

RESEARCH PAPER

Succession Effect of Wheat Cultivation After Some Crops on Mycorrhizal Infection, Yield, and Quality of Wheat

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ABSTRACT:

The present study was conducted during wheat growing season (from November to June 2017) at Grdmalla village, Qushtapa district, Erbil governorate with Global Positioning System (GPS) reading of 36° 01' N, 44° 01' E and 413.8m above sea level to study the impact of crop rotation or cultivation of wheat after some vegetable crops and wheat itself such as broccoli, tomato, pepper, cucumber, eggplant and wheat. The results showed that the lowest infection percentage was observed in case of cultivation of wheat after wheat which was 30% in case of cultivation of wheat after wheat, while this value raised to 70-90% in case of cultivation of wheat after the mentioned vegetables. The increase in infection percentage of plant roots with mycorrhizal fungi caused significant increase in wheat yield, phosphorus and protein content. The wheat yield increased from 2.50 Mega gram ha⁻¹ to 4.86 Mega gram ha⁻¹(ton ha⁻¹) in case of cultivation wheat after wheat and broccoli respectively. On the other hand, the protein percentage was increased from 12.20 to 16.50% in case of cultivation of wheat after wheat and cultivation of wheat after broccoli respectively. The significant correlation was recorded between both of yield and protein content of wheat with mycorrhizal infection with correlation coefficient values of (r=0.89^{**} and 0.99^{**}) respectively.

KEY WORDS: Crop rotation, mycorrhizal infection, protein content, wheat yield and protein content.

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1. INTRODUCTION

Mycorrhiza is defined as a symbiotic association between the fungi organisms (specific for soil and plant life) and the plants root (or other substrate contacting parts) of a living plant which is primarily responsible for the transfer of the nutrients. Mycorrhizas in specialized organs of plant, where intimate communications formed from the coordinated development of plant-fungus (Brundrett, 2008).

Arbuscular mycorrhiza fungi (AMF) are a symbiotic relationship between soil fungi and terrestrial plants which the fungi supply the plant with water and nutrients in exchange for carbon, increasing plant growth and yield production. Several studies have reported to the important role of (AMF) in promoting (P) uptake by plant. Moreover, it is yet a matter of debate which how (AMF) affect soil (N) dynamic and as result plant (N) uptake. The important parts such affects by (AMF) are significance to health and productivity of the ecosystem (Miransari, 2012 and Miransari, 2017).

The infected plants with (AMF) are protected from salinity, drought condition, and also from excess phytotoxic elements (Ganugi et al; 2019).

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Enhancement of mycorrhizal inoculum potential by a given pre-crop may improve the mycorrhizal activity of a subsequent crop in the rotation (Barea et al., 1993). This is generally supposed to the fungi develop and sporulate most on the roots of those plant species which are most susceptible to mycorrhizal infection. Susceptible crops which, in the rotation, follow non-host plants (or plants which develop little mycorrhizal infection) may carry less infection than they would follow a strongly mycorrhizal crop (Ocampo and Hayman, 1981). Black and Tinker (1977) found fewer pores in soil kept fallow than in adjacent soil cropped with barley.

The (AMF) enhance the Chlorophyll concentration and photosynthetic rates. Phosphorus (P), and potassium (K) content in the plant parts (leaf, stem, and root), and nitrogen (N) content in the leaf and stem of arbuscular mycorrhizal seedlings were significantly more than in non- arbuscular mycorrhiza seedlings (Wang et al; 2019).

Howard, (1996) Indicated that crop rotation is a very ancient and cultural practice and has critical effect on soil microbial communities, soil structure, and organic matter. The main idea behind crop rotation practice is to disrupt disease cycle (Pierce and Rice, 1998). Few researches have been executed to distinguish mycorrhizal fungi community composition and diversity. The AMF spores' surveys as a baseline in the field soil to assess the impact of agricultural practice on mycorrhizosphere (Douds and Millner, 1999).

Agricultural practice management influence AM communities structure qualitatively and quantitatively (Miller et al., 1995). Crop rotation is known to affect AMF in the field. Crop rotation also affects species diversity, spore population of AMF in another crop-rotation management trial utilizing a maize-vegetable-small grain rotation and chemical fertilizer organic amendments as source of mineral nutrition (Douds. and. Schenck, 1990). Mycorrhiza are used as bio fertilizer and can decrease using of the chemical fertilizer especially phosphorus fertilizer (Ortas, 2012), therefore, they can significantly boost the phosphorus concentration in both root and shoot systems (Al-Hmoud and

Al-Momany, 2017). It has been observed that AMF maintain P and N uptake ultimately helping in plant development at higher and lower P levels under different irrigation regimes (Liu et al., 2014; Liu et al., 2018). Lately, it has been found that treatments with native Vascular arbuscular mycorrhiza lead to produce significant change in the N in crop plants (Turrini et al., 2018).

The important role of (AMF) is to provide roots with phosphorus because element phosphorus is an highly not mobile elements in soils (Turk et al. 2006). The phosphorus and nitrogen formed in shoots and dry mass of plants colonized with mycorrhiza were more than those of plants without mycorrhiza (Al-Amir et al. 2013).

The important limiting nutrient for plant growth is nitrogen (Sawers et al. 2008). Which is the major component of both protein and coenzymes, indeed nitrogen (N) is a major nutrient which enhance taking of nutrients from poor soils to roots which improved by arbuscular mycorrhizal colonization (Jin, et al., 2005). Nitrogen is obtained by the extraradical hyphae of AM fungi in different forms ranging from peptides, amino acids, (Ike-Izundu 2007 and Bago et al. 1996). Vascular arbuscular mycorrhiza enhance taking of nitrogen by mycorrhizal plant compared to non-mycorrhizal plant. Vascular arbuscular mycorrhiza fungi is enhance the taking of ammonium NH_4^+ that their movement lower than nitrate NO_3^- , its uptake rate affected by low diffusion (Tobar et al., 1994). Since there are little or no studies about the role of plant rotation on mycorrhizal infection, phosphorus absorption, yield and protein content of wheat in calcareous soil.

2. MATERIALS AND METHODS

The field experiment was conducted from November to June 2017, which carried out in a clay loam soil in Grdmalla Village, Qushtapa, Erbil with Global Positioning System (GPS) reading of $36^{\circ} 01' \text{ N}$ and $44^{\circ} 01' \text{ E}$, 413.8 m above sea level, to study the effect of sowing wheat after some other plants such as broccoli, tomato, cucumber, eggplant, and wheat. Three plots were taken from each site of the field or the number of experimental units equal to 18 experimental units.

The area of each experimental unit was 6 m² (2m x 3 m) for wheat cultivated after each of the mentioned vegetables and wheat itself and the space between experimental unit was 1m for all sites as shown from the table below.

Table (1) explains the crop rotation of the studied crops.

Sites	Description	Number of Plots
Site number 1	Wheat cultivated after broccoli	3 plots
Site number 2	Wheat cultivated after tomato	3 plots
Site number 3	Wheat cultivated after pepper	3 plots
Site number 4	Wheat cultivated after cucumber	3 plots
Site number 5	Wheat cultivated after eggplant	3 plots
Site number 6	Wheat cultivated after wheat	3 plots

On 8th of June, 2017 the wheat (*Triticum aestivum* L) plants were harvested from all sites of the field and the root samples were taken to determine infection with mycorrhizal using the international method as mentioned by Troyvelote et al, (1986).

The total nitrogen and phosphorus were determined according to the standard methods as mentioned by Rowell (1996). The protein content of wheat seeds was calculated according to the equation mentioned by Darwesh (2007) as follow: Protein% = nitrogen % * 5.70.

Infection percentage:

In present study the method of Phillips and Hayman (1970) were applied to clearing and staining of roots colonized by (AMF). After removal of shoot, the root samples should be washed under running tap water. Washed roots were cut into 1cm pieces, 10 randomly chosen root segments were cleared with 10% KOH overnight, segments were placed in 10% HCl for 10 minutes for removing excess KOH, then washed with distilled water, after that 0.05% Trypan blu in lactophenol was used to staining of it and microscopically examined for (AMF) colonization. The intensity of the infected stained roots with mycorrhiza (M %) were determined according to Troyvelote et al., (1986). The percentage of fungus colonization was calculated as follow:

$$\text{Fungus colonization\%} = (\text{No. of root segments colonized} / \text{No. of total root segments examined}) \times 100.$$

3. RESULT AND DISCUSSION

Table (2) and figures (1-6) explain the infection percentage of wheat roots cultivated after some vegetable's crops such as tomato, cucumber, eggplant, pepper, broccoli, in additional to cultivation of wheat after wheat itself. Its appeared that the infection percent with mycorrhiza was ranged between (30 – 90) %. The lowest infection value was recorded form cultivation of wheat after wheat, while the infection was increased from cultivation of wheat after some vegetative plants from 30% to (70, 70, 80, 85, and 90 %) for cultivation of wheat after tomato, cucumber, eggplant, pepper, and broccoli respectively, similar results was obtained by Bakhshandeh et al.,(2017). It means that the crop rotation plays an important role in increasing mycorrhizal root infection.

Table (2) Mycorrhizal infection percentage of wheat sowing after some crops

Treatments or Sowing wheat after	Infection %	Yield Mg ha ⁻¹ Or (Tons ha ⁻¹)	P %	Protein %
Tomato	70	3.91	0.23	12.90
Cucumber	70	3.50	0.26	13.00
Eggplant	80	3.30	0.27	14.10
Pepper	85	4.60	0.30	13.80
Broccoli	90	4.86	0.33	16.50
Wheat	30	2.50	0.20	12.20

Effect of root infection with mycorrhizae on wheat yield and quality:

As shown in table (2) the wheat yield increased from (2.50 Mg ha⁻¹ in case of cultivation wheat after wheat to (3.91, 3.50, 3.30, 4.60, and 4.86) Mg ha⁻¹ in case of crop rotation or cultivation of wheat after tomato, cucumber, eggplant, pepper, and broccoli respectively.

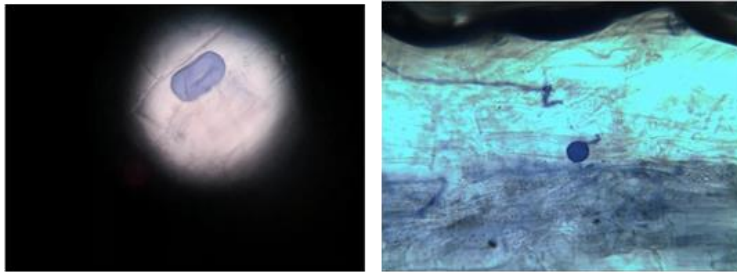


Figure 1: Long section for wheat roots infected with AMF shown fungus arbuscules and hyphae cultured after Tomato (Magnification = 400X)

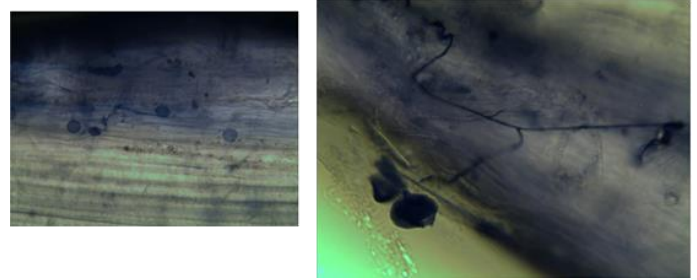


Figure 5 : Long section for wheat roots infected with AMF shown fungus arbuscules and hyphae cultured after broccoli (Magnification = 400X).

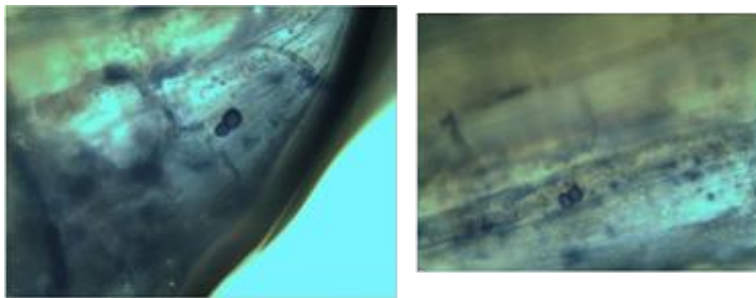


Figure 2: Long section for wheat roots infected with AMF shown fungus arbuscules and hyphae in cultured after Cucumber (Magnification = 400X).

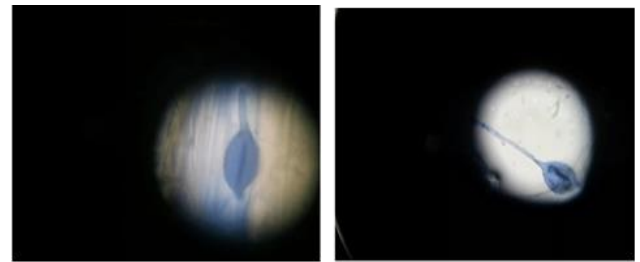


Figure 6 : Long section for wheat roots infected with AMF shown fungus arbuscules and hyphae cultured by Wheat (Magnification = 400X).

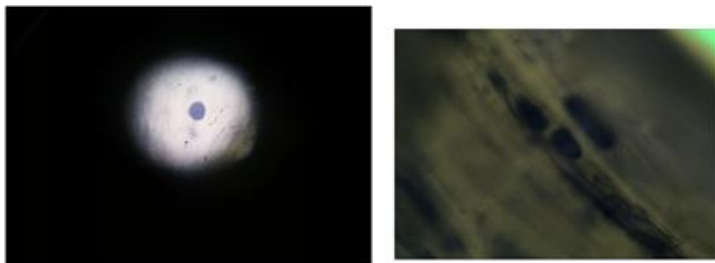


Figure 3: Long section for wheat roots infected with AMF shown fungus arbuscules and hyphae cultured by Eggplant (Magnification = 400X).

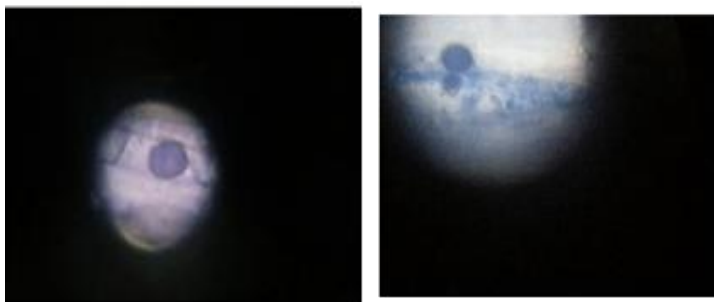


Figure 4: Long section for wheat roots infected with AMF shown fungus arbuscules and hyphae cultured after Pepper (Magnification = 400X).

These explain the role of crop rotation in increasing mycorrhizal colonization which caused increase in nutrient uptake in a balance form (Bakhshandeh et al.; 2017).

On the other hand, figure (7) indicated to significant correlation coefficient between wheat yield and infection percentage of root `wheat with the correlation coefficient value of ($r = 0.89^{**}$) this explains the role of mycorrhizal infection in increasing wheat yield.

It means wheat roots mycorrhizal infection caused increase in yield by (1.32 to 1.94) times, or caused (32 to 94 %) increase in wheat yield.

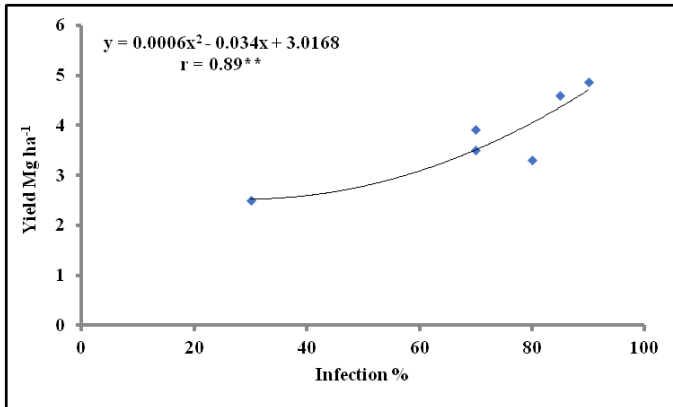


Figure 7: correlation between percentage of infection and yield

This increase in yield related to more uptake of phosphorus and availability which plays an important role in seed formation figure (8) support this result which indicated to significant correlation coefficient ($r = 0.87^{**}$) between wheat yield and phosphorus content of wheat.

Infection with mycorrhiza caused increase in available phosphorus and its concentration in plant as shown from figure (9), the significant correlation coefficient between phosphorus concentration in plant and mycorrhizal infection of wheat roots with the correlation coefficient value of ($r = 0.96^{**}$) support the above results.

Effect of mycorrhizal infection on wheat protein content

In current study table (2) and figure (10) showed that the mycorrhizal infection of wheat root with caused increase in protein content which was varied or depended on the type of plants used in crop rotation.

The protein content increased from 12.20% to (12.90, 13.00, 14.10, and 16.60) % for wheat cultivated after wheat, tomato, cucumber, eggplant, pepper, and broccoli respectively. The results of correlation coefficient explain the above results, since the significant correlation coefficient was recorded between wheat protein content and mycorrhizal infection percentage of wheat roots with the correlation coefficient value of ($r = 0.95^{**}$) as shown from figure (10). Similar results were obtained by (Abdulkarim and Esmail, 2013).

Moreover, figure (11) indicated to significant effect of phosphorus concentration on protein

content of wheat seeds this may due to the role of phosphorus in increase in root growth and absorption of nitrogen then increase in protein content as mentioned by (Esmail and Sharef, 2015).

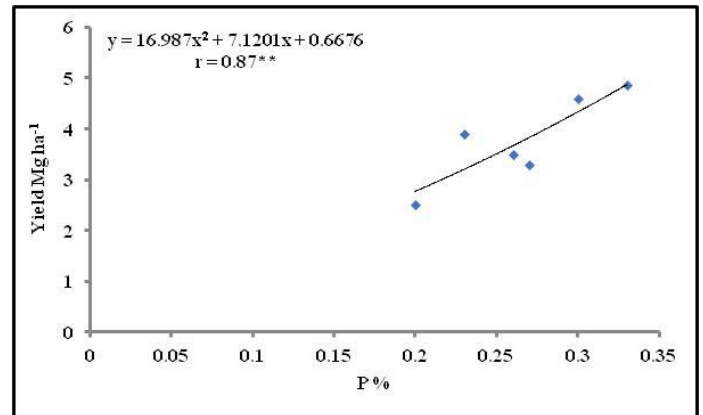


Figure 8: correlation between percentage of phosphorus and yield.

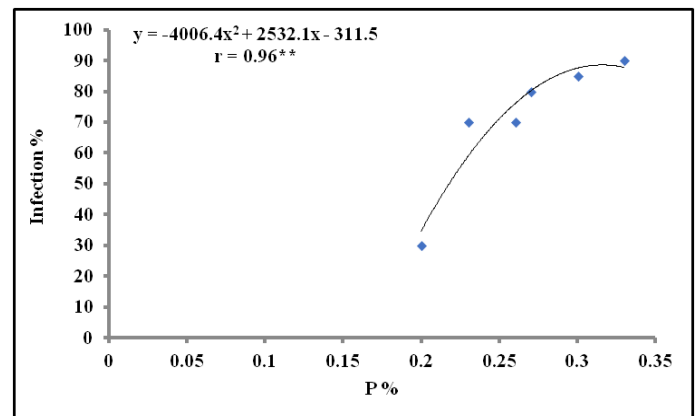


Figure 9: correlation between percentage of phosphorus and infection

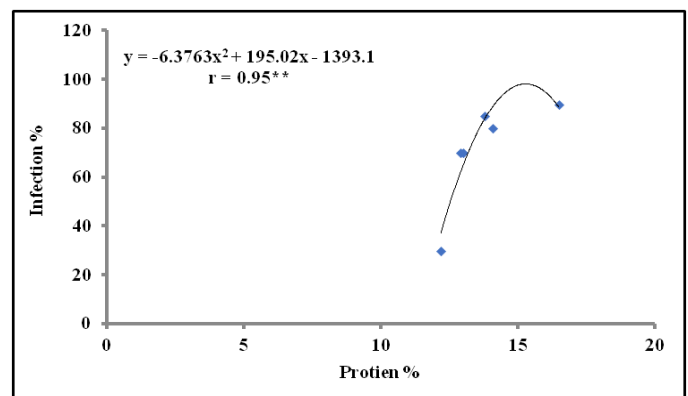


Figure 10: correlation between percentage of protein and infection

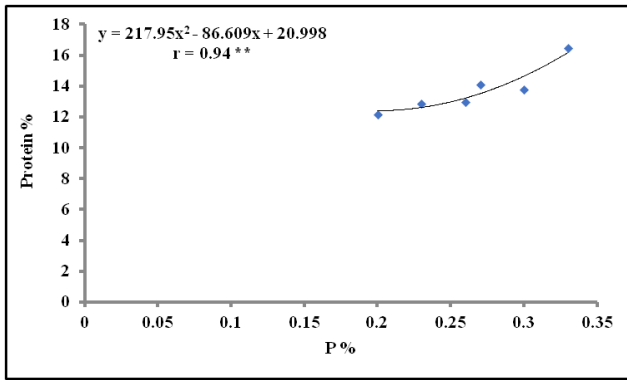


Figure 11: correlation between percentage of phosphorus and protein

The significant correlation coefficient between wheat protein content and concentration of phosphorus in wheat with the correlation coefficient value of ($r = 0.94^{**}$) supported the above explanation.

4. CONCLUSION:

The interesting findings in this research points to the importance of selecting or choosing the type of vegetative crops in a rotation system, which have positive effect on wheat root infection with mycorrhizal colonies then increase in yield and quality of wheat.

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