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Original article

# Soil enzymatic activities and available P and Zn as affected by tillage practices, canola (*Brassica napus* L.) cultivars and planting dates

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ABSTRACT

Due to high sensitivity and rapid response, soil biological properties including microbial enzymatic activities are appropriate indicators of soil quality, under different agricultural systems. Hence, a two-year field experiment was performed in 2002 and 2003 hypothesizing that soil microbial activities and P and Zn availability differ under different management practices. The objective was to evaluate the effects of different tillage (T) practices, canola (*Brassica napus* L.) cultivars (V's) and planting dates (PD's) on the soil enzymatic activities of alkaline and acid phosphatase and dehydrogenase and available P and Zn. Using a split plot design, different T practices (no (NT), minimum (MT) and conventional (CT)) and the combination of different V's (Hyola 401 and PF) and PD's (8th (PD1), 23rd September (PD2) and 7th October (PD3)) were assigned to the main and subplots, respectively. Soil enzymatic activities and P and Zn were measured. The actions and interactions of T, and PD significantly affected the activity of alkaline and acid phosphatase. Although, dehydrogenase activity at 0–10 cm was affected by T, V and PD and the interaction of T and PD, only T and the interaction of T and PD influenced the activity of this enzyme at 10–20 cm. Compared with other tillage practices, NT significantly increased enzymatic activities. The enzymatic activity at the 0–10 cm depth was in the order of PD1 > PD2 > PD3. However, at the 10–20 cm depth MT had a significant effect on dehydrogenase activity. NT reduced soil available P and Zn. NT can significantly influence soil biological properties and hence canola growth, resulting in a sustainable agricultural system.


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*Abbreviations: P, phosphorous; Zn, zinc; N, nitrogen; C, carbon; NT, MT, CT, no-, minimum-, and conventional tillage, respectively; PD1, PD2 and PD3, 8th and 23rd of September, and 7th of October, respectively.*

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## 1. Introduction

### 1.1. Tillage practices and soil enzymatic activities

Soil enzymes are used as biological indexes of soil fertility under different tillage practices [70]. With respect to their interaction with plants and nutrients and organic matter cycling, microorganisms are important fractions of the ecosystem [37,52]. In addition, they are also involved in the formation and stability of soil aggregates. All these microbial influences are very much affected by tillage practices. Of the total soil organic matter, 1–5% exists in the microbial biomass [24,30].

It has been known that the plant–microbe interactions are very much under the influence of tillage practices [34]. In addition to the soil texture influencing the distribution of soil microorganisms and enzymatic activities (e.g., alkaline phosphatase activity was found in the silt (37.9–43.0%) and clay (48.9–54.0%) fractions); different soil tillage practices also affected the amounts and distribution of soil enzymatic activities at different soil depths [25,64]. The nature and the method of soil fractioning also determine the distribution of soil enzymatic activities [26,32].

The significance of soil enzymatic amount and distribution in the soil is because of planning an appropriate tillage practice for the enhancement of soil organic N and C, and hence, long term productivity of soil [26].

Since the rate of physical and chemical processes in the soil is slow, soil biological parameters, including soil microbial population and enzymatic activities can be used as good indicators of soil quality, when soil is subjected to ecological changes such as different soil practices [14,25,26]. At different management practices, the microbial attributes, including the amount and activity of phosphatase and dehydrogenase enzymes determined soil biological quality more sensitively and more responsively, compared with total organic C and N [5,11,42].

MT affects soil properties, including soil temperature [12], soil physical properties [43], soil organic C [40], soil phosphatases [8] and soil microorganisms [21].

Green manure of crop residues can enhance microbial population and activities [5,13,15,38,42,]. Different tillage practices alter microbial composition and C utilization of substrates [2,6,13], and increase microbial variation [63].

### 1.2. Canola genotypes and soil biological activities

Since canola prices are competitively comparable with cereals price, its cultivation has extensively increased. Different plant genotypes may have different microorganisms combination in their rhizosphere [65], attributed to the production of their root exudates [39,44,60]. Usually brassica genotypes can efficiently utilize P, compared with other crop plants [17]. This has been attributed to their root architecture, which is delicately branched, and has long root hairs. They are also able to enhance P uptake by production of organic acid anions [39,44,49,60]. The amount of canola P uptake from the soil is usually 1% of its yield production [23]. It is worth mentioning high levels of P inhibit such mechanisms [59].

Plant roots release about 17% of plant photosynthate into the soil [37,50], resulting in enhanced microbial population and activity [28,53].

### 1.3. P and phosphatase

Although there is a high amount of P in the soil only soluble P, in small concentration (usually $<1 \mu g$ [4]), is available to plants and soil microorganisms. P availability is very much affected by the formation of insoluble P compounds, soil fixation and microbial immobilization [39,44,60].

Microbial biomass and organic P are the most important sources of P in the soil, accounting for up to 10% [57] and 80% [62] of total soil P, respectively. The mineralization of organic P, and hence its availability, is dependent on the production of phosphatase enzymes by plant roots and microorganisms [39,44,60].

Soil microorganisms are able to increase plants available P by decreasing soil pH, and hence increasing phosphatase solubility, and also production of organic acid onions [39,71] and phosphatase enzymes (exocellular enzymes) [60,69].

### 1.4. Zn availability

The dynamic of Zn in the soil, like other nutrients, is subject to alteration of soil properties including the physical, chemical and biological ones. However, unlike P, Zn is not directly under the influence of soil microbial and enzymatic activities. Under different tillage practices soil properties such as the potential of oxidation–reduction are altered, affecting soil microorganisms activities, and eventually influencing Zn availability. Hence, the solubility of different nutrients, including Zn, in the rhizosphere of different plants, cropped at various planting dates, may differ depending upon their microbial combination and also soil properties, resulted by tillage practices.

Since to our knowledge there is very little documented data regarding the effects of different tillage practices, canola genotypes and planting dates on soil enzymatic activities and P and Zn, we performed these experiments.

## 2. Materials and methods

### 2.1. Experimental design

Two field experiments were conducted in 2002 and 2003 as split plots on the basis of completely randomized block design, in the Research Agricultural Center of Sari, Iran. The main plots were devoted to tillage practices including no- (planting at the previous cereal residues), minimum- (using chisel plow), and conventional tillage (using moldboard plow). The combination of canola cultivars, including Hyola 401 and PF, and planting dates (PD) of 8th (PD1) and 23rd (PD2) of September, and 7th of October (PD3) was assigned to subplots.

### 2.2. Experimental procedure

Each subplot was made of ten 7-m rows with a 20-cm spacing between the rows and 3-m spacing between the plots,