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Urban waste compost, manure and nitrogen fertilizer effects on the initial growth of corn (*Zea mays L.*)

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Abstract

Field experiment was conducted in 2008 at the Research Field of Agricultural College of Shiraz University, Shiraz, Iran to investigate the effects of urban waste compost (UWC), manure and chemical fertilizer on the initial growth of corn (*Zea mays*). Experimental design was split plot factorial with three replications. Main plots were assigned to nitrogen (N) fertilizer (0 and 200 kg N ha^{-1}), and sub plots were factorial application of municipal waste compost (0, 25 and 50 t ha^{-1}) and manure (0, 25 and 50 t ha^{-1}) with all possible combinations. Results showed that increase in urban waste compost and manure increased corn dry matter, height, stem diameter, leaf area, leaf number, SPAD meter readings and leaf N. There was a close relationship between SPAD meter readings and leaf N (R^2=0.84). Correlation and path analyses showed that leaf area and SPAD readings are major components which affect corn dry matter at initial growth stage. Results of the present study revealed that organic fertilizer can improve initial growth of corn similar to chemical fertilizer. It can be concluded that manure and compost can be effective nutrient sources for corn production and can be considered as potential alternatives to chemical N fertilizer.

Keywords: Corn, Organic fertilizer, Inorganic fertilizer, SPAD meter, Early growth

1. Introduction

One of the most important crops in Iran, especially Fars province is corn. It is used to feed livestock and to manufacture industrial products. Nitrogen is a key element nutrient with an essential role in corn production. Many researchers have reported that its application as fertilizer could increase crop yield (Berenguer *et al*., 2009; Lawrence *et al*., 2008; Ghadiri and Naderikharaji, 2008). Nitrogen fertilization management is very crucial due to its high environmental risks and cost. In Iran, municipal waste production is increasing. It is clear that its accumulation and burial is labor-intensive and costly (Kazemeini *et al*., 2008). Moreover, intensive industrial animal production has led to more production of manure which is an important environmental issue to be dealt with. Therefore, manure and municipal waste compost could be used as potential resources of essential nutrients for crop production. In recent years, scientists and farmers have shown interest in using municipal waste compost and manure to provide soil nutrient and organic matter in Iran's farming systems. Nyiraneza *et al*., (2009) found that application of cattle manure caused an increase in corn yield and N uptake. Applications of manure and compost could improve soil properties and provide sufficient nutrients for corn (Eghbal *et al*., 2004). Sulivan *et al*., (2002) in a study on tall fescue (*Festuca arundinacea* Schreb.) reported that application of waste compost increased its yield. Eriksen et al., (1999) also reported that municipal waste compost can increase soil organic matter and nutrient for corn production. The objective of this research was to investigate the effects of manure, municipal waste compost, and N on the

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initial growth of corn in southern Iran (Fars Province).

2. Materials and methods

A field experiment was conducted in 2008 at the Research Field of Agricultural College of Shiraz University, Shiraz, Iran to investigate the effects of UWC, manure and chemical fertilizer on initial growth of corn. Plots were located on a silty loam soil with 0.76 % organic matter, 0.08 % N, 21.8 p.p.m phosphorus, 600 p.p.m potassium, pH of 7.85, and EC of 0.52 dSm^{-1}. Commercial corn seeds, cultivar 370, were sown on June 22, 2008 in 3×6 m plots. Each plot consisted of 4 rows spaced 75 cm apart expecting a plant density of 80, 000 plants ha^{-1}. Experimental design was split plot factorial with three replications. Main plots were chemical N levels (0 and 200 kg N ha^{-1}), and sub plots were factorial application of municipal waste compost (C) (0, 25 and 50 ton ha^{-1}) and manure (M) (0, 25 and 50 ton ha^{-1}) with all possible combinations. Before planting, compost and manure were evenly mixed in soil. Selected characteristics of compost and manure are shown in Tables 1 and 2. Irrigation intervals were 8 days according to the concurrent local practice. All plots were kept free from pests, diseases and weeds during the experiment period. Chlorophyll meter (SPAD meter) readings were taken on upper leaves of 10 plants per plot and average values were recorded for each plot. At the end of the experimental period, 35 days after planting, corn dry weight, height, stem diameter, leaf area, leaf number, and leaf N content were measured. Data were subjected to analysis of variance (ANOVA) and the means were compared (LSD test, $p<0.05$) using SAS and M STAT-C software. Correlation and path analysis were also performed using SAS (2002).

Table1. Some Characteristics of manure that was applied in this experiment

pH	EC	Total N (%)	C/N	P (mg/kg)	K (mg/kg)
8.7	7.9	2.15	21	8000	341

Table 2. Some Characteristics of municipal waste compost that was applied in this experiment

pH	EC	Total N(%)	C/N	P (%)	K (%)	Cr (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
6.9	11.56	1.42	21.41	0.63	0.61	49.03	187.57	6.43	71	281.92	352.64	826.23

3. Results and discussion

Results showed that there were no significant differences in corn emergence percentage between 0 and 200 kg N ha^{-1} and among 0, 25 and 50 t manure ha^{-1} but the trait significantly decreased with increasing compost levels (Table 3). This may be because of toxicity of urban waste compost. It is clear that germination stage is the most sensitive crop growth stage to metal toxicity. Melland *et al*. (2005) reported that composted swine manure had no significant effect on corn, soybean (*Glycine max* L.) and winter wheat (*Triticum aestivum* L.) seedling emergence. Pal and Bhattacharyya (2003) found that municipal solid waste compost reduced seed germination of rice (*Oryza sativa* L.), wheat and cucumber (*Cucumis sativus* L.).

Increased compost and manure levels significantly increased corn dry matter (Table 3). Compared to control, application of compost even at a low rate of 25 ton ha^{-1} caused 59 % increase in corn dry matter. Similarly, 25 ton manure ha^{-1}, increased the trait 57 %. There were no significant differences between compost, manure at 50 ton ha^{-1}, and N level. Ahmad *et al*. (2008) also in a study on the effect of compost on growth of corn reported similar results. Like inorganic fertilizer, dairy manure compost could increase dry matter of silage corn (Butler et al., 2008). Studying the effects of municipal solid waste compost on forage crops, Zheljazkov *et al*. (2006) found that application of compost increased forage dry matter. Sinaj *et al*. (2002) also reported that compost could increase white clover (*Trifolium repense* L.) dry matter.

Increased compost and manure application significantly increased corn height only up to 25 t ha^{-1} with no significant difference between 25 and 50 ton ha^{-1}. There were no significant differences between highest levels of N, compost, and manure treatments (Table3). Application of compost and manure at 25 t ha^{-1} increased 19 % and 23 % in corn height, respectively. Prince *et al*. (2000) reported that compost could increase height of mulberry (*Morus alba*). Application of manure increased tomato (*Lycopercicum esculentum*) height (Ojeniyi *et al*., 2007).

All levels of manure and compost significantly increased corn leaf area compared to control. There were no significant differences between highest levels of manure, compost, and

N (Table 3). Manure and compost at 25 t ha^{-1} increased leaf area 64 % and 51 %, respectively. These results are in agreement with those of Kazemeini *et al*., (2008) for compost application in dryland wheat and Boateng *et al*. (2006) for poultry manure application in corn. Compared to control, corn leaf number significantly increased with 25 t manure ha^{-1}, while it significantly increased only when 50 ton of compost ha^{-1} was applied. There were no significant differences among compost and manure, organic fertilizer, and N levels. Ravindran *et al*. (2007) showed that organic fertilizer application increased leaf number of peanut (*Arachis hypogaea*). Same results have been reported by different researchers, e.g., Wahid *et al*. (1998) reported that manure could increase wheat leaf number. Olfati *et al*. (2009) found that municipal solid waste compost could increase lettuce (*Lactuca sativa*) leaf number. Increasing compost and manure at the rate of 25 t ha^{-1} increased leaf N content 25 and 20 %, respectively. It has been shown that leaf N had close correlation with N status in soil (Aregui *et al*., 2006; Le Bail *et al*, 2005). Interaction effects of treatments on measured traits are given in Table 4.

SPAD meter readings were highly responsive to manure application (Table 3). All levels of manure significantly increased the trait. Studying effects of manure on corn, Eghbal and Power (1999) found similar results when growing corn using composted and non composted manure. Increased compost application up to 25 t ha^{-1} significantly increased SPAD meter readings with no significant difference between 25 and 50 ton compost ha^{-1}. Application of compost in sunflower (*Helianthus annuus* L.) enhanced the total chlorophyll content (Abd El-Sabour *et al*., 1997). The trait also significantly increased by N application. Similarly, Dordas and Sioulas (2008) in a study on the effect of N levels on chlorophyll content and other traits of safflower (*Carthamus tinctorious* L.) showed that with increase in N fertilizer SPAD meter readings increased. Control treatment had the lowest value of SPAD meter readings. There were no significant differences among 50 t manure and compost ha^{-1}, and 200 kg ha^{-1} N (Table 3). This indicated that organic materials (manure and compost) like chemical fertilizers could increase soil fertility and satisfy the nutrient demands of crops. These results also revealed that organic fertilizer can provide sufficient nutrient supply for crop growth and development.

Nitrogen, manure and compost had significant effects on corn stem diameter. There were no significant differences between both compost and manure at 25 and 50t ha^{-1} (Table 3). Stem diameter increased 40 and 39 % at 25 t manure and compost ha^{-1}, respectively compared to control which confirm the result of Lima et al (2004).

Simple correlation coefficients calculated among the traits are shown in Table 5. There were highly significant correlations among corn dry matter and corn height, leaf area, SPAD meter readings and leaf nitrogen.

The relationship between corn dry matter and the measured traits was determined using path analysis (Figure 1). There was a significant direct effect, path coefficient, among corn dry matter, leaf area, SPAD meter readings and stem diameter. Based on both correlation and path analysis, leaf area and SPAD meter readings are major components which affect corn dry matter at initial growth stage.

Regression analysis showed that there were significant correlations between SPAD meter readings and corn dry matter (R^2= 0.82) and percentage of N in leaves (R^2= 0.84). Also, there was a significant correlation between corn dry matter and leaf N content (R^2= 0.61). Polynomial quadratic models were fitted for them (Figures 2, 3 and 4). Some researchers have reported that SPAD meter readings, crop dry weight and percentage of N in leaves were highly correlated (Scharf *et al*., 2006; Loria *et al*., 2007).

4. Conclusion

The present study showed that organic fertilizer can improve initial growth of corn (e.g., plant height, stem diameter, leaf number and corn dry weight) similar to chemical fertilizers. Like N fertilizer, organic fertilizer also increased chlorophyll and leaf N content of corn. Therefore, manure and compost can be effective nutrient sources for corn production and can be considered as potential alternatives to chemical N fertilizer. The results also showed that SPAD meter can be used as a tool for determination of soil N deficiency. More research is required to understand whether different methods of organic fertilization have significant effect on corn initial growth.

Table 3. Effects of compost (C), manure (M) and (N) on corn dry matter, height, leaf area, SPAD meter readings, % germination, leaf number, stem diameter, leaf N.

		Dry matter (g/plant)		Height (cm)		Leaf area (cm)		SPAD readings		Germination (%)		Leaf number		Stem diameter (mm)		Leaf N (%)	
C(t/ha)	M(t/ha)	N0	N200	N0	N200	N0	N200	N0	N200	N0	N200	N0	N200	N0	N200	N0	N200
1	1	0.63	2.041	40	53	60.33	122	32.67	43.2	97.22	100	4	5	1	1.663	2.525	3.9
	2	1.573	2.993	49.5	57	44	160.3	41.67	44.34	97.22	91.67	5	5	1.67	1.7	3.168	4
	3	3.4	3.5	51	67.5	101	186	46.33	46.7	97.22	97.22	5	5.5	1.73	1.8	3.643	4.04
2	1	1.4787	3.208	52.5	60	117.7	102.7	45	45.4	91.67	91.67	4.5	5	1.61	1.663	3.385	4.09
	2	3.461	3.525	54	63	152	134	45	46.67	91.67	91.67	5	5	1.64	1.7	3.311	4.1
	3	4.967	5.127	60.5	65	137.3	183	46.67	48	91.67	91.67	5	5	1.61	1.78	3.732	4.153
3	1	3.2	4.87	55.5	63	130.3	199.7	45.33	46.33	83.33	80.56	5	5.5	1.663	1.72	3.863	4.2
	2	5.1	5.809	60	66	130	229	48.67	47.6	83.33	83.33	5	5	1.9	1.947	3.962	4.23
	3	5.9	6.376	62	67.5	184.7	242	47.67	48.33	77.78	83.33	5.5	5.5	2.1	2	4.19	4.3
LSD value (p<0.05)		0.94		6.3		42.31		1.2		10.35		0.75		0.1		0.2	

Table 4. Analysis of variance for measured traits of corn

Source of Variations	Degrees of Freedom	Mean square							
		Dry matter	Height	Leaf area	SPAD readings	Germination	Leaf number	Stem diameter	Leaf N
block	2	2.87920035	177.3472222	3640.88889	1.4074074	0.00297272	82.307819	0	0.00871667
N	1	6.25668817**	805.0416667**	41889.18519**	17.7962963**	2.24277824*	185.188889*	1.5*	3.39502963**
Error	2	0.004	7.347	168.074	0.296	15.435	0.222	0	0.053
C	2	1.40069291*	181.625**	1637.38889	68.462963*	0.85368817**	9.001955	0.16666667	0.38942222**
M	2	5.52586274**	298.625**	25191.16667**	114.2962963*	0.28902756**	850.076646**	0.54166667	0.24926667**
N*C	2	0.03271006	5.2916667	2824.46296*	16.462963*	0.48486202	50.159568	0.5	1.25442963
N*M	2	1.06244267	15.5416667	9119.12963*	23.4074074*	0.19977919	73.304938	0.875	0.72111852
C*M	4	1.68988752*	12.4375	1255.80556	11.6296296*	0.03878472	61.084362	0.72916667	0.35415556
N*C*M	4	0.59483372	43.9791667	4456.49074*	35.5740741	0.01710196	13.503858	0.4375	0.26306852
Error	32	10.543	14.691	667.606	0.539	32.954	0.205	0	0.012

Table 5. Simple correlation coefficients among corn dry matter and measured traits.

	DM	H	LA	SPAD	L No.	S.D	Leaf N
DM+	1						
H	0.83**	1					
LA	0.85**	0.78**	1				
SPAD	0.71**	0.81**	0.71**	1			
L. No	0.61*	0.72**	0.72**	0.62*	1		
S.D	0.41ns	0.62*	0.56*	0.85**	0.56*	1	
Leaf N	0.70**	0.86**	0.76**	0.77**	0.80**	0.75**	1

+Corn dry matter (DM), height (H), leaf area (LA), SPAD meter readings (SPAD), leaf number (L. NO.), stem diameter (S. D), leaf nitrogen (Leaf N).
* and **: significant at p<0.05 and p<0.01, respectively.

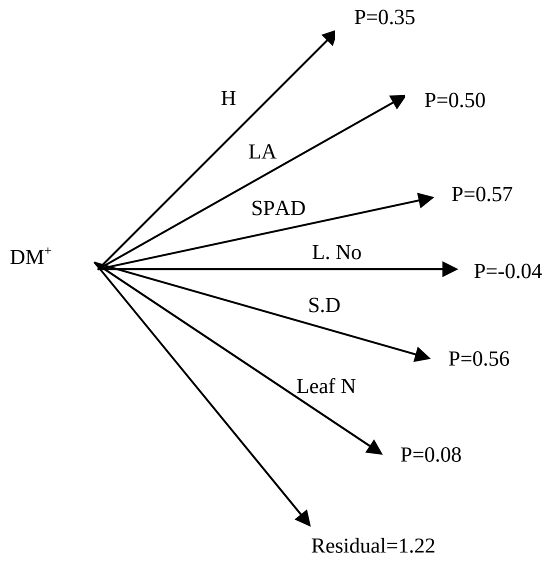

Fig.1. Path coefficient diagram showing the direct effects of corn dry weight and measured traits
+Corn dry matter (DM), height (H), leaf area (LA), SPAD meter readings (SPAD), leaf number (L. NO.), stem diameter (S. D), leaf nitrogen (Leaf N).

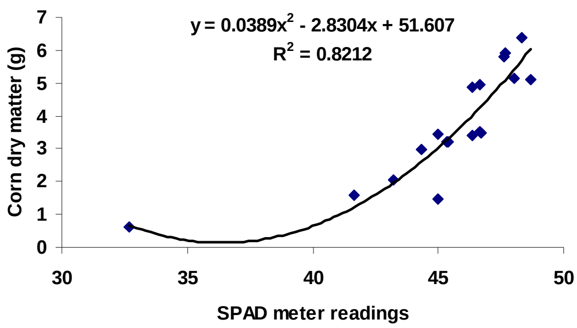

Fig.2. Relationship between corn dry matter and SPAD meter readings

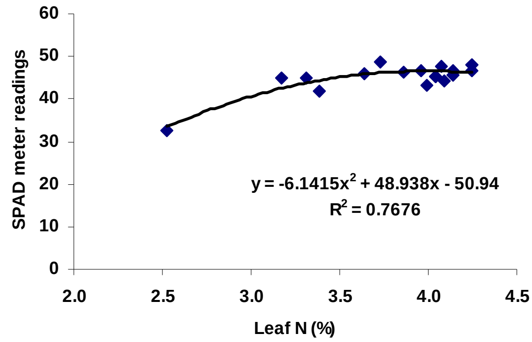

Fig 3. Relationship between leaf nitrogen and SPAD meter readings.

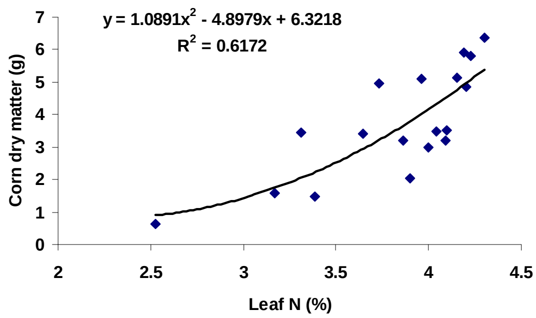

Fig 4. Relationship between leaf nitrogen and corn dry matter

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