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Effect of Vermicompost and Chemical Fertilizers on Growth Parameters of three Corn Cultivars

[1]Zeinab Amanolahi-Baharvand, [1]Hossein Zahedi, [2]Masoud Rafiee

[1]*Department of Agronomy and Plant Breeding, Eslamshahr Branch, Islamic Azad University, P.O.Box:33135-369, Tehran, Iran*
[2]*Department of Crop Improvement, Faculty of Agricultural and natural resources research centre, P.O.Box:68158, Lorestan, Iran*

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ABSTRACT

Nutrient management plays a key role in improving crop yield with maintenance of soil fertility for sustainable production in intensive cropping. A field experiment was conducted to assess the effect of integrated nutrient management on the growth of three corn cultivar in Agricultural and Natural Resources Research Centre in Lorestan, Iran. The experimental design was a randomized complete block design arranged in factorial with three replications. The first factor comprised three corn cultivars (Single cross 704, Single cross 677 and Single cross 580) and the second factor was three levels of fertilizers [Chemical (100% urea), full organic (100% vermicompost) and integrated (50% urea and 50% vermicompost)]. The results showed that corn cultivars vary in some growth parameters such as leaf number, leaf area index and plant height. In addition, vermicompost application had great impact on corn growth especially when it was combined with chemical fertilizer. Integrated fertilizer management significantly increased leaf number, leaf area index, stem diameter, plant height, chlorophyll content and remobilization compared to full chemical and full organic treatments. In general, to get maximum growth and yield, the application of integrated organic and inorganic fertilizer is best option.

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INTRODUCTION

Excessive use of chemical fertilizers, decline in soil and food quality due to loss of soil organic matter is the main characteristics of the conventional farming systems which are more pronounced in arid and semi-arid areas (Singh *et al.*, 2007; Melero *et al.*, 2008; Liu *et al.*, 2009). Increasing public awareness of the negative environmental impacts, growing consumer demand for healthier products and criticism of high input production systems lead to more emphasis on organic crop production under integrated management systems (Guarda *et al.*, 2004).

Vermicomposts are organic materials broken down by interactions between micro-oganism and earthworms in a mesophilic process, to produce fully stabilized organic soil amendments with low C: N ratios (Ramasamy, *et al*., 2011). Vermicompost has large particulate surface area that provides many micro-sites for the microbial activity and strong retention of nutrients. Vermicompost contains significant quantities of nutrients; a large beneficial microbial population; and biologically active metabolites; particularly gibberellins, cytokinins, auxins and group B vitamins which can be applied alone or in combination with organic or inorganic fertilizers, so as to get better yield and quality of diverse crops (Atiyeh *et al*., 2002; Arancon *et al*., 2006 and Jack *et al*., 2011). The use of vermicompost helps in maintaining soil fertility since the mineral elements contained in it were changed to forms more that could be readily taken up by plants such as nitrates, exchangeable phosphorous, soluble potassium, calcium, manganese etc. Various workers have examined the suitability of vermicompost as plant growth media (Zhao and Huang, 1988; Pashanasi *et al*., 1996) and have addressed their potential commercial value.

A number of field experiments have reported positive effects of quite low application rates of vermicompost to field crops. It has been reported that vermicompost increases growth, yield and tomato quality when used as a soil supplement (Gutierrez-Miceli *et al*., 2007) or as an alternative to mineral fertilizers in rice–legume intercropping (Jeyabal and Kuppuswamy, 2001). The addition of vermicompost to field strawberries was found to produce significantly higher yields than the addition of equivalent amounts of mineral fertilizers, and the presence of plant growth regulators in the vermicompost was suggested (Arancon *et al*., 2004).

Corresponding Author: Hossein Zahedi, Department of Agronomy and Plant Breeding, Eslamshahr Branch, Islamic Azad University, P.O.Box:33135-369, Tehran, Iran
E-mail: hzahedi2006@gmail.com

Vermicomposts applied at 12 t/ha to field soils together with 100% or 75% of the recommended application rate of inorganic fertilizers increased yields of okra (*Abelmoschus esculentus* Moench) significantly (Ushakumari *et al*., 1999). It has been shown that vermicompost stimulates plant flowering, increases the number and biomass of the flowers (Arancon *et al*., 2008, Ramasamy and Suresh, 2011), as well as increases fruit yield (Singh *et al*., 2007). In addition, soil analyses after the vermicompost applications showed marked improvements in the overall physical and biochemical properties of the soil.

The literature survey revealed that the study on the influence of vermicompost is scanty. Hence, in the present investigation, an attempt was made to study the influence of vermicompost on growth parameters of corn which is a very important food plant around the world.

MATERIAL AND METHODS

In order to investigate the effects of integrated chemical and organic (vermicompost) fertilizers on growth parameters of three corn (*Zea mays* L.) cultivars an experiment was conducted in Agricultural and Natural Resources Research Centre in Lorestan, Iran (latitude: 33° 299 N; longitude: 48° 189 E; 1371 m altitude; rainfall: 525 mm; mean temperature: 17.2°C) during 2013 growing season. The experimental design was a randomized complete block design arranged in factorial with three replications. The first factor comprised three corn cultivars (Single cross 704, Single cross 677 and Single cross 580) and the second factor was three levels of fertilizers [Chemical (100% urea), full organic (100% vermicompost) and integrated (50% urea and 50% vermicompost)]. Before the beginning of the experiment, vermicompost was purchased from the local market and transferred to the field. Soil and vermicompost samples were collected and analysed in terms of nitrogen content using Kjeltec Auto 1030 Analyzer and other parameters. Results are given in table 1 and 2. At this time, seed bed was prepared by ploughing and disking. Then plots were designed with 4 m long and consisted of five rows, 0.7 m apart each other. Between all plots, 1 m alley was kept to eliminate all influence of lateral water movement.

Table 1: Chemical properties of the soil

pH	µmoh.cm^{-1}	Texture	O.C %	N %	P mg.kg^{-1}	K mg.kg^{-1}	Fe mg.kg^{-1}	Znmg.kg^{-1}	Mn mg.kg^{-1}	Cumg.kg^{-1}
6.5	1.8	Loam	1.1	0.2	9	278	6	0.2	3.2	0.69

Table 2: Chemical properties of the vermicompost.

pH	dS.m^{-1}	O.C %	N %	P g.kg^{-1}	K mg.kg^{-1}	Femg.kg^{-1}	Zn mg.kg^{-1}	Mn mg.kg^{-1}	Cu mg.kg^{-1}	Mg Meq.l^{-1}	Ca Meq.l^{-1}
8.5	6.21	17.5	2.24	1020	9340	75	37.85	30.5	6.12	11.8	5.2

According to recommended amount of nitrogen for corn (150 kg.ha^{-1}) and results of the soil and vermicompost analysis, the amount of required vermicompost to supply 100% of required nitrogen in full organic treatment was calculated using following formula (Sabahi, 2006).

Equation 1: Rn = Md. Mn. An

Where Rn: Requirement nitrogen from vermicompost; Md: vermicompost dry weight; Mn: vermicompost nitrogen percent; An: Available nitrogen percent

In integrated treatment, 50% of required nitrogen was supplied by vermicompost and another 50% was provided by chemical nitrogen fertilizer (Urea). In chemical treatment all required nitrogen was supplied by supplied by chemical nitrogen fertilizer. Based on these calculations, 10, 5 and 0 ton per hectare vermicompost was applied in full organic, integrated and chemical treatments, respectively.

In full organic and integrated treatments the certain amount of vermicompost consider to plots area, was distributed in the plots and mixed with surface soil. Half of urea was used at sowing time and rest was applied at tasseling stage in all treatments. The corn seeds were disinfected and sown in 15^{th} of May. Irrigation was performed immediately after seed sowing. Weeds were removed manually across the growing season. At harvesting time, flag leaf temperature and ear leaf temperature were measured an then the crop was harvested and growth parameters including leaf number, ear leaf number, leaf area index, stem diameter, plant height, flag leaf and ear leaf chlorophyll content were determined. Chlorophyll was extracted in 80 % acetone from the leaf samples. Extracts were filtrated and content of total chlorophyll was determined by spectrophotometry at 645 and 663 nm, respectively. The content of chlorophyll a, b and total was expressed as mg g^{-1} fresh weight (Arnon, 1949).The percentage of remobilization during grain filling was calculated following Papakosta and Gagianas (1991).

The results were submitted to statistical analysis using the software SAS System for Windows 9.1. The analysis of variance (ANOVA) was carried out, and based on the level of significance in the F test ($p < 0.05$). Mean values were compared using Duncan's Multiple Range Test.

Results:

Analysis of variance showed that the effect of cultivar was significant on all traits except for stem diameter, flag leaf and ear leaf temperature and ear leaf chlorophyll content (Table 3). In addition, the effect of fertilizer was significant on leaf number, leaf area index, stem diameter, plant height, flag leaf and ear leaf chlorophyll content (Table 3). There was no significant interaction in this study. As can be seen from table 4, there is significant difference between corn cultivars regarding leaf number, ear leaf number, leaf area index, plant height and percentage of remobilization. Single cross 704 produced the most leaves while single cross 580 had the least leaves (Table 4). The ears were emerged in different positions in different cultivars (Table 4). In single cross 704 ears were appeared from 7^{th} leaves while in single cross 677 and 580 ears were appeared from 5^{th} and 4^{th} leaves, respectively (Table 4). In case of leaf area index the highest value was observed in single cross 704 and then single cross 677 and 580 (Table 4). The highest plants were observed in single cross 704 plots while the shortest plants were related to single cross 580 (Table 4). There was no significant difference between single cross 704 and single cross 677 as to chlorophyll content; however these cultivars had more chlorophyll content compared with single cross 580. Remobilization in single cross 704 was the highest while in single cross 580 it was observed at the lowest amount (Table 4).

Comparison of means indicated that integrated fertilizer management improved corn growth, chlorophyll content and remobilization in corn plants (Table 5). Leaf number significantly increased in full organic and integrated treatments compared with chemical treatment (Table 5). In other words, in chemical plots the least leaves were produced. Similarly, lead area index increased with increasing vermicompost application in corn plants. The highest leaf area index was observed when plants were grown under integrated fertilizer management (Table 5). Stem diameter was affected by different fertilizer management. Although, application of vermicompost led to increase in stem diameter, the highest stem diameter was related to integrated treatments (Table 5). The highest plants were observed in full organic and integrated plots; however there was no significant difference between these treatments (Table 5). Similar results were found when flag leaf and ear leaf chlorophyll content were measured. The highest chlorophyll content was observed in chemical and integrated treatments (Table 5). Remobilization increased in full organic plots compared with chemical plots. This increase was more pronounced when corn plants were grown under integrated fertilizer management (Table 5).

Table 3: Analysis of variance on some growth parameters of three corn cultivars

Sources of variation	d.f	Leaf number	Ear leaf number	Lead area index	Stem diameter	Plant height	Flag leaf temperature	Ear leaf temperature	Flag leaf chlorophyll	Ear leaf chlorophyll	Remobilization
Block	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cultivar	2	*	**	*	ns	**	ns	ns	*	ns	*
Fertilizers	2	*	ns	**	**	*	ns	ns	**	**	*
Cultivar × Fertilizers	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Error	16	0.68	0.58	0.22	3.85	69.94	54.79	0.98	107.62	97.16	1930.95
C.V (%)		6.28	10.32	10.62	22.98	3.60	3.97	3.78	21.54	18.13	5.52
*, ** and ns significant at 0.01, 0.05 and no significant, respectively											

Table 4: Main effects of cultivar on some growth parameters of three corn cultivars.

Cultivars	Leaf number	Ear leaf number	Lead area index	Plant height (cm)	Flag leaf chlorophyll ($mg.g^{-1}$ FW)	Remobilization (%)
Single cross 704	13.50a	7.22a	4.53a	235.01a	53.00a	87.92a
Single cross 677	11.23b	5.21b	3.77b	174.22b	52.60a	58.24b
Single cross 580	9.13c	4.32c	3.32c	137.32c	38.70b	55.01c
Values within the each column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test.						

Table 5: Main effects of fertilizers on some growth parameters of three corn cultivars.

Fertilizers	Leaf number	Lead area index	Stem diameter (cm)	Plant height (cm)	Flag leaf chlorophyll ($mg.g^{-1}$ FW)	Ear leaf chlorophyll ($mg.g^{-1}$ FW)	Remobilization (%)
Chemical	11.24c	3.01c	7.12c	224.40b	48.90a	57.00a	66.33c
Organic (Vermicompost)	13.11b	3.87b	8.43b	234.40a	38.90b	47.02b	75/33b
Integrated	13.55a	4.35a	9.22a	237.00a	56.50a	59.00a	85.45a
Values within the each column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test.							

Discussion:

From this experiment, application of vermicompost in combination with nitrogenous fertilizers showed better performance than only nitrogenous fertilizers. It can be stated that the increase in growth parameters of corn are due to greater availability of nitrogen in full organic and integrated treatments. In full chemical treatments most of nitrogen would be leached from the soil profile. In addition, high porosity and water holding capacity of vermicompost that helps in better aeration and drainage. From the other hand, increase in growth parameters may be attributed to presence of growth hormones, enzymes, and other secretions of earthworms which could stimulate the growth and development of crop. It has been demonstrated that vermicompost contains many humic acids which improves morphological traits of the crop and thus increases the leaf number, leaf area index, stem diameter, plant height and reduces the period of slow growth (Atarzadeh *et al*., 2013). Humic acid increases leaf area index and leaf expansion rate because of increased plant nitrogen (Albayrak and Camas, 2005). Hoque (1999) found that plant height significantly increased with the application of compost along with chemical fertilizer. The increased plant height through the application of composts along with N, P and K was also reported by many other scientists (Kobayashi *et al*. 1989). Xu (2001) reported that upon inoculation with effective micro-organism and organic fertilizer application, sweet corn showed better growth, grain yield as well as increase in root growth and activity. Nitrogen being the major constituent of chlorophyll therefore increases in nitrogen availability leads to increase in chlorophyll content. In chemical treatments, nitrogen is supplied more quickly and chlorophyll synthesis proceeds rapidly while in organic treatment nitrogen release slowly and supply required nitrogen during time. The significant differences between chemical and organic (whether full organic whether integrated) treatments may be attributed to the higher levels of nutrients besides growth stimulating substances (enzymes, antibiotics and growth hormones) available in vermicompost (Vadiraj *et al*. 1998). It has been reported that application of vermicompost increases the supply of easily assimilated major as well as micronutrients to plants besides mobilizing unavailable nutrients into available form. Choudhary and Jat (2004) also reported similar findings. Channabasanagowda *et al*. (2008) have also shown that the differential action of vermicompost may be because of the fact that the vermicompost has slow release of nitrogen due to slow mineralization which helps in availability of nutrients to the plants throughout the growth of the plant and thus resulting in higher growth. Manivannan *et al*. (2009) stated that the increased growth of the beans, (*Phaseolus vulgaris*), were due to the application of vermicompost which indirectly influenced the physical conditions of the soil and supported better aeration to the plant roots and absorption of water. The earthworm casts influenced the development of the plants and promoted plant biomass, which suggest the linkage between biological effects of vermicompost and microbial metabolites that influence the plant growth and development (Tomati *et al*., 1995). Further, the lower growth in the plants cultivated in full organic condition may be due to the presence of high level of inorganic salts (Arancon and Edwards, 2009). Vermicompost along with chemical nitrogenous fertilizer exerted positive effect on assimilates remobilization. This is due to adequate supply of photosynthates for development of sink and balanced nutrition with integrated nitrogen management. These findings are alike with those reported by Sujatha *et al*. (2008).

Conclusions:

From the experiment, it was found that integrated fertilizer resulted higher growth of corn crop as compared to full organic or full chemical treatments. Vermicompost was found to be effective in improving soil physical, chemical and biological properties. So, it can be concluded that combined use of vermicompost as growing media can meet the crop nutrient demand throughout the growth stages for increasing yield and quality of the corn through improvement of soil physical, chemical and biological properties.

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