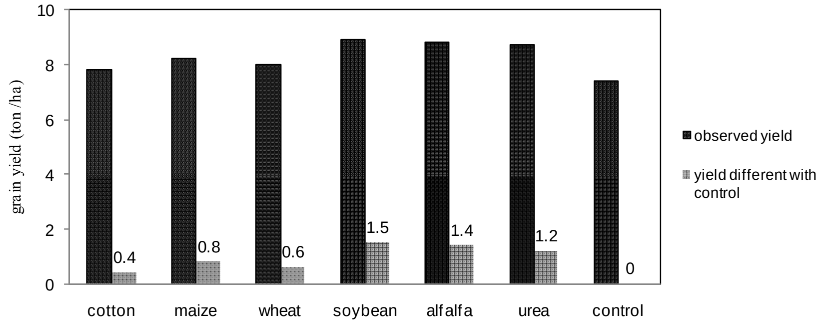

Fig 5.Observed grain yield (ton. ha^{-1}) and yield difference with control in different residue treatments.

After alfalfa, urea, maize, wheat and cotton were ranged. These results were gained while looking at the first amounts of C:N in used treatments showed there is no specific relation between C:N ratio of treatments and grain yield (fig 6).

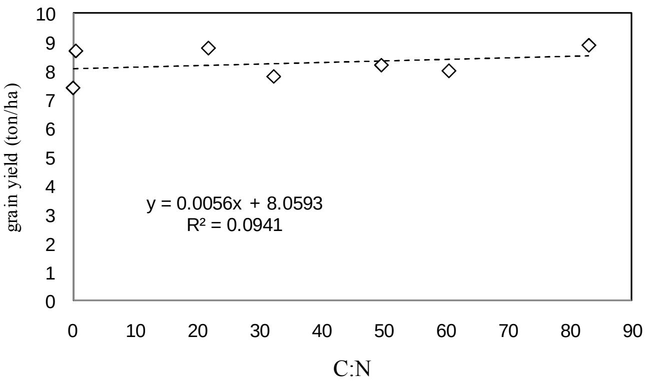

Fig 6. Relation of grain yield in residues treatment with different ratio of C:N.

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