Effect of compost and animal manure with phosphorus and zinc fertilizer on yield of seed potatoes

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Abstract

This study was carried out to investigate the effect of compost and manure with phosphorus and zinc on potato yield (*Solanum tuberosum* L.). The experiment was conducted in the Kerman agricultural and natural resources research centre (Iran) by using a factorial design in randomized complete block in two independent experiments with three replications. In the first experiments compost with phosphorus and zinc were used, and in second experiment animal manure with phosphorus and zinc were used. The three levels of compost (0, 10 and 20 ton ha^{-1}) and same level of animal manure were used as main. Four levels of phosphorus (0, 75, 150 and 225 kg ha^{-1}) and two levels of zinc (0 and 50 kg ha^{-1}) used as the sub factors. Results showed that the main factors of compost and animal manure application had no significant effect on any of the all evaluated traits in the experiments. Effect of zinc on number of small tubers was significant in the first experiment. The highest number of large tubers were found in 20 ton ha^{-1} compost + 225 kg ha^{-1} phosphorus + 50 kg ha^{-1} zinc in first experiment and 20 ton ha^{-1} animal manure + 75 kg ha^{-1} phosphorus + no zinc in second experiment. Tubers dry matter was significantly affected by the interaction effect of zinc and phosphorus, the maximum dry matter being obtained with the application of 225 kg ha^{-1} phosphorus +50 kg ha^{-1} zinc.

Keywords: Organic manure, compost, dry matter, potato, tuber.

1. Introduction

Environmental problems caused by irregular application of chemical fertilizers, inappropriate energy production methods and excessive consumption costs have all had harmful effects on biological cycles and destroyed farming stability systems; these factors altogether encourage the application of bio fertilizers (Kannayan, 2002). Sustainability and safety of food production associated with environmental protection and fair socio-economic interactions in the societies involved are the most important debates in many multidisciplinary issues of agriculture, ecology and environmental sciences. These topics have attracted attention of researchers, farmers, policymakers and other stakeholders worldwide. Since soil as a living entity is the basis of management in sustainable food production, enhancing soil productivity through utilization of organic fertilizers has been gaining significant importance in organic food production (Neeson, 2004). These organic sources have a profound effect on crop yield and quality (Toor *et al*., 2006). In organic farming composts, organic manures and their extracts are used for improving soil fertility and in combating pests and diseases (Khadem, *et al*., 2010; Barker and Bryson, 2006; Montemurro *et al*., 2005; Litterick *et al*., 2004; Abbasi *et al*., 2002). Organic manures and composts have been found to have a direct anti disease effect by stimulating competing micro organisms and also by inducing resistance to plant diseases (Brinton *et al*., 1996; Ghorbani *et al*., 2006). However, there are other contradicting evidences indicating the reverse impact of using these sources (Chauhan *et al*., 2000). The use of fertilizers and manure to enhance soil fertility and hence crop yield improvement is a traditional method being used quite long a go by farmers (Sandeen *et al*., 2003). On the other hand the use of compost on agricultural land can be important in products based on the principles of sustainable agriculture (Perez *et al*., 2007). Use of municipal compost affect on the economic and environmental factors, such as reducing transport costs and bury it, to support environmental laws, reduce the use of inorganic fertilizers and improved soils crop characteristics (Hargreaves *et al*., 2008). The compost enriched with chemical fertilizers in the field the ability to access the elements of high consumption caused by the products and can be increased ability to production and soil fertility (Ramadass *et al*., 2007). Positive role of compost application has been reported in many crops, garden and pasture (Marcote *et al*., 2001). The application of compost increased microbial activity, nitrogen concentration and grain yield (Tejada *et al*., 2003). Use of compost in the Mediterranean semi-arid lands increased nitrogen, phosphorus, potassium and organic carbon content in the rhizosphere (Caravaca *et al*., 2003). Application of manure in the soil causes soil hollow, increased water holding capacity in soil and improved it physical properties, besides increasing soil fertility, crop growth and thus the water use efficiency (Karlen and Camp, 1985). The application of compost improved seed germination and yield dry matter as compared to compost-free treatments (McCallum *et al*., 1998). Phosphorus is the second most important macro nutrient after nitrogen that plays significant role in physiological and biochemical reactions such as photosynthesis and transfer characteristics (Mehrvarz *et al*., 2008). Phosphorus fertilizers and manure in the soil increased phosphorus uptake by plants, through favoring production of carbonic acid, the acid that increases solubility of phosphate compounds in calcareous soils (Yosefi *et al*., 2011; Chien, 2003). Zinc is also one of the essential micronutrients required for crop growth since it is an important component carbonic anhydrase enzyme which is present in all photosynthetic tissues, and is also required for chlorophyll biosynthesis (Mousavi, 2011; Mousavi *et al*., 2007; Graham *et al*., 2001). The purpose of the present study was to determine the effects of compost, animal manure, phosphorus and Zinc fertilizer on seed potatoes production.

2. Materials and Methods

2.1 Description of the project site

This experiment was carried out in 2009 at the Kerman Natural Resources and Agriculture Research Center, Iran, located in 56º34´ longitude and 29º55´ latitude and, 2044 m altitude from sea level with an arid and semi-arid climate. The pH of soil was 7.15 with sandy-loamy texture, (physical and chemical properties of soil in experimental field were presented in Table 1). Experiment was conducted in factorial randomized complete block design in two independent experiments with three replications. In the first experiment compost, phosphorus and zinc fertilizer and in the second experiment, animal manure, phosphorus and zinc fertilizer was utilized. The treatments consisted of three levels of compost (0, 10 and 20 ton ha^{-1}), three levels of animal manure (0, 10 and 20 ton ha^{-1}) as the main factors, four levels of phosphorus fertilizer (0, 75, 150 and 225 kg ha^{-1}) and two levels of zinc fertilizer (0 and 50 kg ha^{-1}) as the sub factors. Planting was done as rows in 75cm wide rows with 25cm spacing within-rows in February 2010. All operations such as irrigation, weed control and earthing up were done regularly during the growing season.

Table 1. Soil analysis result for physical and chemical characteristics

Characteristic	Soil depth (cm)	Soil texture	OC (%)	EC (dS m^{-1})	pH	P	K	Zn	Fe	Mn	Cu
						(mg kg^{-1})					
Value	0-30	sandy-loamy	0.15	1.88	7.15	10.06	174.2	0.74	5.06	1.40	1.18

2.2 Crop sampling and calculation

At the mid of July 2010 by harvesting 2.5 m^2 from each plot plant dry matter, tuber weight, number of tubers per plant and tuber size were determined. Tubers of each plot were graded into three size categories (small tuber (< 30 mm), medium tuber (30–60mm) and large tuber (> 60mm)).

2.3 Statistical analysis

Data analysis was done by using SAS and MSTATC software. The ANOVA test was used to determine significant ($p \leq 0.05$) treatment effect and Duncan Multiple Range Test to determine significant difference between individual means.

3. Results and discussion

3.1 First Experiment (effect of compost, phosphorus and zinc fertilizer on potato yield)

Results showed that compost and phosphorus fertilizer application had no significant effect on traits (Table 2), also application of zinc fertilizer had no significant effects on traits except number of small tubers. Mean comparison showed that number of small tubers increased by application of zinc fertilizer compared with no zinc fertilizer (Figure 1). The most number of small tubers were obtained by use of 50 kg ha^{-1} zinc. It seems that tuber buds increased by use of zinc fertilizer. The small tubers of potato do not have a good quality, so high application of zinc fertilizer was not useful for potatoes. Shoot dry matter significantly affected by compost, zinc and phosphate fertilizer interactions. Maximum shoot dry matter (52.7 g) was obtained by use of compost (10 ton ha^{-1}), phosphorus (150 kg ha^{-1}) and no zinc fertilizer; also minimum shoot dry matter (17 g) was obtained by control treatment and application of compost (10 ton ha^{-1}) and no phosphorus and zinc fertilizer (Figure 2). Main effect of compost, phosphorus and zinc fertilizer were not significant on shoot dry matter (Table 2). Potato shoot dry matter increased by compost application, due to improved soil structure and ventilation, and thereby tubers development increased in the better soil bed. Soil resistance against to tubers growth was reduced by compost application (Tu *et al*., 2006; Arancon *et al*., 2003).

Table 2. ANOVA of the effects of compost with phosphorus and zinc fertilizer on potato yield.

SOV	df	Shoot dry matter (g)	Tuber weight (kg m^{-2})	Tuber number/ Tuber total number (%)			Number of tuber per plant
				Large tuber	Medium tuber	Small tuber	
Compost (A)	2	1036.00ns1	0.141ns	30.10ns	100.5ns	53.40ns	6.68ns
Error 1	4	428.10	1.743	366.20	554.4	52.90	4.58
P (B)	3	199.50ns	0.743ns	86.90ns	133.3ns	47.70ns	3.50ns
A×B	6	53.57ns	0.764ns	35.00ns	82.2ns	35.50ns	4.11ns
Zn (C)	1	4.50ns	0.175ns	2.47ns	172.7ns	133.90*	1.68ns
A×C	2	42.79ns	0.094ns	30.80ns	23.8ns	39.70ns	5.26ns
B×C	3	257.50ns	0.180ns	1.86ns	58.5ns	58.00ns	1.98ns
A×B×C	6	341.20*	0.421ns	31.30ns	47.4ns	38.50ns	6.62ns
Error 2	42	142.90	0.423	42.50	88.9	44.2	5.28

1- ns= Non significant and * = $p<0.05$

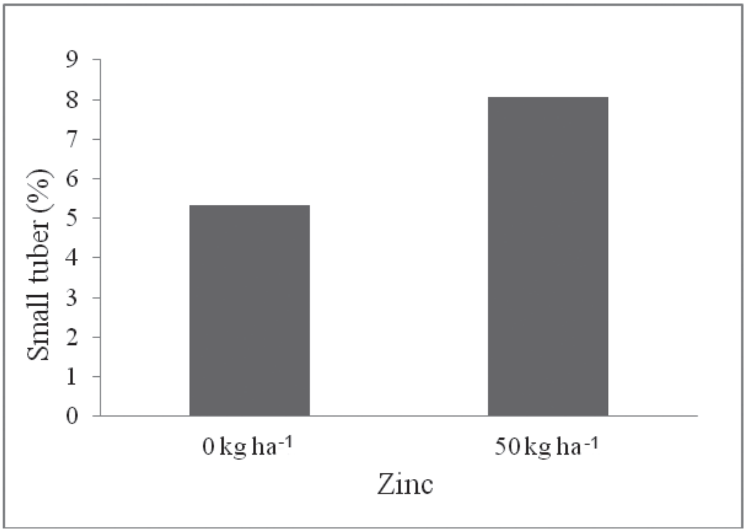

Figure 1. Effect of zinc fertilizer on number of small tuber.

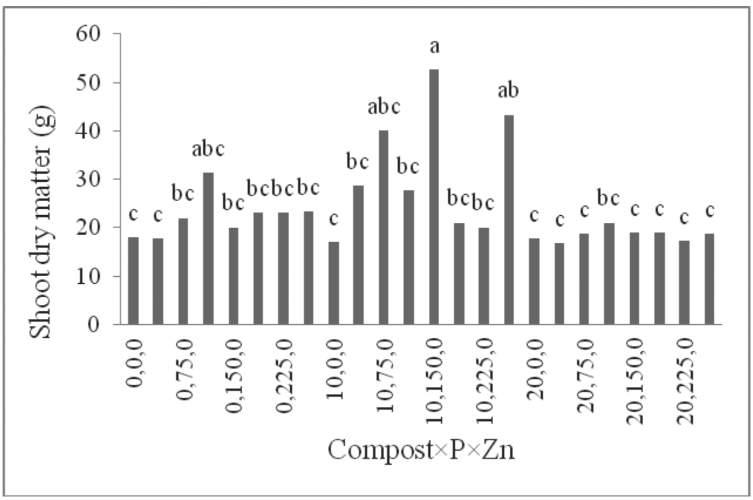

Figure 2. Effects of compost, phosphorus and zinc fertilizer interaction on shoot dry matter (same letter are not significantly different at 0.05 probability level).

3.2 Second Experiment (effect of manure, phosphorus and zinc fertilizer on potato yield)

Results showed that manure application had on significant effect on traits (Table 3). It seems that manure application was not enough to have a significant effect on the traits; also main effect of phosphorus fertilizer wasn't significant on potato yield. Zinc fertilizer except on the number of tubers per plant had no significant effect on the other traits (Table 3). Zinc fertilizer decreased number of tubers per plant significantly ($p<0.05$) (Table 4). Most tuber weight was 1.85 kg m^2 that obtained by use of 150 kg ha^{-1} phosphorus fertilizer without manure (Figure 3). Most number of small tubers (6.15%) was obtained by use of 10 ton ha^{-1} manure treatments without zinc fertilizer and least number of small tubers (1.32%) was obtained by no fertilizer and manure treatment (Figure 4); there were no significantly different between other treatments. Most number of tubers per plant (7.74) was obtained by application of 10 ton ha^{-1} manure without zinc fertilizer; also lowest number of tubers per plant was obtained by other treatments, without significant differences (Figure 5). Shoot dry matter, tuber weight and ratio of large and medium tuber to total number significantly affected by zinc and phosphorus interaction (Table 3). Maximum shoot dry matter per plant (28.7 g) was obtained by use of 225 kg ha^{-1} phosphorus and 50 kg ha^{-1} zinc; also minimum shoot dry matter per plant (20 g) was obtained by use of 225 kg ha^{-1} phosphorus and no zinc fertilizer. Maximum and minimum ratio of large tuber was obtained by use of 75 kg ha^{-1} phosphorus without zinc and 225 kg ha^{-1} phosphorus without zinc respectively (Table 4). Maximum ratio of medium tuber was obtained by use of kg ha^{-1} phosphorus without zinc fertilizer (Table 4). Microorganism's activity is low in poor soils of organic matter; thereupon speed of organic material decomposition decreased by decreasing the populations of microorganisms. Compost and manure had no significant influence on potato yield because population of microorganisms was low in the field experimental

Table 3. ANOVA of the effects of manure with phosphorus and zinc fertilizer on potato yield.

SOV	df	Shoot dry matter (g)	Tuber Weight (kg m^{-2})	Tuber number/ Tuber total number (%)			Number of tuber per plant
				Large tuber	Medium tuber	Small tuber	
Manure (A)	2	530.80ns1	0.139ns	9.44ns	51.94ns	28.89ns	4.66ns
Error 1	4	396.20	0.092	16.30	27.07	39.41	1.82
P (B)	3	12.61ns	0.190ns	22.36ns	40.51ns	13.45ns	0.97ns
A×B	6	86.49ns	0.334*	50.84ns	58.12ns	8.66ns	3.27ns
Zn (C)	1	46.31ns	0.127ns	3.70ns	10.49ns	1.73ns	20.26*
A×C	2	34.62ns	0.029ns	97.52ns	79.43ns	52.15*	11.50*
B×C	3	175.70*	0.391*	131.10*	202.00*	10.17ns	4.68ns
A×B×C	6	13.42ns	0.122ns	32.03ns	22.03ns	8.92ns	1.35ns
Error 2	42	48.62	0.109	34.96	51.97	19.08	3.30

1- ns= Non significant and * = $p < 0.05$

Table 4. Means comparison of interaction effects of phosphorus and zinc fertilizer on dry matter, tuber weight, ratio of tuber and tuber number per plant.

Traits Treatments		Shoot dry matter (g)	Tuber weight (kg m^{-2})	Tuber number/ Tuber total number(%)			Number of tuber per plant
				Large tuber	Medium tuber	Small tuber	
P (0 kg ha^{-1})	Zn (0 kg ha^{-1})	21.4ab1	1.79a	9.83abc	85.70ab	4.47	7.22
	Zn (50 kg ha^{-1})	25.9ab	1.36b	7.16bc	90.10a	2.69	5.22
P (75 kg ha^{-1})	Zn (0 kg ha^{-1})	27.5ab	1.40b	14.22a	81.30b	4.52	5.99
	Zn (50 kg ha^{-1})	21.9ab	1.42.b	8.01abc	88.90ab	3.09	5.33
P (150 kg ha^{-1})	Zn (0 kg ha^{-1})	23.3ab	1.54ab	10.15abc	87.00ab	2.90	5.78
	Zn (50 kg ha^{-1})	22.2ab	1.70ab	10.72abc	85.50ab	3.80	5.96
P (225 kg ha^{-1})	Zn (0 kg ha^{-1})	20.0b	1.51ab	5.58c	92.10a	1.35	6.78
	Zn (50 kg ha^{-1})	28.7a	1.38b	13.07ab	84.50ab	2.43	5.00

1- Columns means followed by the same letter are not significantly different at 0.05 probability level.

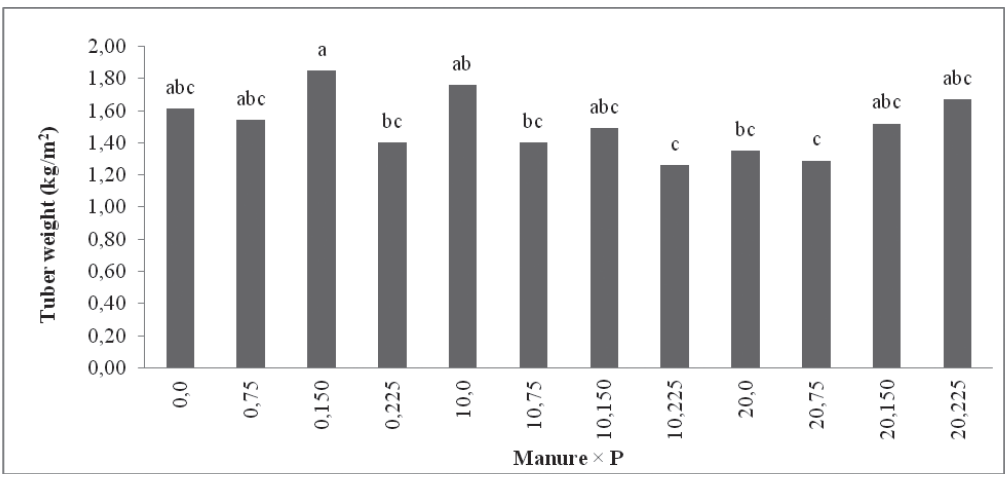

Figure 3. Effects of manure and phosphorus interaction on tuber weight (same letter are not significantly different at 0.05 probability level).

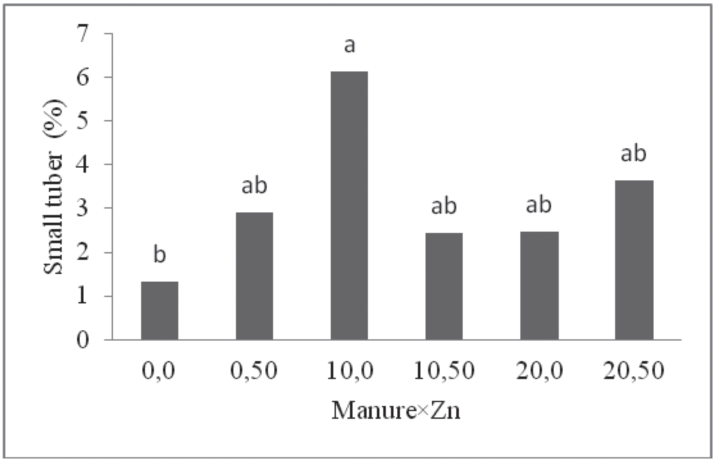

Figure 4. Effects of manure and zinc interaction on ratio of small tuber (same letter are not significantly different at 0.05 probability level).

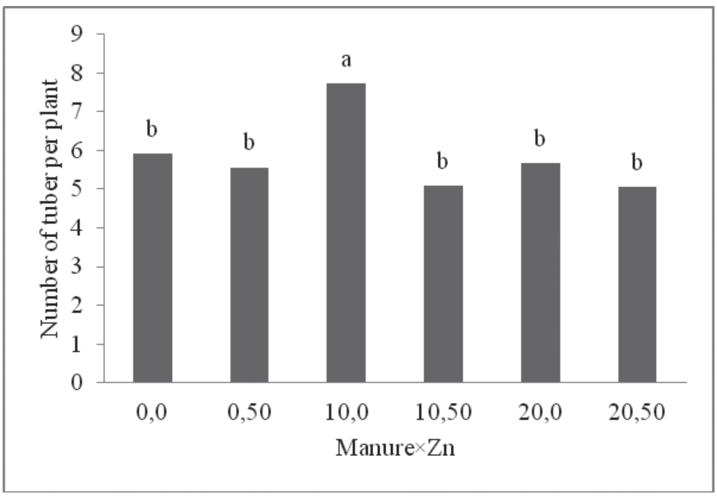

Figure 5. Effects of manure and zinc interaction on number of tuber per plant (same letter are not significantly different at 0.05 probability level).

4. Conclusion

In this research compost and manure had no considerable significant effect on potato yield, because experimental soil field was poor of organic matter, so application of this amount of compost and manure could not have a high effect on potato yield. Animal manure and compost was improves the soil physical characteristics over several years. This research was done for a crop year, so the influence of compost and manure were not evident in the first year. According to the result application of zinc fertilizer increased percent of small tuber, so application of zinc fertilizer is not recommended for seed potatoes production.

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