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Effect of vermicompost and biofertilizers on yield and yield components of common millet (*Panicum miliaceum*)

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ABSTRACT

In order to investigate the effect of vermicompost and biofertilizers on yield and yield components of common millet, an experiment was carried out in split-factorial in randomized complete block design with four replications. The main plots were two levels of vermicompost, and sub plots were a factorial combination of incubation with mycorrhiza and Azotobacter. The results showed that incubation of G. intraradices significantly increased the 100-grains weight and biological yield, while incubation of G. mosseae not increased these yield components in comparison with control. 100-grains weight of plants that incubated with A. chroococcum significantly higher than those not incubated with A. chroococcum. In addition, effect of mycorrhiza and Azotobacter in presence of vermicompost was greater. In addition, biological yield was higher when mycorrhiza applied along with Azotobacter and vermicompost. Grain yield of plants that incubated with A. chroococcum significantly higher than those not incubated with A. chroococcum. Also, effect of Azotobacter in presence of vermicompost was greater. The highest and the lowest harvest index were observed in control and vermicompost + Azotobacter treatments, respectively. Colonization of G. intraradices and G. mosseae showed different response to presence of vermicompost. G. intraradices showed higher colonization when applied along with vermicompost, while G. mosseae was not influenced by vermicompost levels. Colonization of G. intraradices and G. mosseae were higher in presence of Azotobacter.

Keywords: common millet, vermicompost, Azotobacter, mycorrhiza.

INTRODUCTION

Common millet (*Panicum miliaceum*) was among the world's most important and ancient domesticated crops. They were staple foods in the semiarid regions of East Asia and even in the entire Eurasian continent before the popularity of rice and wheat [16]. The millets are grown mainly for feed grain in the western hemisphere but these crops play an important role in the economy of many developing countries as they can be used for food, fodder, feed, brewing and for cottage [15]. Common millet has the lowest water requirement among all grain crops; it is also a relatively short-season crop, and could grow well in poor soils [21]. Recently, common millet is frequently cultivated in warm temperate and sub-tropical zones as a late-seeded, short-season summer catch crop with several cultivars [18].

Fertilization, particularly nitrogen fertilizers, is considered as one of the main sources of pollution caused by agriculture. Nitrogen fertilizers cause nitrate pollution of surface and groundwater water and ultimately caused the poisoning of humans, livestock and aquatic animals. Also, increased the denitrification and led to further increase in toxic gases (nitrogen oxides) synthesis and the destruction of the vital ozone layer. The emergence of such damaging effects and many other issues, emphasized the necessity for change the increasing production methods and the necessity to provide conditions for effective use of natural processes, such as biological nitrogen fixation [1].

With increased public awareness of certain adverse effects of fertilizers, pesticides and other routinely used agrochemicals on both animals (including man) and the environment, the deliberate application of beneficial microorganisms is becoming extremely attractive [3]. The chemical fertilization increases productivity, but the increasing cost of fertilizer, environmental hazards, health hazards and failure in sustaining yield have given the way for use of organic manures and biofertilizers instead of chemical fertilizers. Biofertilizers are products containing living cells of different types of microorganisms, which have an ability to convert nutritionally important elements from unavailable to available form through biological processes [6].

Mycorrhiza fungi which constitute a group of important soil micro-organisms are ubiquitous throughout the world are known to improve the plant growth through better uptake of nutrients. They also improve the activity of N fixing organisms in the root zone [4]. VAM Fungi can increase the drought resistance. Their extra-radical hyphae can influence rhizosphere architecture and improve host water dynamics [12]. The association between non-legumes and N2 fixing bacteria as shown by increased nitrogenase activity is now well established. Azotobacter and Azospirillum have been widely tested to increase yields of cereals [2]. Kapulnik et al. [22] reported an increase in root and shoot weight of Sorghum with Azospirillum treatment. Sarig and Kapulnik [19] reported that more dry matter was produced with Azospirillum inoculation as compared to control.

Vermicomposts are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, water-holding capacity [5]. They have greatly increased surface areas, providing more microsites for microbial decomposing organisms, and strong adsorption and retention of nutrients [23]. Albanell et al. [8] reported that vermicomposts tended to have pH values near neutrality which may be due to the production of CO_2 and organic acids produced during microbial metabolism.

The present experiment was conducted to assess the significance of Mycorrhiza, Azotobacter, vermicompost and the combination on the improvement of growth and yield of common millet.

MATERIALS AND METHODS

This experiment was performed in research field of Islamic Azad University, Arak branch (34º3´ N, 49º48´ E, 2192 m above sea level) in 2011. Monthly values of weather elements during the years 2011 are presented in Table 1. The results of soil analysis are presented in Table 2. The results of vermicompost analysis for samples used in this study are listed in Table 3.

Table 1. Climatic characteristics of the region of experimental site during growing season.

Month	Average maximum humidity (%)	Average minimum humidity (%)	average annual precipitation (mm)	average maximum temperature (°C)	average minimum temperature (°C)	GDD
June	37.43	10.25	0	33.56	16.25	14.90
July	29.19	10.41	0.03	36.22	19.64	17.93
August	32.48	10.25	0	36	19.83	17.91
September	44.96	16.80	0	31.09	14.93	13.01
October	42.50	11	0	30	12.25	11.12

Table 2. Some of chemical and physical properties of experimental field soil.

S	Si	C	Texture	P_{ava} (mg/kg)	K_{ava} (mg/kg)	N (%)	OC (%)	pH	EC (dS/m)	Soil Depth
48	26	26	SL	5.1	169	0.15	1.4	7.7	4.6	0-30

Table 3. Important characteristics of vermicompost used in the experiment.

P (%)	K (%)	Total N (%)	Fe (Mg/kg)	Cu (meq/lit)	Zn (Mg/kg)	Mn (ppm)
0.16	3.19	4.92	36-50	15.5	27-40	15-25

Experiment was split-factorial in randomized complete block design with four replications. The main plots were two levels of vermicompost (no vermicompost and vermicompost; 5 t/ha), and sub plots were a factorial combination of incubation with mycorrhiza (inoculation and non-inoculation of *Glomus intraradices* and *G. mosseae*) and Azotobacter (inoculation and non-inoculation of *A. chroococcum*). Seeds of common millet (Bastan cultivar) were sown in four rows of 4.5 m length, among which plants were grown 60 cm apart.

In order to eliminate the marginal effect, one crop row was left out from each side of the experimental plots, and five randomly plants were harvested from each plot. Grain yield, 100-grains weight, harvest index and biological yield were measured for each treatment.

Root colonization measurements. To visualize the AMF colonization, fresh roots were cleared by boiling 4 min in 10% KOH, rinsed three times with tap water and stained by boiling for 4 min in a 5% ink (Shaeffer; jet-black)/household vinegar (=5% acetic acid) solution [11]. After staining, the percentage of root colonization was determined according to the method of Newman [9].

RESULTS AND DISCUSSION

100-grains weight. 100-grains weight was significantly affected by mycorrhiza and Azotobacter, with a significant interaction between mycorrhiza and Azotobacter or vermicompost. Incubation of *G. intraradices* significantly increased the 100-grains weight, while incubation of *G. mosseae* did not increased the 100-grains weight in comparison with control (Fig 1). 100-grains weight of plants that incubated with *A. chroococcum* was significantly higher than those not incubated with *A. chroococcum*. In addition, effect of mycorrhiza and Azotobacter in presence of vermicompost was greater (Fig 2). Prajapati et al. [13] carried out an experiment to study the growth promotion of rice (*O. sativa*) due to dual inoculation of *Azotobacter chroococcum* and *Piriformospora indica* along with vermicompost. Dual inoculated plants in presence of vermicompost gave better positive effects on both 45th and 90th day, in comparison to single inoculation of *A. chroococcum*, *P. indica* and vermicompost.

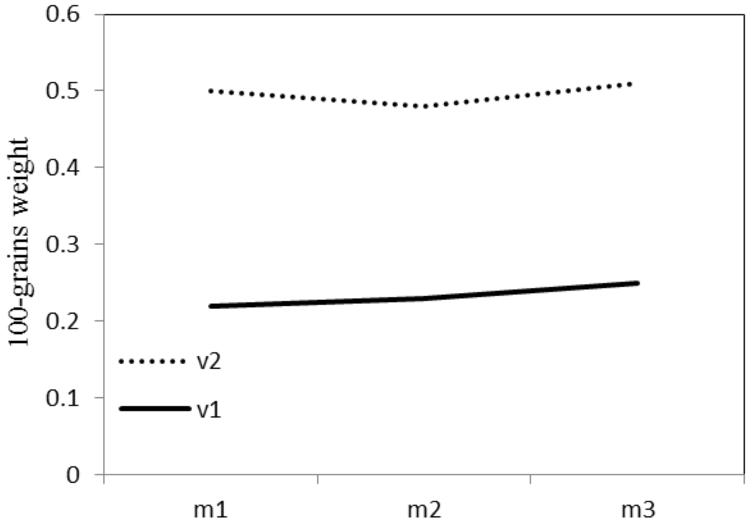

Figure 1. Effect of vermicompost (V1 and V2 are no vermicompost and vermicompost, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mosseae* and *Glomus intraradices*, respectively) levels on 100- grains weight.

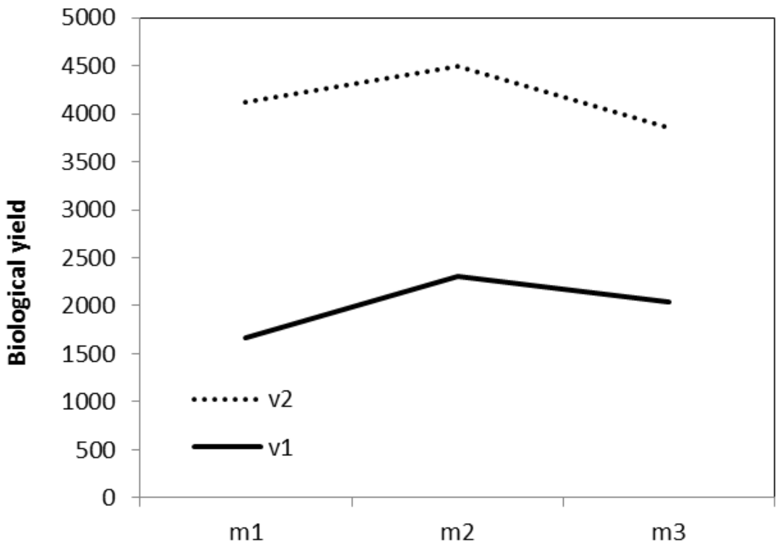

Figure 2. Effect of vermicompost (V1 and V2 are no vermicompost and vermicompost, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mosseae* and *Glomus intraradices*, respectively) levels on biological yield.

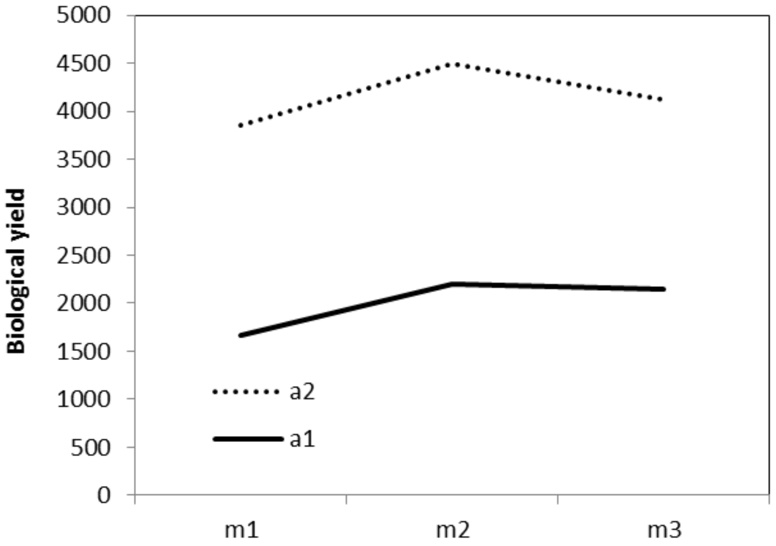

Figure 3. Effect of Azotobacter (A1 and A2 are inoculation and non-inoculation of *A. chroococcum*, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mosseae* and *Glomus intraradices*, respectively) levels on biological yield.

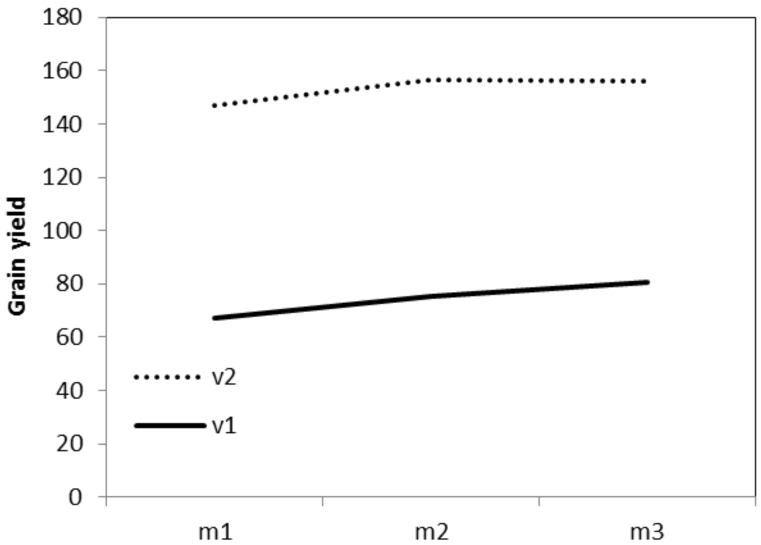

Figure 4. Effect of vermicompost (V1 and V2 are no vermicompost and vermicompost, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mossae* and *Glomus intraradices*, respectively) levels on grain yield.

Biological yield. Biological yield was significantly affected by mycorrhiza, with a significant interaction between mycorrhiza and Azotobacter or vermicompost. Incubation of *G. intraradices* significantly increased the biological yield, while incubation of *G. mosseae* not increased the biological yield in comparison with control (Fig 2). In addition, biological yield was higher when mycorrhiza applied along with Azotobacter and vermicompost (Fig 3). Uma Mahesweri et al. [20] reported that among the treatments tested, inoculation of Rhizobium and vesicular arbuscular mycorrhiza (VAM) along with vermicompost yielded better than uninoculated and controlled treatments.

Grain yield. Grain yield was significantly affected by Azotobacter, with a significant interaction between Azotobacter and vermicompost. Grain yield of plants that incubated with *A. chroococcum* was significantly higher than those not incubated with *A. chroococcum*. In addition, effect of Azotobacter in presence of vermicompost was greater (Fig4). Chatterjee et al. [17] found that inoculation with Azophos, a commercial biofertilizer preparation containing the Azotobacter and phosphate-solubilizing bacteria exerted more positive result over uninoculated treatments and benefits of biofertilizer application were more in presence of vermicompost as compared to farmyard manure. Chamle and Mogle [7] concluded that the application of bacterial inoculants along with vermicompost were more effective in increasing leaf area, total chlorophyll and yield of tomato.

Harvest index. Harvest index was significantly affected by Azotobacter and vermicompost interaction (Fig 5).

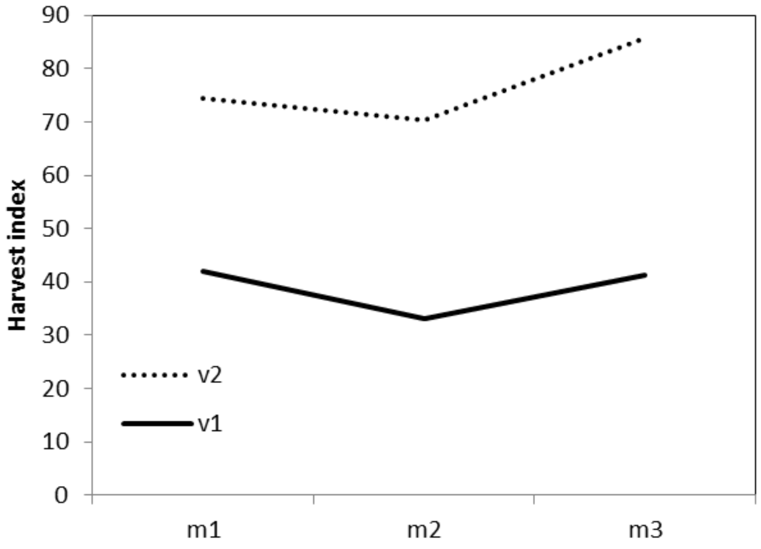

Figure 5. Effect of vermicompost (V1 and V2 are no vermicompost and vermicompost, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mosseae* and *Glomus intraradices*, respectively) levels on harvest index.

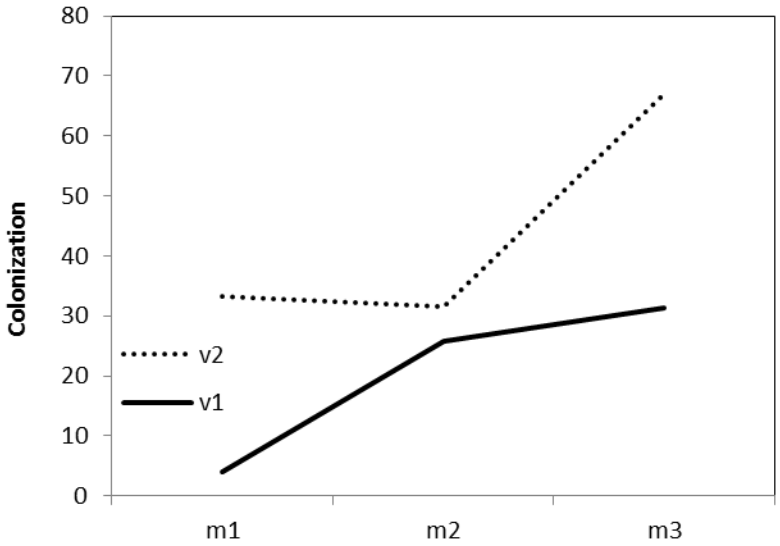

Figure 6. Effect of vermicompost (V1 and V2 are no vermicompost and vermicompost, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mosseae* and *Glomus intraradices*, respectively) levels on colonization.

Colonization. Colonization was significantly affected by mycorrhiza and vermicompost, with a significant interaction between mycorrhiza and vermicompost, between vermicompost and Azotobacter, and between mycorrhiza and Azotobacter. Colonization of *G. intraradices* and *G. mosseae* showed different response to presence of vermicompost (Fig 6). *G. intraradices showed* higher colonization when applied along with vermicompost, while *G. mosseae* was not influenced by vermicompost levels (Fig 7). Colonization of *G. intraradices* and *G. mosseae* were higher in presence of Azotobacter (Fig 8). One of the most important indicator of mycorrhiza activity is the level of roots colonization by these fungi, that affected by many factors, including physical and structural properties of the root system, the quantity and quality of root exudates, and the use of phosphate fertilizers and high concentrations of heavy metals [10, 14].

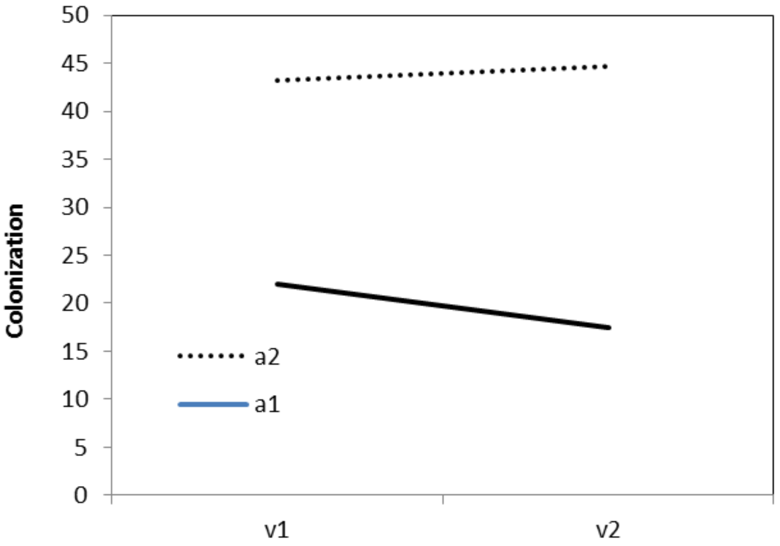

Figure 7. Effect of vermicompost (V1 and V2 are no vermicompost and vermicompost, respectively) and Azotobacter (A1 and A2 are inoculation and non-inoculation of *A. chroococcum*, respectively) levels on colonization.

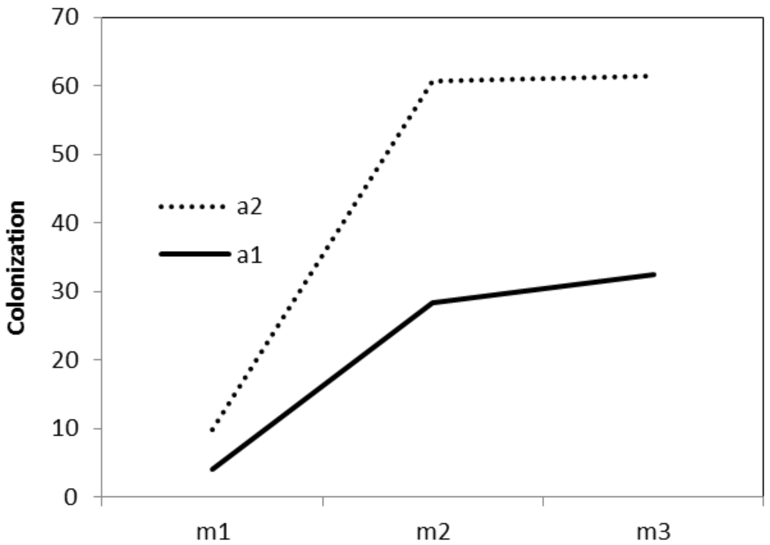

Figure 8. Effect of Azotobacter (A1 and A2 are inoculation and non-inoculation of *A. chroococcum*, respectively) and mycorrhiza (M1, M2 and M3 are inoculation and non-inoculation of *G. mosseae* and *Glomus intraradices*, respectively) levels on colonization.

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