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EFFECT OF MAIZE RESIDUES ALONE OR IN A COMBINATION WITH ARBUSCULAR MYCORRHIZA (*GLOMUS MOSSEAE*) ON GROWTH AND YIELD OF PEA (*PISIUM SATIVUM* L.)

Arwa A. Tawfiq[1*] and Sraa N. Muslim[2]

[1*]Department of Biology, College of Science for Women, University of Baghdad, Baghdad, Iraq.
[2]Department of Biology, College of Science, AL-Karkh University for Science, Baghdad, Iraq.

Abstract

Plant residues and soil microorganisms, have a role in improving physical, chemical and biological properties of soil and plant growth. A field experiment was conducted during the growing season 2018 to evaluate the response of pea plants growth to soil amended with maize residues (5 t/ha) alone or in combination with Arbuscular Mycorrhiza (AM) fungi. Plots without maize residues and AM were used as a control. Results revealed application of residues and mycorrhiza separately, significantly improved growth and yield of pea plants with the superiority of mycorrhiza compared to maize residues. However, maximum growth and yield was recorded in plots treated with mycorrhiza and amended with maize residues.

Key words: crop residues, biofertilization, mycorrhiza, pea plant, growth and yield.

Introduction

The increase in world population has resulted in a growing need for food production. This can be achieved either through natural or synthetic ways. One natural way is to use plant residues instead of chemical fertilizers and herbicides or reducing their input into agroecosystems (Tawfiq and Alsaadawi, 2015).

Plant residues are left-over materials that remain in the field after harvesting. It biodegrades gradually and benefit plants for a long periods. There are many advantages to plant residues, it is a good source of nutrients for plants, provides carbon source and energy to soil microorganisms, leading to more soil enzyme activity and more nutrients availability to plants (Medina and Azcón, 2010). In addition to improving physical, chemical and biological properties of the soil.

Crop residues can be used as a mulch (Alsaadawi *et al*., 2017, Qin *et al*., 2015), or incorporation with soil (Kumar and Goh, 1999, Ranaivoson *et al*., 2017), with promising results in enhancing yield and minimizing weed growth and herbicide applications (Tawfiq and Alsaadawi, 2015). Utilization of some soil microorganisms like bacteria and fungi may have benefits to agriculture. There are many types of fungi that form symbiotic association with plants, however, the most important one in agriculture is Arbuscular Mycorrhiza (AM). It can associate with more than 85% of all plants species (Campbell *et al*., 2015). Many advantages to plants and soil when adding mycorrhizal fungi, it improves water uptake and nutrients especially phosphate, nitrogen and micronutrients. It also protects the plants from biotic and a biotic stresses (Panneerselvam *et al*., 2017). Mycorrhiza help plants to obtain P because this element has low solubility (Schachtman *et al.*, 1998) and it has been noticed that most of P taken by plants comes from their fungal participant (Smith and Smith, 2012).

The abundance of mycorrhiza and microorganisms could be increased by cover crop residues in soil, especially in low P system (Hallama *et al*., 2019). Many studies implement better growth for plants when using mycorrhiza, especially when it combined with organic matter (Al-Eqaili, 2014, Borie *et al.*, 2002, Tu *et al*., 2006, Wong, 2014). However, mycorrhiza can affect the growth of some plant species especially none hosting ones like weed, it can be used to control weeds especially with cultivated crops (Cameron, 2010, Rinaudo *et al*., 2010).

Author for correspondence :

This phenomenon leads to lower plant-to-weed competition and better plant growth conditions.

The present work is an attempt to use AM with plant residues in a field experiment to evaluate their effects on pea plants growth and production comparing when they used alone and in combination. Knowledge of the interactions between plant residues and mycorrhizal fungi in the field will assist in discovering better strategies for plant production by reducing reliance on synthetic fertilizers and biocides.

Materials and Methods

Preparation of maize residues

The study was conducted at the growing seasons of 2018 at Research Department of Horticulture Office, Ministry of Agriculture in Baghdad. Grains of maize (*Zea mays* L.) were sown on 15 July 2018 in a clay loam soil in plots measured 2×2 m, with space 75cm between rows and 30cm between plants. Nitrogen fertilizers as urea (46% N) and triple super phosphate (46% P_2O_5) were applied to all plots as recommended for maize crop. At physiological maturity, the ears were removed and the plants were harvested and left to dry in their plots for several days under sunlight. These residues tilled twice with soil and left till the pea seeds sowing. The rate of remaining maize residues was 5 ton per hectare (t/ha).

Preparation of Mycorrhiza inoculums

The Arbuscular Mycorrhizal (AM) fungi used in this experiment were *Glomus mosseae*. Field soil was sterilized in an autoclave for 30 minutes period for two days and put in 1 kg capacity plastic pots. Spores of AM were extracted according to the method described by (Smith and Smith, 1997). This extract was mixed with the upper part of the pot soil. Then five seeds of millet were sown and irrigated with water as needed. After 3 months of planting, shoot parts were cut, then the soil with roots was mixed well and used as inoculation (Matloob, 2012).

Effects of maize residues and AM on pea plants

Field plots containing maize residues from the previous trial were used for the planting of pea plants in mid-October 2018. Seeds of pea were manually sown in rows with a distance of 75cm between rows and 25cm between seeds. Fertilizers were applied as recommended and irrigation as needed. All plots received equal irrigated water during the growing season.

Treatments included AM alone, maize residues alone and with AM and control treatment free from maize residues and AM. Each field plot with AM was treated on lines with 250g of mycorrhizal inoculums (spores, hyphae and roots of the host) before sowing pea seeds.

At physiological maturity, five plants were randomly selected from the plots as data source for pea growth parameters. The traits measured were plant height (cm), number of shoots per plant, shoot dry weight, seed per pod, pod per plant, green pod yield and yield per hectare.

Both field experiments were conducted in randomized complete block design with 3 replicates. Data were statistically analyzed using analysis of variance (ANOVA) with the aid of GENSTAT computer software package. Differences among treatment means were compared using LSD at 0.05 probability level.

Results

Effects of maize residues and AM on some growth parameters

Results showed the ability of both residues and AM to increase plant height, number of shoots and shoot dry weight with the superiority of AM compared to maize residues. However, when maize residues and AM were used together, these parameters were additionally enhanced (Table 1).

There is no significant difference in plant height between treatments with maize residues or AM, but there is significant increase from control with all treatments.

Growth of plants was also affected by the treatment with maize residues and AM. They exhibited significant effects on number of shoots and shoot dry weight, while their mixed incorporation with soil increased significantly these parameters over control and individual treatments as shown in table 1.

Effects of maize residues and AM on yield components

All treatments significantly increased seed, pods and green pod yield of pea plants over control (Table 2). Both sole incorporation of maize residues at rates of 5 t/ha and AM with soil increased seed per pod by 70 and 91% and pods by 91 and 149% over control, respectively. The increase in seed and pods was further improved when

Table 1: Effect of maize residues and Arbuscular Mycorrhizal fungi (*Glomus mosseae*) alone and in combination on some pea growth parameters.

Treatments	Plant height (cm)	No. of shoots / plant	Shoot dry weight (g)
Control plants	32.6	1.3	5.3
Maize residues (5 t/ha)	37	2.3	9.3
Arbuscular Mycorrhiza	38.8	4.0	17.6
Maize residues + Arbuscular Mycorrhiza	45.6	6.0	21.6
LSD ≤ 0.05	3.8	1.2	1.4

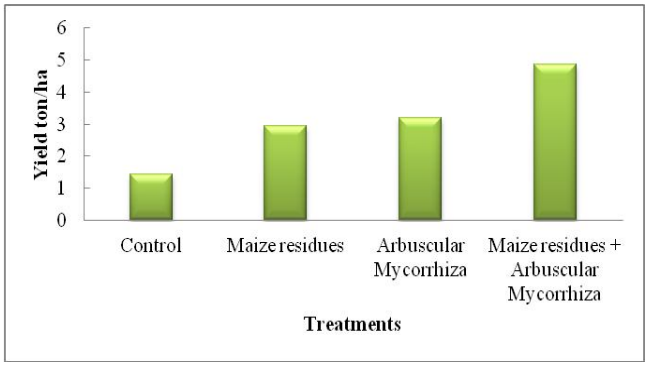

Fig. 1: Effect of maize residues and Arbuscular Mycorrhizal fungi (*Glomus mosseae*) alone and in combination on seed yield t/ha of pea plants. LSD $\leq$ 0.05 = 0.39.

maize residues were combined with AM. Their combination increased seed and pods by 161 and 219% over control, respectively.

The same observation was found in green pod yield per plant, which showed a considerable increase in all treatments over control. No significant differences were recorded between the application of maize residues or AM on the number of seed per pod and green pod yield per plant.

Effects of maize residues and AM on seed yield

Seed yield was enhanced by the applications of maize residues and AM. It rose from 1.43 t/ha in control to 2.93 and 3.20 t/ha in sole application of maize residues and AM respectively. Maximum seed yield was gained in the combination of maize residues and AM which reached 4.86 t/ha (Fig. 1). The increase in plant yield was attributed to the increase in the number of seed and pods per plant, which was reflected positively on the final seed yield of the crop.

Discussion

Safe agriculture requires safe amendments to the soil and plants. Plant residues and Arbuscular mycorrhiza are among these amendments. Plant residues as organic material when incorporated with soil, provide minerals to plants through their gradual decay, while mycorrhizal fungi facilitate minerals acquisition by plants. This reflects by better plant growth and yield.

Results of present study approved that. All studied parameters increased when using maize residues and AM in the field soil either separately or in combination. There are significant increases between all the treatments and control with the superiority of AM on maize residues and combined application on sole application.

The stimulation effects suggested that the residues could provide the plants with macro and micro elements needed for plant growth through their gradual biodegradation by soil microorganisms (Abiven *et al*., 2009, Carter, 2001, Panneerselvam *et al*., 2017, Torma *et al*., 2018). Plant residues are the main source of soil organic matter and their biodegradation is critical to the productivity of the ecosystem (Kögel-Knabner, 2002).

Furthermore, humus content in soil increases their water holding capacity and microbial activities (Caravaca *et al*., 2002). Plant residues also have a role in increasing soil pH which leads to enhance mineral availability in soil and mineral acquisition by plants, increasing soil pH positively correlated with more cation concentration in plants material (Borie *et al*., 2002, Tang and Yu, 1999).

Other effects of increasing minerals in plants is attributed to the mycorrhiza, it seems that more minerals available leads to more AM development and activity. Plant residues after their decay could increase mycorrhizal activity, which was crop dependent (Al-Eqaili, 2014, Borie *et al*., 2002). There are many evidences that mycorrhizal growth increased in the presence of organic matter added to the soil (Gryndler *et al*., 2009, Hodge *et al*., 2001, Joner and Jakobsen, 1995). In spite of their role in mineral acquisition, mycorrhizal fungi could contribute in residues decomposition through its growth activity (Hodge, 2014, Wong, 2014).

Pea plants have a good response to the use of maize residues as organic matter and mycorrhizal fungi, which is manifested in plant growth and yield. Pea plants are legumes, thus mycorrhiza work on such host plants need phosphorus for nodule formation and nitrogen fixation (Hayman, 1986). Many legumes have rough, thick roots with short branches and benefit from mycorrhizal partnership to increase their absorbing surface (Harinikumar and Bagyaraj, 1989).

Table 2: Effects of maize residues and Arbuscular Mycorrhizal fungi (*Glomus mosseae*) alone and in combination on yield components of pea plants.

Treatments	Seed /pod	% of control	Pod/ plant	% of control	Green pod yield/plant (g)	% of control
Control	3.3	-	4.7	-	33.6	-
Maize residues (5 t/ha)	5.6	70	9.0	91	39.3	17
Arbuscular Mycorrhiza	6.3	91	11.7	149	40.6	21
Maize residues + Arbuscular Mycorrhiza	8.6	161	15.0	219	45.3	35
LSD $\leq$ 0.05	1.2	-	2	-	3.9	-

Conclusion

The use of organic compounds such as plants residues and certain types of soil microorganisms like mycorrhizal

fungi are an effective way to improve plant growth. The combination of organic residues with AM has better effects, it provides appropriate growth medium for growth of pea plants so that significant yield improvement over control was noticed. This cost-effective procedure can be used in agricultural systems to decrease the reliance on mineral fertilizers and improve crops productivity.

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