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Comparative assessment of conventional and organic nutrient management on yield and yield components of three corn cultivars

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Abstract

A field experiment was conducted to assess the effect of integrated nutrient management on the yield and yield components 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 yield components related traits such as ear length, ear diameter, seed number in row, row number, seed weight and seed and biological yield as well as protein yield. In addition, vermicompost application had great impact on corn yield components related traits especially when it was combined with chemical fertilizer. Integrated fertilizer management significantly increased ear diameter, seed number in row, row number, see weight, seed and biological yield and protein yield compared to full chemical and full organic treatments. In general, to get maximum yield, the application of integrated organic and inorganic fertilizer is best option.

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Introduction

Due to the extensive and improper use of chemical fertilizers in the soil, our soil is degrading to an alarming level, causing an imbalance in the ecosystem and environmental pollution as well (Mirza-Hasanuzzaman *et al.*, 2010). More recently, attention is being focused on the global environmental problems; utilization of organic wastes, farm yard manure, compost, vermicompost and poultry manures as the most effective measure for the purpose. Organic materials are the safer sources of plant nutrient without any detrimental effect to crops and soil. Cowdung, farm yard manure, poultry manure and also green manure are excellent sources of organic matter as well as primary plant nutrients (Pieters, 2004). Vermicomposts are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Earthworms consume and fragment the organic wastes into finer particles by passing them through a grinding gizzard and derive their nourishment from microorganisms that grow upon them. The process accelerates the rates of decomposition of the organic matter, alter the physical and chemical properties of the material, leading to a humification effect in which the unstable organic matter is fully oxidized and stabilized (Albanell *et al.*, 1988; Orozco *et al.*, 1996). The end product, commonly referred to as vermicompost is greatly humified through the fragmentation of the parent organic materials by earthworm sand colonization by microorganisms (Edwards, 1998). Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium and micro nutrients, microbial and enzyme activities and growth regulators (Chaoui *et al.*, 2003) and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth *et al.*, 1999) as well as beneficial effect on the growth of a variety of plants (Atiyeh *et al.*, 2002) due to higher levels growth stimulating substances such as enzymes, antibiotics and growth hormones available in vermicompost (Vadiraj *et al.* 1998). 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). Manivannan *et al.* (2009) stated that the increased growth and yield 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. In addition, increase in yield and yield components of corn have been previously reported by Radhakrishnan (2009).

In the present investigation, we evaluated the effect of vermicompost as organic source of fertilizer applied alone or in combination of chemical fertilizer on yield and yield components of three corn cultivars. Consequently, the objectives of this study were, to assess yield and yield components of the crop under conventional and organic nutrient management practices.

Materials and methods

In order to investigate the effects of integrated chemical and organic (vermicompost) fertilizers on yield and yield components 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 tables 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.

Amount of required vermicompost

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.

Agronomic traits

After harvesting, ear length, ear diameter, seed number in row, row number, 400 seed weight, seed yield, biological yield were measured.

Protein yield

Protein yield was estimated using Inframatic device. 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 and discussion

Agronomic traits

Analysis of variance showed that there is significant difference between corn cultivars in terms of ear length, ear diameter, seed number in row, row number, seed yield, seed weight, biological yield and protein yield (Table 3). In addition, the effect of fertilizer was significant on all above mentioned traits except for ear number (Table 3). Interaction between cultivar and fertilizer was not significant on all traits. Therefore, the main effects of cultivar and fertilizer are given in table 4 and 5, respectively. From table 4, the longest ears were observed in single cross 704 and then single cross 677 and 580. There was no significant difference between single cross 704 and single cross 677 in terms of ear diameter (Table 4); however these cultivars produced the thickest ears compared with single cross 580. Seed number in row was statistically different from cultivar to cultivar. Single cross 704 comprise the highest seed number while single cross 580 revealed the minimum number (Table 4). Similar results were found regarding row numbers. It is not surprising that single cross 704 produce the maximum row number as it showed the thickest ears (Table 4).

In the present study, maximum ear number, seed number in row, row number, seed weight, seed yield, biological yield and protein yield were recorded in the plants cultivated under integrated fertilizer management concentration; however there was no significant difference between chemical and full organic treatments regarding row number and seed weight. Vermicompost with a high content of humic compounds, active micro organisms and enzymes greatly contribute to the enhancement of the biochemical fertility of soils (Perucci, 1992).

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	Zn mg.kg-1	Mn mg.kg-1	Cu mg.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 mg.kg-1	K mg.kg-1	Fe mg.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

Hendrix *et al.* (1994) revealed that the higher yields in plants may be due to the fact that vermicompost supplies direct available nutrients such as nitrogen to the plants and improves the proportion of water table of the soil. 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 yields. The heaviest seeds were observed in single cross 704, then single cross 677 and finally in single cross 580. According to yield components results, it is clear that single cross 704 would produce the highest seed yield (Table 4). Similarly, the highest biological yield was related to single cross 704, 677 and 580, respectively (Table 4). Better seed yield in corn exposed to vermicompost may be due to the influence of combined effect of various ingredients of vermicompost such as macro and micro nutrients, plant growth hormones, vitamins (Prabha, 2006; Ramasamy, 2009), enzymes, and many beneficial microbes such as nitrogen fixing bacteria and hormone synthesizing microbes such as *Azospirillum brasilence* (Molla, 2001). The increase in protein yield with vermicompost addition was similar trend as of seed yield (Table 4). As can be seen from table 5, ear diameter increased on account of vermicompost application, nonetheless, the thickest ears were found when vermicompost was integrated with chemical fertilizer. Similar results were obtained when seed number in rows was counted (Table 5). Integrated fertilizer management increased seed number in row; however full organic treatment showed a positive effect o this trait compared with full chemical treatment (Table 5). Although, integrated fertilizer management increased row number in corn, there was no significant difference between chemical and organic treatments (Table 5). The heaviest seeds were obtained from integrated treatment and organic and chemical treatments were as the same in terms of seed weight (Table 5). The highest seed yield and biological yield were found in integrated fertilizers management treatments (Table 5). Subsequently, protein yield increased in integrated treatments (Table 5). The yield components were significantly influenced by integrated fertilizers management. Vermicompost application which led to adequate supply of photosynthates as well as to direct supply of major and micronutrients to developing ears and seeds (Radhakrishnan 2009). In other words, the increase in seed yield and biological yield was due to better photosynthetic efficiency under integrated fertilizer management. The results were supported by the findings of Gopal *et al.* (2010). Similar results have been found by Xu (2001) who reported that upon inoculation with effective micro-organism and organic fertilizer application, sweet corn showed better seed yield. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Sarker *et al.* (2004). On the other hand the lower seed yield in the plants cultivated under full chemical treatment may be due to the presence of high level of inorganic salts (Arancon and Edwards, 2009). Biological yield is the sum of seed yield and straw yield and thus it was also followed the trend like seed yield. Increase in biological yield because of applying integrated fertilizer management might be due to more photosynthesis and dry matter accumulation on account of more nitrogen availability by vermicompost. These results were supported by Channabasavanna and Biradar (2001).The results of the present study correlate with the results in corn yield (Ferreira, 1992) and two varieties of wheat (Garg and Bhardwaj, 2000).

Table 3. Analysis of variance on some yield components related traits of three corn cultivars.

Sources of variation	d.f.	Ear length	Ear diameter	Seed number in row	Row number	Seed weight	Seed yield	Biological yield	Protein yield
Block	2	ns	ns	ns	ns	ns	ns	ns	ns
Cultivar	2	*	*	*	*	*	**	*	**
Fertilizers	2	ns	**	*	*	*	*	*	*
Cultivar × Fertilizers	4	ns	ns	ns	ns	ns	ns	ns	ns
Error	16	2.44	0.04	48.87	0.20	187.23	1701279.96	12261799.80	26662.56
C.V (%)		7.31	5.57	18.95	3.17	8.46	12.60	10.28	8.28

*, ** and ns significant at 0.01, 0.05 and no significant, respectively.

Table 4. Main effects of cultivar on some yield components related traits of three corn cultivars.

Cultivars	Ear length (cm)	Ear diameter (cm)	Seed number in row	Row number	Seed weight (g)	Seed yield ($kg.ha^{-1}$)	Biological yield ($kg.ha^{-1}$)	Protein yield ($kg.ha^{-1}$)
Single cross 704	22.11a	5.01a	39.93a	15.33a	173.08a	11508.34a	37088.89a	985.27a
Single cross 677	21.21b	4.98a	37.91b	14.40b	161.85b	10881.22b	34273.56b	973.94b
Single cross 580	20.80c	4.61b	32.82c	13.42c	150.43c	8665.69c	30822.22c	720.24c

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 fertilizer on some yield components related traits of three corn cultivars.

Fertilizers	Ear diameter (cm)	Seed number in row	Row number	Seed weight (g)	Seed yield ($kg.ha^{-1}$)	Biological yield ($kg.ha^{-1}$)	Protein yield ($kg.ha^{-1}$)
Chemical	3.23c	34.78c	13.82b	156.76b	9417.24c	32155.56c	791.69c
Organic (Vermicompost)	3.56b	36.58b	13.98b	159.49b	10469.19b	33940.22b	841.22b
Integrated	4.97a	39.31a	14.33a	169.11a	11168.82a	36088.89a	1046.54a

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.

Conclusions

In conclusion our study clearly showed that combined application of vermicompost and chemical fertilizers can uplift the row number, seed number in rows and increase seed weigh which gave maximum seed yield. Therefore, similar strategy can be followed by farmers to increase long term productivity and enhancement of ecological sustainability.

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