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Effect of Organic Manure with Phosphorus and Zinc on Yield of Seed Potato

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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 compost in three levels (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 effect 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 significantly 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 significantly affected by Zinc and phosphorus interaction, so that maximum dry matter was obtained by using 225 kg ha^{-1} phosphorus × 50 kg ha^{-1} zinc, also number of small tuber increased by zinc fertilizer.

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

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 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 manure has been gaining in organic food production (Neeson, 2004). These organic sources have a profound effect on crop yield quality and quantity (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 (Abbasi *et al*., 2002; Litterick *et al*., 2004; Montemurro *et al*., 2005; Barker and Bryson 2006). Use of fertilizers and manure to enhance soil fertility and crop yield improvement is a traditional method, the farmers who of centuries ago were familiar with it also the use of compost and spread it on the farm compared with fresh manure was much easier and possible pathogens in the compost is much less (Sandeen *et al*., 2003).

On the other hand the use of municipal 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 municipal 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).

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Positive role of municipal compost application has been reported in many crops, garden and pasture (Marcote *et al*., 2001). In study application compost in soil increased microbial activity, nitrogen concentration and grain yield (Tejada *et al*., 2003). Use of municipal compost in the Mediterranean semi-arid lands increased nitrogen, phosphorus, potassium and organic carbon 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 the increased power of soil fertility, crop growth and thus the high water use efficiency to promoting (Karlen *et al*., 1985). Compost with improved germination and increased dry matter than the compost-free treatments increased crop yield (Mc Callum *et al*., 1998). Phosphorus plays significant role in physiological and biochemical reactions such as photosynthesis, transfer characteristics, and convert sugar into starch in plant (Mehrvarz *et al*., 2008). Fertilizers and manure in the soil increased phosphorus uptake by plants, one reason for this is to produce carbonic acid, which acid in calcareous soils, increases solubility phosphate compounds (Chein, 2001). Elements behavior in the soil and its availability for plants depends to soil conditions, plant species, climatic and agronomic factors. Zinc is high mobility and strength of the soils often is weak kept these elements in soil (Alloway, 1990). Zinc is suitable for production and optimal size of fruit, also it required in the carbonic enzyme which present in all photosynthetic tissues, and required for chlorophyll biosynthesis (Graham *et al*., 2003). According to Adverse effects of chemical fertilizers, the purpose of the present study was to determine the effects of compost, animal manure, phosphorus and Zinc fertilizer on seed potatoes production.

MATERIAL AND METHODS

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, 2044m Altitude from sea level with an arid and semi-arid climate. The pH of the experimental soil was 7.15 with sandy-loamy texture (Table 1). Experiment was conducted in factorial design in randomized complete block in two independent experiments with three replications. In the first experiment compost, phosphorus and zinc and in the second experiment, animal manure, phosphorus and zinc were used. The treatments were compost in three levels (0, 10 and 20 ton ha^{-1}), animal manure in three levels (0, 10 and 20 ton ha^{-1}) as the main factors, four levels of phosphorus (0, 75, 150 and 225 kg ha^{-1}) and two levels of zinc (0 and 50 kg ha^{-1}) as the sub factors. Seeds were planted a spacing of 75 cm x 25 cm on February 2010. All operations such as irrigation, weed control and earthing up were done regularly during the growing season.

Crop Sampling:

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)).

Statistical Analysis:

Data analysis was done by using SAS and MSTATC software. The ANOVA test was performed to determine significant ($p \leq 0.05$) treatment effect and the mean values were adjudged by DMRT (P=0.05) method.

RESULTS AND DISCUSSION

First Experiment (Effect of Compost, Phosphorus and Zinc Fertilizer on Potato Yield):

Results showed that compost and phosphorus application had no significant effect on traits (Table 2). Zinc had no significant effects on traits except number of small tubers. Mean comparison showed that number of small tubers increased the application of zinc fertilizer compared with no zinc (Fig 2). The highest number of small tubers was obtained in 50 kg ha^{-1} zinc. It seems that tuber was increased the use of zinc. 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 interactions. Maximum shoot dry matter (52.7g) was found in compost (10 ton ha^{-1}), phosphorus (150 kg ha^{-1}) and no zinc; the minimum shoot dry matter (17g) was obtained the control and only the compost (10 ton ha^{-1}) and treated plot (Fig 2). Main effect of compost, phosphorus and zinc were not significant on shoot dry matter (Table 2). Potato shoot dry matter increased by compost application, due to improved soil structure and aeration, and thereby tubers increased in the better soil bed. Soil resistance against to tubers growth was reduced by compost application (Arancon *et al*., 2003; Tu *et al*., 2006).

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
						(ppm)					
Value	0-30	sandy- loamy	0.15	1.88	7.15	10.06	174.2	0.74	5.06	1.4	1.18

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
				Large tuber	Medium tuber	Small tuber	per plant
Compost (A)	2	1036.00ns1	0.141ns	30.10ns	100.5ns	53.40ns	6.68ns
Error 1	4	428.1	1.743	366.2	554.4	52.9	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	142.9	0.423	42.5	88.9	44.2	5.28

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

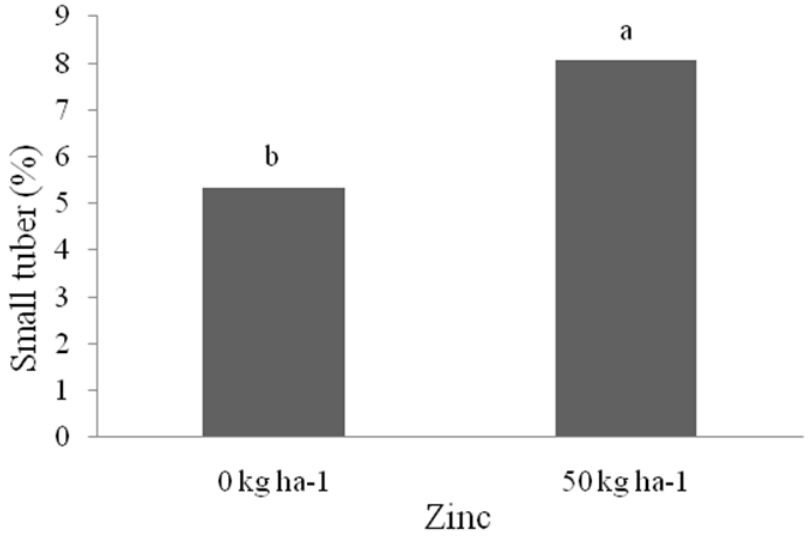

Fig. 1: Effect of zinc fertilizer on number of small tuber.

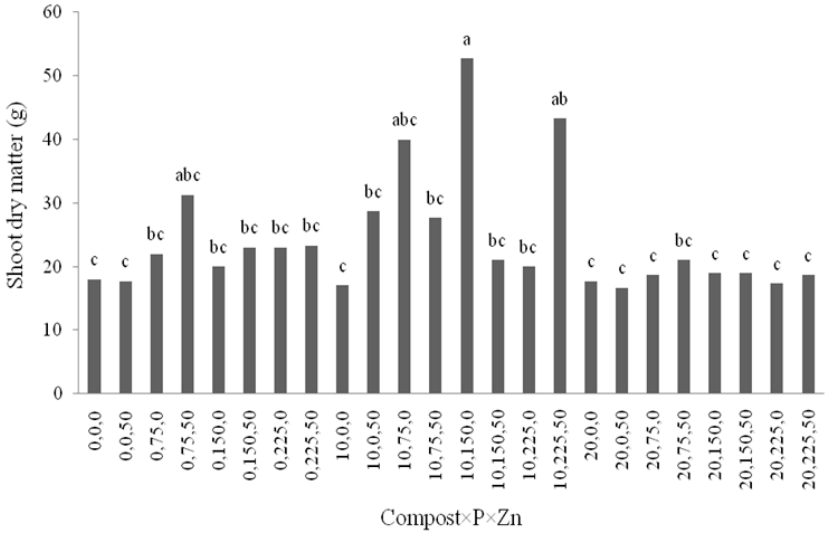

Fig. 2: Effects of compost, phosphorus and zinc fertilizer interaction on shoot dry matter.

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 wasn't significant on potato yield. Zinc except on the number of tubers per plant had no significant effect on the other traits (Table3). Zinc decreased number of tubers per plant significantly ($p<0.05$) (Table 4). Highest tuber (1.85 kg m^2) was found in 150 kg ha^{-1} phosphorus (Fig. 3). Maximum number of small tubers (6.15%) was recorded in only 10 ton ha^{-1} manure treatments and the minimum number (1.32%) was in the control (Fig. 4). There were no significantly different among other treatments. Highest number of tubers per plant (7.74) was obtained in 10 ton ha^{-1} manure; and the lowest number was also in other treatments (Fig. 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 (28.7g) was obtained in 225 kg ha^{-1} phosphorus and 50 kg ha^{-1} zinc; and the minimum shoot dry matter per plant (20g) was obtained in 225 kg ha^{-1} phosphorus and. Maximum and minimum ratio of large tuber was obtained in 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 (Table 4).

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
				Large tuber	Medium tuber	Small tuber	per plant
Manure (A)	2	530.80ns1	0.139ns	9.44ns	51.94ns	28.89ns	4.66ns
Error 1	4	396.2	0.092	16.3	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.

Treatments	Traits	Shoot dry matter(g)	Tuber weight (kg m^2)	Tuber number/ Tuber total number (%)			Number of tuber
				Large tuber	Medium tuber	Small tuber	per plant
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	2.9	5.78
	Zn (50 kg ha-1)	22.2ab	1.70ab	10.72abc	85.50ab	3.8	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.

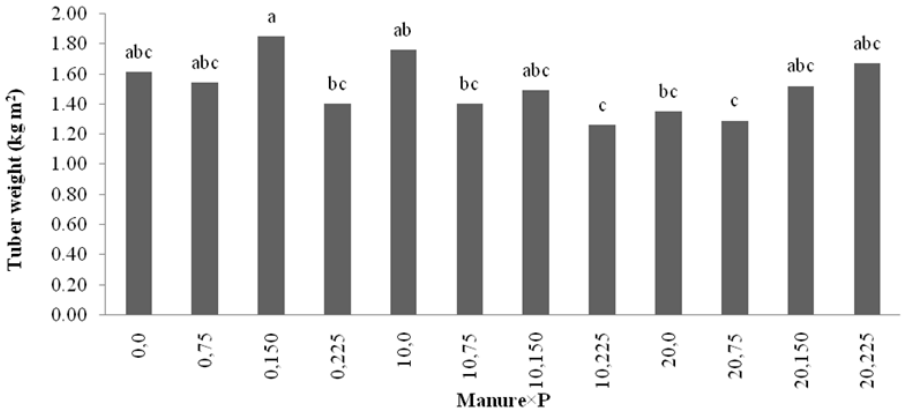

Fig. 3: Effects of manure and phosphorus interaction on tuber weight.

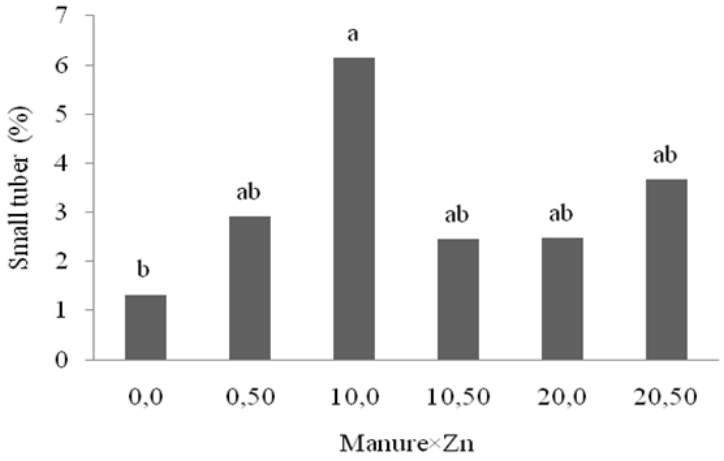

Fig. 4: Effects of manure and zinc interaction on ratio of small tuber.

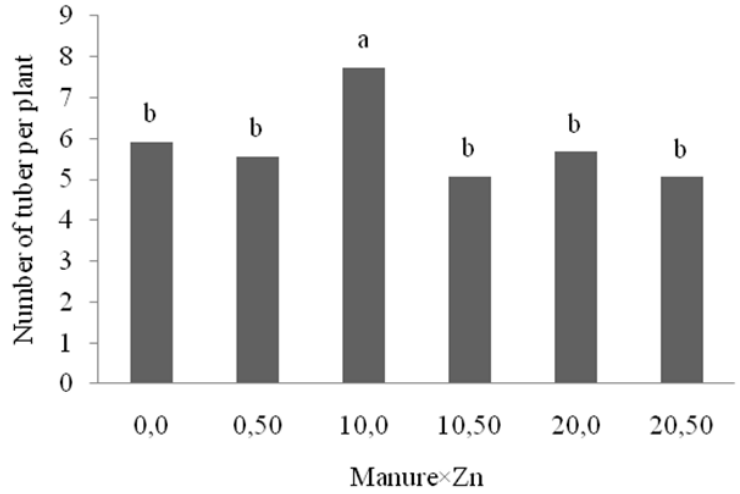

Fig. 5: Effects of manure and zinc interaction on number of tuber per plant.

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 couldn't have a high effect on potato yield. 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. Animal manure and compost was improved the soil physical characteristics after several years. This research was done for a crop year, so the influence of compost and manure weren't 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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